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Original Research Article

Adaptation of G x E Interaction of Wheat Genotypes in Chhattisgarh State through Regression Analysis

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A B S T R A C T

The GxE effect was crossover type as revealed by differential yield ranking of the varieties across the environment. The estimates of the squared deviations from regression for many varieties were near zero, whereas extremely large estimates were obtained for other varieties. Eberhart & Russell's joint regression analysis is also describes in three most stable varieties were Lok-1 (G2), GW-273(G5) and GW-322 (G6) on the basis of mean yield (q/ha) against regression coefficient (b_i), Regression coefficient (b_i) against deviation from regression (S^2_{di}) was found to be the most stable variety GW-322 (G6). Relationship between CV (%) and mean yield it was observed that GW-322 (G6), Lok-1(G2), GW-366 (G7) and HI-1531(G8) were three most stable. The factors that influence the adoption of modern agricultural production technologies are broadly categorized into economic factors, social factors and institutional factors. Accordingly, these varieties are recommended as having especially good adaptability in all environments. The aim of this work was to determine which environment is most desirable for enhancing wheat varieties selection. Statistical model was used to describe Genotype x Environment Interaction (GEI) and adaptation to certain environments.

Keywords

Eberhart & Russell's model, GxEI, promising varieties, Regression analysis and Stability analysis

Introduction

Wheat is an important food grain, making it the second most produced cereal. Currently, Wheat is grown in India in an area of about 30 million ha. with a production of 93 MT.

The normal national productivity is about 29.8 q/ha. This study has contributed in use of best wheat promising varieties suited to different environments and growing situations. In Chhattisgarh state *Rabi* season major crops are wheat, whereby covered area in 162 thousand hectare and productivity are 14.55 q/ha.

Large numbers of statistical measures have been developed to enhance scientists understanding of genotype by environment interaction, stability of varieties and their relationships. Moreover, genotype x environment interaction (GEI) is of great concern if the ensuing varieties are to be used across a large area. The aims of this study were to examine the nature and to enumerate the extent of genotype x environment interaction (GEI) effects on wheat yield and to determine the gratifying genotype (s) for varied environments in

Chhattisgarh state. A dynamic approach to interpretation of varying environments was developed by Finlay and Wilkinson (1963).

It leads to the discovery that the components of a genotype and environment interaction were linearly related to environmental effects, when these effects were measured on the same scale as the genotypic effects. The regression technique of Finlay and Wilkinson was improved upon by Eberhart and Russell (1966) by adding another stability parameter, viz. the deviation from regression and provided a fresh approach to GE interaction analysis. Bucio Alanis and Hill (1966) extended the above model by including some parental effect for averaged dominance over all environments. Perkins and Jinks (1968a) extended the technique to include many inbred lines and considered analysis of GE interaction with different angle. Freeman and Perkins (1971) developed an approach, known as modified approach. Digby (1979) developed a modified regression approach wherein he improved upon the adjustment of Patterson by introducing a sensitivity parameter. Finney (1980), Patterson and Silver (1980) & Patterson (1980) further extended the approach for such cases. Laxmi (1992) found a relationship between different regression models and different components in a model by a graphic method and had shown how these are interlinked with each other. Bhardwaj *et al.,* (2016) assessment of genotype x environment interaction and adaptation of wheat using multivariate statistical analysis.

Materials and Methods

Secondary data has been collected from department of agriculture Chhattisgarh state. Data presented in table 1 are list of wheat varieties and table 2 give the information about locations were used in analysis.

Analysis of variances (ANOVA)

$$Y_{ij} = \mu + G_i + E_j + GE_{ij} + e_{ij}$$

Where, μ is the general mean; G_i, E_j, and GE_{ij} represent the effect of the genotype, environment, and the GEI, respectively; and ε_{ij} is the average of the random errors associated with the r^{th} plot that receives the i^{th} genotype in the j^{th} environment.

Eberhart & Russell's joint regression analysis

In order to improve the method of assessing stability through the method of Finlay and Wilkinson, in the year 1966, Eberhart & Russell's proposed a model with the following modifications additions:

Instead of using environmental mean, an index called environmental index was formulated for each and every environment.

A new parameter in the form of non-linear response was introduced in the model. As a result the variance due to environment and genotype-environment interaction (GEI) were further partitioned due to linear and deviation from linearity components.

