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Assessment of Interrelationship among Agronomic and Yield Characters of Chickpea

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ABSTRACT: This study was conducted to analyze the association among agronomic traits and with seed yield for fifty eight chickpea genotypes including two check varieties under field conditions. Alpha lattice design with three replications was used. Data agro-morphological traits were recorded using descriptors for chickpea and analysed using Genstat 2015. The results showed there was positive and significant correlation of seed yield with biomass, pod filling period, pod plant $^{-1}$, number of primary and secondary branches plant $^{-1}$. These traits could be improved simultaneously and given prior emphasis for indirect selection of high yielding chickpea genotypes. Principal component analysis indicated that the existence of genetic variation among the evaluated genotypes. The first four principal components explained significant proportion of the total variations and accounted for 77.04 %. The first principal component was positively associated with days to flowering, plant spread, plant height, number of primary and secondary branches plant $^{-1}$, days to maturity, pods plant $^{-1}$, pod length, biomass and seed yield. The second principal component was positively related with plant spread, pod length, plant height, pod filling period, pod plant $^{-1}$, seed yield and 100 seed weight. These could be a good indication for significance of both agronomic and yield traits attributed substantially to the overall variations among genotypes. The presence of substantial genetic variations, positive and highly significant correlated characters can be exploited in breeding programmes for improvement of chickpea in the region.
***Key Words**:* Cicer arietinum; Correlation; Variations; Yield Improvement

INTRODUCTION

Chickpea (Cicer arietinum L.) is the 3rd most important pulse crop in the world, after dry bean and field pea (FAOSTAT, 2008). It is the main source of vegetable protein in the world and used as human food and animal feed due to its high protein content. Investigation on yield and yield components could provide a fundamental framework for identifying potentially useful characters in chickpea improvement programme. Most plant breeders are interested in maximizing selection efficiency that facilitates the identification of elite genotypes. Correlation among yield attributing traits and with yield is the basic prerequisite for indirect selection of high yielding chickpea varieties. Estimation of correlation is useful in planning future breeding and provides a measure of association among characters and with targeted traits and could be used for indirect selection high yield chickpea genotypes.

Previous studies in chickpea have reported positive and highly significant correlation of seed yield with number of secondary branches plant $^{-1}$, plant height, number of pods plant $^{-1}$ and negatively significant with days to flowering, days to maturity and 100-seed weight (Ali and Ahsan, 2012), seed yield with biomass yield and number of secondary branches plant $^{-1}$ but negatively correlated with 100 seed weight (Malik et al., 2010).

In other legumes, earlier studies have reported positive and significant correlation of seed yield with biomass yield, number of pods plant $^{-1}$ and plant height but negatively correlated with days to flowering (Al-Ghzawi et al., 2011) in lentil, seed yield with number of seeds pod $^{-1}$, 100 seed weight, number of pods plant $^{-1}$, pod length, days to flowering and days to maturity (Okonkwo and Idahosa 2013) in soybean. Aghili et al. (2012) also reported positive and significant correlation of seed yield with plant height, number of pods plant $^{-1}$, number of seeds pod $^{-1}$, biomass yield and 100 seed weight in lentil.

In cereals, earlier studies have reported positive and significant correlation of seed yield with plant height, ear height, number of grains row $^{-1}$, number of grains ear $^{-1}$ and 100 seed weight (Selvaraj and

Nagarajan, 2011) in maize, grain yield with number of kernels head $^{-1}$ and panicle length (Ali et al., 2012) in sorghum.

Correlation among agronomic characters and with seed yield could supply more reliable information on the nature and level of interrelationships of seed yield with its attributes. Assessment of characters that are positively associated among them and with seed yield is essential as it increases breeding efficiency of the targeted traits. The objective of this study was to analyze the association among agronomic traits and with seed yield. Such findings could assist chickpea breeder, a good opportunity for further improving of chickpea in the region. Principal component analysis could assist chickpea breeders to identify which characters most strongly contribute to the principal component that explain the total variances.

