Wheat Genotype Evaluation for Spot Blotch Disease Resistance:Unveiling Resilient Varieties

ABSTRACT

Spot blotch, caused by *Bipolarissorokiniana*(Sacc.) Shoemaker is a major disease of wheat (*Triticum aestivum* L.), in all the six agro climatic zones of India.Estimation of losses due to this disease vary from location to location, due to diverse environmental conditions. The use of resistant cultivars is the most effective, long-lasting, cost-effective, and environmentally friendly technique for sustainable disease control. The experiment was conducted at Crop Research Centre, Chirodi farm of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). Among the tested varieties, disease index and AUDPC values varied significantly for both years' data viz. 2021-22 and 2022-23. In this experiment 32 wheat ~~variety~~ varietieswere screened against *B. sorokiniana* under artificial epiphytotic conditions in the field. Each varietywere sown in two row of three-meter length with three replications, two line of susceptible check RAJ 4015 was sown at every ten genotypes of interval. Among 32 wheat varieties, twovarieties were found to be resistant, eleven varieties were found moderately resistant, fourteen varieties were found moderately susceptible and five varieties were found susceptible, none of the variety ~~were~~ wasfound immune and highly susceptible against spot blotch disease. Area Under Disease Progress Curve (AUDPC) was calculated for the thirty- two wheat varieties on the basis of disease index. AUDPC varies from 212.90 to 1143.9 and 198.80 to 1144.90 during the 2021-22 and 2022-23 years' data. The pooled mean, Area Under Disease Progress Curve varied from 205.85 to 1144.40, showing the fast progress of disease in all genotypes. It was observed that different wheat varieties expressed varied type of disease response against *B. sorokiniana*.

Keywords:Spot blotch; Varieties; Wheat; Bipolarissorokiniana; AUDPC

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important crop which belongs to family Poaceae (Graminae). This is one of the oldest cereals(Yadawad*et al.,* 2015) and typically a self-pollinating, hexaploid plant. *Triticum aestivum* L. (Bread wheat), *Triticum durum*Desf. (Macaroni or durum wheat) and *Triticum dicoccum*Schrank. (Emmer wheat) are the three speciesof wheat grown in India (Gupta, 2004). Approximately 95% of the wheat grown is bread wheat, with the remaining 4% being durum wheat and 1% being *dicoccum* wheat (Gupta, 2004). Major wheat producing countries around the world are China, India, Russia, USA, France, Canada, Germany, Pakistan and Australia. Globally, total area under wheat

cultivation is 215.48 million ha with production 731.4 million tonnes with an average productivity of 3390 kg/ha (Anonymous, 2022). In India wheat is cultivated in an area of 30.47 million hectares with a production of 106.84 million tonnes and productivity of 3507 kg/ha(Ministry of Agriculture & Farmers Welfare, 2022). Uttar Pradesh is usually considered to be at the top of the list in terms of wheat production with a total record production of 33.95 million tonnes (31.77%), 9.47 million hectares' area under cultivation and productivity of 3604 kg/ha, followed by Madhya Pradesh 22.42 mt (20.98%). (Ministry of Agriculture & Farmers Welfare, 2022).

A variety of diseases affect the wheat crop. One of these, the hemibiotrophic, phytopathogenic fungus *Bipolarissorokiniana* (Sacc.) Shoem, ~~which~~ is common in warmer and more humid wheat-growing regions of the world (Joshi *et al*., 2007), is responsible for the spot blotch disease of wheat. The pathogen survives in soil, plant debris, and on seed (Mehta, 1993; Duzeck*et al*., 1996). Estimation of losses due to this disease vary from location to location, due to diverse environmental conditions, varieties prevalent in the area fertigation scheduling and strategies adopted against the devastating disease (Pandey *et al*., 2005; ~~and~~ Vaish *et al*., 2011).The major goal of disease control measures in wheat is to prevent outbreaks or epidemics through the use of chemical pesticides and host-plant resistance. Chemical pesticides are expensive to employ, poisonous to non-target creatures, and harmful to the environment since they have a negative impact on soil fertility, soil micro fauna, and human health (Aktar*et al*., 2009). Management of this disease through host resistance has become a prime concern of scientists. The control strategy for the diseases caused by *Bipolarissorokiniana* is based on an integrated approach where genetic resistance is a prominent factor, because economic returns have not always led to commercial grain production from fungicidal inputs (Duveiller and Sharma, 2009). Therefore, it is crucial to look for non-fungicidal methods of controlling spot blotch disease. The use of resistant cultivars was employed in this study because it is the most effective, long-lasting, cost-effective, and environmentally friendly technique for sustainable disease control.

