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GENETIC VARIATION AND GRAIN YIELD PERFORMANCE OF IMPROVED COMMON BEAN VARIETIES UNDER IRRIGATED CONDITION: THE CASE OF BAKO TIBE DISTRICT, WEST SHOA ZONE, ETHIOPIA

BELAY, KEBEDE TADESSE

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GENETIC VARIATION AND GRAIN YIELD PERFORMANCE OF IMPROVED COMMON BEAN VARIETIES UNDER IRRIGATED CONDITION: THE CASE OF BAKO TIBE DISTRICT, WEST SHOA ZONE, ETHIOPIA

MSc. Thesis

ΒY

BELAY KEBEDE TADESSE

BAHI R DAR UNIVERSIT Y, BAHIR DAR August, 2015 GENETIC VARIATION AND GRAIN YIELD PERFORMANCE OF IMPROVED COMMON BEAN VARIETIES UNDER IRRIGATED CONDITION: THE CASE OF BAKO TIBE DISTRICT, WEST SHOA ZONE, ETHIOPIA

A THESIS SUBMITTED TO

SCHOOL OF GRADUATE STUDIES

THE DEPARTMENT OF BIOLOGY

BAHIR DAR UNIVERSITY

BY

BELAY KEBEDE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER IN BIOLOGY

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BAHIR DAR UNIVERSITY, BAHIR DAR, ETHIOPIA AUGUST, 2015

SCHOOL OF GRADUATE STUDIES BAHAR DAR UNIVERSITY APPROVAL SHEET

As thesis research advisors, we here by certify that we have visited his research work on field condition, checked the collected data ,read and evaluated this thesis entitled Genetic Variation and Grain Yield Performance of Improved Common Bean Varieties Under Irrigation Condition: The Case of Bako Tibe District, West Shoa, Ethiopia;• prepared by the candidate BELAY KEBEDE TADESSE under our guidance. We recommend that it can be submitted to school of graduate studies as fulfilling the thesis requirement.

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As members of the Board of Examiners of the MS Thesis Open Defense Examination, we certify that we have read, evældathe thesis prepared by Belay Kebede and examined the candidate. We recommend that the thesis be accepted as fulfilling the thesis requirement for the Degree of Master of Science in Biology

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| Internal Examiner | Signature | Date |
| External Examiner | Signature | Date |

DEDICATION

This thesis is dedicated my lovely mother, and fathefor their partnership in the success of my life.

STATEMENT OF THE AUTHOR

I declare that this thesis is ubmitted to School of Graduate Studies of Bahir Dar University in partial fulfillment of the requirement for Mast of Science (MSc), degree in Biology. I would like to attest through my signature affixed below that it is my own independent work and has not previously been submitted elsewhere by me or anybody for the award of any academic degree, diploma, or certificate.

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Name: Belay KebedeSignature: _____Place: Bahir Dar University, Bahir DarDate of subrission: August 2015

ACKNOWLEDGMENT

First, I would like to thank the almighty God who helped me to bring this work to the end. I feel great pleasure to express special gratitude to mynajor advisor, Dr. Bizuayehu Kerisew, for his guidance and insightful comments from which I benefited much. Without his professional assistance, the task would have been more difficult. I will never forget his kind and friendly treatment.

I would like to express my deepest gratitude and expipation to my coadvisor, Dr. Dagnachew Lulefor providing me his valuable comments and for his professional advice from the very inception of the research idea to the final thesis write up.

I extend my sincere thanks to my friend waki Feyera (model farmer), Zewudu Mesfin (MSc), and Girma Awaki (MSc.) for encouragement to pursue yreducation. Indeed, without their commitment and dedication, I would have not been successful.

LIST OF ACRONYMS AND ABBREVATIONS

- ADLI Agricultural development Led Industrialization
- CIAT The Centro International de Agricultura Tropical
- CSA Central Statistics Authority
- DAT Date After Flowering
- DNA DeoxyribeNucleic Acid
- EPPA Ethiopian Puses Profile Agency
- FAO Food and Agricultural Organization
- HARC Holeta Agricultural Research Center
- IBPGR International Board for Plant Genetic Resources
- IFPRI International Food Policy Research Institute
- IRISAT International research Institute for SeArrid Tropics
- MoFED Ministry of Finance and Economic Development
- MARC Melkasa Agricultural Research Center
- OESO Oromia Economic Study Office
- RCBD Randomized Completelock Design
- USDA United State Agricultural DevelopmeAgency

ABSTRACT

Common bean (Phaseolus vulgaris L.) is the most important food, export and cash crop and it is also the source of pteoin for the majority of peoplen Ethiopia. Screening and selecting the most promising haricot bean varieties which are high yielding and adaptable for raifed and/or irrigation condition is crucial in minimizing the risk of maize mono cropping that is widely practiced in Bako Tibe an its neighboring districts. Tohis end, twenty common beanherseolus vulgaris L) varieties were evaluated under irrigated condition at Bako to assess the genetic variability and grain yield performance under this condition. The Design was Randomized Copplete Block Design (RCBD) with three replication The mean, minimum, maximum, range, deviation from the mean and standard error of mean were showed a wider ranges of variation between the tested common bean varieties for most of quantitative traits he analysis of variancelso indicated that the mean square due to varieties were highly significant€(P,05) for all quantitative traits recorded in the present study. This indicated the possibility to produce heterotic progeny upon crossing of genetilyadiverse varieties. Correlatin analysis indicated that most yield and yield related traitexhibited positive association Fore example yield per plantwas positively correlated witharvest index(r=0.91)biomass yiel(t • 0.802), the number of seeds ppod(r=0.549), grain yield peplot (r=0.435), and grain yield per plant (r=0.338). The grain yield exhibited significant positive correlation with 100 seed weight indicating relative utility of this trait for selection.100 seed weight exerted maximponsitive direct effect and exhibited significant positive correlation with yield indicating a true relationship among the traits. The estimation of phenotypic coefficient of variation, genotypic coefficient of variation, broad sense heritability and genoetiadvance were high for the 13 guantitative traits of the tested common bean genotypes.indicated that selection of these traits is likely to accumulate more additive genes leading to further improvement of their performance and these traits may be as selection criterian common bean breeding programe overall performance of the test varieties was very good in that particular area except Awasa Dume under irrigated growing condition. Therefore, it is advisable to promote haricot bean as any able crop in the study areas to improve production level, increase source of cash for farmers and foreign currency for the country as export cromme genotypes like Ramada, Nassir, Omo-95 and Seef 19 can be recommended for product under irrigated conditions. However, caution should be taken in the use of these results as the study was conducted only in one location and for one season. In order to validate the findings, the study should be conducted for a number of years and in many locations

