Chemical Science Review and Letters ISSN 2278-6783

Research Article

# Evaluation of Phenotypic Stability in Chickpea Genotypes Tested under Diverse Environments

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**Abstract**

Twenty chickpea genotypes were studied for stability for various characters at Rahaula farm of Faculty of Agriculture, Mahatma Gandhi Gramodaya Vishwa Vidyalaya Chitrakoot (MGCGV), Satna (M.P.) during rabi seasons of 2014-15, 2015-16 and 2016-17. Analysis of variance for seed yield and its component traits revealed that the genotypes differed significantly for all the characters except plant height. Mean square due to Genotypes X Env. (linear) were significant for number of pods per cluster, number of seeds per plant, hundred seed weight, harvest index and grain yield per plant. The genotype Ujjawala, KAK 2, PG 0517, HK 1 and Shubhra were stable with above average grain yield per plant, regression co-efficient close to unit and least deviation from regression line. However, JG 16 and JG 14 were also reported as stable across the environments with regression co-efficient close to unit and least deviation from regression line, although the grain yield per plant were below the average of all the genotypes. Among the stable genotypes, KAK 2, JG 14 and JG 16 recorded regression co-efficient lower than one indicates its superiority of these genotypes under poor environmental conditions.

**Keywords:** Chickpea, Stability analysis, Genotype x Environment, Regression coefficient

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## Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important crops, belongs to pulse group, in the world [1]. India is the largest chickpea producer accounting a share of about 67% in global chickpea production with about 8.17 million ha area, 7.48 million tonnes production and productivity of 915 kg/ha. Distribution of chickpea in six states *viz*., Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Karnataka and Andhra Pradesh together contribute 90.2% of the production and 90.8 % of the chickpea area in the country. Madhya Pradesh covers 3.43 million ha area with production 4.61 million tonnes and productivity of 1344 kg/ha [2]. Direct selection for complex traits like seed yield is not effective. Knowledge of association of the simply inherited traits, which are less influenced by environment, is required to have sound selection criteria [3]. In any breeding programme, it is necessary to find out phenotypically stable genotypes for yield, which could perform more or less uniformly under different environmental conditions. Seed yield is a complex character and largely depends upon its component characters, with an interaction with the environment resulting into the ultimate product, i.e., seed yield. To breed a stable variety, it is necessary to get the information on the extent of genotype x environment interaction for yield and its component characters. Therefore, an attempt has been made in the present study to evaluate different chickpea genotypes across the seasons to know the role of G x E interactions and also to analyze the stability of genotypes for different traits [4].

## Materials and Methods

The experiment was conducted in Randomized Complete Block Design with two replications during three consecutive rabi seasons of 2014-15, 2015-16 and 2016-17 at Rahaula farm of Faculty of Agriculture, Mahatma Gandhi Gramodaya Vishwa Vidyalaya Chitrakoot (MGCGV), Satna (M.P.) situated at the latitude of 25.14° ′N, 80.85 ‘E, longitude and an altitude of 315 meter above the mean sea level. Four row trials with 4 m row length plots were planted with inter and intra-row spacing of 30 and 10 cm, respectively. Standard agronomic practices were adopted to raise a good crop. Five healthy plants were randomly tagged in each plot to record data on various economic traits from each replication. The data collected from all the individual environments and combined across the environments were subjected to stability analysis. A two-way analysis of variance was performed and the stability parameters are computed following the model proposed by [5]. The type of stability is decided on regression coefficient (bi) and mean values [6]. If bi is equal to unity, a genotype is considered to have average stability (same performance in all the environments). If bi is more than unity, it is suggested to have less than average stability.

## Results and Discussions

Results of analysis of variance for stability analysis for seed yield and its components (**Table 1**) revealed that mean squares due to genotype were significant for all the traits except plant height indicated significant differences among them. Similarly, environments in which the genotypes were grown were also differing significantly for plant height, number of branches per plant, number of seeds per pod and hundred seed weight. Mean squares due to Genotypes X Environment (linear) were significant for number of pods per cluster, number of seeds per plant, hundred seed weight, harvest index and grain yield per plant indicated that the varieties differed genetically for their regression on the environmental index and hence the performance is predictable in nature for these traits. The existence of genotype x environment interactions for seed yield and its important component traits has been reported by [7].

