

Correlation and Path Coefficient Analysis Among Seed Yield and Yield Related Traits of Ethiopian Chickpea (*Cicer arietinum*L.) Landraces

Awol Mohammed^{1*} And Asnake Fikre²

¹Sirinka Agricultural Research Center, Woldia, Ethiopia

²ICRISAT Ethiopia

Abstract

*An experiment was under taken on 202 new chickpea (*Cicer arietinum* L.) accessions and two released varieties to determine the association of different characters with seed yield, direct and indirect influence of characters towards yield and yield contributing traits. The experiment was planted at Sirinka and Jari test stations under rain fed condition in 2016 using alpha lattice design with three replications. Data were collected on yield and yield related traits. Analysis of variance showed highly significant differences ($P < 0.001$) among the tested genotypes. The correlation of grain yield with biomass ($r_g = 0.71$ and $r_{ph} = 0.72$) and with harvest index ($r_g = 0.52$ and $r_{ph} = 0.54$) was positive and highly significant both at genotypic and phenotypic levels. In addition, its association with pod filling period, plant height, secondary branches and hundred seed weight was positive but non-significant both at genotypic and phenotypic levels. Path coefficient analysis at genotypic level showed that among the fifteen causal (independent) traits; biomass (0.84), harvest index (0.69), pod length (9.73), days to pod setting (0.024), pod filing period (0.020), and number of pods per plant (0.019) had positive directly influence on grain yield. Despite the days to flowering, plant height and hundred seed weight had positive genotypic correlation with grain yield, and their direct effects on grain yield were negative. This implies that the observed positive correlations of these traits with grain yield were due to their indirect positive effects on grain yield through primary branches, number of seeds per pod, biomass, pod length, canopy width and harvest index. Therefore, future selection of chickpea genotypes should be focused on traits which had positive correlation and direct effect on grain yield at both genotypic and phenotypic levels for obtaining high yield in chickpea breeding program.*

Key words: Chickpea, direct and indirect relation, seed yield, traits.

*Corresponding author email: mawol50@yahoo.com

Introduction

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world next to dry bean and field pea (Padmavathi *et al.*, 2013). Southeast Turkey and Syria are considered as the two primary centers of origin of chickpea (Singh *et al.*, 1997). The world chickpea production reached 13.3 million tons in 2013 and 14.2 million tons in 2014 (FAO, 2014). India is the largest chickpea producing country accounting for 72% of the global chickpea production (Ojiewo, 2016). Ethiopia is considered as one of the secondary centers of diversity for chickpea (Van der Maesen, 1987). In Ethiopia, chickpea is the second largest legume crop in area and production, next to faba bean (CSA, 2017).

There are two types of chickpea depending on seed color, shape, and size: kabuli and desi. The kabuli type has large, round or ram head and cream-colored seeds, and it is grown in temperate regions (ICRISAT, 2010). The desi type chickpea is grown in the semi-arid tropics and it is characterized by relatively small angular shaped seeds with light brown, yellowish or black colour (ICRISAT, 2010).

Chickpea is very important due to its good nutritional value having an average of 4.5% fat, 8% crude fiber, 22% protein, 63% carbohydrate and 2.7% ash (Shafique *et al.*, 2016). Besides being an important source of human food and animal feed, it is also an important contributor to soil fertility as it provides nitrogen to soil through fixation of atmospheric nitrogen (Gul *et al.*, 2011).

Many international agreements proclaim food security which implies the conservation of plant genetic resources for food and agriculture. The landraces or farmer varieties are important source of the genetic diversity and potential material that could be used to broaden the base for plant breeding. An indigenous landrace is a variety with a high capacity to tolerate biotic and abiotic stress, resulting in high yield stability and an intermediate yield level under a low input agricultural system (FAO, 1998). Ethiopia has a large number of chickpea landraces which are cultivated by the farmers through traditional method of selection over a long time which constitute the basic material for developing any variety or hybrid.

Study of yield and yield components provide a basic framework for selecting useful characters in chickpea improvement

programs. Seed yield is an important character that is polygenic in nature and significantly influenced by environmental conditions (Singh *et al.*, 2014). Most plant breeders are interested in maximizing selection efficiency that supports the identification of best genotypes. Estimation of correlation coefficient is useful in planning future breeding and providing a measure of association among traits, which could be useful as a selection guide. The path coefficient analysis enables to determine the direct and indirect contribution of various traits toward yield. Correlation analysis provides information of associations among yield components. Path coefficient analysis permits the separation of the correlation coefficient into component of direct and indirect effects and to measure the relative importance of each (Singh and Chaudhary, 1977; Sharma, 1998). The objective of this study was set to determine the association of different characters with seed yield, direct and indirect influence of characters towards yield and yield contributing traits and assess the magnitude to define seed yield.

Materials and Method

Description of Experimental Sites

The experiment was executed under rain fed condition at Sirinka and Jari Agricultural stations. The former one is located at 11° 45' North latitude and 39° 36' 36" East longitudes. Its altitude is 1850 meter above sea level located in North Wollo Zone. The annual rainfall of this site is 1006.3mm with 13.6°C minimum and 26.7°C maximum temperature. Jari is located at 11° 21' North latitude and 39° 47' East longitudes and at an altitude of 1680 meter above sea level in South Wollo Zone. The annual rainfall of this site is 987.3 mm with 14.2°C minimum and 28.7°C maximum temperature. According to Sirinka Agricultural Research Center soil classification (unpublished), the soils of the sites are classified as *Vertisols*.

Experimental Materials and Design

A total of 202 newly collected Desi type landrace from Amhara, Oromiya and SNNP Regional States were used for this study. The collection expedition was done on elevations ranging from 1174 to 2660 meter above sea level. The collections were made in 2013 (N=42) and 2016 (N=160). This puts 90 landraces from Amhara region, 91 from Oromiya and 24 from SNNP (Appendix table

1). A total of 202 collected landraces with two released varieties as checks, Fetenech (early maturing) and Minjar (high yielder) were used for this study. The experiment was planted on 02 September 2016 by using alpha lattice design with three replications. Each landrace was sown in two rows at 60 cm, 30 cm, and 10 cm spacing between plots, rows, and plants, respectively, with 1 m row length. All agronomic practices were done uniformly for all accessions as required. There was no fertilizer application. For controlling pod borer, *Karat* was sprayed at the rate of 200ml/300 liter/ha and picked by hand.

Data Collection

The data of morphological, phenological, and agronomical traits were collected during the growth period of the crop, depending on the descriptors for chickpea (IBPGR, ICRISAT and ICARDA, 1993). The data of plant height, stem color, number of leaflet per leaf, plant canopy width, number of primary branches, number of secondary branches, pod length, number of pods per plant, number of seeds per pod, days to 50% flowering, days to 50% pod setting, pod filling period, days to 75% maturity, total biomass, hundred seed weight, seed yield, harvest index, seed coat color, seed shape, diseases and insect damage score (1-9) and seed testa texture.

Analysis of Variance

Analysis of variance (ANOVA) was performed for the quantitative data using SAS computer software (SAS, 2004) as per the following linear model for alpha lattice design.

$Y_{ijk} = \mu + R_i + B_{ij} + T_k + e_{ijk}$: Where, μ = the grand mean of trait **Y**; **R_i** = the effect of Replicate **I**; **B_{ij}** = effect of Block **j** within Replicate **I**; **T_k** = Effect of treatment **k**

Phenotypic and Genotypic Correlation Coefficients

Phenotypic and genotypic correlation was estimated using the formula suggested by Miller *et al.* (1958)

Phenotypic correlation was computed as: r_{pxy}

$$= \frac{\sigma^2_{pxy}}{\sqrt{(\sigma^2_{px})(\sigma^2_{py})}}$$

Genotypic correlation was computed as: r_{gxy}

$$= \frac{\sigma^2_{gxy}}{\sqrt{(\sigma^2_{gx})(\sigma^2_{gy})}}$$

Where r_{pxy} is phenotypic correlation coefficient and r_{gxy} is genotypic correlation coefficient between characters x and y; σ^2_{pxy} and σ^2_{gxy} are phenotypic covariance and genotypic covariance between characters x and y, respectively. σ^2_{px} and σ^2_{gx} are phenotypic and genotypic variances for character x and σ^2_{py} and σ^2_{gy} are

phenotypic and genotypic variances for character y.

