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# STABILITY ANALYSIS OF YIELD AND RELATED TRAITS IN CHICKPEA (*CICER ARIETINUM* L.)

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## ABSTRACT

**A set of fifty genotypes of chickpea (*Cicer arietinum* L.)were evaluated in three different environments during 2008-09 to determine the stability for seed yield plant height , number of branches per plant, number of pods per plant, number of seeds per pod, biological yield, seed yield per plant, harvest index (%), 100 seed weight . Analysis of variance revealed significant differences among the genotypes for all the characters studied. Stability analysis showed that a major portion of genotype × environment (G × E) interaction was accompanied by linear component for number of branches per plant, number of pods per plant, number of seeds per pod, biological yield, seed yield per plant and 100 seed weight, whereas, non-linear portion predominantly contributed towards plant height, number of branches per plant and harvest index. Environment two (E2) was observed to be best for most of the yield attributing traits. Considering all the parameters, genotypes H06-79, H04-31, HK05-151, HK06-162, HK06-170, HK06-171, HK-2, HK-3, H06-32 having bi> 1 and i = 0 found promising for favourable environment, while genotype HC-3 having bi< 1 and $S^{-2}d_i$= 0 found promising for unfavourable environment and genotypes H05-10, HK06-152, HK06-155 having bi= 1 and $S^{-2}d_i$ = 0 across the environments.**

**Key words:** Chickpea, G x E interaction, Phenotypic stability.

## INTRODUCTION

Chickpea is an important winter season pulse crop in India and Asia and traditionally a low input crop grown in moisture stress environment of drought prone semi-arid and tropical regions. Large number of important high yielding varieties of chickpea have been evolved, yield of these varieties are not stable over environments which is one of the reason for poor adaptation. The yield of this crop fluctuates greatly as genotypes respond differently due to variation in the environments of its cultivation. (Bahl, 1988; Singh and Jaiswal, 1990). Varietal adaptation to environmental fluctuation is important for stabilization of crop production, both over region and years. Therefore, there is an urgent need for genetically upgrading the yield potential along with stabilization of production. Thus, high productivity and stability are two most desirable features of any crop variety (Costa *et al.*, 2004).Therefore, the present study was conducted to know the G x E interaction of 50 genotypes of chickpea for seed yield and yield attributing traits.

## MATERIALS AND METHODS

Fifty genotypes of chickpea (Table 1) were evaluated at experimental farm area of Pulses Section, Department of Plant Breeding, Hisar and Regional Research Station (CCS Haryana Agricultural University), Bawal. The crop at Hisar was sown on two different dates (9-11-2008 and 10-12-2008) and normal sown in Bawal (11-11-2008) thus creating three environments in a randomized block design with three replications in each environment. For each genotype the plot size was 9.60 $m^2$ (4 × 2.40 sq. meter) with a spacing of 30 cm between rows and 10 cm within a row. All the recommended agronomic package of practices was followed to raise the crop. At maturity, data was recorded on different characters from five competitive randomly selected plants from each genotype per replication in each environment. The

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TABLE 1: Genotype's pedigree description

