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**ORIGINAL RESEARCH PAPER**

# Evaluation and Identification of High Yielding Kabuli Chickpea (*Cicer arietinum* L.) Varieties in Wegdi and Legambo Districts, Amhara Region, Ethiopia

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**Abstract:** Chickpea (*Cicer arietinum* L.) is a member of the legume plants and it has genomes with 16 chromosomes (2n = 2x = 16). The use of poor yielder local chick pea varieties was the problem of chickpea production in Ethiopia. Therefore, the present study designed to investigate the variability and adaptability of Kabuli chickpea varieties for yield and yield component traits. It was specifically, to evaluate genetic adaptability of Kabuli chickpea varieties and to identify promising candidate varieties to be used in Kabuli chickpea production. The study was carried out on 13 Kabuli chickpea varieties and the experiment was laid out in a complete randomized block design at two locations with arrangement of 13 x 3 for each location. Results obtained on variability assessment and associations among yield related traits presented here. The analysis of variance showed highly significant variation among the varieties for all the traits at each location. Qobo with 4153 and 3932 kg ha$^{-1}$, Kasech with 3839 and 3767 kg ha$^{-1}$, Qoqa with 3673 and 3543 kg $^{-1}$, Akuri with 3083 and 2883 kg ha$^{-1}$ yield Kabuli chickpea varieties were top four potential and better performing varieties to distribute for farmers further adoption and yield improvement under different agro-ecologies.
**Keywords:** Correlation, Genotype, Heritability, Phenotype, Variance.

## 1. Introduction

Chickpea (*Cicer arietinum* L.) (2n = 2x = 16) is the world's second most widely grown legume and originated in the present day South-Eastern Turkey and boundary of Syria (Maheri-sis *et al.*, 2008). Chickpea is a cool-season annual pulse crop that is grown in tropical, sub-tropical and temperate region of the world (Muruiki *et al*., 2018). Chickpea is the most widely produced food legume in south Asia and the third largest produced globally (Shumi *et al*., 2018). Its cultivation is importance to food security in the developing Countries (Basha *et al.*, 2020). Chickpea is a member of Papilionoidea subfamily of legumes, a clade that contains essentially all of the important legume crops. Within this subfamily, chickpea is most closely related to crops such as alfalfa (Medicago sativa), clover (Trifolium spp.), pea (*Pisum sativum*) and lentil (*Lens culinaris*) (Purushothaman *et al*., 2014). There are two main types of chickpeas: small-seeded Dessi and larger-seeded kabuli. Consumption of kabuli is a popular and valuable global commodity. Recent breeding efforts over the past 60 years have been restricted to the limited introduction of diverse germplasm (Repository, 2019). It is grown in more than 50 countries, with more than 90% of Kabuli chickpea production coming from Asia, predominantly India (Abdula, 2013). Ethiopia supplies more than 60% of Africa's global Kabuli chickpea exports. In Ethiopia, 80% of the Kabuli chickpea is marketed locally while 20% is exported mainly to Asia and Middle East (Abdula, 2013).

Kabuli chickpea is play important roles in the development of sustainable agriculture by supplying human food maintain soil fertility, supplying animal feed and by increasing cash source of farmers due to their high market price (Wordofa, 2015). The amount of nitrogen fixed by Kabuli chickpea is estimated to be 130 kg ha$^{-1}$ year$^{-1}$ (Wordofa, 2015). Chickpea seed has 38-59% carbohydrate, 3% fiber, 4.8- 5.5% oil, 0.2% calcium and 0.3% phosphorus (Sfayhi and Kharrat, 2011). Kabuli chickpea seeds are eaten fresh as a green vegetable, parched fried and boiled as snack food and condiments. Seeds are ground and the flour can be used as soup and to make bread, prepared with paper, salt and lemon it is served as side dish (Girma *et al.*, 2017). Kabuli chickpea is white gram in this group the color of the seed is usually white, grains are bold and attractive (Girma *et al.*, 2017).

Kabuli chickpea production during terminal drought, seed yield decreases significantly compared with irrigated Kabuli chickpea, due to flower and pod abortion, reduced pod production and reduced seed size (Mekuanint *et al*., 2018). Recently studies have shown that flower and pod production and seed set of kabuli chickpea is sensitive to drought stress (Joshi *et al*., 2018). The terminal drought imposed from early poding reduced biomass, reproductive growth, harvest index and seed yield of different varieties of kabuli chickpea. Terminal drought doubled the percentage of flower abortion, pod abscission and number of empty pods (Cobos *et al.*, 2016).

Ethiopia ranks fifth in the world production of Kabuli chickpea. But Ethiopia current share in the global markets is limited as compare to its potential. This is due to various constraints, poor quality seeds, in sufficient seed production and lack of improved variety in irrigation and main cropping season (Cobos *et al.*, 2016). Even though kabuli chickpea has a number of uses, the productivity of the crop in Ethiopia under farmer's condition is low (1.73 t ha-$^{1}$) as compared to its potential yield of the crop under improved management conditions 3.5 t ha-$^{1}$ (Mallu, 2015).

In Ethiopia, a number of problem that contribute to the low productivity of kabuli chickpea. In study areas, production of Kabuli chickpea is low due to poor evaluation of the variability and adaptability of Kabuli chickpea varieties in study areas. Most of the studies that conducted so far with the genetic variation and adaptability in Ethiopian Kabuli chickpea varieties carried out elsewhere out of their major kabuli chickpea producing areas. In the study area, lack of released Kabuli chickpea varieties to determine magnitude of genetic variability and adaptability using morphological traits. Narrow genetic variability and adaptability was major problem to develop Kabuli chickpea varieties with better adaptation to different agro-ecologies, resistant and tolerant to biotic and abiotic stresses. The critical problem of Kabuli chickpea production was use of poor yielder local Kabuli chickpea varieties. Similarly, there is no detailed information on extent of association among traits and their selection efficiency in different climatic condition.

**Null Hypothesis:** implies that no variability and adaptability in Kabuli chickpea varieties in different climatic condition.

**Alternative Hypothesis:** implies that presence of variability and adaptability in Kabuli chickpea varieties in different climatic condition.

Identification of improved varieties adapted to different location to improve productivity of Kabuli chickpea production is very essential. It is also important to determine the magnitude of association between yields and yield component traits by estimate selection efficiency of the traits of Kabuli chickpea varieties. Production of high yielder varieties approaches, which have large influence on yield quality and quantity of Kabuli chickpea production. The facts of genetic variability and adaptability in Kabuli chickpea varieties is important to use for further production and breeding programs of kabuli chickpea. It is, necessary to evaluate the variability and adaptation of Kabuli chickpea varieties along with released varieties to determine the magnitude of genetic variability and adaptability using morphological traits variation. Information on adaptability and association of traits is essential to use genetic variation for further kabuli chickpea improvement particularly, in the study areas and generally in Ethiopia. The present study estimated the magnitude of correlation between grain yield and yield contributing traits. The present study important for selection of promising candidate Kabuli chickpea varieties to be used in future chickpea production and breeding programs for similar agro ecologies.

The objectives of this study, implied to evaluate and identify Kabuli chickpea varieties variability and adaptability for their yield and yield component traits performance at different location in general. In specifically, to evaluate genetic adaptability of Kabuli chickpea varieties; to investigate important yield component traits of Kabuli chickpea varieties; to determine magnitude of association between yield and yield component traits of Kabuli chickpea; and to identify promising candidate varieties to be used in future Kabuli chickpea production and breeding program.