The coefficient of correlation at phenotypic level was tested for its significance with table for simple correlation coefficient using n-2 df as suggested by Gomez and Gomez (1984) or using 't' table, with observed t expressed as

$$t = \frac{r_{p_{xy}} \sqrt{n-2}}{\sqrt{1-r_{p_{xy}}^2}}$$

The calculated 't' value was compared with the tabulated 't' value at n-2 degree of freedom, (n=204) at 5% and 1% level of significance (where n is the number of genotypes). The coefficient of correlation at genotypic level was tested according to Robertson (1959);

$$t = \frac{r_{g_{xy}}}{SEr_{g_{xy}}} \quad \text{Where, } r_{g_{xy}} = \text{genotypic}$$

correlation coefficient,
SEr_{g_{xy}}= standard error of genotypic correlation coefficient

$$SEr_{g_{xy}} = \sqrt{\frac{(1-r_{g_{xy}}^2)^2}{2h_1^2 h_2^2}}$$

Where h²₁ and h²₂ are broad sense heritability for character 1 and 2

The calculated 't' value was comparing with the 't' tabulated value at n-2 (df = 202) at the

5% and 1% level of significance (where n is the number of accessions).

Path Coefficient Analysis

Association of yield with its components was determined by the application of correlation and path analysis. The use of path analysis requires a cause and effect situation among the variables. Path coefficient analysis was calculated using the formula suggested by Dewey and LU (1959) to assess direct and indirect effects of different traits on grain yield as:

$$r_{ij} = p_{ij} + \sum r_{ik} p_{kj}$$

Where r_{ij} is mutual association between the independent traits (i) and the dependent trait (j) as measured by the correlation coefficient, p_{ij} is component of direct effect of the independent trait (i) on the dependent variable (j); and r_{ik}p_{kj} is

the components of indirect effect of a given independent trait (i) on the dependent traits (j) via all other independent traits (k). The residual effect (U) which is the unexplained variation of the trait that is not accounted for by path coefficient and was calculated using the formula of Dewey and LU (1959) as:

$$U = \sqrt{1-R^2}, \text{ where } R^2 = \sum r_{ik} p_{kj}$$

Result and Discussion

Analysis of Variance

Analysis of variance revealed highly significant differences ($P < 0.001$) among

Table 1: Mean squares, significance and CV% of morpho-agronomic characters of chickpea germplasm

Traits	Mean square (CV %)		
	Sirinka	Jari	Combined
DF	24.25** (6.56)	23.73** (5.04)	4.24 ^{ns} (8.2)
DP	31.23** (6.46)	15.06** (4.89)	9.73 ^{ns} (4.98)
PFP	18.70** (6.07)	24.54** (5.02)	5.99 ^{ns} (6.23)
DM	42.32** (4.28)	22.08** (5.68)	5.39 ^{ns} (4.52)
CW	38.83** (8.15)	122.25** (11.5)	14.03* (22.31)
NL _t L	0.87** (5.97)	3.04* (15.78)	0.79* (16.23)
PH	31.12** (9.85)	96.27** (17.60)	8.61** (20.13)
PB	0.72** (19.65)	0.05 ^{ns} (21.5)	0.11 ^{ns} (28.9)
SB	11.11** (17.16)	0.62 ^{ns} (20.42)	1.88* (25.61)
NPP	520.46** (21.02)	267.32* (28.6)	50.90** (30.2)
NSP	0.08 ^{ns} (12.06)	0.02 ^{ns} (15.23)	0.029 ^{ns} (11.6)
PL	0.24** (26.5)	0.65* (29.42)	0.25* (31.2)
HSW	8.34** (13.23)	6.27** (12.52)	0.43 ^{ns} (8.96)
GYKH	441140.22** (28.66)	393086.47** (24.56)	23558.56 ^{ns} (30.2)
BMKH	1936174.5** (25.97)	1734469.2* (29.62)	123242.6 ^{ns} (32.21)
HI	240.00** (21.48)	189.23* (18.96)	1.42 ^{ns} (28.9)

DF = Days to flowering, DP = Days to pod setting, PFP = Pod filling period, DM = Days to maturity, CW = Canopy width, NL_tL = Number of leaflets per leaf, PH = Plant height, PB = Primary branches, SB = Secondary branches, NPP = Number of pods per plant, NSP = Number of seeds per pod, PL = Pod length, HSW = Hundred seed weight, GYKH = Grain yield kilo gram per hectare, BM = Biomass kilo gram per hectare, HI = Harvest index, ^{ns} = non – significant and *, ** significant at 5% and 1% probability level, respectively.

This low magnitude of mean squares indicated that the traits were relatively sensitive to environmental effects. These results are also confirmed similarly by

reports of Zerihun (2011), Feven (2002) and Melese (2005).

Correlation Studies

Studies on correlations among agronomic traits and seed yield can supply reliable information on the nature and level of their inter relationships. Identification and exploitation of traits positively attributing to seed yield is essential as it enhances breeding efficiency of chickpea. In this study, genotypic and phenotypic correlation coefficients for all possible combinations among 16 traits are presented in Table 2.

Association of Grain Yield with Other Traits

The linear correlation coefficient analysis determines the magnitude and degree of relationship between two traits. Association between traits could be due to genotypic correlation, which is attributed to linkage between genes or pleiotropic gene effect (Shafique *et al.*, 2016), or due to environmental effect, or both (Falconer and Mackey 1996). The correlation of grain yield with biomass ($r_g = 0.71$ and $r_{ph} = 0.72$) and with harvest index ($r_g = 0.52$ and $r_{ph} = 0.54$) was positive and highly significant both at genotypic and phenotypic levels. The correlation of grain yield with pod filling period, plant height, secondary branches and hundred seed weight was positive but non-significant both at genotypic and phenotypic

levels. Muhammad *et al.* (2005) reported similar results. On the other hand, the correlation of grain yield with days to maturity, primary branches, and number of seeds per pod was negative but no significant at both levels.

The genotypic correlations of grain yield with days to flowering, days to pod setting, canopy width and number of pods per plant were positive but not significant. On the other hand, grain yield was negatively and non-significantly correlated with number of leaflets per leaf. However, genotypic correlation between grain yield and biomass yield

was positive and highly significant, which is in agreement with the reports of Zerihun (2011), Melese (2005), and Tesfamickael *et al.* (2014). That means breeding for better biomass cultivars could be an indirect selection on chickpea improvement or landrace promotion.

Associations Among Other Traits

Days to flowering was positively and significantly correlated with days to maturity, days to pod setting, number of leaflets per leaf, secondary branches, number of pods per plant, and hundred seed weight, but negatively correlated with primary branches

at phenotypic and genotypic level (Table 2). Moreover, the genotypic correlation coefficients of days to flowering with these traits were greater than the corresponding phenotypic correlation coefficients, indicating genetic causes for the observed association. As a result, late flowering varieties are expected to take long duration to develop pods and mature late. According to Thakur and Sirohi (2009), genotypic correlation coefficients higher than that of phenotypic correlation coefficients indicate strong inherent association between the traits and the possibility of effective phenotypic selection.

Days to maturity showed significant and positive correlations with days to flowering, days to pod setting, number of leaflets per leaf, canopy width, secondary branches, number of pods per plant, and hundred seed weight at both phenotypic and genotypic levels. This is in agreement with Zerihun (2011). However, the correlation of days to maturity with primary branches and number of seeds per pod was negative at both phenotypic and genotypic levels (Table 2).

Plant height correlated positively and strongly with days to pod setting, number of leaflets per leaf, canopy width, and pod filing

period; but negatively associated with number of seeds per pod both at genotypic and phenotypic levels. Primary branches had strong negative correlation with days to pod setting, pod filing period, days to maturity, and secondary branches at genotypic level; and with harvest index at phenotypic level. On the other hand, it had positive and significant correlation with number of pods per plant and number of seeds per pod at phenotypic level.

Secondary branches had high positive correlation with days to flowering, days to pod setting, pod filing period, canopy width, plant height, number of pods per plant, and hundred seed weight at both phenotypic and genotypic levels. However, it showed negative correlation with primary branches at both levels.

Hundred seed weight showed high positive correlation with days to flowering, days to pod setting, days to maturity, plant height, and secondary branches both at genotypic and phenotypic level; but negatively associated with the number of seeds per pod at both levels. Biomass yield had high positive correlation with grain yield at genotypic and phenotypic levels, but negatively correlated with harvest index at

both levels (Table 2). Generally, among the 16 traits in this study, biomass and harvest index correlated positively and significantly with grain yield at both genotypic and phenotypic levels.

In general, all positive correlation between grain yield with traits of pod filling period, plant height, secondary branches, hundred seed weight and biomass both at genotypic and phenotypic levels are best traits which are important in the direct selection process.

