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GENETIC DIVERGENCE AND CHARACTER ASSOCIATION OF KABULI-TYPE CHICKPEA (*CICER ARIETIUM*) GENOTYPE UNDER RAINFED CONDITIONS IN ETHIOPIA

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ABSTRACT

Chickpea is the major pulses grown in Ethiopia, mainly by subsistence farmers usually under rain-fed conditions Variability, heritability and correlation are the backbone of every selection method. The objective of the present study was to assess genotypic variability, heritability and correlation of 17kabuli-type genotypes for yield and yield related traits under rainfed condition. The experiments were conducted at the field area of Akaki, Chefe donssa, Deber zeit, Dembia and Haramay under RCB Design with four replication including 17 diverse genotypes of chickpea. There were significant genetic differences between genotypes for all the characters studied which suggested enormous scope of genotypes selection with desirable characters. High heritability for seed per pod, 100 seed weight and pod per plant high genetic advance revealed that additive gene effects were important in determining these traits. High heritability with low genetic advance for days to flowering and seed per pod indicated influence of dominant and epistatic genes. Estimation of correlation coefficients showed that pods per plant, plant biomass, plant height, and harvest index and 100-grain weight were positively correlated with grain yield. The traits, which revealed high amount of heritability and genetic advance, were controlled by additive genes, which advocated the chances of their improvement through selection. In the present investigation high to low heritability with moderate estimates of genetic advance recorded for pod per plant, seed per pod, plant height days to flowering, days to maturity,100 seed weight and grain yield where careful selection may lead towards improvement for these traits. Hence, provides better opportunities for selecting plant material for these traits in chickpea.

Keywords: Correlation, Environmental variance, Genetic advance, Genetic variability, Heritability, Phenotype variance, Yield components.

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1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is self-pollinated crop with diploid chromosome number (2n= 2x=16), and genus Cicer, tribe Cicereae, family Fabaceae, and subfamily Papilionaceae. Chickpea is the third leading legume grain in the world and third of the area and production of pulses following faba bean (V*iciafaba L.*) and haricot bean (*Phaseolus vulgaris* L.) in Ethiopia. Its range of cultivation extends from the Mediterranean basin to the Indian sub-continent and south ward of Ethiopia and eastern Africa highlands [1]. 92% of the area and 89% of production of the grain are concentrated in the semi-arid tropical countries [1].

The crop provides an important source of food and nutritional security for the rural poor, those who cannot produce or cannot afford costly livestock products as source of essential proteins. The consumption of chickpea is also increasing among the urban population mainly because of the growing recognition of its health benefits and affordable source of proteins. Chickpea is the cheapest and readily available source of protein (19.5%), fats (11.4%), carbohydrate (57-60%), ash (4.8%) and moisture (4.9-15.59%), more over its resistance to dry condition is also well recognized [2]. Chickpea is one of the most important crops in Ethiopia both in terms of its share of the total cropped pulse area and its role for human consumption. The total cultivated area of chickpeas in 2012 amounts to 231298.54 ha and its production 400207.719tones, but the national average yield of 1.73 ton/ha [3] remains less than its genetic potential indicating limited adoption of new high-yielding and stress tolerant varieties in Ethiopia. In the export market, chickpea contributes a significant portion of the total value of pulse exports. For example, chickpea constituted about 48% of the pulse export volumes in 2002. During this period of time, the exported volume accounts about 27% of the total quantity of chickpea production while the balance remains for domestic market [4]. However, in recent years, Ethiopia has exported around 0.03-0.05 million tones of chickpea annually, or around 10-15% of total production [5], to countries in South Asia, Middle East and North Africa (MENA), and Sub-Saharan Africa(SSA).

Research to improve the productivity of chickpea has been conducted for more than 40 years mainly at Debre Zeit Agricultural Research Center (DZARC) and other regional centers. Several new Desi- and Kabuli-type chickpea varieties have been developed through collaborative research programs involving ICRISAT and ICARDA [4]. Most of the improved chickpea varieties with their appropriate agronomic practices have been demonstrated to farmers.