Key words: Correlation coefficient, cluster analysis, Genetic advance, Genetic variability, haricot bean and Heritability.

TABLE OF CONTENT

| DEDICATION | i.i.i |
|--|---------------|
| STATEMENT OF THE AUTHOR | i.v |
| ACKNOWLEDGMENT | ¥ |
| LIST OF ACRONYMS AND ABBREVATIONS | v .i |
| ABSTRACT | v .i.i |
| TABLE OF CONTENT | |
| LIST OF TABLES | x |
| LIST OF FIGURES | x.i |
| APPENDICES | x .i.i |
| 1. INTRODUCTION | 1 |
| 1.1.1 General objective | 1.0 |
| 1.12 Specific objectives | 1.0 |
| 2. Literature Review | 11. |
| 2.1 The common bean crop, origin, evolution and distribution | 11 |
| 2.1.1 Origin,domestication and distribution | 1.2 |
| 2.1.2 Morphology and Botany | 1.3 |
| 2.1.3 Plant Development | 1.4 |
| 2.2 Importance of Common Beans in GlobAgriculture | 1.5 |
| 2.2.1 Importance of common bean in eastern and southern Africa | 1 5 |
| 2.2.2 Common bean Production and its Economic Importance in Ethiopia | 1.6 |
| 2.3 Climate requirements and adaptation | 1.8 |
| 2.4 Phosphorus and Nitrogen fertilizers on coom bean production | 1 9 |
| 2.4.1 Phosphorus (P) use efficiency of Common bean | 1.9 |
| 2.5 Irrigation and its advantage in Ethiopia | 2.0 |
| 2.6 Improved Common bean Varieties | 2.2 |
| 2.7 Heritability, genetic advance and association of major quantitatitme. trai | 2 .4 |
| 2.8 Agronomic Practices on Common bean Production | 2.5 |
| 2.9 Evaluation of Improved Crop Varieties by Farmers | 2.6 |
| 2.10 Overview of Technology Adoption | 2.7 |
| 3. Materials and Methods | 2.8 |
| 3.1 Description of the Study Area | 2.8 |
| 3.2 Experimental/Plant Materials | 2.9 |

| 3.3 Experimental Designs and Treatment arrangements | 2.9 |
|---|------|
| 3.4 Phenological and growth parameters recorded | |
| 3.5 Data analysis | 3.1 |
| 3.5.1 Analysis of variance | |
| 3.5.2 Cluster analysis | |
| 3.5.3Principal component analysis (PCA) | 3.1 |
| 3.5.4 Estimation of correlation coefficient | |
| 3.5.5 Phenotypic and Genotypic coefficient of variation | 3.2 |
| 3.5.6 Estimate of Broad sense heritability | |
| 3.5.7 Estimation Shannoweavers diversity index (H) for qualitative traits | 3.3 |
| 4. Result and Discussion | 3.4 |
| 4.1 Mean, range and standard deviation for quantitative characters | 3 .4 |
| sourcemodel | 3.5 |
| 4.2. Pearson correlation coefficient analysis | |
| 4.3. Principal component analysis | |
| 4.4. Cluster analysis | 3.9 |
| 4.5 Phenotypic and Genotypic coefficient of variation | 4.1 |
| 4.6. Broad sense heritability (H2) and Genetic advance | 4.2 |
| 4.7 Agronomic Performance of some (20) Released Common bean Varietie | s4.4 |
| 4.8 Morphological diversity | |
| 5. Conclusion and Recommendation | |
| 5.1 Conclusion | 5.3 |
| 5.2 Recommendation | |
| 6. References | 5.6 |
| 7. Appendices | 7.0 |

LIST OF TABLES

| Table 1List of improved Haricot bean varieties and their characteristics | |
|--|------|
| Table 2Descriptive statistics on yield and 13 yield related parameters35 | |
| Table 3. Correlations coefficient of yield and yield related mponents of the | |
| common bean genotypes | |
| Table 4 principal component analysis of 13 quantitative traits of 20 improv | ed |
| commonbean genotypes | |
| Table 5 Estimation of the different variances parameters, heritability and gen | etic |
| advance for 13 major quantitize traits of 20 released varieties44 | |
| Table 6. Grain yield (kg ha1) and other major agronomic traits of 20 release | d |
| commonbean varieties under irrigated condition, 2015, Bako | |

LIST OF FIGURES

| Figure 1 Mapof the study area | 28 |
|---|-----|
| Figure 2 Dendrogram showing genetic similarity and differences between 20 improve | b |
| common bean genotypes twated for 13 major phenotypic traits at 80% similarity level | for |
| standardized data | 4 1 |

