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Research Note

Character association among physiological and yield attributes in *kabuli* chickpea (*Cicer arietinum* L.)

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Abstract
Character association studies among physiological and yield attributes in 21 *kabuli* chickpea genotypes revealed that shoot biomass per plant and number of branches per plant are most important traits contributing directly to the seed yield. Besides traits like days to first flowering, days to 50 per cent flowering, number of branches per plant, SCMR, SLA also influenced seed yield per plant indirectly through shoot biomass per plant. Trait 100- seed weight though exhibited negative correlation with seed yield per plant, its indirect influence *via* other traits is positive indicating that the association between number of pods per plant, 100 seed weight and shoot biomass per plant should be considered carefully while selecting high yielding genotypes. Physiological traits like SLA, SCMR and RWC which are related to photosynthesis efficiency and water use efficiency exerted indirect and positive effects *via* other traits. Thus integration of these physiological traits in breeding programmes will greatly enhance the progress expected, especially in breeding for drought prone environments.

Keywords Chickpea, kabuli, drought, physiological traits

Chickpea (*Cicer arietinum* L.) is the world's second largest grain legume crop with a total annual production of 11.62 m t from a cultivated area of over 13.20m ha.. In India, chickpea accounts for 30% and 38% of national pulse acreage and production, respectively. In India, chickpea cultivation was done in 9.51 m ha with the production of 8.83 m t with a productivity of 929 kg/ha. Andhra Pradesh is one of the important states growing chickpea in southern India with an area of 6.81 lakh ha and a production of 7.59 lakh t and recorded a productivity of 1115 kg/ha (AICRP Annual Report, 2013-14). In Andhra Pradesh chickpea growing season is short (75-110 days) and crop frequently suffers due to drought. *Desi* types are predominantly grown in Andhra Pradesh. Recently there is increase in area under *kabuli* chickpeas in Andhra Pradesh as farmers are getting attracted towards *kabuli* especially extra large seeded *kabuli* on account of its premium price in the markets. Currently most of the cultivated bold seeded *kabuli* varieties are poorly adapted to drought prone environments. However, small seeded *desi* chickpeas are better suited to drought prone environments than *kabuli* types (Yadav *et al.* 2003). Therefore there is need to incorporate drought tolerance into *kabuli* chickpeas for attaining stable yields under receding soil moisture conditions.

Breeding for drought tolerance is generally considered slow due to many reasons *viz.*, the quantitative and temporal variability of available moisture across years, the low genotypic variance in yield under these conditions, inherent methodological difficulties in evaluating component traits, together with the highly complex genetic basis of this character. Many physiological processes associated with crop growth and development is reported to be influenced by water deficits. Their significant role in crop adaptation to drought stress was reported by several researchers. (Ludlow and Muchow 1990; Saxena and Johansen 1990; Subbarao *et al.*, 1995). In general the information available on important physiological traits influencing drought tolerance in *kabuli* chickpea is very meager and therefore in the present study character association among traits influencing yield and drought tolerance was investigated.

The present study was carried out during *rabi* 2012-13 at Regional Agricultural Research Station, Nandyal of Acharya N. G. Ranga Agricultural University, Andhra Pradesh with 21 *kabuli* chickpea genotypes. The genotypes were sown in a randomized block design in three replications with 45 cm x 10 cm inter and intra row spacing of 4 m length. To raise competent crop recommended agronomic practices were followed. Five plant were randomly selected from each genotype for recording observations on 16characters *viz.*, days to first flowering, days to 50 percent flowering, days to first poding, days to maturity, plant height, number of branches per plant, SPAD chlorophyll meter reading, specific leaf area, relative water content, root length, root weight, number of pods per plant, shoot biomass per plant, harvest index, seed yield and 100 seed weight. Data was subjected to statistical analysis as per Johnson *et al.*, (1955) and Dewey and Lu (1959).

