Society for Advancement of Wheat and Barley Research
ICAR-Indian Institute of Wheat & Barley Research
Karnal - 132 001, India

Journal of Wheat Research
8(2):31-37
Homepage: http://epubs.icar.org.in/ejournal/index.php/JWR

Research Article

Characterization of bread wheat germplasm for spot blotch resistance and its association with yield and yield related traits

Chandni Latwal[1], Deepshikha[1], Bimla Kumari[1], Pawan Kumar Singh[2] and Jai Prakash Jaiswal[1*]

[1]*G. B. Pant University of Agriculture and Technology, Pantnagar- 263145, Uttarakhand*
[2]*International Centre for Maize and Wheat Improvement (CIMMYT), El Batan, Texcoco-56237, Mexico*

Article history

Received: 11-07-2016
Revised : 02-12-2016
Accepted: 15-12-2016

Citation

Latwal C, Deepshikha, B Kumari, PK Singh and JP Jaiswal. 2016. Characterization of bread wheat germplasm for spot blotch resistance and its association with yield and yield related traits. *Journal of Wheat Research* **8**(2):31-37.

****Corresponding author***

Email: *jpj.gbpu@gmail.com*

Abstract

Spot blotch (*Bipolaris sorokinana* Sacc. In Borok. Shoem) is an important foliar disease of wheat in South-East Asia. This is a destructive disease of wheat in warm and humid wheat growing regions of the world. In India spot blotch (*B sorokinana*) is reported to be important leaf blight disease. Two hundred accessions obtained from CIMMYT were evaluated against spot blotch severity under epiphytotic conditions during 2014-2015 and 2015-2016 at G.B. Pant University of Agriculture and Technology, Pantnagar to identify resistant genotypes against spot blotch. The accessions were evaluated in augmented block design (ABD) and data were recorded for six characters viz., disease severity, days to 75% heading, days to maturity, plant height, thousand grain weight and grain yield. The statistical analysis revealed that variance was found highest for area under disease progress curve AUDPC followed by grain yield and lowest for days to maturity. Spot blotch severity has significant and negative correlation with grain yield, thousand grain weight, plant height, days to 75% heading and days to maturity. Simultaneously, AUDPC has shown negative correlation with all the characters. Out of 200 accessions, 78 were found resistant to spot blotch over 2 years and four accessions were found highly resistant on the basis of area under disease progress curve (AUDPC) in both the years which could be used as donors for the development of spot blotch resistant varieties of wheat. The development of disease resistant cultivars is considered as the most effective control strategy for spot blotch.

Key words: Wheat, germplasm, *Bipolaris sorokiniana*, spot blotch, resistance

1. Introduction

Wheat (*Triticum aestivum* L.) is the staple food for a large part of the world population. In India, the crop ranks second in terms of total production next to rice. Grain yield is a complex trait and highly influenced by many genetic factors and environmental fluctuations. The production of bread wheat is constrained by several biotic and abiotic stresses. Among these diseases, spot blotch or foliar blight caused by *Bipolaris sorokiniana* is one of the most damaging disease in warm and humid regions of India and other South Asian countries due to its wider prevalence and increasing severity (Chowdhery *et al.*, 2013). Yield losses due to foliar blight are variable and in last two decades spot blotch has emerged as serious concerns for wheat cultivation in the developing world. The average yield loss due to spot blotch in South Asia and India has been estimated to be 19.6 and 15.5%, respectively (Dubin and van Ginkel, 1991). Yield losses between 20 and 80% have been reported by Duveiller and Gilchrist (1994) and losses up to 100% may occur under the most severe conditions of infection (Srivastava *et al.*, 1971, Mehta 1993). In India, losses due to disease may be 10-50 per cent which can be devastating for farmers in the Eastern Gangetic Plains (EGPs) and depend on the level of resistance in a cultivar against leaf blight and weather conditions. Spot blotch has been considered as a major constraint to wheat yields in South Asia due to reduction in 1000-grain weight and grain yield (Singh *et al.*, 2007). It is an important disease