APPENDICES

| Appendices | 1 | list | of | common | bean | studied | under | irrigated | condition | with | their |
|--------------|------|-------|------|----------|------|---------|-------|-----------|-----------|------|-------|
| randomizatio | on (| on th | ne 6 | 60 plots | | | | | | | 70 |
| Appendices | 2 F | Field | ph | oto | | | | | | | 71 |

1. INTRODUCTION

Common beam Phaseolus vulgaris. 2n = 2x = 22 originated in Latin America and has two primary centers of origin in the Mesoamerican and Andean regions that are easily distinguished by molecular mean **B** (air et al., 2010). All species of the genus are diploid and most have 22 chromosomes (2n=22, x=11). The genome of common bean is one of the smalles in the legume family at 625 Mbp per haploid genome

Common bean Rhaseolus vulgarisL.) is the third most important food legumes worldwide next to soybean and peanut (Singh, 1999) ong the pulses (i.e. annual leguminous food crops that are harvested for dry seeds), the common bean is the most important crop. The genut Rhaseolusis of American origin and comprises over 30 species (Debouck, 1991). Five of them, namelyacutifolious A. Gray (tepary bean)?. coccineus(runner or scarlet bean)?. lunatus (lima, butter or madagascar beaf?), polyanthusGreenman (yealong bean) and P. vulgaris (common bean, haricot bean, navy, French or snap bean) were domesticated (Debouck, 1999) these species, the common bean is the most widely distributed and has the broadest range of genetic resources. It is mostly used as food crop throughout the world, especially in Latin America and Africa (Singh, 1999).

Crop genetic resources are tpeoduct of the interaction between human and natural selection of plants, yielding a set of domesticated crops and varieties used in agricultural production(Win, 2011). Crop genetic resources are embedded in seeds and they are an important determinant of the characteristics and attributes of the crop species, together with environmental and human management factors.

Evaluation of crop genetic resources **ipre**requisite for which the future breeding work is based. The value of germplasm relies not only on the number of accessions it possesses, but also upon the genetic variability present in those accessions **conie**gron and yield components (W,ir2011). Heitability act as predictive tool in expressing the reliability of phenotypic traits and thus high heritability could assist in effective selection of particular characters and devise future breeding programme of common bean. Generally, conserving, characizeing genetic resources and developing novel breading methods or tools are important for improving efficiency of the crop improve (Asfatw et al., 2009).

Each race has its own characteristics, ecological adaptation, and agronomic traits (Beebe et al, 2000). Most beans are herbaceous annuals, although, under tropical conditions, some beans (such as large limas) may behave as short lived perennials. They may be of determinate or indeterminate growth habit, with pinnately compound trifoliolate leaves. Growth and development of common bean is divided into vegetative and reproductive stages. The common bean flower has an elongated twisted keel containing the style and ten stamens. Cross pollination is possible if the stigma contacts a pollen coated bee whe it is extended. Otherwise the stigma will be self pollinated when it retracts and contacts its own pollen at the opening of the keel.

Self-pollination is thus the norm in the common bean, and it probably occurs automatically at or before the flower orpsein the morningFor the grower, there is no yield or other economic advantage of crosspollination. For the bean breeder, cross pollination is actually a hazard to maintaining the purity of a cultivar.

Common bean (haseolus Vulagris), locally known as *f* Boleqe,, and also termed as dry bean, haricot bean, kidney bean and field bean is a very important legume crop grown worldwide. Common bean form an important food and cash crop in Africa, particularly in the eastern, southern and Great lates continent (Fikreet al., 2012). In Ethiopia, it was most likely introduced by the Portuguese in the 16th century (Imru, 1985). Ethiopia is the third producer of bean in eastern African countries next to Kenya and Ugahata, (1996).

Common beams the most important food, export and cash crop and also the source of protein for the majority of peoples in Ethiop Faa(rris and Kagan z2008). It is the second most important grain legume cultivated as cash crop in Ethiopia (CSA, 2011) and is

widely produced in the rift valley area of the count por instance, the major common bean producing areas of Ethiopia are the central, eastern and southern parts of the country in general and Oromia (169,600 tons) and Southern Nations, Nationalities and SPeople, Region (SNNPR) (106,700 tons) makes up 81.08% of the total national production of common bean in particular (CSA 2011).

It is one of the fast expanding legume crops that provide an essential part of the daily diet and foreign earnings for Ethiopians alimholder farmers particularly inhabiting the rift valley regions (Girma, 2009). It is an excellent source of protein, fiber, complex carbohydrates, vitamins and minerals and thus reduces malnutrition and improves human health, especially for the poor wlogannot afford livestock produc(Philip, 2013).The demand in both the domestic and export markets of beans provides a source of cash for smallholder producers (interim report by Sackatchewan and Hawasa Univers)t, 2014

Beside supplementation of priorte and vitamins beans are also rich in essential micronutrients that are found only in low amounts in cereals or root crops (Wang 2003). The average composition of micronutrients in common bean per 100g edible portion is being protein 21.4g, carbydrate 49.7g, fat 1.6g, dietary fibre 22.9eg, ergy 1218kj, minerals 679.5mg and vitamins 3.64rOg the other hand the essential amino acids composition per 100g edible portion being lysine 1540mg, methionine 240mg, phynylanine 1130mg, threonine 860mtgyptophan 210mg, valine 990mg, leucine 1640 mg and isoleucine 890mg (assi, 2010).

