Received: 13 Jul 2023 | Revised: 26 Mar 2024 | Accepted: 21 Apr 2024

Electronic Journal of Plant Breeding

Research Article

Evaluation of stability for grain yield and its attributing traits in wheat (*Triticum aestivum* L.)

Yendluri Elijah Prabhanth[1], Saikat Das[2], Suvendu Kumar Roy[1]*, S. Vishnupriya[1], Puspendu Dutta[3] and Satyajit Hembram[4]

[1]Department of Genetics and Plant Breeding, UBKV, Pundibari, Cooch Behar, West Bengal
[2]AICW&BIP, Directorate of Research, UBKV, Pundibari, Cooch Behar, West Bengal
[3]Department of Seed Science and Technology, UBKV, Pundibari, Cooch Behar, West Bengal
[4]Regional Research Station (Terai Zone), UBKV, Pundibari, Cooch Behar, West Bengal
***E-Mail**:suvendukumarroy@gmail.com

Abstract
Understanding stability for grain yield in combination with the physiological traits would make screening for spot blotch successful in wheat, as this is presently required under the changing climatic condition. The present study was conducted with 37 wheat genotypes from Indian Institute of Wheat & Barley Research (ICAR-IIWBR, Karnal) including two checks (Sonalika and Raj 3765) under timely sown and late sown conditions over two years (2017-18 and 2018-19) at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. The wheat genotypes differed significantly for all the seven morpho-reproductive traits. The G×E interaction was found to be significant for all the traits. In different traits different genotypes were found to be adaptable to favourable and unfavourable environments, created by the different dates of sowing over the two years. Regarding stability for grain yield the genotypes NEST-17-04 and NEST-17-37 were found to be promising for optimum yield over varying environments.

Keywords: Wheat, grain yield stability, G×E Interaction, linear component

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major staple crop of South Asia and meets on an average 20% calorie requirement of people in this part of the world (Joshi *et al*., 2011). With the introduction of new semi-dwarf and photo insensitive wheat genotypes during the 1960's, cultivation of wheat has been spread to new non-traditional areas like West Bengal, Assam and other eastern states of India. There was a remarkable upward movement in wheat growing area in West Bengal from 1967-68. Districts like Burdwan and Murshidabad in the year 1967-68, followed by Birbhum, Hooghly, Nadia and Cooch Behar in 1968-69 and Midnapore, Malda, 24-Parganas and Howrah in 1969-70, had shown considerable changes in wheat area (Pal*,* 1990). These areas with characteristic high humidity along with short winters remain distinct from other traditional wheat growing locations in India and pose a great challenge to the breeders to select suitable genotypes with good adaptability to the local agro-climatic condition. Moreover, the decreasing trend of potential wheat grain yield was observed in different areas of West Bengal due to climatic fluctuation in the last few decades (Mukherjee and Huda, 2018).

Genotype and its interaction with the prevailing environment is the basic factor determining the final yield. Thus, in order to have unbiased estimates of various genetic components, it is important that the experiment should be repeated over different environments. Grain yield and its components are complex functions of genotype, environment and genotype × environment interaction [P=G+E+(G×E)] (Falconer 1989; Sharma 2001; Hamam *et al*., 2009). The estimates of genotype x environment interactions give an idea of stability or buffering ability of populations under study. Hence, it is always desirable to study the stability of genotypes in respect of economically important traits as it supports the need for specific breeding programmes in different environments (Stagnari *et al*., 2013). In the present study, 37 advanced wheat genotypes have been studied for different yield attributing traits under two entirely different environments (i.e., timely sown and late sown condition) for two successive years and stability parameters were analyzed.

MATERIALS AND METHODS

The experiment was carried out during the *rabi* seasons (winter seasons) of 2017-18 and 2018-19 with two dates of sowings in each season i.e., timely sown and late sown, at Agricultural Farm, Uttar Banga Krishi Vishwavidyalaya, Pundibari, Cooch Behar. The experimental material comprised of thirty-seven wheat genotypes (*Triticum aestivum* L.) of advanced generation developed by Indian Institute of Wheat and Barley Research (IIWBR), Karnal, India. Two check varieties viz. Sonalika and Raj 3765 were also among the studied genotypes. Seven quantitative characters were studied viz., plant height (cm), tillers per metre, spike length (cm), grains per spike, 1000 grain weight (g), grain yield (g) and biomass (g). The data was collected from five random plants selected from each plot in all three replications and an average value obtained was considered for further statistical calculations.