MATERIALS AND METHODS

Experimental Sites

The experiment was conducted at the University farm of Jomo Kenyatta University of Agriculture and Technology, Juja and the field station of the University of Nairobi, Kabete, Kenya during the long and short rain seasons of each site. Juja is located about 36 km North East of Nairobi at 1^{o} 11´ 0´´ S, 37 ^{o} 7 ´ 0 ´´ E with an altitude of 1530 m above sea level. It is in upper midland zone 4, semi-humid to semi-arid. It receives an annual rainfall of 600 – 800 mm and mean annual temperature of 18.9 ^{o} C and clay soils (Kaluli *et al.*, 2011). Kabete is located about 15 km to the West of Nairobi and lies at a latitude of 1° 15' S, longitude 36 ° 41' E with an altitude of 1940 m above sea level and is in upper midland zone 3 (Sombroek *et al.*,1982). It is semi-humid with mean annual rainfall of 1000 mm and mean annual temperature of 18 ^{o} C and deep and friable reddish or brown, friable clay soils ((Karuku *et al*., 2012). Both experimental sites have bimodal rainfall pattern with peaks in April (long rain season) and November (short rain season).

PLANT MATERIALS AND EXPERIMENTAL DETAILS

Fifty eight *desi* genotypes including two checks were used in this study. The genotypes were obtained from ICRISAT gene bank, Nairobi, Kenya. Prior to planting, the experimental fields were ploughed and manually leveled with the help of spade and fork jembe.

Genotypes were evaluated under field conditions; alpha lattice design with three replications was used. Each experimental plot comprised of two rows with a gross area of 2.5 m^{2}. Genotypes were randomly allocated to entire plots in each block within replication at both sites. All genotypes were sown in two rows with inter row spacing of 50 cm.

Seeds were sown by hand drilling on 15th May (long rain Kabete), 28th May (long rain Juja), 18th November (short rain Kabete) and 29th December (short rain Juja), 2013 for season I and II, respectively. Two weeks after emergence, plants were thinned to maintain intra-row spacing of 10 cm.

The experiment was rain-fed and supplementary irrigation was provided when necessary. All the cultural practices were performed as recommended for chickpea production.

Data Collection

Data were recorded based on the available descriptors for chickpea (*Cicer arientinum* L) (IBPGR, ICRISAT and ICARDA, 1993). Data on days to 50 % flowering, days to 50 % podding, pod filling period, days to 75 % maturity, biomass yield and seed yield ha $^{-1}$ were recorded on per plot basis while plant spread, number of leaflet leaf $^{-1}$ at podding, pod length, plant height, number of primary and secondary branches plant $^{-1}$, number of pods plant $^{-1}$, number of seeds pod $^{-1}$ and 100 seed weight were recorded on six randomly selected and pre-tagged plants from the middle two rows of each plot.

The main characters recorded were as follows:

Days to 50 % Flowering (D to F)

Number of days from emergence to the time when 50 % of the plants in the plots produced at least one open flower.

Days to 50 % Podding (D to P)

Number of days taken from emergence to time when 50 % of plants in the plot produced at least one pod.

Number of Leaflet Leaf $^{-1}$ at Podding (NLLP $^{-1}$)

It was recorded during podding stages using scales: 1,2,3,4 and 5, when number of leaflets leaf $^{-1}$ ranged from 5 - 7, 7 – 9, 9 – 11 and greater than 13 respectively.

Plant Spread (PS)

The diameter of the plant was measured in centimeter using a measuring tape during peak pod filling period.

Pod Length (PL)

It was recorded at maturity by measuring ten pods each from six randomly selected and pre-marked plants using a ruler and recorded as plant $^{-1}$ and the length grouped as 3 = short (< 15 mm), 5 = medium (15 – 20 mm) and 7 = long (> 20 mm).

Plant Height (PH

The height (cm) of the main stem was measured from the ground level to the tip of the plant using a ruler at 75 % physiological maturity.

Number of Primary Branches (NPB)

The total number of branches originating from the main stem which gives rise to secondary branches was counted at 75% physiological maturity.

Number of Secondary Branches (NSB)

The total number of branches which rise from primary branches was counted at 75 % physiological maturity.

