ISSN: 2637-7721

MEDDOCS Open Access Publisher

Journal of Plant Biology and Crop Research

Open Access | Review Article

Correlation Analysis on Yield and Yield Related Components in the Chickpea Genotypes under Irrigation of North East Ethiopia

Alemu Doda Gemeda[1]*; Gudeta Nepir Gurmu[2]

[1]Ethiopian Institute of Agricultural Research, Kulumsa Agricultural Research Center, P.O.Box, 489, Assela, Ethiopia.

[2]Ambo University College of Agriculture and Veterinary Science School of Graduate Studies Department of Plant Science, Ambo, Ethiopia.

***Corresponding Author(s): Alemu Doda Gemeda**

Ethiopian Institute of Agricultural Research, Kulumsa Agricultural Research Center, P.O.Box, 489, Assela, Ethiopia.

Email: gemedalex@gmail.com

Received: June 10, 2024

Accepted: July 04, 2024

Published Online: July 11, 2024

Journal: Journal of Plant Biology and Crop Research

Publisher: MedDocs Publishers LLC

Online edition: http://meddocsonline.org/

Keywords: Chickpea; Correlation; Seed yield; Yield components.

Abstract

The present investigation was conducted to estimate the extent of twelve parameters association existing among 65 chickpea genotypes including one local check which was evaluated during off-season 2017/18 under 6 x11 alpha lattice design having three replications. Data were collected for days to 50% flowering, days to 90% maturity, total number of pod per plant, total number of seed per pod, plant height, total number of seed per plant, number of secondary branches, biomass, hundred seed weight, seed yield and harvest index. The success in plant breeding program mainly depends on availability of adequate information on the nature and magnitude of variation existing in breeding materials and interrelationships between quantitatively inherited plant traits. For exploring the suitability of chickpea genotypes under irrigation it is necessary to analysis yield and yield related parameters. The intention of correlation analysis is to understand the extent and strength of a trait to main parameters that would imply as selection indicator. Phenotypic correlation is the net result of genetic and environmental correlation. The dual nature of phenotypic correlation makes it clear that the magnitude of genetic correlation cannot be determined from phenotypic correlation. For this, a measure of correlation of yield and yield related traits in the available chickpea genotypes is important. Hence, this research was proposed to study genotypic and phenotypic association of grain yield with yield components. Number of pods per plant(r=1) and number of seeds per pod(r=1) had positive and high significant genotypic correlation coefficient with seed yield hence, direct effect on seed yield. Among the phenotypic traits considered, number of pods per plant(r=0.25) and number of seeds per plant(r=0.25) had positive correlation with seed yield could be used for indirect selection of increased seed yield. It can be concluded that seed yield in chickpea can be improved by selecting the plant that have greater number of pods per plant and number of seeds per plant.

Cite this article: Doda Gemeda A, Nepir Gurmu G. Correlation Analysis on Yield and Yield Related Components in the Chickpea Genotypes under Irrigation of North East Ethiopia. J Plant Biol Crop Res. 2024; 7(2): 1101.

Introduction

Ethiopia is one of the major countries of chickpea producers; chickpea is an important grain legume next to faba bean and common bean both in terms of area coverage and production. It is mainly grown as a source of food protein, income generation, and soil fertility renewal and used for animal feedstuff [1]. Chickpea grain production in area coverage in Ethiopia is about 242,703.73 hectares and whereas grain production is 4, 994, 25.550 ton and also with national average yield of 2.058 t/ha [2].

There are two main types of chickpea, distinguished by their seed size, shape and color: Desi produces relatively small seeds with an angular shape, light tan to dark color, and Kabuli produces large, rounded white to pale cream color seeds. Kabuli chickpea seeds are grown in temperate regions whereas the Desi type is grown in the semi-arid tropics [3].

Chickpea is being valued for its high dietary protein content, its ability to fix atmospheric nitrogen and the absence of specific major anti-nutritional factors. This makes it an important component of the cropping system and considered as nutritious and healthy food [4]. The seeds of chickpea contain protein of 16.7% to 30.6% for desi type and 12.6% to 29.0% for kabuli type, commonly 2-3 times higher than that of cereal grains; carbohydrate of 51-65% in desi type and 54 -71% in kabuli type [5]; lipid of 2.9% to 7.4% for desi and 3.4% to 8.8% for kabuli types, and high percentage of different minerals nutrients such as calcium, magnesium, potassium, phosphorus, iron, zinc and manganese [6].

