Estimation Of Correlation and Path Analysis for Quantitative Traits Associated with Drought Tolerance in Magic Lines of Chickpea (*Cicerarietinum*L.)

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Abstract: ***An investigation entitled "Estimation of correlation and path analysis for quantitative traits in MAGIC lines of Chickpea" wascarried out with 40 genotypes in F_4 derived F_5 MAGIC lines consisting of eight parents: ICC-4958, ICCV-10, JAKI-9218, JG-11, JG-130, JG-16, ICC97105, 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), pods per plant, primary branches, secondary branches, pod length (cm), seed yield (g), 100 seed weight (g),seeds per pod, root length (cm), root weight-fresh and dry (g), relative water content of leaf and partitioning coefficient to roots, stem, leaves and pods. The information was derived on genotypic correlation and path. 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 weight 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 which were directly associated with the drought tolerance in chickpea. The developmental characters like days to 50% flowering and maturity contributed to grain yield indirectly via, plant height and 100 seed weight.***

Keywords: Phenotypic correlation, genotypic correlation

1. Introduction

Chickpea is a diploid with 2n = 16 chromosomes and genome size of approximately750 Mbp (Arumuganathan and Earle, 1991). *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).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). Chickpea like most other beans is a good source of cholesterol lowering fibre (Pittaway*et al.*, 2006

2. Materials and Methods

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 a1-9 scale on the basis of ICRISAT/ICARDA recommendation.

The material was received from ICRISAT, Hyderabad as F_4 bulk of MAGIC population by the A.I.C.R.P. on chickpea, Sub-Station Samba; under ICAR-ICRISAT collaborative work. MAGIC lines consisted of eight parents (ICC 4958, ICCV 10. JAKI 9218, JG 11, JG 130, JG 16, ICCV 97105, ICCV 00108).In this case of chickpea multi-parent advanced generation inter cross (MAGIC) populations are being developed to enhance the genetic base. Eight elite lines/cultivars (ICC 4958, ICCV 10, JAKI9218, JG11, JG130, JG16, ICCV97105, and ICCV00108) were selected by ICRISAT, Hyderabad from Ethiopia, Kenya and India for development of a MAGIC population for *desi*chickpea. Twenty-eight two-way, fourteen four-way and seven eight-way crosses were made to develop this MAGIC population.The seed was collected and sown at the said location, in *rabi* season of 2013-14 in plant to progeny row, under R.B.D. trial. Each plot consisted of four rows; in each row 10 seeds were sown. The seed was sown manually at an approximate depth of 5 cm below the soil. The data was recorded on different yield and yield contributing traits on 5 plants in each progeny.

Correlation coefficient

The following formulae were used for estimating the phenotypic and genotypic correlation coefficients as suggested by Ai- Jibouri*et al.*,(1958)

1) Phenotypic correlation $[\{r_{xy}(p)\}] = \frac{Cov.xy(p)}{[Vx(p)XVy(p)]^{\frac{1}{2}}}$

2) Genotypic correlation $[\{r_{xy}(g)\}] = \frac{Cov.xy(g)}{[Vx(p)XVy(p)]^{\frac{1}{2}}}$

Where,

Cov.xy (p) = phenotypic covariance between characters x and y and this was obtained as follows

Cov.xy (p) = $Cov.xy(g) + Cov.xy(e)$

Cov.xy (g) = genotypic covariance between characters x and y and this was obtained as follows

Cov.xy (g) = $Cov.xy(p) - Cov.xy(e)$

$V_x(P)$ and $V_y(p)$ = phenotypic variances for the characters x and y, respectively

$V_x(g)$ and $V_y(g)$ = genotypic variances for the characters x and y, respectively

Path analysis

The path coefficient is the ratio of standard deviation of effect to the total standard deviation when all causes are constant, except one in question, the variability of which was kept unchanged and was obtained by the simultaneous solution with the help of matrix algebra.

The direct effect of a character via another causal factor was obtained by multiplying the genotypic correlation coefficient between the two with direct effect (i.e., path coefficient) of the later upon effect.