Pod Filling Period (PFP)

Number of days from 50 % flowering to the time when 75 % the plants in the plot reached physiological maturity.

Days to 75 % Maturity (D to M)

Number of days from emergence to the time when 75 % of the plants in the plot reached 75 % physiological maturity.

Number of Pods Plant $^{-1}$ (NPP $^{-1}$)

The total number of pods plant $^{-1}$ were counted and recorded as number of pods plant $^{-1}$.

Number of Seeds Pod $^{-1}$ (NSP $^{-1}$)

The total number of seeds pod $^{-1}$ were counted in ten pods each from six randomly selected plants and average seeds pod $^{-1}$ was computed.

Biomass Yield (BM)

The total weight of above ground biomass was weighed using electronic balance (in g or kg net plot $^{-1}$) and converted into kilogram ha $^{-1}$.

Seed Yield (SY)

This parameter was taken after harvesting, threshing and winnowing (in g or kg net plot $^{-1}$). The seed yield was weighed using electronic balance net plot $^{-1}$ basis and converted into kilo gram ha $^{-1}$ for each genotype in three replications.

Hundred Seed Weight (HSW)

Hundred seeds were counted in triplicate and weighed using electronic balance and recorded in gram plot $^{-1}$of each genotype in three replications.

Data Analysis

Data were subjected to Gen-Stat (Gen-Stat release 15.1, 2015). Correlation analyses among the mean values of quantitative traits were conducted as outlined by Kwon and Torrie, (1964) to determine the association among agronomic traits and with seed yield.

The mean data of each trait was standardized prior principal components analysis to avoid differences in measuring scales. Principal component analysis of the standardized mean was performed to assess the importance of different traits in explaining multivariate variations (Mallikarjuna *et al*. 2003) based on variance-covariance matrix.

RESULTS

The average rainfall, maximum and minimum temperatures in the long and short rain seasons at Kabete were 123.5 mm , 21.0 ^{o} C and 11.8 ^{o} C and 92.9 mm, 25.1^{o} C and 14.0 ^{o} C respectively. While at Juja, average rainfall, maximum and minimum temperatures in the long and short rain seasons were 85.0 mm, 26.1 ^{o} C and 13.9 ^{o} C and 75.0 mm, 28 ^{o} C and 14.5 ^{o} C respectively.

The results of correlation coefficient indicated that positive and significant association among most studied agronomic characters and with seed yield (Table 1). Seed yield ha $^{-1}$ showed positive and significant correlation with biomass yield ha $^{-1}$ (r = 0.80 **), pod filling period (r = 0.34**), number of pods plant $^{-1}$ (r = 0.31*), number of primary branches plant $^{-1}$ (r = 0.28*) and number of secondary branches plant $^{-1}$ (r = 0.25*). Seed yield ha $^{-1}$ was correlated negatively significant with days to 50 % flowering (r = - 0.27*) and days to 50 % podding (r = - 0.30*) but non-significantly correlated with remain characters (Table 1).

There was positive and highly significant correlation of biomass yield ha $^{-1}$ with number of primary branches plant $^{-1}$ (r = 0.60**), number of secondary branches plant $^{-1}$ (r = 0.57**), number of pods plant $^{-1}$(r = 0.53**), days to 75 % maturity (r = 0.42**), plant height (r = 0.38**) and plant spread (r = 0.35**) but non-significantly correlated with remain traits.

Number of pods plant $^{-1}$ correlated positively and highly significantly with plant spread (r = 0.53**), plant height (r = 0.46**), number of primary branches plant $^{-1}$ (r = 0.47**), number of secondary branches plant $^{-1}$ (r = 0.57**), days to 75 % maturity (r = 0.44**) and positively significant correlated with pod filling period (r = 0.30*). Days to 75 % maturity indicated positive and highly significant correlation with days to 50 % flowering (r = 0.50**), days to 50 % podding (r = 0.44**), plant spread (r = 0.51**), plant height (r = 0.44**), number of primary branches plant $^{-1}$ (r = 0.44**) and number of secondary branches plant $^{-1}$ (r = 0.46**).