in the mega-environment which is characterized by high humid conditions around and after heading stage. At present spot blotch of wheat is a major pathogen at national level in India and most frequent in north eastern plains zone (NEPZ) amongst six agro-climatic zones due to prevalence of hot and humid weather conditions. The pathogen reduces yield, germination, seedling emergence and the rooting intensity in the subsequent crop (Joshi, 1986). Several morphological characteristics of the host plant, such as leaf surface waxes and leaf angle (Joshi and Chand, 2002) may be positively correlated with the resistance against spot blotch of wheat spot blotch destroys leaf tissue and reduces photosynthetic potential, thereby reducing kernel plumpness and often resulting in loss of the grain yield (Gurung *et al.*, 2012). Severe infection may also reach to the spikes, resulting in less weight due to shriveled grains.

Therefore, analyzing spot blotch resistance along with its correlation with yield traits would help in identification of better donors for spot blotch resistance with higher yield to be used in breeding programme.

2. Materials and methods

2.1 Plant materials and field evaluation for disease severity

Field experiment was conducted at N. E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during *rabi*, 2014-15 and 2015-16. A total of two hundred wheat germplasm accessions obtained from International Centre for Maize and Wheat Improvement (CIMMYT), Mexico were evaluated in field trials for spot blotch resistance under epiphytotic conditions in Augmented block design. Four checks, two each resistant (Chirya 3 and Francolin) and susceptible (Sonalika and Ciano T 79) were included in the trial. Each accession was grown in 2 rows of 1 m long plot with 20 cm distance between rows. The recommended cultural practices were adopted to raise good crop. To identify the accessions possessing resistance to spot blotch, plants were inoculated following the method of Chaurasia *et al.*, (1999). The aggressive isolate of *B sorokiniana*, a casual agent of Spot blotch was obtained from ICAR-Indian Institute of Wheat and Barley (IIWBR), Karnal, India, which was later multiplied on sorghum seeds at Pantnagar. The whole experimental material was inoculated at three different growth stages (GS): tillering (GS20), flag leaf emergence (GS37) and anthesis (GS65) (Zadoks *et al.*, 1974) with sporidial suspension (10^4 spores/ml) in the evening hours.

2.2 Disease assessment and recording of morpho-agronomic traits

Disease severity was recorded on each plant using as a modified Sarri and Prescott's severity scale to assess foliar blight diseases in wheat (Sarri and Prescott, 1975) by visually scoring the percent diseased area on the flag (F) and penultimate (F-1) leaves (Table 1). The first digit (D1) indicates diseased covered area on the flag leaf and the second digit (D2) indicates severity measured on the penultimate leaf.

Table 1. A double digit scale for recording the spot blotch severity

Severities**		Rating	
Top flag leaf	Second top leaf	Diseases responses	Scale Value
0	0-1	Immune (I)	00-01
1-2	2-4	Resistant (R)	12-24
3-4	4-6	Moderately resistant (MR)	34-46
5-6	6-8	Moderately susceptible (MS)	56-68
7-8	8-9	Susceptible (S)	78-89
9	9	Highly susceptible (HS)	99

*First and second values represent percent blighted area on the top (flag) and second top leaves, ** Values 1, 2, 3, 4, 5, 6, 7, 8 and 9 correspond to 10, 20, 30, 40, 50, 60, 70, 80 and 90 percent blighted area, respectively.*

Disease severity (%) displayed by all the leaves of each row was recorded at three different growth stages (GS), viz., GS 63 (beginning of anthesis to half complete), GS 69 (anthesis complete) and GS 77 (late milking). The area under disease progress curve (AUDPC) based on disease severity (GS63, GS69 and GS77) over time was estimated using the formula given by Roelfs *et al.,* (1992), which has been suggested to be an appropriate parameter to distinguish the resistance of genotypes (van der Plank 1968, Duveiller *et al.,* 1998a).