The Kabuli type chickpeas are characterized by white-colored seed with ram's head shape, thin seed coat, smooth seed surface, white flowers, and lack of anthocyanin pigmentation on the stem. The plant is medium to tall in height, with large leaflets and white flowers. As compared to Desi types, the Kabuli types have higher levels of sucrose and lower levels of fiber. The Kabuli types generally have large sized seeds and receive higher market price than Desi types [6].

The concept of heritability explains whether the differences observed among individuals arose as a result of differences in genetic makeup or due to environmental forces. Genetic advance gives an idea of possible improvement of new population through selection, when compared to the original population. The genetic gain depends upon the amount of genetic variability and

magnitude of the masking effect of the environment. Information of the genetic variability, heritability and association of various characters provides a basis to the plant breeders to breed the chickpea genotypes possessing higher yield potential. Plant breeders are continuously engaged to improve the genetic yield potential of this crop to meet the demands of ever increasing population. The information on nature and magnitude of genetic variation in quantitative characters and their inter-relationship in population comprising diverse genotypes is an important prerequisite for systematic breeding program. Therefore several research workers [7-12] have emphasized the utility of the estimates of genetic components in the response prediction of quantitative characters to selection as well as the correlated response of various traits to grain yield. Hence, the present studies were undertaken in Ethiopia which falls under tropical climate to estimate the genetic component of variance for grain yield and its related traits to compute broad sense heritability, genetic advance in Kabuli-type chickpea.

2. MATERIALS AND METHODS

The present study was carried out to seek information on heritable variation and association of various characters with grain yield in breeding material for effective selection of genotypes for yield increments of chickpea during the 2012/13 main cropping season at five locations representing various chickpea growing agro-ecologies of Ethiopia. The testing sites were Akaki, Chefe Donsa, Debre Zeit, Dembia and Haramaya. Thirteen pipelines and four released Kabuli-type chickpea genotypes were included in the study. The plant materials were obtained from Debre Zeit Agricultural Research Center. Planting of the genotypes were done in early mid-August up to first week of September using Randomized Complete Block Design with four replications at each site under rain fed conditions. Each genotype was planted in a six row plot with four meter length. The plant-to-plant and row-to-row distances were maintained at 10 and 30 cm, respectively. Recommended cultural practices were adopted to maintain a healthy crop growth under rainfed conditions. Data were recorded on days to 50% flowering in a plot, 90% physiological maturity, plant height, number of pods per plant, number of seeds per plant, 100-seed weight, above ground dry biomass yield, grain yield, and harvest index. Harvest index was calculated as ratio between grain yield per plot and biological yield per plot. Data were computed by using SAS 9.1.3 for analysis of variance.

Table-1. Some characteristic features of the tested sites

Trial site	Soil type	Altitude (masl)	Rainfall average (mm)	Temperature (°C)		Geographical position	
				Min	Max	Latitude(N)	Longitude(E)
Akaki	Vertisol	2120	1055	10.36	22.3	08°52'	38°48'
Chefe Donsa	Vertisol	2450	950	10.5	23.2	08° 52'	39°08'
Dembia	Vertisol	2021	1000	14.0	29.2	12°1'	37°19'
Debre zeit	Vertisol	1950	851	10.8	26.9	08° 44'	38°58'
Haramaya	Vertisol	1980	780	15.8	24.3	9°26'	42°30'

Source: Debre Zeit Agricultural Research Center (2012)

Table-2. List of Kabuli-type chickpea genotypes included in the experiment

Entry no	Entry name	Entry no	Entry name	Entry no	Entry name
1	DZ-2012-CK-0001	8	DZ-2012-CK-0008	15	EJERE (SC)
2	DZ-2012-CK-0002	9	DZ-2012-CK-0009	16	HABRU (SC)
3	DZ-2012-CK-0003	10	DZ-2012-CK-0010	17	DZ-10-4
4	DZ-2012-CK-0004	11	DZ-2012-CK-0011		
5	DZ-2012-CK-0005	12	DZ-2012-CK-0012		
6	DZ-2012-CK-0006	13	DZ-2012-CK-0013		
7	DZ-2012-CK-0007	14	ARERTI (SC)		

3. RESULT AND DISCUSSION

3.1. Analysis of Variance and Genetic Diversity

Variability plays an important role in crop breeding. An insight in to the magnitude of variability present in crop species is of greatest importance as it provides the basis of selection. Results of analysis of variance revealed that genotypes differed significantly for all the characters recorded (Table 3).