| Genotype | Pedigree |
|---|---|
| H04-68 | H91-35 × H82-2 (m) |
| H04-75 | HC-5 × H91-36 |
| H05-10 | NARC 9006 × HC 5 |
| H05-11 | H 89-171 × HC 5 |
| H05-24 | (HC 5 × GNG 711) × (PDG84-16 × NARC 9006) |
| H05-29 | IPC94-19 × IPC 71 |
| H06-07 | H91–35 × E100 Y m |
| H06-11 | PBG98-5 × H92-67 |
| H06-15 | PBG98-5 × H92-67 |
| H06-18 | H90-64 × H92-67 |
| H06-30 | H91-36 × H92-67 |
| H06-32 | H91-35 × HC 5 |
| H06-41 | H91-35 × HC 5 |
| H06-52 | H89-59 × HC 5 |
| H06-55 | CSG 8962 × HC 5 |
| H06-56 | GNG 711 × HC5 |
| H06-63 | H99-109 × HC 1 |
| H06-70 | HC 5 × E 100 Ym |
| H06-75 | H92-67 × E 100 Ym |
| H06-79 | Katila × BG 362 |
| H06-80 | (HC 1 × E 100 Ym) × H91-36 |
| H04-31 | (ICCV 10 × ICC 4958) × ICC11320 |
| HC-5 | H89-78 × H89-84 |
| HC-1 | F 61 × L 550 |
| C-235 | IP58 × C 1234 |
| HC-3 | L550 × E 100 Ym |
| H06-97 | HC 1 × BGD 112 |
| H06-98 | HC 1 × Vijay |
| H06-135 | HC 1 × PGD 84-16 |
| H06-136 | HC 1 × ICC 4958 |
| H07-12 | C235 × GL 94022 |
| H07-93 | HC 1 × H89-84 |
| H07-23 | H96-51 × GL 94022 |
| H07-86 | (HC 1 × GL 94022) × GL 94022 |
| H07-88 | HC 1 × ICCV 96029 |
| H07-121 | (HC 5 × ICCV 96030) × ICCV 96030 |
| H07-169 | (CSG 8962 × H92-67) × GL 94022 |
| HK05-151 | HK 92-94 × HK 1 |
| HK06-152 | PG 95412 × HC 3 |
| HK06-155 | (HK 92-94 × HK 95-67) × HK 1 |
| HK06-158 | HK 95-70 × HK 1 |
| HK06-159 | HK 95-70 × HK 1 |
| HK06-160 | HK 95-70 × HK 1 |
| HK06-162 | HK 95-70 × HK 1 |
| HK06-168 | HK 95-70 × HK 1 |
| HK06-169 | HK 95-70 × HK 1 |
| HK06-170 | (HK 92-98 × HK 95-67) × HK 1 |
| HK06-171 | PG 95412 × HC 3 |
| HK-2 | (H82-5 × E100Ym) × Bhim |
| HK-3 | ICCV 2 × Surrutato 77 |

mean of the five plants in each replication was used for statistical analysis of all the characters. The environments and genotypes were assumed to be fixed for Statistical analysis. The phenotypic stability of genotypes was estimated using the parameters developed by Eberhart and Russell (1966) model.

## RESULTS AND DISCUSSION

There exists a great agro-climatic variation in the environments due to uneven rainfall and variation in soil texture. Such environmental variation play a significant role in genotype x environment interaction. Hence, there is an urgent need to obtain stable genotypes which could give high and uniform yield of gram.

The pooled analysis of variance revealed the existence of considerable amount of genetic variability among genotypes and environments (Table 2) for all the traits. The experimental results indicated that mean squares due to genotypes, environment and G × E interaction were highly significant for all the 11 traits, indicating that genotypes interacted significantly with varied environmental conditions. This showed the presence of G × E interaction for all the traits. The present findings of G × E interaction are in agreement with earlier workers, (Samad *et al.*, 1989; Rathore and Gupta, 1999; Chetia and Yadav, 2002; Rao and Rao, 2004; Sharma *et al.*, 2007; Abbas *et al.*, 2008; Yadav *et al.*, 2010, Choudhary and Haque,2010).

With the availability of different analytical approaches, the most important conclusion which has emerged out from these studies is that bulk of G × E interaction is often a linear function of the environmental means, although both linear and non linear functions play an important role in building up of total genotype × environment (G × E) interaction. The linear component of genotype ×

TABLE 2: Stability analysis of variance for different characters studied (Eberhart & Russell, 1966)

| Source of variation | D.F. | Plant height (cm) | Number of branches/ plant | Number of pods/ plant | Number of seeds per pod | Biological yield/ plant(g) | Seed yield/ plant | Harvest index (%) | 100 seed weight (g) |
|---|---|---|---|---|---|---|---|---|---|
| Genotype | 49 | $222.13^{++}$ | 2.24 | $334.63^{++}$ | $2.07^{++}$ | $77.39^{+}$ | $13.21^{++}$ | 70.23 | $12.33^{++}$ |
| E+ G× E) | 100 | $98.45^{**}$ | $8.59^{++}$ | $271.87^{++}$ | $0.07^{++}$ | $76.62^{++}$ | $9.09^{++}$ | $62.90^{**}$ | $11.25^{++}$ |
| Env.(L) | 1 | $1331.81^{++}$ | $662.88^{++}$ | $13930.52^{++}$ | $1.51^{++}$ | $3486.92^{++}$ | $256.03^{++}$ | $689.20^{++}$ | $264.97^{++}$ |
| G × E (L) | 49 | $66.42^{**}$ | $1.46^{**}$ | $1165.60^{**,+}$ | $0.09^{**,++}$ | $45.96^{**}$ | $8.89^{**,++}$ | $20.50^{*}$ | $16.37^{**,++}$ |
| Pooled deviation | 50 | $105.18^{**}$ | $2.50^{**}$ | $102.83^{**}$ | $0.03^{**}$ | $38.47^{**}$ | $4.34^{**}$ | $91.94^{**}$ | $1.15^{**}$ |
| Pooled Error | 294 | 5.81 | 0.68 | 33.79 | 0.02 | 8.49 | 0.96 | 15.14 | 1.49 |