The results further showed positive and highly significant correlation of days to 50 % podding with days to 50 % flowering (r = 0.92**), plant height with plant spread (r = 0.89**).

Pod filling period was positively and significantly correlated with plant spread (r = 0.27*), plant height (r = 0.25*) but negatively and significantly correlated with days to 50 % flowering (r = - 0.81**) and days to 50 % podding (r = - 0.75**).

Furthermore, there was positive and highly significant correlation for number of primary branches plant $^{-1}$ with days to 50 % flowering (r = 0.43**) and days to 50 % podding (r = 0.39**) while negatively and significantly correlated with 100 seed weight (r = - 0.28*).

Number of secondary branches plant $^{-1}$ showed positive and highly significant correlation with days to 50 % flowering (r = 0.44**), days to 50 % podding (r = 0.41**), plant spread (r = 0.31*), plant height (r = 0.29*), number of primary branches plant $^{-1}$ (r = 0.88**) but non-significant correlated with others traits (Table 1).

The results of principal component analysis indicated that the first four components with eigenvalue greater than one explained substantial portion of the total variations and accounted for 77.04 %. Other principal components which had less than one eigenvalues have not included and interpreted here. The proportion of cumulative variance accounted by each of the first four principal components were 29.34 %, 51.62 %, 67.02 % and 77.04 % respectively. A summary of the characters in the first four components, eigenvalues, percentage of variances, cumulative percentage variances are presented (Table 2). Eigenvalues versus seven principal components are given the scree plot (fig 1). The first principal component explained 29.34 % of the total variation. The 1st principal component result in due to differences in days to 50 % flowering, days to 50 % podding, plant spread, plant height, number of primary and secondary branches plant $^{-1}$, days to 75 % maturity, number of pods plant $^{-1}$, pod length, biomass yield ha $^{-1}$ and seed yield ha $^{-1}$ as main positive contributors. The second principal component, which contributed to total variability of 22.27 % and was positively associated with plant spread, pod length, plant height, pod filling period, number of pods plant $^{-1}$, seed yield ha $^{-1}$ and 100 seed weight whereas in negative direction, it was highly related with days to 50 % flowering and days to 50% podding. The third principal component explained 15.41 % of the total variation. It was predominantly and positively attributed though number of primary branches plant $^{-1}$, pod filling period, number of seeds pod $^{-1}$, biomass yield ha $^{-1}$ and seed yield ha $^{-1}$. While in negative direction, it was associated with days to 50 % flowering, days to 50 % podding, plant spread, pod length, plant height and 100 seed weight. The 4th principal component explained 10.02 % of the total variation. In positive direction, it was mainly contributed due to differences in number of leaflet leaf $^{-1}$ at podding, pod length, biomass yield ha $^{-1}$,seed yield ha $^{-1}$ and 100 seed weight. While in negative direction, plant spread, plant height, days to 75 % maturity and number of seeds pod $^{-1}$ were predominately the major contributors.

DISCUSSION

Yield improvement can be achieved through direct selection for seed yield or by indirect selection through yield related characters. Characters to be considered for indirect selection for yield improvement should be positively and significantly correlated with seed yield. Analysis of agronomic and yield related traits and their correlation towards seed yield could provide a good opportunity for effective indirect selection of high yielding genotypes. The results from this study, showed there was positive and highly significant correlation of seed yield ha $^{-1}$ with biomass yield ha $^{-1}$, number of primary and secondary branches plant $^{-1}$, pod filling period and number of pods plant $^{-1}$ but non-significant correlated with 100 seed weight and plant height (Table 1). The results indicated that increased seed yield ha $^{-1}$ was not due to heavier 100 seed weight and tall plant height but rather results from increased biomass yield ha $^{-1}$, high number of pods plant $^{-1}$, longer pod filling period, more number of primary and secondary branches plant $^{-1}$. According to Qureshi *et al.* (2004), characters which positively and significantly correlated with yield could be used for indirect selection of high yielding genotypes without evaluating for yield *per se*. Thus these characters could be selected and improved simultaneously for further enhancement of yield in chickpea in the region.