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2. MATERIALS AND METHODS

2.1 Experimental site

The experimentwas conducted at Crop Research Centre, Chirodi farm of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), India, during two consecutive rabi season 2021-22 on sandy loamy soil. The site is situated at 29^0 4' North latitude and 77^0 42'East longitudes with an elevation of 237m above mean sea level.

2.2 Seed collection

Seed of thirty-two wheat varieties were received from ICAR- Indian Institute of Wheat and Barley Research, Karnal. The details of wheat varieties are presented below (Table- 1). The seeds were sown in

two lines for each ~~varieties~~variety and normal agronomic practices were followed to ensure proper plant growth. The experiment was conducted in randomized block design (RBD), each genotype was sown in line of 3m length with row to row spacing of 25cm and row to row spacing between each ~~varieties~~variety was 50cm with a total of three replications that were maintained for each variety. Two lines of susceptible check RAJ 4015 ~~was~~ were sown ~~at~~ for every ten genotypes of interval (Singh *et al*. 2017).

2.3Mass multiplication of *Bipolarissorokiniana* on wheat grains

Mass multiplication of *B. sorokiniana* was done on wheat grains. Wheat grains were soaked overnight in tap water and dried under the fan, after getting dried,~~,~~ 1mg/500g of chloramphenicol was added, mixed thoroughly with wheat grains to prevent the saprophytic bacterial contamination. Conical flasks (250 ml) containing 50g of wheat grains were filled and sealed with non-absorbent cotton before being autoclaved (15 lb pressure) at 121 °C for 20 minutes to ensure complete sterilization. The sterilized grain were kept for cooling, meanwhile the Laminar Air Flow chamber was cleaned with the rectified sprit followed by exposed UV light for 20 minutes' prior to inoculation. After cooling of the wheat grains, it was inoculated with pure culture of*Bipolarissorokiniana* grown in the Petri plate by ~~cuting~~cutting 5mm bit with the sterilized cork borer. After inoculation, the flasks were kept for incubation in the BOD incubator at 25±1°C for 20 days for the mass multiplication of the pathogen. The flask was shaken every day to remove the clumps and mix the wheat grains for good colonization and sporulation. The inoculum raised on wheat grains was used for inoculation with spray atomizer.

2.4 Preparation of spore suspension

The sporulated wheat grains were filtered using muslin cloth in distilled water to harvest spores of *B. sorokiniana* and to make aqueous solution which was adjusted to spore density $4x10^4$ conidia per ml of water. The conidial concentration count was made under microscope with a magnification of 40x.

2.5 Pathogen inoculation

The experimental wheat field was uniformly inoculated with spore suspension of *Bipolarissorokiniana* at booting stage and second field inoculation was made again in the same manner after the 15 days of the first inoculation. This suspension was sprayed by using hand atomizer. The field was irrigated after inoculation to maintain proper humidity. After inoculation, the entries were regularly monitored for recording the observations of disease severity.

2.6 Disease observation

Assessment of spot blotch ~~of~~ was done using double digit scale, based on percent blighted area on the flag leaf and one leaf just below flag leaf as mentioned in Table 2~~.~~(Kumar *et al*. 1998). Fifty leaves per

replication from each variety were selected randomly for recording the observation ofper cent foliar infection (severity). The mean of replication was given and the overall reaction of the pathogen to particular varieties.