The success in plant breeding program mainly depends on availability of adequate information on the nature and magnitude of variation existing in breeding materials and interrelationships between quantitatively inherited plant traits is of great importance [7].

Crop improvement depends on the availability of genes for better agronomic traits, such as disease resistance, earliness and high yield. For exploring the suitability of chickpea genotypes under irrigation it is necessary to analysis yield and yield related parameters. The intention of correlation analysis is to understand the extent and strength of a trait to main parameters that would imply as selection indicator. Breeders generally select for multiple traits. If the traits are unrelated, then there is no problem; we can select independently for each, possibly weighting effort or selection intensity by their importance [8]. Standard measure of correlation between two continuous variables is the Pearson correlation coefficient also known as the 'product moment' correlation coefficient [9]. If the traits are completely correlated there is no problem either, except to ask why we are measuring two traits in the first place when one will do. The problem is how to treat traits for which the correlation is less than perfect but too high to ignore. In some instances, it is useful to treat selection in different environments for the same trait, as if we were selecting for separate traits too. This approach can have advantages yet is not something that plant breeders generally do. If the variables are correlated, life is a little harder. We shall restrict the discussion to variables considered in pairs. This usually gets us most of what we require. The simplest way to study the relationship is to plot one variable against another. This is always worth doing. To quantify the way in which the two variables vary together, we use the covariance, which is analogous to the variance for a single variable. The correlation coefficient relating an individual trial's performance with the mean performance over all trials indicates how well the individual trial's results agree with the overall mean. Cereal variety trials' yield usually give correlation coefficients greater than 0.40 and therefore a trial with a correlation coefficient of less than this is an indication that the varieties are performing very differently at that site, i.e. that there is a variety x site interaction [10]. Phenotypic correlation is the net result of genetic and environmental correlation. The dual nature of phenotypic correlation makes it clear that the magnitude of genetic correlation cannot be determined from phenotypic correlation [11]. Indicated [12] that most of the character pairs had higher values of genotypic correlations with their corresponding phenotypic correlations. They obtained high amount of genotypic correlations which resulted due to masking or modifying effect of environmental on the association of characters. This indicates that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. Contrarily, the phenotypic correlation coefficients were higher than their genotypic correlation coefficients may be due to the non- genetic causes probably environment inflated the value of phenotypic correlation [13].

For this, a measure of correlation of yield and yield related traits in the available chickpea genotypes is important. Hence, this research was proposed to study genotypic and phenotypic association of grain yield with yield components.

Materials and methods

Experimental Site and Description of the Study Area

The experiment was conducted at Werer Agricultural Research Center (WARC) which is one of the Agricultural Research Centers of Ethiopian Institute of Agricultural Research (EIAR) during the cool season (November, 2017 to February, 2018 G.C). It is located in Afar National Regional State of the Federal Government of Ethiopia 280 km East of Addis Ababa with an altitude of 740 m.a.s.l. and at latitudes of 9° 60'N and 40° 09' E longitude. The dominant soil type of the study areas is Chromic Vertisol (clay to silt clay) with particle size distribution of Sand 3.83%, Silt 61.1% and clay 35.07 % with a bulk density of 1.17% [14]. The pH of the soil is slightly alkaline and ranges from 7.5 to 8.5. The mean annual rainfall is 540 mm and the mean maximum and minimum temperatures are 34^0C and 19^0C, respectively. Planting was done at the beginning of December 2017, using surface irrigation arrangement.

Experimental Materials

About 66 (65 accessions and one standard check) were obtained from Debre Zeit Agricultural research center in 2017 and used for this experiment.

Experimental Design

A total of 66 chickpea genotypes were laid in Alpha Lattice Design consisting of six incomplete blocks per each of the replications. Each block was planted with 11 entries. Each experimental plot was 4m x 0.60m (2rows per plot). Inter and intra row spacing of 30cm x 10 cm were used. Each plot was planted with two seeds per hill and thinned to one plant per hill 15 days after emergence. Agronomic practices such as irrigation and weeding were applied to the crop during experiment.

Table 1: Lists of 66 chickpea genotypes used in the study.