Stability Parameters: The statistical analysis of genotype × environment interaction and stability parameters were worked out by Eberhart and Russell (1966) method for different traits under study. Genres (GENRES 1994, version 3.11), STAR (version 2.0.1, January 2014), Windowstat (version 9.1) and SPSS (version 17.0) were used for statistical analysis.

RESULTS AND DISCUSSION

The pooled ANOVA (**Table 1**) revealed that the 37 wheat genotypes and the effects of environments differed significantly for all the seven morpho-reproductive traits over the four environments, created by the two different dates of sowing (timely and late sown) over two years (2017-18 and 2018-19). Similar findings have been reported earlier for all the traits under study by Krupal *et al.* (2018). Genotype × Environment (G×E) interaction was found to differ significantly for all the seven characters studied indicating that stability analysis could be carried out among these genotypes for the concerned traits. Similar findings for genotype × environment interaction for all the traits studied was reported by Singh *et al.* (2017), Banerjee *et al.* (2006) and Singh and Chaudhary (2007).

Mean performance of wheat genotypes over four environments: The mean performance of the wheat genotypes over all the environments are given in the **Table 2**. Out of the four environments, environment 3 gave highest mean PH (92.20) and environment 2 gave the lowest mean PH (51.53) for the genotypes (**Table 2**) and the tallest genotype was NEST-17-18 (86.05). For tillers per metre, out of all environments, environment 3 exhibited the highest mean (84.15) and environment 4 (57.96) exhibited the least mean. For spike length, among the four environments, the highest mean spike length (SL) was observed in environment 2 (9.60) and the least mean SL was observed in the environment 3 (7.32). For grains per spike, environment 3 (70.54) was observed to have shown the highest grains per spike (GPS) and environment 1 (53.72) gave the least mean GPS. For 1000 grain weight, environment 3 (41.98) was observed to show the highest value while environment 4 (33.74) was observed to show the least mean TGW, respectively. For grain yield, environment 3 was observed to exhibit the highest mean grain yield (25.89) and environment 4 had recorded least mean yield (8.93) among all the four environments (**Table 2**). For biomass, environment 3 (53.49) and environment 4 (18.86) had recorded highest and the least mean biomass values for all the genotypes, respectively (**Table 2**). The highest yielding wheat genotype was NEST-17-27 (21.89 q/ha) followed by NEST-17-36 (20.38 q/ha) although there were several others with grain yield greater than the population pooled mean. Related observations on the different grain yield attributes were also expressed by Gao *et al*. (2017) and Gutierrez *et al*. (2010).

Table 1. Pooled ANOVA for the seven morphological traits over the four environments

Sources of variation	df	Mean sum of squares						
		Plant height	Tillers per meter	Spike length (cm)	Grains per spike	1000 grain weight(g)	Yield (Q./ha.)	Biomass (Q./ha.)
Genotype	36	552.71 **	517.44 **	5.40 **	774.28 **	125.68 **	59.75 **	308.05 **
Environments	3	35328.32 **	14433.86 **	153.97 **	6052.94 **	1460.03 **	6753.88 **	27906.23 **
G x E interaction	108	188.44 **	604.57 **	2.81 **	298.42 **	63.28 **	76.04 **	298.63 **
Pooled Error	288	22.92	35.03	0.48	100.34	34.75	8.33	34.90