Table 2 Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among 16 traits of 204 chickpea genotypes

Trait	DF	DP	FPF	DM	CW	NLtlL	PH	PB	SB	NPP	NSP	HSW	GY	BY	HI	PL
DF		0.94**	0.03	0.48**	0.24**	0.17*	0.44	0.23**	0.32**	0.17*	-0.18	0.25**	0.04	-0.07	0.1	0.10
DP	0.89**		0.09	0.44**	0.25**	0.17*	0.43**	-0.25	0.32**	0.16*	0.16*	0.27**	0.02	-0.05	0.09	0.09
FPF	-0.1*	0		0.35**	0.06	0.2*	0.32**	-0.2*	0.19*	0.16*	0.17*	0.2*	0.06	0.01	0.06	0.1
DM	0.39**	0.35**	0.33**		0.24*	0.27**	0.44**	-0.18*	0.24*	0.15*	0.15*	0.10	-0.01	-0.03	0.01	0.07
CW	0.16	0.16**	0.12*	0.18**		0.04	0.55**	-0.05	0.42**	0.29**	0.01	-0.02	0.05	0.05	0.01	0.01
NLtlL	0.11*	0.11*	0.09*	0.16**	0		0.18*	-0.11	0.09	-0.02	0.04	0.05	-0.06	-0.07	0.01	0.03
PH	0.34**	0.33**	0.29**	0.37**	0.54**	0.10*		-0.11	0.51**	0.5**	0.23*	0.17*	0.1	0.04	0.1	0.03
PB	0.18**	-0.2**	0.17**	0.15**	0.01	-0.06	-0.06		-0.14*	0.07	0.06	0.06	-0.05	0.03	-0.12	0.03
SB	0.20**	0.22**	0.13*	0.19**	0.39**	0.05	0.42**	-0.06		0.57**	0.02	0.14*	0.05	-0.02	0.06	0.08
NPP	0.12*	0.12*	0.16**	0.15**	0.32**	-0.03	0.46**	0.08*	0.55**		0.04	0.05	0.02	0.01	-0.03	0.01
NSP	-0.13	-0.13*	-0.11*	-0.1*	0.06	0.07	-0.12*	0.08*	0.06	0.08		-0.2*	-0.08	-0.04	-0.06	0.07
HSW	0.18**	0.18**	0.13	0.11*	-0.01	0.01	0.12*	0.04	0.09*	0.05	0.14*		0.07	0.09	-0.02	0.04
GY	-0.04	-0.02	0.06	-0.02	-0.02	0.04	0.05	-0.05	0.02	-0.01	-0.06	0.04		0.72**	0.54**	0.02
BY	-0.1*	-0.07	0.06	-0.01	0.01	-0.03	0.02	0.02	0.03	-0.03	-0.03	0.05	0.71**		-0.18*	0.04
HI	0.06	0.06	0.01	-0.01	-0.05	0.07	0.04	-0.10*	0.03*	-0.01	-0.05	-0.04	0.52**	0.22**		0.02
PL	-0.06	-0.07	0.04	-0.03*	0.01	-0.04	0.01	-0.01	-0.06	-0.04	0.03	-0.03	0.04	-0.03	0.07	

DF = Days to flowering, DP = Days to podding, DP = Pod filling period, DM = Days to maturity, CW = Canopy width, Number of leaflets per leaf, PH = Plant height, PB = Primary branches, SB = Secondary branches, NPP = Number of pods per plant, NSP = Number of seeds per pod, HSW = Hundred seed weight, GY = Grain yield, BY = Biomass, HI = Harvest index, PL = Pod length, and *, ** significant at 5% and 1% probability level, respectively

Path Coefficient Analysis

Grain yield is a resultant of many component traits known as yield components.

Associations between yield and yield components as determined by correlation coefficients do not indicate the relative

importance of the direct and indirect effects of associated trait on grain yield. Hence, path coefficient analysis would give the opportunity to see grain yield as the dependent variable and other traits as casual factors (independent variables). The results of genotypic path coefficient analysis are given in Table 3.

Path coefficient analysis at genotypic level showed that among the fifteen causal (independent) traits: biomass (0.84), harvest index (0.69), pod length (9.73), days to pod setting (0.024), pod filing period (0.020), canopy width (0.003), primary branches (0.007), secondary branches (0.003), and number of pods per plant (0.019) had positive directly influence on grain yield.

Other traits, such as days to flowering (-0.016), days to maturity (-0.015), number of leaflets per leaf (-0.004), plant height (-0.019), number of seeds per pod (-0.002), and hundred seed weight (-0.002) had negative direct effects on grain yield. This study's findings are also in line with the reports of Yucelet *et al.* (2006), Yucel and Anlarsal (2010), Ali *et al.* (2011) and Jadhav *et al.* (2014) in chickpea. Padmavathi *et al.*, (2013) also reported high positive direct effects of biological yield, number of pods per plant, and harvest index on grain yield signifying

the importance of these traits in the improvement of grain yield.

Pod length exerted the highest direct effect (9.73), and also positive indirect effects on grain yield via pod filing period, plant height, number of pods per plant, and harvest index. However, the positive direct effect of pod length on grain yield was counter balanced by relatively high negative indirect effects via days to flowering, days to pod setting, days to maturity, canopy width, number of leaflets per leaf, primary branches, secondary branches, number of seeds per pod, hundred seed weight and biomass which resulted in negative correlation with grain yield ($r_g = -1.44$) (Table 3). Biomass yield exerted the second highest positive direct effect (0.84) on grain yield. It also exhibited positive indirect effects on grain yield through pod filing period, canopy width, plant height, primary branches, number of pods per plant and hundred seed weight. However, it had high negative indirect effects on grain yield through days to flowering, days to pod setting, days to maturity, number of leaflets per leaf, secondary branches, and number of seeds per pod, harvest index, and pod length. Although the days to flowering, plant height and hundred seed weight had positive genotypic correlation with grain yield, their

direct effect on grain yield were negative. This implies that the observed positive correlations of these traits with grain yield were due to their indirect positive effects on grain yield through primary branches, number of seeds per pod, biomass, pod length, canopy width and harvest index. This indicates the importance of these traits in the breeding program to identify high yielding genotypes through indirect selection for these traits. According to Singh and Chaudhary (1977), whenever a character has positive association and high positive indirect effects but negative direct effect on economic trait like grain yield, emphasis should be given to the indirect effects. The estimated residual effect of path analysis was low (0.156), which indicated that about 85% of the variability in grain yield was contributed by the traits studied. This residual effect towards grain yield in the present study might be due to other characters or environmental factors and, or sampling errors (Sengupta and Kataria, 1971).

According to the path coefficient analysis at phenotypic level biomass (0.86), harvest index (0.71), pod length (0.01), days to pod setting (0.021), primary branches (0.004) hundred seed weight (0.003) and number of pods per plant (0.011) had positive directly influence on grain yield and signifying the importance of these traits in the improvement of grain yield (Table 4).

Other traits, such as days to flowering (-0.02), days to maturity (-0.004), number of leaflets per leaf (-0.02), plant height (-0.04), canopy width (-0.01), secondary branches (-0.04), and pod filing period (-0.01) had negative direct effects on grain yield (Table 4). The estimated residual effect of path analysis at phenotypic level was low (0.168), which indicated that about 84% of the variability in grain yield was contributed by the traits studied (Sengupta and Kataria, 1971).