## 2. Material and Methods

### *2.1. Description of the Experimental Site*

The experiments were conducted at two locations, Wegdi and Legambo districts under Mekdela Amba University Research site.

#### *2.1.1. Wegdi District*

Wegdi district was one of the major kabuli chickpea producing area of Amhara Region, Ethiopia. Wegdi district was located between 10°30'0'' N and 11°30'0'' N Latitude and between 38°30'0''E and 39°30'0'' E Longitude in South Wollo, Ethiopia (South Wollo Zone Agricultural Sector, 2019). Mekdela Amba University Research site was located within Wegdi district. Wegdi district had altitude range of 1200-3200 meter above sea level (Wegdi Agricultural Sector, 2021). The rainy season in Wegdi district was from May to September with mean annual rainfall of 500-800 mm (Wegdi Agricultural Sector, 2019).

Mean annual temperature of Wegdi district ranges from 20ºC to 23ºC. The land use pattern in the districts consisted about 35% cultivated land, 6% wasteland, 15% shrub, 14% natural forest, 6% construction roads and houses, 23% natural pasture and 1% perennial fruits (Wegdi Agricultural Sector, 2021). The livelihood of most of the district's population was dependent on agriculture mainly crop production. The soil of the experimental sites are characterizing by vertisol in the district (Wegdi Agricultural Sector, 2021).

### *2.1.2. Legambo District*

Mekdela Amba University Agricultural Research site is located at Legambo district in South Wollo Zone at $10^0$, 20'0''N longitude and 38, 20'0'E latitude at an altitude of 3200 meters above sea level. Kabuli chickpea varieties were evaluated at Legambo districts Research sites of Mekdela Amba University, South Wollo, and Ethiopia similar to Wegdi districts in the same season. A Legambo district was one of the major kabuli chickpea producing areas of South Wollo, Ethiopia. The mean annual temperature of Legambo district ranges from 15ºC to 20ºC. The rainy months extend from June until the end of September. The time of sowing in the area involved from August to mid of September. Soil of the experimental site are characterizing by vertisol in the district similar to Wegdi district (Legambo Agricultural Sector, 2021).

### *2.2. Experimental Materials*

Thirteen Kabuli chickpea varieties were used and the seeds of the varieties were obtained from Debrezeit, Debrebrhan and Sirinka research center, Ethiopia. The Kabuli chickpea varieties are listed in (Table 1).

Table 1: Description of thirteen Kabuli chickpea test varieties

| **Varieties** | **Maintainer** | **Varieties** | **Maintainer** | **Varieties** | **Maintainer** |
|---|---|---|---|---|---|
| Ak. Dubie | SRARC | Habru | DZARC | Koka | SRARC |
| Akuri | SRARC | Hora | DZARC | Shasho | DZARC |
| Chefe | DZARC | Kasech | SRARC | Teji | DZARC |
| Dehara | DZARC | Kobo | SRARC | | |
| Enjer | DZARC | Yelbie | SRARC | | |

Source: Sirinka, Debrebrhan and Debrezeit Agricultural Research Center

### *2.3. Experimental Design*

The experiment was laid out in complete randomized block design with the arrangement of 13x3 for Kabuli chickpea varieties in each location. This made all together 39 for Kabuli chickpea varieties experimental units. Size of each plot 1.2m with 2m and the distance between adjacent plots and replications kept at 0.5 m and 1 m apart, respectively. The area of experimental field covered 250.8 $m^2$ with 33 m length and 7.6 m width for each location. Each treatment was assigned randomly to experimental units within a replication in each location. Each experimental unit consisted four rows of 2 m length with 30 cm spacing between rows. Data were collected from the central two rows for most of the variables and from randomly sampled plants for some of traits in each location. All experimental factors were applied uniformly to the entire plot except varieties of Kabuli chickpea in each location.

### *2.4. Data to be collected*

Data collection was done at plot basis and sample plant basis. The following data were collected from net plot: - days to 50% flowering, days to maturity, above ground biomass in gm per plot, grain yield in gm per plot, thousand seed weight and Harvest index.

The following data were collected from randomly selected ten plants from two middle rows of each plot:- Plant height, number of primary branch per plant, number of secondary branches, number of pods per plant, number of seed per pod and number of seed per plant.

### *2.5. Statistical Analysis*

The data was analyzed as per the design used in the experiment using R ($64^{th}$ edition) computer software (R-software, 2021). The data obtained for different traits statistically analyzed using appropriate ways for analysis of range, variance, and correlation and stability of traits.

### *2.5.1 Analysis of variance (ANOVA)*

The analysis of variance (ANOVA) was performing using R ($64^{th}$ edition) computer software for Complete Randomize Block Design (R-software, 2021). For each location and combined data over locations, analyses of variances were done using the mean of ten sample plants for the traits like plant height, number of primary branch per plant, number of secondary branches, number of pods per plant, number of seed per pod and number of seed per plant on plant basis. However, plot basis will use for traits such as days to 50% flowering, days to maturity, dry biomass, grain yield, thousand seed weight, harvest index for analysis of variance. Mean separation performed with DMRT at (*P<0.05*) 5% level of significance. The analyzed results will interpret based on statistical hypothesis, scientific and biological facts (Gomez and Gomez, 1984). For individual locations, the analyses of variance were computed using the following mathematical model:

$$\chi_{ij} = \mu + \tau_i + \beta_j + E_{ij}$$

Where $\chi_{ij}$ = observation of the i$^{th}$ treatment in the j$^{th}$ r eplication, μ = overall mean,

$\tau_i$ = i$^{th}$ treatment effect, $\beta_j$ = j$^{th}$ replication, $E_{ij}$ = the experimental error associated with the trait y for the $i^{th}$ varieties in replication and $j^{th}$ replication (Gomez and Gomez, 1984). For combined analyses of variance were computed using the following mathematical model:

$$Yijk = \mu + gi + Ej + GEij + Bk(j) + \varepsilon ijk$$

Where, $Yijk$ = observed value of variety i in replicati on k of location j, μ = grand mean, g$i$ = effect of variety i , $Ej$ = environment or location effect, $GEij$ = the interacti on effect of variety i with environment j,

$_{(j)}$ = effect of replication k in location/environment j
$\varepsilon ijk$= random error or residual effect of genotype i in block k of location j.

*2.5.2. Estimation of phenotypic and genotypic correlations*

The character associations represented by correlation coefficient between different pairs of characters at the genotypic and phenotypic levels calculated from the genotypic and phenotypic covariance (Joshi *et al*., 2018). Phenotypic and genotypic correlations coefficients between yield and yield related traits would estimate using the standard method as described (Sabaghpour *et al*., 2012).