The accsseions that showed AUDPC (< 500) were considered resistant and the lines that showed AUDPC (> 2000) were considered susceptible (Tyagi *et al.*, 2008). The data were also recorded for 5 morpho-agronomic traits viz., days to 75% heading, days to maturity, plant height, thousand grain weight and grain yield as per the standard procedure.

2.3 Statistical analysis

Analysis of variance for augmented design was performed with the method given by Federer (1956). The estimation of correlation coefficient the significance of correlation coefficient the calculated t-value was compared with tabulated t-value at n-2 degree of freedom (Snedecor and Cochran, 1967).

3. Results and discussion

3.1. Analysis of variance

The analysis of variance revealed highly significant differences among the genotypes for plant height and grain yield and a significant difference in thousand grain weight and AUDPC distribution. Variance was found highest for AUDPC (114417.71), followed by grain yield (6261.5), thousand grain weight (40.12), plant height (32.30), days to 75% heading (13.05) and days to maturity (11.85) Table 2. The genotypes exhibited high variability for the characters like AUDPC (19.05), thousand grain weight (9.35), grain yield (9.05), days to maturity (4.26), days to 75% heading (3.99) and lowest for plant height (3.12).

Table 2. Analysis of variance (ANOVA) for different characters of 200 germplasm accessions

S. No.	Character	Mean sum of squares		
		Block (7)	Check (3)	Error (21)
1	Days to 75% heading	13.05	791.70	10.06
2	Days to maturity	11.85	999.75	18.82
3	Plant height	32.30**	242.94	7.55
4	1000 grain weight	40.12*	811.23	12.18
5	Grain yield	6261.5**	81942.33	1162.09
6	AUDPC	114417.71*	632008.33	49422.66

***Significant at 1% probability level, *Significant at 5% probability level*

3.2 Phenotypic evaluation of spot blotch severity

In 2014-2015 and 2015-16 crop seasons, 200 accessions of bread wheat germplasm were screened for spot blotch resistance under epiphytotic conditions. The observations for disease severity were taken at weekly intervals starting from the last week of February till 3rd week of March in both the years covering different growth stages (GS) viz., tillering (GS20), flag leaf emergence (GS37) and anthesis (GS65). The AUDPC values of checks during the year 2014-15 and 2015-16 have been given in Table 3. The number of accessions falling in different categories with respect to resistance and susceptibility based on AUDPC distribution has been shown in Table 4**.**

Table 3. AUDPC values of check entries during 2014-15 and 2015-16

Checks	Level of resistance/susceptibility	AUDPC values in different years	
		2014-15	2015-16
Chirya 3	Resistant (R)	375.0	454.3
Francolin	Moderately resistant (MR)	584.5	914.5
Sonalika	Susceptible (S)	2072.0	2267.0
Ciano T 79	ModeratelySusceptible (MS)	1263.0	1891.50

Table 4. Categorization of 200 germplasm accessions in to resistant and susceptible according to AUDPC values during 2014-15 and 2015-16

Spot blotch resistant/ susceptible	2014-15		2015-16	
	No. of accessions	AUDPC values (range)	No. of accessions	AUDPC values (range)
Highly resistant	4	0	2	0
Resistant	80	10.5-458.5	84	44.0-455.0
Moderately resistant	50	528.5-1134.0	49	546.0-1151.5
Moderately susceptible	47	1260.0-1928.5	49	1260.0-1981.0
susceptible	19	2152.0-2516.5	16	2030.0-2257.5

During the first field trial in 2014-15, out of the 200 accessions, 5 accessions were found highly resistant, 79 resistant, 46 moderately resistant, 42 moderately susceptible, 10 susceptible and 18 highly susceptible. The highly resistant accessions were accession No. 8 (VORONA/CNO79), accession No. 9 (KAUZ*3// DOVE/BUC), accession No. 17 (INQALAB 91), accession No. 27- (JUP/ BJY// URES/ 3/ HD 2206/ HORK// BUC/ BUL), and accession No. 132 (CHIBIA/ 5/ CNDO/ R143// ENTE/ MEXI-2/ 3/ AEGILOPS SQUARROSA.