2.6.1 Percent disease index

The Observations ofper cent foliar infectionwere recorded after diseaseappearance. Percentdiseaseindex(PDI)for spot blotchwerecalculatedbyusingformulagiven by wheeler (1969).

$$PDI = \frac{\text{Sumofalldiseaseratings}}{\text{Totalnumberofplants /Leaves}} \times \frac{1}{\text{maximum rating scale}} \times 100$$

2.6.2 Area Under Disease Progress Curve (AUDPC)

Area Under Disease Progress Curve were calculated separately for all varieties using the following formula given by Simko and Piepho (2012).

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{Yi+Yi+1}{2}\right)(t_{i+1}-t_i)$$

Where,

Y_i = disease severity (%) at the 1st observation

T_i = Time (days) of the first observation

n = Total number of observation

Table 1. List of wheat varieties

S.No.	Variety	S.No.	Variety
1.	DWR 185	17.	HS 507 (PUSA SUKETI)
2.	HI 8713 (PUSA MANGAL)	18.	PBW 343
3.	DBW 14	19.	PBW 644
4.	DBW 71	20.	RAJ 4083
5.	DBW 90	21.	WH 1021
6.	DBW 93	22.	WH 1080
7.	HD 2329	23.	WH 1105
8.	HD 2864 (URJA)	24.	WH 1124
9.	HD 2888	25.	WH 1142
10.	HD 2932	26.	PBW 723
11.	HD 2967	27.	HD 4728 (PUSA MALWI)
12.	HD 2985	28.	WB 2
13.	HD 3086	29.	PBW 757

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14.	HS 375 (HIMGIRI)	30.	HD 3226 (PUSA YASHASVI)
15.	HS 490	31.	DBW 303
16.	HUW 234	32.	WH 147

Table 2.Thedouble-digitscale,basedonpercentblightedareaontheflagleafandoneleaf was recorded following Kumar et al., 1998) ~~justbelowgiven Kumar *et al.* (1998).~~

Adoubledigit*scaleforappraisingblightseverity				
S. No.	**Severity****		**Rating**	
	Flagleaf	**Flag-1leaf**	**Diseaseresponse**	**Range of value**
1	0	0-1	Immune(I)	00-01
2	1-2	2-4	Resistant	12-24
3	3-4	4-6	ModeratelyResistant (MR)	34-46
4	5-6	6-8	Moderatelysusceptible (MS)	56-68
5	7-8	8-9	Susceptible(S)	78-89
6	9	9	Highlysusceptible (HS)	99

* First and second value respectively, represents per cent blighted area on the flag leaf and flag-1leaves.

** Values 1,2,3,4,5,6,7,8 and 9, respectively correspond to 10, 20, 30, 40, 50, 60, 70, 80 and 90percent blighted area.

3. RESULTS AND DISCUSSION

3.1 Disease reaction on variety

Use of resistant variety is a cheapest and most economical method of disease control. Thirty-two varieties (Table 3.) were screened under field conditions by double digit scale based on per cent blighted area on the flag and flag-1 leaf at hard dough stages of the crop. Out of which, none of the varieties ~~were~~ wascompletely immune. Two varieties were resistant namely PBW 757 & DWR 185, eleven varieties were moderately resistant namely HD 2967, HS 490, WH 1080, DBW 303, DBW 71, WH 1021, HD 2864,