A symbiotic relationship between a bacterium calRebizobiumand common beans provide nitrogen to the soil where they are groluegumes the group of plants to which beans belong, fix atmospheric nitrogen in the soil in associationRubitzobiumbacteria (Kay, 1979). The fixation of atmospheric nitrogen improves the soil nitrogen level benefiting the crop that are grown thereaftenereby reducing production costEhe fixed nitrogen is an important source of nitrogen nitrate for plant growth and developmentThe common bean residues left on the field improve the soil structure (Barrett, 1990).

Nodulation and N2 fixation depend on the genotype of the host plaiztobium strain, and their interaction with soland environmental conditions (Kilassi, 20,10Under optimized environmental conditions, genetically superior genotypes of common bean that are nodulated with efficientrhizobium strain are able to fix enough N2 topport grain yield. Nitrogen derived from biological fixation is 5,070 % more efficient than applied N because only 3,050 % of the latter is recovered by plants (Bliss, 19)3

The major producing countries for national consumption are Brazil and Mexico while the United States, Canada, Argentina and China are all exporting countries. The crop is also important in a number of developing countries of Easternoa Subuthern Africa Kilasi, 2010. In these regions beans are grown for both subsistence agriculture and for regional markets where they play an important role in food security and income generations.

Total world production cannot be calculated with certainty due to confusition ther legumes in some of the data, but is between 11and12millionatensroduced annually worldwide, of which 8 million tones are from Latin America and Afr(ethilip, 2013). Latin America is the region of greatest production of common beans, seeptineg about 50% of world volume, followed by Africa with 25%. Brazil, Mexico and the United States of America are the three largest producers in the western hemisphere. In Africa, most bean production is found in the eastern and southern highlands, inegrateroch Ethiopia to South Africa, with Kenya being the largest producer in the region. In West Africa, bean production is localized in specific environments, with Cameroon being the principal producer.

Ferris and Kaganzi (2008) have shown that an averagitional production is approximately 150 thousand tons per annum. The level of production in 2005 was approximately 175 thousand tones with a domestic market value of USD 30 million in Ethiopia. Although haricot bean is largely growing Ethiopia, thenational average yield of haricot beans is low ranging from 50 to 0.8 ton per ha whicks far below from the corresponding yield record end research sites (2,53 tones ha) using improved

varieties (EPPA, 2004)The yearly average production of common beans in Ethiopia has increased steadily up to 11.67 qt/ha (CSA, 2011), 2011/12, total **b**aricot bean production in the country was about 3,878,023.01 quintals (1.77% of the grain production) on approximately 331,708.15 hectares of lawhole(h constitutes 2.74% of the total number of farms in Ethiopia of the grain crop area (CSA, 2011b) small scale farmers without irrigation and with little use of agrochemidations is very low as compared to the world average of/Hat and that of the developeophid 8.0 t/ha.

In 2013/14, total Haricot bean production in the country was about 4,574,116.13 quintals (1.82% of the grain production) on approximately 326,465.88 hectares of **21**a030% (of the grain crop area) (Daniet al., 2014) Early maturity anothoderate degree of drought tolerance led the crop,s vital role in farmers, strategies for risk aversion in drouglet pron lowland areas of the country (Abebeal., 2013) The low national mean yield observed for haricot bean could be attributed to varioconstraints related to low adoption of improved agricultural technologies, drought, and lack of improved varieties, poor cultural practices, disease, and environmental degradation (Leges 2006).

Irrigation development in Ethiopia is in its infanstage and not contributing its share to the growth of the agriculture sector accordingly. But the country has the potential for its developmenboth in terms of vast suitable land and availability of fresh water resources suitable for irrigation purpose However, currently limited land is being cultivated under irrigated agriculture and herefore, crop production is predominantly based on feed n agriculture.

Irrigated agriculture isbeing practiced under smallholders, medium and large scale farming. The smallscale irrigationschemes are understood to include traditional and modern communal schemes up to 200(NRMD, 2011). However, *f* traditional, spate irrigation and even some modern irrigation schemes also being managed by smallholders as part of mall-scale irrigation schemes, whereas threa is quite larger than indicated above. This has been confirmed by some studies carried NMMby (2011)which showed that some schemes have the capacity of over 2000 ha that are being

managedby smallholders. Traditionally, farmers have built smadale schemes on their own initiative, but sometimes with some technical and material support from the government and other developmantors.

According to a study conducted by OESO (2000) are is 17 million hectares of land suitable for surface irrigation in the Omia region that can benefit about 6.8 million household heads. OESO (2000) have also shown that the amount of water potential to be utilized for the purpose of irrigation in Oromia istiensated to be 58 billion cubic meter of mean annual run off generated in the region and 2.1 billion cubic meter of underground water.

Bako Tibe district is one of the areas in the region that possess high irrigation potential and small scale irrigation ibeing practiced. However, there was no adequate study which analysed the grain performance (highelding and highquality) of improved haricot bean varieties under smadale irrigation and ystematic attempts have not been made on the collection of ion fmation on genotypes with reference to quantitative traits under irrigated condition the study area

In the study areathe productivity of haricot bean is below the national average at farmer level (discussion with farmers and profile from Bake Tibe woreda Agricultural bureau). In essence of things, the generation and transfer of technologies and improved varieties is not an end in itself. Therefore, increasing productivity and production of haricot bean will be realized if and only if the farmers adopt the technologies including improved varieties that are developed by researcemter for raifed and/or irrigated agricultural conditions.