$^{*,**}$ = Significant mean square against pooled error at 5% and 1 % probability level respectively.

$^{+,++}$ = Significant mean square against pooled deviation at 5% and 1 % probability level respectively.

TABLE 3: Stability parameters for different traits in chickpea

| Genotypes | Plant height (cm) | | | No. of branches per plant | | | No. of pods per plant | | | No. of seeds per pod | | | Biological yield per plant (g) | | | Seed yield per plant (g) | | | Harvest index (%) | | | Seed weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gen. Mean | bi= 1 | $S^2d_i$ | Gen. Mean | bi= 1 | $S^2d_i$ | Gen. Mean | bi= 1 | $S^2d_i$ | Gen. Mean | bi= 1 | $S^2d_i$ | Gen. Mean | bi= 1 | $S^2d_i$ | Gen. Mean | bi= 1 | $S^2d_i$ | Gen. Mean | bi= 1 | $S^2d_i$ | Gen. Mean | bi= 1 | $S^2d_i$ |
| H04-68 | 77.0 | 3.457 | 3.663 | 6.1 | 1.152 | 0.232 | 51.8 | 1.698 | 1.294 | 1.6 | -0.278 | 1.199* | 26.0 | 0.173 | 0.721 | 8.3 | 0.238 | 1.551 | 31.7 | 1.014* | 0.000 | 15.6 | 1.683 | 0.041 |
| H04-75 | 84.2 | 1.842 | 0.531 | 6.1 | 0.618 | 0.074 | 72.8 | -0.269 | 0.183 | 1.4 | 4.145 | 0.073 | 37.5 | 1.270 | 0.100 | 11.7 | 0.048 | 0.906 | 35.7 | 0.378 | 17.854 | 16.2 | 1.422* | 0.000 |
| H05-10 | 73.6 | 1.941 | 1.765 | 5.6 | 0.899 | 0.023 | 62 | 0.022 | 0.057 | 1.4 | 0.830 | 0.955* | 30.7 | 1.156 | 0.068 | 10.4 | 1.225* | 0.001 | 34.0 | 0.452 | 0.022 | 16.7 | 1.235 | 0.279 |
| H05-11 | 66.8 | 3.071 | 2.796 | 6.0 | 0.585 | 0.041 | 65.0 | 1.749 | 1.596 | 1.4 | -0.059 | 8.930* | 30.6 | 1.747 | 0.095 | 10.2 | 0.926 | 2.166 | 32.8 | 0.250 | 1.737 | 18.0 | 1.486* | 0.009 |
| H05-24 | 68.5 | 0.995 | 6.628 | 5.3 | 0.692 | 0.006 | 52.4 | 0.742 | 1.389 | 1.5 | 3.096 | 1.408* | 25.1 | 0.869 | 0.944 | 9.4 | 0.593 | 3.484* | 37.3 | -0.479 | 0.134 | 15.3 | 1.801 | 0.908 |
| H05-29 | 54.5 | 2.556 | 4.855 | 5.2 | 0.724* | 0.001 | 46.4 | 0.738 | 0.062 | 1.8 | -2.653 | 0.128 | 29.2 | 0.096 | 0.085 | 11.1 | 0.244 | 1.713 | 39.1 | 1.542 | 0.063 | 15.7 | 0.490 | 0.005 |
| H06-07 | 81.4 | 4.001 | 1.480 | 6.2 | 0.695 | 0.014 | 62.2 | 0.459* | 0.000 | 1.5 | 4.145 | 0.073 | 27.5 | 0.552 | 0.005 | 9.5 | -0.051 | 0.225 | 34.7 | 0.482 | 1.753 | 16.4 | 1.634 | 0.042 |
| H06-11 | 71.0 | 2.235 | 4.942 | 6.3 | 0.598 | 0.243 | 69.2 | 0.817* | 0.010 | 1.6 | 2.780 | 1.279* | 30.8 | 0.958 | 0.362 | 9.8 | 0.216 | 1.165 | 32.2 | 0.575 | 0.787 | 16.3 | 0.973 | 0.027 |
| H06-15 | 72.8 | 1.703 | 4.678 | 5.8 | 0.581 | 0.544 | 57.8 | 0.422 | 0.045 | 1.6 | 2.822 | 5.758* | 29.6 | 0.754 | 0.007 | 9.8 | -0.514 | 0.257 | 33.6 | 1.221 | 5.330 | 16.8 | 1.052 | 0.053 |