** Significant at 1% level of probability

Table 2. Performance of wheat genotypes over four environments

	Plant height				Tillers per metre				Spike length (cm)				Grains per spike			
Environments	**E-1**	**E-2**	**E-3**	**E-4**	**E-1**	**E-2**	**E-3**	**E-4**	**E-1**	**E-2**	**E-3**	**E-4**	**E-1**	**E-2**	**E-3**	**E-4**
Mean	85.69	51.53	92.20	76.27	78.44	77.26	84.15	57.96	9.54	9.60	7.32	7.78	53.72	60.82	70.54	66.98
CV (%)	4.65	14.82	2.95	4.18	1.46	3.18	9.05	14.92	8.91	8.09	7.20	7.10	10.43	14.79	21.62	11.22
CD (P=0.05)	6.48	12.43	4.42	5.19	1.86	4.00	12.40	14.07	1.38	1.26	0.86	0.90	9.12	14.64	24.82	12.24
SEm(±)	2.30	4.41	1.57	1.84	0.66	1.42	4.40	4.99	0.49	0.45	0.30	0.32	3.24	5.19	8.80	4.34

E-1: Timely sown in 2017-18, E-2: Late sown in 2017-18, E-3: Timely sown in 2018-19 and E-4: Late sown in 2018-19

Table 2. (Continued)

	1000 grain weight				Yield (q/ha)				Biomass (q/ha)			
Environments	**E-1**	**E-2**	**E-3**	**E-4**	**E-1**	**E-2**	**E-3**	**E-4**	**E-1**	**E-2**	**E-3**	**E-4**
Mean	37.23	40.29	41.98	33.74	21.20	12.44	25.89	8.93	42.58	25.27	53.49	18.86
CV (%)	15.38	15.43	15.25	15.28	15.61	15.61	15.53	17.57	15.53	15.64	15.58	17.46
CD (P=0.05)	9.32	10.12	-	8.39	5.39	3.16	6.54	2.55	10.76	6.44	13.56	5.36
SEm(±)					1.91	1.12	2.32	0.91	3.82	2.28	4.81	1.90

E-1: Timely sown in 2017-18, E-2: Late sown in 2017-18, E-3: Timely sown in 2018-19 and E-4: Late sown in 2018-19

Stability analysis: The ANOVA for stability analysis as per Eberhart and Russell (1966), indicated highly significant differences among the wheat genotypes for all the traits studied over four different environments, indicating that sufficient variability was present among the genotypes for the traits studied (**Table 3**). Similar views were opined by Krupal *et al.* (2018) and Hamam *et al.* (2009). The components after partitioning of the mean sum of squares like the genotypes and environment + (genotype × environment) were found to be significant for all the characters, which indicated presence of genetic variability in the wheat genotypes under present study. The mean sum of squares due to the environment along with linear component of environment were significant for all the characters, suggesting presence of variation among the four environments (two dates of sowing over two years) tested. The wheat genotypes differed significantly for all the characters, which indicated differential response of the genotypes to the environments and independence of the genetic systems in determining the stability parameters. The genotype × environment (linear) component differed significantly for all the traits except 1000 grain weight, which meant that the performance of the genotypes could be predicted across the environments for all the traits except 1000 grain weight. This was due to the lack of linear response to the environments among the

Table 3. ANOVA for stability as per Eberhart and Russel (1966)

Source	df	Plant height	Tillers per metre	Spike length	Grains per spike	1000 grain weight	Yield (q/ha)	Biomass (q/ha)
Genotypes	36	184.23 **++	172.48**	1.80 **++	258.09 **++	41.89**++	19.92**	102.68**
E + (G × E)	111	379.39 **++	326.11**++	2.29 **++	151.31 **++	33.68**	85.51 **++	348.26 **++
Environments	3	11776.11 **++	4811.29**++	51.32 **++	2017.63 **++	486.67 **++	2251.29 **++	9302.07 **++
G × E	108	62.81 **++	201.52**	0.93 **++	99.47**+	21.09**	25.34**	99.54**
Environments (Lin)	1	35328.33 **++	14433.89 **++	153.96 **++	6052.91 **++	1460.37 **++	6753.88 **++	27906.21 **++
G × E (Lin)	36	110.48 **++	198.78**	1.59 **++	154.86 **++	8.47	28.81**	127.11**++
Pooled deviation	74	37.92 **	197.41 **	0.59 **	69.83 **	26.66 **	22.97 **	83.44 **
Pooled error	288	7.64	11.67	0.15	33.44	11.58	2.77	11.63
Total	147	331.59	288.48	2.17	177.46	35.69	69.44	288.11

*, ** Significance at 5% and 1% level of probability, respectively against pooled error, respectively; +, ++ indicates the significance at 5% and 1% level of probability against pooled deviation, respectively. E- Environment, G-Genotype, env. – Environment, Lin- Linear

genotypes for 1000 grain weight.