**Table 1** Joint regression analysis for yield and yield components in chickpea genotypes

| Source of Variation | DF | PH | NBPP | NPOdsPP | NSPPlant | HSW | BIOMPP | HI | GYPP |
|---|---|---|---|---|---|---|---|---|---|
| Genotype | 19 | 41.73 | 2.93** | 184.11** | 301.81** | 333.81** | 279.03** | 113.25** | 81.53** |
| Environment | 2 | 339.68** | 0.52** | 186.18** | 180.63** | 32.12** | 23.78** | 79.78** | 26.08** |
| Genotype x Environment | 38 | 35.90** | 0.64** | 87.69** | 158.05** | 12.24** | 27.60** | 32.68** | 16.91** |
| Environment + Genotype x Environment | 40 | 51.08** | 0.63** | 92.61 | 159.18 | 13.29** | 28.41 | 35.54 | 17.87 |
| Environment (Linear) | 1 | 679.37** | 0.45 | 372.36** | 361.25** | 64.24** | 47.56** | 159.57** | 52.15** |
| Genotype x Environment (Linear) | 19 | 33.44 | 0.41 | 62.10 | 172.95** | 6.41** | 6.25 | 27.57** | 7.01** |
| Pooled Deviation | 20 | 36.44 | 0.64 | 107.61 | 136.00 | 1.28 | 8.50 | 16.91 | 6.46 |
| Pooled Error | 114 | 13.98 | 0.26 | 25.25 | 44.23 | 2.86 | 8.53 | 10.59 | 3.49 |

PH= Plant height (cm); NBPP= Number of branches per plant; NPodsPP= Number of pods per plant; NSPPlant= Number of seeds per plant; HSW= 100 Seed weight (g); BIOMPP=Biomass per plant (g); HI=Harvest Index (%); GYPP=Grain Yield per plant (g)