In the year 2015-16, out of the 200 germplasm accessions, 4 accessions were found highly resistant, 80 resistant, 43 moderately resistant, 45 moderately susceptible, 8 susceptible and 20 highly susceptible. The three accessions which were found highly resistant during both the years were accession No. 8- VORONA/CNO79, accession No. 9- KAUZ*3//DOVE/BUC and accession No. 27- JUP/ BJY// URES/ 3/ HD 2206/ HORK// BUC/ BUL.

3.3 Analysis of spot blotch resistance based on AUDPC distribution

The AUDPC value was calculated to screen the 200 germplasm accessions against spot blotch (*Bipolaris sorokiniana*) severity in the field under epiphytotic conditions. During the first experiment in 2014-15, out of 200 accessions, 5 accessions were observed highly resistant, 79 resistant, 46 moderately resistant, 42 moderately susceptible, 10 susceptible and 18 accessions highly susceptible. During the second experiment in 2015-16, out of 200 accessions, 4 accessions were observed highly resistant, 80 resistant, 43 moderately resistant, 45 moderately susceptible, 8 susceptible, 20 accessions highly susceptible. The accessions showing resistance in both the years along with their AUDPC values have been given in Table 5. The AUDPC distribution and grain yield patterns in different categories of resistant and susceptible accessions during 2014-15 and 2015-16 are given in Fig. 1 to 4.

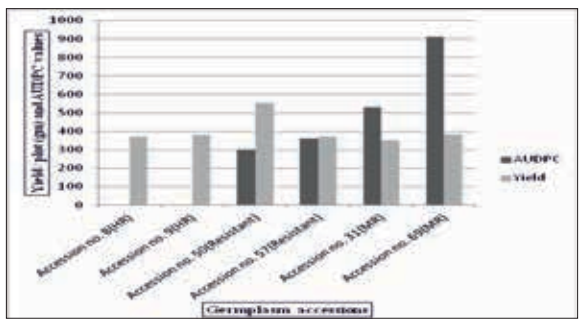

Fig. 1 Histograms of AUDPC for spot blotch and yield pattern in germplasm accessions showing different levels of resistance in 2014-15 (HR: Highly resistant, R: Resistant, MR: Moderately resistant)

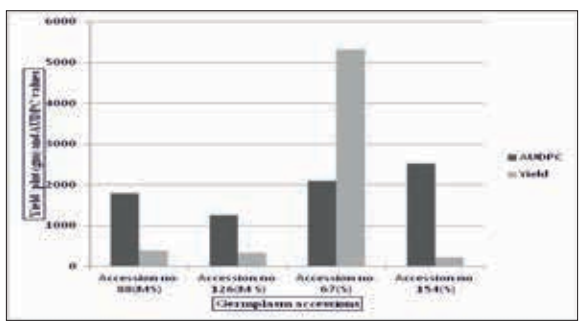

Fig. 2 Histograms of AUDPC for spot blotch and yield pattern in germplasm accessions showing different levels of susceptibility in 2014-15 (MS: Moderately susceptible, S: Susceptible)

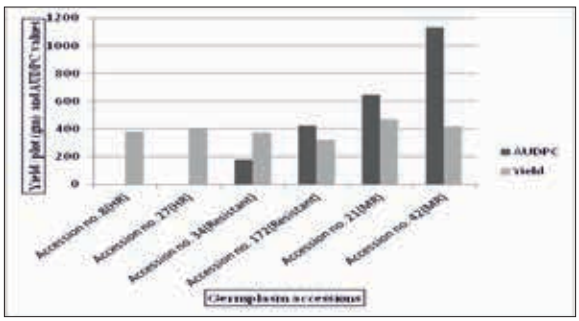

Fig. 3 Histograms of AUDPC for spot blotch and yield pattern in germplasm accessions showing different levels of resistance in 2015-16