The area suitable for haricot bean production in the study area under irrigation is around 484.04 hetare. However, the area sown is only 283.41 ha for only maize, sugarcane and different vegetablecrops. Haricot bean production using irrigation is not common in the study area (secondary data from Bako Tibe Agricultureatu)r. Its adaptation to the area where it is cultivated is optimal to marginal, which depends on the environmental conditionsin eachpeasant association

In the study area, haricot beanpisoduced by smallscale farmersonly under rain fed condition. Small-scale farmers refer to two groups of farmers: 1) those who produce haricot bean only for their subsistence and, 2) those who **deltive**ans for their subsistence but who may also produce an excess for the market. Both groups of farmers are common in Bakdistrict. It is a well established agricultural component or product in the study area and it is among theost important food leguess such as soya bean, field pea, chicken pea, lentiles and haricot bean (secondary data from the woreda agricultural bureau).

The wide rangef growth habits of haricot bean amother different/varieties has enabled the crop to fit many growing situation (Kristin et al., 1997). Early maturity and moderate degree of drought tolerance led the crop,s vital role in farmers, strategies for risk aversion in drought prone lowland areas of the cour Attoget (eet al., 2013). More than 80% of the farm land in Bako Tibe district was allotted for maize production every year (secondary data from the Woreda agricultural bureau). Common bean is one of the potential crops used for maizegume intercropping and rotation crdpr maize continuous cropping Screening and selecting the most promising common bean varieties which are high yielding and adaptable to rainfed and/or irrigation condition is crucial in minimize the risk of maize mono cropping that is widely practiced in Bake **arited** the neighboring districts.

Horizontal increase (expansion of new farm lands) to increase crop production is over exploited to the limit and thusnicreasing the productivitiper unit areaof the shortly maturing and widely adapted pulseeps sub as common beapresents an opportunity in reversing poverty and food insecuriparticularly in the rift valley regions where the rainfall duration is very shortCommon bean productioalso depends on applied ₂N fertilizer. Relatively high rates of N fertilizer are applied regardless of the cultivars and other factors such as residual soil N. The majority of Ethiopian farmers, however, are unable to afford the high mineral fertilizer coated.

To mitigate this,Biological N2 fixation, a key source of N for poor farmers, constitutes a potential solution and may play a key role in sustainable bean production. Stababan Africa (Philip, 2013). Besides, the crop can fix freetmospheric nitrogein to usable nitrates form insoils and thus improve soil fertility and save fertilizer costs in subsequent crops Apart from aforementioned advantages, inclusion of this crop in to the farming system helps to improve soil fertility through symbiotic nitrogetfon. Commonbeans are also used for different cropping systems.

It is compatible for intercropping with maize and sorghum and for alley cropping with perennial leguminous shrubs which can also improve soil fertility. This system can produce an additional biomass, which can be used for fodder or for mulching or for green manuring without any significant grain yield reduction of haricot be@aommon bean is also the most preferred pulse crops for intercropping, crop rotation or rgamerringto restore soil structures and fertility, and increase land equivalent ration (ILEGR)tion can therefore be used as an alternative N source, particularly under low input production system for resource limited small scale common bean produce as a break crop in Maizebased another cropsbased farming systems to reduce decline in soil fertility.

Yield is the principalparameterin the improvement of **a**y crop. Like other legumes, seed yield in common bean is a quantitative characted influenced by a number of yield contributing traits. Improved common bearproduction involves use of different agronomic practices such as improved variety, seed rate, spacing, fertilizer igentee on practices and pesticide application are the recommended rate.

Nonetheless, sizeable improvement in production and productivity depends on the extent to which a household has applied the recommended package practices. The selection or evaluation of desirable genotypes should therefore also be **basged** as well as on other yield components. Number of pods per plant, number of seeds per pod, and mean seed weightare the three major yield related traitslienhuis and Singh, 1986). Improving the yielding potential and related desirable trait is the main objective of common bean breeding program. The efficiency of breeding program increases by careful choice of parents capable of producint progeny with desirable trait combinations (Angelæt al., 2002, Cristina et al., 2002). Information on mutual association between grain yield and yield components is necessary for efficient utilization of the genetic stock in crop improvement program of ang.cro

Yield is the principal factor for determining improvement of a crop. Like other legumes, seed yield in common bearPh(aseolus vulgarisL.) is a quantitative character and influenced by a number of yield contributing traits. Improved haricot bean **ctiodu** involves use of different agronomic practices such as improved variety, seed rate, spacing, fertilizer rate, and pesticide application at the recommended rate. Nonetheless, sizeable improvement in production and productivity depends on the exterhid a household has applied the recommended package practices. To increased use of improved seeds varieties and to achieve sustainable agricultural development in the country, the Ethiopian government has identified improving the efficiency of the symptomic is one of the most effective means of meeting the Millennium Development Goals (Yebaas 2008).Therefore, it is needed to identify the genetic variation and grain yield potential of the existing improved haricot bean varieties under both rainafied irrigated condition in Ethiopia.

The selection or evaluation of desirable genotypes should therefore also be based on yield as well as on other yield componebts in rainfed and irrigated condition Number of pods per plant, number of seeds **ped**, and mean seed weighte the three major yield related traits (Nienhuis and Singh, 1986) Improving the yielding potential and related desirable trait is the main objective of normon bearbreeding program. The efficiency of breeding program increases careful choice of arentscapable of producing terrotic progeny with desirable trait comtations (Angelæt al., 2002); Cristina et al., (2002). Information on mutual association between grain yield and yield components is necessary for efficient utilization of the genetic stock in crop improvement program of any crop.

Generally, to achieve significant progress in breedinograms, it is essential to know the relationship between grain yield and its components both under rain fed and irrigation condition (Win, 2011). Therefore, thenain aim of this study wate evaluate and identify the best performing ommon beam arieties under irrigated condition in the study area

1.1 Objectives

1.1.1 General objective

The generalobjective of the present study was to assess the genetic variation and grain yield performance of improved common bean varieties under irrigated condition around Bako area.

