Genetic analysis for various traits of *Cicer arietinum* under different spacing

Muhammad Waseem[1], Qurban Ali[2], Arfan Ali[2], Tahir Rehman Samiullah[2], Dost Muhammad Baloch[1], Shafique Ahmad[2], Mustajab Ahmad Khan[1], Sajed Ali[2], Adnan Muzaffar[2], Malik Adil Abbas[2], Idrees Ahmad Nasir[2] and Tayyab Husnain[2]

[1]Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Sciences Uthal, Pakistan
[2]Centre of Excellence in Molecular Biology, University of the Punjab, Lahore Pakistan
saim1692@gmail.com (+9203219621929)

Abstract: Prescribed study was conducted in Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Sciences Uthal, Pakistan during crop sowing season of 2013-14. Three varieties were sown in triplicate completely randomized block design using 2 factor factorial analyses. It was suggested that higher genotypic variance, genotypic coefficient of variation, heritability and genetic advance indicated that the traits dry biomass, grain yield per plant, pods per plant, 100-seed weight and seeds per pod. Punjab-2008 and Bakhar-2011 performed batter for most of the grain yielding and its contributing traits. Significant genotypic and phenotypic correlations were reported for dry biomass, pods per plant, 100-seed weight, grain yield per plant and seeds per pod. higher positive direct effects of days to flowering, primary branches per plant, plant height and secondary branches per plant were reported for grain yield per plant on chickpea. Heritability, genetic advance, principle component analysis, principle component biplot and path coefficient analysis indicated that these traits may be used for the development of higher grain yielding chickpea genotypes to improve yield of chickpea.
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Key words: *Cicer arietinum,* heritability, genetic advance, principle component analysis, principle component biplot, genotypic, phenotypic, correlation, path coefficient analysis

1. Introduction

Cicer arietinum is an important pulse crop, constitute an important source of balanced human diet throughout the world. It is the third leading grain legume in the world and first in the South Asia. Its range of cultivation extends from the Mediterranean basin to the Indian sub-continent and southward of Ethiopia and the East African highlands. Two types of chickpea, one namely Kabuli is grown in temperate regions while the desi type chickpea is grown in the semi-arid tropics (Muehlbauer and Singh, 1987). Chickpea is the principal rabi pulse crop and important source of calories which is predominantly grown in the vast rainfed areas of Pakistan. Pakistan ranks second to India in terms of acreage under chickpea which is 975 thousand hectares with an annual production of 475 thousand tons (Anonymous, 2013-14). It is rich and readily available source of protein both for human and animals. The average yield of chickpea is low as compared to other chickpea growing countries. In Punjab about 90% gram is cultivated in rainfed areas; the major chickpea production belt is Thal including the districts of Bhakhar, Mianwali, Layyah, Khushab and parts of Jhang. Chickpea is the cheapest and readily available source of protein (19.5%), fats (1.4%), carbohydrates (57-60%), ash (4.8%) and (4.9-15.59%) moisture (Huisman and Van der Poel, 1994). It also helps in replenishment of soil fertility by fixing of atmospheric nitrogen through symbiosis coupled with deep root system. Unfortunately, despite immense significance and nutritional value of crop in the Agriculture, chickpea production in the country has been unsatisfactory. The average yield of chickpea in Pakistan is low as compared to other chickpea growing countries of the world. This is primarily due to poor genetic makeup of the cultivars, excessive vegetative growth, low tolerance to diseases and no availability of seeds of improved varieties. Grain yield is of primary importance and the most complex trait as it is dependent upon the interaction of growth, environment and genetic makeup of the plant. Apart from direct selection for grain yield, the objective of yield enhancement may in most situations be more effectively fulfilled on the basis of performance of yield and its components. These components contribute to grain production both directly and indirectly. Genotypic and phenotypic correlations are of value to indicate the degree to which various quantitative traits of the plant are associated with economic productivity. Correlation study thus provides information on correlation response of important plant traits and therefore leads to a directional model for yield response (Ali *et al*., 2010a, b; Ali and Ahsan, 2011; Ali *et al*., 2011a, d, e; Jahangir *et al*., 2014 and Anwar *et al*., 2013). Path-coefficient analysis is one of the reliable statistical techniques which provides means not only to quantify the interrelationships of different yield components but also indicates whether the influence is directly reflected in yield or takes some other pathway for effect. However, present study was initiated with the prime objective of observing the mutual relationships of different quantitative traits and extent of their contribution to seed yield at seedling and maturity stages of chickpea. The studies thus clearly envisage augmenting the relatively scarce information available on these characters which may be profitably exploited in future breeding program of chickpea improvement (Ali *et al*., 2010a, b; Ali and Ahsan, 2011; Ali *et al*., 2011a, d, e; Ali *et al*., 2012a, b, c; Saeed *et al*., 2012; Naveed *et al*., 2012; Ali *et al*., 2013; Muhammad *et al*., 2013; Qamar *et al*., 2014a,b).