The results, pooled analysis of variance for gain yield, indicated highly significant differences for genotype environment interaction (Table 3).Yield and its components are multigenic traits and are strongly influenced by environment in chickpea. Significant variation was observed for grain yield in chickpea by Khan, et al. [13]; Khan, et al. [14]. The maximum grain yield was recorded in the genotype DZ-2012-CK-0013, while minimum was noted in DZ-10-4. Days to flowering result revealed significant differences not only for genotypes but also high magnitude of genotype environment interaction, reflecting genetic variability in experimental material as well as difference in the environmental conditions (Table 3). Two varieties Habru and Ejeri with 49 days to 50% flowering were early in flowering where as DZ-2012-CK-0008 was late in flowering. Flowering time of a variety plays an important role in its selection and has a direct relationship with earliness or lateness of a genotype, because early flowering genotype usually mature early. Early flowering traits has significant beneficial effects by reducing crop duration in chickpea and escape most of the weather hazards like hill storm, floods, rains and diseases etc. Besides, it vacates the land early for sowing of succeeding crop. Days to flowering is mostly used as basis for determining the maturity. Maturity time of different genotype varied from 124 to 134 days. The genotype, Dz-10-4 matured in 124 days where as another genotype DZ-2012-CK-0006 matured in 134 days. Plant height results revealed significant differences not only for genotypes but also high magnitude of genotype environment interaction, reflecting genetic variability in experimental material as well as difference in the environmental conditions. Plant height ranged from 35cm to 49cm. The minimum plant height was recorded in Arerti and the maximum plant height was recorded in DZ-2012-CK-0009. It could be concluded from results that plant height is sensitive to environmental fluctuations and indicated that relative performance of genotypes was markedly inconsistent over the locations. These results are consistent with the findings of Malik, et al. [8] in chickpea. Number of pods per plant is an important selection criterion for the development of high yielding genotypes and is strongly influenced by environment in chickpea [8]. Marked variation was observed in the performance of genotypes over five locations. Pod per

plant ranged from 28-52. The maximum pod peer plant was obtained from the Dz-10-4 where as the minimum pod per plan was recorded from DZ-2012-CK-0006. Biological yield ranged from 1078g to 1810g. Minimum biological yield was obtained from Dz-10-4 whereas genotype DZ-2012-CK-0013 produced maximum biological yield 1810g, as well as maximum 100-seed weight 37g which is recorded from DZ-2012-CK-0006. 100 seed weight was also a highly variable character and the largest 100 seed weight was recorded from DZ-2012-CK-0006 which is 37g per 100 seed and the smallest from Dz-10-4 which is 17g per 100 seed. 100 seed weight is an important yield component which is genetically controlled Singh and Bains [15]; Khan, et al. [14]; Khan, et al. [13]. Harvest index of genotype were ranged from 31 to 43.The highest harvest index were recorded from Habru and the lowest was recorded DZ-2012-CK-0006.

Table-3. Mean performance of yield (kg/ha) and yield related traits of 17 Kabuli-type chickpea genotypes grown at five environments.

Genotypes	DF	DM	PPP	SPP	PHT	HSW	BM	HI	Mean YLD
DZ-2012-CK-0001	58	129	34	1.1	39	31	1775	37	2304
DZ-2012-CK-0002	57	132	34	1	39	33	1585	34	1968
DZ-2012-CK-0003	58	131	35	1	41	35	1640	32	2128
DZ-2012-CK-0004	57	129	33	1	38	30	1487	37	2042
DZ-2012-CK-0005	59	132	30	1	44	34	1540	37	2210
DZ-2012-CK-0006	58	134	28	1	40	37	1655	31	1774
DZ-2012-CK-0007	57	131	32	1	46	30	1585	33	1774
DZ-2012-CK-0008	60	133	33	1	43	36	1775	33	2135
DZ-2012-CK-0009	59	130	33	1	49	31	1572	36	2042
DZ-2012-CK-0010	51	131	41	1	43	34	1420	39	2090
DZ-2012-CK-0011	57	131	32	1	36	30	1335	34	1718
DZ-2012-CK-0012	52	130	34	1	46	31	1635	35	2023
DZ-2012-CK-0013	58	131	36	1	41	33	1810	38	2635
Arerti (SC)	57	127	43	1	35	24	1620	41	2412
Ejere(SC)	49	124	37	1	38	33	1438	41	2025
Habru (SC)	49	124	39	1	40	30	1395	43	2393
Dz-10-4	57	126	52	1.7	39	17	1078	39	1510
Means	56	130	36	1.1	41	31	1550	37	2081
CV (%)	5	2	15	18	9	5	15	14	18
LSD	2	2	3	0.1	2	1	141	3.1	56