Let there be *'t'* genotypes whose performance are to be tested in *l* environments. Then according to this model:

$$Y_{ij} = \mu_i + \beta_i E_j + \delta_{ij}$$ (i= 1,2,,…t) and (j= 1,2,….l)

Where, Y_{ij}= Mean of i^{th} variety in j^{th} situation; μ_i= Mean of the variety over the entire situation; β_i= Regression coefficient i^{th} variety on the environmental indices; E_j= Environmental index for j^{th} situation; δ_{ij} =Deviation of the regression of i^{th} variety on the environmental indices.

Once the GEI effect found significant then comes the question of using suitable stability model.

Before the analysis of the stability parameter, a parameter called environmental index is required to be worked out.

The Environmental Index is defined as the deviation of the average performance of all the varieties at a given environment from the overall average performance. That is,

$$E_j = \frac{\sum_{i=1}^{t} Y_{ij}}{t} - \frac{\sum_{i=1}^{t}\sum_{j=1}^{l} Y_{ij}}{tl} \text{ for } \sum_{j=1}^{l} E_j = 0$$

The environmental index is a type of arrangement to measure the performances of different environment overall the genotypes and accordingly the environments can be ranked also.

According to Eberhart and Russell model there are two stability parameters viz. (i) regression coefficient and (ii) the mean squared deviation from the regression.

The regression coefficient (bi) is estimated as

$$b_i = \frac{\sum_{j=1}^{l} Y_{ij} E_j}{\sum_{j=1}^{l} E_j^2}$$

Where, $\sum_{j=1}^{l} Y_{ij} E_j$ is the sum of products of average performance of j[th] location and j^{th} environmental index, and $\sum_{j=}^{1} E_j^2$ is the sum of square of due to environmental index.

The mean square deviation $\overline{S_{di}^2}$ from the regression is given as

$$\overline{S_{di}^2} = \frac{1}{E-2}\left[E_j(X_{ij} - \bar{X}_i - \bar{X}_j + \bar{X}_.)^2 - (b_i - 1)^2 E_i(\bar{X}_i - \bar{X}_.)^2\right]$$

Results and Discussion

Eberhart and Russell's joint regression measure are presented in Table 4, significant ($p \leq 0.01$) differences between varieties, environments and G x E interaction for wheat yield, implying that considerable differential performance of the varieties and they are genetically, environmentally diverse for yield.

The sums of squares due to environments and varieties x environment was partitioned into environments (linear), genotype x environment (linear) and deviations from the regression model. According to this model stable varieties considered having high mean yield, b_i = 1.0 and $\overline{S_{di}^2}$ = 0. It was however specifically the deviation from the regression ($\overline{S_{di}^2}$) which used as a measure of a varieties stability across environments.

In Table 4 (ANOVA) the G x E (linear) sum of squares were not as large portion of the G x E interaction when compared with the environment E (linear) sum of squares and the residual sum of squares.

Hence, only the deviation mean square is considered to be important.

On the basis of the mean yield, regression coefficient value (b_i) and the deviation from the regression $\overline{S_{di}^2}$ considered together, only the most stable variety GW-322 (G6) with mean yield 20.91 q/ha., regression coefficient (b_i) (0.65) nearest to 1 and lowest $\overline{S_{di}^2}$ (8.00) followed by GW-273 (G5) with mean yield (23.13 q/ha), regression coefficient (b_i) (0.92) nearest to 1 and $\overline{S_{di}^2}$ (20.53). The most unstable variety with highest $\overline{S_{di}^2}$ value was DL-803-3 (Kanchan) (56.79) followed by GW-366 (34.50) in Table 5.

Table.1 List of wheat varieties used for analysis

S N.	Varieties	Duration	Characteristics
1	Sujata	132-135	Sharbati, large grain, brightness, affecting due to rust
2	Lok-1	105-110	Stout and brightness grain medium duration
3	HW-2004 (Amar)	130-135	Sharbati, slender and medium grain
4	DL803-3 (Kanchan)	120-125	Sharbati, slender and medium grain, rust resistant.
5	GW-273	115-120	Medium-dwarf, resistance for rust
6	GW-322	120-125	Sharbati, medium grain, resistance to rust
7	GW-366	120-125	HYV, brightness, resistance for brown and black rust.
8	HI-1531	115-120	HYV, brightness, resistance for brown and black rust.
9	HI-1544	120-125	HYV, brightness, resistance for brown and black rust. used more fertilizer

Table.2 Locations that were used in the study from 2011-12 to 2013-14 for varieties of wheat

S N.	Location	Latitudes	Longitude	Temp.	Rainfall (mm)	Area
1	Surguja	22.79	83.48	24^o-41^o	1210	1 Ha.
2	Raigarh	21.89	83.39	29^o-49^o	1520	1 Ha.
3	Bilaspur	22.07	82.13	23^o-43^o	1229	1 Ha.
4	Raipur	21.23	81.63	28^o-47^o	1352	1 Ha.
5	Durg	21.18	81.28	27^o-45^o	1330	1 Ha.
6	Rajnandgaon	21.09	81.03	30^o-46^o	1505	1 Ha.
7	Bastar	19.08	82.02	19^o-41^o	1540	1 Ha.