Table 3 Genotypic direct (bold, underlined and diagonal) and indirect effects of 15 traits on grain yield for 204 chickpea genotypes

Traits	DF	DP	PFP	DM	CW	NL/L	PH	PB	SB	NPP	NSP	HSW	BM	HI	PL
DF	<u>0.016</u>	0.023	0.001	0.07	0.001	-0.02	-0.09	-0.02	0.001	0.003	0.001	-0.01	-0.06	0.069	-9.82
DP	0.015	<u>0.024</u>	0.002	0.06	0.001	-0.01	-0.08	-0.02	0.001	0.003	0.001	-0.01	-0.04	0.061	-8.33
PFP	0.001	0.002	<u>0.020</u>	0.05	0.002	-0.01	-0.06	-0.05	0.001	0.003	0.001	-0.01	0.010	0.04	9.60
DM	0.007	0.010	0.006	<u>0.02</u>	0.001	-0.01	-0.08	-0.01	0.001	0.003	0.001	-0.01	-0.02	0.009	-6.25

CW	0.004	0.006	0.001	0.03	0.003	-0.01	-0.01	-0.01	0.001	0.005	-1.3	3.49	0.044	0.004	-6.72
NLL	0.003	0.004	0.003	0.03	0.001	-0.04	-0.04	-0.01	0.001	-0.01	-6.2	-0.01	-0.06	0.007	-3.04
PH	0.007	0.010	0.006	0.06	0.002	-0.01	-0.02	-0.01	0.002	0.009	0.001	-0.01	0.035	0.067	3.31
PB	0.004	-0.06	-0.04	0.03	-0.01	0.001	<u>0.002</u>	0.01	-0.01	0.001	-0.01	-0.01	0.024	-0.08	-2.77
SB	0.005	0.007	0.003	0.03	0.001	-0.01	-0.01	-0.01	0.003	0.011	-2.7	-0.01	-0.02	0.041	-7.56
NPP	0.003	0.003	0.003	0.02	0.001	6.48	-0.09	0.001	0.001	0.019	-7.4	-0.01	0.007	-0.02	1.30
NSP	0.003	-0.04	-0.03	0.02	2.42	-0.01	0.004	0.001	5.22	0.001	-0.02	0.001	-0.03	-0.04	-6.99
HSW	0.004	0.007	0.004	0.02	-4.8	-0.02	-0.03	0.005	0.001	0.001	0.004	-0.02	0.08	-0.01	-3.90
BY	0.001	-0.01	0.001	4.82	0.002	0.001	-0.01	0.001	-6.1	0.001	6.9	-0.01	0.84	-0.12	-3.71
HI	0.002	0.002	0.001	0.01	2.02	-3.7	-0.01	-0.01	0.001	-6.2	0.001	4.37	-0.15	0.69	2.18
PL	0.001	-0.01	0.002	0.01	-2.2	1.11	-0.01	-0.01	-0.01	0.001	0.001	9.37	-0.03	0.02	9.73

DF = Days to flowering, DP = Days to podding, DP = Pod filling period, DM = Days to maturity, CW = Canopy width, Number of leaflets per leaf, PH = Plant height, PB = Primary branches, SB = Secondary branches, NPP = Number of pods per plant, NSP = Number of seeds per pod, HSW = Hundred seed weight, BM = Biomass, HI = Harvest index, PL = Pod length; **Residual= 0.156**

Table 4 Phenotypic direct (bold, underlined and diagonal) and indirect effects of 15 traits on grain yield for 204 chickpea genotypes

Traits	DF	DP	PFP	DM	CW	NLL	PH	PB	SB	NPP	NSP	HSW	BM	HI	PL
DF	-0.02	0.019	0.000	-0.002	0.000	0.000	-0.01	-0.01	-0.01	0.001	0.000	0.001	-0.07	0.039	-0.001
DP	-0.02	0.021	0.000	-0.002	0.000	0.000	-0.01	-0.01	-0.01	0.001	0.000	0.001	-0.06	0.045	-0.001
PFP	0.002	0.000	-0.01	-0.001	0.000	0.000	-0.01	-0.01	-0.01	0.002	0.000	0.000	0.049	0.008	0.000
DM	-0.09	0.008	0.000	-0.004	0.000	0.000	-0.01	-0.01	-0.01	0.002	0.000	0.000	-0.01	-0.06	0.000
CW	-0.04	0.003	0.000	-0.001	-0.01	0.000	-0.02	0.000	-0.02	0.004	0.000	0.000	0.011	-0.03	0.000
NLL	-0.02	0.002	0.000	-0.001	0.000	-0.02	0.000	0.000	0.000	0.000	0.000	0.000	-0.02	0.046	0.000
PH	-0.07	0.007	0.000	-0.002	-0.01	0.000	-0.04	0.000	-0.02	0.005	0.000	0.000	0.019	0.030	0.000
PB	0.004	-0.04	0.000	0.001	0.000	0.000	0.000	0.004	0.000	0.001	0.000	0.000	0.019	-0.07	0.000
SB	-0.05	0.005	0.000	-0.001	0.000	0.000	-0.02	0.000	-0.04	0.006	0.000	0.000	0.003	0.023	-0.001
NPP	-0.03	0.003	0.000	-0.001	0.000	0.000	-0.02	0.000	-0.02	0.011	0.000	0.000	-0.03	-0.09	0.000
NSP	0.003	-0.03	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	-0.02	-0.04	0.000
HSW	-0.04	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.003	0.042	-0.03	0.000
BY	0.002	-0.02	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.86	-0.16	0.000
HI	-0.01	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.19	0.71	0.001
PL	0.001	-0.02	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.02	0.050	0.010

DF = Days to flowering, DP = Days to podding, DP = Pod filling period, DM = Days to maturity, CW = Canopy width, Number of leaflets per leaf, PH = Plant height, PB = Primary branches, SB = Secondary branches, NPP = Number of pods per plant, NSP = Number of seeds per pod, HSW = Hundred seed weight, BM = Biomass, HI = Harvest index, PL = Pod length

Residual= 0.168

In general, the information obtained from path analysis revealed that number of pods per plant, biomass, harvest index, secondary branches per plant, canopy width, days to podding and pod filing period had positive direct effect on grain yield at both genotypic and phenotypic levels. Thus, these traits may be used as effective selection parameters for obtaining high yield in breeding program for yield enhancement in Chickpea.

Conclusion

The correlation of grain yield with biomass and harvest index was positive and highly significant both at genotypic and phenotypic levels. In addition, its association with pod filling period, plant height, secondary branches and hundred seed weight was positive both at genotypic and phenotypic levels. In general, all positive correlation between grain yield with traits of pod filling period, plant height, secondary branches, hundred seed weight and biomass both at genotypic and phenotypic levels are best traits which are important to direct selection process. Path coefficient analysis at genotypic level showed that among the fifteen causal (independent) traits, biomass, harvest index, pod length, days to pod setting, pod filing period, canopy width, primary branches, secondary branches and number

of pods per plant had positive direct effects on grain yield per plot. In general, the information obtained from path analysis revealed that number of pods per plant, biomass, harvest index, secondary branches per plant, canopy width, days to podding and pod filing period had positive direct effect on grain yield at both genotypic and phenotypic levels. Therefore, future selection of chickpea genotypes should be focused on traits which had positive correlation and direct effect on grain yield at both genotypic and phenotypic levels for obtaining high yield in chickpea breeding program.

Acknowledgements

First of all, the authors' deepest gratitude and acknowledge goes to Amhara Agricultural Research Institute and/or Sirinka Agricultural Research Center for providing research budget and facilitate the process. We would also like to express our sincere thanks to Sirinka Agricultural Research Center pulse case team members for contributing their great efforts for the successful accomplishment of the experiment.

References

- Ali, Q., Tahir, M.H.N., Sadaqat, H.A., Arshad, S., Farooq, J., Ahsan, M., Waseem, M. and Iqbal, A. (2011). Genetic variability and correlation analysis for quantitative traits in chickpea

