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Yield stability of chickpea genotype in environment condition

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Abstract
Chickpea variety were evaluated using Randomized complete block design with three replications for estimating genotype x environment interaction (GEI) and yield stability of 10 genotype across six environments during 2015-2016 at Chhattisgarh. The objectives were to analyze yield stability of chickpea genotypes performance under Chhattisgarh conditions. Several statistical analyses were conducted:: Coefficient of Variance (CV_i); Wricke's Eco valence parameter **(**W_i); Lin and Binns cultivar performance measure (P_i); Finlay and Wilkinson's regression coefficient(b_i); and Shukla's stability variance parameter $\left(\sigma_i^2\right)$. RG 2009-11 and Vaibhav© are the stable genotype according to the ranking order of the different method i.e. Shukla's (1972), Wricke's (1962) eco valence. JG 16 was ranked first on mean yield, also most stable genotype. According to Lin & Binn's, JG 14 were unstable.

Keywords: Chickpea, genotype x environment interactions and yield stability

Introduction

In India chickpea is grown on 23.63 million hectares. It accounts for about 45% of total pulse produced in the country. In Chhattisgarh the area under chickpea cultivation during 2015 is 823.8 hectares as compared to 839.3 hectares during Rabi. Introduction of improved genotypes with high yield potential, together with technological packages (minerals, fertilizers, pesticides, irrigation etc) designed to significantly improve the cropping environment has greatly contributed to the increase in agricultural production in a several regions by the Green Revolution. Development of this high input model of agriculture is not sustainable. However, due to the high costs involved, and the negative impact on natural resources. Agricultural productivity and performance show wide variations across different regions of the country. The promising genotypes of major crops are study in different agro-ecological regions for adaptability to varying climatic and soil conditions. These trials are commonly referred to as multi location variety adaptability trials- (Abeysiriwardena *et al*. 1991) [1] or Multi-–environment trials-"MET" (Crossa, 1992) [2]. The yield variation due to changing environment is commonly referred to as G × E interaction (Kempton, 1984) [7]. The occurrence of G × E interaction complicates the selection of a genotype with superior adaptability to vary environments. Stability methodologies have been used for interaction among genotypes and environment studied and interpreted by a wide variety of genotype. The performance of any crop genotype actually depends on the effect of its genotype and environment in which it grows. Therefore, the phenotypic variation can be expressed as the sum of the two component representing genotype and environmental source of variation. Genotypes under assessment is grown in various locations, and overs a number of years to know the importance of G × E interaction, and the stability of performance. A wide array of statistical techniques has been proposed to analyze the adaptability of genotypes.

Different stability procedures are developed over the years to research to investigate genotype x environment interaction, particularly yield stability over environments. variety of various applied statistics techniques are used, as an example, Shukla's stability, Superior variety performance, coefficient of variation, Wricke's Ecovalence and regression coefficient to explain the performance of genotypes over environments. trials are wont to accurately estimate and predict yield supported restricted experimental knowledge, confirm yield stability, and therefore the pattern of the response of genotypes across environments, and supply reliable facilitate for choosing the simplest genotypes for planting in future years and at new sites (Crossa, 1990) [2].

Three ideas of stability given by Lin *et al*. (1986)

Sort 1: Among-environment variance is tiny, genotype is taken into account as stable. Becker and Léon, (1988) known as this stability a static. A stable genotype withhold type unchanged performance in any case of variation of the environmental conditions. This idea of stability is beneficial for quality traits and disease resistance. Parameters wont to describe this kind of stability are constant of variability (CVi) employed by Francis and Kannenberg (1978) [5] for every genotype as a stability parameter and also the type variances across environments.

Sort 2: A genotype is taken into account as stable if its response to environments is parallel to the mean response of all genotypes within the trial. Becker and Léon, (1988) known as this stability the dynamic or scientific discipline sort of stability. A regression coefficient, Finlay and Wilkinson (1963) [3] and Shukla's (1972) [10] stability variance will be wont to accustomed stability.

Sort 3: The residual MS from the regression model on the environmental index is tiny, genotype is taken into account as stable. The environmental index indicates the mean yield of all the genotypes in every location minus the grand mean of all the genotypes altogether locations. Sort three is additionally a section of the dynamic or agronomical stability conception according Becker and Léon (1988). The current study was disbursed live, estimate the genotype–environment interaction in chickpea and stability statistics.