2. Material and methods

A). Experiment site and genetic traits

The present study was conducted in the Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Sciences Uthal, Pakistan during crop sowing season of 2013-14. Three varieties Noor-2009, Bakhar-2011 and Punjan-2008 were sown in triplicate two factor factorial completely randomized block design. The data was recorded for following traits including days to maturity, days to flowering, seed/pod, plant height (cm), pods/plant, primary branches, secondary branches, dry biomass (g), 100-seed weight (g) and grain yield/plant (g).

B) Planting spacing (cm)

S_1 = 10 cm, S_2 = 20 cm, S_3 = 30 cm

Sowing time	28 Nov, 2013
R×R Distance	30 cm
Design	RCBD factorial
Plot size	1.5 x 1.8 m
Seed rate	20 kg ha^{-1}

C). Statistical analysis

Data regarding all the indices were collected using standard procedures and analyzed by using Fisher's analysis of Variance technique. LSD test at 5% probability was used to compare the differences among treatments means (Steel *et al.,* 1997). Genotypic and phenotypic correlation was calculated (Know and Torrie 1964) while significance was checked by using Reeve (1955) technique and path coefficient (Dewey and Lu, 1959) was computed to access trait association among various grain and its contributing traits. Principle component and biplot were also computed to access variability in chickpea genotypes. Heritability and genetic advance (Falconer 1989) was also computed to access trait trans-ability to next generations.

3. Results and discussions

3.1. Analysis of variance

It was persuaded from table 1 that significant differences among genotypes, spacing and genotypes × spacing interaction were reported for all agronomic traits. It was found from table 2 that higher genotypic and phenotypic variance was found for pods per plant 85.942; 111.022, dry biomass 55.136; 77.842 and days to maturity 6.923; 13.969 respectively. Higher genotypic and phenotypic coefficient of variation was recorded for dry biomass 79.437%; 94.387%, 100-seed weight 33.848%; 45.264% and pods per plant 85.942%; 138.553% respectively. It was found that higher heritability and genetic advance was found for dry biomass 70.831%; 12.552%, pods per plant 77.410%; 24.752% and seeds per pod 56.919%; 12.208% respectively. It was suggested that higher genotypic variance, genotypic coefficient of variation, heritability and genetic advance indicated that the traits dry biomass, pods per plant, 100-seed weight and seeds per pod may be used for the development of higher grain yielding chickpea genotypes to improve yield of chickpea. Results were in accordance with Ali and Ahsan (2011); Ali *et al*. (2010a,b); Ali *et al*. (2011a,b,d,e,f); Naveed *et al*. (2012) and Saeed *et al*. (2012). It was found from table 3 that very little differences for mean performance were found among the varieties, however Noor-2009 performed batter for all traits under different spacing. It was suggested that Noor-2009 may be used for higher grain yield under various environmental conditions. The spacing among the lines showed very low effects on the performance of Noor-2009. There is also an improvement in the genotype potential to grow under adverse environmental conditions. Similar finding were reported by Ali and Ahsan (2011); Ali *et al*. (2010a,b); Naveed *et al*. (2012) and Saeed *et al*. (2012).

