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Studies on interrelationships among yield and yield contributing traits and stability analysis of yield in some promising Chickpea (*Cicer arietinum* L.) varieties in Assam soils under rain fed situation

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Abstract
The present investigation was undertaken to study the genetic variability, correlation and path analysis for yield and yield attributes in 40 early maturing genotypes of *desi* and *kabuli* chickpea which is a nontraditional pulse crop of Assam. Another eight nationally recommended *desi* type varieties were utilized for identifying suitable stable varieties for cultivation in Assam. There was considerable genetic variation for most of the characters studied. Seed yield per plant, pods per plant and effective branches per plant possessed high amount of genotypic coefficient of variation and exhibited high estimates of genetic advance coupled with moderately high heritability. Correlation and path coefficient are important tools for getting information regarding relationship among different traits for use in selection. In the present investigation estimates of genotypic correlation revealed positive and highly significant association among seed yield, 100 seed weight, harvest index, pods per plant, effective branches per plant and biological yield. The phenotypic correlations also revealed the same pattern. Path coefficient at genotypic level showed that harvest index and biological yield made maximum direct contribution and also exerted appreciable indirect influence towards seed yield.
The pooled analysis of variance for the eight *desi* type chickpea varieties subjected to stability analysis was found to be significant for grain yield. This indicated that the performance of some of the genotypes were not stable over environments. The genotypes KPG 59 and BG 372 were stable for unfavourable seasons and having more yield than most of the genotypes.

Keywords: Chickpea, variability, correlation, path analysis, suitable varieties, Assam, stability analysis

Introduction
Chickpea is a nontraditional pulse crop of Assam. Despite being the most important pulse crop of India in terms of acreage and production, it occupies a minor position in Assam among the grain legumes with small area and production. Nevertheless, there is tremendous possibility of increasing its cultivation in Assam as the soil and weather condition is suitable and there is also high demand for the crop in the state as chickpea is an essential item for several religious functions of Assam.
The reverine(*Char*) areas of Assam will be particularly suitable for growing of chickpea in the *rabi* season. During the last few years work is going on to asses the suitability of chickpea for Assam soils. Varietal trials are being conducted in Research stations and farmers' fields to identify promising materials of both *desi* and *kabuli* types for the state and also to identify suitable materials with resistant /tolerant reactions against biotic and abiotic stresses for inclusion in varietal development programme.
Chickpea also has an important role to play in crop diversification through crop legumes; as short duration varieties of both *desi* and *kabuli* types could be fitted profitably in various existing cropping systems of Assam for maximum benefit to the farmers'.
Keeping all these factors in mind the experiments were conducted to generate maximum possible information on chickpea in Assam condition as information on variability and association of characters are essential for a successful breeding programme for varietal development.
Again, and for the successful introduction of this important pulse crop into Assam some potential genotypes are to be released for commercial cultivation. Therefore it is imperative

to evaluate the promising genotypes over different environments to ascertain their consistency and stability of performance. The knowledge regarding the nature and relative magnitude of different types of GxE interactions are vital for making choices among breeding methods, selection programme and testing procedure in any crop improvement programme (Baker, 1969) [2]. Therefore the present study was undertaken to understand the differential GxE interactions of eight potential genotypes of chickpea and to assess the stability in performance of these genotypes for grain yield.

Materials and methods

The experimental material consisted of forty early maturing genotypes of chickpea (*Cicer arietinum* L.) comprising 20 each of *desi* and *kabuli* types collected from ICRISAT, Patancheru. These were grown in a randomized block design with three replications during rabi, 2012-13 and 2013-14 at the experimental farm of RARS, Nagaon, Assam. Each genotype was grown in double row of 4m length with a spacing of 30cm. X 10cm.Observations were recorded on five randomly selected plants from each genotype for seed yield and its components as listed in Table1. The values of variability parameters, heritability, genetic advance and correlation were worked out as per the method suggested by Johnson *et al.* (1955) [6]. Path coefficient analysis was done as suggested by Dewey and Lu (1959) [3].

For stability analysis the experimental material comprised eight diverse genotypes *viz*., 'BG 256', 'BG 372', 'KPG 59', 'JG 16', 'JG 11', 'GCP 105', 'DCP 92-3' and 'KWR 108'. These genotypes were evaluated for their stability performance in the randomized complete block design (RCBD) with three replications over 10 environments (different dates of sowing) during *rabi* 2005-06 to 2008-09. Each genotype was sown in 8 row plots of 4 metre length with a spacing of 30 cm x10 cm between rows and between plants respectively. The observations were recorded on grain yield (kg/ha).The statistical analysis for GxE interactions and stability parameters were carried out as suggested by Eberhart and Russell (1966) [4].