The analysis of variance for 16 characters in 21 genotypes showed significant differences for all traits. Correlation coefficients estimated both at genotypic and phenotypic level were presented in Table 1. Estimates of genotypic correlation coefficients were higher between pairs of characters than the corresponding phenotypic correlation coefficients indicating the influence of environment on the phenotypic expression. Shoot biomass per plant (r_p = 0.949; r_g = 1.002) and number of pods per plant (r_p = 0.937; r_g = 1.054) had very strong and significant positive correlation with seed yield per plant followed by number of branches per plant(r_p = 0.783; r_g = 0.895), specific leaf area (r_p = 0.575 r_g = 0.678), days to 50 per cent flowering (r_p = 0.388; r_g = 0.498) and days to first flowering (r_p = 0.383; r_g = 0.647) at both phenotypic and genotypic level. These traits emerged as most important traits and improvement in seed yield in chickpea can be obtained by applying selection pressure on these traits. The importance of these traits was also emphasized by Reddy Yamini (2012), Usman *et al.*, (2012) and Shanthi Bhushan and Jaiswal (2009).

However, to know the direct and indirect effects of these traits on seed yield correlations were further partioned into direct and indirect effects through path coefficient analysis and the results of genotypic path coefficient analyses are presented in table 2. Genotypic path coefficient analysis revealed that number of pods per plant (-1.987) and days to 50 per cent flowering (-0.2666) had negative direct effects. In case of SLA both phenotypic and genotypic direct effects are high and negative. Number of branches per plant recorded positive and moderate (0.2026) direct effect at genotypic level. Shoot biomass per plant recorded a very high direct effect in genotypic path analysis in contrast to low and negligible direct phenotypic effects on seed yield per plant. There are deviations in the genotypic and phenotypic direct effects in magnitude as well as direction. This may be due to the effect of environment on the expression of the traits. Shanthi Bhushan and Jaiswal (2009) and Padmavathi *et al.* (2013) reported that number of pods per plant (1.249) had positive and very high direct effect on seed yield. Sanjay *et al*. (2009) and Gohil and Patil (2010) reported high direct effects of biological yield on seed yield.

The two phenological traits *i.e.* days to first flowering and days to 50 per cent flowering, though exhibited highly significant positive correlation with seed yield, both of them exhibited moderate and negative direct effects at genotypic level. Its positive and significant correlation with seed yield was established on account of its high indirect effects *via* shoot biomass per plant and RWC apart from moderate indirect effects *via* days to maturity and SCMR. The indirect effects of days to first flowering and days to first poding *via* days to maturity were established by Shanthi Bhushan and Jaiswal (2009). Number of branches per plant recorded moderate and positive direct effect in genotypic path analysis but its high correlation with seed yield was established *via* shoot biomass per plant and 100 seed weight. High positive indirect effect *via* shoot biomass per plant (1.98) and 100 seed weight (0.48) was reported by Renukadevi and Subbalakshmi (2006), Vaghela *et al.*(2009) and through shoot biomass per plant reported by Reddy Yamini (2012).

Besides high negative direct effect at genotypic level, the trait SCMR also exerted its influence *via* shoot biomass per plant (-1.54) thus established highly significant negative correlation (-0.727) seed yield per plant. SLA exerted high and negative direct on seed yield per plant at genotypic level but its association with seed yield was positive and significant on account of its positive and indirect effects *via* shoot biomass per plant (1.559), 100 seed weight (0.403) and RWC (0.541).

Number of pods per plant had very high and significant positive association with seed yield. But at genotypic level, it had high and negative direct effects (-1.987). Its correlation with seed yield was on account of its high and positive indirect effects *via* shoot biomass per plant (2.146), 100 seed weight (0.723) and SCMR (0.213). Joshi *et al.* (2006) and Dubey *et al.* (2007) reported positive indirect effects of number of pods per plant through seed weight. Shoot biomass per plant emerged as an important attribute on account of its high positive and direct effect (2.170) and it also influenced seed yield indirectly through 100 seed weight (0.588), SCMR (0.344) and RWC (0.2656). Positive indirect effect of this trait through 100 seed weight was reported by Talebi *et al.* (2007).

The negative correlation of 100 seed weight with seed yield was justified on account of its high and negative direct effect at genotypic and phenotypic level. However it also had positive and indirect effects *via* SLA (0.359) and number of pods per plant (1.577). Positive indirect effect of 100 seed weight through number of pods per plant was reported by Joshi *et al.* (2006) and Lokare *et al*. (2007)

In path analysis, the residual effects were very low (0.1678 at genotypic level) which indicates that most of the important characters accounting for cause and effect relationships on seed yield of chickpea were included in the present study.