The mean and stability parameter (**Table 4 and Table 5**) for the seven morpho-reproductive traits are given in the **Table 4 and Table 5**. For plant height, five genotypes (stable), were found to be stable and adapted to all the four environments, because of their mean performance greater than population mean, bi=1 and $s^2di=0$. For tillers per meter, a single genotype NEST-17-12 was found (**Table 4**) to be stable and adapted to all the four environments, because of its mean performance greater than population mean. A single genotype namely

Table 4. Estimation of mean and stability parameters as per Eberhart and Russel (1966)

S.No.	Genotype	Plant height			Tillers per meter			Spike length			Grains per spike		
		Mean	bi	S²di	Mean	bi	S²di	Mean	bi	S²di	Mean	bi	S²di
1	NEST-17-01	75.64	1.1	-4.75	72.87	2.13	122.92**	9.03	0.63	0.28	62.41	1.76	-13.06
2	NEST-17-04	82.34	1.47	29.78*	59.78	1.31	583.33**	9.58	1.79	0.27	79.00	0.67	42.85
3	NEST-17-05	73.88	1.08	20.32*	71.07	-0.12*	-15.16	9.02	1.47	0.34*	61.54	-0.75	53.99
4	NEST-17-07	74.55	1.38	13.54	74.23	0.09	3.92	8.60	0.6	0.31	62.66	1.4	-11.72
5	NEST-17-08	83.33	1.41	102.99**	80.51	0.35	301.18**	8.99	1.84	0.10	74.75	0.28	-20.29
6	NEST-17-10	76.33	0.91	-5.67	70.36	1.43	21.69	7.94	0.27	0.05	69.50	1.59	-24.30
7	NEST-17-11	70.44	0.77	18.05	68.56	1.63	4.91	9.85	-0.62	2.16**	58.91	1.32	32.30
8	NEST-17-12	82.19	0.86	20.13*	79.11	1.04	8.32	8.77	0.09	0.75**	50.16	1.47	-15.67
9	NEST-17-13	74.82	0.54	8.46	90.52	0.67	353.69**	7.85	0.7	0.08	48.12	0.51	-25.93
10	NEST-17-14	72.59	1	-1.43	72.44	1.43	44.71*	8.95	1.2	-0.01	70.50	2.52	-0.88
11	NEST-17-15	82.58	1.36	73.68**	74.00	1.38	69.27**	9.02	1.35	0.02	69.54	1.05	188.34**
12	NEST-17-16	69.25	1.03	3.64	71.45	0.92	672.91**	7.83	0.48	-0.03	57.33	1.86	66.86
13	NEST-17-18	86.05	0.74	132.67**	78.75	0.58	47.54*	7.45	0.9	0.30	66.75	3.39	358.27**
14	NEST-17-19	77.06	0.9	42.45**	73.83	1.26	48.53*	8.78	0.85	-0.12	60.16	0.72	30.14