**Table 2** Stability parameters for yield traits of twenty chickpea genotypes across three environments

| Genotypes | Plant Height (cm) | | | Number of primary branches | | | Number of pods per plant | | | Number of seeds per plant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | $b_i$ | $S^2$ di | Mean | $b_i$ | $S^2$ di | Mean | $b_i$ | $S^2$ di | Mean | $b_i$ | $S^2$ di |
| BG 1053 | 48.00 | 0.28 | -3.72 | 5.33 | 13.72** | -0.29 | 49.03 | 0.11 | 459.45 | 58.68 | -0.10 | 618.97 |
| BG 256 | 37.89 | 0.00 | 144.44 | 3.78 | 3.58** | -0.31 | 38.23 | -2.34* | 286.07 | 43.64 | -4.18 | 112.60 |
| Shubhra | 52.34 | -0.14 | -4.65 | 5.83 | 0.00 | -0.32 | 71.82 | 0.19 | 37.62 | 78.02 | 0.26 | 9.26 |
| BGM 547 | 43.67 | 1.81 | -2.68 | 4.67 | 5.49** | 3.68 | 56.18 | 2.38* | 6.01 | 64.04 | 1.21 | -3.80 |
| DCP 92-3 | 42.96 | 0.57 | 110.88 | 4.00 | 1.75 | 0.28 | 52.11 | 0.62 | 62.55 | 60.55 | -2.11* | 62.71 |
| GCP 105 | 46.89 | 1.95 | -4.55 | 4.00 | -2.99** | -0.30 | 60.61 | 2.57* | 95.32 | 75.12 | 0.64 | 166.83 |
| GNG 1581 | 42.37 | -0.07 | -4.29 | 3.33 | 0.00 | -0.32 | 47.85 | -1.27 | 295.13 | 56.28 | -3.28 | 256.51 |
| GNG 469 | 48.00 | 1.53 | -3.24 | 5.56 | -2.33** | 0.74 | 56.66 | 0.15 | 10.93 | 64.68 | -0.03 | 1.70 |
| H.K. 1 | 47.00 | 1.53 | -3.24 | 4.78 | 7.19** | -0.07 | 53.59 | 1.84 | 38.93 | 72.22 | 3.76** | -14.57 |
| HC-5 | 40.78 | -0.42 | 98.09 | 3.33 | -1.25 | 0.53 | 48.48 | 2.99** | 41.91 | 58.14 | 3.12** | 65.47 |
| IPC 97-67 | 44.89 | 2.10* | 13.87 | 4.22 | -2.33* | 0.74 | 55.89 | 4.11** | 28.68 | 62.99 | 5.02** | -30.86 |
| JG 11 | 47.44 | 1.96 | 5.75 | 3.89 | -1.83 | 0.12 | 46.78 | 1.44 | -13.36 | 54.10 | 2.83* | -10.35 |
| KWR 108 | 44.55 | 1.26 | 2.01 | 4.11 | -4.16** | -0.19 | 53.72 | 4.81** | 99.27 | 73.62 | 8.32** | -15.13 |
| PG 0517 | 47.78 | -0.28 | -4.61 | 6.56 | -3.58** | -0.31 | 63.47 | 0.97 | 162.78 | 80.23 | 3.68** | 559.54 |
| Ujjawala | 50.56 | -0.28 | -4.61 | 6.33 | -1.25 | 0.53 | 56.80 | 2.00 | -13.24 | 67.65 | 0.45 | -17.59 |
| JG 315 | 45.56 | 1.55 | 17.79 | 4.56 | -0.58 | -0.26 | 57.30 | -0.34 | -6.85 | 70.09 | -0.48 | -23.73 |
| KAK 2 | 37.67 | 0.39 | 278.27 | 5.33 | 3.62** | 0.05 | 67.08 | -0.54 | 163.99 | 79.41 | 2.52* | 78.77 |
| JG 14 | 43.00 | 2.51* | -4.48 | 4.39 | 3.78** | 2.49 | 60.58 | 0.58 | 34.00 | 65.39 | 1.38 | 5.08 |
| JG 16 | 44.56 | 2.36* | -4.23 | 3.33 | 0.00 | -0.32 | 65.67 | -1.45 | 23.59 | 83.28 | -4.17** | 175.45 |
| CSG 8962 | 45.89 | 1.40 | 8.74 | 3.56 | 1.16 | -0.06 | 56.73 | 1.18 | 68.62 | 65.72 | 1.16 | 91.54 |
| Overall Mean | 45.09 | | | 4.54 | | | 55.93 | | | 66.69 | | |

Eberhart and Russell (1966) [5] defined a stable genotype as the one which showed high mean yield, regression coefficient (bi) around unity and deviation from regression near to zero. Accordingly, the mean and deviation from regression of each genotype were considered for stability and linear regression was used for testing the varietal response.

The estimates of stability parameters in respect of eight characters that had direct influence on genotypes performance is presented in **Table 2** and **3**.