| H06-18 | 83.3 | 4.154 | 2.854 | 5.7 | 1.038 | 0.008 | 61.0 | 1.631 | 0.634 | 1.2 | 1.309 | 0.520* | 30.3 | 0.590 | 0.797 | 9.1 | -0.106 | 0.171 | 31.0 | 0.540 | 5.721 | 15.6 | 1.478 | 0.115 |
| H06-30 | 59.4 | 0.906 | 0.957 | 5.3 | 0.965 | 0.157 | 49.7 | 1.503 | 0.209 | 1.4 | 1.108 | 4.294* | 22.1 | 1.322 | 0.041 | 6.8 | 1.269 | 0.016 | 31.2 | 0.583 | 0.091 | 14.5 | 1.271* | 0.004 |
| H06-32 | 60.8 | 2.277 | 2.468 | 5.3 | 0.802 | 0.027 | 56.6 | 1.636 | 0.489 | 1.4 | 1.291 | 1.597* | 27.1 | 1.511* | 0.010 | 8.4 | 0.984 | 0.178 | 30.9 | 1.299* | 0.005 | 15.2 | 1.067 | 0.028 |
| H06-41 | 66.7 | 2.635 | 0.668 | 5.1 | 0.931 | 0.035 | 59.3 | 3.210 | 1.860 | 1.3 | 4.145 | 0.073 | 20.6 | 1.341 | 0.393 | 8.9 | 0.909 | 0.055 | 48.1 | 0.462 | 36.133 | 15.6 | 1.344 | 0.082 |
| H06-52 | 67.8 | 1.611 | 11.057 | 6.3 | 1.618 | 0.137 | 55 | 2.112 | 0.044 | 1.3 | 0.496 | 0.637* | 26.8 | 1.184 | 1.454 | 10.6 | -0.764 | 0.590 | 46.7 | -0.669 | 119.033* | 14.3 | 1.505 | 0.038 |
| H06-55 | 73.8 | 0.843 | 2.963 | 4.9 | 1.103* | 0.007 | 62 | 0.938 | 0.054 | 1.8 | -1.362 | 0.821* | 23.2 | 0.961 | 0.457 | 7.8 | 0.918 | 0.136 | 34.3 | -1.033 | 4.678 | 15.1 | 1.613 | 0.644 |
| H06-56 | 60.0 | 1.634 | 5.209 | 5.4 | 0.889* | 0.002 | 69.6 | 1.134 | 0.160 | 1.5 | 2.301 | 0.766* | 24.2 | 0.555 | 0.626 | 8.4 | 0.413 | 0.126 | 36.1 | 1.910 | 2.345 | 17.4 | 0.835 | 0.232 |
| H06-63 | 51.1 | 1.911 | 2.978 | 6.0 | 1.361 | 0.257 | 61 | 1.419* | 0.009 | 1.5 | 0.662 | 1.133* | 23.7 | 1.341 | 0.000 | 9.1 | 0.449 | 0.216 | 40.0 | 1.950 | 5.346 | 16.0 | 1.405 | 0.074 |
| H06-70 | 66.9 | 2.057 | 10.662 | 5.6 | 1.339* | 0.004 | 69.6 | 1.751 | 0.161 | 1.4 | 2.780 | 1.279* | 32.5 | 0.970 | 0.043 | 10.7 | 0.286 | 1.028 | 33.2 | 0.059 | 2.246 | 15.9 | 0.376 | 0.002 |
| H06-75 | 77.9 | 3.172* | 0.001 | 7.0 | 1.103 | 0.634 | 67.5 | 1.490 | 0.173 | 1.2 | 2.579 | 0.048 | 28.4 | 1.214* | 0.001 | 8.0 | 1.337 | 0.056 | 28.3 | 0.181 | 0.247 | 15.6 | 1.586* | 0.000 |
| H06-79 | 46.9 | -0.727 | 0.015 | 6.2 | 0.918 | 0.103 | 64.6 | 0.227 | 0.115 | 1.7 | 2.378 | 2.467* | 26.9 | 1.447 | 0.016 | 12.1 | 3.242 | 0.990 | 44.0 | -1.033 | 3.639 | 17.6 | 0.766 | 0.005 |
| H06-80 | 54.0 | -0.769 | 0.051 | 6.5 | 0.584 | 0.163 | 55.8 | -0.148 | 0.208 | 1.7 | -2.139 | 2.885* | 34.7 | 1.833 | 1.732 | 11.6 | 3.284 | 0.573 | 34.7 | 1.589 | 15.040 | 17.3 | 1.178 | 0.076 |
| H04-31 | 55.1 | -2.833 | 1.460 | 6.4 | 1.205* | 0.000 | 53.8 | 1.792 | 1.168 | 1.7 | -1.013 | 0.028 | 27.8 | 0.841* | 0.004 | 12.5 | 2.244 | 0.862 | 44.1 | -1.796 | 1.402 | 13.8 | 0.778 | 0.103 |
| HC-5 | 62.6 | 0.435 | 9.078 | 5.8 | 1.086 | 0.121 | 54.5 | 0.076 | 0.073 | 1.2 | 1.070 | 0.721* | 28.1 | 0.595 | 0.122 | 9.2 | 0.331 | 0.363 | 33.0 | 0.283 | 0.058 | 17.0 | 1.063 | 0.189 |
