Research Article

Determination of Genetic Variation and Association Analysis of Yield Contributing Traits for Suitable Selection Criteria in Chickpea

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Abstract | The main purpose of the study was to determine the suitable selection method for genetic improvement in chickpea. The current investigation was conducted at the research area of the Arid Zone Research Institute, Bhakkar, Punjab, Pakistan. Twelve chickpea genotypes were sown in RCBD following three replicates. Data regarding primary & secondary per plant, days for maturity, plant height as well as potential yield were recorded. The measured data were analyzed to principal component analysis (PCA), correlation, and path coefficient analysis. Analysis of variants revealed good variation among the accessions for the data recorded traits. Principal coefficient analysis differentiates all the traits into six PCs. Two components expressed more than one Eigenvalue which collectively contributed 80.12% towards the genetic variation. High positive loadings were expressed by the secondary branches per plant and pods per plant in all components. Path analysis revealed that secondary branches/plants expressed the highest direct positive effect (0.872) grain yield followed by the pods per plant (0.623). Analysis of correlation coefficient also confirmed the highest significant contribution of secondary branches per plant (91.57%) followed by pods (78.12%) and each plant's primary branches (64%). It was proved from the current experiment that Plants with secondary branches as well as pods may be focused on while assessing meaningful selection criteria for genetic improvement in chickpea.

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Introduction

Chickpea (*Cicer arietinum*) is the largest profitable Rabi pulse crop and stands 3rd worldwide after common bean and field pea (Padmavathiv *et al.*, 2013). It belongs to leguminoseae family and grown in tropical, subtropical, and temperate climates globally (Adams *et al.*, 2018; Agrawal *et al.*, 2018; Yadav *et al.*, 2001; Shafique *et al.*, 2016). Legumes are a rich source of nutrients including protein, carbohydrates and minerals (Adsule *et al.*, 1989; Dar *et al.*, 2016). These are not only the rich source of nutrients but has the good capability to fix the atmospheric N_2 into its roots and other succeeding crop (Gul *et al.*, 2011; Adams *et al.*, 2018). The probable average chickpea production potential appears to be substantially greater than 0.78 tons/ha. (Sudupak *et al*., 2002). Pakistan's average chickpea production is very low from the world's average production. Increasing the genetic potential to increase the yield is the core objective of the breeders (Collard *et al*., 2003).

Major issues for the low production are drought, environmental changes, scarcity of high yielding genotypes although the existing cultivars' genetic foundation is limited (Farshadfar *et al*., 2013). To overcome this challenge, It is critical to determine their genetic potential (Yaghoutipor and Farshadfar, 2007). Path analysis is the most common multivariate technique in the statistic. It's a kind of factor analysis that uses the principal component approach. (Yaghoutipor and Farshadfar, 2007; Darvishzadeh *et al*., 2011) and the most effective to analyze the genotypic correlation coefficient. Researchers seldom do not take interest in any single trait, they also focus on other characters and mutual relationships. Various traits are linked with each other for the production of the best phenotype (Adams *et al*., 2018; Mahmood *et al*., 2018; Mahpara *et al*., 2017) maximum yield is also associated with these traits (Saleem *et al*., 2002; Yucel *et al*., 2006).

Table 1: *Mean Monthly Climatic data of the location.*

Months	Max. Temperature (C°)	Min. Temperature C°)	Rainfall (mm)
October-2019	36	18	-
November-2019	28	13	11
Decemebr-2019	19	4	230
January-2020	18	4	24
February-2020	24	9	18
March-2020	23	13	114
April-2020	30	19	31

The study of yield and yield-related components provide the groundwork for choosing the best characteristics for chickpea development initiatives. The production of grain is beneficial and is substantially impacted by environmental factors (Singh *et al*., 2014). Correlation coefficient and path analysis may be utilized for the genotypes selection for the best chickpea breeding program (Sakthivel *et al*., 2019). Correlation and path coefficient analysis has been adopted by many researchers to check the direct and indirect impacts of chickpea genetic improvement (Amin *et al*., 2015; Pandey *et al*., 2015). There is a scarcity of knowledge on genetic variation and the relationship between various yield contributing characteristics. It is vital to approach information on genetic diversity in chickpea germplasm to use, as well as well as to look at the link between yield and yield-related factors. The goal of this investigation was to collect data on genetic variability and associations among various yield contributing variables to establish the most effective selection strategies for genetic improvement.

