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Correlation and Path Coefficient Analysis for Grain Yield and Related Traits in Kabuli Chickpea (*Cicer arietinum L.*) at Central Highland of Ethiopia

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ABSTRACT

Chickpea (*Cicer arietinum L.*) is one of the most important pulse crop in Ethiopia. However, the national average productivity of chickpea is lower than the potential. The present study was carried out to assess the relationship between yield and yield related traits and measure the direct and indirect contribution of yield components on grain yield in kabuli chickpea using statistical procedures. Forty nine kabuli chickpea genotypes were studied for thirteen traits at Debre Zeit and Akaki using 7 × 7 simple lattice design in 2019 cropping season. The study results showed that grain yield had significant and positive correlations with harvest index, biological yield, number of primary branches, days to flowering and number of pod per plant both at genotypic and phenotypic levels indicating the possibility of improving these traits through selection. On the contrary, hundred seed weight had a significant and negative relationship with grain yield at the genotypic level. Path coefficient analysis revealed that harvest index (0.668) followed by biological yield (0.578) had the highest positive direct effect on grain yield, indicating that both traits could be considered important in kabuli chickpea yield improvement.

Keywords: Association; Chickpea; Correlation coefficient; Grain yield; Path coefficient; Relationship; Yield components

Introduction

Chickpea (Cicer arietinum L.) is a cool season food grain legume cultivated almost all over the world, including temperate and sub-tropical regions. It is cultivated on 17.8 million ha with a production of 17.2 million tons and productivity of 0.97 ton ha-1. Asia accounts 1 for 76.9% of the global chickpea production and Africa accounts for 4.3%. Ethiopia is the major chickpea producer in Africa, with a region occupying about 47% of the total area [1].

Chickpea is a good source of energy, protein, minerals, vitamins, fiber and also contains potentially health beneficial phytochemicals [2,3]. The protein concentration of chickpea seed ranges from 12.6%-30.6% and is commonly 2-3 times higher than that of cereal grains [4]. Chickpea also exhibits total lipid concentration ranges from 2.9%-8.8%. Since chickpea is high in fiber, low in sodium and fat, and also cholesterol free, it is a healthy food that is beneficial to the prevention of coronary and cardiovascular diseases. It may also lower blood cholesterol levels due to the high content of soluble fiber and vegetable protein [5]. It is consumed in various ways; seed, young shoots and pods are used for human consumption.

Chickpea is a widely grown pulse crop in Ethiopia, mainly in the central, northern and eastern highland areas of the country at an altitude of 1400-2300 m.a.s.l. where annual rainfall ranges between 700 and 2000 mm [6,7]. It is maintaining soil fertility through biological nitrogen fixation and saves fertilizer costs in subsequent crops. The crop is grown mainly on vertisol from late August to the end of September on residual moisture where seasonal water logging is severe. Its straw is used as animal feed and stalk and roots as fuel. It is also a cash source, which provides income for growers [8].

Grain yield is the most important quantitative trait, which is governed by both various genetic and environmental factors. Due to quantitative interaction, direct selection considering only grain yield could not be much more effective since both factors determine plant characteristics [9]. Therefore, effective improvement in yield may be through selection based on yield contributing characters. In this regard, information on correlation and path coefficients analyses is very important to plant breeders for selection and increased grain yield. The correlation coefficient is a measure of a linear association between traits, whereas path coefficient analysis measures the direct and indirect contribution of various yield components and other morphological characters on grain yield [10-12]. Therefore, the present study aimed to determine the association between different traits of kabuli chickpea and their contribution to grain yield improvement.

Materials and Methods

Forty nine genotypes of kabuli chickpea were grown in a simple lattice design with two replications at Debre Zeit Agricultural Research Center and Akaki research station. Of these 49 experimental materials, the two released varieties and all others were pipeline and obtained from Debre Zeit Agricultural Research Center (Table 1). The experiment was conducted under field conditions during 2018 main cropping season. The Debre Zeit Agricultural Research Center is characterized by annual minimum and maximum temperatures of 11.6 and 26.5° C, respectively and receives 821 mm annual rainfall. The soil type of the center is classified as black soil (vertisol). The Akaki research station has minimum and maximum annual temperatures of 7°C and 22.5° C, respectively and receives 1055 mm annual rainfall.