Phenotypic correlation coefficient = $\frac{Cov_{p_{xy}}}{\sqrt{(\sigma^2_{p_x})\,(\sigma^2_{p_y})}}$

Where, $Cov_{p_{xy}}$ = phenotypic covariance between character x and y

$\sigma^2_{p_x}$ = phenotypic variance for character x

$\sigma^2_{p_y}$ = phenotypic variance for character y

Genotypic correlation coefficient ($r_{g_{xy}}$) = $\frac{COV_{g_{xy}}}{\sqrt{(\sigma^2_{g_x})\,(\sigma^2_{g_y})}}$

Where, $Cov_{g_{xy}}$ = genotypic covariance between character x and y

$\sigma^2_{g_x}$ = genotypic variance for character x

$\sigma^2_{g_y}$ = genotypic variance for character y

Phenotypic correlation coefficient was tested their significance using the formula suggested by (Sabaghpour *et al*., 2012).

$$t = \frac{r_p}{SE(r_p)}$$

Where, $r_p$ = Phenotypic correlation $SE_{r_p}$= Standard error of phenotypic correlation was obtained using in the following procedure (Sabaghpour *et al*., 2012).

$$SE_{(r_p)} = \sqrt{\frac{1-r_p^2}{n-2}}$$

Where, *n* is the number of varieties tested

$r_p$ = phenotypic correlation coefficient

Genotypic correlation coefficient was tested with the following formula as suggested by

Sabaghpour *et al*. (2012).

$$t_{cal} = \frac{r_g}{SE(r_g)}$$

Where, $SE_{r_g}$= Standard error of genotypic correlation coefficient

$$SE_{r_g} = \sqrt{\frac{1-r_g^2}{2H_x^2 * H_y^2}}$$

Where, $H_x^2$ = Heritability of trait x

$H_y^2$= Heritability of trait y

The calculated absolute *t*-value tested against the tabulated *t*-value at *n-2* degree of freedom for both phenotypic and genotypic correlations.

To compute the DMRT value at α (1% and 5%) level of significant:

$$DMRT_\alpha = (t_\alpha)\,(s_{\bar{d}})$$

But, $s_{\bar{d}} = \sqrt{\frac{2MSE}{r}}$

Where, $s_{\bar{d}}$ is the standerd error of the mean difference and $t_\alpha$is the tabulated *t*-value at α level of significant and with *n* = error degree of freedom (Gomez and Gomez 1984).

## 3. Results

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*3.1. Analysis of Variance of Studied Traits*

The individual location (table 2 and 3) and across locations (table 4) analysis of variance was carried out for 12 traits recorded at *Wegdi* and *Legambo* Districts, respectively. There was a highly significant difference among the varieties for days to 50% flowering, days to maturity, number of primary branch per plant, number of secondary branches, plant height, number of pods per plant, number of seed per pod and number of seed per plant, thousand seed weight, dry biomass, seed yield and harvest index at individual locations showed the genetic variability for yield and its components (table 2 and 3). Similar to the present study,(Maqbool *et al*., 2015) reported considerable genetic variability for seed yield and its component traits in studied kabuli chickpea varieties in Ethiopia. Sikdar *et al*. (2015) reported highly significant differences among varieties for days to maturity, number of primary branch per plant, number of secondary branches, plant height, number of pods per plant, number of seed per pod and number of seed per plant, thousand seed weight, dry biomass, seed yield and harvest index in agreement with the present study. However, Sikdar *et al*. (2015) reported non-significant differences among kabuli chickpea varieties for days to 50% flowering, days to maturity, number of primary branch per plant, number of secondary branches, number of seed per plant and harvest index contradict to the present study.

Highly significant location effects were observed for all the traits except number of secondary branch and number of seed per pod that indicated the differences in growth conditions showed across the two locations (table 4).Mean squares of varieties were significant ($P<0.01$) for days to 50% flowering, days to maturity, number of primary branch per plant, plant height, number of pods per plant, number of seed per plant, thousand seed weight, dry biomass and seed yield across the two location that i ndicated variability in studied varieties at Wegdi and Leg ambo Districts (table 4). Selection to be effective for diff erent traits for creating variability (Keneni *et al.*,2011).

The location × varieties interaction was highly significant for number of primary branch per plant, number of secondary branches, number of seed per pod and number of seed per plant, thousand seed weight, dry biomass and seed yield across the two locations (table 4). However, days to 50% flowering and days to maturity were weak significant across the two locations. This significant variation indicated that different performance of kabuli chickpea varieties across the two locations and the varieties responded differently to the different environmental condition suggested the importance of the assessment of varieties under different environments in order to identify better performing kabuli chickpea variety for Wegdi and Legambo district environment. On the other hand, plant height, numbers of pods per plant and harvest index were non-significant across the study location (table 4).

Table.2. Mean squares of twelve traits of Kabuli chickpea varieties tested at *Wegdi* district

| Traits | Rep.(df=2) | Genotype(df=12) | Error(df=24) | CV |
|---|---|---|---|---|
| DF | 0.64 | 20.73** | 0.47 | 1.6 |
| DM | 4.41 | 83.18** | 1.27 | 1.1 |
| NPB | 0.10 | 4.05** | 0.13 | 8.4 |
| NSB | 0.10 | 12.14** | 0.13 | 6.0 |
| PH | 4.41 | 140.14** | 0.49 | 1.4 |
| NPPl | 2.79 | 1063.42** | 1.24 | 2.8 |
| NSP | 0.03 | 0.47** | 0.03 | 8.6 |
| NSPl | 3.77 | 6860.14** | 5.88 | 3.1 |
| HSW | 0.54 | 69.65** | 0.18 | 1.2 |
| BYPKG | 16264.00 | 5983051.00** | 72661.00 | 3.3 |
| SYPHA | 40300.00 | 810659.00** | 34694.00 | 6.1 |
| HI% | 8.42 | 290.33** | 15.14 | 10.1 |

Table.3. Mean squares of twelve traits of Kabuli chickpea varieties tested at *Legambo* district

| Traits | Rep.(df=2) | Genotype(df=12) | Error(df=24) | CV |
|---|---|---|---|---|
| DF | 1.64 | 23.72** | 0.78 | 1.9 |
| DM | 3.77 | 99.41** | 6.69 | 2.4 |
| NPB | 0.03 | 4.80** | 0.05 | 6.3 |
| NSB | 0.08 | 17.70** | 0.19 | 7.0 |
| PH | 3.41 | 162.80** | 0.55 | 1.5 |
| NPPl | 0.18 | 1146.27** | 1.10 | 2.8 |
| NSP | 0.03 | 0.64** | 0.03 | 8.9 |
| NSPl | 6.26 | 5637.79** | 6.56 | 3.6 |
| HSW | 0.33 | 63.09** | 0.11 | 0.9 |
| BYPKG | 13791.00 | 5969593.00** | 78491.00 | 3.5 |
| SYPHA | 59466.00 | 1006123.00** | 29323.00 | 6.0 |
| HI% | 19.75 | 335.33 | 19.57 | 11.9 |

Table.4. Mean squares of twelve traits of Kabuli chickpea varieties tested across locations

| Traits | Rep. (df=2) | Genotype (df=12) | Location (df=1) | Genotype.Location (df=12) | Error (df=50) | $G_{mean}$ | CV |
|---|---|---|---|---|---|---|---|
| DF | 2.17 | 44.14** | 472.62** | 0.61* | 0.31 | 45.2 | 1.7 |
| DM | 6.17 | 176.74** | 370.51** | 5.85* | 3.9 | 106 | 1.9 |
| NPB | 0.04 | 8.34** | 8.01** | 0.51** | 0.09 | 4 | 7.6 |
| NSB | 0.17 | 27.57** | 0.32$^{ns}$ | 2.27** | 0.15 | 6.1 | 6.4 |
| PH | 7.78 | 302.32** | 55.85** | 0.63$^{ns}$ | 0.50 | 50.9 | 1.4 |
| NPPl | 2.19 | 2206.24** | 113.28 | 3.45$^{ns}$ | 1.15 | 38.9 | 2.8 |
| NSP | 0.05 | 1.00** | 0.12* | 0.12** | 0.02 | 1.8 | 8.6 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NSPl | 7.17 | 12210.14** | 1280.21** | 287.79** | 6.09 | 74.5 | 3.3 |
| HSW | 0.78 | 125.99** | 10.05** | 6.75** | 0.14 | 35.5 | 1.1 |
| BY | 29570 | 11951352** | 1005043** | 1292** | 257.3 | 8034 | 3.4 |
| SYH | 74497 | 1797009** | 779600** | 19773** | 1739 | 2956 | 6 |
| HI% | 20.17 | 620.13** | 41.18ns | 26.53ns | 16.98 | 37.9 | 10.9 |