SerN0.	Name Genotypes	Status	Source	Types	Ser N0.	Name Genotypes	Status	Source	Types
1	FLIP-09-371C	Not released	ICARDA	Kabuli	34	FLIP-08-38C	Not released	ICARDA	Kabuli
2	FLIP-08-42C	Not released	ICARDA	Kabuli	35	ICCV-11106	Not released	ICARDA	Kabuli
3	FLIP-09-376C	Not released	ICARDA	Kabuli	36	FLIP-88-85C	Not released	ICARDA	Kabuli
4	FLIP-09-50C	Not released	ICARDA	Kabuli	37	FLIP-07-4C	Not released	ICARDA	Kabuli
5	FLIP-93-93C	Not released	ICARDA	Kabuli	38	FLIP-09-114C	Not released	ICARDA	Kabuli
6	FLIP-09-161C	Not released	ICARDA	Kabuli	39	FLIP-08-53C	Not released	ICARDA	Kabuli
7	ICCV-11102	Not released	ICARDA	Desi	40	FLIP-05-157C	Not released	ICARDA	Kabuli
8	FLIP-03-128C	Not released	ICARDA	Kabuli	41	FLIP-09-189C	Not released	ICARDA	Kabuli
9	FLIP-09-277C	Not released	ICARDA	Kabuli	42	FLIP-09-348C	Not released	ICARDA	Kabuli
10	FLIP-03-155C	Not released	ICARDA	Kabuli	43	FLIP-05-19C	Not released	ICARDA	Kabuli
11	FLIP-09-134C	Not released	ICARDA	Kabuli	44	FLIP-09-185C	Not released	ICARDA	Kabuli
12	FLIP-09-188C	Not released	ICARDA	Kabuli	45	FLIP-09-157C	Not released	ICARDA	Kabuli
13	FLIP-03-101C	Not released	ICARDA	Kabuli	46	FLIP-09-354C	Not released	ICARDA	Kabuli
14	FLIP-07-26C	Not released	ICARDA	Kabuli	47	FLIP-09-360C	Not released	ICARDA	Kabuli
15	FLIP-09-184C	Not released	ICARDA	Kabuli	48	FLIP-09-379C	Not released	ICARDA	Kabuli
16	FLIP-09-179C	Not released	ICARDA	Kabuli	49	FLIP-08-41C	Not released	ICARDA	Kabuli
17	FLIP-09-187C	Not released	ICARDA	Kabuli	50	FLIP-09- 240C	Not released	ICARDA	Kabuli
18	FLIP-09-146C	Not released	ICARDA	Kabuli	51	FLIP-03-125	Not released	ICARDA	Kabuli
19	FLIP-09-359C	Not released	ICARDA	Kabuli	52	FLIP-09-6C	Not released	ICARDA	Kabuli
20	FLIP-09-171C	Not released	ICARDA	Kabuli	53	FLIP-09-343C	Not released	ICARDA	Kabuli
21	FLIP-09-174C	Not released	ICARDA	Kabuli	54	FLIP-09-233C	Not released	ICARDA	Kabuli
22	FLIP-09-126C	Not released	ICARDA	Kabuli	55	FLIP-09-380C	Not released	ICARDA	Kabuli
23	FLIP-09-438C	Not released	ICARDA	Kabuli	56	FLIP-09-140C	Not released	ICARDA	Kabuli
24	FLIP-09-244C	Not released	ICARDA	Kabuli	57	FLIP-09-393C	Not released	ICARDA	Kabuli
25	FLIP-09-347C	Not released	ICARDA	Kabuli	58	FLIP-09-357C	Not released	ICARDA	Kabuli
26	FLIP-03-40C	Not released	ICARDA	Kabuli	59	FLIP-09-120C	Not released	ICARDA	Kabuli
27	FLIP-09-339C	Not released	ICARDA	Kabuli	60	ICC-4958/EJERE-P6-19	Not released	ICC-4958XEJEREP6-19 CROSSING	Desi
28	FLIP-09-162C	Not released	ICARDA	Kabuli	61	ICCX-060045-F3-P203-BP	Not released	ICCX060045-F3-P203-BP TLL	Desi
29	FLIP-09-241C	Not released	ICARDA	Kabuli	62	ICCV-11115	Not released	ICCV-11115	Desi
30	FLIP-09-18IC	Not released	ICARDA	Kabuli	63	ICC-4958/EJERE-P2-20	Not released	ICC-4958XEJEREP2-20 CROSSING	Desi
31	FLIP-09-261C	Not released	ICARDA	Kabuli	64	ICCX-060039-F3-P65-BP	Not released	ICCX-060039-F3-P65-BP TLL	Desi
32	FLIP-08-98C	Not released	ICARDA	Kabuli	65	ICCV-09108	Not released	ICCV-09108 ICRSAT	Desi
33	FLIP-09-309	Not released	ICARDA	Kabuli	66	Habru variety (Check)	released	DZARC	Kabuli