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The soil type of the experimental station is classified as Vertisol. Each plot consisted of four rows of four meters in length with a spacing of row to row and plant to plant distance was maintained at 30 and 10 cm, respectively. All recommended management practices were followed during the crop season. Observations for days to 50% flowering, grain filling period, days to maturity, plant height, number of primary branches, number of secondary branches, number of pods per plant, number of seeds per pod and number of seeds per plant were recorded on plot and plant basis. The data collected were subjected to statistical analysis. Phenotypic and genotypic correlation coefficients among different characters were estimated [13] and Path Coefficient Analysis were calculated (Table 1) [11].

No	Genotypes	Status	No	Genotype	Status
1	DZ-2012-CK-0260	Pipeline	26	DZ-2012-CK-0259	Pipeline
2	DZ-2012-CK-0261	Pipeline	27	DZ-2012-CK-0264	Pipeline
3	DZ-2012-CK-0265	Pipeline	28	DZ-2012-CK-0263	Pipeline
4	DZ-2012-CK-0268	Pipeline	29	DZ-2012-CK-0271	Pipeline
5	DZ-2012-CK-0273	Pipeline	30	DZ-2012-CK-0287	Pipeline
6	DZ-2012-CK-0275	Pipeline	31	DZ-2012-CK-0282	Pipeline
7	DZ-2012-CK-0277	Pipeline	32	DZ-2012-CK-0276	Pipeline
8	DZ-2012-CK-0279	Pipeline	33	DZ-2012-CK-0266	Pipeline
9	DZ-2012-CK-0281	Pipeline	34	DZ-2012-CK-0291	Pipeline
10	DZ-2012-CK-0283	Pipeline	35	DZ-2012-CK-0243	Pipeline
11	DZ-2012-CK-0284	Pipeline	36	DZ-2012-CK-0309	Pipeline
12	DZ-2012-CK-0285	Pipeline	37	DZ-2012-CK-0274	Pipeline
13	DZ-2012-CK-0286	Pipeline	38	DZ-2012-CK-0278	Pipeline
14	DZ-2012-CK-0288	Pipeline	39	DZ-2012-CK-0300	Pipeline
15	DZ-2012-CK-0242	Pipeline	40	DZ-2012-CK-0290	Pipeline
16	DZ-2012-CK-0244	Pipeline	41	DZ-2012-CK-0280	Pipeline
17	DZ-2012-CK-0061	Pipeline	42	DZ-2012-CK-0310	Pipeline
18	DZ-2012-CK-0305	Pipeline	43	DZ-2012-CK-0272	Pipeline
19	DZ-2012-CK-0246	Pipeline	44	DZ-2012-CK-0303	Pipeline
20	DZ-2012-CK-0065	Pipeline	45	DZ-2012-CK-0294	Pipeline
21	DZ-2012-CK-0249	Pipeline	46	DZ-2012-CK-0306	Pipeline
22	DZ-2012-CK-0064	Pipeline	47	DZ-2012-CK-0220	Pipeline
23	DZ-2012-CK-0178	Pipeline	48	Ejere	Released variety
24	DZ-2012-CK-0248	Pipeline	49	Hora	Released variety

Table 1: List of Experimental material used for the study.

Results and Discussion

Analysis of variance

The pooled analysis of variance showed genotype effects was statistically significant for all traits. These highly significant differences indicate the existence of variability among genotypes for all traits studied (Table 2).

Mean squares							
Traits	**Replication**	**Block(rep)**	**Genotypes**	**Location**	**Genotype x location**	**Error**	**CV**
DF	0.25	5.14	130.40**	326.58**	15.14**	4.51	3.77
DM	28.7	5.05	48.32**	4614.29**	8.55**	4.33	1.7
GFP	8.58	2.26	43.64**	1160.86**	10.48**	2.39	2.39
NPB	0.02	0.07	0.49**	15.32**	0.20**	0.07	8.42
NSB	1.26	0.43	6.59**	150.06**	1.45**	0.58	9.2
BY	19281717	1147181	2834392.7**	95865546**	1909765.6**	634066.4	13.61
PLHT	12.05	3.63	46.92**	2057.27**	18.42**	4.34	4.22
NPP	48.2	16.46	136.23**	3854.64**	54.21**	12.91	11.05
NSPP	116.02	25.78	236.22**	6482.55**	94.41**	20.7	12.07
NSP	0.02	0.004	0.03**	0.805**	0.02**	0.004	5.77
HSW	6.69	2.41	71.90**	1259.24**	6.19**	2.32	4.39