3.2. Correlation analysis

It was persuaded from table 4 that positive and highly significant genotypic and phenotypic correlation was reported for days to maturity with plant height, pods per plant, secondary branches per plant and 100-seed weight while negative and higher significant genotypic correlation of days to maturity was found for days to flowering, seeds per pod and primary branches per plant. Days to flowering was significantly and positively correlated with plant height, 100-seed weight and grain yield per plant while negatively and significantly correlated with seeds per pod, pods per plant, primary, days to maturity and secondary branches per plant. Significant and positive genotypic correlations indicated that selection on the basis of 100-seed weight and grain yield may be helpful to improve grain production of chickpea (Ali and Ahsan (2011); Ali *et al*. (2010a,b); Ali *et al*. (2011a,b,d,e,f); Naveed *et al*. (2012) and Saeed *et al*. (2012)). Seeds per pod were positively and significantly correlated with secondary branches per plant, dry biomass and 100-seed weight while negative and significant correlation was found for days to maturity, days to flowering, pods per plant and grain yield per plant at genotypic level and significantly and positively correlated at phenotypic level with days to maturity, days to flowering, pods per plant and secondary branches per plant. Plant height was found positively and significantly correlated with days to maturity, days to flowering, pods per plant, seeds per pod, 100-seed weight and grain yield per plant at genotypic and phenotypic levels. Grain yield was significantly correlated with dry biomass, days to flowering and plant height at genotypic level while negative genotypic correlation was found for 100-seed weight, primary branches per plant and seeds per pod. Selection on the basis of seeds per pod, 100-seed weight and grain yield per plant may be fruitful to develop higher yielding chickpea genotypes under various environmental conditions. Results were found similar as reported by Ali and Ahsan (2011); Ali *et al*. (2010a,b); Ali *et al*. (2011a,b,d,e,f); Naveed *et al*. (2012) and Saeed *et al*. (2012).

Table 1. Pooled ANOVA for agronomic traits of chickpea under different spacing

Source	Dry biomass	Grain yield	100-seed weight	Primary branches	Plant height	Pods per plant	Secondary branches	Days to maturity	Days to flowering	Seed/pod
Replication	2.73	3.33	2.9412	0.21	3.72	3.72	3.72	3.1296	4.17222	0.0372
Genotypes	188.375*	9.80347**	11.1248**	0.06407*	21.66**	282.907**	0.88167*	27.8148**	7.00667**	0.07922*
Spacing	299.762*	0.55815*	16.1768**	0.05195*	143.127**	81.06**	1.12667*	2.5741*	0.6218*	0.0054*
Genotypes×Spacing	0.375**	4.8152*	3.0819*	0.02322*	38.22*	314.687**	1.20667*	1.6852*	0.55939*	0.06855*
Error	22.706	2.37804	2.3149	0.01236	8.997	25.08	0.495	7.0458	2.66685	0.01596
Grand Mean	87.375	39.506	25.632	2.8617	51.417	57.833	8.8417	153.86	116.29	1.575
Coefficient of variation	5.45	3.9	5.94	3.89	5.83	8.66	7.96	1.73	1.4	8.02

Table 2. Pooled analysis of various genetic components for agronomic traits of chickpea