Materials and Methods

Research site

The research experiment was planned and conducted at Arid Zone Research Institute (AZRI), Bhakkar, Punjab, Pakistan during Rabi 2019-20. The annual rainfall is 250 mm with a temperature range of about -1 to 50 C°. Table 1 shows the climatic data relevant to the research region.

Research design

The expriment consisted of sixteen chickpea genotypes with three replications, was laid out in a randomised complete block design (RCBD). The plot was 4mx1.2m in size, with row to row 30cm spacing. The sowing was completed in October by a manual drill. All the cultural practices were applied equally when and on a required basis. Data of all parameters like primary & secondary branches/plant, days to maturity, and yield were recorded from time to time.

Table 2: *Performance of various traits of chickpea genotypes.*

Genotypes	PBPP	SBPP	NPP	PH (cm)	DM	YLD (kg/ha)
TG1910	2.15	8.22	45.00	38.00	155.00	1971
TG1912	1.77	7.34	48.24	34.55	167.25	1834
TG1903	2.35	6.90	34.05	41.90	156.50	1708
TG1902	2.67	5.00	35.50	29.90	151.25	1602
TG1904	1.90	4.33	24.50	31.50	162.00	1630
TG1911	2.00	7.00	28.00	27.00	159.00	1644
TG1908	2.00	6.76	32.25	35.50	161.70	1840
TG1901	1.88	7.00	20.67	52.00	155.90	1390
TG1905	2.50	6.00	22.70	39.00	156.90	1480
TG1906	2.00	5.45	29.90	34.35	164.00	1505
Bittle-2016	2.00	5.76	37.67	47.90	163.00	1532
Bhakkar-2011	2.70	6.44	30.00	38.70	149.00	1710

PBPP: *Primary branches/plant;* **SBPP:** *Secondary branches/plant;* **NPP:** *Numbers of pods/ plant;* **PH:** *Plant height;* **DM:** *Days to maturity;* **YLD:** *Yield.*

Table 3: *Mean square values of the contributing traits of chickpea entries.*

Source	DF	PBPP	SBPP	NPP	PH	DM	YLD
Replications	02	0.273	5.695	59.250	79.654	0.654	312.765
Genotypes	11	0.48*	2.967**	207.583**	24.987**	61.765**	8455.62**
Error	22	0.108	1.364	19.301	2.734	2.521	481.55

Statistical analysis

The data were analysed using principal component analysis. The approach described by Dewey and Lu (1959) was used to conduct the path analysis and correlation was assessed as suggested by Singh and Chaudhry (1979).

Results and Discussion

Results enables the selection of genotypes with the greatest field performance of the traits. Correlation analysis of various qualities is a critical and significant part of selection programmes as it enables breeders to make efficient selection decisions based on correlated and uncorrelated traits. Maximum number of primary branches (2.70) were recorded in the variety Bhakkar-2011 followed by the test entry TG1902 which has 2.67. The minimum primary branches were recorded by the entry TG1912 (1.77). Maximum numbers of secondary branches (8.22) were expressed by the accession TG1910 while minimum (4.33) were showed by the entry TG1904. Maximum numbers of pods per plant (48.24) were counted in TG1912 followed by TG1910 (45-00) while minimum numbers of pods (20.67) were recorded in TG1901.

Plant height is directly correlated with the yield. The excessive vegetative growth resulted in minimum yield. Maximum plant height (52.00) was expressed by TG1901 while minimum plant height (27.00) showed by the test entry TG1911. More days to maturity (167.25) were recorded in TG1912 followed by maturity days TG1906 (164.00) while early maturing behavior was noted in Bhakkar-2011 (149.00) days. Maximum yield potential (1971) was expressed by TG1910. Moreover, check varieties, Bhakkar-2011 and Bitle-2016 showed a yield potential of 1710 and 1532 kg/ha. Three test entries TG1910, TG1912 and TG1908 out-yielded both check varieties Bhakkar-2011 and Bittle-2016. The analysis of variance revealed substantial differences between genotypes in the characteristics studied (Table 3), increasing the reliability of selecting the genotypes with the best performance.

