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

Journal of Cereal Research

12(2): 109-113

Homepage: http://epubs.icar.org.in/ejournal/index.php/JWR

Research Article

Selection of wheat genotypes under variable sowing conditions based on stability analysis

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Article history

Received: 3 Apr., 2020
Revised: 4 July, 2020
Accepted: 5 Aug., 2020

Citation

Suresh, Swami P and Munjal R 2020. Selection of wheat genotypes under variable sowing conditions based on stability analysis. *Journal of Cereal Research* **12(2)**:109-113. http://doi.org/10.25174/2582-2675/2020/99755

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Abstract

Thirty wheat genotypes were tested for yield stability under two dates of sowing i.e. late and very late for two consecutive years. Stability was measured based on regression (bi) and stability parameter (S2di). With these parameters, four varieties (HD 3059, WH 1105, HTW 66 and WH 1124) for late sown conditions whereas three varieties (HTW 11, WH 730 and BWL 5186) for very late sown conditions were found promising with their yield stability under late and very late sown environment. Four genotypes namely, HD 3059, WH 1105, HTW 66 and WH 1124 with bi significantly greater than 1 and higher average productivity than overall mean are suitable for late sown condition. Similarly, genotypes HTW 11, WH 730 and BWL 5186 with bi less than unity and higher mean yield were found suitable for marginal environment i.e. for very late sown condition.

Keywords: GXE interaction, wheat, stability analysis, grain yield

1. Introduction

Every crop needs a specific soil and environment factors for proper growth and development. A plant can give its maximum or potential yield only under optimum environmental conditions. Appropriate soil conditions, temperature and humidity are important abiotic factors which play important role in crop productivity. But it is not possible to control all the environmental factors according to the need of crop. When there is some fluctuation in any of these environmental factors from optimum, production and productivity of crop plants decreases drastically (Reynolds *et al.*, 2015). These abiotic stresses have more severe effect on sensitive crop such as wheat. Wheat (*Triticum aestivum* L.) is one of the major cereals and cultivated globally as a staple food. A large population of world consumes wheat as a staple food. Demand of wheat is expected to increase further due to the growing population size. There is a need to increase wheat production by 77% only in developing countries to feed a huge population by the year 2050 (Sharma *et al.,* 2015). But under the present situations of changing climatic conditions this improvement seems to be impossible. This crop is very sensitive to water scarcity and high temperature stresses (Semenov and Shewry, 2011).This condition is more severe in country like India where sowing of wheat is delayed due to various factors which forces reproductive phase of wheat to face terminal heat stress (Shpiler and Blum, 1986). Terminal stage high temperature has adverse effect both on grain yield and quality of wheat (Labuschagne *et al.,* 2009). This problem can be overcome by the development of wheat genotypes which are stable even under stress conditions. A stable genotype has potential to perform equally under different environments and years (Becker and Leon, 1988). Stability of genotypes can be tested by comparing them under a number of locations and years varying for environmental conditions (Abraha *et al.*, 2019). During last century various methods were developed to find out the effect of genotype x environment (GxE) effects. In this study we have tried to identify stable wheat genotypes for late sown conditions based on Eberhart and Russell model (1966) of stability analysis. A stable genotype has low GxE interaction and performs equally under different environmental conditions.

2. Materials and methods

The present investigation was carried out at Research Area of Wheat and Barley Section, Department of Genetics and Plant Breeding, CCS HAU, Hisar during rabi 2017-18 and 2018-19. For this study 30 released wheat varieties used, received from Indian Institute of Wheat & Barley Research, Karnal under Multi Location Heat Tolerance Trial – New were used. It consisted of diverse germplasm and aim was to find the stable genotypes under changing climatic condition. Some of these varieties are recommended for normal sown conditions whereas others are released for late sown conditions. The experiment was conducted using Randomized Block Design (RBD) with two replications. Sowing was done at two dates of sowing i.e. late (December) and very late (January) for two consecutive years. Thus the investigation was carried out in four environments i.e. late sown (E1) and very late sown (E2) of 2017-18, late (E3) and very late (E4) of 2018-19. All the recommended package and practices were followed and proper nutritional and irrigational requirements of the crops were fulfilled. Grain yield was measured on plot basis after harvesting and threshing of mature dried plants of every genotype. The analysis of the data was carried out using standard statistical programmes. To find out genotypic variability and partition into various components, Analysis of Variance (ANOVA) was carried out for individual environment as well as for pooled data using the standard method given by Fisher (1925). To evaluate the genotypes for their stability, linear regression model was used (Eberhart and Russell, 1966), this model helped in calculation of two stability parameters i.e. regression coefficient (bi) and mean squared deviation from linear regression (S2di). The standard procedure for calculation of these parameters was used (Singh and Chaudhary, 1979).

