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Estimation of correlation among the morpho-physiological traits in MAGIC population of chickpea (*Cicer arietinum* L.)

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Abstract
An investigation entitled “Estimation of correlation among the morpho-physiological traits in MAGIC population of chickpea (*Cicer arietinum* L.)” was carried out with 40 genotypes in F4 derived F5 MAGIC lines consisting of eight parents.ICC-4958, ICCV-10, JAKI-9218, JG-11, JG-130, JG-16,.ICCV-97105, ICCV-00108 during *rabi* 2012-13 and 2013-14.The observations were recorded for quantitative traits namely, days to 50% flowering, days to maturity, plant height (cm), pod per plant, primary branches, secondary branches, pod length (cm), seed yield (g), 100 seed wt.(g),seed per pod, root length (cm), root wt., (fresh and dry) in (g), relative water content of leaf and partitioning coefficient to roots, stem, leaves and pods. The information was derived on phenotypic and genotypic correlation the values of correlation coefficient at genotypic level were higher than those for phenotypic counterpart. Plant height, primary branches, secondary branches, pod per plant, 100 seed wt. and seed yield had direct and positive effect. Root length, relative water content, partitioning coefficient to root, stem, and leaves showed positive and significant correlation. The developmental characters like days to 50% flowering and maturity contributed to grain yield indirectly via., plant height and 100 seed weight.

Keywords: estimation, correlation, morpho-physiological, population

Introduction
Chickpea is a diploid with 2n = 16 chromosomes and genome size of approximately750 Mbp (Arumuganathan and Earle, 1991) [1]. *Cicer* genus has 43 species (Van der Maesen, 1987). Eight of these share the annual growth habit with chickpea and are of particular interest to breeders (Arumuganathan and Earle, 1991) [1]. Two distinct forms of cultivated chickpeas are desi (small seeds, angular shape, and coloured seeds with a high percentage of fibre) and Kabuli types (large seeds, owl-head shape, beige coloured seeds with a low percentage of fibre). A third type, designated as intermediate or pea-shaped, is characterized by medium to small size, and round/pea-shaped seeds. Hair like structures on its stems leaves and pods secrete acids that provide the first line of defence against pests, reducing the need for chemical sprays (Yadav *et al.,* 2007).
Chickpea is an annual grain legume or pulse crop that is used extensively for human consumption.Chickpea seeds contain protein, fibre, calcium, potassium, phosphorus, iron, zinc and magnesium along with appreciable quantities of selenium, sodium and copper, which make it one of the nutritionally best composed edible dry legumes, for human consumption (Esha, 2010) [3]. Chickpea like most other beans is a good source of cholesterol lowering fibre (Pittaway *et al.,* 2006) [8]. In addition to lowering cholesterol, the high fibre content prevents blood sugar levels from rising too rapidly after a meal, making chickpea a good choice for individuals with diabetes, insulin resistance or hypoglycemia (McIntosh and Miller, 2001) [6].

Material and Method
The experiment material comprised of 40 chickpea lines with susceptible check, were laid in RCBD design with three replications, at Pulses Research Sub-station, SKUAST-J, Samba, during 2012-13 and 2013-14. The experiment was sown late by 30 days (first week of December) in comparison to normal sowing date, for subjecting the material to terminal drought stress. The material was received from ICRISAT, as chickpea magic lines under ICAR-ICRISAT collaboration work. The genotypes were recorded for drought tolerance score on a 1-9 scale on the basis of ICRISAT/ICARDA recommendation. The material of study comprised of bulk population of F_4 generation of chickpea MAGIC lines derived from eight parented chickpea lines viz.

Table 1: Characteristics of eight parents in the MAGIC population

S. No.	Parent Name	Days to 50% flowering	Days to maturity	100 - seed weight(g)	Remarks
1.	ICC 4958	35	96	31.6	Drought tolerance, high root biomass.
2.	ICCV 10	48	92	16.3	Erect type, wide adaptation, drought tolerance.
3.	JAKI 9218	46	90	22.5	High yield, fusarium wilt resistance.
4.	JG 11	37	89	22	Highly popular variety in Southern India early maturity.
5.	JG 130	45	96	26.2	Farmer preferred cultivar from Central India.
6.	JG 16	48	91	16.6	Multiple disease resistance.
7.	ICCV 97105	54	97	22.2	High yield, fusarium wilt resistance.
8.	ICCV 00108	52	96	25.2	High yield, fusarium wilt resistance.