15	NEST-17-21	82.96	0.93	55.86**	65.82	1.44	264.14**	8.72	1.53*	-0.12	73.91	0.80	261.25**
16	NEST-17-22	70.47	0.64	10.98	63.58	1.64	204.42**	8.22	0.27	0.63**	56.45	1.82	60.56
17	NEST-17-24	84.47	0.51	39.94**	80.41	1	119.86**	8.76	0.62	0.16	55.54	0.36*	-34.66
18	NEST-17-26	71.66	1.1	13.92	70.51	1.62	95.71**	7.94	1.56	0.01	67.13	2.33	56.84
19	SONALIKA	76.14	1.18	3.85	73.15	1.28	-8.35	9.59	-0.38	5.36**	57.95	-0.84	24.30
20	RAJ 3765	76.08	0.94	16.33	71.38	1.1	0.46	8.43	1.06	-0.10	65.91	1.4	-11.28
21	NEST-17-27	74.60	0.98	9.17	77.77	-0.23	156.81**	8.28	0.38	0.01	52.17	0.13	-13.31
22	NEST-17-28	66.23	0.88	79.53**	69.75	0.36	82.52**	7.72	0.82	0.15	53.25	0.68	-5.04
23	NEST-17-30	51.30	-0.16*	4.64	79.15	-1.06	4.06**	6.76	0.48	1.40**	59.45	1.66	86.01*
24	NEST-17-31	72.41	0.96	70.72**	82.55	-0.41	456.76**	8.36	1.41	-0.10	56.75	1.57	49.88
25	NEST-17-33	78.86	1.06	8.33	83.10	0.60	58.66*	8.38	1.64	0.41*	77.12	2.11	114.89*
26	NEST-17-34	80.04	1.03	43.34**	80.76	1.78	120.83**	8.85	1.22	0.64**	74.79	0.84	-13.21
27	NEST-17-35	83.48	1.28	6.45	82.91	0.81	80.20**	8.70	1.4	0.07	69.83	1.63	-3.88
28	NEST-17-36	80.53	1.19	26.48*	84.40	2.06	214.90**	8.60	1.67	0.49*	64.50	1.33	18.56
29	NEST-17-37	79.78	1.44	46.38**	77.25	2*	-10.91	8.52	1.19*	-0.15	64.37	-0.31	44.13
30	NEST-17-38	85.62	1.26	5.04	80.37	1.71	131.47**	8.91	0.42	-0.06	61.95	0.98	34.44
31	NEST-17-39	76.48	1.79	153.18**	64.94	0.59	22.29	8.11	1.57*	-0.15	69.00	1.06	-21.79
32	NEST-17-40	82.78	0.96	0.07	72.45	1.26	301.24**	8.70	1.32	0.88**	67.25	0.15	36.51
33	NEST-17-41	79.39	1.26	5.51	68.08	1.41	233.72**	9.03	1.57	0.14	59.30	-1.62*	-6.12
34	NEST-17-42	65.11	0.59	7.77	72.81	1.2	162.19**	7.73	0.8	0.09	49.70	0.96	10.00
35	NEST-17-43	72.97	1.02	-5.77	71.68	0.86	200.44**	7.71	1.53	1.02**	55.33	0.85	-19.95
36	NEST-17-46	78.67	0.89	7.06	77.83	0.78	142.23**	9.01	1.4	0.10	71.25	1.16	-22.90
37	NEST-17-47	76.43	0.72*	-6.66	66.55	1.05	-3.48	9.89	1.87	0.61**	57.16	0.16	-20.30
Population Mean		76.42			74.45			8.56			63.01		