- genotypes (*Cicer arietinum* L.) *Journal of Bacteria Research.*, 3:6-9.
- Central Statistical Authority. (2014/2015). Agricultural Sample Survey, Volume I: Report on Area and Production for major crops (Meher Season) *Statistical Bulletin No. 578* Addis Ababa, Ethiopia.
- Dewey, J.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of yield components of crested wheat seed production *Agronomy Journal* 51: 515-518.
- Falconer, D.S. and T.F. and Mackay, C. (1996). Introduction to Quantitative Genetics 4th ed. Longman Group Limited, Malaysia. 438 p.
- FAO. (1998). The state of *ex situ* conservation. Page 90 in the state of world's plant genetic resources for food and agriculture. Rome, Italy: Food and Agriculture Organization of the United Nations.
- Feven, W. (2002). Morphological and biochemical diversity analysis in chickpea (*Cicer arietinum* L.) Landraces of Ethiopia. M.Sc. Thesis submitted to Addis Ababa University, Addis Ababa
- Gomez, A.K. and Gomez, A.A. (1984). Statistical procedure for agricultural research. John Wiley and Sons 680 p.
- Gul, R., Khan, H., Sattar, S., Farhatullah, M. F., Shadman, K. B., Khattak, S.H., Arif, M. A. (2011). Comparison among nodulated and non nodulated chickpea genotypes, *Sarhad Jorna of Agriculture* 27(4): 577-581.
- IBPGR, ICRISAT and ICARDA. (1993). Descriptor for chickpea (*Cicer arietinum* L.). International Board for Plant Genetic Resources, Italy; International Crop Research Institute for the Semi-Arid Tropics, Patancheru, India and International Center for Agricultural Research in Dry Areas, Aleppo, Syria.
- Pooran, M. G., Shailesh, T., Laxmipathi, G. C.L., Ranga, R.G.V., Sharma, H.C., Suresh, P. and Mamta, S. (2010). International crop research institute for semi-arid tropics. P. 502 324 Andhra Pradesh, India, Chickpea *Seed Production Manual*.
- Melese, D. (2005). Morphological and Random Amplified Polymorphic DNA (RAPD) marker variation analysis in some drought tolerance and susceptible chickpea (*Cicer arietinum* L.) genotypes; Thesis submitted to University of Addis Ababa, Ethiopia.
- Ojiewo, C. (2016). Presentation of Chickpea Production, Technology Adoption and Market Linkages in Ethiopia on Pan-African Grain Legume and World Cowpea Conference Livingstone - Zambia Feb 28 – Mar 4, 2016
- Padmavathi, P.V., Sreemannarayana, S., Murthy, V., Satyanarayana, R. and Lal, A. M. (2013). Correlation and Path Coefficient Analysis in *Kabuli* Chickpea (*Cicer arietinum* L.) on *International Journal of Applied Biology and Pharmaceutical Technology*,
- Robertson, G.E. (1959). The sampling variance of genetic correlation coefficient. *Biometrics*. 15: 469-485.
- SAS Institute. (2004). SAS/STAT guide for personal computers, version 9.0 edition, SAS Institute Inc. Cary, NC.
- Sengupta, K. and Kataria, A.S. (1971). Path coefficient analysis for some characters in soybean. *Indian Journal of Genet*, 31: 290-295.
- Shafique, M.S., Ahsan, M., Mehmood, Z., Abdullah, M., Shakoor, A. and Ahmad, M.I. (2016). Genetic variability and interrelationship of various agronomic traits using correlation and path analysis in Chickpea (*Cicer arietinum* L.) *Academic Journal of Agricultural Research*, 4(2): 082-085.
- Sharma, J.R. (1998). Statistical and biometrical techniques in plant breeding. *New Age International (P) Limited Publishers. New Delhi*. 432 p.
- Singh, R. and Chaudhary, K. (1977). Biometrical methods in quantitative genetic analysis. *Kalyani Publisher, New Delhi, Ludhiana, India*. 300 p.

- Singh, K. B., Omar, M. C., Saxena, M. and Johansen, C. (1997). Screening for drought resistance in spring chickpea in the Mediterranean region. *Jornalof Agronomy & Crop Science*, 178: 22-235.
- Singh, J.L., Prasad, C., Madakemohekar, A.H. and Bornare, S.S. (2014). Genetic variability and character association in diverse genotypes of barley (*Hordeum vulgare* L.) The Bioscan (Supplement on Genetics and Plant Breeding). **9**(2): 759-761.
- Tesfamichael, S.M., Stephen, G. M., Aggrey, B. N., Ganga, R., Damaris, A. O., Abhishek, R. and Anil, K. (2014). Assessment of genetic variation and heritability of agronomic traits in chickpea (*Cicer arietinum* L.). *International Journal of Agronomy and Agricultural Research (IJAAR)*ISSN: **5**(4),76-88
- Thakur, S.K. and Sirohi, A. (2009). Correlation and path coffient analysis in chickpea (*Cicerarietinum* L.) under different seasons. *Legume Research* 32: 1-6.
- Uday, C. J., Singh, D.P. and Roopa, L. (2012). Assessment of genetic variability and correlation of important yield related traits in chickpea (*Cicer arietinum* L.) Department of Genetics and Plant Breeding G.B. Pant University of Agriculture & Technology, Pantnagar – 263-145 India agricultural research communication center www.arccjournals.com/indianjournals.com*Legume Res.*, 35 (4): 341 - 344, 2012.
- Van der, M. L.J.G. (1987). Origin, history and taxonomy of chickpea. In: Saxena MC, Singh KB (eds) *The Chickpea*. Wallingford: *C.A.B International*, pp. 11-34.
- Yucel. D.O., Anlarsal, A.E., Yucel, C. (2006). Genetic Variabilty, Correalation and Path Analysis of Yield and Yield Components in Chickpea (*Cicer arietinum* L.). *Turky Journal of Agriculture*, 30: 182-188.
- Yucel, D.O. and Anlarsal, A.E. (2010). Determination of selection criteria with path coefficient analysis in chickpea (*Cicer arietinum* L.) breeding. *Bulgarian Journal of Agricultural Science*, **16**(1): 42-48.
- Zerihun, J. B. (2011). Genetic diversity of elite chickpea (*cicer arietinum* l.) Varieties using morphological and inter simple sequence repeat markers. Thesis Submitted to the College of Natural and Computational Sciences, Department of Biology, School of Graduate Studies Haramaya University, Haramaya 2011

Appendix: Table1: List of Chickpea landrace collections with their location and altitude

SN	Collection Number	Date of collection	Region	Zone	District	Village	Altitude (m)	LAT	Longitude
1	DLRWAA001	21/12/2013	Oromiya	SW Shewa	Sebeta	Onhikie	2113	08°48'00.4"	038°38'00.0"
2	DLRWAA002	21/12/2013	Oromiya	SW Shewa	Sebeta	GejaDaleti	2130	08°44'19.4"	038°38'54.1"
3	DLRWAA003	21/12/2013	Oromiya	SW Shewa	Kersamalima	Godeti	2013	08°41'16.8"	038°35'53.5"
4	DLRWAA004	21/12/2013	Oromiya	SW Shewa	Kersamalima	multialibo	2056	08°38'23.0"	038°35'59.3"
5	DLRWAA005	22/12/2013	Oromiya	SW Shewa	Sododachie	Badu sonbo	2082	08°30'50.9"	038°48'39.3"
6	DLRWAA006	22/12/2013	Oromiya	SW Shewa	Sododachie	Bukierobele	1854	08°26'14.9"	038°43'15.7"
7	DLRWAA007	22/12/2013	Oromiya	SW Shewa	Sododachie	Hodo kotiyoy	1825	08°26'0.2"	038°43'41.7"
8	DLRWAA008	22/12/2013	Oromiya	SW Shewa	Sododachie	Gerersa	1787	08°24'0.03"	038°44'29.9"
9	DLRWAA009	22/12/2013	Oromiya	SW Shewa	Kersamalima	Mitichole	2111	08°39'22.1"	038°35'01.5"
10	DLRWAA0010	22/12/2013	Oromiya	SW Shewa	Ketsamalima	Mutideyu	2158	08°38'22.3"	038°32'56.9"
11	DLRWAA0011	22/12/2013	Oromiya	SW Shewa	Kersamalima	Adadi	2284	08°37'41.7"	038°30'36.6"
12	DLRWAA0012	23/12/2013	Oromiya	East -Shewa	Ada'a	Mukiye	1880	08°37'58.6"	038°55'39.9"
13	DLRWAA0013	23/12/2013	Oromiya	East -Shewa	Ada'a	Bekejo	1817	08°36'56.6"	038°56'25.7"
14	DLRWAA0014	23/12/2013	Oromiya	East -Shewa	Liben	Werejarso	1927	08°37'17.2"	038°49'00.7"
15	DLRWAA005	23/12/2013	Oromiya	East -Shewa	Liben	Gulu	1938	08°32'31.2"	038°48'06.8"
16	DLRWAA0016	23/12/2013	Oromiya	East -Shewa	Liben	Ashufie	1896	08°31'23.0"	038°48'10.1"
17	DLRWAA0017	23/12/2013	Oromiya	East -Shewa	Liben	Agamsa	1879	08°30'34.2"	038°47'53.2"
18	DLRWAA0018	23/12/2013	Oromiya	East -Shewa	Liben	Rogicha	1878	08°30'18.6"	038°47'40.02"