Principal component analysis was applied for testing of genetic variability distributed among the characters into six PCs. A bar graph was designed for quick and easy presentation of the results (Figure 1). Eigenvalues showed by all six components PC1, PC2, PC3, PC4, PC5 and PC6 were 3.76, 1.42, 0.81, 0.39, 0.20 and 0.10. The principal components 1st and 2nd expressed more than one Eigenvalues and showed 61% and 22.85% contribution towards the genetic variability with a cumulative share of 61 and 81.75% in genetic diversity (Table 4). Saleem *et al.* (2002); Yucel *et al.* (2006); Benbrahim *et al.* (2017) and Sharifi *et al.* (2018), reported on the same investigation. They also observed more than 80% of genetic variation by the first two components.

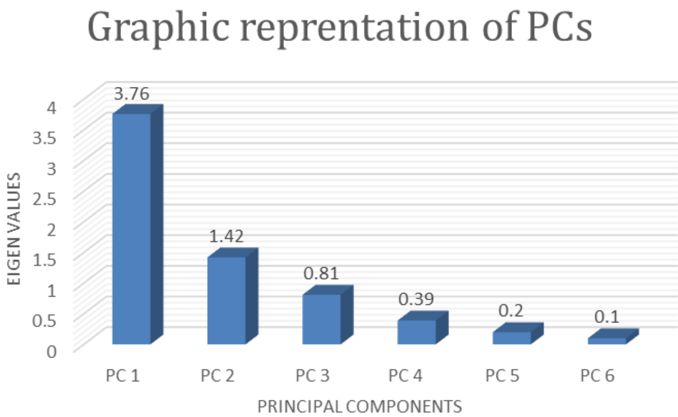

Figure 1: *Bar graph showing Eigen values.*

Table 4: *Principal component analysis among chickpea genotypes.*

Principal components	Eigen-value	% of variance	Cumulative % of variance
PC 1	3.76	61.00	61.00
PC 2	1.42	22.85	81.75
PC 3	0.81	12.12	88.90
PC 4	0.39	6.00	95.75
PC 5	0.20	2.97	96.90
PC 6	0.10	1.00	99.99

The differential study of the characters depicted in principal component analysis is evident that the number of major branches each plant (0.5507), the number of pods per plant (0.55010), and secondary branches/

plant (0.5486) were recorded in principal component one, while principal component analysis two depicted higher numbers of secondary branches/plant (0.6534) and numbers of pods per plant (0.5935) indicating that these characteristics share the best amount of genetic variation (Table 5). This study agreed with Rizwan *et al*. (2017) and Mahmood *et al*. (2017). They also found that secondary branches and pods per plant also contributed significant genetic variation.

Table 5: *Different traits performance in principal component analysis.*

Variables	PC1	PC2	PC3	PC4	PC5	PC6
PBPP	0.5507	0.4539	-0.0735	-0.7291	0.5287	0.1254
SBPP	0.5487	0.6534	-0.1051	0.2448	0.1030	0.2402
NPP	0.5010	0.5935	0.0396	-0.1992	-0.7830	0.2577
PH	0.2112	-0.2109	0.7892	0.0100	0.1956	0.0782
DM	-0.0300	0.2354	-0.5955	-0.2465	-0.0211	0.0457
YLD	0.4893	-0.0247	-0.2548	0.6147	-0.3087	0.5144

PBPP: *Primary branches/plant;* **SBPP:** *Secondary branches/plant;* **NPP:** *Numbers of pods/ plant;* **PH:** *Plant height;* **DM:** *Days to maturity;* **YLD:** *Yield.*

Table 6: *Direct effect of different characteristics of chickpea genotypes.*

Characters	PBPP	SBPP	NPP	PH	DM	YLD
PBPP	-0.148	-0.278	0.054	0.956	-0.435	0.076
SBPP	-0.076	0.924	0.213	-0.298	0.088	0.376
NPP	0.029	-0.281	0.741	-0.354	-0.231	0.987
PH	-0.145	-0.187	0.107	0.287	-0.329	0.421
DM	0.875	-0.078	0.065	-0.392	-0.432	-0.134