Where: DF= days to flower, DM=days to mature, PPP= pod per plant, SPP= seed per pod, PHT=plant height, BM= biomass yield, HI= harvest index, HSW= hundred seed weight. SC= Standard check and YLD=yield

4. HERITABILITY AND GENETIC ADVANCE

The present investigation the heritability estimates were found to be high for 100 seed weight (98.7 %), seed per pod (93.5%), pod per plant (84.01 %), plant height (83.8.%), days to 90% physiological maturity(82.5%) and 50% days to flowering (89.8%). High heritability of 100-seed weight along with high genetic advance indicated that maximum improvement by selection could be possible considering this trait. Whereas low estimates of heritability was recorded for grain yield (47.7%).These results indicated the influence of dominant and epistatic genes for these characters. High value of heritability in broad sense indicates that the character is least influenced by environmental effects Muhammad, et al. [16]. Heritability alone provides no indication of the

amount of genetic improvement that would result from selection of individual genotypes. Hence knowledge about genetic advance coupled with heritability is most useful. Character exhibiting high heritability may not necessarily give high genetic advance. Johanson, et al. [17] showed high heritability should be accompanied by high genetic advance to arrive at more reliable conclusion. Genetic variance characters were extremely higher than the environmental variance indicating greater influence of genotype than environment on the trait (Table 4).The genetic advance (5% selection intensity) was highest for yield, number of pod per plant and 100 seed weight (Table 4). This implies that progress on improving seed yield could be achieved through simple selection of the number of pod per plant and 100 seed weight. These results get support from the findings of Burli, et al. [18] and Adhaikari and Pandey [19].

Phenotypic variance for number of days taken to 50% flowering, number of days taken to 90% maturity, plant height, and number of pod per plant, 100seed weight, number of seed per pod and seed yield was higher than genotypic variance indicating the influence of environmental factors.

Table-4. Genetic parameters for various quantitative characters in 17 Kabuli-type chickpea genotypes.

Character	Mean	Range	SE	Vg	Vp	Ve	$H^{2(\%)}$	GA%
DF	56.1	49-60	0.5	59	65.7	6.7	89.8	0.12
DM	129.9	124-134	1.0	36.8	44.6	29.6	82.5	3.47
PHT	41.1	35-49	0.4	63.9	76.2	12.3	83.8	5.92
PPP	35.9	28-52	1.0	155.85	185.5	29.6	84.01	14.41
SPP	1.01	1-1.7	0.01	0.145	0.155	0.01	93.5	0.01
HSW	30.8	17-37	0.3	179.3	181.6	2.3	98.7	14.11
YLD	2080.8	1510-2635	9.9	65.1	136.4	71.3	47.7	858.4

Where: SE= Standard Error, Vg. = Genotypic Variance, Vp. = Phenotypic Variance, Ve. = environmental variance, H^2 (%) = Heritability in Broad Sense, G. A. = Genetic Advance (5% selection intensity), value of k=1.554

Bartlett's test showed that homogenous error variance for the grain yield and allowed to proceed further for pooled analysis across environments. The combined analysis of variance (Table 5) for grain yield exhibited differences P≤0.01 among environments, genotypes and GEI, indicating differences in environments and the presence of genetic variability among genotypes.