19	DLRWAA0019	24/12/2013	Oromiya	East -Shewa	Lume	Ejerewelkitie	2264	08°47'24.1"	039°16'0.01"
20	DLRWAA0020	24/12/2013	Amhara	North shewa	M/shenkora	Bililgn	2296	08°48'35.4"	039°17'00.0"
21	DLRWAA0021	24/12/2013	Amhara	Northshewa	M/shenkora	chercha	2254	08°48'51.1"	039°18'12.5"
22	DLRWAA0022	24/12/2013	Amhara	Northshewa	M/shenkora	W/amlk	2200	08°51'125.8"	039°19'47.5"
23	DLRWAA0023	24/12/2013	Amhara	Northshewa	M/shenkora	Arerti	1764	08°55'32.8"	039°36'36.0"
24	DLRWAA0024	24/12/2013	Amhara	Northshewa	M/shenkora	Korkoroamba	1757	08°55'38.3"	039°26'30.5"
25	DLRWAA0025	24/12/2013	Amhara	Northshewa	M/shenkora	Shewa genet	1792	08°54'28.9"	039°24'42.9"
26	DLRWAA0027	24/12/2013	Amhara	Northshewa	M/shenkora	BulloGorgis	1988	08°50'00.0"	039°21'42.6"
27	DLRWAA0029	24/12/2013	Oromiya	East - shewa	Lume	Nanawa	2205	08°46'00.3"	039°15'13.0"
28	DLRWAA0031	25/12/2013	Amhara	Northshewa	SiyaDebir	Wele	2660	09°46'48.3"	039°11'28.4"
29	DLRWAA0032	25/12/2013	Amhara	Northshewa	Moretinajiru	Kallele	2600	09°46'45.3"	039°10'28.4"
30	DLRWAA0033	25/12/2013	Amhara	Northshewa	Moretinajiru	Bollo	2656	09°56'03.1"	039°11'45.9"
31	DLRWAA0034	25/12/2013	Amhara	Northshewa	Moretinajiru	Agulamba	2615	09°56'15.1"	039°12'68"
32	DLRWAA0035	25/12/2013	Amhara	Northshewa	Moretinajiru	Weyraamba	2610	09°56'56.6"	039°12'57.8"
33	DLRWAA0036	25/12/2013	Amhara	Northshewa	Moretinajiru	amba	2640	09°56'18.4"	039°12'13.2
34	DLRWAA0037	26/12/2013	Oromiya	East shewa	Werdea2	Kela	2086	08°50'48.0"	038°48'30.6"
35	DLRWAA0038	26/12/2013	Oromiya	East shewa	Gelan	Beda oda	2072	08°50'22.0"	038°48'03.6"
36	DLRWAA0039	26/12/2013	Oromiya	East shewa	Werdea2	Cholo	2098	08°50'45.9"	038°48'47.9"
37	IE-16-028	24-01-16	Amhara	N. Gonder	Dembia	Ayimba	2110	12°49'98.7"	037°31'18.9"
38	DLRWAA0041	26/12/2013	Oromiya	East shewa	Ada'a	Gerbicha	2002	08°40'3.2"	038°58'36.3"
39	DLRWAA0042	26/12/2013	Oromiya	East shewa	Ada'a	Gindebel	1966	08°41'09.6"	038°58'59.7"
40	DLRWAA0043	26/12/2013	Oromiya	East - shewa	Ada'a	Gichie	1935	08°39'56.7"	038°59'14.7"
41	DLRWAA0044	26/12/2013	Oromiya	East - shewa	Ada'a	Gerbabo	1923	08°39'55.7"	038°59'19.2"
42	DLRWAA0045	26/12/2013	Oromiya	East - shewa	Ada'a	GichieGerbabo	1929	08°40'0.28"	038°59'09.3"
43	IE-16-001	23-01-16	Amhara	N. Gonder	Dembia	Loza Mariam	2000	12°50'34.2"	037°40'8.04"
44	IE-16-002	23-01-16	Amhara	N. Gonder	Dembia	Mariam Debir	2026	12°48'16.2"	037°38'95.7"
45	IE-16-003	23-01-16	Amhara	N. Gonder	Dembia	Deresge	2009	12°47'75.3"	037°39'34.2"
46	IE-16-004	23-01-16	Amhara	N. Gonder	Dembia	Angot	1995	12°47'89.2"	037°24'54.5"
47	IE-16-005	23-01-16	Amhara	N. Gonder	Dembia	Deresge	2004	12°54'32.1"	037°39'87.7"
48	IE-16-006	23-01-16	Amhara	N. Gonder	Dembia	HamusGebeya	1910	12°48'24.6"	037°38'89.5"
49	IE-16-007	23-01-16	Amhara	N. Gonder	Dembia	Grarge	1970	12°47'74.5"	037°38'40.9"
50	IE-16-008	23-01-16	Amhara	N. Gonder	Dembia	Galaje	1930	12°47'28.4"	037°37'64.2"
51	IE-16-009	23-01-16	Amhara	N. Gonder	Dembia	Grarge	1850	12°47'50.1"	037°37'33.5"
52	IE-16-010	23-01-16	Amhara	N. Gonder	Dembia	Aba Libanos	1878	12°46'69.3"	037°36'34.4"
53	IE-16-011	23-01-16	Amhara	N. Gonder	Dembia	Checher	1450	12°46'18.5"	037°35'79.8"
54	IE-16-012	23-01-16	Amhara	N. Gonder	Dembia	Checher	1758	12°34'56.6"	037°30'81.0"
55	IE-16-013	23-01-16	Amhara	N. Gonder	Dembia	Gebeta	1800	12°49'21.1"	037°30'90.4"
56	IE-16-014	23-01-16	Amhara	N. Gonder	Dembia	Janga Mariyam	1895	12°39'65.1"	037°29'94.5"

SN	Collection Number	Date of collection	Region	Zone	District	Village	Altitude (m)	LAT	Longitude
57	IE-16-015	23-01-16	Amhara	N. Gonder	Dembia	Janga Mariyam	1750	12°39'19.1"	037°29'22.0"
58	IE-16-016	23-01-16	Amhara	N. Gonder	Dembia	Janga Mariyam	1900	12°36'67.4"	037°26'23.4"
59	IE-16-017	23-01-16	Amhara	N. Gonder	Dembia	Jarna Mariyam	1956	12°37'46.2"	037°23'48.1"
60	IE-16-018	23-01-16	Amhara	N. Gonder	Dembia	Sechicha	1980	12°30'06.5"	037°22'41.4"
61	IE-16-019	23-01-16	Amhara	N. Gonder	Dembia	Chuhawit	1820	12°29'44.2"	037°22'61.1"
62	IE-16-020	23-01-16	Amhara	N. Gonder	Dembia	Chuhawit	1800	12°27'87.3"	037°23'22.6"
63	IE-16-021	24-01-16	Amhara	N. Gonder	Dembia	Girmara	2062	12°52'94.8"	037°34'89.5"
64	IE-16-022	24-01-16	Amhara	N. Gonder	Dembia	Girmara	2090	12°52'73.6"	037°33'96.4"
65	IE-16-023	24-01-16	Amhara	N. Gonder	Dembia	Girmara	2095	12°52'78.5"	037°33'39.2"
66	IE-16-024	24-01-16	Amhara	N. Gonder	Dembia	Ambaguwal	2075	12°53'02.6"	037°32'38.2"
67	IE-16-025	24-01-16	Amhara	N. Gonder	Dembia	Ambaguwal	2082	12°52'92.3"	037°32'25.4"
68	IE-16-026	24-01-16	Amhara	N. Gonder	Dembia	Ambaguwal	2095	12°52'90.4"	037°32'22.3"

69	IE-16-027	24-01-16	Amhara	N. Gonder	Dembia	Ayimba	2102	12°53'07.3"	037°31'17.8"
70	DLRWAA0040	26/12/2013	Oromiya	East shewa	Gelan	Sidamo	2085	08°50'0.74"	038°48'32.8"
71	IE-16-029	24-01-16	Amhara	N. Gonder	Dembia	Ayimba	2015	12°53'23.5"	037°29'69.6"
72	IE-16-030	24-01-16	Amhara	N. Gonder	Dembia	Ayimba	2012	12°53'23.5"	037°29'77.8"
73	IE-16-031	24-01-16	Amhara	N. Gonder	Dembia	Chingage	1992	12°52'67.3"	037°26'26.7"
74	IE-16-032	24-01-16	Amhara	N. Gonder	Dembia	Amanuel	1980	12°52'81.1"	037°26'00.4"
75	IE-16-033	24-01-16	Amhara	N. Gonder	Dembia	Amanuel	1979	12°52'74.5"	037°25'96.9"
76	IE-16-034	24-01-16	Amhara	N. Gonder	Chilga	Amanuel	1999	12°52'79.2"	037°25'92.0"
77	IE-16-035	24-01-16	Amhara	N. Gonder	Chilga	Amanuel	1976	12°52'86.6"	037°25'90.5"
78	IE-16-036	24-01-16	Amhara	N. Gonder	Chilga	Amanuel	1971	12°53'00.9"	037°26'38.9"
79	IE-16-037	24-01-16	Amhara	N. Gonder	Chilga	Buwasma	1956	12°52'97.4"	037°24'53.0"
80	IE-16-038	24-01-16	Amhara	N. Gonder	Chilga	Gala Meda	1775	12°52'57.8"	037°21'53.8"
81	IE-16-039	24-01-16	Amhara	N. Gonder	Chilga	Gala Meda	1768	12°52'69.3"	037°21'17.7"
82	IE-16-040	24-01-16	Amhara	N. Gonder	Chilga	Gebaba	1748	12°52'94.2"	037°20'00.5"
83	IE-16-041	24-01-16	Amhara	N. Gonder	Chilga	Adeza	1992	12°54'95.6"	037°13'67.6"
84	IE-16-042	24-01-16	Amhara	N. Gonder	Chilga	Awaga	1899	12°55'55.6"	037°12'65.5"