Table.3 Stability parameter from Eberhart & Russell's regression

SN	Means	Regression coefficient (b_i)	$\overline{S^2_{di}}$	Inference
1	$\bar{g_i} > \bar{y}$	$b_i = 1$	Non-Sign.	Genotype is stable and widely adapted for all environment
2	$\bar{g_i} < \bar{y}$	$b_i = 1$	Non-Sign.	Genotype is stable but adapted for poor environment
3	$\bar{g_i} > \bar{y}$	$b_i > 1$	Non-Sign.	Genotype is above average stable and adapted for rich environment
4	$\bar{g_i} > \bar{y}$	$b_i < 1$	Non-Sign.	Genotype is stable and adapted for poor environment
5	$\bar{g_i} > \bar{y}$	$b_i < 1$	Significant	Genotype is unstable

Table.4 ANOVA from Eberhart and Russell's for grain yield of wheat varieties at each location over three years

Source of variation	DF	MS	SS	F-Value	P<0.01
Rep within Env	21	1.93	0.09	0.01	1.0000
Varieties	8	1058.87	132.35	16.31	0.0000
Env+ (Var x Env)	180	3300.72	18.33	2.26	0.0000
Environments	20	1395.97	69.79	8.60	0.0000
Var x Env	160	1904.74	11.90	1.46	0.0069
Environments (Lin.)	1	1395.97	1395.97	172.09	0.0000
Var x Env (Lin)	8	517.64	64.7	7.97	0.0000
Pooled Deviation	171	1387.09	8.11	136.98	0.0000
Pooled Error	168	9.94	0.05		
Total	**188**	**4359.59**	**23.18**		

Table.5 Eberhart and Russell's regression coefficient (b_i) and deviation from regression ($\overline{S^2_{di}}$) of wheat at across locations

SN.	Varieties	Mean yield (q/ha)	Rank	(b_i)	Rank	$\overline{S^2_{di}}$	Rank
G1	Sujata	17.33	8	0.92	5	18.06	4
G2	Lok-1	21.98	4	0.85	4	15.64	3
G3	HW-2004	16.26	9	-0.22	1	8.16	2
G4	DL803-3	21.40	5	2.03	9	56.79	9
G5	GW-273	23.13	2	0.92	6	20.53	5
G6	GW-322	20.91	6	0.65	2	8.00	1
G7	GW-366	22.31	3	1.42	7	34.50	8
G8	HI-1531	23.54	1	1.64	8	30.01	7
G9	HI-1544	19.80	7	0.81	3	22.23	6
	Grand Mean	20.74					

Fig.1 Eberhart and Russell's mean yield against regression coefficient (b_i) of wheat varieties across environments

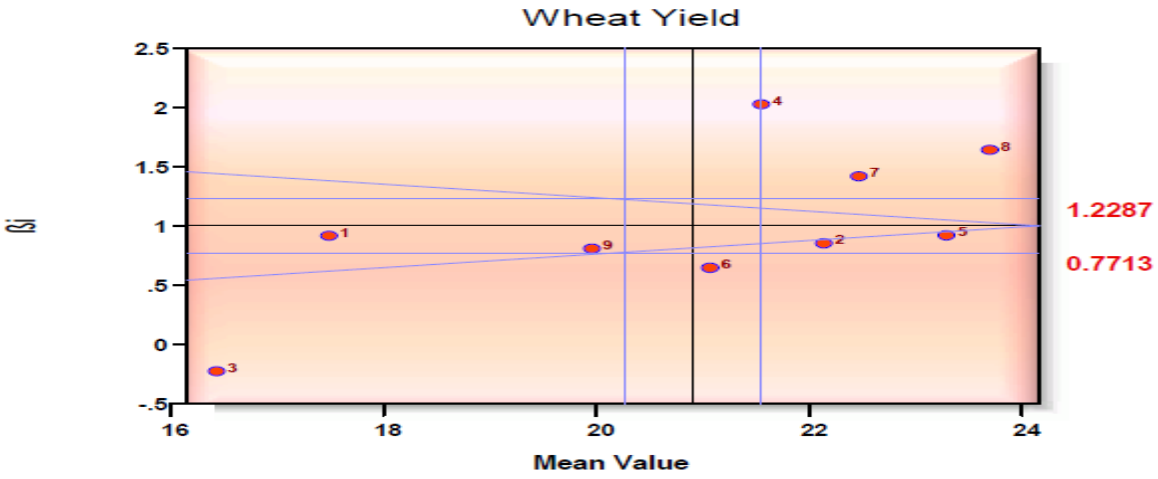


Fig.2 Eberhart and Russell's regression coefficient (b_i) and deviation from regression ($\overline{S^2_{di}}$) of wheat varieties in across environments