Table-5. Mean sum of squares of yield and other traits from combined ANOVA of 17 Kabuli-type chickpea genotypes grown across five environments in Ethiopia

Source	DF	DF	DM	PPP	SPP	PHT	HSW	BM	HI	YLD
E	4	3225**	12608**	7937**	0.01**	1432**	401.1**	29037069**	11097**	1504219**
G	16	242.7**	155**	653**	0.59**	268**	719.5**	662654**	258**	84562**
G X E	64	81.4**	24**	198**	0.09**	21**	7.9**	243679**	63**	28149**
Error	240	6.7	7.8	29.6	0.01	12.3	2.3	51319	24.4	8138

DF= days to flowering, DM=days to maturity, PPP= pod per plant, SPP= seed per pod, PHT= plant height, HSW= hundred seed weight, HI= harvest index and YLD= grain yield.

4.1. Correlation Analysis of Quantitative Characteristics of Kabuli-Type Chickpea Genotypes

Plant biomass, plant height and above ground dry biomass, were positively correlated with days to flowering and negatively correlated with pod per plant and harvest index. This result is in accordance with the findings of Yousefi, et al. [20] and Ali, et al. [12] in chickpea. Pod per plant

and plant height were positively correlated with days to maturity and negatively correlated with hundred seed weight, grain yield and above ground dry biomass. Hundred seed weight, grain yield and harvest index were negatively correlated with pod per plant. Seed per pod was positively correlated with number of pod per plant. The positive association of pods per plant with other yield components had been reported by Malhotra, et al. [21] and Rao, et al. [22] in chickpea. Seed per pod were positively correlated with harvest index. Hundred seed weight and grain yield were negatively correlated with seed per pod. Grain yield, above ground dry biomass and hundred seed weight were positively correlated with plant height and negatively correlated with harvest index. Hundred seed weight were positively correlated with grain yield and above ground dry biomass. Above ground dry biomass was positive correlation with grain yield and negatively correlated with harvest index. Grain yield was positive correlation with harvest index (Table 6). Similar finding have been reported in chickpea researcher [23].

The analysis of the relationships among these characters and their associations with grain yield is essential to establish selection criteria. High and positively significant correlation were observed between plant height and above ground biomass(r= 0.54**), between days to flowering and above ground dry biomass(r= 0.51**) while high and negatively significant correlation were examined between seed per pod and hundred seed weight(r= 0.55**) (Table 6). This result in agreement with the works of Chavan, et al. [24]; Arshad, et al. [25].On the basis of the results i.e. the higher positive correlation of 50% days to flowering and plant height with above ground dry biomass, it is suggested that these two traits are the major and direct contributors towards biomass yield.

Table-6. Pearson Correlation Coefficients between yield and yield related components in 17 kabuli-type chickpea genotypes.

	DF	DM	PPP	SPP	PHT	HSW	BM	YIL	HI
DF	1.00								
DM	0.00ns	1.00							
PPP	-0.26**	0.14*	1.00						
SPP	-0.09ns	-0.02ns	0.21**	1.00					
PHT	0.18**	0.35**	0.10ns	-0.06ns	1.00				
HSW	0.19**	-0.18**	-0.46**	-0.55**	0.21**	1.00			
BM	0.51**	-0.25**	0.08ns	-0.10ns	0.54**	0.19**	1.00		
YLD	0.01ns	-0.43**	-0.35**	-0.10*	0.15**	0.29**	0.24**	1.00	
HI	-0.45**	-0.09ns	-0.25**	0.04*	-0.42**	0.00ns	-0.72**	0.40**	1.00

Where: YLD= grain yield, DF= days to flower, DM= days to mature, PPP= pod per plant, SPP= seed per pod, PHT=plant height, BM= biomass yield, HI= harvest index, HSW= hundred seed weight.

5. CONCLUSION

Chickpea is one of the major pulses grown in Ethiopia, mainly by subsistence farmers usually under rain-fed conditions Variability, heritability and correlation are the backbone of every selection method. There were significant genetic differences among the genotypes for all the traits, which suggested massive scope of selection for genotypes with desirable characters. The traits which revealed high magnitude of heritability and genetic advance were controlled by fixed genetic factors which advocate that they might be improved through selection. The characters

positively and significantly associated with grain yield could be reliable selection criteria for grain yield in chickpea for this group of genotypes. In the present investigation high to low heritability with moderate estimates of genetic advance recorded for pod per plant, seed per pod, plant height days to flowering, days to maturity,100 seed weight and grain yield where careful selection may lead towards improvement for these traits. Hence, provides better opportunities for selecting plant material for these traits in chickpea.

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