Results and discussion

The analysis of variance revealed significant differences among genotypes in respect of most of the characters, indicating the presence of considerable variability in the material studied (Table1). The values of genotypic coefficient of variation ranged from 1.24 for days to maturity to 74.12 percent for seed /pod. The characters *viz*., seeds/pod, pods/plant and seed yield/plant exhibited high estimates of genotypic coefficient of variation indicating high degree of variation due to genetic factors. The remaining characters showed moderate to low amount of genetic variation. Samal and Jagdev (1996) [11], Shinde *et al.* (1996) [12] and Sable *et al.* (2003) [10] also reported high GCV and PCV values for seed yield/plant. Raut *et al.* (2004) [8] also reported high GCV and PCV for numbers of pods/plant and seeds/pod. Similar results were also reported by Jahagirdar *et al*. (1994) [5].

In the present investigation all the characters exhibited high heritability values, except number of pods/plant and harvest index. This indicates that these characters are less influenced by environmental fluctuations. Efficient selection cannot be made on the basis of heritability estimates alone, since it does not give us the correct measurement for the genotypic variation and should be considered along with expected genetic advance. In the present investigation, 100 seed weight, seed yield/plant and biological yield/plant showed high estimates of heritability (b.s) accompanied by high genetic advance as percentage of mean indicating that these traits could be prominently governed by additive gene action and selection based on these traits be more effective for desired genetic improvement. These findings are in conformity with Raut *et al.* (2004) [8], Sable *et al*. (2003) [10] and Shinde *et al*. (1996) [12].

Correlation and path analysis

Estimates of correlation coefficients at genotypic and phenotypic levels are presented in Table 2 and Table 3. Genotypic correlation coefficients between most of the characters were higher in magnitude than the phenotypic correlation coefficients indicating strong association between various characters studied and that the genotypic expression of the correlation was comparatively less influenced by the environmental deviation. In the present study, the characters like plant height, effective branches/plant, pods/plant, 100 seed weight, biological yield/plant and harvest index had positive and significant correlation with seed yield indicating a strong association and these characters can be given importance during selection to improve the yield potential of chickpea. This was in accordance with the findings of Renukadevi and Subbalakshmi (2006) [9] and Raut *et al*. (2004) [8]. Among these characters harvest index had the highest correlation with seed yield.

Among the yield components, number of effective branches/plant and pods/plant was significantly positively correlated with each other indicating the possibility of simultaneous improvement of these characters through selection. Biological yield had significant positive correlation with pods/plant and 100 seed weight. This indicates that grain yield genetically depends on 100 seed weight and total biomass production. Harvest index also had positive significant correlation with 100 seed weight. These findings are in conformity with Bahl and Jain (1977) [1] and Yadav *et a*l. (2002) [13].

Path coefficient analysis provides direct as well as indirect causes of association rather than mere correlation. Path analysis with direct and indirect effects is shown in Table 4. The genotypic residual value was low (0.0212). The positive direct effect on seed yield was revealed by plant height, effective branches/plant, seeds/pod, biological yield/plant and harvest index. Selection based on these characters would be highly effective. Harvest index had the highest direct effect (0.812) on seed yield followed by biological yield/plant (0.415). These direct effects are mainly responsible for significant positive association of these traits with seed yield. Harvest index contributed indirectly mostly through pods/plant and plant height. Biological yield exerted its influence mainly through effective branches /plant. Similar conclusions were earlier drawn by Yadav *et a*l. (2002) [13] and Renukadevi and Subbalakshmi (2006) [9].

Negative direct effects on seed yield was recorded by pods/plant and 100 seed weight. This was in agreement with Renukadevi and Subbalakshmi (2006) [9] in chickpea. Positive indirect effects compensated these negative direct effects. In case of pods/plant negative direct effect was compensated by positive indirect effects through biological

yield /plant and 100 seed weight. In case of 100 seed weight it was compensated by positive indirect effects through biological yield /plant, harvest index and pods/plant. Indirect selection through biological yield /plant will lead to considerable yield improvement in this crop.
Considering the direct and indirect effects of various characters on yield, it can be concluded that it is possible to develop an ideal plant type with more number of effective branches /plant, pods /plant, high biological yield /plant and harvest index.

Stability analysis
The pooled analysis of variance for genotypes was found to be significant for grain yield indicating the presence of considerable genetic variability among the genotypes. This indicated that the performance of some of the genotypes were not stable over environments (Table 5), indicating the need for selection of stable or situation specific genotypes for grain yield. Similar results for grain yield were also reported by Patel and Acharya (2011) [7] for field pea. In the present investigation all the three parameters of stability ie., mean (x), regression coefficient (bi) and deviation from regression (S^2di) were estimated (Table 6). All the genotypes were found with significant S^2di. The genotypes KPG 59 and BG 372 were having significant bi values. Both the genotypes which were significant were having bi values less than unity and hence suitable for unfavourable environments alone. These two genotypes (KPG 59 and BG 256) also had more than the other genotypes.