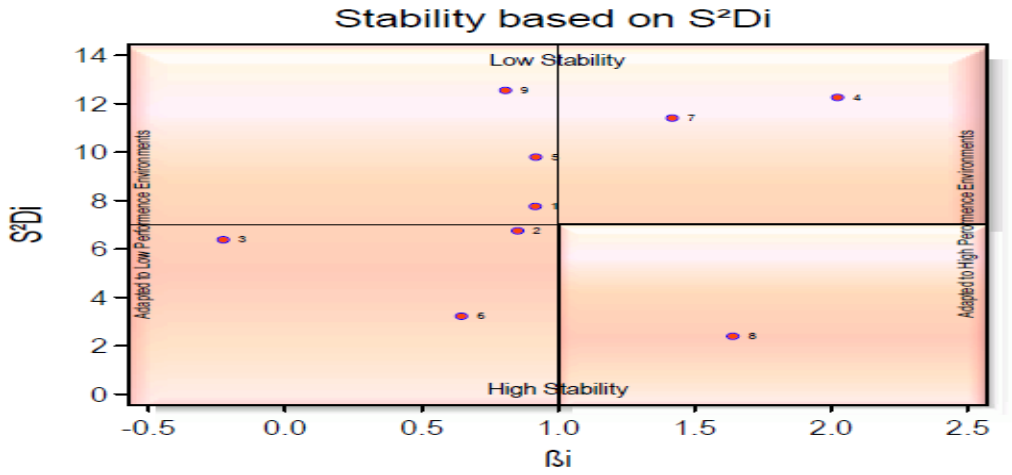
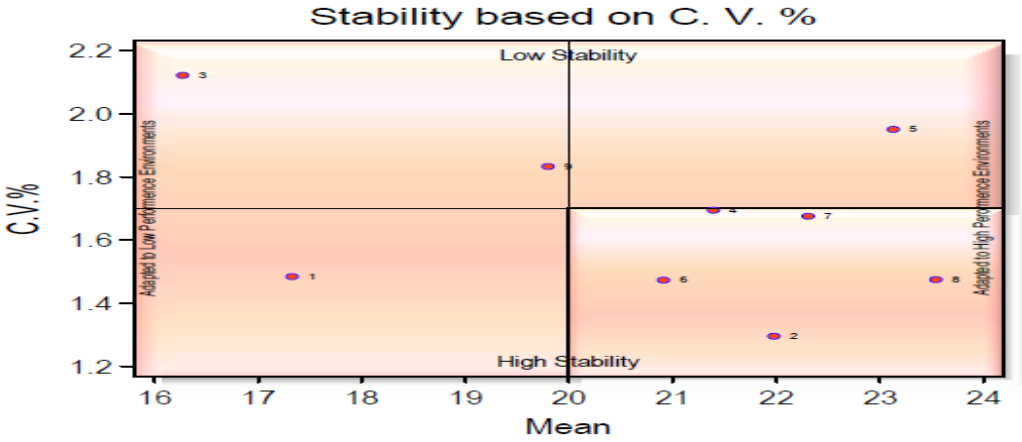


Fig.3 Eberhart and Russell's wheat mean yield against CV (%) under across environments



Eberhart & Russell's joint regression analysis is also described in Figure 1. The three most stable varieties were Lok-1 (G2), GW-273(G5) and GW-322 (G6) on the basis of mean yield (q/ha) against regression coefficient (b_i), Figure 2 shows regression coefficient (b_i) against deviation from regression ($\overline{S^2_{di}}$) was found to be the most stable variety GW-322 (G6). Figure 3, shown relationship between CV (%) and mean yield it was observed that GW-322 (G6), Lok-1(G2), GW-366 (G7) and HI-1531(G8) were three most stable.

Most adapted varieties in Chhattisgarh condition are Lok-1 (G2), GW-273(G5) and GW-322 (G6). Location performances of wheat are Bilaspur and Surguja district are most stable due to low temperatures and favorable climatic conditions.

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