PBW 723, WB2, HS 507, HS 375, fourteen varieties were moderately susceptible namely PBW 644, HD 2888, HD 2932 DBW 14, WH 1105, HD 3226, HD 3086, HD 4728, WH 1124, RAJ 4083, WH 1142, DBW 93, DBW 90, HD 2985, five varieties were susceptible HUW 234, WH 147, PBW 343, HI 8713, HD 2329 and none of the varieties ~~were~~ was highly susceptible for spot blotch under field conditions. Singh *et al*. (2016) tested the resistance of 250 genotypes against *Bipolarissorokiniana* under artificial epiphytotic conditions. Variety Raj 4015 was used as check and was sown after every 20 genotypes. Pure culture of pathogen was inoculated on genotypes by using cleaned sprayer, at evening. Out of 250 genotypes, one namely KARAWANI/4NIF-3/SOTY/NAD63/CHRIS was found immune, 20 genotypes were found resistant, 146 were moderately resistant, 75 were moderately susceptible and 8 were found susceptible against spot blotch disease of wheat. The findings were also similar with Ojha *et al*. (2016) who evaluated 100 entries out of these 20 number of genotype found to be highly resistant or Immune to the disease, whereas 28 genotype were resistant, 22 genotypes moderately resistant, 15 moderately susceptible and 15 genotypes susceptible. Indian germplasm lines tended to be more susceptible as compared to lines originated from CIMMYT and China. The recent findings were also similar with Singh *et al*. (2020) screened 200 genotypes for resistance against *Bipolarissorokiniana* under artificial epiphytotic conditions. Out of these 200 genotypes, thirty-six genotypes were found resistant, 91 were moderately resistant, 43 were moderately susceptible and 30 were found susceptible against spot blotch disease of wheat.

Comment [M3]: State similarities with your study rather telling the whole study in Singh et al., 2016

Comment [M4]: Are the genotypes used in their study used also in your study and are found like in their article?
Discuss your results please

Comment [M5]: This whole section must be well discussed

3.2Area Under Disease Progress Curve (AUDPC)

The Area Under Disease Progress Curve (AUDPC) was calculated for thirty- two wheat varieties on the basis of disease index. Area under disease progress curve varies from 212.90 to 1143.9 and 198.80 to 1144.90 during the 2021-22 and 2022-23 years' data. The pooled mean, Area Under Disease Progress Curve varied from 205.85 to 1144.40, showing the fast progress of the disease in all genotypes. It was observed that different wheat varieties expressed varied type of disease response against *B. sorokiniana* under artificial epiphytotic conditions in the field. Area Under Disease Progress Curve was found between 205.85 to 305.82 with and 443.82 to 634.52under the resistant and moderately resistant disease reaction. The range of Area Under Disease Progress Curve~~were~~ was recorded between 687.15 to 883.97 and 930.40 to 1144.40 under the moderately susceptible and susceptible disease reaction. VarietyWH 147 showedhighestvalue (1144.40)while,DWR 185showedsleastvalue (205.85)of Area Under Disease

Progress Curve amongthevarieties line(Table4.).Mostof thewheatvarietiesshowedmoderatelysusceptiblereaction.Kumar *et al*. (2015) studied variability for spot blotch resistance and their study revealed a AUDPC ~~Atotalof147diversebreadwheat(*Triticumaestivum*)genotypeswere used for the experiments. Area under the disease progress curve(AUDPC)~~value~~varies~~fromthe92.6to123.5acrosstheresistantlines.The recent findings were also similar with Singh *et al*. (2018) screened sixty-two wheat genotypes against spot blotch disease. Out of sixty-two genotypes, eight genotypes were identified as resistant, with disease severity ranging from 34.26 to 35.0% and a AUDPC value of 330.90-402.80. While as, Twenty-four genotypes were found to be moderately resistant, with disease severity ranging from 39.45% to 57.00% and a AUDPC value of 429.60-742.10. The remaining wheat genotypes are moderately and highly sensitive, with high disease severity and AUDPC values. Pandey et al. 2018 reported that Genotype BL 4699 and NL 1247 were found to be resistant with AUDPC value 141.7 and 140.6 and yield 3.335MT/ha and 3.604MT/ha, respectively. Similarly, genotype BL 4708, NL 1327 and BL 4707 were found to be tolerant with AUDPC value 567.2, 570.6 and 274.6 and yield 3.761MT/ha, 3.642MT/ha and 3.681Mt/ha, respectively.