Materials and methods

Chickpea genotypes taken from the department of Genetics and Plant Breeding in College of Agriculture,Raipur and evaluated in six environment Raipur, Bemetra, Bhatapara, Kawardha, Korea and Jagdalpur. The experiment was laid down in a complete randomized block design with three replications.

Statistical analysis

A combined analysis of variance procedure is the most common method used to identify the existence of genotype and environment interaction from replicated multi-location trials. If the genotype and environment interaction variance is found to be significant, one or more of various methods for measuring the stability of genotypes can be used to identify the stable genotype(s).

Some of stability methods to estimate yield stability discussed here.

Francis and Kannenberg's coefficient of variability (CV_i)

The mean CVi analysis introduced by Francis (1977) [4] was designed to help in studies on the physiological basis of yield stability. He introduced a simple graphical approach to assess performance and stability concurrently. It measures the performance and CVi for each genotype overall environments, and the mean yield plotted against the CVi. It was found to characterize genotypes in groups rather than individually (Francis and Kannenberg, 1978) [5].

$$s_i^2 = \sum_{j=1}^{q} (X_{ij} - \overline{X_{1.}})^2/(q-1) \quad CV_i = \frac{S_i}{\overline{X}_1} x100$$

The stability method employed was the genotype grouping technique of Francis and Kannenberg (1978) [5], which groups genotypes based on their mean yields, and their coefficients of variation relative to the grand mean and average CVi. (Groups: I high yield, small variation; II high yield, large variation; III low yield, small variation; IV low yield, large variation.)

Lin and Binns cultivar performance measure (P_i)

Lin and Binns (1988) [8] defined the superiority measure (P_i) of the i^{th} test cultivar as the MS of distance between the i^{th} test cultivar and the maximum response as

$$P_i = \sum_{j=1}^{n} (X_{ij} - M_j)^2/2n$$

$$P_i = \frac{[n(\overline{X}_1 - \overline{M}_i)^2 + (\sum_{j=i}^{n}(X_{ij} - \overline{X_{1.}} - M_{j.} + \overline{M_{..}})^2]}{2n}$$

Where, X_{ij} is the average response of the i^{th} genotype in the j^{th} environment, X_i is the mean deviation of i^{th} genotype, M_j is the genotype with maximum response among all genotypes in the j^{th} location, and n is the number of locations. The first term of the equation represents the genotype sum of squares and the second part the GE sum of squares. The smaller the value of P_i, the less is the distance to the genotype with maximum yield and better the genotype. A pair wise GEI mean square between the maximum and each genotype is also calculated.

Shukla's stability variance parameter (σ_i^2)

Shukla's (1972) [10] proposed an unbiased estimate of the variance of $(ge)_{ij} + \varepsilon_{ij}$ for i^{th} genotype (Lin *et al.*, 1986). The stability statistic is termed "stability variance" (σ_i^2) and is estimated as follows:

$$\sigma_i^2 = \frac{1}{(G-1)(G-2)(E-2)}[G(G-1)\sum_j (Y_{ij} - \overline{Y}_{1.} - \overline{Y}_{.j} + \overline{Y}_{..})^2 - \sum_i \sum_j (Y_{ij} - \overline{Y}_{1.} - \overline{Y}_{.j} + \overline{Y}_{..})^2]$$

Where Y_{ij} is the mean yield of the i^{th} genotype in the j^{th} environment, $Y_{j.}$ is the mean of the i^{th} genotype in all environments, $Y_{.j}$ is the mean of all i^{th} genotypes in j^{th} environments and $Y.$ is the mean of all genotypes in all environments.

The stability variance is a linear combination of the Eco valence and therefore both W_i and σ_i^2 are equivalent for ranking purpose:

A genotype is called stable if its stability variance (σ_i^2) is equal to the environmental variance(σ_e^2) which means that σ_i^2 =0. A relatively large value of (σ_i^2) will thus indicate greater instability of i^{th} genotype. As the stability variance is the difference between two sums of squares, it can be negatived, but negative estimates of variances are not uncommon in variance component problems. Negative estimates of σ_i^2 may be taken as equal to zero as usual.