This F_4 chickpea MAGIC population was raised at Research Farm of Pulses Research Sub-Station, SKUAST-J Samba; in 82 lines of 4m each under rain fed condition. The 40 single plants were selected from F_4 generation on the basis of morphological and yield traits. The single plant selections were evaluated in randomised block design (RBD) during *rabi* 2013-14 under late sown conditions. The observations on grain yield and its contributing traits had been recorded during course of the experiments for analysis.

In *Rabi* 2013-14 the selected 40 plants were sown in plant to progeny rows at SKUAST-J Pulses Research Sub-Station Samba and besides above said ten morphological and yield traits, these progenies were also selected on the basis of physiological traits, for drought tolerance. The progenies showing transgressive segregants were selected on the basis of final results from the mean of five plants data of these progenies and which will be recommended to be carried over to F_6 generation for further investigations under initial yield trials in further generations.

Results and Discussion

Phenotypic and genotypic correlation in F_4 generation

In order to assess the pattern of phenotypic and genotypic association among the ten quantitative characters in F_4 generation, the correlation coefficients were worked out and the estimates have been given in the Table 1 and the results are described below.

Highly positive and significant correlation was observed between days to 50% flowering and plant height. However, significant but negative correlation was observed between days to maturity and seed yield. Positive and significant correlation was observed between primary branches and secondary branches, primary branches with pods per plant.

Highly significant and positive correlation was observed between secondary branches and pods per plant, secondary branches with seed yield. However, significant but negative correlation was observed between secondary branches and days to maturity. Plant height is positively correlated with the pods per plant.

Seeds per pod showed positive and significant correlation with the pod length. Pods per plant were positively correlated with the seed yield at 5% level of significance.

Phenotypic correlation in F_5 generation among morphological traits

In order to assess the pattern of phenotypic association among ten morphological characters in F_5 generation, the correlation coefficients were worked out and the estimates have been given in the Table 2 and the results are described below:

Highly significant and positive correlation was observed between seed yield and secondary branches, seed yield with 100 seed weight at 5% level of significance. Seed yield also showed highly significant and positive correlation with pod length at 1% level of significance.

Plant height showed highly positive and significant correlation with secondary branches, pod length at 1% level of significance and with pods per plant at 5% level of significance. Highly significant and positive correlation recorded between primary branches and pod length.

Phenotypic correlation in F_5 generation among physiological characters

In order to assess the pattern of phenotypic association among eight physiological characters in F_5 generation, the correlation coefficients were worked out and the estimates have been given in Table 3 and the results are described below.

Root fresh weight showed positive and significant correlation with root dry weight and partitioning coefficient to roots at 1% level of significance. Highly significant and positive correlation was observed between partitioning coefficient to leaves and partitioning coefficient to pods at 1% level of significance.

Genotypic correlation in F_5 generation among morphological characters

The genotypic correlation was calculated in the F_5 generation. The figures of this parameter have been given in the Table 4. It may be mentioned that estimates of this parameter, in general, have been found higher than their phenotypic counterparts. Also, irrespective of the direction a large number of character combinations showed significant genotypic correlations.

Highly positive and significant correlation was observed between seed yield and plant height. Seed yield also showed high correlation with primary branches, secondary branches, pod length and 100 seed weight, at 1% level of significance.

Days to 50% flowering showed positive and significant correlation with days to maturity at 1% level of significance.

Highly positive and significant correlation was observed between days to maturity and pods per plant, at 1% level of significance.

Plant height showed high positive and significant correlation with primary branches, secondary branches, pods per plant at 1% level of significance. Highly positive and significant correlation was also observed between plant height and 100 seed weight at 5% level of significance.

Primary branches showed highly positive and significant correlation with secondary branches, pods per plant, pod length and 100 seed weight, at 5% level of significance.

Secondary branches exhibited high and significant correlation with pods per plant at 1% level of significance. Highly positive and significant correlation was observed between pods per plant and pod length at 5% level of significance. Pod length showed significant correlation with 100 seed weight at 1% level of significance.