## 4. Discussion

*4.1. Days to flowering*

Analysis of variance showed significant variability (*p<0.01*) among varieties for days to flowering at *Wegdi* location (table 2). Kabuli varieties showed narrower range of days to flowering from 37-46 (9) days between early and late flowering varieties. Early and late flowering varieties were *Kobo* with mean of 37 days and *Dehara* and *Qoqa* with mean of 46 days, respectively, (table 5). Fifty-four percent (54%) varieties had fewer days to flowering than the grand mean (43) days to reach their 50% flowering. However, forty-six percent (46%) varieties had greater number of days to flowering than the grand mean (43) days to reach their 50% flowering stage at *Wegdi* location (table 5). Similarly, Shiferaw *et al*.(2018) reported a narrow variation of days to flowering, ranged from 38 to 47 days among Kabuli chickpea varieties. As presented (table 5), *Kobo* was identified early flowering variety in future breading program of kabuli chickpea to combine earliness with higher seed yield at *Wegdi* location. Because, earliness of variety for days to flowering alone is not a desired trait without other traits like higher seed yield for adoption of varieties by farmers. Since, earliness of varieties for days to flowering used to prevent negative impacts of terminal drought for chickpea production.

The analysis of variance indicated highly significant difference between varieties for days to flowering at Legambo location (Table 3). Kabuli varieties showed narrower range of days to flowering from 41-51 (10) days between early and late flowering varieties. Early and late flowering varieties were *Kobo* with mean of 41 days, and *Dehara* and *Qoqa* with mean of 51 days, respectively, (Table 6). Forty-six percent of (46%) varieties had greater days to flowering than the grand mean (48) days to reach their flowering stage. On the other hand, fifty-four percent of (46%) varieties had fewer number of days to flowering than the grand mean (48) days to reach their 50% flowering stage at *Legambo* location (Table 6). In agreement with the present study, Verma *et al.* (2014) reported a narrow variation of days to flowering, ranged from 37 to 53 days between chickpea varieties. As presented in (Table 5 and 6), *Kobo* was identified early flowering variety in future breading program of kabuli chickpea to combine earliness with higher seed yield at both *Wegdi* and *Legambo* location.

*4.2. Days to maturity*

The analysis of variance indicated highly significant variability among the varieties for the traits days to 50% maturity at *Wegdi* location (Table 2). The varieties showed a wide range of variation from 95-112 (17) days for days to 50% maturity. As presented in (Table 5), forty-six percent (46%) varieties were matured in fewer days than the grand mean (103) days. Early and late maturing varieties were *Kobo* with mean of 95 days and *Hora and Chefe* with mean of 112 and 111 days, respectively, at *Wegdi* location (Table 5). Therefore, variety *Kobo* can be used as a parent in future breading program to develop early maturing Kabuli chickpea varieties. Similarly, Muruiki *et al*. (2018) reported a wide variation of days to maturity ranged from 98 to 115 days among chickpea varieties. As presented in (Table 5), *Kobo* was identified early-matured variety can be used as a parent to combine higher yielder variety with early-matured kabuli chickpea varieties, which make them desirable as they are combined for the two important traits at *Wegdi* and related locations. Because, earliness to maturity alone is not a primary target in breading programs, without higher seed yield, early varieties cannot adapted by farmers.

The analysis of variance showed significant difference (*p<0.01*) among the varieties for the traits days to 50% maturity at *Legambo* location (Table 3). The varieties indicated range of variation from 99-118 (19) days for days to 50% maturity. As presented in (Table 6), fifty four percent (54%) varieties were matured in greater days than the grand mean (108) days. Early and late maturing varieties were *Kobo* and *Shasho* with mean of 99 days and *Hora and Chefe* with mean of 116 and 118 days, respectively, at *Legambo* location (Table 6). Therefore, variety *Kobo* and Shasho can be used as a parent in future breading program to develop early maturing Kabuli chickpea varieties for *Legambo* and related locations. Similarly, Joshi *et al*. (2018) reported a wide variation of days to maturity ranged from 102 to 120 days between chickpea varieties.

*4.3. Primary branch*

The analysis of variance showed highly significant variability between the tested varieties for the number of primary branches per plant at *Wegdi* location (Table 2). The number primary branches per plant, which contributes to the number of productive branches per plant, ranged from 2 to 6.3 with grand mean of 4.3 at *Wegdi* study location. Varieties with lowest and highest numbers of primary branches per plant were *Kasech* and *Qoqa* with mean of 6.3 and 6, and *Akoso Dubie* with mean of 2.0, respectively, (Table 5). The result indicated that sixty-two percent of (62%) varieties have lower primary branches number than the grand mean (4.3). Only thirty-eight percent of (38%) varieties had higher primary branches number than the grand mean (4.3) at *Wegdi* location. In agreement with the present study, Belete *et al*. (2017) reported a variation in primary branches number per plant, which ranged from 3 to 7 between chickpea varieties. Joshi *et al*. (2018) also reported a narrow range of variation for primary branches number per plant, which ranged from 3 to 5 between the chickpea varieties. Because, highest number of primary branches is desired traits provide highest final number of primary branches per unit area, above ground biomass and grain yield for adoption of varieties by different farmers.

The analysis of variance indicated significant variability (*p<0.01*) among the Kabuli chick pea varieties for the number of primary branches per plant at *Legambo* location (Table 3). The number primary branches per plant, which ranged from 2 to 6 with grand mean of 3.6 at *Legambo* study location. Varieties with lowest and highest numbers of primary branches per plant were *Kasech, Kobo* and *Qoqa* with mean of 6 and 5 and *Akoso Dubie* and *Yelbie* with mean of 2, respectively, (Table 6). The result indicated that fifty-four percent (54%) varieties have lower primary branches number than the grand mean (3.6). forty-six percent (46%) varieties had higher primary branches number than the grand mean (3.6) at *Legambo* study location. Similarly, with the present study, Mallu (2015) reported a variation in primary branches number per plant, which ranged from 2 to 6 between chickpea varieties.

### *4.4. Secondary branch*

The analysis of variance showed significant difference (*p<0.01*) between the varieties for secondary branch per plant at *Wegdi* location (Table 2). Number secondary branch per plant, which contributes to the number of plants per square meter, ranged from 2 to 10 with grand mean of 6 in the present *Wegdi* location study. The varieties with lowest and highest numbers of secondary branch per plant were *Akoso Dubie* with mean of 2 and *Kobo* with mean of 10, respectively. Sixty-two percent of (60%) of varieties had higher number of secondary branch per plant than the grand mean (6). However, thirty eight percent of (38%) varieties had lower number of secondary branch per plant. In agreement with the present study, (Maqbool *et al*., 2016) reported a variation in secondary branch per plant ranged from 3 to 9 between kabuli chickpea varieties. Kobo variety was finding to be high grain yielder with higher number of secondary branch per plant, which makes them desirable as they combined with seed yield of important trait at *Wegdi* and related locations. Because, high numbers of secondary branch per plant is a desired trait to increase seed yield of chickpea varieties and it is important for easier adoption of varieties by farmers.