*, ** Significance at 5% and 1% level of probability, respectively

Table 4. (Continued)

S.No	Genotype	1000 grain weight (gm)			Grain Yield (q/ha)			Biomass (q/ha)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	NEST-17-01	38.53	1.47	3.14	17.03	0.47	24.09*	37.79	1.38	100.38**
2	NEST-17-04	34.44	1.62	1.58	17.84	1.25	39.57*	37.87	1.42	20.52
3	NEST-17-05	34.22	0.69	27.77**	17.58	1.27	-9.31	37.78	0.57	92.44**
4	NEST-17-07	41.99	1.23	37.16**	18.38	2.11	69.45**	37.91	0.68	-1.64
5	NEST-17-08	38.14	0.48	24.48**	18.91	0.33	3.83	43.79	0.67	-3.04
6	NEST-17-10	36.46	1.06	2.68	18.17	0.78	-9.12	36.48	1.27	10.65
7	NEST-17-11	42.53	0.75	10.66**	13.25	2.54	214.89**	27.91	1.04	28.80*
8	NEST-17-12	43.37	0.65	0.15	16.28	1.02	-10.96	39.09	0.7	-5.70
9	NEST-17-13	41.72	0.8	26.38**	18.82	1.02	34.88*	36.32	1.03	105.91**
10	NEST-17-14	36.79	0.94	26.35**	16.16	0.80	-3.06	38.90	1.58	70.28**
11	NEST-17-15	40.14	1.43	40.39**	17.79	0.94	-7.12	36.37	1.67	101.56**
12	NEST-17-16	43.76	1.09	0.37	17.84	1.12	-4.91	37.33	1.02	-8.83
13	NEST-17-18	35.92	1.23*	-2.38	16.16	0.64	-5.46	40.02	1.36	13.40
14	NEST-17-19	37.59	1.35*	-1.90	18.68	0.89	-6.68	30.58	1.32	6.77
15	NEST-17-21	30.96	1.18	21.12**	19.11	1.03	83.19**	36.24	1.41	13.00
16	NEST-17-22	41.50	0.93	10.51**	12.85	0.92	13.52	25.82	1.16	45.31**
17	NEST-17-24	43.12	1.48*	-2.55	19.06	0.46	-10.40	37.83	1.38	17.00
18	NEST-17-26	39.02	1.5	34.29**	16.17	0.39	-5.54	31.30	1.61	93.72**
19	SONALIKA	38.10	1.23	27.95**	17.90	1.27*	-11.26	36.45	1.41	31.56*
20	RAJ 3765	42.80	1.51	18.15**	16.50	1.9	130.99**	34.55	1.66	39.09*
21	NEST-17-27	38.40	1	40.93**	21.89	0.58	-10.05	38.11	0.89	114.07**
22	NEST-17-28	34.42	0.51	100.94**	19.42	1.08	40.62*	30.96	0.01	55.55**
23	NEST-17-30	31.51	0.66	40.89**	18.63	1.42	-3.22	37.20	0.86	247.78**
24	NEST-17-31	37.06	0.10	13.74**	15.92	0.74	15.01	30.94	0.26	212.06**
25	NEST-17-33	37.81	0.44	6.87*	17.92	0.70	-2.97	37.56	0.46	7.68
26	NEST-17-34	33.81	0.53*	-2.34	17.56	0.63	10.76	36.22	0.7	26.51*
27	NEST-17-35	36.99	0.51	34.95**	18.20	1.1	4.60	44.99	0.71	12.29
28	NEST-17-36	37.72	1.31	-1.10	20.35	1.13	9.67	41.12	1.12	-6.55
29	NEST-17-37	40.35	1.49	4.23	19.27	0.93	5.98	38.82	1.17	151.65**
30	NEST-17-38	40.87	0.7	25.05**	17.80	0.35	-6.95	37.39	0.61	78.21**
31	NEST-17-39	34.83	0.79	9.99**	12.83	0.95	-7.42	25.59	0.62*	-9.65
32	NEST-17-40	35.35	0.54	35.82**	15.05	1.23	-10.12	31.41	0.63	119.66**
33	NEST-17-41	38.99	1.59	1.71	16.07	1.22	-6.63	35.51	1.42	106.30**
34	NEST-17-42	39.86	0.72	34.43**	10.92	1.2	8.20	22.86	0.66	108.05**
35	NEST-17-43	39.42	1.23	44.58**	15.69	0.56	1.10	31.32	0.77	298.27**
36	NEST-17-46	39.29	0.87	40.77**	14.43	0.90	-3.12	28.77	0.91	323.60**
37	NEST-17-47	39.58	1.37	11.99**	16.69	1.13	-7.26	27.76	0.86	50.50**
Population Mean		37.33			17.11			35.05		

*, ** Significance at 5% and 1% level of probability, respectively

NEST-17-21 was found to be specially adapted to favourable (rich) environments as its main performance > population mean. For grains per spike, a total of thirteen genotypes were found to be stable and well adapted to all four environments because of their mean performance > population mean.