GY	1191743	169206.6	860734.7**	140232187.5**	430985.8**	136058	13.1
HI	363.49	32.53	233.51**	14776.43**	73.03ns	61.06	16.26

*, ** Significant at p ≤ 0.05, and p ≤ 0.01 probability level, respectively. DF=days to flowering, DM=days to maturity, GFP=grain filling period, PLHT=Plant height, NPB=number of primary branches, NSB=number of secondary branches, NPP=number of pods per plant, NSPP=number of seeds per plant, NSP=number of seeds per pod, BY=biological yield, HSW=hundred-seed weight, GY=grain yield, HI=harvest index, MS=mean square.

Correlation coefficient of agronomic traits

In the present study, estimates of phenotypic and genotypic correlation coefficients among 13 traits combined over two locations are presented in the below table. The magnitudes of genotypic correlation coefficients for most of the traits were higher than phenotypic correlation coefficients, which indicate the presence of inherent or genetic association among traits. The result of correlation analysis revealed that grain yield had significant and positive genotypic and phenotypic correlations with harvest index, biological yield, and number of primary branches, days to flowering, number of secondary branch and number of pods per plant.

These results indicate that genotypes with high harvest index, biological yield, number of primary branches, days to flowering and number of pods per plant produce high seed yield and vice versa. A significant and positive correlation of grain yield with the number of pod per plant, number of primary branches, number of seeds per plant and biological yield at both phenotypic and genotypic levels was reported [14,15]. On the contrary, hundred seed weight had a significant and negative relationship with grain yield at the genotypic level. This may indicate the fact that when a hundred seed weight (seed size) increases the number of seeds per pod and number of pods per plant reduced in most cases, which in turn leads to a reduction in yield. This significant and negative correlation of grain yield with hundred seed weight is in accordance with the findings of [15,16]. Days to maturity, number of seed per plant and number of seed per pod showed positive and significant association with grain yield at the genotypic level. These indicate that the genotype with late maturity, the high number of seed per plant and the high number of seed per pod produce high seed yield and a similar finding was previously reported [17].

The biological yield had a positive and significant phenotypic and genotypic correlation with days to flowering, days to maturity, number of primary branches and number of secondary branches. This indicates that breeding for increased biomass yield might result in a high number of primary and secondary branches and produce late flowering and late maturing genotypes. Similar results were reported [14]. Days to flowering was positively and significantly correlated with days to maturity, number of primary and secondary branches. The result showed that late flowering genotypes are expected to mature late and produce a high number of primary and secondary branches. A similar association between days to flowering and days to maturity was reported [18].

The number of pods per plant had a positive and significant correlation with days to maturity, number of secondary branches, and number of seeds per plant and harvest index at the genotypic level. On the other hand number of pods per plant had a positive and significant correlation with the number of seeds per plant and the number of seeds per pod both at the phenotypic and genotypic levels. Improving these traits increases the development of the number of pods per plant that support increasing grain yield [19]. The number of primary branches had a significant and positive phenotypic and genotypic correlation with the number of secondary branches and days to maturity. This result is in harmony with [20], who reported a significant and positive correlation number of primary branches with the number of secondary branches and days to maturity.

Hundred seed weight had a significant and negative phenotypic and genotypic correlation with the number of pod per plant, number of seeds per pod and number of seeds per plant. This negative association indicates a compensatory relationship between them. Similar to the present result, [16,17] found the correlation of hundred seed weight with number of pods per plant and number of seeds per pod to be significant and negative. The correlation coefficient analysis exhibited that harvest index showed a significant and positive association with days to maturity, number of secondary branch and number of seeds per plant at the genotypic level. These show that genotype with high number of secondary branches, high number of seeds per plant and late maturity producing high harvest index (Table 3).