1.1.2Specific objectives

... To assess the genetic variabilitymong the released commons and varieties under irrigated condition and identify promising varieties for further binese and production activities,

.. To estimate the genetic parameters, genotypic and phenotypic coefficient of variations, heritability and genetic devance for quantitative traits;

...To determine the ssociation between grain yield and yield related components

2. Literature Review

2.1 The common bean crop, origin, evolution and distribution

Common bear(Phaseolus vulgarisL.) belongs to order Rosales, familyeguminosae subfamilyPapilionideae tribe Phaseolinae(CIAT, 1986). Common bean was originated in Tropical America (Mexico, Guatemaland Peru), but there are also evidences for its multiple domestication within CentraAmerica (Kay, 197). The crop is now widely distributed throughout the world and consequently, it is grown in all continents except Antarctica (Singh, 1999 It is well adapted to areas that receive an annual average rainfall ranging from 50,01500 mmwith optimum temperature range of 16,224 °C, and a frost free period of 105 to 120 days. Moreover, it performs best on deep, friable and well aeatedsoil types with optimum pH range of 6.0 to 6.8 (Kay, 1979)Ethiopia the major common bearproducing egions are Central, Eastern, and Southern parts of the country and in central Ethiopia; farmers grow early maturing white pea bean crop for export as their cash crop (CSA, 2005).

The current organization of genetic diversity in the cultivated genect common bean is the result of evolution under both natural conditions (i.e., prior to domestication) and cultivation. Before domestication, with aseolus vulgarits adalready diverged into two major gene pools, each with its characteristic geographic distribution, in Mesoamerica and the Andes. In addition to these two major gene pools, recently discovered wild bean populations constitute a third, distinct germplasm segment of particular significance for the evolutionary history of common b(Geopts 1998).

These two wild gene pools can be distinguished at the morphological (Getpts an Dubouck, 1996) and molecular level F(aschianiet al., 2009). They also separated by incomplete reproductive isolation, which lead to F1 lethality in some, but not costs sets (Koinange and Gepts, 1996) The existence of this reproductive isolation and the level of divergence at the molecular level suggest that these two gene pools may actually represent two subspecies. Over evolutionary time solutions vulgaris could eventually split into two geographilos isolated species (Gepts, 1998) However, many

crops have been marked by a progressive reduction in genetic div(@eptys, 1998), and common bean is no exception.

2.1.1 Origin, domestication and distribution .

The genusPhaseolusL. includes numerous wild and cultivated species that originated in the New World, the exact number is still unknown (Debouck, 1979) seolus/ulgaris L. is the most widely cultivated species owing to its high nutritional vallbere are four major gene pools; namely Mesoamerican, Andean, Northern Andean and Columbia. Two major gene pools of common bean were first recognized in the wild form, Mesoamerican and Andean (Gepts, 1998). Evidence of this distribution was based on **hogripab** traits (Singh, 1989; Singlet al., 1991), phaseolinseed protein (Geptet al., 1986), isozymes (Gepts, 1989), and molecular markers (Fretyrel, 1996; Tohme et al., 1996). A third, genetically unique gene pool was later described indthern Andes (Debouck, 1999; Tohme et al., 1996). The northern Andes gene pool is located in Ecuador and northern Peru and is considered to be the nucleus of diversity, from where wild beans dispersed both northward and southward (Broughtath, 2008). A fourth gene pool in Colombia might also exist, but it is still poorly understood (Debouck, 1999; Tohme et al., 1996). However, recent work done by Bitocethal., (2011) identifies the origin of Phaseolus/ulgaris as Mesoamerican.

The first domestiation of Phaseolusvulgaris by humans is said to have started slightly more than 4,000 years ago in Mesoamerica and South America (Kapplan and Lynch, 1999). The work of Kamet al., (1995) suggested that, starting from the core area of the western slopes f the Andes in northern Peru and Ecuador, the wild bean was dispersed north (Colombia, Central America, and Mexico) and south (southern Peru, Bolivia, and Argentina), which resulted in the Mesoamerican and Andean gene pools, respectively. The common beathen spread to Europe and Africa (Geptsal, 1986, 1988).The common bean was taken to Africa and other parts of the world by Spaniards and the Portuguese (Raniet al, 2010)

2.1.2 Morphology and Botany

Common bean R(haseolus vulgarisL), also referred to as dry bean, is an annual leguminous plant that belongs to the gen Basaseolus with pinnately compound trifoliate large leaves (Katunget al., 2009). It is cultivated on all continents except Antarctica, under very diverse cultivations (Chaco, 2005).

Common beansilargely a selfpollinated plant though crossollination does occur if the stigma is exposed to foreign pollen. Seeds are **end**ospermic and vary greatly in size and colour from the small black wild type **to**etlarge white, brown, red, black or mottled seeds of cultivars, which are 176 mm long Acquaah, 201)2

Common bean shows variation in growth habits from determinate bush to indeterminate, extreme climbing types. The bushy type bean is the most pre**alorniy**pe grown in Africa (Buruchara, 2007)... Bush varieties form erect bush **£6**(200 m tall, while pole or running varieties form vinesv2, 3 m long. All varieties bear alternate, green or purple leaves, divided into three oval, smooted ged leaflets, each, **£5** cm long and **,311** cm wide. The white, pink, or purple flowers are about 1 cm long, and give way to **p20** is 8 cm long, **1**,1.5 cm wide, greenyellow, black or purple in coto each containing **,46** beans. The beans are smooth, plumpl, kidneyshaped, up to 1.5 cm long, **gen** widely in color, and are **dfen** mottled in two or more cots (Acquaah, 2012)

The leavesare broad at the lade and are attached to the stem by means of a-listelk petiole. The leaf may be simple (have only coblade per petiole) or compound (usually three blades per petiole). There may be stimople leaves or one compound leaf attached at a spot on the stem called hade. The veins of each leaf blade are arrangied a complicated network. Where the stem detail join, there is a swollen area of the tiole that is responsible for leaf movements. At night the bean leaves to the stem at down toward the soil; at dawn the leaves unfold and are lifted into the Ramiaet al., 2010).