Previous studies in chickpea, have reported positive and significant correlation of seed yield with number of primary and secondary branches plant $^{-1}$, number of pods plant $^{-1}$and biomass yield (Malik *et al*., 2014), seed yield with biomass yield and harvest index (Ahmad *et al*., 2012). In chickpea, Ali *et al*. (2011) reported negative and non-significant correlation of seed yield with plant height. In cereal crops, earlier studies have reported positive and highly significant correlation of seed yield with number of tillers, biomass yield, plant height and number of grains spike $^{-1}$ (Habibpour *et al*., 2012) in wheat, seed yield with biomass yield ha $^{-1}$ and plant height (Pratap *et al.,* (2012) in rice.

Results from this study further showed negative correlation of seed yield with days to 50 % flowering and days to 50 % podding. These results were in agreement with those of Khan and Bangulzai (2006) who reported negative correlation of seed yield with days to flowering and days to podding in pea. However, these results contradict with those of Vaghela *et al.* (2009) who reported positive and significant correlation of seed yield ha $^{-1}$ with 100 seed weight in chickpea. Negative correlation of seed yield with days to 50 % flowering and days to 50 % podding could be due to the fact that early flowering and podding genotypes utilize only a short period for photosynthates and this leads to low ultimate yield. In marginal rainfall areas, earliness enables genotypes to escape from biotic and abiotic stresses that occur late in the growing season. Generally short growth duration gives low yields compared to medium and long growth duration. In chickpea, Namvar and Sharifi (2011) reported high biomass and seed yield obtained from medium and longer growth period compared to shorter growth. The existence of negative correlation among characters indicated breeders could make decision in selection of essential traits for development of varieties because those negatively correlated traits cannot be improved concurrently.

Biomass yield ha $^{-1}$ was correlated positively and significantly with plant spread, plant height, number of primary and branches plant $^{-1}$, days to 75 % maturity and number of pods plant $^{-1}$ (Table1). Similar results were reported in previous studies by Qureshi *et al.* (2004) in chickpea, Miheretu *et al*. (2013) in coriander, Aghili *et al*. (2012) in lentil germplasm. A positive and significant correlation between biomass and seed yield ha^{-1} indicated that both of these characters could be selected and improved simultaneously in future chickpea breeding programme. In those circumstances, where chickpea is produced as forage for animal feed, it could be a good opportunity to select for genotypes with high biomass yield ha $^{-1}$. The selection indices of superior genotypes rely on the prior objectives of chickpea breeding and farming system and hence it varied from place to place. Larger plant spread, tall plant height , more number of primary and secondary branches plant $^{-1}$, high number of pods plant $^{-1}$ and late maturity could be associated with high biomass yield ha $^{-1}$.

Number of pods plant $^{-1}$ correlated positively and highly significant with plant spread, plant height, number of primary and secondary branches plant $^{-1}$, days to 75 % maturity and pod filling period while non-significantly correlated with other traits. Larger plant spread, higher number of primary and secondary branches plant $^{-1}$, late maturity and late pod filling period could be attributed for more number of pods plant $^{-1}$ and hence final seed yield. All these characters can be improved simultaneously. These results were in agreement with those of Qureshi *et al.* (2004) who reported positive and significant correlation for number of pods plant $^{-1}$ with number of primary and secondary branches plant $^{-1}$ and plant height in chickpea.

There was positive and highly significant correlation of days to 75 % maturity with days to 50 % flowering, days to 50 % podding, plant spread, plant height, number of primary and secondary branches plant $^{-1}$, number of pods plant $^{-1}$ and biomass yield ha $^{-1}$ (Table 1). These indicated that early flowering and podding genotypes were not only early maturing but rather had small plant spread, short plant height, low number of primary and secondary branches plant $^{-1}$, low of pods plant $^{-1}$ and low biomass yield ha $^{-1}$ and vice versa. Malik *et al*. (2014) reported positive and significant correlation of days to maturity with number of primary and secondary branches plant $^{-1}$ and number of pods plant $^{-1}$.