Traits	DF	DM	GFP	PLHT	NPB	NSB	NPP	NSPP	NSP	BM	HSW	HI	GY
DF	1	0.642**	-0.332*	0.07	0.438**	0.403**	0.435**	0.416**	0.303*	0.484**	-0.149	0.470**	0.694**
DM	0.546**	1	0.510**	0.199*	0.484**	0.429**	0.444**	0.450**	0.311*	0.572**	-0.307*	0.429**	0.718**
GFP	-0.465**	0.488**	1	0.166	0.104	0.076	0.057	0.086	0.043	0.161	-0.210*	0	0.105
PLHT	0.174	0.377**	0.217*	1	0.082	0.084	0.058	0.069	0.044	0.094	-0.032	0.099	0.137
NPB	0.426**	0.368**	-0.054	-0.1	1	0.499**	0.412**	0.432**	0.246*	0.551**	-0.183	0.335**	0.624**
NSB	0.296*	0.206	-0.091	0.053	0.447**	1	0.288*	0.247*	0.074	0.429**	-0.081	0.380*	0.572**
NPP	0.224	0.076	-0.154	-0.031	0.181	-0.065	1	0.932**	0.500**	0.373*	-0.536**	0.435**	0.598**
NSPP	0.227	0.101	-0.13	-0.041	0.192	-0.12	0.933**	1	0.620**	0.391**	-0.584**	0.447*	0.610**
NSP	-0.055	-0.128	-0.079	-0.119	-0.076	-0.352*	0.381**	0.547**	1	0.289*	-0.545**	0.410**	0.507**
BY	0.551**	0.563**	0.022	0.224	0.489**	0.340*	0.083	0.066	-0.048	1	-0.077	0	0.656**
HSW	0.125	0.038	-0.09	0.119	0.032	0.216	-0.543**	-0.639**	-0.603**	0.198	1	-0.358**	-0.331*

HI	0.138	-0.332*	-0.494**	-0.143	0.043	0.106	0.21	0.274	0.28	-0.365*	-0.162	1	0.738**
GY	0.642**	0.175	-0.485**	0.039	0.487*	0.395*	0.304*	0.233	0.205	0.503**	0.034	0.601**	GY

*,** Significant at p ≤ 0.05 and p ≤ 0.01 probability level, respectively. DF=days to flowering, DM=days to maturity, GFP=grain filling period, PLHT=Plant height, NPB=number of primary branches, NSB=number of secondary branches, NPP=number of pod per plant, NSPP=number of seed per plant, NSP=number of seed per pod, BY=biological yield, HSW=hundred seed weight, GY=grain yield,

Table 3: Correlation coefficient (r) of different traits at genotypic (above diagonal) and phenotypic level (below diagonal) in chickpea.

Path coefficient analysis

The phenotypic and genotypic direct and indirect effects of different grain yield characters were presented in Tables 4 and 5, respectively. The result showed that the harvest index had the highest direct effect on grain yield, followed by biological yield at the phenotypic level. The two traits had a significant and positive correlation with yield. The highest positive and direct effect of harvest index and the biological yield on grain yield were reported [21]. Although, the number of primary branches, days to flowing and number of secondary branches had a positive direct effect on grain yield, its high indirect effect via biological yield counterbalances the very low direct effect of those traits on grain yield. The number of pod per plant had a small positive direct effect on grain yield. However, these smaller positive direct effects can be counterbalanced by the high direct effect through the harvest index. The grain filling period had a negative direct effect and the phenotypic correlation it had with grain yield was also negative and significant.