3. Results and Discussion

The phenotypic and genotypic correlation of seed 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). 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), Tripathi*et al.* (1995), Jeena and Arora (2002), Noor *et al.* (2003) and Talebi*et al.* (2007).

Table 1: 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
Daystomaturity			-	-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)										-

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

Table 2: 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 (%)								-

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

Table 3: 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
Daystomaturity			-	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 4: 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
Rootfresh 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**

Table 5: Phenotypic path coefficient in F_5 generation of Chickpea during 2013-14

Traits	DF	DM	PH	PB	SB	PPP	PL	SPP	RL	RFW	RDW	PCR	PCS	PCL	PCP	RWC%	HSW	Cor. With SY
DF	-.0172	-.0591	.0000	-.0010	.0049	.0055	-.0212	-.0182	-.0013	.0147	-.0112	-.0044	-.0353	-.0075	-.0106	.0057	-.0157	-.1721
DM	-.0041	-.2474	-.0004	-.0025	-.0139	.0065	-.0329	-.0023	-.0042	-.1024	.0589	-.0204	.0097	-.0212	-.0059	.0056	-.0079	-.3846
PH	.0001	.0164	.0056	.0004	.0132	-.0099	.0636	.0048	.0040	.0378	.0015	.0121	-.0079	.0248	.0086	.0015	.0067	.1832
PB	.0014	.0492	.0002	.0123	.0049	.0003	.0369	.0079	.0015	.0447	-.0103	-.0027	-.0040	.0147	.0053	.0079	.0061	.1763
SB	-.0016	.0666	.0014	.0012	.0516	-.0056	.0162	.0009	.0024	.0777	-.0102	.0189	-.0599	.0361	.0030	.0066	.0003	.2054
PPP	.0019	.0317	.0011	-.0001	.0058	-.0506	-.0074	.0126	.0063	-.0208	.0288	.0012	-.0175	.0130	.0016	-.0023	-.0344	-.0292
PL	.0020	.0452	.0020	.0025	.0047	.0021	.1800	.0025	.0033	.0642	-.0296	.0259	-.0019	.0240	.0132	.0038	.0027	.3465
SPP	.0029	.0053	.0002	.0009	.0004	-.0058	.0041	.1095	.0019	.0240	.0100	.0145	-.0139	.0046	.0021	.0015	-.0377	.1243
RL	.0011	.0526	.0011	.0009	.0061	-.0160	.0295	.0104	.0200	.0066	.0036	-.0028	-.0189	.0175	-.0019	.0022	-.0008	.1113
RFW	.0006	-.0589	-.0005	-.0013	-.0093	-.0024	-.0269	-.0061	-.0003	-.4295	.2552	-.0235	.0110	.0043	-.0040	-.0050	.0052	-.2917
RDW	.0006	-.0480	.0000	-.0004	-.0017	-.0048	-.0176	.0036	.0002	-.3612	.3034	-.0160	.0116	.0030	-.0024	.0011	.0044	-.1332
PCR	-.0006	-.0387	-.0005	.0003	-.0075	.0005	-.0357	-.0122	.0004	-.0773	.0373	-.1305	.0490	.0723	-.0155	-.0010	.0044	-.1553
PCS	-.0030	.0120	.0002	.0002	.0154	-.0044	.0017	.0076	.0019	.0235	-.0175	.0319	-.2007	.0584	-.0146	-.0029	-.0108	-.1010
PCL	-.0005	-.0219	-.0006	-.0008	-.0078	.0028	-.0180	-.0021	-.0015	.0077	.0038	.0394	.0490	.2393	-.0200	-.0058	-.0260	-.2417
PCP	.0032	.0261	.0009	.0012	.0028	-.0014	.0421	.0041	-.0007	.0306	-.0131	.0358	.0520	.0847	.0564	.0075	.0271	.3592
RWC%	.0022	.0306	-.0002	-.0021	-.0075	-.0025	-.0150	-.0036	-.0010	-.0475	-.0076	-.0028	-.0130	.0305	-.0094	-.0452	-.0162	-.1714
HSW	.0019	.0136	.0003	.0005	.0001	.0122	.0035	-.0290	-.0001	-.0157	.0031	-.0040	.0152	.0437	.0107	.0051	.1426	.2037