Traits	Genotypic Variance	Genotypic Coefficient Variance	Phenotypic Variance	Phenotypic Coefficient of Variance	Environmental Variance	Environmental Coefficient of Variance	h^2bs%	Genetic Advance %
Dry biomass	55.136	79.437	77.842	94.387	22.706	50.977	70.831	12.552
Grain yield	2.475	25.031	4.853	35.049	2.378	24.534	51.001	4.991
100-seed weight	2.937	33.848	5.252	45.264	2.315	30.052	55.920	8.774
Primary branches	0.017	7.761	0.030	10.170	0.012	6.572	58.239	6.144
Plant height	4.221	28.652	13.218	50.703	8.997	41.831	31.934	3.963
Pods per plant	85.942	121.903	111.022	138.553	25.080	65.853	77.410	24.752
Secondary branches	0.129	12.074	0.624	26.564	0.495	23.661	20.659	3.239
Days to maturity	6.923	21.212	13.969	30.131	7.046	21.399	49.560	2.113
Days to flowering	0.502	6.569	3.169	16.507	2.667	15.144	15.836	0.425
Seed/pod	0.021	11.571	0.037	15.337	0.016	10.066	56.919	12.208

Table 3. Pooled mean significance differences among chickpea varieties for agronomic traits under different spacing

Varieties/Traits	Seeds Per Pod	Dry Biomass	Grain Yield	100-seed Weight	Primary Branches	Plant Height	Pods per Plant	Secondary Branches	Days to Flowering	Days to Maturity
Noor-2009	1.6808A	92.333A	38.363B	26.072A	2.8992A	53.933A	54.183B	9.0583A	115.97A	154.5A
Bakhar-2011	1.5608AB	89.258A	40.573A	26.782A	2.9167A	53.783A	60.033A	8.4083A	116.5A	153.42A
Punjab-2008	1.4833B	80.533B	39.582AB	24.042B	2.7692B	46.533B	59.283A	9.0583A	116.39A	153.67A

Table 4. Pooled genotypic and phenotypic correlation among various agronomic traits of chickpea

Traits	r	Days to flowering	Seed/pod	Plant Height	Pods/Plant	Primary Branches	Secondary Branches	Dry Biomass	100-seed weight	Grain Yield
Days to maturity	g	-0.865*	-0.739*	0.936*	0.595*	-0.347**	0.685*	0.667*	0.683*	-0.128
	p	0.491*	0.372**	0.927*	0.616*	0.405**	0.457*	0.563*	0.331**	0.742*
Days to flowering	g		-0.649*	0.584*	-0.607*	-0.503*	-0.455*	-0.017	0.615*	0.389**
	p		0.702*	0.459*	0.258	0.293	0.269	0.966*	0.078	0.453**
Seed/pod	g			0.239	-0.318**	0.768*	0.612*	0.466*	0.419*	-0.548*
	p			0.536*	0.404*	0.016	0.758*	0.269	0.261	0.126
Plant height	g				-0.562*	0.109	-0.496*	0.327**	0.377**	0.407*
	p				0.116	0.078	0.174	0.391**	0.317**	0.278
Pods/plant	g					0.181	0.601*	-0.378**	-0.09	0.085
	p					0.642*	0.087	0.316**	0.218	0.129
Primary Branches	g						0.784*	-0.166	0.459*	-0.322**
	p						0.635*	0.067	0.214	0.398**
Secondary Branches	g							0.824*	-0.097	-0.699*
	p							0.563*	0.103	0.208
Dry biomass	g								-0.516*	0.579*
	p								0.466*	0.239
100-seed weight	g									-0.546*
	p									0.524*