Field Managements

Land preparation was done in November 2017 using tractor and human labor. The soil was leveled to permit furrow irrigation. The rows were raised to increase soil surface area, aeration and drainage. Chickpea plants were sown by human labor into the prepared rows using inter and intra row spacing of 30cm x 10 cm, respectively. Furrow irrigation was applied throughout the crop growing season. Irrigation was applied once a week at emergence and every two weeks at flowering and pod production. Cultural practices were applied for weed control. The crop was harvested at maturity to determine at and after harvest parameters.

Traits Evaluated

The data for the following traits were recorded from five randomly selected plants from each experimental plot, and average value was considered: Days to 50% flowering, Days to physiological maturity, Number of pods per plant, Number of Seeds per plant. Number of branches per plant: Number of primary branches, Number secondary branches. Hundred seed weight, Plant height, Biomass, Harvest index and Grain yield per plot.

Statistical Analysis

Analysis of Variances

All collected data were subjected to analysis of variance using appropriate computer using SAS software. Duncan's Multiple Range Test (DMRT) at probability of 0.05 was used to separate the means and ranges for significant parameters.

Correlation Coefficients

Phenotypic and genotypic correlations among yield, yield related traits was estimated using the method described by [15].

$$r_{p_{xy}} = \frac{Cov_{p_{xy}}}{\sqrt{\sigma^2_{p_x}\sigma^2_{p_y}}}$$

Where, r_p = phenotypic correlation coefficient, $Covp_{xy}$ = Phenotypic covariance between character x and y, $\sigma^2 p_x$ = Phenotypic variance for character x, $\sigma^2 p_y$ = Phenotypic variance for character y

$$r_{p_{xy}} = \frac{Cov_{p_{xy}}}{\sqrt{\sigma^2_{p_x}\sigma^2_{p_y}}}$$

Whereas, rg = genotypic correlation coefficient, $Covg_{xy}$ = genotypic covariance between character x and y, $\sigma^2 g_x$ = genotypic variance for character x, $\sigma^2 g_y$ = genotypic variance for character y.

Result and Discussion

Estimate of phenotypic and genotypic correlation coefficients

Mutual association of the traits is expressed in phenotypic and genotypic correlation with direction and magnitude of correlation coefficients among seed yield and yield related traits.

Phenotypic and genotypic correlation coefficients of possible combinations of 12 characters of 66 chickpea genotypes are presented in Table 1 and 2.

Genotypic correlation coefficients

Genotypic Correlations of grain yield with related traits are presented in table 1. As presented in Table 1, the grain yield had highly significant and positive genotypic correlation with number of pods per plant(r =1), number of seeds per plant(r =1). This result is comparable with [16] who reported significant and positive genotypic correlation for number of pods per plant with grain yield. Also similar findings with [17] they reported that the positively significant association of grain yield per plant with number of pods per plant suggesting direct selection for these traits would therefore the most effective in the improvement of chickpea genotypes for grain yield. Similar results were reported by [18,19] who reported positive and significant relationships between seed yield and number of seeds per plant, number of pods per plant. These results suggest that any positive increase in such traits which will improve the seed yield of chickpea. The reverse is true in the finding of [20] who reported positively and highly significantly association of grain yield with harvest index, as a result, variation in harvest index had possibility of improving and boosting up grain yield in chickpea. Also found that [21] harvest index had significant positive association with seed yield and therefore selection for this trait would lead to high seed yield. On the other hand days to 50% flowering (r= -0.74), days to maturity (r = -1.0) and plant height (r = -0.80) had highly significant and negative genotypic association with grain yield. Similarly, biomass (rg = -0.73) and 100 seed weight (rg = -0.45) had significant negative genotypic association with grain yield. Similar findings with [22]. They were reported that days to 50% flowering and days to maturity had significant negative genotypic association with grain yield and they were suggested that significant negative genotypic association; this had a high indirect effect on seed yield.