Underlined shows direct effect **Residual variation = 0.568**

Table 6: Genotypic path coefficient in F_5 generation of chickpea during 2013-14

Traits	DF	DM	PH	PB	SB	PPP	PL	SPP	RL	RFW	RDW	PCR	PCS	PCL	PCP	RWC%	HSW	Cor. with SY
DF	.1757	-.1420	-.0185	-.2255	-.0021	.0208	.2575	-	-.0085	-.3392	.1561	-.0061	-.0118	.0113	-.1418	-.0597	.0145	-.3193
DM	.1704	-.1464	.0605	-.3923	.1241	.0459	.3878	-	-.1225	-.3791	.1446	.0229	.0071	-.1508	-.2947	-.1431	-.0577	-.7234
PH	.0169	.0461	-.1922	.0971	-.0902	-.0610	.0348	-	.0330	.3855	-.2220	-.0147	.0008	.0784	.2606	-.0689	.0389	.3430
PB	-.1921	.2773	-.0901	.2072	-.1280	-.0489	-.5350	-	.0361	2.0728	-1.1299	-.0449	.0349	.1761	.5850	-.2092	.0927	1.1093
SB	.0013	.0656	-.0626	.0957	-.2771	-.0384	.1006	-	.0214	-.0120	.3716	.0254	-.0107	.1533	-.0508	-.1121	.0617	.3330
PPP	-.0317	.0583	-.1019	.0881	-.0925	-.1151	-.0251	-	.1156	-.2002	.2657	-.0196	-.0064	-.0025	.0672	.0414	-.0625	-.0211

PL	-.4065	.5103	.0601	.9878	.2505	-.0259	-.1113	-	.1686	.3865	-.5507	-.0446	.0855	.0326	1.3675	.2695	.1579	3.1470
SPP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.0000
RL	-.0064	.0769	-.0272	.0321	-.0254	-.0570	-.0805	-	.2332	.0494	.0456	-.0070	-.0063	-.0006	-.0638	-.0088	-.0007	.1533
RFW	.0641	-.0597	.0796	-.4616	-.0036	-.0248	.0466	-	-.0124	-.9306	.8378	-.0128	-.0088	-.0317	-.0306	.0700	-.0806	-.5589
RDW	.0294	-.0227	.0458	-.2510	-.1104	-.0328	.0657	-	.0114	-.8359	.9327	-.0233	-.0018	-.0175	.0948	-.0485	-.0603	-.2243
PCR	-.0174	-.0543	.0458	-.1509	-.1139	.0366	.0805	-	-.0266	.1926	-.3521	.0617	-.0082	.0372	-.0514	.0609	.0052	-.2541
PCS	.0649	.0327	.0049	-.2268	-.0927	-.0231	.2983	-	.0461	-.2558	.0535	.0159	-.0319	.1405	-.2718	.0083	-.0212	-.2580
PCL	-.0094	-.1044	.0713	-.1726	.2008	-.0014	.0171	-	.0007	-.1395	.0771	-.0108	.0212	-.2115	-.1930	.0936	-.0676	-.4285
PCP	-.0541	.0938	-.1088	.2634	.0306	-.0168	-.3306	-	-.0323	.0619	.1922	-.0069	.0188	.0887	.4603	-.1082	.0746	.6263
RWC%	-.0270	.0540	.0341	-.1116	.0800	-.0123	-.0772	-	-.0053	-.1678	-.1166	.0097	-.0007	-.0510	-.1282	.3884	-.0666	-.1980
HSW	.0122	.0405	-.0358	.0921	-.0819	.0344	-.0842	-	-.0008	.3596	-.2693	.0015	.0032	.0685	.1644	-.1239	.2087	.3894

Underlined shows direct effect **Residual Variation: 0.5030**

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).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).

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