3.3. Path coefficient analysis

It was suggested from table 5 that higher positive direct effects of days to flowering (0.1538), primary branches per plant (0.1089), plant height (0.0827) and secondary branches per plant (0.239) were reported for grain yield per plant on chickpea. Higher positive direct effects showed that selection on the basis of days to flowering, primary branches per plant, plant height and secondary branches per plant may be helpful to improve grain yield of chickpea under various environmental conditions (Ali and Ahsan (2011); Ali *et al*. (2010a,b); Naveed *et al*. (2012) and Saeed *et al*. (2012)). Higher positive indirect effects of days to maturity on grain yield via days to flowering, plant height and pods per plant while negative indirect effects via seeds per pod, primary branches per plant, secondary branches per plant and dry biomass were found. Days to maturity showed negative and non-significant correlation for grain yield per plant. The traits showed positive indirect effects may be used to select higher grain yielding chickpea genotypes (Ali and Ahsan (2011); Ali *et al*. (2010a,b) and Saeed *et al*. (2012)). Higher and positive indirect direct effects of days to flowering on grain yield per plant via plant height primary branches per plant and dry biomass while negative for pods per plant and secondary branches per plant were reported. Significant genotypic correlation between days to flowering and grain yield per plant showed that selection of higher grain yield and early maturing chickpea may be made to improve production of chickpea(Ali and Ahsan (2011); Ali *et al.* (2010a,b); Naveed *et al.* (2012) and Saeed *et al.* (2012). Seeds per pods showed positive indirect effects via days to flowering, days to maturity and pods per plant while all negative indirect effects for all others traits. Genotypic correlation of seed per pod with grain yield per plant was significant and negative. Plant height showed positive indirect effects via all agronomic traits on grain yield per plant. Genotypic correlation between plant height and grain yield was found to be positive and highly significant. Pods per plant showed positive indirect effects on grain yield per plant expect plant height and primary branches per plant. Genotypic correlation between pods per plant and grain yield per plant was non-significant. Primary branches per plant showed negative indirect effects on grain yield via days to flowering, days to maturity and seeds per pod while other traits showed positive indirect effects via primary branches per plant. Negative and significant genotypic correlation was found between primary branches per plant and grain yield per plant. Negative indirect effects suggested that selection on the basis of traits showed negative indirect effects may be used to fix decrease in the respective trait. Similar results were reported by Ali and Ahsan (2011); Ali *et al*. (2010a,b); Ali *et al*. (2011a,c,f); Naveed *et al*. (2012) and Saeed *et al*. (2012).

Secondary branches showed positive indirect effects on grain yield via days to flowering and maturity, and 100-seed weight while all other traits showed negative indirect effects on grain yield per plant. Negative and significant genotypic correlation was found between secondary branches per plant and grain yield per plant. Dry biomass showed positive indirect effects on grain yield via all traits except days to flowering and days to maturity. Genotypic correlation of dry biomass with grain yield per plant was pound to be positive and significant. 100-seed weight showed negative and significant genotypic correlation with grain yield per plant and negative indirect effect via days to flowering, seeds per pod and plant height. Positive indirect effects were found for days to maturity, pods per plant, primary branches per plant, secondary branches per plant and dry biomass. Positive indirect effects suggested that selection of higher yield chickpea genotypes may be made on the basis of these traits. Similar findings were reported by Ali and Ahsan (2011); Ali *et al*. (2010a,b); Ali *et al*. (2011a,b,d,e,f); Naveed *et al*. (2012) and Saeed *et al*. (2012).

Table 5. Pooled direct (Parenthesis) and indirect effects for various agronomic traits of chickpea

Traits	Days to maturity	Days to flowering	Seed/pod	Plant Height	Pods/Plant	Primary Branches	Secondary Branches	Dry Biomass	100-seed weight	rg Grain yield
Days to maturity	**(0.0009)**	0.2429	-0.1301	0.2164	0.0609	-0.2108	-0.2832	-0.0371	0.012	-0.128
Days to flowering	0.0258	**(0.1538)**	0.0019	0.1217	-0.0771	0.0927	-0.1903	0.1798	0.0807	0.389*
Seed/pod	0.0912	0.0129	**(0.0081)**	-0.1529	0.0422	-0.0128	-0.1199	-0.2147	-0.2021	-0.548**
Plant Height	0.0182	0.1023	0.0129	**(0.0827)**	0.0019	0.0157	0.1039	0.0096	0.0598	0.407*
Pods/Plant	0.0003	0.0171	0.0029	-0.2399	**(0.0097)**	-0.0238	0.1219	0.1567	0.0401	0.085
Primary Branches	0.0239	-0.1029	-0.4098	-0.1028	0.1002	**(0.1089)**	0.0071	0.0136	0.0398	-0.322**
Secondary Branches	0.0192	0.1293	-0.382	-0.1092	-0.2087	-0.0928	**(0.0239)**	-0.1071	0.0283	-0.699*
Dry Biomass	0.1202	-0.0986	-0.3092	0.0128	0.2093	0.3084	0.2098	**(0.0024)**	0.1229	0.579*
100-seed weight	0.0127	-0.1114	-0.2701	-0.2103	0.0019	0.0201	0.0091	0.0002	(0.**0018)**	-0.546*