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Table 3. Screening of wheat varieties for resistance against spot blotch disease under field conditions during 2021-22 and 2022-23

S. No.	Variety	Percent disease index (2021-22)			Percent disease index (2022-23)			*AUDPC (2021-22)	*AUDPC (2022-23)	Pooled Mean
		28th February	8th March	18th March	6th March	16th March	26th March			
1	DWR 185	4.20	10.08	18.22	5.86	9.10	15.70	212.9	198.8	205.85
2	HI 8713	19.46	40.12	79.55	21.36	44.22	83.11	896.25	964.55	930.4
3	DBW 14	13.29	35.80	58.20	13.00	37.20	56.00	715.45	717	716.22
4	DBW 71	13.00	25.26	46.22	10.32	20.46	39.03	548.7	451.35	500.02
5	DBW 90	12.90	34.86	65.62	12.08	32.78	63.11	741.2	703.75	722.47
6	DBW 93	12.10	32.41	64.70	10.90	32.28	57.78	708.1	666.2	687.15
7	HD 2329	27.22	57.12	85.78	24.48	57.83	80.29	1136.2	1102.15	1119.17
8	HD 2864	9.85	18.36	38.22	10.25	23.32	35.85	423.95	463.7	443.82
9	HD 2888	11.20	33.74	65.33	12.26	39.68	60.00	720.05	758.1	739.07
10	HD 2932	12.06	34.21	64.88	13.08	39.41	59.18	726.8	755.4	741.1
11	HD 2967	13.15	30.86	50.36	13.33	33.48	48.29	626.15	642.9	634.52
12	HD 2985	18.24	42.31	71.11	16.20	40.61	65.78	869.85	816	842.92
13	HD 3086	13.00	35.91	59.70	13.24	39.62	56.14	722.6	743.1	732.85
14	HS 375	12.90	24.41	43.18	11.94	25.13	36.59	524.5	493.95	509.22
15	HS 490	12.22	35.56	48.07	12.00	33.58	43.18	657.05	611.7	634.37
16	HUW 234	27.30	57.28	86.67	26.32	58.10	81.33	1142.65	1119.25	1130.95
17	HS 507	12.00	34.12	44.81	11.48	30.21	40.22	625.25	560.6	592.92
18	PBW 343	18.12	44.26	82.22	17.82	48.30	78.67	944.3	965.45	954.87
19	PBW 644	21.80	42.30	70.66	20.76	44.33	67.11	885.3	882.65	883.97
20	RAJ 4083	17.23	39.12	68.45	15.10	34.12	58.22	819.6	707.8	763.7

21	WH 1021	11.41	32.26	45.92	10.32	27.22	34.37	609.25	495.65	552.45
22	WH 1080	12.84	24.43	43.18	11.78	34.20	35.18	524.4	576.8	550.6
23	WH 1105	13.38	42.13	58.12	13.68	44.56	56.44	778.8	796.2	787.5
24	WH 1124	25.21	41.84	62.30	24.32	43.30	56.89	855.95	839.05	847.5
25	WH 1142	23.72	30.58	68.16	22.62	36.73	61.77	765.2	789.25	777.22
26	PBW 723	11.43	21.41	40.22	12.47	24.65	38.51	472.35	501.4	486.87
27	HD 4728	12.80	38.21	66.96	13.00	42.28	63.25	780.9	804.05	792.47
28	WB 2	12.00	24.58	48.88	12.08	29.51	46.36	550.2	587.3	568.75
29	PBW 757	6.32	13.83	25.03	8.43	18.78	17.33	295.05	316.6	305.82
30	HD 3226	15.12	36.20	62.07	15.32	40.51	58.35	747.95	773.45	760.7
31	DBW 303	12.04	30.21	45.33	13.76	29.81	39.25	588.95	563.15	576.05
32	WH 147	28.12	56.33	88.00	30.14	57.20	84.44	1143.9	1144.9	1144.4

*AUDPC – Area Under Disease Progress Curve

Table 4. Categorization of resistance response exhibited by wheat varieties based on PDI obtained from the years 2021-22 and 2022-23