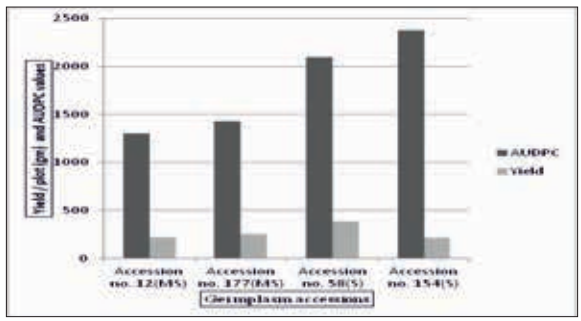

Fig. 4 Histograms of AUDPC for spot blotch and yield pattern in germplasm accessions showing different levels of susceptibility in 2015-16

Table 5. Germplasm accessions showing resistance against spot blotch and their mean AUDPC values during 2014-15 and 2015-16

Acc. No.	Name of germplasm accession	Mean AUDPC value	
		2014-15	2015-16
4	PBW343*2/KUKUNA/4/BAV92//ATTILA/3*BCN/3/PASTOR/5/PBW343	63	259
8	VORONA/CNO79	0	0
9	KAUZ*3//DOVE/BUC	0	3.5
14	KAUZ// BOW/ NKT	350	413
19	ALTAR84/ AEGILOPS SOUARROSA (TAUS)// OPATA	248.5	178.5
24	CLC89// ESDA/ KAUZ/ 3/ BJY/ COC//PRL/ BOW	49	178.5
25	KAUZ/ 5/ PAT 10/ ALD// PAT 72300/ 3/ PVN/ 4/ BOW	252	343
27	JUP/ BJY// URES/ 3/ HD 2206/ HORK// BUC/ BUL	0	0
45	HEILO// MILAN/ MUNIA	49	126
46	QUAIU#1	336	336
47	BETTY/3/ CHEN/ AE. SQ// 2*OPATA	111.5	56
48	MILAN// PRL/ 2*PASTOR/4/ CROC-1/ AE. SQUARROSA(213)// PGO/3/…	301	266
50	NSM*4/ 14-2// FRTL/ 2* PIFED/ 3/ VORB	300	346.5
55	NEU MONG 19/ MONARCA F2007	140	140
57	MN94382/3/ WEAVER/ PLATA-3// 2*BORL 95	360.5	360.5
59	ERNEST/3/ CROC-1/ AE. SQUARROSA(205)// KAUZ	133	171.5
70	GLE/ 4/ CROC-1/ AE. SQUARROSA(224)// YACO/3/ MUNIA/ 5/…	416.5	423.5
74	AC SPLENDOR// PBW 343*2/ KUKUNA/ 3/ AC SPLENDOR	266	266
90	CHEN/ AEGILOPS SQUARROSA(TAUS)// FCT/3/ STAR/4/ PBW 343*2/..	259	346.5
97	MN6616M/3/ NL 456/ VEE#5// DUCULA/ 4/ KARAGANDINSKAYA 70	416.5	423.5
121	CHIL/ BUC// SERI/ CEP 80120/ 4/ VEE/ MJI// 2*TUI/ 3/ PASTOR	217	269.5
131	SOKOLL/ EXCALIBUR	140	133
132	CHIBIA/ 5/ CNDO/ R143// ENTE/ MEXI-2/ 3/ AEGILOPS SQUARROSA (T…	10.5	224
133	CHIBIA/ 5/ CNDO/ R143// ENTE/ MEXI-2/ 3/ AEGILOPS SQUARROSA (T…	416.5	332.5
148	CBC 509 CHILE/5/ 2* AJAIA-16// HORA/ JRO/3/ GAN/4/ ZAR	248.5	336
165	WHEAR/ KRONSTAD F2004	210	238
171	SAAR*2/3/ C80.1/ 3* BATAVIA// 2*WBLL 1	339.5	336
172	PBW 343*2/ KUKUNA/3/ PASTOR// CHIL/ PRL/4/ PBW 343*2/ KUKUNA	413	423.5
182	NELOKI	259	336
193	FRET 2*2/3/ SNI/ TRAP#1// KAUZ*3/ TRAP/4/ PARUS/5/ FRET 2*2/…	133	150.5
194	58769// 28PBW 343*2/ KUKUNA	374.5	420
195	FRET 2/ KUKUNA// FRET 2/3/ WHEAR	56	49