| HC-1 | 54.5 | 0.598 | 2.566 | 6.0 | 1.423 | 0.026 | 56.3 | 1.045* | 0.007 | 1.8 | 0.809 | 0.621* | 22.7 | 0.876* | 0.003 | 8.0 | 0.140 | 0.009 | 36.7 | 1.544 | 2.282 | 14.2 | 1.737 | 0.208 |
| C-235 | 58.2 | -1.537 | 1.480 | 9.0 | 1.078 | 0.698 | 58.8 | -0.330 | 0.603 | 1.9 | 0.295 | 0.305* | 23.0 | -1.056 | 0.016 | 9.8 | -1.572 | 0.109 | 43.9 | 0.403 | 0.113 | 16.7 | 5.607 | 0.485 |
| HC-3 | 63.8 | -0.599 | 1.029 | 7.5 | 1.102 | 0.274 | 55.5 | -0.705 | 1.101 | 1.5 | 0.517 | 0.935* | 34.4 | -2.529 | 0.110 | 15.4 | -3.919 | 2.176 | 45.2 | 0.380 | 0.566 | 22.8 | -5.236 | 0.009 |
| H06-97 | 45.5 | -0.450 | 1.502 | 5.8 | 0.607 | 0.483 | 31.5 | 1.404 | 0.215 | 1.7 | 0.479 | 0.065 | 30.3 | -0.003 | 6.431 | 6.3 | 0.244 | 0.007 | 24.8 | 3.325 | 10.380 | 13.6 | 1.222* | 0.001 |
| H06-98 | 56.8 | 1.183 | 11.175 | 7.0 | 1.070 | 1.274 | 38.3 | 0.940 | 0.491 | 1.4 | -1.270 | 0.252 | 27.2 | 0.659 | 0.005 | 8.2 | 0.884 | 0.724 | 30.8 | 2.034 | 3.835 | 14.5 | 1.806 | 0.088 |
| H06-135 | 66.8 | -1.046 | 10.291 | 5.9 | 0.321 | 0.681 | 40.9 | 0.683* | 0.000 | 1.2 | 2.744* | 0.002 | 20.5 | 1.434 | 0.018 | 6.8 | 0.532 | 0.145 | 35.8 | 3.861 | 0.897 | 16.2 | 1.497* | 0.005 |
| H06-136 | 59.9 | 1.450 | 0.222 | 6.9 | 0.700 | 0.616 | 45.0 | 1.033 | 0.022 | 1.4 | 0.092 | 0.163 | 26.6 | 1.602 | 0.034 | 8.6 | 0.786 | 0.123 | 33.7 | 2.161 | 0.573 | 16.3 | 1.312* | 0.002 |
| H07-12 | 63.1 | -0.583 | 0.481 | 6.5 | 0.302 | 0.199 | 36.1 | 1.211* | 0.002 | 1.3 | 1.823 | 0.384 | 22.1 | 0.913* | 0.003 | 6.7 | 1.669 | 0.413 | 31.0 | 1.311 | 8.443 | 17.1 | 1.653* | 0.011 |
| H07-93 | 63.0 | 0.180 | 31.999* | 6.9 | 0.951 | 0.013 | 40.3 | 0.228 | 0.048 | 1.2 | -1.749 | 0.574 | 25.5 | 1.346 | 0.046 | 7.2 | 1.589 | 0.116 | 29.7 | 2.074 | 3.453 | 14.2 | 1.126 | 0.030 |
| H07-23 | 63.0 | 3.489 | 1.581 | 5.8 | 1.388 | 0.078 | 36.7 | 0.878 | 0.025 | 1.6 | -1.070 | 0.721 | 25.9 | -0.176 | 2.911 | 8.0 | 0.530 | 0.334 | 34.7 | -2.345 | 10.093 | 14.8 | 1.065 | 0.074 |
| H07-86 | 67.8 | 0.994 | 0.079 | 4.9 | 1.052 | 0.053 | 41.8 | 0.163 | 0.286 | 1.4 | 1.474 | 0.207 | 24.4 | 0.848 | 0.075 | 7.5 | 0.686 | 0.223 | 30.9 | 0.568 | 0.005 | 15.7 | 1.169* | 0.003 |
| H07-88 | 69.8 | 1.047 | 0.047 | 5.1 | 0.636 | 0.007 | 41.3 | 0.457 | 0.868 | 1.2 | 2.671* | 0.034 | 23.9 | 1.061 | 1.362 | 8.3 | 0.262 | 3.905* | 36.6 | 0.223 | 3.247 | 16.2 | 0.884 | 0.099 |
| H07-121 | 57.6 | -0.732 | 16.935 | 5.1 | 0.725 | 0.010 | 41.1 | 0.380 | 0.143 | 1.7 | -3.740 | 0.442 | 20.9 | 1.088 | 0.642 | 7.8 | 0.808 | 0.529 | 39.4 | 3.214 | 1.758 | 17.6 | 5.739 | 0.229 |
| H07-169 | 58.2 | -1.570 | 0.006 | 6.8 | 1.269* | 0.002 | 45.6 | 1.305* | 0.001 | 1.3 | 0.848 | 0.189 | 32.7 | 1.109 | 1.065 | 10.9 | 1.929 | 2.282 | 33.7 | 0.954 | 0.848 | 24.2 | 0.944* | 0.003 |