Finlay and Wilkinson's joint regression analysis (b_i)

Finlay and Wilkinson (1963) [3] defined a genotype with $b_i = 0$ as stable, Once the genotype-environment interaction in usual analysis of variance is found significant, next by taking genotypic means of any genotype at different environments as dependent variable and environmental means as an independent variable one can frame regression equations for

different genotypes on environmental means. Thus, the sum of squares due to interactions is partitioned in to two components viz. sum of square due to regression and deviation from regression.
suppose there be i (i= 1,2,.. v) number of genotypes to be tested in j (j=1,2,..s) number of environments then

$$\bar{g_i} = \frac{1}{s}\sum_{j=1}^{s} \overline{y_{ij}} = \text{mean of } i^{th} \text{ genotype}$$

$$\bar{e_j} = \frac{1}{v}\sum_{i=1}^{v} \overline{y_{ij}} = \text{Mean of } j^{th} \text{ environment}$$

b_i = regression coefficient of i^{th} genotype on environmental means

$$bi = \frac{\sum_{i=1}^{v}\sum_{j=1}^{s}\overline{y_{ij}} \times \bar{e_j}}{\sum_j(\bar{e_j})^2} = \frac{Cov(\overline{y_{ij}}, \bar{e_j})}{Var(\bar{e_j})}$$

Where, $\overline{y_{ij}}$ is the mean response of i^{th} genotype in j^{th} environment. Where, $(\overline{g_i})$ is the mean of the i^{th} genotype and b_i is the regression coefficient of the i^{th} genotypes on environmental means.

Wricke's Ecovalence (*Wi*)
Wricke's (1962 and 1964) defined the concept of ecovalence as the contribution of each genotype to the GEI sum of squares. The ecovalence (W_i) or stability of the i^{th} genotype is its interaction with the environments, squared and summed across environments, and express as

$$W_i = [\overline{Y_{ij}} - \bar{Y}_{i.} - \bar{Y}_{.j} - \bar{Y}_{..}]^2$$

Where, Y_{ij} is the mean performance of i^{th} genotype in the j^{th} environment and $Y_{i.}$ and $Y_{.j}$ are the genotype and environment mean deviations, respectively, and $Y.$ is the overall mean. For this reason, genotypes with a low W_i value have smaller deviations from the mean across environments and are thus more stable.

Result and Discussion
In Table 1, the analysis of variance is shown where it represents the partitioning of sum of square of components indicated location and genotype 77% and 13.3% respectively. From this analysis, we predict that in Chhattisgarh, there is great influence of environment. In genotypes chickpea which affect the yield performance. When genotypes & genotype x environment variance is compared then it is more than double when only genotypes as main effect which is very important result. Effect which highly significant (P<0. 01) for chickpea yield are location, genotype x location (Table 1).

Coefficient of variation (CV %)
Indira Chana -1, R G 2009-16 are stable genotype lie into the high yield, and low variation group. The chickpea growing areas of Chhattisgarh and their mean yield ranking and CV of the ten genotype was evaluated at six location in the year 2015-2016.

Lin & Binn's cultivar performance measure (P_i)
J G -16© rank first followed by R G 2009-01 ranked second for are the most stable genotypes. RG 2011-06, RG 2011-01, Vaibhav © and Indira Chana -1 are the some other genotype which having a low values, and high ranking for mean yield. The ranks of the P_i measure, and the mean yield of genotype. P_i measure not really an indication of stability but an indication of performance. JG 14©, RG 2011-02 and RG 2010-18 were the most unstable genotype.

Shukla's stability model (σ_i^2)
The method which decides the most stable genotype are Vaibhav ©, RG 2011-06, RG 2009-05. The genotype that have a poor stability are RG 2009-01 and JG -14 © determined by this model. The genotype which is ranked 1st for mean yield, showed intermediate stability also ranked 2nd for Shukla's stability is RG 2011-06.

Finlay and Wilkinson's joint regression analysis (*bi*)
RG 2011-01(G4) and RG 2011-02 (G8) that are the most stable and adapted to most of the environments. Vaibhav © (G11), RG 2009-01 (G3) and RG 2009-16 (G5) below average stability but specifically adapted to high yielding environments respectively, Indira Chana-1(G9) have above average stability, but are more specifically adapted to lower yielding environments. JG 14© respectively, are not adapted to any of the environments are low yielding.