Study of path analysis in chickpea has clearly indicated that shoot biomass per plant and numbers of branches per plant are most important traits contributing directly to the seed yield. Besides traits like days to first flowering, days to 50 per cent flowering, number of branches per plant, SCMR, SLA also influenced seed yield per plant indirectly through shoot biomass per plant. Trait 100- seed weight though exhibited negative correlation with seed yield per plant, its indirect influence *via* other traits is positive. Thus the association between number of pods per plant, 100 seed weight and shoot biomass per plant should be considered carefully while selecting high yielding genotypes. Physiological traits like SLA, SCMR and RWC which are related to photosynthesis efficiency and water use efficiency exerted indirect and positive effects *via* other traits. Thus integration of these physiological traits in *kabuli* chickpea breeding programmes will greatly enhance the progress expected, especially in breeding for drought prone environments.

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Table 1. Phenotypic and genotypic correlation coefficients among sixteen yield and drought tolerance attributes in chickpea.

Character	DFF	D 50F	D FP	DM	PH	NB/P	SCMR	SLA	RWC	RL	RW	NP/P	SB/P	H.I	100SW	SY/P
DFF	1	0.777**	0.855**	0.506**	0.261	0.453*	-0.477**	0.626**	0.624**	-0.093	0.266	0.467*	0.537**	-0.451*	-0.054	0.388**
D 50F	0.899	1	0.639**	0.570**	0.517**	0.300*	-0.528**	0.608**	0.687**	-0.261	0.172	0.302*	0.500**	-0.511**	0.201	0.383*
DFP	1.172	0.972	1	0.442*	0.386*	0.192	-0.314*	0.405*	0.511**	-0.247	0.130	0.243	0.257	-0.342*	0.102	0.176
DM	0.774	0.756	1.146	1	0.198	0.247	-0.030	0.333*	0.376*	-0.636**	-0.361*	0.267	0.311*	-0.526**	0.050	0.153
PH	0.651	0.816	1.506	0.218	1	-0.301*	-0.400*	0.142	0.616**	-0.177	-0.056	-0.386*	-0.148	-0.428*	0.706**	-0.247
NB/P	0.604	0.294	0.340	0.217	-0.382	1	-0.304	0.352*	0.181	0.108	0.224	0.843**	0.826**	-0.264	-0.475**	0.783**
SCMR	-5.80	-0.585	-0.648	0.054	-0.615	-0.319	1	-0.348*	-0.500**	-0.240	-0.251	-0.356*	-0.522**	0.333*	-0.018	-0.465*
SLA	0.866	0.719	0.839	0.393	0.163	0.375	-0.413	1	0.705**	-0.288	0.083	0.596**	0.647**	-0.158	-0.435*	0.575**
RWC	0.987	0.876	1.212	0.515	0.850	0.223	-0.642	0.816	1	-0.151	0.079	0.195	0.338*	-0.431*	0.126	0.178
RL	-0.144	-0.289	-0.557	-0.783	-0.237	0.127	-0.287	-0.316	-0.207	1	0.737**	-0.098	-0.042	-0.025	0.147	-0.044
RW	0.344	0.167	0.238	-0.434	-0.053	0.238	-0.272	0.085	0.108	0.753	1	0.068	0.206	-0.258	0.161	0.171
NP/P	0.620	0.352	0.442	0.284	-0.470	0.899	-0.441	0.608	0.227	-0.101	0.078	1	0.912**	-0.036	-0.754**	0.937**
SB/P	0.792	0.640	0.623	0.294	-0.326	0.916	-0.710	0.718	0.400	-0.047	0.259	0.989	1	-0.345*	-0.557**	0.949**
H.I	-1.156	-1.262	-1.767	-1.273	-0.936	-0.589	0.655	-0.297	-0.868	0.022	-0.585	-0.170	-0.545	1	-0.382*	-0.084
100 SW	-0.042	0.245	0.230	0.063	0.877	-0.535	-0.013	-0.442	0.131	0.167	0.164	-0.793	-0.645	-0.894	1	-0.639**
SY/P	0.647	0.498	0.467	0.092	-0.485	0.895	-0.727	0.678	0.223	-0.031	0.233	1.054	1.002	-0.550	-0.797	1

Phenotypic correlations: above diagonal; Genotypic correlations: below diagonal

* Significant at P≤ 0.05 level, * * Significant at P≤ 0.01 level

DFF= Days to first flowering, D 50 F= Days to 50% flowering, DFP= Days to first poding, DM= Days to maturity PH= Plant height, NB/P= Number of branches per plant, SCMR= SPAD chlorophyll meter reading, SLA= Specific leaf area, RWC= Relative water content, RL= Root length, RW= Root weight, NP/P= Number of pods per plant, SB/P= Shoot biomass per plant, SY/P= Seed yield per plant, HI= Harvest index, 100SW= 100 seed weight.