85	IE-16-043	24-01-16	Amhara	N. Gonder	Chilga	Laza	1932	12°60'75.4"	037°11'79.8"
86	IE-16-044	24-01-16	Amhara	N. Gonder	Chilga	Awarda	1930	12°47'28.4"	037°11'64.2"
87	IE-16-045	24-01-16	Amhara	N. Gonder	Chilga	Awarda	1957	12°56'87.1"	037°11'28.2"
88	IE-16-046	25-01-16	Amhara	N. Gonder	GonderZuriya	Tensaye	1914	12°49'97.3"	037°40'55.7"
89	IE-16-047	25-01-16	Amhara	N. Gonder	GonderZuriya	Tensaye	1891	12°48'47.7"	037°44'46.6"
90	IE-16-048	25-01-16	Amhara	N. Gonder	GonderZuriya	Tensaye	1883	12°44'87.2"	037°44'45.2"
91	IE-16-049	25-01-16	Amhara	N. Gonder	GonderZuriya	Megech	1894	12°48'70.3"	037°45'21.5"
92	IE-16-050	25-01-16	Amhara	N. Gonder	GonderZuriya	Megech	1898	12°48'87.3"	037°45'24.2"
93	IE-16-051	25-01-16	Amhara	N. Gonder	GonderZuriya	Gafi	1900	12°48'84.1"	037°45'59.6"
94	IE-16-052	25-01-16	Amhara	N. Gonder	GonderZuriya	Gafi	1904	12°44'89.4"	037°45'58.8"
95	IE-16-053	25-01-16	Amhara	N. Gonder	GonderZuriya	Tena Tabiya	1900	12°48'03.9"	037°47'07.2"
96	IE-16-054	25-01-16	Amhara	N. Gonder	GonderZuriya	Tena Tabiya	1930	12°45'17.3"	037°49'41.0"
97	IE-16-055	25-01-16	Amhara	N. Gonder	GonderZuriya	Minziro	1941	12°44'92.5"	037°50'55.4"
98	IE-16-056	25-01-16	Amhara	N. Gonder	GonderZuriya	Burbuwaks	1941	12°43'87.3"	037°50'71.1"
99	IE-16-057	25-01-16	Amhara	N. Gonder	GonderZuriya	Burbuwaks	1910	12°52'94.8"	037°51'40.4"
100	IE-16-058	25-01-16	Amhara	N. Gonder	Gonder Z.	Chincha	1917	12°40'84.4"	037°53'30.5"
101	IE-16-059	25-01-16	Amhara	N. Gonder	Gonder Z.	Shedefa	1919	12°42'78.5"	037°53'39.2"
102	IE-16-060	25-01-16	Amhara	N. Gonder	Gonder Z.	Shedefa	1921	12°39'41.9"	037°54'82.7"
103	IE-16-061	27-01-16	Amhara	E .Gojam	Awo Bel	Tabayyegodna	1957	10°22'47.2"	037°09'06.4"
104	IE-16-062	27-01-16	Amhara	E .Gojam	Awo Bel	Tabayyegodna	1960	10°22'46.8"	037°09'95.7"
105	IE-16-063	27-01-16	Amhara	E .Gojam	Awo Bel	Nebiy	2443	10°23'93.7"	038°06'09.2"
106	IE-16-064	27-01-16	Oromiya	N. Shewa	WerJarso	Gedara	2467	09°83'39.4"	038°27'72.8"
107	IE-16-065	27-01-16	Oromiya	N. Shewa	WerJarso	Gedera	2525	09°98'23.1"	038°27'82.1"
108	IE-16-066	27-01-16	Oromiya	N. Shewa	WerJarso	AredeBero	2538	09°97'48.6"	038°28'66.5"
109	IE-16-067	27-01-16	Oromiya	N. Shewa	WerJarso	AredeChende	2517	09°96'97.1"	038°29'14.7"
110	IE-16-068	27-01-16	Oromiya	N. Shewa	WerJarso	AredeChende	2533	09°96'91.2"	038°29'20.7"
111	IE-16-069	27-01-16	Oromiya	N. Shewa	WerJarso	AredeChende	2552	09°96'01.0"	038°30'06.5"
112	IE-16-070	27-01-16	Oromiya	N. Shewa	WerJarso	Wele	2559	09°95'45.9"	038°30'52.2"

113	IE-16-071	28-01-16	Oromiya	w. Shewa	Sebeta	Jewe	2450	08°82'24.5"	038°94'99.7"
114	IE-16-072	28-01-16	Oromiya	w. Shewa	Sebeta	SitoRebeto	2050	08°71'42.8"	038°62'04.8"
115	IE-16-073	28-01-16	Oromiya	w. Shewa	SodoDache	Mehal Shino	2063	08°71'14.7"	038°61'57.2"
116	IE-16-074	28-01-16	Oromiya	w. Shewa	SodoDache	Mehal Shino	2166	08°54'86.2"	038°62'51.3"
117	IE-16-075	28-01-16	Oromiya	w. Shewa	SodoDache	Cheka	2172	08°54'83.2"	038°62'53.7"
118	IE-16-076	28-01-16	Oromiya	w. Shewa	SodoDache	Mehal Shino	2156	08°54'86.2"	038°62'59.2"

119	IE-16-077	28-01-16	Oromiya	w. Shewa	SudenDache	Tere	2150	08°54'43.3"	038°62'31.8"
120	IE-16-078	28-01-16	Oromiya	w. Shewa	SudenDache	Tere	2150	08°54'43.3"	038°62'31.8"
121	IE-16-079	28-01-16	Oromiya	w. Shewa	SudenDache	Tere	2150	08°54'43.3"	038°62'31.8"
122	IE-16-080	28-01-16	Oromiya	w. Shewa	SudenDache	Tere	2150	08°54'43.3"	038°62'31.8"
123	IE-16-081	28-01-16	Oromiya	w. Shewa	SudenDache	Tere	2158	08°54'43.3"	038°63'94.9"
124	IE-16-082	28-01-16	Oromiya	w. Shewa	SudenDache	Tere	2185	08°54'43.3"	038°63'36.9"
125	IE-16-083	28-01-16	Oromiya	w. Shewa	Sodo D.	Sudden	2211	08°52'25.1"	038°63'54.4"
126	IE-16-084	28-01-16	Oromiya	w. Shewa	Sodo D.	Sudden	2205	08°50'88.9"	038°63'53.7"
127	IE-16-085	28-01-16	SNNP	Gurage	Sodo G	Ketero	2139	08°50'70.6"	038°58'96.6"
128	IE-16-086	28-01-16	SNNP	Gurage	Sodo Gurage	Ketero	2136	08°37'58.8"	038°58'99.7"
129	IE-16-087	28-01-16	SNNP	Gurage	Sodo Gurage	Bu'ee	2136	08°37'58.8"	038°58'99.7"
130	IE-16-088	28-01-16	SNNP	Gurage	Sodo Gurage	Bu'ee	2136	08°37'58.8"	038°58'99.7"
131	IE-16-089	28-01-16	SNNP	Gurage	Sodo Gurage	Kela	2136	08°37'58.8"	038°58'99.7"
132	IE-16-090	28-01-16	SNNP	Gurage	Sodo Gurage	Kela	2136	08°37'58.8"	038°58'99.7"
133	IE-16-091	28-01-16	SNNP	Gurage	Sodo Gurage	Kela	1920	08°25'00.1"	038°48'83.8"
134	IE-16-092	28-01-16	SNNP	Gurage	Sodo Gurage	Kela	1912	08°24'81.7"	038°48'67.3"
135	IE-16-093	28-01-16	SNNP	Gurage	Sodo Gurage	Kambolet	1932	08°22'96.1"	038°47'86.1"
136	IE-16-094	29-01-16	SNNP	Gurage	Kebena	QolaKebada	1971	08°26'81.1"	037°76'11.6"
137	IE-16-095	29-01-16	SNNP	Gurage	Kebena	QolaKebada	1795	08°26'81.4"	037°76'07.8"
138	IE-16-096	29-01-16	SNNP	Gurage	Kebena	QolaKebada	1794	08°26'97.3"	037°76'15.7"
139	IE-16-097	29-01-16	SNNP	Gurage	Habeshge	Fenta	1174	08°28'06.4"	037°71'10.8"
140	IE-16-098	29-01-16	SNNP	Gurage	Habeshge	Jejeba	1777	08°28'04.3"	037°71'21.0"