3.4. Principle component analysis

It was suggested from table 6 that higher PC1 value was reported for seeds per pod, plant height, secondary branches per plant, dry biomass, 100-seed weight and grain yield per plant while negative for days to flowering and maturity. The eigen value for PC1 was found to be 9.6545 with proportion of 0.965. It was found from PC2 that higher value was found for days to flowering and maturity, pods per plant, primary branches per plant, dry biomass, 100-seed weight and grain yield per plant with eigen value o.3455 and proportion of 0.035.

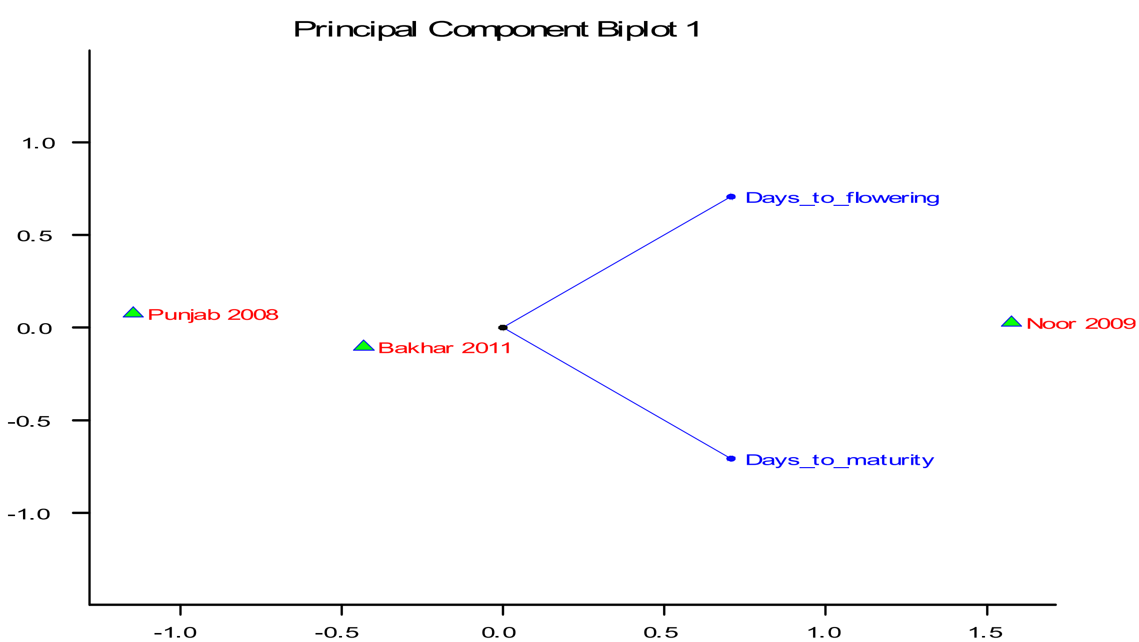
Table 6. Pooled principle component analysis for various agronomic traits of chickpea

Eigen value	9.6545	0.3455
Proportion	0.965	0.035
Cumulative	0.965	1.000
Variable	**PC1**	**PC2**
Days to maturity	-0.308	0.486
Days to flowering	-0.318	0.269
Seed/pod	0.319	-0.211
Plant height (cm)	0.319	-0.211
Pods/plant	0.316	0.318
Primary branches	0.301	0.607
Secondary branches	0.319	-0.211
Dry biomass (g)	0.319	0.208
100-seed weight (g)	0.321	0.083
Grain yield/plant (g)	0.320	0.193