| HK05-151 | 62.3 | 0.018 | 0.054 | 6.9 | 1.457 | 0.053 | 50.5 | 1.663 | 0.084 | 1.2 | 0.257 | 0.449 | 37.6 | 1.516 | 0.015 | 13.0 | 2.583 | 0.445 | 34.6 | 1.157 | 5.402 | 30.6 | 0.826 | 1.205 |
| HK06-152 | 58.2 | -1.042 | 0.870 | 6.2 | 1.539 | 0.036 | 53.5 | 1.355 | 0.026 | 1.2 | 2.579 | 0.048 | 35.4 | 1.134 | 0.196 | 11.8 | 1.308* | 0.004 | 33.7 | 0.063 | 0.106 | 27.5 | 0.757 | 0.157 |
| HK06-155 | 66.1 | 1.244 | 5.578 | 6.5 | 0.902 | 0.010 | 40.6 | 0.724 | 0.093 | 1.1 | 0.700 | 0.025 | 32.0 | 0.343 | 0.618 | 12.2 | 1.718 | 0.186 | 39.1 | 1.113 | 16.616 | 31.9 | 0.751 | 0.012 |
| HK06-158 | 59.1 | 2.085 | 2.011 | 6.9 | 1.167 | 0.013 | 37.4 | 1.191 | 0.096 | 1.1 | 0.074 | 0.019 | 30.9 | 2.177 | 0.628 | 11.2 | 2.051 | 0.431 | 36.8 | 2.024 | 0.037 | 33.6 | 0.855 | 0.364 |
| HK06-159 | 62.2 | 2.611 | 6.609 | 6.2 | 0.713 | 0.018 | 35.2 | 0.980 | 0.340 | 1.2 | 1.196 | 0.409 | 33.2 | 1.766 | 0.053 | 10.3 | 2.115 | 0.787 | 31.4 | 2.079 | 3.565 | 33. | 1.403 | 0.080 |
| HK06-160 | 60.0 | 1.668 | 6.788 | 6.3 | 1.503* | 0.013 | 39.2 | 1.209 | 0.223 | 1.3 | 2.062 | 0.558 | 31.7 | 1.363 | 1.071 | 11.3 | 0.085 | 0.626 | 36.0 | 1.692 | 1.407 | 33.0 | 1.637 | 0.121 |
| HK06-162 | 52.8 | -1.214 | 1.833 | 6.9 | 1.188 | 0.021 | 47.6 | 1.591 | 0.159 | 1.3 | 1.840 | 1.350 | 34.8 | 1.681 | 1.079 | 12.6 | 2.968 | 2.544 | 37.1 | 2.666 | 9.607 | 28.5 | 2.084 | 0.337 |
| HK06-168 | 57.3 | -1.02 | 1.855 | 8.3 | 0.847 | 1.828 | 44.5 | 1.427 | 0.293 | 1.2 | 2.579 | 0.048 | 32.3 | 1.589 | 0.206 | 10.6 | 2.345 | 0.918 | 32.4 | 1.510 | 4.615 | 24.3 | -4.026 | 1.843 |
| HK06-169 | 59.5 | 1.508 | 6.783 | 6.0 | 1.759 | 0.089 | 44.3 | 1.394 | 1.036 | 1.3 | 1.840 | 1.350 | 34.1 | 0.279 | 1.360 | 11.5 | 1.151 | 7.877* | 32.6 | 1.821 | 6.104 | 25.7 | 0.799 | 0.087 |
| HK06-170 | 64.6 | 1.286 | 0.389 | 7.4 | 1.186* | 0.000 | 57.3 | 2.483 | 0.751 | 1.1 | 0.939* | 0.001 | 38.3 | 1.941 | 0.035 | 13.9 | 2.808* | 0.031 | 36.5 | 1.110 | 2.646 | 28.1 | 1.235 | 1.215 |
| HK06-171 | 58.5 | 1.017 | 3.400 | 6.1 | 1.246* | 0.001 | 44.9 | 0.084 | 0.178 | 1.2 | 0.056 | 0.463 | 30.0 | 1.551 | 0.041 | 12.5 | 3.230 | 0.251 | 42.9 | 1.601 | 7.082 | 23.9 | -2.385 | 0.016 |
| HK-2 | 54.6 | -0.176 | 0.114 | 6.1 | 1.207 | 0.026 | 49.1 | 1.931 | 0.193 | 1.5 | -0.405 | 0.155 | 33.0 | 2.021 | 0.126 | 12.0 | 2.608 | 0.315 | 36.7 | 1.325 | 2.063 | 22.7 | 1.345 | 1.135 |
| HK-3 | 62.6 | -0.434 | 0.012 | 8.1 | 1.176 | 0.083 | 45.0 | 0.130 | 1.179 | 1.3 | 1.926 | 1.026 | 42.5 | 2.190 | 1.346 | 13.4 | 2.741* | 0.044 | 34.2 | 2.369 | 4.087 | 27.2 | -3.851 | 0.045 |