Wricke 's eco valence analysis
RG 2011-01,Vaibhav ©, RG 2009-05 and RG 2011-06 are the most stable genotype according to the Eco valence method whereas some genotype are not best ranked to mean yield are 10th,4th, 5th & 13th respectively. According to Eco valence method, most unstable genotype are RG 2009-01, JG-14 ©, RG 2009-16 and JG -16 © are the genotype which ranked as 11th, 9th, 14th & 1st for mean yield, respectively.

Comparison of the stability procedure
According to the different stability parameter indicate the value & ranking order for stability of ten genotype. RG 2009-11 and Vaibhav© are the stable genotype according to the ranking order of the different method i.e. Shukla's (1972) [10] and Wricke's (1962) eco valence (Table 2).
`Table 3 depicts each of the possible pair wise comparisons of the ranks of different stability statistics which is determined by the spearmen's coefficient of rank correlation (steel & Torrie 1980). Mean yield was highly significantly positive (P<0.01) with W_i and but non–significantly negatively correlated with all other parameters.
All the result of spearman's rank correlation coefficient when treated equal with shukla stability variance procedure. Wricke Eco valence procedure which is highly significant (p<0.01). The procedures of Shukla & Wricke had a total correspondence (r=1.000).
Lin & Binn's procedure (P_i) value was significantly correlated to b_i and CV_i. To identify a superior yield performing cultivar a genotype mean yield is used. JG 16 was ranked first on mean yield, also most stable genotype.
With the procedure of Shukla's and Finlay &Wilkinson procedure show limited correspondence with CV% (r = 0.43) it show non significant positive rank correlation with Mean yield, W_i and non significant negative correlation with σ_i^2. For evaluate yield stability, this shows a big variation from other procedure.

Table 1: Combined analysis of variance (ANOVA) for year 2015-2016.

Source	Df	Sum.sq	Mean.sq	F value	Pr(>F)
Locations	5	36026258 7	7205252	38.90	5.226e-07
Rep within Env.	12	2222369	185197	3.04	0.0007206
Genotype	9	1537157	118243	1.94	0.0292973
Genotype x Env.	45	9261376	142483	2.33	9.335e-06
Residual	146	9499806	60896		

Table 2: Stability measurement and their ranking order of chickpea genotype evaluated a cross 6 environment

Genotype	Yi Mean	R	CV	R	P_i	R	$\sigma_i 2$	R	W_i	R	b_i	R
Indira chana-1	1548.16	9	15.83	1	115.85	7	219.01	10	164518.54	9	0.78	4
RG 2011-01	1612.02	4	25.46	6	98.78	4	215.25	9	30891.242	1	0.96	6
RG 2011-02	1553.88	8	21.81	4	135.73	12	209.41	7	156959.63	8	1.01	8
RG 2011-06	1682.05	2	26.61	8	83.09	3	113.9	2	74925.288	4	0.76	3
Vaibhav©	1529.44	11	30.59	11	118.40	9	107.71	1	39398.668	2	1.14	10
JG -14	1378.83	14	32.84	12	263.15	14	245.6	12	333836.1	13	1.05	9
JG-16	1682.38	1	29.35	10	56.33	1	225.08	11	189539.56	11	0.83	5
RG 2009-01	1626.44	3	38.82	14	75.22	2	404.54	14	765187.27	14	1.29	13
RG 2009-05	1546.72	10	26.54	7	103.62	5	121.54	3	59539.357	3	1.45	14

Table 3: Spearman rank correlation for all the stability parameters for 2015- 2016.

	Mean	CV_i	P_i	W_i	b_i	$\sigma_i{}^2$
Mean	1					
CV_i	-0.19	1				
P_i	-0.91	0.12	1			
W_i	0.08	-0.06	-0.06	1		
b_i	-0.29	0.43	0.13	-0.42	1	
$\sigma_i{}^2$	-0.06	-0.16	0.06	-0.33	-0.06	1

The Wricke's procedure of stability statistics showed the significant positive correlation (P<0.01)).

Conclusion
JG-16© is the best; JG -14 is nearly parallel to the maximum responses. JG-14© is more favorable in low yielding than in high-yielding locations. RG 2009-01 is superior according to the superior measure of genotype because its lower value. RG 2009-05 better adapted according to the value best in high yielding variety.

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