Table 2. Genotypic path co-efficients among sixteen yield and drought tolerance attributes in chickpea.

Character	DFF	D50F	DFP	DM	PH	NB/P	SCMR	SLA	RWC	RL	RW	NP/P	SB/P	H.I	100SW
DFF	-0.181	-0.163	-0.213	-0.140	-0.118	-0.109	0.105	-0.157	-0.179	0.026	-0.062	-0.112	-0.144	0.210	0.007
D 50F	-0.239	-0.266	-0.259	-0.201	-0.217	-0.078	0.156	-0.191	-0.233	0.077	-0.044	-0.093	-0.170	0.336	-0.065
DFP	-0.012	-0.010	-0.010	-0.011	-0.015	-0.003	0.006	-0.008	-0.012	0.005	-0.002	-0.004	-0.006	0.018	-0.002
DM	0.232	0.227	0.344	0.300	0.065	0.065	0.016	0.118	0.154	-0.235	-0.130	0.085	0.088	-0.382	0.019
PH	-0.215	-0.269	-0.497	-0.072	-0.330	0.126	0.203	-0.054	-0.281	0.078	0.017	0.155	0.107	0.309	-0.290
NB/P	0.122	0.059	0.069	0.044	-0.077	0.202	-0.064	0.076	0.045	0.025	0.048	0.182	0.185	-0.119	-0.108
SCMR	0.281	0.283	0.314	-0.026	0.297	0.154	-0.484	0.200	0.311	0.139	0.132	0.213	0.344	-0.317	0.006
SLA	-0.703	-0.584	-0.681	-0.319	-0.133	-0.304	0.335	-0.811	-0.663	0.256	-0.069	-0.493	-0.583	0.241	0.359
RWC	0.654	0.580	0.803	0.341	0.563	0.148	-0.425	0.541	0.662	-0.137	0.071	0.150	0.265	-0.575	0.086
RL	0.086	0.172	0.331	0.466	0.141	-0.075	0.170	0.188	0.123	-0.595	-0.448	0.060	0.028	-0.013	-0.099
RW	0.173	0.084	0.120	-0.218	-0.026	0.120	-0.137	0.043	0.054	0.378	0.502	0.039	0.130	-0.294	0.082
NP/P	-1.232	-0.699	-0.879	-0.566	0.935	-1.787	0.876	-1.208	-0.451	0.202	-0.156	-1.987	-1.965	0.338	1.577
SB/P	1.719	1.391	1.352	0.638	-0.708	1.988	-1.542	1.559	0.869	-0.102	0.564	2.146	2.170	-1.183	-1.401
H.I	-0.075	-0.082	-0.116	-0.083	-0.061	-0.038	0.043	-0.019	-0.057	0.001	-0.038	-0.011	-0.035	0.065	-0.058
100 SW	0.039	-0.223	-0.209	-0.057	-0.799	0.488	0.012	0.403	-0.119	-0.152	-0.150	0.723	0.588	0.815	-0.911
Correlation with SY/P	0.647	0.498	0.467	0.092	-0.485	0.895	-0.727	0.678	0.223	-0.031	0.233	1.054	1.002	-0.550	-0.797

Residual effect = 0.1678

DFF= Days to first flowering, D 50 F= Days to 50% flowering, DFP= Days to first poding, DM= Days to maturity, PH= Plant height, NB/P= Number of branches per plant, SCMR= SPAD chlorophyll meter reading, SLA= Specific leaf area, RWC= Relative water content ,RL= Root length, RW= Root weight, NP/P= Number of pods per plant, SB/P= Shoot biomass per plant, SY/P= Seed yield per plant, HI= Harvest index, 100SW= 100 seed weight.