Table 1: Estimates of various genetic parameters for seed yield and its components in early maturing genotypes of chickpea

Characters	Mean± S.Em	Range	6^2g	6^2p	GCV (%)	PCV (%)	h 2 (b.s)(%)	Genetic advance (GA)	GA as % over mean
Days to maturity	112±0.8	104 - 133	1.92	2.04	1.24	1.28	94.1	2.77	2.47
Days to 50% flowering	62 ± 0.8	58 - 81	20.73	21.69	7.34	7.51	95.6	9.17	14.79
Plant height (cm)	52.2±1.8	42.6-71.9	18.43	22.02	8.23	9.00	83.7	8.09	15.51
Effective branches/ plant	8.0± 0.3	4.3 - 12.6	3.70	4.82	23.9	27.3	76.8	3.47	43.21
Pods/plant	24.1±1.6	16.3- 45.1	121.6	189.5	45.7	57.0	64.2	18.2	73.9
Seeds/pod	1.8 ± 0.3	1.7 - 2.2	1.86	2.01	74.1	77.1	92.5	2.70	1.47
100 seed weight (gm)	19.3±0.7	14.3- 35.2	14.68	15.01	19.9	20.1	97.8	7.81	40.55
Biological yield/plant (gm)	25.1±1.3	17.1- 44.7	20.62	23.29	18.1	19.3	88.5	8.80	35.13
Harvest index (%)	38.0±1.9	29.2 -49.2	22.16	30.62	12.4	14.6	72.4	8.25	21.70
Seed yield/plant (gm)	11.1±0.4	7.3 - 19.6	13.32	15.62	32.9	35.8	84.5	6.88	62.38

Table 2: Genotypic correlation coefficients among various quantitative characters in Chickpea

Character	Effective branches/ plant	Pods/plant	Seeds/pod	100 seed weight	Biological Yield/plant	Harvest index	Seed Yield/plant
Plant height	-0.499	-0.471	0.046	0.179	-0.302	0.211	0.317*
Effective branches/plant		0.816**	0.194	0.026	0.216	0.109	0.490**
Pods/plant			0.189	-0.394	0.412*	-0.294	0.512**
Seeds/pod				-0.694	-0.584	-0.012	0.119
100 seed weight					0.599**	0.444**	0.796**
Biological yield/plant						-0.267	0.423*
Harvest index							0.825**

*and ** denote significance at 5% and 1% levels, respectively

Table 3: Phenotypic correlation coefficients among various quantitative characters in Chickpea

Character	Effective branches/plant	Pods/plant	Seeds/pod	100 seed weight	Biological Yield/plant	Harvest index	Seed Yield/plant
Plant height	-0.316	-0.213	0.010	0.132	-0.192	0.164	0.192
Effective branches/plant		0.702**	0.062	0.017	0.113	0.063	0.316*
Pods/plant			0.121	-0.196	0.242*	-0102	0.404*
Seeds/pod				-0.395	-0.393	-0.009	0.106
100 seed weight					0.414*	0.318*	0.623**
Biological yield/plant						-0.162	0.329*
Harvest index							0.592**

*and ** denote significance at 5% and 1% levels, respectively

Table 4: Direct and indirect effects of different quantitative trait on seed yield in Chickpea

Character	Plant height	Effective branches/plant	Pods/plant	Seeds/pod	100 seed weight	Biological Yield/plant	Harvest index	Genotypic Correlation with grain yield
Plant height	0.043	-0.041	0.096	0.001	-0.026	-0.263	0.161	0.317*
Effective branches/plant	-0.072	0.102	-0.132	0.004	0.030	0.123	0.069	0.490**
Pods/plant	-0.062	0.031	-0.123	0.003	0.052	0.300	-0.283	0.512**
Seeds/pod	0.004	0.016	-0.033	0.015	0.072	-0.299	-0.023	0.119
100 seed weight	0.029	-0.008	0.063	-0.012	-0.026	0.461	0.413	0.796**
Biological Yield/plant	-0.026	0.005	-0.053	-0.008	-0.059	0.485	-0.240	0.329*
Harvest index	0.019	0.004	0.082	0.000	-0.042	-0.183	0.812	0.825**

Residual=0.0212 Underline figures are direct path value
* and ** denote significance at 5% and 1% levels, respectively

Table 5: Analysis of variance (mean square) for phenotypic stability for grain yield (kg/ha) in Chickpea

Sources of variation	d.f.	Grain yield(kg/ha)
Environment(E)	9	13488653**
Genotype(G)	7	215624**
G x E	63	61004
E(linear)	1	113287981**
G x E(linear)	7	179065**
Pooled daviations	64	38976**
Pooled error	140	44321

* & **: Significant at P=0.05 and 0.01, respectively

Table 6: Mean performance and stability parameters for yield

Genotype	Grain yield(kg/ha)	bi	S^2di
JG 11	1243	0.20	33354.9
BG 256	1346	3.03	23456.5
JG 16	1001	-0.09	-3401.8
GCP 105	989	2.79	6543.9
KPG 59	1457	-2.98**	8765.5
DCP 92-3	1298	4.54	1324.8
KWR 108	1112	0.52*	68765.9
BG 372	1490	-0.51	65478.9
SE+/-	57.9		
Mean	1242		

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