The analysis of variance indicated significant variability (*p<0.01*) among the varieties for secondary branch per plant at *Legambo* location (Table 3). The varieties with lowest and highest numbers of secondary branch per plant were *Akoso Dubie* with mean of 2 and *Kobo* with mean of 10, *Shasho* with mean of 9.3 and *Kasech* with mean of 9, respectively, at Legambo location (Table 6).

### *4.5. Plant height*

The analysis of variance showed significant variability (*p<0.01*) between varieties for plant height at *Wegdi* location (Table 2). The magnitude of variation for plant height ranged from 41.7 to 63.3 cm with grand mean height of 51.3 cm. The results show that 9 varieties (69%) of the varieties had shorter plant height and 4 varieties (31%) of varieties with taller plant height than 51.3 cm, respectively, (Table 5). As presented (Table 5), shortest and longest plant height varieties were *Chefe* with mean of 41.7 cm and *Kasech, Qobo* and *Qoqa* with mean of 62.3 cm, respectively, at Wegdi location in the present study. (Belete *et al*.(2017) reported a wide variation of plant height, which ranged from 42.2 to 52 cm among kabuli chick pea varieties similar with the present study. Longest plant alone is not a desired trait without having higher above ground biomass and grain yield for adoption of varieties by farmers. Plant height also very important in terms of resistance to lodging and harvest index.

The analysis of variance indicated highly significant difference between varieties for plant height at *Legambo* location study area (Table 3). The magnitude of variation for plant height ranged from 39.7 to 63 cm with grand mean height of 50 cm. The results show that 31% of the varieties had shorter plant height and 69% of the varieties with taller plant height than 50 cm, respectively, (Table 6). As presented (Table 6), shortest and longest plant height varieties were similar with the study that carried out at *Wegdi* location in the present study.

### *4.6. Pod per plant*

The analysis of variance showed highly significant difference among the varieties for the trait Pod per plant at *Wegdi* location (Table 2). The magnitude of variation for pod per plant ranged from 15 to 70 with grand mean of 40. The varieties with lowest and highest numbers of pod per plant were *Akoso Dubie* with mean of 15 and *Qoqa* with mean of 70, respectively. Sixty-two percent (62%) of the varieties had lower number of pod per plant than the grand mean 40 and the rest thirty-eight percent (38%) of varieties had higher number of pod per plant than the grand mean 40. In disagreement with the present study, Mallu (2015) reported a variation on number of pod per plant, which ranged from 12 to 23 among chickpea varieties. Joshi *et al*. (2018) also reported a wide variation on number of pod per plant, which ranged from 15 to 38 among chickpea varieties. *Qoqa* varieties were finding to be high seed yielder and had high number of pod per plant, which make them desirable as they combined higher seed yielder Kabuli chickpea varieties at *Wegdi* and related location.

The analysis of variance indicated significant variability (p<0.01) between the varieties for the trait pod per plant at *Legambo* location similar with *Wegdi* study location (Table 3). The magnitude of variation for pod per plant ranged from 12 to 68 with grand mean of 38. The varieties with highest and lowest numbers of pod per plant were *Kobo* with mean of 68, *Kasech* with mean of 67 and *Qoqa,* with mean of 66 and *Akoso Dubie* with mean of 12, respectively, (Table 6). Kobo, Kasech and *Qoqa* varieties were finding to be high seed yielder and had high number of pod per plant, which make them desirable as they combined higher seed yielder Kabuli chickpea varieties at *Legambo* location.

### *4.7. Seed per plant*

The analysis of variance showed highly significant variability among the Kabuli chickpea varieties for seed per plant at *Wegdi* location (Table 2). Number of seed per plant, which contributes to the seed per hectare, ranged from 17 to 150 with grand mean of 79 in the present study. The varieties with lowest and highest numbers of seed per plant were *Akoso Dubie* with mean of 17 and *Shasho* with mean of 150, respectively. Sixty-two percent (62%) of varieties had lower number of seed per plant than the grand mean (79). However, Thirty-eight percent (38%) of varieties had higher number of seed per plant. Similarly, Mpai and Maseko (2018) reported a variation in seed per plant ranged from 21 to 145 among chickpea varieties. Shasho variety was finding to be high seed yielder with higher number of seed per plant, which make them desirable as they combined with above ground biomass yield of important traits. Because, high numbers of seed per plant is a desired trait to increase the seed yield of variety and it is important for easier adoption of varieties by farmers.

The analysis of variance indicated significant variability (p<0.01) between the Kabuli chickpea for seed per plant at *Legambo* location similar with *Wegdi* location (Table 3). Number of seed per plant, which contributes to the seed per hectare, ranged from 12 to 136 with grand mean of 71 in the present study. The varieties with highest and lowest numbers of seed per plant were Kobo with mean of 136 and *Qoqa* with mean of 133 and *Akoso Dubie* with mean of 12, respectively, for *Legambo* district (Table 6).

### *4.8. Thousand Seed weight*

The analysis of variance showed highly significant variation between Kabuli chickpea varieties for thousand seed weight at *Wegdi* location (Table 2). The presence of highly significant variation between varieties reflected the existence of genetic variation among Kabuli chickpea varieties. Varieties that characterized with higher thousand-seed weight had higher seed yield. The variation in their thousand-seed weight ranged from 28 g to 47.7 g per thousand seed with overall mean of 35.2 g. Thirty-nine percent (39%) of the varieties had higher seed weight than grand mean (35.2 g) of thousand-seed weight. Sixty-one percent (61%) varieties had lower thousand-seed weight than grand mean (35.2) g of thousand-seed weigh. Varieties with the lowest and highest thousand seed weight yield were *Shasho* with mean of 28 g and *Akoso Dubie* with mean of 47.7 g, respectively (Table 4). In agreement with the present results, Mallu (2015) reported a variation of thousand seed weight, which ranged from 21 g to 50 g between Kabuli chickpea varieties. The top varieties for thousand seed weight was finding to be high thousand seed yielder, which makes them undesirable as they combined the seed yield per hectare at *Wegdi* location study area.

The variation in their thousand seed weight ranged from 29 g to 46 g per thousand seed weight with overall mean of 35.9 g at *Legambo* location study area and almost it was similar with *Wegdi* location study area in most varieties.

### *4.9. Seed yield*

The analysis of variance showed significant variation (p<0.01) between Kabuli chickpea varieties for seed yield at *Wegdi* location study area (Table 2). The presence of highly significant variation indicated the existence of considerable genetic variation between the tested Kabuli chickpea varieties at the study area. In addition, seed yield of Kabuli chickpea varieties ranged between 2803 to 4153 kg $ha^{-1}$. Thirty-one percent (31%) of varieties had a seed yield exceeding the grand mean (3056) kg$ha^{-1}$. However, sixty-nine percent (69%) of varieties had performed below grand mean (3056) kg$ha^{-1}$. From the tested Kabuli chickpea varieties with the lowest and highest seed yield were *Akoso Dubie* with mean of 2353 kg $ha^{-1}$ and *Akuri* with mean of 3083 kg$ha^{-1}$, *Kobo* with mean of 4153 kg$ha^{-1}$, *Qoqa* with mean of 3673 kg$ha^{-1}$ and *Kasech* with mean of 3839 kg $ha^{-1}$, respectively, at *Wegdi* location study area (Table 5). In harmony with present finding, Ghribi *et al.*(2015) reported a wide variation in seed yield per *hectare* which ranged from 2215 kg $ha^{-1}$ to 3955 kg $ha^{-1}$ among Kabuli chickpea varieties at *Wegdi* location study area. The top four Kabuli chickpea varieties identified for high seed yield to be higher for the above ground biomass, which make them desirable as they combined both yield and yield components of seed yield at the same Kabuli chickpea varieties at the study

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area. Because of this high seed yielder per hectare is a desired trait to increase the seed yield of variety and it is important for easier adoption of varieties by farmers.