environment (G × E) interaction was significant for number of pods per plant, seeds per pod, 100-seed weight and seed yield per plant when tested against pooled deviation, indicating that major portion of interaction was linear in nature and prediction over environments was possible only for these traits. The linear component of genotype × environment (G × E) interaction was non significant against pooled deviation for remaining traits *viz.*, plant height, number of branches per plant, biological yield per plant and harvest index which indicated that prediction for consistency in performance of the genotypes was not possible. However, relative magnitude of both these portions i.e., linear and non linear vary with the traits. In the present study the linear portion was higher in magnitude for all the traits except plant height, number of branches per plant and harvest index .This indicated the preponderance of linear portion for most of the economic traits and thus performance of the genotypes can be predicted across environments with greater reliability. Predominance of linear component of G × E interaction for different characters was also reported by Singh and Kumar, (1994); Popalghat *et al.*, (1999); Sirohi *et al.*, (2001), Rao and Rao, (2004); Verma *et al.*, (2008) in chickpea.

The stability parameters i.e., mean ($\overline{X}$), regression coefficient (bi) and deviation from regression ($S^{-2}d_i$) were estimated for each genotype separately for each trait. Both linear regression (bi) and deviation from regression ($S^{-2}d_i$) components of genotype × environment (G × E) interaction should be considered along with mean while judging the phenotypic stability of a genotype (Table 3).