**Table 3** Stability parameters for yield traits of twenty chickpea genotypes across three environments

| Genotypes | Hundred seed weight (g) | | | Biomass per plant (g) | | | Harvest Index (%) | | | Grain yield per plant (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | $b_i$ | $S^2di$ | Mean | $b_i$ | $S^2di$ | Mean | $b_i$ | $S^2di$ | Mean | $b_i$ | $S^2di$ |
| BG 1053 | 27.33 | 3.13 | -0.51 | 35.14 | 3.14** | 12.10 | 46.79 | 3.27** | 8.01 | 16.62 | 3.31** | 11.03 |
| BG 256 | 15.67 | -1.62 | -0.72 | 22.33 | -1.85 | 3.34 | 43.64 | -2.02* | 85.98 | 9.90 | -1.52 | 9.51 |
| Shubhra | 36.75 | 0.84 | -0.54 | 52.33 | 0.46 | 2.33 | 49.33 | -0.01 | 0.68 | 25.87 | 0.21 | 6.72 |
| BGM 547 | 31.56 | 0.82 | 4.95 | 44.72 | 1.85 | 3.34 | 41.87 | 0.92 | 12.52 | 18.57 | 1.52 | 9.51 |
| DCP 92-3 | 13.11 | 0.44 | -0.60 | 30.13 | 3.14** | 12.10 | 37.56 | 4.48** | 19.52 | 11.59 | 3.31** | 11.03 |
| GCP 105 | 17.67 | -0.53 | 2.83 | 38.47 | 3.14** | 12.10 | 34.75 | 3.66** | 12.42 | 13.60 | 3.31** | 11.03 |
| GNG 1581 | 15.00 | 1.57 | -0.84 | 33.20 | 1.31 | -1.27 | 35.30 | 1.73 | 0.22 | 11.83 | 1.40 | 1.72 |
| GNG 469 | 29.00 | 2.40* | -0.86 | 37.00 | 2.62* | 10.46 | 50.21 | 2.42 | 5.24 | 18.71 | 2.80* | 10.36 |
| H.K. 1 | 24.67 | 2.40* | -0.86 | 35.90 | 1.48 | 0.28 | 47.98 | 0.82 | 8.65 | 17.28 | 1.21 | 5.67 |
| HC-5 | 17.78 | -1.86 | -0.93 | 29.95 | -1.97 | 3.62 | 39.50 | -2.54* | 16.34 | 11.86 | -2.10* | 5.32 |
| IPC 97-67 | 16.00 | 0.94 | 4.18 | 31.24 | 1.62 | -2.78 | 34.74 | 1.53 | 10.59 | 10.81 | 1.41 | 2.31 |
| JG 11 | 20.00 | 2.40* | -0.86 | 32.43 | 1.79 | -4.76 | 34.41 | 2.33* | -6.80 | 11.11 | 1.88 | -1.15 |
| KWR 108 | 14.67 | 2.40* | -0.86 | 38.57 | 1.48 | 0.28 | 30.90 | 1.03 | 17.24 | 12.00 | 1.21 | 5.67 |
| PG 0517 | 53.33 | 0.84 | -0.54 | 66.00 | -0.12 | 29.46 | 37.77 | -0.01 | -0.02 | 25.33 | 0.21 | 6.72 |
| Ujjawala | 36.33 | 1.57 | -0.84 | 41.91 | 0.74 | -3.81 | 45.63 | 0.38 | -3.61 | 19.10 | 0.61 | 0.55 |
| JG 315 | 15.67 | 2.40* | -0.86 | 35.16 | 2.34* | 0.67 | 37.89 | 2.93** | 5.07 | 13.50 | 2.60* | 5.82 |
| KAK 2 | 34.21 | -0.11 | 1.68 | 51.41 | -0.74 | -3.81 | 52.84 | -0.28 | -5.14 | 26.71 | -0.88 | -1.08 |
| JG 14 | 19.00 | -0.11 | 1.68 | 35.07 | -1.17 | -3.76 | 38.26 | -1.26 | -5.01 | 13.62 | -1.09 | -0.89 |
| JG 16 | 16.33 | -0.11 | 1.68 | 37.47 | -0.74 | -3.81 | 39.39 | -0.49 | -1.43 | 14.77 | -0.61 | 0.55 |
| CSG 8962 | 15.11 | 2.16 | -0.55 | 32.13 | 1.48 | 0.28 | 37.64 | 1.09 | 20.44 | 12.03 | 1.21 | 5.67 |
| Overall Mean | 23.46 | | | 38.02 | | | 40.82 | | | 15.74 | | |