141	IE-16-099	29-01-16	SNNP	Gurage	Habeshge	Jejeba	1767	08°28'02.1"	037°71'10.9"
142	IE-16-100	29-01-16	SNNP	Gurage	Habeshge	Gofele	1785	08°28'05.2"	037°71'28.6"
143	IE-16-101	29-01-16	SNNP	Gurage	Habeshge	Tawela	1768	08°27'96.2"	037°69'68.9"
144	IE-16-102	29-01-16	SNNP	Gurage	Habeshge	Tawela	1765	08°28'00.4"	037°69'50.2"
145	IE-16-103	29-01-16	SNNP	Gurage	Habeshge	Tawela	1780	08°27'35.7"	037°67'51.1"
146	IE-16-104	29-01-16	SNNP	Gurage	Habeshge	Hole	1790	08°27'44.1"	037°66'98.2"
147	IE-16-105	29-01-16	SNNP	Gurage	Habeshge	Hole	1768	08°37'58.8"	038°66'98.3"
148	IE-16-106	29-01-16	SNNP	Gurage	Kebena	Kela	1767	08°32'33.4"	037°78'6.0"
149	IE-16-107	29-01-16	SNNP	Gurage	Kebena	Muzu	1764	08°34'26.6"	037°79'26.2"
150	IE-16-108	29-01-16	SNNP	Gurage	Kebena	Muzu	1762	08°34'30.2"	037°79'20.2"
151	IE-16-109	29-01-16	Oromiya	W. Shewa	Weliso	Goro	1824	08°37'46.6"	037°84'35.1"
152	IE-16-110	29-01-16	Oromiya	W. Shewa	Weliso	Goro	1825	08°37'68.7"	037°84'94.4"
153	IE-16-111	30-01-16	Oromiya	W. Shewa	Weliso	Seyoma	2260	08°64'33.9"	038°15'11.1"
154	IE-16-112	30-01-16	Oromiya	W. Shewa	Becho	Seyoma	2256	08°64'26.4"	038°15'21.4"
155	IE-16-113	30-01-16	Oromiya	W. Shewa	Becho	Seyoma	2250	08°15'35.4"	038°15'34.5"
156	IE-16-114	30-01-16	Oromiya	W. Shewa	Becho	Seyoma	2270	08°63'27.2"	038°63'27.3"
157	IE-16-115	30-01-16	Oromiya	W. Shewa	Becho	SeyomaGenji	2273	08°63'62.7"	038°17'23.1"
158	IE-16-116	30-01-16	Oromiya	W. Shewa	Becho	SeyomaGenji	2251	08°63'66.9"	038°17'2.4"
159	IE-16-117	30-01-16	Oromiya	W. Shewa	TuluBolu	Awash Bune	2126	08°71'7.4"	038°26'45.5"
160	IE-16-118	30-01-16	Oromiya	W. Shewa	TuluBolu	Awash Bune	2148	06°54'02.1"	039°01'01.0"
161	IE-16-119	30-01-16	Oromiya	W. Shewa	Elu	Asgori	2095	08°78'15.2"	038°32'35.0"
162	IE-16-120	30-01-16	Oromiya	W. Shewa	Elu	Asgori	2095	08°78'15.2"	038°32'35.0"
163	IE-16-121	30-01-16	Oromiya	W. Shewa	Elu	Asgori	2095	08°78'15.2"	038°32'35.0"
164	IE-16-122	30-01-16	Oromiya	W. Shewa	Elu	Asgori	2095	08°78'15.2"	038°32'35.0"
165	IE-16-123	30-01-16	Oromiya	W. Shewa	Elu	Asgori	2095	08°78'15.2"	038°32'35.0"
166	IE-16-124	30-01-16	Oromiya	W. Shewa	Elu	Asgori	2095	08°78'15.2"	038°32'35.0"
167	IE-16-125	30-01-16	Oromiya	W. Shewa	Elu	Kentey	2079	08°81'60.1"	038°35'71.1"
168	IE-16-126	30-01-16	Oromiya	WS. Shewa	Elu	Teji	2050	08°68'16.0"	038°37'11.4"

169	IE-16-127	30-01-16	Oromiya	WS. Shewa	Elu	Teji	2268	08°56'60.1"	038°35'71.1"
170	IE-16-128	30-01-16	Oromiya	WS. Shewa	Elu	Teji	2275	08°64'16.0"	038°27'14.5"
171	IE-16-129	30-01-16	Oromiya	WS. Shewa	Tefgi	Tefgi	2136	08°37'54.8"	038°58'32.7"
172	IE-16-130	30-01-16	Oromiya	WS. Shewa	Tefgi	Tefgi	2136	08°37'54.8"	038°58'32.7"

173	IE-16-131	30-01-16	Oromiya	WS. Shewa	Tefgi	Tefgi	2136	08°37'54.8"	038°58'32.7"
174	IE-16-132	01-02-16	Amhara	N.Shewa	M/shenkora	Arerti	2246	08°92'94.4"	039°43'11.4"
175	IE-16-133	01-02-16	Amhara	N.Shewa	M/shenkora	Arerti	2246	08°92'94.4"	039°43'11.4"
176	IE-16-134	01-02-16	Amhara	N.Shewa	M/shenkora	Arerti	2246	08°92'94.4"	039°43'11.4"
177	IE-16-135	01-02-16	Amhara	N.Shewa	M/shenkora	Minjar	2246	08°92'94.4"	039°43'11.4"
178	IE-16-136	01-02-16	Amhara	N.Shewa	M/shenkora	Minjar	2246	08°92'94.4"	039°43'11.4"
179	IE-16-137	01-02-16	Amhara	N.Shewa	M/shenkora	Balchi	2246	08°92'94.4"	039°43'11.4"
180	IE-16-138	01-02-16	Amhara	N.Shewa	M/shenkora	Balchi	2246	08°92'94.4"	039°43'11.4"
181	IE-16-139	01-02-16	Amhara	N.Shewa	M/shenkora	Balchi	2246	08°92'94.4"	039°43'11.4"
182	IE-16-140	01-02-16	Amhara	N.Shewa	M/shenkora	Balchi	2246	08°92'94.4"	039°43'11.4"
183	IE-16-141	01-02-16	Amhara	N.Shewa	M/shenkora	Balchi	2246	08°92'94.4"	039°43'11.4"
184	IE-16-142	01-02-16	Amhara	N.Shewa	M/shenkora	Balchi	2246	08°92'94.4"	039°43'11.4"
185	IE-16-143	01-02-16	Amhara	N.Shewa	M/shenkora	Balchi	2246	08°92'94.4"	039°43'11.4"
186	IE-16-144	01-02-16	Oromiya	E.Shewa	Lume	Ejere	2269	08°78'45.3"	039°26'38.1"
187	IE-16-145	01-02-16	Oromiya	E.Shewa	Lume	Ejere	2269	08°78'45.3"	039°26'38.1"
188	IE-16-146	01-02-16	Oromiya	E.Shewa	Akaki	Finchwuh	2445	08°85'70.9"	038°39'52.3"
189	IE-16-147	01-02-16	Oromiya	E.Shewa	Akaki	Finchwuh	2445	08°85'70.9"	038°39'52.3"
190	IE-16-041	24-01-16	Oromiya	E.Shewa	Akaki	Finchwuh	2325	09°98'23.5"	038°27'72.1"
191	IE-16-042	24-01-16	Oromiya	E.Shewa	Akaki	Finchwuh	2338	09°93'48.6"	038°28'36.5"
192	IE-16-043	24-01-16	Oromiya	E.Shewa	Akaki	Finchwuh	2417	09°95'97.3"	038°29'54.7"
193	IE-16-044	24-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
194	IE-16-045	24-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
195	IE-16-046	25-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"

196	IE-16-047	25-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
-----	-----------	----------	---------	---------	-------	----------	------	-------------	--------------

197	IE-16-048	25-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
198	IE-16-049	25-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
199	IE-16-050	25-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
200	IE-16-051	25-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
201	IE-16-052	25-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
202	IE-16-053	25-01-16	Oromiya	E.Shewa	Ade'a	Bishoftu	2417	09°95'97.3"	038°29'54.7"
203	Fetenech	Released variety							
204	Minjar	Released variety							