An examination of two parameters *viz.*, bi and $S^{-2}d_i$ di for individual genotypes revealed that plant height and harvest index were observed to be the most stable traits for maximum number of genotypes followed by biological yield, number of pods per plant, seed yield per plant, number of branches, 100 seed weight and number of seeds per pod. Predictable response among the genotypes was found to be larger for days to maturity, whereas, plant height exhibited the lowest. Some workers, however, demonstrated that even for unpredictable traits, prediction could still be made when the stability parameters of individual genotypes were considered (Kapoor, 1972; Singh, 1981 and Sandhu, 1983:, Choudhary and Haque ,2010). Similar conclusions could be drawn when the stability parameters of individual genotypes were considered in the present study.

Twenty genotypes showed un-predictable response across the environments for number of seeds per pod ,whereas, none of the genotype showed this type of response for number of branches per plant, number of pods per plant, biological yield and 100 seed weight. None of the genotypes had both predictable and non-predictable response across the environments.

The results indicated that genotypes showing high and stable seed yield also exhibited either high or above average response for a number of yield contributing traits. It can, therefore, be suggested that while making selection, attention should be paid to the phenotypic stability of the traits associated with seed yield and the genotypes having average response for different traits could be identified as stable genotypes across the environments.

The simultaneous assessment of three stability parameters *viz.*, ($\overline{X}$), bi and $S^{-2}d_i$, and mean revealed that genotypes H06-79, H04-31, HK05-151, HK06-162, HK06-170, HK06-171, HK-2, HK-3 for yield per plant; H05-11, H06-135, H07-12 for 100 seed weight; H06-07, H06-75, HK06-168, H07-88, H06-41 for seeds per pod; H05-11, H06-52, H06-18, H06-70 for number of pods per plant, H06-75 (Tall) for plant height; HK05-151, HK05-152, HK06-160, HK06-169, for branches per plant; H05-11, HK06-159 for biological yield; exhibited high mean performance, above average response and were observed to be stable too. Hence these genotypes could safely be termed as ideal for favourable environmental conditions.

The desirable genotypes having Xi> X, bi= 1.0 and $S^{-2}d_i$ = 0, for average environments were H05-10, HK06-152, HK06-155 for seed yield per plant; H04-75, H06-30, H06-97, H06-136, H07-86, H07-169, HK06-155, HK06-159, for 100 seed weight; H06-97, HK06-170 for seeds per pod ; H04-31, C-235, HK-3, for number of branches per plant; H06-63, HC-1, H07-169, H06-11, H06-07, H06-55, for number of pods per plant; H07-88, HK05-151, HK-3, H06-80 for plant height; H07-93, HC-5, HC-1, H06-07, H04-31, H06-15, H06-70, H06-75, H06-32, H06-63, H06-98, for biological yield;

H04-68, H06-41, C-235, HC-3 for harvest index. These genotypes were observed to be stable and generally suitable across the environments.

For unfavourable environmental conditions the desirable genotypes were HC-3 for yield per plant; HC-3, H06-70, H05-29, HK-3, HK06-177 for 100 seed weight; H07-169, for plant height; H05-29 for seeds per pod ; HK06-171, C-235, HC-5, H06-79, H04-75, H05-10 for number of pods per plant; C-235, HC-3, H07-23, H06-97, H05-29 for biological yield. These genotypes were expected to perform better under poor environmental conditions.

Considering the seed yield and its contributing traits, genotype H05-10 was observed to be stable for six traits, genotypes H06-79, HK06-170 for five traits, genotypes H06-32 and H06-41, HK06-171, HK06-155 for four traits as indicated by the high mean performance, average to above average response and non significant values. The performance of these genotypes could be predicted across the environments. Some other genotypes viz., H06-79 and H04-31 and HC-3 were also observed to be stable across the environments.

The genotypes included in the present study did not exhibit uniform stability and responsiveness pattern for the different traits. The stability and response appeared to be specific for individual traits of an individual genotype and not common for all the traits.

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