For 1000 grain weight, it was found that eighteen genotypes were well adapted to all the four environments as they showed greater mean performance than the population mean. A single genotype Sonalika was specially adapted to favourable (rich) environments showing mean > population mean. For grain yield,

Table 5. Stability status of Wheat genotypes under four environments based on stability parameters

Stability	Plant height	Tillers per metre	Spike length	Grains per spike	1000 grain weight	Grain Yield (q/ha)	Biomass (q/ha)
Well adapted to all environments (mean> Population mean, bi=1 and S^2di= 0)	NEST-17-33, NEST-17-38, NEST-17-40, NEST-17-41, NEST-17-46	NEST-17-12	NEST-17-01, NEST-17-04, NEST-17-07, NEST-17-08, NEST-17-14, NEST-17-15, NEST-17-24, NEST-17-35, NEST-17-38, NEST-17-41, NEST-17-46	NEST-17-04, NEST-17-08, NEST-17-10, NEST-17-14, NEST-17-26, Raj 3765, NEST-17-34, NEST-17-35, NEST-17-36, NEST-17-37, NEST-17-38, NEST-17-40, NEST-17-46	NEST-17-08, NEST-17-12, NEST-17-15, NEST-17-16, NEST-17-19, NEST-17-22, NEST-17-24, NEST-17-26, NEST-17-27, NEST-17-33, NEST-17-36, NEST-17-37, NEST-17-38, NEST-17-41, NEST-17-42, NEST-17-43, NEST-17-46, NEST-17-47	NEST-17-04, NEST-17-10, NEST-17-16, NEST-17-34, NEST-17-36, NEST-17-37	NEST-17-04, NEST-17-07, NEST-17-08, NEST-17-10, NEST-17-12, NEST-17-16, NEST-17-18, NEST-17-21, NEST-17-24, NEST-17-33, NEST-17-35, NEST-17-36
Specially adapted to favorable (rich) environments (Mean > Population mean, bi>1 and S^2di=0)	-	NEST-17-37	NEST-17-21	-	Sonalika	NEST-17-24	-
Specially adapted to unfavorable (poor) environments (Mean > Population mean, bi<1 and S^2di=0)	NEST-17-47	-	-	-	-	NEST-17-34	-

bi – Regression coefficient, S^2di – Mean square deviation from linear regression

six genotypes were found to be well adapted to all the four environments, because their mean performance > population mean. Only one genotype (**Table 5**), NEST-17-24 was found to be specially adapted to favourable (rich) environments showing its mean > population mean. Another single genotype, NEST-17-34 was found to be specially adapted to unfavorable (poor) environments with its mean value > population mean. For biomass, it was found that 12 genotypes were well adapted to all environments. Similar identification of stable genotypes for biomass and yield were found as reported by Vishnu *et al.* (2014). In the past few decades, the major genetic gains in wheat were related to harvest index and in future gains would be related to increase in biomass (Pedro *et al*., 2011).

Mean performance of all the genotypes indicated that year II, timely sown (E3) was the best for all the characters except spike length. Overall, timely sown condition was found favorable for major yield component traits along with yield. When the genotypes were grouped according to stability parameters as per Eberhart and Russel (1966), it was found that six genotypes viz. NEST-17-04, NEST-17-10, NEST-17-16, NEST-17-34, NEST-17-36, NEST-17-37 were found to have stable performance under both timely and late sown conditions in terms of yield. Whereas, the genotype NEST-17-17 was found specifically adapted to favourable environment i.e., timely sown condition (**Table 5**). Similarly, genotype NEST-17-26 was found specifically adapted to poor environment i.e., late sown condition.

When stability for grain yield was taken into consideration, it was found that the wheat genotypes NEST-17-04 and NEST-17-37 were stable in all environments for grain yield and its attributing traits and so these genotypes could be recommended for the North Eastern Plain zone (NEPZ), under all types of sowing conditions. Genotypes like NEST-17-10 and NEST-17-34 were found to be stable for rich environments i.e., timely sown condition thus they could be recommended for timely sown condition only.

ACKNOWLEDGEMENT

The authors are thankful to the Dean, Faculty of Agriculture, UBKV and AICW&BIP, UBKV-Centre for providing all the financial and infrastructural help for the present study.

