Stability analysis in wheat(*Triticum aestivum* L.) genotypes under different Environmental Conditions

ABSTRACT

In this investigation aimed to assess the interactions betweenG X E and identify stable genotypes for yield traits in wheat. They conducted the experiment with 30 different wheat genotypes using a Randomized Complete Block Design (RCBD) with two replications. Additionally, they planted the wheat genotypes on three different sowing dates at the ZARS farm collage of Agriculture Powarkheda, JNKVV, Jabalpur during the *Rabi* Season of 2022-2023.The analysis of variance was performed on 13 different quantitative traits, both individually and pooled over different environmental conditions. The stability analysis, specifically for grain yield per plant, was carried out using Eberhart and Russell's model. The results showed significant variations among different genotypes and environmental conditions. This indicates that the performance of the wheat genotypes was influenced by both their genetic constitute and the specific growing conditions.The analysis revealed that the mean squares associated with both environmental factors and genotype-environment interactions (E + G x E) demonstrated significant interactions between the genotypes and environments in which they were grown. Furthermore, they found that the partitioning of G X E (linear) interactions was highly significant for grain yield per plant. This suggests that the choice of genotype can significantly impact the yield of wheat in different environmental conditions.Based on the findings, two genotypes GW 322 and MP 3336were identified as ideal and stable genotypes for grain yield per plant. These genotypes exhibited a mean value higher than the population mean, a regression coefficient close to unity (Bi=1), and minimal deviation from regression (S^2di~0). These stable genotypes can be recommended for cultivation in various seasons and different growing regions, as they are likely to consistently perform well and produce stable yields under different environmental conditions. These identified genotypes can be used to improve wheat cultivation and achieve reliable production.

Keywords: Stability; Eberhart & Russell model; Stable Genotypes;Wheat.

1. INTRODUCTION

Wheat stands as a crucial annual cereal crop globally and holds a significant position in Indian agriculture, ranking just after rice. Among the 17 wheat species, only three are predominantly cultivated worldwide: *Triticum aestivum,Triticum durum* and *Triticum dicoccum.* Wheat is widely grown as a primary grain in the cereal category and contributes approximately 30% to the nation's food supply. There is a pressing need for substantial progress in wheat production, not only to meet the ever-growing domestic food demand but also to bolster exports and earn foreign currency.

Wheat stands out favorably in terms of its nutritional composition when compared to other cereals. It boasts an impressive nutritional profile, consisting of 12.1% protein, 1.8% lipids, 1.8% ash, 2.0% reducing sugars, 6.7% pentoses, and a substantial 59.2% starch content. Moreover, it is rich in carbohydrates, with a total carbohydrate content of 70%, providing a significant energy value of 314 kilocalories per 100 grams of food. Additionally, wheat serves as a valuable source of essential minerals and vitamins, including calcium at 37 milligrams per 100 grams, iron at 4.1 milligrams per 100 grams, thiamine at 0.45 milligrams per 100 grams, riboflavin at 0.13 milligrams per 100 grams, and nicotinic acid at 5.4 milligrams per 100 grams, as documented by Lorenz and Kulp in 1991 [1].

Wheat cultivation exhibits versatility, thriving in a range of environmental conditions, including mild, humid to arid, and cold climates. Its cultivation varies from irrigated to rainfed, encompassing regions with high rainfall.The performance of genotypes in terms of yield potential is significantly influenced by various uncontrollable environmental factors, such as location-specific effects and seasonal fluctuations, as well as their interactions. To assess the impact of these environmental factors on crop response, a common approach is to conduct experiments across multiple locations within a single year or across different crop seasons at a single location, or sometimes both (Gauch and Zobel, 1996) [2]. Since grain yield is a complex quantitative trait, it is heavily shaped by the surrounding environment. The Genotype x Environment interaction poses a significant challenge for plant breeders and complicates the recommendation of cultivars due to the inconsistency of top-performing genotypes across various growing conditions. However, it also presents an opportunity to increase yields by cultivating genotypes specifically adapted to particular regions (Kumaresan and Nadarajan, 2010) [3]. Achieving a substantial increase in yield can be realized through the development of a genotype that consistently performs exceptionally well across all environments. Therefore, investigating genotype x environment interaction using appropriate biometric techniques can successfully identify stable genotypes, which can then be considered for commercial cultivation or incorporated into future breeding programs.