$$Yij = m + biIj + dij + eij$$

whereYij is the mean yield of ith genotypes at location j; m is the general mean for genotype i; bi represents regression coefficient for the ith genotype at a particular location; Ij is the environmental index; dij is the deviation from regression for the ith genotype at the jth location; and eij is the experimental error. Other yield attributes like Biomass,100 grain weight, no. of productive tillers etc. were also recorded.

3. Results

Analysis of variance for grain yield for individual environment was carried out to find out genetic variability among 30 genotypes of bread wheat (Table 1). It is clear from mean sum of square (Table 1) that significant genetic variability is present among these 30 genotypes for grain yield under all the environments. Pooled analysis of four environments is given in Table 2. Environment (E), genotype (G) and E X G are highly significant ($p < 0.01$). This indicates that not only genotypes are significantly different from each other but also the four environments are significant different. Further highly significant GXE component showed that different genotypes performed differently in these environments (Table 2).

Range and mean value for grain yield under different environment is given in Table 3. Average grain yield ranged from 0.950 (E4) to 2.880 kg/plot (E1). Range of mean yield was reported maximum in E1 (1.600) followed by E2 (1.115), E3 (1.031) and E4 (0.716).

The results of the combined analysis of variance according to stability model of Eberhart and Russell is given in Table 4 & figure 1. From this table it is clear that significant differences for grain yield among genotypes and environments were present. This reveals that variability was present not only among the genotypes but different environments also significantly from each other. The mean square for GXE interaction was highly significant for grain yield ($P < 0.01$) which revealed that different genotypes ranked differently among these environments. Further linear interaction of GXE was also significant, indicating differences among the regression coefficients.

Overall mean of grain yield averaged over four environments ranged from 1.556 (DHTW 60) to 2.119 Kg/plot (DBW 90). The regression coefficient (bi) and stability parameter (S2di) are given in Table 5. Regression coefficient ranged from 0.509 (BWL 5388) to 1.562 (HD 3059). It is clear that most of the genotypes have unit bi along with stability parameter of zero indicating average stability of these genotypes. As none of the genotype is deviating for stability parameter from zero further conclusions were made only based on regression value. Four genotypes namely, HD 3059, WH 1105, HTW 66 and WH 1124 with bi significantly greater than 1 and higher average productivity than overall mean are suitable for high input and timely sown conditions. Similarly genotypes HTW 11, WH 730 and BWL 5186 with bi less than unity and higher mean yield are suitable for marginal environment i.e. for very late sown conditions.

4. Discussion

In Indian subcontinent sowing of wheat is always delayed due to late harvesting of previous season crops such as rice and cotton. Normally sowing of wheat is recommended from last week of October to mid-November but most of the time it is delayed upto late December due to which it get shorter period to complete its life cycle. With this regard, the present study was designed to identify stable genotypes over late and very late situations. The model used for this analysis was that of Eberhart and Russell (1966). In this study we found that significant genetic variability was present for grain yield in wheat as also noticed by previous researchers (Zaharieva *et al.,* 2010; Chandrasekhar *et al.,* 2017). Grain yield was lower under very late conditions in comparison to late sowing (Ahmed and Hassan, 2015). Further like the study of Akcura *et al.* (2005), we also noticed significant environmental influences and GxE interactions. Under late sown conditions wheat genotypes face terminal heat stress which is the main cause of change in ranking of these genotypes. Stability was measured based on regression (bi) and stability parameter (S^2di). With these parameters, four varieties for late sown conditions, whereas three varieties for very late sown conditions were found suitable (Fig 1).