Table 2: Genotypic correlations coefficient.

	DFF	DM	PPP	SPFP	PHT	SPP	PB	SB	BM	HSW	YLD	HI
DFF		0.61	-0.85	-0.22	0.46	-0.91	0.16	0.23	0.41	0.59	-0.74	-0.61
DM			-0.93	-0.04	0.57	-1	0.14	-0.2	0.56	0.39	-1	-0.82
PPP				0.21	-0.76	0.94	0.19	-0.1	-0.48	-0.73	1	0.88
SPFP					0.4	0.46	0.44	-0.4	0.45	-0.41	-0.19	0.16
PHT						-0.96	0.18	-0.2	0.97	0.38	-0.8	-0.15
SPP							0.19	-0.03	-0.51	-0.9	1	0.86
PB								0.2	1	-0.15	-0.32	0.55
SB									0.28	0.04	-0.23	-0.1
BM										0.12	-0.73	0.08
HSW											-0.45	-0.46
YLD												0.66

Keys: DFF: days of flowering; DM: days of maturity; PPP: number of pod per plant; SPFP: number of seed per pod; PHT: plant height; SPP: number of seed per plant; PB: primary branch; SB: Secondary Branch; BM: biomass (t/ha); HSW: hundred seed weight; and YLD (t/ha): yield t/ ha; HI: harvest index.

Phenotypic correlation coefficient

Phenotypic Correlations of grain yield with related traits are presented in table 2. The values of phenotypic correlations were in accordance with genotypic correlations, which reflect the due contribution of genotype in the expression of different traits. The information generated will help in understanding relationship between traits in studied population which subsequently may help in selection process for important traits in breeding program.

However, pods per plant (r = 0.25), seeds per plant(r = 0.25), and harvest index(r = 0.39) had moderate to high phenotypic association with grain yield. Traits viz number of seeds per pod (r = -0.08), days to maturity (r = -0.15), plant height (r = -0.25), number of primary branches (r = -0.15), number of secondary branches (r = -0.20), 100 seed weight (r = -0.22) and biomass yield (r = -0.6) had negatively lower to higher phenotypic correlation coefficients with grain yield.

On the other hand, negative and significant correlation coefficients (at phenotypic and genotypic level) of grain yield with days to flowering, days to 90% maturity and100 seed weight were recorded. This was disagreed with the findings of [17].

Table 3: Phenotypic correlation coefficients.

	DFF	DM	PPP	SPFP	PHT	SPP	PB	SB	BM	HSW	YLD
DFF											
DM	0.33										
PPP	-0.44	-0.36									
SPFP	-0.09	0.01	0.17								
PHT	0.28	0.26	-0.15	0.09							
SPP	-0.33	-0.3	0.74	0.21	-0.13						
PB	0.02	-0.05	0.14	0.15	-0.06	0.15					
SB	0.14	-0.14	0.04	-0.13	-0.08	0.05	0.04				
BM	0.07	0.09	0.02	0.15	0.36	-0.04	0.11	0.12			
HSW	0.44	0.18	-0.41	-0.22	0.18	-0.41	-0.07	0	0.04		
YLD	-0.28	-0.15	0.25	-0.08	-0.28	0.25	-0.15	-0.2	-0.6	-0.22	
HI	-0.28	-0.11	0.36	0.05	0.13	0.26	-0.05	-0.1	0.43	-0.2	0.39

In generally the study of associations among various traits is useful to breeders in selecting genotypes possessing groups of desired characteristics. Hence, in this investigation, chickpea genotypes were used and an attempt was made to see the inheritance, relationship of yield and its components and their implication in selection of better genotypes of chickpea. The pairs of traits which showed non-significant genotypic and phenotypic correlations indicate that they were independent with each another.

Conclusion

The intention of correlation analysis is to understand the extent and strength of a trait to main parameters that would imply as selection indicator. Phenotypic correlation is the net result of genetic and environmental correlation. The dual nature of phenotypic correlation makes it clear that the magnitude of genetic correlation cannot be determined from phenotypic correlation. In this study among the phenotypic traits measured, number of pods per plant and number of seeds per plant had positive correlation with seed yield could be used for indirect selection of increased seed yield.