The results of principal components analysis showed that the 1st four principal components with eigenvalue greater than one explained 77.04 % of the total variation among genotypes. The results indicated 1st principal component were positively associated with days to 50 % flowering, days to 50 % podding, plant spread, plant height, number of primary and secondary branches plant $^{-1}$, days to 75 % maturity, number of pods plant $^{-1}$, biomass and seed yield ha $^{-1}$.

Table 1. Correlation Coefficient among Quantitative Characters of Chickpea Genotypes at Juja and Kabete

Characters	D to F	D to P	PS	PH	NPBP $^{-1}$	NSBP $^{-1}$	D to M	PFP	NPP $^{-1}$	NSP $^{-1}$	BM	SY	HSW
D to F	1												
D to P	0.92**	1											
PS	0.07 NS	-0.01NS	1										
PH	0.05NS	-.0.04NS	0.89**	1									
NPBP $^{-1}$	0.43**	0.39**	0.19NS	0.21NS	1								
NSBP $^{-1}$	0.44**	0.41**	0.31*	0.29*	0.80**	1							
D to M	0.50**	0.44**	0.51**	0.44**	0.44**	0.46**	1						
PFP	-0.81**	-0.75**	0.27*	0.25*	-0.17NS	-0.20NS	0.11NS	1					
NPP $^{-1}$	0.00NS	-0.04NS	0.53**	0.46**	0.47**	0.57**	0.44**	0.30*	1				
NSP $^{-1}$	0.18NS	0.13NS	-0.15NS	-0.14NS	0.12NS	0.03NS	0.16NS	-0.09NS	0.03NS	1			
BM	0.12NS	0.07NS	0.35**	0.38**	0.60**	0.57**	0.42**	0.15NS	0.53**	0.22NS	1		
SY	-0.27*	-0.30*	0.04NS	0.10NS	0.28*	0.25*	0.05NS	0.34**	0.31*	0.21NS	0.80**	1	
HSW	-0.22NS	0.16NS	0.04NS	0.20NS	-0.28*	-0.23NS	-0.19NS	0.11NS	-0.19NS	-0.55**	-0.17NS	-0.04NS	1

Note: **- significant at 1 % level of significant ($Pr < 0.01$), * - significant at 5 % level of significant ($Pr < 0.05$) and NS – non - significant at 5 % ($Pr > 0.05$)

Table 2. Characters Associated with the First Four Principal Component Analysis and their Loading at Juja and Kabete

	Eigenvectors			
Characters	PC1	PC2	PC3	PC4
Days to 50 % flowering	0.23	-0.42	-0.23	-0.02
Days to 50 % Podding	0.20	-0.43	-0.24	0.05
Number of Leaflet Leaf $^{-1}$ at Podding	0.09	-0.10	0.01	0.62
Plant Spread	0.30	0.27	-0.25	-0.27
Pod Length	0.15	0.27	-0.39	0.20
Plant Height	0.29	0.29	-0.26	-0.15
Number of Primary Branches Plant $^{-1}$	0.36	-0.14	0.14	0.08
Number of Secondary Branches Plant $^{-1}$	0.39	-0.11	0.06	0.07
Days to 75 % Maturity	0.35	-0.04	-0.08	-0.21
Pod Filling Period	-0.03	0.45	0.21	-0.12
Number of Pods Plant $^{-1}$	0.34	0.19	0.09	-0.12
Number of Seeds Pod $^{-1}$	0.07	-0.18	0.37	-0.23
Biomass Yield ha $^{-1}$	0.37	0.11	0.27	0.24
Seed Yield ha $^{-1}$	0.17	0.19	0.42	0.36
Hundred Seed Weight	-0.10	0.22	-0.38	0.40
Eigenvalues	4.401	3.341	2.312	1.504
Proportion of Variance (%)	29.34	22.27	15.41	10.02
Cumulative Variance (%)	29.34	51.61	67.02	77.04

The 1st principal component accounted for the highest variability in the data compared with succeeding components. The 2nd principal component positively related with plant spread, pod length, plant height and pod filling period while negatively associated with days to 50 % flowering and days to 50% podding (Table 2). This implies that the potential candidate breeding materials could be selected from genotypes in first and second principal components. Earlier study in chickpea, Malik *et al*. (2014) reported the 1st four principal components with eigenvalue greater than one explained 71.99% of the total variation. In addition Malik *et al*. (2014) reported that seed yield, biomass yield, number of pods plant $^{-1}$, number of secondary branches plant $^{-1}$ and plant height positively associated with the first principal component while days to flowering, days to maturity and 100 -seed weight positively contributed to the second principal component.