3.4 Association of spot blotch severity with morpho-agronomic traits

The relationship between disease severity and different characters were studied and the correlation coefficient for respective character is given in the Table 6. Spot blotch severity exhibited significant negative correlation with plant height (-0.175**), grain yield (-0.254**) and 1000 grain weight (-0.363**). This finding is in complete agreement with Joshi *et al.* (2002). On the other hand, AUDPC also shows significant and negative correlation with grain yield (-0.263**) and thousand grain weight (-0.376**). Singh *et al., (*2002) has also reported that infection of spot blotch resulted in to significant reduction of 1000 grain weight as well as grain yield due to shriveling of grains. These findings are in complete agreement with Sharma *et al.* (1997) and Singh *et al.,* (2007).

Table 6. Correlation coefficient among different characters

Traits	Disease severity	Days to 75% heading	Plant height	Days to 75% maturity	Grain yield	TGW	AUDPC
Disease Severity	1.000						
Days to 75% heading	-0.210**						
Plant height	-0.175**	0.266**					
Days to 75% maturity	-0.186**	0.798**	0.265**				
Grain yield	-0.254**	0.317**	0.455**	0.212**			
1000 grain weight (TGW)	-0.363**	0.435**	0.452**	0.335**	0.901**		
AUDPC	0.986**	-0.217**	-0.196**	-0.177**	-0.263**	-0.376**	1.000

** Significant at 1% probability level

On the basis of findings of the present investigation it was concluded that sufficient genetic variability was present in the germplasm accessions for disease severity as accessions were grouped into highly resistant, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible categories under epiphytotic conditions. The accessions showing low AUDPC were considered as resistant and with high AUDPC as susceptible. Negative association between spot blotch severity and important yield components reveals its impact on yield and yield contributing traits. One of the important reasons for the slow progress in breeding for spot blotch resistance has been suggested to be the quantitative nature of resistance (Duveiller *et al.*, 1998) and the absence of suitable resistance parents. Therefore, selection of genotype (s) showing consistent performance for resistance based on AUDPC distribution over the years, will certainly help in developing spot blotch resistant varieties of wheat as well as these could be as parents in developing mapping populations for identifying QTLs for spot blotch resistance.

Acknowledgments

The authors pose sincere thanks to CIMMYT, Mexico for providing the germplasm accessions under Seeds of Discovery project funded by Sustainable Modernization of Traditional Agriculture (MasAgro) project supported by the Mexican Government and Director, Experiment Station, GBPUAT, Pantnagar for providing necessary facilities for carrying out the investigation.

References

1. Chaurasia S, AK Joshi, R Dhari and R Chand. 1999. Resistance to foliar blight of wheat: a search. *Genetic Resources and Crop Evolution* **46(5)**: 469-475.
2. Chowdhury AK, Gyanendra Singh, BS Tyagi, A Ojha, T Dhar and PM Bhattacharya. 2013. Spot blotch disease of wheat – a new thrust area for sustaining productivity. *Journal of Wheat Research* **5**(2): 1-11.

3. Dubin HJ and M van Ginkel. 1991. The status of wheat diseases and disease research in warmer areas. In: D. A. Saunders (ed.), Wheat for Nontraditional Warmer Areas, 125–145. CIMMYT, Mexico, D.F.