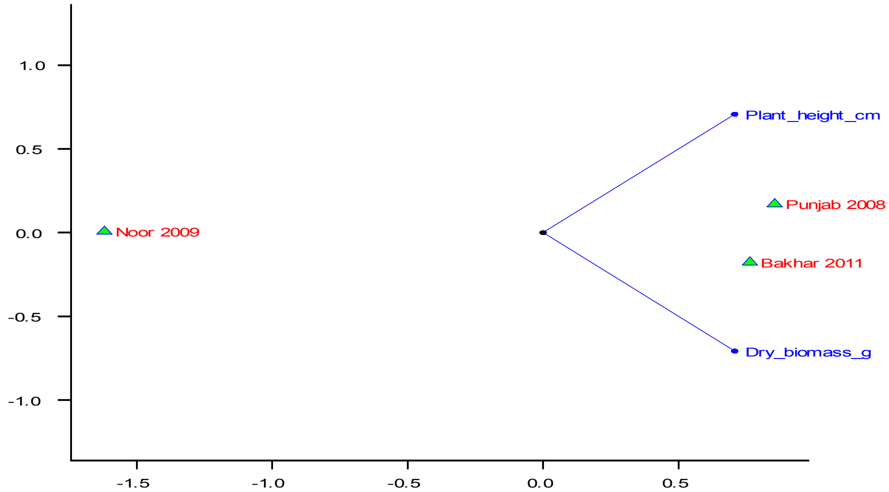
It was suggested that selection of higher yield chickpea genotypes may be developed by selecting on the basis of these traits (Ali and Ahsan (2011); Ali *et al*. (2010a,b); Ali *et al*. (2011a,b,d,e,f); Naveed *et al*. (2012) and Saeed *et al*. (2012).

3.5. Pooled principle component Biplot

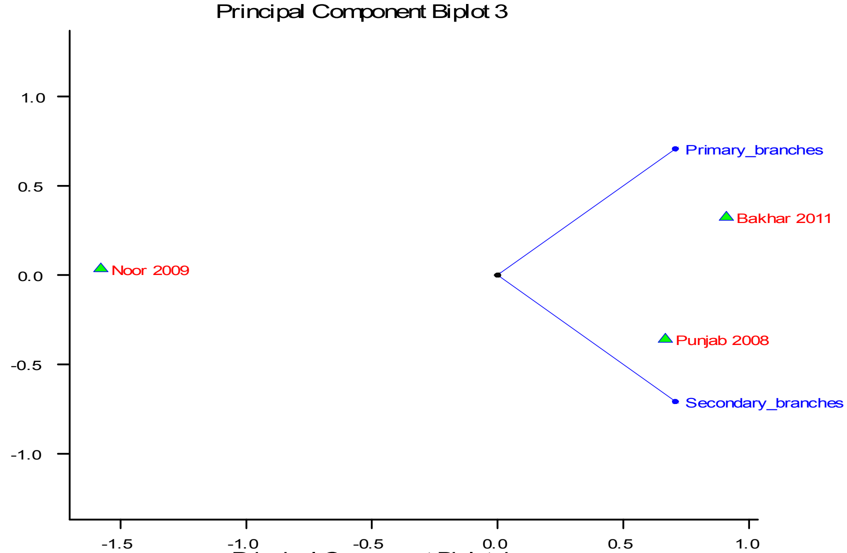
It was indicated from principle component biplot 1 that Noor-2009 showed late maturing as comparing Punjab-2008 and Bakhar-2011 which showed early maturing nature. Noor-2009 may be used for late sowing to improve grain yield per plant. Punjab-2008 and Bakhar-2011 may be used for early sowing and to save time for crop growing season. It was indicated form principle component biplot 2 showed that higher plant and dry biomass was reported for Punjab-2008 and Bakhar-2011 as compared to Noor-2009. It was suggested that in early sowing and early maturing the most of organic compounds are used to store in plant body to improve crop yield and production (Amanullah *et al.* (2001); Ali and Ahsan (2011); Ali *et al*. (2010a,b); Ali *et al*. (2011a,b,d,e,f); Naveed *et al*. (2012) and Saeed *et al*. (2012). It was found from principle component biplot 3 that Punjab-2008 and Bakhar-2011 showed higher primary and secondary branches per plant as compared with Noor-2009. Higher pods per plant, 100-seed weight, seeds per pod and grain yield per plant were found for Punjab-2008 and Bakhar-2011 as compared with Noor-2009 (principle component biplot 4). It was suggested that late maturing of Noor-2009 caused to decrease in the grain yield per plant. Punjab-2008 and Bakhar-2011 showed higher grain yield potential under different spacing and may be used for higher yielding chickpea genotypes in various environmental conditions. Similar results were reported by Amanullah *et al.* (2001); Ali and Ahsan (2011); Ali *et al*. (2010a,b); Ali *et al*. (2011a,b,d,e,f); Naveed *et al*. (2012) and Saeed *et al*. (2012).