The analysis of variance showed highly significant variation among Kabuli chickpea varieties for seed yield at *Legambo* location (Table 3). Seed yield of Kabuli chickpea varieties ranged between 1820 to 3932 kg $ha^{-1}$. Thirty-one percent (31%) of varieties had a seed yield greater than the grand mean (2856) kg$ha^{-1}$. On the other hand, sixty-nine percent (69%) of varieties had performed lower amount of seed yield than the grand mean (2856) kg$ha^{-1}$ similar to *Wegdi* study location. From the tested Kabuli chickpea varieties with the highest and lowest seed yield were *Kobo* with mean of 3932 kg$ha^{-1}$, *Kasech with* mean of 3767 kg$ha^{-1}$ *Qoqa* with mean of 3543 kg$ha^{-1}$, and *Akuri* with mean of 2883 kg$ha^{-1}$ and *Akoso Dubie* with mean of 1820 kg$ha^{-1}$, respectively, at Legambo Location (Table 5). Similar to the present study, Mpai and Maseko (2018) reported a variation in seed yield per hectare which ranged from 1789 kg $ha^{-1}$ to 3786 kg $ha^{-1}$ between Kabuli chickpea varieties. The top four Kabuli chick pea varieties identified for high seed yield were similar to *Wegdi* location, but lower yielder when we compared between the two locations.

### *4.10. Harvest index*

The analysis of variance showed significant variation ($p<0.01$) between Kabuli chickpea varieties for harvest index for both study location which were *Wegdi* and *Legambo* districts (Table 2 and 3). Harvest index of varieties ranged from 39% to 65% for *Wegdi* location and 27% to 64% for *Legambo* location. The highest Kabuli chickpea varieties were finding to be highest harvest index, which make them the desirable varieties as they combined both harvest index and grain yield. Grain yield is the result of biological product of above ground biomass and harvest index. Therefore, higher harvest index that provide higher and desired final grain yield products for Kabuli chickpea varieties at *Wegdi* and *Legambo* study location.

Table: 5. Mean performance of 13 Kabuli type chickpea varieties tested at *Wegdi* District

| Geno. | DF | DM | NPB | NSB | PH | NPPI | NSP | NSP | HSW | BYPK | SYH | HI% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ak.D | $44^{e}$ | $102^{cd}$ | $2^{g}$ | $2^{i}$ | $51^{bc}$ | $15^{j}$ | $1^{c}$ | $17^{j}$ | $48^{a}$ | $6943^{e}$ | $2353^{e}$ | 34 |
| Akuri | $44^{e}$ | $105^{e}$ | $5^{cd}$ | $6^{d}$ | $45^{e}$ | $46^{d}$ | $2^{b}$ | $89^{d}$ | $36^{d}$ | $9363^{bc}$ | $3083^{c}$ | 33 |
| Chefe | $43^{cd}$ | $111^{g}$ | $4^{e}$ | $5^{dg}$ | $42^{f}$ | $25^{i}$ | $1^{c}$ | $28^{i}$ | $35^{e}$ | $7990^{d}$ | $2813^{cd}$ | 35 |
| Dehara | $46^{f}$ | $104^{e}$ | $4^{e}$ | $5^{deg}$ | $49^{d}$ | $34^{f}$ | $2^{b}$ | $66^{f}$ | $36^{e}$ | $9178^{c}$ | $2913^{c}$ | 32 |
| Enjer | $43^{cd}$ | $100^{c}$ | $4^{ce}$ | $6^{d}$ | $50^{c}$ | $31^{g}$ | $2^{b}$ | $61^{g}$ | $30^{i}$ | $9769^{ab}$ | $2853^{cd}$ | 29 |
| Habru | $42^{c}$ | $105^{e}$ | $4^{cde}$ | $6^{de}$ | $51^{bc}$ | $39^{e}$ | $2^{b}$ | $77^{e}$ | $38^{c}$ | $9217^{c}$ | $3040^{c}$ | 33 |
| Hora | $39^{b}$ | $112^{g}$ | $5^{c}$ | $5^{defg}$ | $46^{e}$ | $27^{h}$ | $2^{b}$ | $46^{h}$ | $32^{h}$ | $7703^{d}$ | $2810^{cd}$ | 37 |
| Kasech | $40^{b}$ | 97b | $6^{a}$ | $9^{b}$ | $62^{a}$ | $68^{b}$ | $2^{a}$ | $137^{c}$ | $34^{ef}$ | $9961^{a}$ | $3839^{b}$ | 39 |
| Qobo | $37^{a}$ | $95^{a}$ | $5^{b}$ | $10^{a}$ | $62^{a}$ | $67^{b}$ | $2^{b}$ | $134^{c}$ | $33^{g}$ | $6382^{f}$ | $4155^{a}$ | 65 |
| Qoqa | $46^{f}$ | $102^{d}$ | $6^{a}$ | $8^{c}$ | $63^{a}$ | $70^{a}$ | $2^{b}$ | $143^{b}$ | $39^{b}$ | $9053^{c}$ | $3673^{b}$ | 41 |
| Shasho | $44^{de}$ | 97b | $4^{e}$ | $6^{defg}$ | $51^{bc}$ | $51^{c}$ | $2^{b}$ | $150^{a}$ | $28^{j}$ | $5507^{g}$ | $2803^{cd}$ | 51 |
| Teji | $45^{e}$ | $108^{f}$ | $4^{cde}$ | $6^{def}$ | $48^{d}$ | $24^{i}$ | $2^{b}$ | $26^{i}$ | $34^{ef}$ | $8029^{g}$ | $2547^{de}$ | 32 |
| Yelbie | $42^{e}$ | $106^{e}$ | $3^{f}$ | $4^{h}$ | $52^{b}$ | $24^{i}$ | $2^{b}$ | $47^{h}$ | $34^{f}$ | $6830^{ef}$ | $2850^{cd}$ | 42 |
| $G_{mean}$ | 43 | 103 | 4 | 6 | 51 | 40 | 2 | 79 | 35 | 8148 | 3056 | 39 |
| CV | 1.6 | 1.1 | 8.4 | 6.0 | 1.4 | 2.8 | 8.6 | 3.1 | 1.2 | 3.3 | 6.1 | 10 |
| DMRT at 5% | 1.2 | 1.9 | 0.6 | 0.6 | 1.2 | 1.9 | 0.3 | 4.1 | 0.7 | 454.3 | 313.9 | 6.6 |