One of the primary goals of most breeding programs is to develop cultivars that offer both high and consistent yields, along with desirable yield-related traits. Breeders need to determine whether a particular cultivar is better suited to specific environmental conditions and whether its performance remains consistent when compared to other cultivars. Having predictable performance across a wide range of conditions is advantageous for farmers and seed producers because it extends the adaptability of the cultivar, enhances uniformity, and increases potential sales. As a result, potential cultivars are systematically evaluated across various locations or growing seasons to gauge their adaptability.

The challenge in this context lies in the phenomenon known as Genotype by Environment interaction (GXE), which plays a significant role in the development, testing, and release of cultivars. GXE interaction occurs when the performance of different genotypes varies across different environments. Dealing with GXE interaction and trying to reduce its impact is particularly challenging, especially in regions characterized by extensive climatic variations.

2. MATERIAL AND METHODS

The experiment was carried out on the site of ZARS farm collage of Agriculture Powarkheda, JNKVV, Jabalpur (M.P.) during *Rabi* season 2022-23.Experimental material consisted of 30 wheat genotypes including three checks were obtained from AICRP on wheat and barley, College of Agriculture, Powarkheda. The experiment was laid out in Randomized Complete Block Design (RCBD) in two replications along with three different dates of sowing (8th November 2022 – (normal), 18th November 2022 – (late) and 28th November 2023 – (extra late). All the genotypes were sown in four rows pattern keeping 20.0 cm row to row distance. A total of 10morphologicaltraits based observations were made. Further, Observations for Plant growth habit, Foliage colour, Flag leaf length, Flag leaf width, Ear time of emergence, Ear Shape, Ear Density, Ear colour, Grain colourand Grain shape were recorded each of the three environments individually and pooled environments. The observations based on mean of the five individual plants was statistically analyzed to find out stability present in the experimental material for each traits especially for yield. The stability analysis was done as per Eberhart and Russell (1966) [4] model.

3. RESULTS AND DISCUSSION

The analysis of variance demonstratedfor various yield characters in Table 1.The analysis of variance found highly significant differences among the genotypes for various traits, including days to 50% heading, days to maturity, plant height, number of tillers per plant, spike length, spike weight, peduncle length, number of spikelets per spike, number of grains per spike, biological yield per plant, harvest index, thousand grain weight and grain yield per plant. Additionally, the genotype x environment interaction was found to be significant for all the traits. This implies that the environmental conditions significantly influence these traits, leading to variations in their performance.The variation attributed to the linear effect of the environment was observed to be significant for all the traits. This suggests that genetic factors play a substantial role in how genotypes respond to environmental changes and this trend was consistent across all three environments at the same location. This significance of environmental influence satisfies the prerequisites for conducting stability analysis.Similar results were reported for grain yield per plant by Sharma *et al*. (2010) [5]. Soleman Mohamed Al-Otayk (2010) [6] for for plant height, spike length and yield. Arain *et al*. (2011) [7] and Mahmoud *et al.* (2011) [8] for grain yield per plant, Sharma *et al.* (2012) [9] for grain yield per plant.The linear component of genotype-environment interaction (G x E) was highly significant for all the traits, suggesting that genotypes exhibit similar regression patterns in response to variations in their environmental indices. Similar results were reported for grain yield per plant by Birla *et al*. (2012) [10] and Singh *et al*. (2012) [11] for spike weight, spike length and grain yield Jaberson*et al*. (2017) [12] for days to 50% heading.

In Table 2, stability parameters for seed yield per plant and its contributing traits were examined across 30 different genotypes. Genotypes GW 322 and MP 3336were identified as ideal and stable for grain yield per plant because they had mean values higher than the general mean, regression coefficients close to unity (Bi=1), and minimal deviation from regression (S^2di~0). Genotypes CG 1029,GW 3211,and MP 4010 were also considered stable for grain yield per plant, with mean values lower than the general mean, regression coefficients near unity (Bi=1), and minimal deviation from regression (S^2di~0). On the other hand, genotypes WAPD 1505, HI 1634 and DBW 71 displayed regression coefficients lower than unity (Bi<1) with minimal deviation from regression (S^2di~0), indicating above-average stability in unfavorable environments. All other genotypes exhibited deviations in S^2di values (away from zero) with varying Bi values, suggesting unstable for seed yield per plant. These results are in conformity with the finding of Singh *et al.* (2012) [11] and Sharma*et al*. (2019) [13] for grain yield perplant.