4. Duveiller E and L Gilchrist. 1994. Production constraints due to *Bipolaris sorokiniana* in wheat: current situation and future prospects. In: D. A. Saunders, and G. P. Hettel (eds), Wheat in Heat-Stressed Environments: Irrigated, Dry Areas and Rice-Wheat Farming Systems, 343–352. CIMMYT, Mexico, D.F.

5. Duveiller E, I Garcia, J Franco, J Toledo, J Crossa and F Lopez. 1998. Evaluating spot blotch resistance of wheat: Improving disease assessment under controlled condition and in the field. In: E. Duveiller, H. J. Dubin, J. Reeves, and A. McNab (eds), Helminthosporium Blights of Wheat: Spot Blotch and Tan Spot, 171–181. CIMMYT, Mexico, D.F.

6. Federer WT. 1956. Augmented (or hoonuiaku) designs. Hawaiian Planters' Record, ***55:*** 191-208.

7. Gurung S, Sharm RC, Duveiller E and Shrestha SM. 2012. Comparative analysis of spot blotch and tan spot epidemics on wheat under optimum and late sowing period in South Asia. *Europium Journal f Plant Pathology.*

8. Joshi AK and R Chand (2002). Variation and inheritance of leaf angle and its association with spot blotch (*Bipolaris sorokiniana*) severity in wheat (*Triticum aestivum). Euphytica.* **124**: 283-291.

9. Joshi AK, R Chand and B Arun. 2002. Relationship of plant height and days to maturity with resistant to spot blotch in wheat. *Euphytica.* **123**:221-228.

10. Mehta YR. 1993. Manejo Integrado de Enfermedadas de Trigo-Santa Cruz, Bolivia, 314. CIAT/IAPAR.

11. Roelfs AP, RP Singh and EE Saari. 1992. Rust diseases of wheat: concepts and methods of disease management. CIMMYT, Mexico.

12. Saari EE and JM Prescot. 1975. A scale for appraising the foliar intensity of wheat diseases. *Plant Disease Report.* **59**: 337-380.

13. Sharma RC, HJ Dubin, MR Bhatta and RN Devkota. 1997. Selection for spot blotch resistance in four spring wheat populations. *Crop Sci*ence. **37(2):** 432-435.

14. Singh DP, AK Sharma, A Singh, RV Singh, AN Tiwari, AK Singh, RN Singh, , SP Singh, BM Khanna, DS Dodan, PS Bagga and Kalppanavar IK**.** 2002. Losses due to leaf blight in wheat in different agroclimatic zones of India. *Plant Disease Research.* **17(2):** 313-317.

15. Singh DP, AK Chowdhury and P Kumar. 2007. Management of losses due to seed-borne infection of *Bipolaris sorokiniana* and *Alternaria triticina* in wheat (*Triticum aestivum*) using seed treatment with Vitavax 200WS. *Indian Journal of Agricultural Sciences* **77**:101-103.

16. Snedecor GW and WG Cochran. 1967. Statistical methods. Iowa State University Press, pp 593.

17. Srivastava OP, JK Luthra and PN Narula. 1971. Inheritance of seedling resistance to leaf blight of wheat. *Indian Journal of Genetics and Plant Breeding* **45**: 941-943.

18. Tyagi K, R Nandan, U Kumar, LC Prasad, R Chand and AK Joshi. 2008. Inheritance and identification of molecular markers associated with spot blotch (*Cochliobolus sativus* L.) resistance through microsatellites analysis in barley. *Genetics and Molecular Biology* **31(3)**: 734-742.

19. Vander Plank JE. 1968. Disease resistance in plants. Academic Press, New York and London. pp 206.

20. Zadoks JC, TT Chang and CF Konjak. 1974. A decimal code for the growth stages of cereals. *Weed Research* **14**: 415–421