Two special leaves may till be attached to your bean plant. These arecomy edonsor seed leaves. These leaves are very fleshy and are used by the plant stattbrend

other complex molecules in the seed for the later nourishment of the grplarintgOn your plant, the cotyledons may be withering due to loss of starch and may thaved green to help produce more nutrients through photosynthesis. The cotyledohaveay been completely used up and abscised (fallen off). The portion of the stem the low cotyledons is alled the hypocotyls (Buruchara, 2007)

The bearstemis quite long and thinternodesbetween leaf attachmentso(des) are quite obvious. The lowest portion of the stem is below the cotyledons and is called the hypocotyl The stem terminates at the topthoe plant in the apical bud Lateral budsare found in the axils of each leaf just above the node. This bean plant is a "bush" thratiety has shorter stems than the wilk pe "pole" beans. The stem tips of pole beans greeny rapidly in a twistingmanner and "whip around" at several cycles per day. Whest the touches an object, changes in three duction of plant hormones cause the stertwist tightly around and grow up the object. This twining habit is called circumnutation is common amongines like pole beans. How did we get bush beans from wild preades? They resulted from a plant with a chance mutation in a gene coding for an plant one involved with stem growth. They cannot produce enough gibberellic aciextensive stem growth (Koning, 1994).

Koning (1994) the roots of the bean plant are mostly fibrous, although a single main root (the taproot) is larger than the others. The taproot forms many **lätter** alroots that make up the bulk of the mineral absorption area. Some planets are contractile; they shorten to pull the plant around in the soil. In one case the roots can pull the plant 60 cm through the soil in one year. While they operate very slowly, these roots prove that plant locomotion is possible. Many plant species de contractile roots, but they usually serve only to pull the stem deeper into the soil, not across the soil.

2.1.3Plant Development

The development of bean (determinate and indeterminate plant types) pass through two main stages of vegetative (V), (\$\vec{\alpha}\$ 40 days) and reproductive (R\vec{\alpha}0(to 94 days) as indicated inVegetative stages are determined by counting the number of fully expanded

trifoliolate leaves on the main stem while the reproductive stages are described by pod and seed characters. Thesfipod developing on the plant is described and followed to full size. At the time of first bloom (R stage), secondary branching begins in the axis of lower nodes which will produce secondary groups of blooms or pods. To determine the growth state, the maistem is followed, which is readily discernible on both determinate and indeterminate plants. A trifoliolate is counted when it is fully unfolded (Kandel, 2010).

2.21 mportance of Common Beans in GlobaAgriculture.

Common bean is the world*f*'s mosp**or**tant grain legume for direct human consumption (Broughtonet al, 2003), with 20.3 million tons of dry beans harvested from 27.9 million ha worldwidein 2008 (FAO, 201). The annual production value of common bean is estimated to be over U.S \$ 10 bihig(Rao, 2001). The leading bean producer and consumer is Latin America, where beans are an important traditized, especially in Brazil, Mexico, the Andean Zone, Central America, and the Caribbean. In Africa, beans are grown mainly for subsistence, where **Great**Lakesregion has the highest per capita consumption in the world. Beans are a major source of dietary protein in Kenya, Tanzania Malawi, Uganda, and Zambia (CIA^T2014). It is also an excellent loviat source of complex carbohydrates, fibrelate, potassium and B vitamints also serves as a break crop in Maizesed and ricebased farming systems to reduce decline in soil fertility (Canada, 2003).

2.2.1 Importance of common bean in eastern and southern Africa

It has been reported by Lunze (2001) that common bean is an important grain legume grown on over 3.7 million of hectares every year in Eastern, Central and Southern Africa (ECSA) where bean consumption per capita exceeds 50 kg a year and is perhaps the highest in the world, reaching over 66 kg in densely populated western Kenya (Wortmannet al, 1998). Common bean is mainly produced by the small scale farmers that are resource poor.

Apart from the high protein content, common bean is also a good source rogly and provides folic acid, dietary fibre and complex carbohydra Retrailip, 2013). Common bean protein is high in lysine, which is relatively deficient in maize, cassava and rice, making it a good complement to these staples in the diet. It is growwiths green leaves, green pods, and immature and/or dry seeds. Beans are appreciated throughout the Eastern and Southern Africa because they have a long storage life, good nutritional properties and can be easily stored and prepared for eating (Centro Cultura, and Ciat, 1999). The cost of common bean is low as compared to meat products thus its high consumption in Africa. Beyond promoting foodhealth and nutritional securitybeans provide a steady and lucrative source of income for many ruturalus cholds, with the value of bean sales exceeding US \$ 500 million annually F(AO, 2011).

The cost of inorganic fertilizer keeps on increasing and particular in the Eastern and Southern Africa making the poor farmers unable to access these inputs whicheeddey to raise their productivity. Common bean is usually grown either in a pure stand, in rotation with cereals or in crop mixtures usually with maize and the bean fixes nitrogen which benefits the next crop. In this way, the poor resource farmer is a blere ase their productivity. The yield of common bean in Eastern and Southern African ranges from 0.60 to 0.80 ton ha though the potential yield of some improved varieties can go up to 2.00 ton ha (Philip, 2013).