Table: 6. Mean performance of 13 Kabuli chickpea varieties tested at *Legambo* District

| Geno. | DF | DM | NPB | NSB | PH | NP | NS | NSP | HS | BYK | SYH | HI% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ak. D. | $50^{hi}$ | $110^{def}$ | $2^{e}$ | $2^{i}$ | $49^{b}$ | $12^{j}$ | $1^{c}$ | $12^{j}$ | $46^{a}$ | $6689^{e}$ | $1820^{e}$ | 27 |
| Akuri | $49^{dfgh}$ | $111^{ef}$ | $4^{c}$ | $6^{de}$ | $43^{d}$ | $46^{d}$ | $2^{b}$ | $92^{d}$ | $36^{ef}$ | $9163^{bc}$ | $2883^{c}$ | 32 |
| Chefe | $47^{cd}$ | $118^{g}$ | $3^{d}$ | $6^{def}$ | $40^{e}$ | $22^{hi}$ | $1^{c}$ | $23^{i}$ | $37^{e}$ | $7790^{d}$ | $2613^{cd}$ | 34 |
| Dehar | $51^{i}$ | $106^{bcd}$ | $3^{d}$ | $4.3^{g}$ | $47^{c}$ | $31^{f}$ | $2^{b}$ | $61^{f}$ | $36^{f}$ | $8945^{c}$ | $2713^{c}$ | 30 |
| Enjer | $47^{cde}$ | $105^{bc}$ | $3^{d}$ | $5.3^{ef}$ | $48^{b}$ | $27^{g}$ | $2^{b}$ | $56^{g}$ | $30^{j}$ | $9535^{ab}$ | $2653^{cd}$ | 28 |
| Habru | $47^{cde}$ | $109^{cde}$ | $3^{d}$ | $5^{fg}$ | $49^{b}$ | $36^{e}$ | $2^{b}$ | $72^{e}$ | $38^{d}$ | $8917^{c}$ | $2840^{c}$ | 32 |
| Hora | $44^{b}$ | $116^{g}$ | $4^{c}$ | $6.3^{d}$ | $44^{d}$ | $24^{h}$ | $2^{b}$ | $45^{h}$ | $31^{i}$ | $7470^{d}$ | $2610^{cd}$ | 35 |
| Kasec | $46^{c}$ | $102^{ab}$ | $6^{a}$ | $9^{bc}$ | $62^{a}$ | $67^{ab}$ | $2^{a}$ | $128^{b}$ | $36^{f}$ | $9767^{a}$ | $3767^{ab}$ | 39 |
| Qobo | $41^{a}$ | $99^{a}$ | $6^{a}$ | $10^{a}$ | $62^{a}$ | $68^{a}$ | $2^{b}$ | $136^{a}$ | $40^{b}$ | $6172^{f}$ | $3932^{a}$ | 64 |
| Qoqa | $51^{i}$ | $106^{bcd}$ | $5^{a}$ | $8^{c}$ | $62^{a}$ | $66^{b}$ | $2^{b}$ | $133^{a}$ | $39^{c}$ | $8820^{c}$ | $3543^{b}$ | 40 |
| Shash | $48^{defg}$ | $99^{a}$ | $4^{c}$ | $9^{ab}$ | $49^{b}$ | $49^{c}$ | $2^{b}$ | $97^{c}$ | $29^{k}$ | $5273^{g}$ | $2763^{c}$ | 53 |
| Teji | $50^{ghi}$ | $111^{f}$ | $3^{d}$ | $6^{def}$ | $46^{c}$ | $21^{i}$ | $1^{c}$ | $21^{i}$ | $35^{g}$ | $7795^{d}$ | $2347^{d}$ | 30 |
| Yelbie | $48^{def}$ | $109^{cde}$ | $2^{e}$ | $3^{h}$ | $48^{b}$ | $21^{i}$ | $2^{b}$ | $42^{h}$ | $33^{h}$ | $6637^{ef}$ | $2650^{cd}$ | 40 |
| $G_{mean}$ | 48 | 108 | 3.6 | 6.2 | 50 | 38 | 1.8 | 70.6 | 35.9 | 7921.1 | 2856 | 37 |
| CV | 1.9 | 2.4 | 6.3 | 7.0 | 1.5 | 2.8 | 8.9 | 3.6 | 0.9 | 3.5 | 6.0 | 11 |
| DT 5% | 1.5 | 4.4 | 0.4 | 0.7 | 1.3 | 1.8 | 0.3 | 4.3 | 0.6 | 472.1 | 288.6 | 7.5 |

*4.11. Correlation of yield with yield related traits*

Seed yield is a complex trait and formed by the effect of numerous multiple traits. Therefore, understanding of inheritance and relation of seed yield and yield related traits influencing these traits are highly important for formulating selection criteria. Thus, estimation of the magnitudes of genotypic and phenotypic correlations of seed yield and its component between yield related traits is highly crucial to utilize existing variability through selection. At phenotypic level, seed yield was strong positive and significantly correlated with number of primary branch per plant, number of secondary branches, plant height, number of pods per plant, number of seed per pod and number of seed per plant and harvest index (Table 7). However, seed yield was weak negatively and significantly correlated with days to 50% flowering, days to 50% maturity (Table 10). On the other hand, seed yield was none significant with thousand seed weight and above ground biomass in the present study (Table 7). The result are in agreement with (Verma *et al*. (2014) reported for correlation of seed yield with harvest index, number of secondary branches, plant height, number of pods per plant, number of seed per pod and number of seed per plant in agreement with the present study.

At genotypic level, seed yield showed strong and positive significant correlation with different traits at *Wegdi* study area (Table 7). Therefore, improvement of these traits would result substantial increase on seed yield. At genotypic level, seed yield was strong and positive significantly correlated with number of primary branch per plant, number of secondary branches, plant height, number of pods per plant, number of seed per pod and number of seed per plant, thousand seed weight and harvest index (Table 7). This positive genotypic correlation with seed yield was in agreement with previous report (Wordofa, 2015). On the other hand, seed yield showed strong and negative significant correlated with days to 50% flowering, days t o 50% maturity (Table 7). However, seed yield was non significant correlated with biomass yield (Table 7).There fore in those traits grain yield showed positive significan t correlation component interaction in which a gene promotes an increase in one trait also positive influence another trait provided other conditions to be constant (Table 7). Similarly, at phenotypic and genotypic level, seed yield showed different significant correlation nature with different traits at Legambo study area (Table 7). Therefore, improvement of these traits would result substantial increase on seed yield of Kabuli chick pea varieties.

Table.7. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients of traits of Kabuli chickpea at *Wegdi* District

| | DF | DM | NPB | NSB | PH | NPP | NSP | NSP | HSW | BY | SY | HI% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DF | 1 | 0.87** | -0.68* | -0.88** | -0.78* | -0.79* | -0.65* | -0.76* | 0.88** | 0.85** | -0.89** | -0.77* |
| DM | 0.19$^{ns}$ | 1 | -0.65* | -0.97** | -0.98** | -0.86** | -0.68* | -0.85** | 0.42$^{ns}$ | 0.37$^{ns}$ | -0.84** | -0.88** |
| NPB | -0.3* | -0.23$^{ns}$ | 1 | 0.98** | 0.87** | 0.91** | 0.76* | 0.85 | 0.64* | 0.46$^{ns}$ | 0.96** | 0.79* |
| NSB | -0.44** | -0.46** | 0.85** | 1 | 0.85** | 0.96** | 0.78* | 0.89 | 0.66* | 0.65* | 0.93** | 0.87** |
| PH | -0.24$^{ns}$ | -0.73** | 0.56** | 0.64** | 1 | 0.87** | 0.69* | 0.78 | 0.12$^{ns}$ | 0.21$^{ns}$ | 0.85** | 0.79* |
| NPP | -0.24$^{ns}$ | -0.63** | 0.81** | 0.86** | 0.78** | 1 | 0.61* | 0.98 | -0.32$^{ns}$ | 0.56$^{ns}$ | 0.97** | 0.75* |
| NSP | -0.15$^{ns}$ | -0.29$^{ns}$ | 0.52** | 0.56** | 0.41** | 0.52** | 1 | 0.78 | -0.34$^{ns}$ | 0.76* | 0.86** | 0.43$^{ns}$ |
| NSP | -0.19$^{ns}$ | -0.70** | 0.66** | 0.73** | 0.72** | 0.94** | 0.55** | 1 | 0.64* | 0.67* | 0.93** | 0.82** |
| HSW | 0.33* | 0.1$^{ns}$ | 0.28$^{ns}$ | 0.39* | 0.09$^{ns}$ | -0.2$^{ns}$ | -0.52** | -0.32* | 1 | 0.46$^{ns}$ | 0.94** | 0.74* |
| BY | 0.24$^{ns}$ | 0.15$^{ns}$ | 0.43** | 0.22$^{ns}$ | 0.03$^{ns}$ | 0.15$^{ns}$ | 0.28$^{ns}$ | -0.01$^{ns}$ | 0.11$^{ns}$ | 1 | 0.35$^{ns}$ | -0.87** |
| SY | -0.47** | -0.51** | 0.77** | 0.87** | 0.75** | 0.87** | 0.44** | 0.74** | -0.16$^{ns}$ | 0.15$^{ns}$ | 1 | 0.98** |
| HI% | -0.55** | -0.55** | 0.25$^{ns}$ | 0.50** | 0.52** | 0.54** | 0.14$^{ns}$ | 0.58** | -0.27$^{ns}$ | 0.65** | 0.63** | 1 |