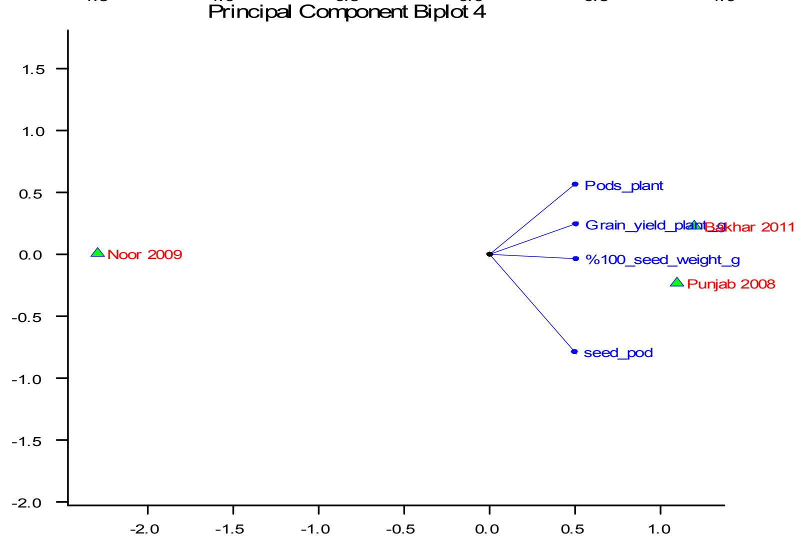
Principal Component Biplot 2



Principal Component Biplot 3



Principal Component Biplot 4



Conclusion

It was suggested that higher genotypic variance, genotypic coefficient of variation, heritability and genetic advance indicated that the traits dry biomass, grain yield per plant, pods per plant, 100-seed weight and seeds per pod. Punjab-2008 and Bakhar-2011 performed batter for most of the grain yielding and its contributing traits. Significant genotypic and phenotypic correlations were reported for dry biomass, pods per plant, 100-seed weight, grain yield per plant and seeds per pod. higher positive direct effects of days to flowering, primary branches per plant, plant height and secondary branches per plant were reported for grain yield per plant on chickpea. Heritability, genetic advance, principle component analysis, principle component biplot and path coefficient analysis indicated that these traits may be used for the development of higher grain yielding chickpea genotypes to improve yield of chickpea.

Correspondence to:
Dr. Qurban Ali (PhD)
Assistant Professor
National Centre of Excellence in Molecular Biology, University of the Punjab, Lahore Pakistan
Emails:saim1692@gmail.com,saim_1692@yahoo.com

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