Genotypic correlation in F_5 generation among physiological characters

The results for the genotypic correlation in the physiological traits have been given in the Table 5. Root length showed highly positive and significant correlation with partitioning coefficient to stem, at 1% level of significance. Highly positive and significant correlation was observed between root fresh weight and root dry weight, partitioning coefficient to stem at 1% level of significance. Root fresh weight showed high significant correlation with relative water content at 5% level of significance.

Root dry weight showed highly positive and significant correlation with partitioning coefficient to pods at 5% level of significance. Highly positive and significant correlation was observed between partitioning coefficient to roots with partitioning coefficient to stem at 1% level of significance.

Highly positive and significant correlation was observed between partitioning coefficient to leaves and relative water content of leaf at 1% level of significance.

Correlation response of the characters among one another for which selection have been exercised in the segregating generations.

The phenotypic and genotypic correlation of yield per plant and its components were worked out. These correlation studies revealed that, the genotypic correlation coefficients between most of the characters were higher in magnitude than the phenotypic correlation coefficients indicating strong inherent association between various characters studied and that the genotypic expression of the correlation was comparatively less influenced by the environmental conditions. The significant positive correlation was reported between seed yield per plant with number of secondary branches per plant, number of pods per plant and 100 seed weight this was due to the increased additive effect of the genes controlling pods per plant. Similar findings were also reported by Singh *et al.* (1994) and Sharma and Maloo (1987).

Similarly strong association between primary and secondary branches per plant and number of pods per plant was noticed through the highly significant positive values of correlation coefficients. This indicates the simultaneous improvement of these characters through selection.

The importance of this association was also reported by Singh *et al.* (1994) and Sandhu (1991) [9]. Similarly, days to 50 per cent flowering was strongly associated with days to maturity, plant height and number of primary branches per plant suggesting that maturity period can be predicted by days taken to 50 per cent flowering. A negative correlation of these characters observed with seed yield per plant, number of pods per plant will help in developing early maturity and high yielding varieties.

The direct and indirect contributions of each character as revealed by path coefficient analysis indicated that 100 seed weight had highest direct effect on seed yield per plant followed by number of pods per plant and number of secondary branches per plant. These direct effects are mainly responsible for significant positive association of these characters with seed yield per plant. The number of secondary branches exerted its effect on seed yield through number of pods per plant and 100 seed weight through primary branches per plant which is similar to finding of Tagore and Singh (1990) [12], Tripathi *et al.* (1995) [14], Jeena and Arora (2002) [4], Noor *et al.* (2003) [7] and Talebi *et al.* (2007) [13].

Table 2: Genotypic correlation among ten morphological traits in Chickpea during 2013-14

Traits	Seed yield (g)	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches	Secondary branches	Pods per plant	Pod length (cm)	Seeds per pod	100-seed weight (g)
Seed yield (g)	-	-0.31	-0.72	0.34**	1.10**	0.33**	-0.02	3.14**	0.00	0.38**
Days to 50% flowering		-	0.96**	0.09	-1.08	0.01	-0.18	-2.31	0.00	0.06
Days to maturity			-	-0.31	-1.89	-0.44	0.39**	-3.48	0.00	-0.27
Plant height(cm)				-	0.46**	0.32**	0.53**	-0.31	0.00	0.18*
Primary branches					-	0.46**	0.42**	4.76**	0.00	0.44**
Secondary branches						-	0.33**	-0.90	0.00	0.29
Pods per plant							-	0.22*	0.00	-0.29
Pod length (cm)								-	0.00	0.75**
Seeds per pod									-	0.00
100-seed weight (g)										-

Table 3: Genotypic correlation among eight physiological traits in Chickpea during 2013-14

Traits	Root Length (cm)	Root fresh weight (g)	Root dry weight (g)	Partitioning Coefficient to roots (%)	Partitioning Coefficient to stem (%)	Partitioning Coefficient to leaves (%)	Partitioning Coefficient to pods (%)	Relative Water content (%)
Root length(cm)	-	-0.053	0.048	-0.114	0.197*	0.002	-0.138	-0.022
Root fresh weight(g)		-	0.898**	-0.207	0.274**	0.149	-0.066	0.180*
Root dry weight(g)			-	-0.377	0.057	0.082	0.206*	-0.125
Partitioning Coefficient to roots (%)				-	0.257**	-0.175	-0.111	0.053
Partitioning Coefficient to stem (%)					-	-0.664	-0.590	0.021
Partitioning Coefficient to leaves (%)						-	-0.419	0.241**
Partitioning Coefficient to pods (%)							-	-0.278
Relative Water content (%)								-

Table 4: Phenotypic correlation among ten morphological traits in F_5 generation of Chickpea during 2013-14.