Traits	DF	GFP	NPB	NSB	NPP	BY	HI	rp
DF	0.065	0.025	0.02	0.004	0.009	0.405	0.113	0.642
GFP	-0.03	-0.054	-0.003	-0.001	-0.006	0.016	-0.406	-0.485
NPB	0.028	0.003	0.047	0.006	0.007	0.36	0.035	0.487
NSB	0.019	0.005	0.021	0.014	-0.003	0.251	0.087	0.395
NPP	0.015	0.008	0.009	-0.001	0.04	0.061	0.173	0.304
BY	0.036	-0.001	0.023	0.005	0.003	0.736	-0.299	0.503
HI	0.009	0.027	0.002	0.002	0.008	-0.268	0.821	0.601

DF=days to flowering, DM=days to maturity, GFP=grain filling period, PLHT=Plant height, NPB=number of primary branches, NSB=number of secondary branches, NPP=number of pod per plant, NSPP=number of seed per plant, NSP=number of seed per pod, BY=biological yield, HSW=hundred seed weight, GY=grain yield, HI=harvest index, rp=phenotypic correlation with grain yield.

NSB

Table 4: Phenotypic direct (bold and diagonal) and indirect effects of different traits on grain yield of chickpea.

Traits	DF	DM	NPB	NSB	NPP	NSPP	NSP	BM	HSW	HI	rg
DF	0.037	0.026	0.009	0.006	0.037	-0.024	0.009	0.28	-0.001	0.314	0.694
DM	0.024	0.04	0.01	0.007	0.038	-0.026	0.009	0.331	-0.001	0.286	0.718
NPB	0.016	0.019	0.021	0.008	0.035	-0.025	0.007	0.318	-0.001	0.224	0.624
NSB	0.015	0.017	0.01	0.015	0.025	-0.014	0.002	0.248	0	0.254	0.572
NPP	0.016	0.018	0.008	0.004	0.085	-0.053	0.015	0.216	-0.002	0.29	0.598
NSPP	0.015	0.018	0.009	0.004	0.079	-0.057	0.019	0.226	-0.003	0.298	0.61
NSP	0.011	0.012	0.005	0.001	0.043	-0.035	0.03	0.167	-0.002	0.274	0.507
BM	0.018	0.023	0.011	0.007	0.032	-0.022	0.009	0.578	0	0	0.656
HSW	-0.006	-0.012	-0.004	-0.001	-0.046	0.033	-0.017	-0.045	0.005	-0.239	-0.331
HI	0.017	0.017	0.007	0.006	0.037	-0.025	0.012	0	-0.002	0.668	0.738

DF=days to flowering, DM=days to maturity, GFP=grain filling period, PLHT=Plant height, NPB=number of primary branches, NSB=number of secondary branches, NPP=number of pod per plant, NSPP=number of seed per plant, NSP=number of seed per pod, BY=biological yield, HSW=hundred seed weight, GY=grain yield, HI=harvest index, rg==genotypic correlation with grin yield

Table 5: Genotypic direct (bold and diagonal) and indirect effects of traits on grain yield in chickpea.

Harvest index, which had a significant and positive association with grain yield, exhibited the highest direct effect on grain yield. The next highest direct effect on grain yield was recorded from biological yield, which also had a significant and positive association with grain yield. These results indicate that both traits had a true association with grain yield and their importance in determining these complex traits. Therefore, an important consideration should be given while practicing selection aimed at the improvement of grain yield. These results were in accordance with [22], who reported the highest direct effect of harvest index and the biological yield on grain yield.

Days to maturity and number of the primary branch had a positive direct effect on grain yield but low magnitude. However, both traits had a high positive indirect effect on grain yield via biological yield. Similarly, the number of pod per plant, number of secondary branches, number of seeds per pod and days to flowering had a positive indirect effect on grain yield through harvest index. The number of seed per plant had a negative direct effect on grain yield; likewise, the significant and positive correlation between the number of seed per plant and grain yield might be due to the considerable indirect impact of the number of seed per plant via harvest index and biological yield Tables 4 and 5.

Conclusion and Recommendations

Grain yield had a significant and positive phenotypic and genotypic correlation with harvest index, biological yield, and number of primary branches, days to flowering, number of secondary branch and number of pod per plant. By selecting these traits that reveal a positive and significant correlation with grain yield, there is a possibility of increasing the grain yield of chickpea. Path coefficient analysis based on grain yield as a dependent variable showed that harvest index and biological yield had the highest direct effects on yield at phenotypic and genotypic levels. Since these two traits had a positive and significant association with grain yield in the selection process, much attention should be given to them as these traits are helpful for indirect selection to improve yield in chickpea.

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