Likewise Muniraja *et al*. (2011) reported that the 1st principal component was associated with pods plant $^{-1}$, seed yield plant $^{-1}$, plant height and number of secondary branches plant $^{-1}$. The 2nd principal component positively related with days to flowering, days to maturity and pod damage percentage.

Habibpour *et al*. (2012) reported the 1st five principal components explained 69.3 % of the total variations; first principal component was associated with tiller numbers, fertile tillers, biological yield and grain yield in wheat.

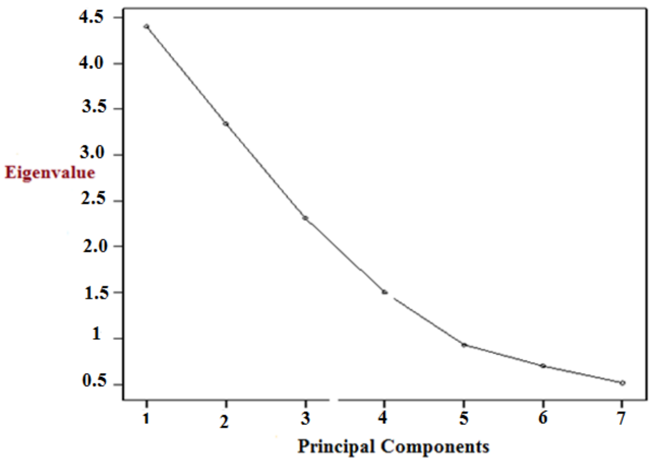

Figure 1. Scree Plot Constructed based on Seven Principal Component and their Eigenvalues

CONCLUSION

It can be concluded from the above results that correlation among most agronomic characters and seed yield were positive and highly significant. The results from this study indicated seed yield enhancement in chickpea was highly associated with biomass yield ha $^{-1}$, pod filling period, number of pods plant $^{-1,}$ number of primary branches plant $^{-1}$ and number of secondary branches plant $^{-1}$. The characters positively and significant correlated with seed yield could be used for indirect selection of high yielding chickpea genotypes in the region. Principal component analysis showed the existence of high genetic variation among genotypes. The main agronomic, yield and yield related traits explained 1st principal component as positive contributors. These could be a good indication for importance of both agronomic and yield related traits contributed to substantial total variations. The presence of substantial genetic variations, positive and significant correlation among agronomic and with seed yield traits can be exploited for future breeding programmes for improvement of chickpea in the region.

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REFERENCES

Aghili P, Imani AA, Shahbazi H, Alaei Y. 2012. Study of correlation and relationships between seed yield and yield components in lentil (Lens culinaris Medik). Annals of Biological Research 3 (11): 5042-5045.

Ahmad Z, Mumtaz AS, Nisar M, Khan N.2012. Diversity analysis of chickpea (Cicer arietinum L.) germplasm and its implications for conservation and crop breeding. Agricultural Sciences 3 (5): 723 – 731.

Al-Ghazawi AA, Bsoul E, Aukour F, Al-Ajlouni Z, Al-Azzam M, Ajlouni MM. 2011. Genetic variation for quantitative traits in Jordanian lentil landraces. Advances in Environmental Biology 5 (11): 3676 - 3680.

Ali Q, Ahsan M. 2012. Estimation of genetic variability and correlation analysis for quantitative traits in chickpea (Cicer arietinum L.). Inter J for Agro Veterinary and Medical Sciences 6 (4): 241- 249.

Ali Q, Tahir MH, Sadaqat SA, Farooq J, Ahsan M, Waseem M, Iqbal A. 2011. Genetic variability and correlation analysis for quantitative traits in chickpea genotypes (Cicer arietinum L.) J of Bacteriology Research. 3(1): 6 – 9.