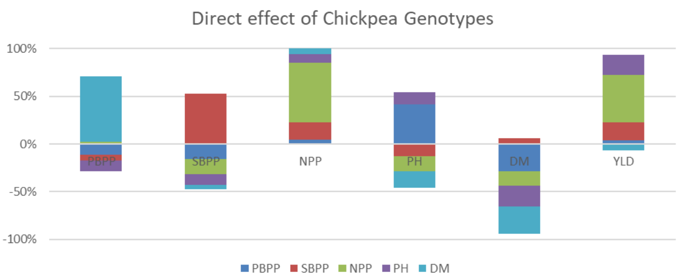

Figure 2: *Path coefficient performance.*

Path coefficient and correlation analyses were followed to establish a link between prospective yield and its constituents. The implementation of path analysis necessitates the existence of a cause-and-effect relationship between the variables. The formula proposed by Dewey and Lu (1959) can be used to calculate path analysis. It was revealed from the present study that significantly direct effect on yield of the chickpea was presented by the number of secondary branches per plant (0.924) and the number of pods per plant are also high (0.741) (Table 6; Figure 2) and the negative direct effect Days to maturity were documented. The same immediate positive impact in both secondary and pods/plant. Ali *et al*. (2011), Babbar *et al*. (2012) and Amin *et al*. (2013), have all made similar observations). Analysis of path coefficient suggested that plant's pod numbering and secondary branches/plant may be more considered as most effective agronomic character toward maximum yield contribution. The same results were reported by Tejashwini *et al*. (2018).

Correlation studies among all agronomic variables and yield-related factors can provide reliable knowledge about the information and extent of their interrelationship. It is very important to search out the best positive correlation among traits for better seed yield potential to enhance breeding efficiency. Correlation coefficient analysis was performed for all the genotypes for different yield (Table 7). The data clearly shows that secondary branches per plant have a strong positive association (0.993) towards the maximum yield production which was followed by the the number of major branches per plant (0734) and the number of pods per plant are also important factors to consider (0.723). It was clear from the current study that the number of days till harvest is inversely proportional to the yield.. It was reported by Ali *et al*. (2011). Delay in maturity or late-harvested test entry will give minimum yield. Secondary branches per plant significantly expressed a positive correlation to yield (99%) which was followed by the primary The number of branches per plant (73%) and the number of pods per plant (72%) are the features that have the biggest influence for determining the grain yield. Saleem *et al*. (2002), Yucel *et al*. (2006), Melese (2005) and Mallu *et al*. (2005), all found similar findings (2014).

Table 7: *Correlation coefficient of various chickpea traits.*

Characters	PBPP	SBPP	NPP	PH	DM	YLD
PBPP	1	0.833	0.894	0.177	-0.197	0.734
SBPP		1	0.934	0.457	0.023	0.993
NPP			1	0.456	-0.120	0.723
PH				1	0.345	0.300
DM					1	1

Conclusions and Recommendations

The results indicated that principal component analysis is very effective for assessing the genetic variation in chickpea crops. Our results shows a significant positive correlation among the primary, secondary, and pods/plant. The principal component analysis recognized the number of pods per plant and the amount of grain as a trait that briefly describes the variation among the chickpea genotypes. Results revealed that the genotypes possessing a higher The number of pods per plant and the number of secondary branches per plant are also important factors to consider and may be preferred for assessing genetic improvement in chickpea.

Novelty Statement

The researcher will be able to determine the suitable selection method for genetic improvement in chickpea through this investigation.

Author's Contribution

Abdul Ghaffar: Conducted the research trial and wrote the paper.
Niaz Hussain: Project administration.
Muhammad Nadeem: Analyzed and compiled the data.
Khalid Hussain: Provide resources.
Muhammad Aslam: Supervised the whole research.
Mudassar Khaliq: Collected data.
Muhammad Irshad: Corrected the paper.
Zubeda Parveen: Helped in data collection.
Muhammad Younas: Conceived the idea

Conflict of interest
There are no conflicts of interest stated by the authors.

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