Traits	Seed yield	Days to 50% flowering	Days To maturity	Plant height (cm)	Primary branches	Secondary branches	Pods per plant	Pod length (cm)	Seeds per pod	100-seed weight (g)
Seed yield	-	-0.172	-0.384	-0.183	0.176	0.205*	-0.029	0.346**	0.124	0.203*
Days to 50% flowering		-	-0.239	-0.003	-0.083	0.004	-0.109	-0.117	-0.166	-0.110
Days to maturity			-	0.066	-0.199	-0.269	-0.128	-0.182	-0.182	-0.055
Plant height (cm)				-	0.029	0.258**	0.195*	0.353**	0.043	.046
Primary branches					-	0.094	-0.006	0.204*	0.071	0.043
Secondary branches						-	0.111	0.090	0.008	0.002

Pods per plant								-	-0.041	0.114	-0.241
Pod length (cm)									-	0.022	0.019
Seeds per pod										-	-0.264
100-seed weight(g)											-

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

Table 5: Phenotypic correlation among eight physiological traits in Chickpea during 2013-14.

Traits	Root Length (cm)	Root fresh weight (g)	Root dry weight (g)	Partitioning Coefficient to roots (%)	Partitioning Coefficient to stem (%)	Partitioning Coefficient to leaves (%)	Partitioning Coefficient to pods (%)	Relative Water content (%)
Root length (cm)	-	-0.015	0.012	0.021	0.094	-0.073	-0.034	-0.047
Root fresh weight (g)		-	0.841**	0.179**	-0.054	-0.017	-0.071	0.110
Root dry weight(g)			-	0.123	-0.057	0.012	0.043	-0.025
Partitioning Coefficient to roots (%)				-	-0.244	-0.302	-0.274	0.021
Partitioning Coefficient to stem (%)					-	-0.244	-0.258	0.064
Partitioning Coefficient to leaves (%)						-	0.354**	0.127
Partitioning Coefficient to pods (%)							-	-0.165
Relative Water content (%)								-

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

Correlation pattern among morphological and physiological characters in different segregating generations and contribution of different characters to seed yield

At genotypic level, root fresh weight exhibited positive and significant correlation with root dry weight, partitioning coefficient to stem, relative water content of leaf. High positive direct effect at phenotypic level on seed yield by plant height, primary branches, secondary branches, pod length, seeds per pod, root length, root dry weight, partitioning coefficient to pods and 100 seed weight were observed.

100 seed weight had maximum positive direct effect which was followed by pods per plant, plant height and relative water content of leaf. Indirect positive effects of partitioning coefficient to pods on seed yield via partitioning coefficient to roots and partitioning coefficient to stem was observed. Similar results were in accordance with those reported by Erman *et al.* (1997) [2].

Direct positive effect on seed yield per plant, at genotypic level, was displayed by primary branches, root length, partitioning coefficient to pods and 100 seed weight. The direct negative effect was also noted for days to maturity, plant height, secondary branches and pods per plant on seed yield. Several physiological, morphological and phenological traits may play a significant role in crop adaptation to drought stress during soil drying (Serraj *et al.*, 2004).

Conclusion

The study of genotypic and phenotypic correlations revealed the association of seed yield with pods per plant, plant height, 100 seed weight, of high magnitude in positive direction in both the generations. The pattern of this type of correlation suggested that selection for any of these traits can be taken up by chickpea breeders at any stage of population advancement and it is also suggested that selection for one trait will simultaneously improve the related trait side-by-side. Therefore, it can be concluded that the chickpea breeders should concentrate for the selection of these traits.

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