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Table.8. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients of traits of Kabuli chick pea at *Legambo* District

| | DF | DM | NPB | NSB | PH | NPPl | NSP | NSPl | HSW | BY | SY | HI% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DF | 1 | 0.43 ns | -0.67 * | -0.65 * | 0.72 * | -0.86 ** | -0.76 * | -0.74 * | 0.87 ** | 0.83 ** | 0.78 * | 0.69 * |
| DM | 0.15 ns | 1 | -0.86 ** | -0.76 * | 0.87 ** | -0.93 ** | -0.87 ** | -0.95 ** | 0.98 ** | 0.76 * | 0.87 ** | 0.43 ns |
| NPB | 0.46 ** | 0.51 ** | 1 | 0.98 ** | 0.87 ** | 0.76 * | 0.87 ** | 0.64 * | 0.85 ** | 0.89 ** | 0.92 ** | 0.32 ns |
| NSB | 0.43 ** | 0.53 ** | 0.89 ** | 1 | 0.65 * | 0.97 ** | 0.74 * | 0.45 ns | -0.78 * | 0.76 * | 0.89 ** | 0.76 * |
| PH | 0.24 ns | 0.66 ** | 0.71 ** | 0.57 ** | 1 | 0.98 ** | 0.84 ** | 0.87 ** | 0.43 ns | 0.82 ** | 0.43 ns | 0.83 ** |
| NPPl | 0.29 ns | 0.64 ** | 0.93 ** | 0.85 ** | 0.79 ** | 1 | 0.76 * | 0.93 ** | 0.54 ns | 0.65 * | 0.82 ** | 0.67 * |
| NSP | 0.27 ns | 0.52 ** | 0.46 ** | 0.43 ** | 0.45 ** | 0.6 ** | 1 | 0.98 ** | -0.83 ** | 0.76 * | 0.92 ** | 0.64 * |
| NSPl | 0.28 ns | 0.67 ** | 0.89 ** | 0.80 ** | 0.78 ** | 0.98 ** | 0.69 ** | 1 | 0.56 ns | 0.43 ns | 0.97 ** | 0.64 * |
| HSW | 0.11 ns | 0.08 ns | 0.01 ns | 0.25 ns | 0.28 ns | 0.03 ns | -0.39 * | -0.02 ns | 1 | 0.67 * | 0.87 ** | 0.85 ** |
| BY | 0.25 ns | 0.13 ns | 0.11 ns | 0.08 ns | 0.03 ns | 0.14 ns | 0.26 ns | 0.14 ns | -0.01 ns | 1 | 0.76 * | 0.98 ** |
| SY | 0.45 ** | 0.53 ** | 0.88 ** | 0.77 ns | 0.74 ** | 0.90 ** | 0.60 ** | 0.89 ** | -0.02 ns | 0.18 ns | 1 | 0.93 ** |
| HI% | 0.25 ns | 0.13 ns | 0.11 ns | 0.08 ns | 0.03 ns | 0.14 ns | 0.32 * | 0.61 ** | -0.08 ns | 0.58 ** | 0.68 ** | 1 |

## 5. Conclusion

Results obtained from variability assessment and associations between yield and yield related component traits were presented here under the present study at individual and across location. The analysis of variance showed highly significant variation between Kabuli chickpea varieties for days to 50% flowering, days to 50% maturity, number of primary branch per plant, number of secondary branches, plant height, number of pods per plant, number of seed per pod and number of seed per plant, thousand seed weight, above ground biomass, seed yield and harvest index at *Wegdi* and *Legambo* Districts (Table 2 and 3). The result was confirming the presence of genetic variability and adaptability in yield and its component traits between Kabuli chickpea varieties. Coefficients of variation were used to compare precision of experimental results at the study location. Means with lower coefficients of variation for most traits revealed existence of reliability of data. *Qobo* with mean of 4153 and 3932 kg$ha^{-1}$, *Kasech* with mean of 3839 and 3767 kg$ha^{-1}$, *Qoqa* with mean of 3673 and 3543 kg$ha^{-1}$, and *Akuri* with mean of 3083 and 2883 kg $ha^{-1}$ Kabuli chickpea varieties were top four potential and better performing materials to distribute for farmers. In the present study, the phenotypic correlation coefficients were less in magnitude than the genotypic correlation coefficients that revealed the presence of inherent genetic relationships between various traits and less dependent on environmental effects in the individual and across study location.

Generally, the present study in the individual and across study location revealed the existence of significant genetic variability and adaptability between the tested Kabuli chickpea varieties for different traits helpful for direct and indirect selection.

This study recommended that the potential Kabuli chickpea varieties *Qobo, Kasech, Qoqa* and *Akuri* could be used for Kabuli chickpea varieties adoption and breeding programs for yield and yield component traits improvement under study location and similar agro-ecologies. Because, the top four identified Kabuli chickpea varieties were finding to be higher seed yield with other important yield and yield components of seed yield to present study. The top four founding potential Kabuli chickpea varieties should be multiplied for the future in different farmers' location for yield and yield component traits improvement under different agro-ecologies. Farmers, researchers, private organizations and governmental sectors could be beneficiary from this finding.

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## Author's Contributions

This section should state the contributions made by This research was involved with the collaboration of different expertise in plant science (crop improvement, agronomists and crop protection experts). The teams also work with association of research coordinator of the university as well as the communities nearby area. The roles and responsibilities of this team are as follows:

| Members | Role | Responsibility |
|---|---|---|
| Haile Tefera (Plant Breeder) | Principal Investigador | • Develop the proposal<br>• Selecting the proper site<br>• Coordinate and follow up the research activities Collect breeding aspect data<br>• Document write-up and reporting |
| Abebe Mis ganaw (Agronomi st) | Co-investigator | • Develop the proposal<br>• Selecting the proper site<br>• Collect agronomical data<br>• Document write-up |
| Seid Hussen (Bathologi st) | Co-investigator | • Develop Proposal<br>• Selecting the proper site<br>• Collect disease data<br>• Document write-up |

## Ethics

To conduct this study, there were different ethical considerations such as avoid plagiarism, follow research ethics, doing in coordinate, transparent, accountable and responsible and discussion through the principle of attack ideas but not people, to do activities from proposal writing up to report writing and publication.