Table 1.StabilityAnalysisofvarianceforgrain yield andits attributing traitsinwheat

Source of Variation	DF	DH	DM	PH (cm)	NTPP	SL (cm)	SW (g)	PL (cm)	NSPS	NGPS	BYPP (g)	HI (%)	TGW	GYPP
Genotypes	29	6.31**	19.28**	61.70**	1.86**	0.416**	0.12**	7.46**	5.51**	41.26**	57.15**	39.36**	63.60**	8.97**
Env+Var X Env	60	19.44**	7.98**	123.56**	0.69**	1.196**	0.44**	2.25**	0.73**	30.12**	112.22**	68.16**	6.64**	39.02**
Env (Linear)	1	271.93**	111.50**	1497.54 **	9.44**	15.317**	4.62**	32.80**	11.01**	211.71**	712.29**	626.26**	95.01**	386.67**
Env X Var(Lin)	29	1.33**	0.79**	14.42**	0.04**	0.154**	0.08**	0.07**	0.007**	10.11**	44.15**	15.66**	0.29**	7.30**
Pooled Deviation	30	28.53**	11.48**	183.26**	1.03**	1.732**	0.65**	3.35**	1.104**	43.41**	158.02**	100.30**	9.83**	58.10**
Pooled Error	87	9.17**	13.09**	59.74**	0.95**	0.865**	0.31**	8.26**	2.037**	37.44**	82.78**	95.15**	25.97**	14.01**
Total	89													

*Note- * & ** indicate level of significant at 5% and 1 %, respectively.*

DH- days to fifty percent heading, DM- days to maturity PH- plant hight, NTPP- number of tillers per plant, SL- spike length,SW- spike weight, PL- peduncle length, NSPS- number of spikelets per spike, NGPS- number of grain per spike, 1000 GW-thousand grain weight, BYPP- biological yield per plant, HI- harvest index, GYPP- grain yield per plant.

Table2. Stability parameters (ER 1966) for grain yield per plant

	Grain yield per plant		
Genotypes	**Mean**	**βi**	**S²Di**
GW 432	15.335	-0.349	-6.758
PBW 760	14.898	1.782	86.862
HD 3317	16.025	2.695	166.314
IC 296769	13.158	0.693	16.366
MP 3336	14.124	1.826	90.43
HS 661	14.144	1.183	40.212
HI 1624	16.748	1.214	41.991
PBW 820	15.05	0.946	31.552
HD2967	15.11	-0.36	-6.802
GW 328	18.269	-0.32	-6.626
DBW 107	17.185	1.829	90.735
MP 4010	18.752	0.949	120.885
GW 190	16.275	0.823	6.051
K 1317	14.933	0.966	32.615

HI 1634	19.023	0.944	1.79
USA NG 326	15.335	0.294	-6.308
HI1628	14.898	1.446	100.83
WAPD 1505	16.025	1.828	216.875
HD 3237	13.158	0.819	13.91
WGW 2014 596	14.124	1.468	105.605
CG 1029	14.144	1.066	43.601
GW 3211	16.748	1.082	45.902
JW 17	15.05	1.025	29.543
PBW 797	15.11	0.289	-6.208
GW 499	18.269	0.309	-6.534
DBW 110	17.185	1.47	106.015
DBW 71	18.752	1.603	152.959
GW 322	16.275	0.672	2.3
JW 3382	14.933	1.035	30.836
Lok 1	19.023	5.031	-1.975
Population mean	15.93527		

*Note- * & ** Significant At 5% And 1% Levels, Respectively*

4. CONCLUSION

Based on the findings of this investigation, it can be concluded that the genotypes GW 322 and MP 3336are the most suitable and consistent choices for achieving high grain yield per plant. Additionally, the genotypes DBW 107, HD 3317, GW 322 and MP 3336have shown stability in more than two yield-related characteristics. These stable genotypes can be effectively employed in cultivation programs across different seasons and different growing regions to consistently achieve high yields. Furthermore, these identified genotypes can serve as valuable contributors in hybridization programs for developing new and improved wheat varieties that exhibit stable yield performance even in fluctuating environmental conditions.

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