Stability analysis of plant height revealed that the genotype, PG 0517, Ujjawala, Shubhra and GCP 105 were stable across the environment with higher mean, regression coefficient close to unit and least deviation from regression line indicating their superior performance even in poor environments. For number of primary branches per plant genotype, Shubhra, Ujjawala and PG 0517 were stable across the environment with mean performance higher than average of all the genotypes, regression co-efficiency close to unit and least deviation from regression line. For number of pods per plant genotypes, JG 315, Ujjawala, Shubhra, GNG 469 and JG 16 reported as stable with higher mean performance, regression co-efficient close to unit and least deviation from regression line. Genotype, PG 0517 recorded high mean performance and unit regression co-efficient with higher deviation from regression lines. Genotypes, JG 315, Shubhra, GNG 469 and JG 16 had regression co-efficient less than one indicates their superior performance under poor environmental conditions whereas Ujjawala recorded regression co-efficient more than one indicates its responsiveness towards better environmental conditions. The results obtained are in accordance with the earlier reports of [8]. For number of seeds per plant genotypes, JG 315, Ujjawala, Shubhra and H.K. 1 reported as stable with higher mean performance, regression co-efficient close to unit and least deviation from regression line. Shubhra recorded high mean performance among the stable genotypes. Genotypes, GNG 469 had regression co-efficient less than one and least deviation from regression line considered as stable across the environments, however the mean number of seeds per plant in this genotype were lesser than the average of all the genotypes. JG 16 recorded highest number of seeds per plant with regression co-efficient (-4.17) less than unit but higher deviation from regression line. For hundred seed weight genotypes Shubhra, PG 0517, and Ujjawala and KAK 2 were stable with higher hundred seed weight compared to average, regression co-efficient close to unit and least deviation from regression line. Among the stable genotypes, KAK 2 has recorded the regression co-efficient lower than one indicates its superiority under poor environmental conditions. For biomass per plant genotypes Shubhra, BGM 547, and Ujjawala and KAK 2 were stable with higher biomass yield per plant compared to the average of all the genotypes, regression co-efficient close to unit and least deviation from regression line. Among the stable genotypes, KAK 2 has recorded the regression co-efficient lower than one indicates its superiority under poor environmental conditions. PG 0517 highest biomass yield compared to other genotypes with regression co-efficient less than one along with higher deviation from regression line. For harvest Index genotypes Shubhra, Ujjawala and KAK 2 were stable with higher harvest index compared to the average of all the genotypes, regression co-efficient close to unit and least deviation from regression line. Among the stable genotypes, KAK 2 and Shubhra has recorded the regression co-efficient lower than one indicates its superiority under poor environmental conditions. These results are in concomitant with the earlier reports of [9]. Non-linear component of environment was highly significant for test weight indicating the unpredictable nature of environment which is also in agreement with the earlier reports of Shivani and Sreelakshmi (2015) [4]. For grain yield per plant genotypes Ujjawala, KAK 2, PG 0517, HK 1 and Shubhra were stable with above average grain yield per plant, regression co-efficient close to unit and least deviation from regression line. However, JG 16 and JG 14 were also reported as stable across the environments with regression co-efficient close to unit and least deviation from regression line, although the grain yield per plant were below the average of all the genotypes. Among the stable genotypes, KAK 2, JG 14 and JG 16 recorded regression co-efficient lower than one indicates its superiority of these genotypes under poor environmental conditions. Expression of stability of genotypes for seed yield has also been reported by [10]. Although the study did not reveal genotypes exhibiting stability for more than one trait influencing the seed yield, it is highly relevant in identifying genotypes with wider adaptation over seasons or suitable to a specific season for a particular character. Thus, it needs a greater number of genotypes to be involved in further evaluations over the seasons to identify genotypes possessing stability for yield and its influencing traits.

## Conclusion

From the foregoing discussion, it is clear that, genotypes Ujjawala, KAK 2, PG 0517, HK 1 and Shubhra has regression coefficient close to unity coupled with minimum deviation from regression and above average yield than population yield, this genotype was suitable for general adaptation and it is considered as ideal and stable hybrid. Among the stable genotypes, KAK 2, JG 14 and JG 16 recorded regression co-efficient lower than one indicates its superiority of these genotypes under poor environmental conditions.

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| Publication History | |
|---|---|
| Received | 21.05.2021 |
| Revised | 09.08.2021 |
| Accepted | 10.08.2021 |
| Online | 20.09.2021 |