References

1. BekeleN, B Tesso, A Fikre. Assess farmer's skills on Chickpea (Cicer arietinum L.) seed qualities and its components in East showa Zone, Ethiopia. Inter J AgriBiosci. 2019; 8(6): 306-311. www.ijagbio.com (©2019 IJAB. All rights reserved).
2. CSA. The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey. Report On Area and Production of Major Crops. Addis Ababa, Ethiopia. 2017.
3. Naser MS, Mohammad C, Ali AS, Ali MA, Abolfazl, AG. Nutritional evaluation of kabuli and desi type chickpeas (Cicer arietinum L.) for ruminants using in vitro gas production technique. African Journal of Biotechnology. 2008; 7(16): 2946-2951.
4. Mohammed I, Ahmed,AR, Senge B. Dynamic archeological properties of chickpea and wheat flour Dough's. Journal of Applied Science. 2011; 11: 3405-3412.
5. Wood JA, Grusak MA. Nutritional value of chickpea (Cicer arietinum L.). 2007.
6. Ibrikci H, Knewtson SJ, Grusak MA. Chickpea leaves as a vegetable green for humans: evaluation of mineral composition. Journal of the Science of Food and Agriculture. 2003; 83(9).
7. Kotal BD, Das A, Choudhury BK. Genetic variability and association of characters in wheat Triticum aestivum L.). Asian Journal of Crop Science. 2010; 2(3): 155-160.
8. Asuero AG, Sayago A, Gonz alez AG. The Correlation Coefficient. Department of Analytical Chemistry, Faculty of Pharmacy, the University of Seville, Seville, Spain. 2006.
9. Wadud A, Yaqoob M. Regression and correlation analysis in different cultivars of chickpea (Cicer arietinum L.). Sarhad Journal of Agricultural. 1989; 5(2): 171-176.
10. Knott B. Statistical methods and design in plant breeding and genomics. Armidale Animal Breeding Summer Course. Organized by the University of New England, Armidale, Australia. 2011.
11. Anwar J, Ali MA, Hussain M, Sabir W, Khan MA, et al. Assessment of yield criteria in bread wheat through correlation and path analysis. The Journal of Animal & Plant Sciences. 2009; 19.
12. Dev A, Verma P, Kumhar BL. Genetic Character Variability Studies in Desi Chickpea (Cicer arietinum L.) Genotypes. International Journal Current Microbiol. Applied Science. Euphytica. 2017; 27: 465-485.
13. Saki AI, Zaman MA, Tuhina-Khatun M, Kamal MM, Begum H. Genetic variability, correlation and path coefficient analysis for agronomic traits in chickpea (Cicer arietinum L.) The Agriculturists. 2009; 7(1&2).
14. Wendemagegn C, Abere M. (2012). Selected Physical and Chemical characteristics of Soil. 2012.
15. Miller PA, Williams JC, Robinson HF, Comstock RF. (1958). Estimationof genotypic and environmental variances and covariances in upland cotton and their implications in selection. Agronomy Journal. 1958; 50: 126-131.
16. Srivastav S, Lavanya GR, Lal GM. Genetic variability and character association for seed yield in chickpea (Cicer arietinum L.). Journal of Pharmacognosy and Phytochemistry. 2017; 6(4): 748-750.
17. Pandey A, Gupta S, Kumar A, Thongbam PD, Pattanayak A. Genetic divergence, path coefficient and cluster analysis of chickpea (Cicer arietinum L.) cultivars, in the mid-altitudes of Meghalaya. Indian Journal of Agricultural Sciences. 2013; 83(12): 1300-4.
18. Sharanappa SD, Kumar J, Meena HP, Bharadwaj C, Jagadeesh HM, et al. Studies on heritability and genetic advance in Chickpea (Cicer arietinum L.). Journal of Food Legumes. 2014; 27(1).

19. Zali H, Farshadfar E, Sabaghpour SH. Genetic variability and interrelation-ships among agronomic traits in chickpea (Cicer arietinum L.) genotypes. Crop Breeding Journal. 2011; 1(2): 127-132.

20. Khan A, Rahim M, Ahmad F, Ali A. Performance of chickpea genotypes under Swat valley conditions. Journal of Research (Science). 2004; 15(1).

21. Singh BD. Plant breeding. Kalyani publishers, New, Delhi, India. 1990; 702.

22. Sewak S, Iquebal MA, Singhl NP, Solankp RK, Lab S. Genetic diversity studies in chickpea (Cicer arietinum) germplasm. Journal of Food legumes. 2012; 25(1): 31-36.