Ali QM, Ahsan M, Khan NH, Ali F, Elahi M, Elahi F. 2012. Genetic analysis for various quantitative traits of chickpea (Cicer arietinum L.). Inter J for Agro Veterinary and Medical Sciences 6 (1): 51- 57.

FAOSTAT. 2008. Food and Agricultural Organization (FAO), Bulletin of Statistics. [Online] http://faostat.org/faostatcollectionsubset=agriculture

Habibpour M, Ahmadizadeh M, Shahbazi H. 2012. Assessment relationship between agro-morphological traits and grain yield in bread wheat genotypes under drought stress condition. African J of Biotechnology 11 (35): 8698- 8704.

IBPGR, ICRISAT, ICARDA. 1993. Descriptors for chickpea (Cicer arietinum L.). International Board of Plant Genetic Resources, Rome, Italy; International Crops Research Institute for Semi-Arid Tropics, Patancheru, India and International Center for Agricultural Research in the Dry Areas, Aleppo, Syria.

Kaluli W, Mwangi HM, Sira FN. 2011. Sustainable solid waste management strategies in Juja, Kenya. J of Agri. Sciences and Technology 13 (1): 79-90.

Karuku GN, Gachene CKK, Karanja N, Cornelis W, Verplancke H, Kironchi G. 2012. Soil hydraulic properties of a nitisol in Kabete. Tropical and Subtropical Agroecos15: 595 – 609.

Khan AK, Bangulzai MI. 2006. Effect of various levels of nitrogen fertilizer on the yield and yield attributes of pea (Pisum sativum L) cultivars. Pakistan J of Botany 38 (2): 331- 340.

Malik S, Bakhsh A, Asif MA, Iqbal U, Iqbal SM. 2010. Assessment of genetic variability and interrelationship among some agronomic traits in chickpea. Inter J of Agriculture and Biology 12: 81– 85.

Malik SR, Shabbir G, Zubur M, Iqball SM, Ali A. 2014. Genetic diversity analysis of morpho-genetic traits in desi chickpea (Cicer arietinum L.). Inter J of Agriculture and Biology 16: 956–960.

Mallikarjuna BPS, Upadhyaya HD, PV. Kenchana GPV, Kullaiswamya BY, Sing S. 2003. Phenotypic variation for agronomic characteristics in a groundnut core collection for Asia. Field Crops Research 84: 359–371.

Miheretu F. 2013. Correlation studies on yield components, seed and oil yield in coriander (Coriandrum sativum L.) landraces of Ethiopia. Wudpecker J of Agricultural Research 2 (10): 277 – 279.

Muniraja C, Satish RG, Raju C, Hart M. 2011. Principal component analysis among genotypes of chickpea (Cicer arietinum L.). Inter J of Agricultural Sciences **7**(2): 382-386.

Okonkwo FA, Idahosa DO. 2013. Heritability and correlation studies of yield characters in some soybean (Glycine Max) varieties in Ekpoma. American J of Research Communication 2325 - 4076: www.usa-journals.com.

Pratap N, Singh PK, Shekhar R, Soni SK, Mall AK. 2012. Genetic variability, character association and diversity analyses for economic traits in rice (Oryza sativa L.). SAARC J of Agriculture 10 (2): 83 – 94.

Qureshi AS, Shaukat A, Bakhsh A, Arshad M, Ghafoor A. 2004. Assessment of variability for economically important traits in chickpea (Cicer arietinum L.). Pakistan J of Botany 36 (4): 779-785.

Selvaraj CI, Nagarajan P. 2011. Interrelationship and path-coefficient studies for qualitative traits, grain yield and other yield attributes among maize (Zea mays L.). Inter J of Plant Breeding and Genetics 5 (3): 209 - 223.

Sombroek WG, Braun HMH, Vanderpouw BJA. 1982. Exploratory soil survey. Report No. E1. Ministry of Agriculture, Nairobi Kenya.

Vaghela MD, Poshiya VK, Savaliya JJ, Davada BK, Mungra KD. 2009. Studies on characters association and path analysis for seed yield and its components in chickpea (Cicer arietinum L.). Legume Resources 32 (4): 245 – 249.