S. No.	Disease reaction	Double digit scale	*AUDPC value (Pooled mean)	No. of varieties	Varieties
1.	Immune(I)	00-01		0	
2.	Resistant (R)	12-24	205.85 – 305.82	2	PBW 757, DWR 185
3.	ModeratelyResistant (MR)	34-46	443.82 – 634.52	11	HD 2967, HS 490, WH 1080, DBW 303, DBW 71, WH 1021, HD 2864, PBW 723, WB2, HS 507, HS 375
4.	Moderately Susceptible (MS)	56-68	687.15 – 883.97	14	PBW 644, HD 2888, HD 2932 DBW 14, WH 1105, HD 3226, HD 3086, HD 4728, WH 1124, RAJ 4083, WH 1142, DBW 93, DBW 90, HD 2985
5.	Susceptible(S)	78-89	930.40 – 1144.40	5	HUW 234, WH 147, PBW 343, HI 8713, HD 2329
6.	Highlysusceptible (HS)	99		0	

*AUDPC- Area Under Disease Progress Curve

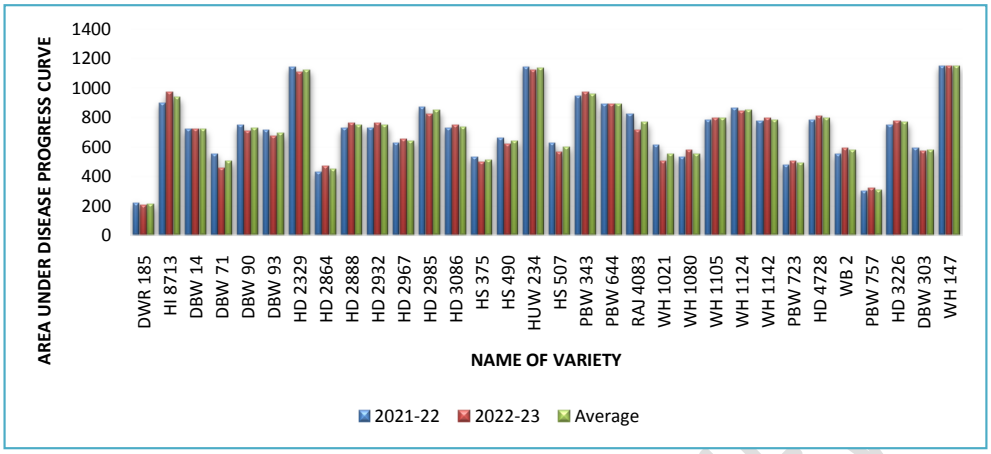

Fig. 1. Area under disease progress curve of wheat varieties during 2021-22 and 2022-23

4. CONCLUSION

The results from the current study revealed that ~~The~~ wheat varieties varied significantly for spot blotch severity and Area Under Disease Progress Curve under artificial epiphytotic conditions. Among 32 wheat varieties~~y~~, none of the variety~~were~~ was found immune and highly susceptible. Two varieties ~~y~~were found to be resistant, elevenvarieties were found moderately resistant, fourteen varieties were found moderately susceptible and five varieties were found susceptible against spot blotch. The disease under artificial epiphytotic condition can be utilized in breeding programme to develop high yielding varieties. Area under disease progress curve (AUDPC) calculated for 32 wheat varieties~~y~~ on the basis of plant disease index varied from 205.85 to 1144.40 showing the fast progress of disease in all varieties. It was observed that different wheat varieties ~~y~~used in this study showedvaried types of disease reaction against *Bipolarissorokiniana* under artificial epiphytotic conditions in field.

REFERENCES

1. Aktar W., Sengupta D. and Chowdhury A. Impact of pesticides use in agriculture: their benefits and hazards. InterdiscToxicol. 2009;2(1): 1-12.
2. Duczek L. J., Jones-Flory L. L., Reed S. L., Bailey K. L. and Lafond G. P. Sporulation of *Bipolarissorokiniana* on the crowns of crop plants grown in Saskatchewan. Can. J. Pl. Sci.1996; 76:861-867.
3. Duveiller E. and Sharma R.C. Genetic improvement and crop management strategies to minimize yield losses in warm non-traditional wheat growing areas due to spot blotch pathogen Cochliobolus sativus. J. Phytopathol.2009;157(9): 521–534.