REFERENCES

Aswini Pal. 1990. Wheat revolution in India: Constraints and Prospects. Mittal Publications. p 366. ISBN: 8170991986.

Banerjee, J., Rawat, R.S. and Verma, J.S. 2006. Stability analysis in bread wheat (*Triticum aestivum* L.) and durum wheat (*T. durum* L.) genotypes. *Indian J. Genet.*, **66**(2):145-146.

Chattopadhyay, N., Mandal, R., Roy, A., Bhattacharya, P. M. and Chowdhury, A. K. 2022. Assessment of wheat genotypes based on genotype-by-environment interaction for durable resistance to spot blotch disease in hot spot. *Cereal Res. Commun.,* **50**(103). [Cross Ref]

Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Sci.* **6**(1):36-40. [Cross Ref]

Falconer, D.S. 1989. *Introduction to Quantitative Genetics*, p 438. 3rd Edition. Longman Scientific and Technical, New York.

Gao, F., Ma, D., Yin, G., Rasheed, A., Dong, Y., Xiao, Y., Xia, X., Wu, X. and He, Z. 2017. Genetic progress in grain yield and physiological traits in Chinese wheat cultivars of Southern Yellow and Huai Valley since 1950. *Crop Sci*., **57**(2):760-773. [Cross Ref]

Gutierrez, M., Reynolds, M.P., Raun, W.R., Stone, M.L. and Klatt, A.R. 2010. Spectral water indices for assessing yield in elite bread wheat genotypes under well-irrigated, water-stressed and high-temperature conditions. *Crop Sci*., **50**(1): 197-214. [Cross Ref]

Hamam, K.A., Sabour, A. and Khaled, G.A. 2009. Stability of wheat genotypes under different environments and their evaluation under sowing dates and nitrogen fertilizer levels. *Aust. J. Basic & Appl. Sci*.,**3**(1): 206-217.

Joshi, A.K., Azab, M., Mosaad, M., Moselhy, M., Osmanzai, M., Gelalcha, S., Bedada, G., Bhatta, M.R., Hakim, A., Malaker, P.K. and Haque, M.E., 2011. Delivering rust resistant wheat to farmers: a step towards increased food security. *Euphytica*, **179**: 187-196. [Cross Ref]

Krupal, S.M., Rathod, S.T. and Kamble, B.G. 2018. Stability analysis for yield and quality traits in wheat (*Triticum aestivum* L.). *Electronic J. Plant Breed.*,**9**(1):160-168. [Cross Ref]

Mukherjee, A. and Huda, A.K.S. 2018. Assessment of climate variability and trend on wheat productivity in West Bengal, India: crop growth simulation approach. *Clim. Change*, **147**:235–252. [Cross Ref]

Pedro, A., Savin, R., Habash, D.Z. and Slafer, G.A. 2011. Physiological attributes associated with yield and stability in selected lines of a durum wheat population. *Euphytica*, 180:195–208. [Cross Ref]

Sharma, J.R. 2001. Principles and Practices of Plant Breeding, p 599. Tata McGraw Hill, New Delhi.

Singh, B., Mavi, G.S., Malhotra, A., Sood, N., Jhinjer, R.K., Kaur, B. and Sohu, V.S. 2017. Stability performance of bread wheat genotype for grain yield, zinc and iron concentrations. *IJAEB.*,**10**(4): 407-413. [Cross Ref]

Singh, G.P. and Chaudhary, H.B. 2007. Stability of wheat genotypes for yield and moisture stress tolerance traits. *Indian J. Genet*.,**67**(2): 145-148.

Stagnari, F., Onofri, A., Codianni, P. and Pisante, M. 2013. Durum wheat varieties in N-deficient environments and organic farming: a comparison of yield, quality and stability performances. *Plant Breed.*, **132**(3): 266-275. [Cross Ref]

Vishnu, K., Tyagi, B.S., Ajay, V. and Indu, S. 2014. Stability analysis for grain yield and its components under different moisture regimes in bread wheat (*Triticum aestivum*). *Indian J. Agric. Sci*.,**84**(8): 931-936. [Cross Ref]