From this study we can conclude that as the sowing of wheat is delayed, its grain yield is reduced accordingly. To attain maximum potential genotype it is advisable to sow it at its recommended sowing date. When sowing has to be done late, sown environment genotypes HD 3059, WH 1105, HTW 66 and WH 1124 are recommended. These have a regression coefficient greater than unity and can respond to this environment very efficiently. For very late sown conditions, genotypes with bi less than one are

Table 1. Mean sum of squares under different environments

Environment	MSS			CV
	Block	Genotype	Error	
E1	0.089	0.131**	0.014	5.094
E2	0.349	0.094**	0.034	9.687
E3	0.007	0.091**	0.033	9.394
E4	0.158	0.065**	0.024	11.749
df	1	29	29	

**Significant at p>0.01

Table 2. Combined analysis of variance for grain yield of 30 bread wheat genotypes tested across different environment

Source of Variation	DF	Mean Squares
Environment (E)	3	10.149**
Genotype (G)	29	0.118**
E X G	87	0.101**
Pooled Error	116	0.026

**Significant at p>0.01

Table 3. Mean value of grain yield over different environment

Environment	Mean (Kg/plot)	Maximum yield (Kg/plot)	Minimum yield (Kg/plot)
E1	2.299±0.044	2.880	1.280
E2	1.896±0.077	2.500	1.385
E3	1.934±0.097	2.381	1.350
E4	1.305±0.100	1.671	0.955

Table 4. Analysis of Variance for Stability (Eberhert and Russel Model)

Source of Variation	df	Mean Squares
Genotype (G)	29	0.086*
Environment (E) + G X E	90	0.216**
E (Linear)	1	15.338
G X E (Linear)	29	0.055*
Pooled Deviation	60	0.050
Pooled Error	116	0.024

Table 5. Estimates of stability and adaptability parameters of grain yield (kg/plot) for 30 wheat genotypes at 4 environments

Sr. No.	Genotype	Mean	bi	S^2di
1	BWL 5179	1.861	0.983	0.208
2	BWL 5186	1.888	0.695*	0.075
3	BWL 5233	1.894	0.775	-0.006
4	BWL 5388	1.780	0.509**	0.190
5	BWL 5391	1.873	0.886	-0.010
6	BWL 5410	1.798	1.037	-0.011
7	BWL 5422	1.865	0.921	0.108
8	DBW 173	1.840	1.129	0.001
9	DBW 71	1.873	1.229	-0.005
10	DBW 88	1.964	0.775	-0.001
11	DBW 90	2.119	1.148	-0.003
12	DHTW 60	1.566	1.490**	0.148
13	DPW 621-50	2.040	0.956	0.112
14	HD 2967	1.809	1.019	0.030
15	HD 3059	1.950	1.562**	-0.004
16	HD 3086	1.805	1.176	-0.007
17	HTW 11	1.922	0.648*	0.066
18	HTW 14	1.878	0.955	-0.002
19	HTW 6	1.674	0.670*	-0.003
20	HTW 64	1.915	1.005	-0.004
21	HTW 65	1.625	0.579**	0.013
22	HTW 66	1.838	1.315*	0.028
23	HTW 67	1.780	0.837	-0.008
24	PB 2017-1	1.742	1.135	0.036
25	PB 2017-2	1.859	0.990	-0.007
26	PBW 1Zn	1.833	1.054	0.002
27	PBW 723	1.893	1.082	0.004
28	WH 1105	1.904	1.448**	0.005
29	WH 1124	2.078	1.291*	0.063
30	WH 730	1.980	0.699*	0.006
Mean	1.861	1.000		

recommended. Genotypes HTW 11, WH 730 and BWL 5186 fall under this category.

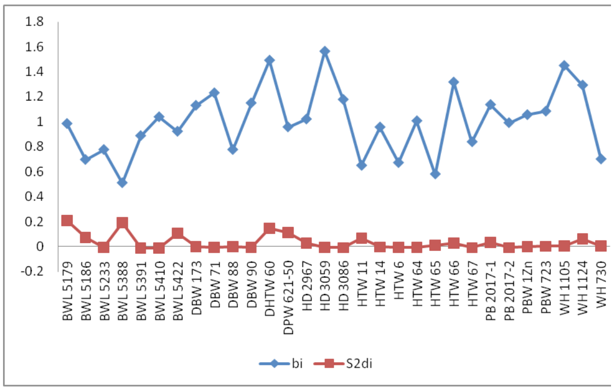

Figure 1. Graphical representation of regression (bi) and stability parameter (S^2di)

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