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4. Joshi A. K., Kumari M., Singh V. P., Reddy C. M., Kumar, S., Rane, J. and Chand, R. Stay green trait: variation, inheritance and its association with spot blotch resistance in spring wheat (Triticum aestivum L.). Euphytica.2007;153: 59–71.
5. Kumar P., Dhari R., Kumar J. and Singh J. Variability for leaf blight resistanceinIndianspringwheat(*Tritricumaestivum*)germplasm.InternationalQuarterly JournalofLifeSciences.2015;10(1):491-494.
6. Mehta Y.R. Spot blotch. In: Mathur S.B., Cunfer B.M. (eds.) Seed Borne Disease and Seed Health Testing of Wheat. Copenhagen, Denmark, Jordhurgsforlaget, pp. 1993;105-112.
7. Ministry of agriculture and Farmer Welfare, Agricultural Statistics at a Glance 2022.
8. Ojha A., Singh G., Tyagi B.S., Singh V., Rajita and Kumar P. Screening of resistance source against spot blotch disease caused by *Bipolarissorokiniana* in *Triticum aestivum* L., Indian Institute of Wheat and Barley Research, Karnal, India, Int. J. Adv Res. 2016;5(1) 23-28.
9. Pandey S.P., Kumar S., Kumar U., Chand R. and Joshi A.K. Sources of inoculum and reappearance of spot blotch of wheat in rice-wheat cropping system in eastern India. Eur. J. Pl. Pathol. 2005;111: 47-55.
10. Gupta R.K. Quality of Indian wheat and infrastructure for analysis. In: Joshi, A.K., Chand, R., Arun, B., Singh, G. (eds.) A compendium of the training program (26-30 December, 2003) on wheat improvement in eastern and warmer regions of India: Conventional and non-conventional approaches. NATP project, (ICAR), BHU, Varanasi, India.2004.
11. Simco I. and Piepho H.P. The area under the disease progress stairs: calculation, advandageand application, Phytopathology.2012;102(4): 381-389.
12. Singh S. K., Singh M., Razdan V. K., Singh V. B., Singh A. K., Gupta S., and Sharma R. Prevalence of Spot Blotch (*Bipolarissorokiniana*) of Wheat and its Management through Host Resistance. International Journal of Current Microbiology and Applied Sciences. 2018;*7*(2), 686-94.
13. Singh S. P., Kumar, S., Singh S., Maurya M. K., Singh K., and Singh H. Evaluation of wheat genotypes for resistance against spot blotch disease. Journal of Pharmacognosy and Phytochemistry. 2020;*9*(6), 341-343.
14. Singh C. K., Gupta S., Tiwari N. K. and Singh D. Evaluation of wheat genotypes for resistance against spot blotch. International Journal of Plant Protection. 2016;*9*(1), 272-274.
15. Vaish S.S., Bilal Ahmed S. and Prakash K. First documentation on status of barley diseases from the high altitude cold arid Trans-Himalayan Ladakh region of India. Crop. Protec. 2011;30: 1129-1137.
16. WheelerB.E.J.AnIntroductiontoPlantDiseases,J.WileyandSonsLtd.London,p. 1969;301.
17. Yadawad A., Hanchinal R.R., Nadaf H.L., Desai S.A., Birader S. and Naik V.R. Genetic variability for yield parameters and rust resistance in F2 population of wheat (*Triticum aestivum*L.). The Bioscan, 2015;10(2): 707-710.

18. Pandey A., Paudel R., Kafle K., Sharma M., Maharjan N., Das N. and Basnet R. Varietal Screening of wheat genotypes against spot blotch disease (Bipolarissorokiniana) under field condition at Bhairahawa, Nepal. *Journal of the Institute of Agriculture and Animal Science*. 2018;*35*(1), 267-276.