2.2.2 Common bean Production andts Economic Importance in Ethiopia

In Ethiopia, faba bean is the crop that has the highest absolute production, and the largest area cultivated. Ethiopia is also the second largest producer of faba bean in the world (after China). Common bean and chickpeare also major legumes, with both a production of more than 200,000 etric tongrain. On the world market, Ethiopia ranks 6th in chickpea production, and th an production of common bean. Among African countries, Ethiopia is the largest producer of **bottic**kpea and common bean (ICRISAT, 2011) In total, the area cultivated with legumes is more than 1 million ha. Production per ha is low and far below the potential production of e.g. 2.9 t/ha for chickpea and 4 t/ha for commonbean and faba bean (IFPE010, USAID, 2011).

Grain legumes occupy about 13% of cultivated land in Ethiopia and their contribution to agricultural value addition is **ra**und 10%. Pulses are the thilad gest export crop of Ethiopia after coffee and sesame, contributing USD 90 milition export arnings in 2007/08 (IFPRI, 2010) Apart from the legumes presented in above topic, field pea and grass pea **a**r also important grain legumes aba bean and common bean together account for half of the total area under production of legumes

The importance ocommon beams a source of income, nutrition and its role in food security at a household level is very high (Simenal, 1998). There is a wide range of common beamseed color classegrown in Ethiopia including mottled, red, whitten and black varieties (Aliet al., 2003). The most commercial varieties are pure red and pure white colored beans and these are becoming the most commonly grown types with increasing market demand (Ferris and Kaganzi, 2008).

To support both the growth in domestic and export bean markets, the Ethiopian Institute of Agricultural Research (EIAR) and Regional Agricultural Research Institutes (RARI) has developed a range of high yielding, mdisease resistant bean varieties (Atlal., 2003). The focus of this genetic improvement program has been on the pure red and white beans to support the commercial sector (Atlal., 2003). Within the red bean types, the most favored and most commercially accepted varieties include Read Mel mottled medium sized red; Red Wolaita, a medium sized pure light red; and Nasser, a small pure dark red variety (emayehu, 2014) With regard to economic importance of common beanit is used as source of foreign currency, food crop, means of emptoy source of cash and plays great role in the farming system (CSA, 2005) g 2000, 2001 and 2002 Ethiopia exported 23994.4, 32932.7 and 42127.0 tones and earning 8.2, 9.98 and 13.2 million USD respectively (EPPA 2004)

The main destination markets were Pakistan, Germany, Yemenited Kingdom, South Africa, India and Mexico having 12.5, 7.8, 6.9, 5.79, 4, 4, 4 % sharespectively (EPPA 2004). The country's exports of mmon beam have increased over the last few

years, from 58,126 Metric Tons in 2005 to 78,271 Metric Tonsin 2007 and Ethiopia gets 63 million dollar from common beam arket in 2005 (Legesset al., 2006).

Common bearproduction is very heterogeneous in terms of ecology, cropping system and yield. It predominantly grows fine low land (3001100 ma.s.l.) to mid highland areas (14002000 ma.s.l.) of the country. The national average yieldcofmmon beam is 0.5-0.8 ton ha⁻¹. The estimated mean yield/ha cofmmon beam in the study area i640. ton ha⁻¹ (IPMS, 2005). Majority of the smallholder farmers do not use fertilizer and use local seed instead of improved seeds for plant@common beams harvested by hand, heaped and sun dried for a week and then threshed by beating the dried vines with sticks or by chasing oxen on threshing floor.

White beans from the northern Rift Valley were sold into export markets to supply European canning factories and red beans were exported from the southern Rift Valley areas to supply drought affected areas in nort**Kern**ya (Ferris and Robbins, 2004). The major storage and trading sites in the southern Rift Valley area are concentrated in the towns of Sodo,Hawassæand Shashemene while the major collection centers for white beans being in Nazareth, prior to exportation point (Ferris and Kaganzi, 2008). There are good prospects that this market will grow as consumers in industrialized countries seek evermore competitive suppliers (Ferris and Kaganzi, 2008). For the major processing companies, Ethiopia is a **tread**y new source of supply and recent investments by a number of international companies from Italy, UK and Turkey indicating that markeprospects are good (CIAT, 2013

2.3 Climate requirements and adaptation

Common bean is adapted to deep well **derd***ins*andy loam, sandy clay loam or clay loam soils with clay content of between 15 and 35% with no nutrient deficiencies (Thung and Rao, 1999). The optimum soil pH range is pH 4560 (CaCl2). Heavy clay soils with poor oxygenation and capping clay sa**ads** not suitable. Thus, it will not grow well in soils that are compacted, too alkaline or poorly drained (Lunze, 2001). The common bean thrives well in a warm climate. It grows optimally at temperatures of 18 to 24 °C. The

maximum temperature during flowing should not exceed 30 °C. High temperatures during the flowering stage lead to abscission of flowers and a low pod set, resulting in yield loss. Day temperatures below 20 °C will delay maturity and cause empty mature pods to develop. Cultivated underain-fed conditions, the crop requires moderate amounts of rainfall (300, 600 mm) but adequate amounts are essential during and immediately after the flowering stage (Katuregial, 2009). Generally, cromon bean is considered a shosteason crop withmost varieties maturing in a range of 65 to 110 days from emergence to physiological maturing (Buruchara, 2007). Maturity period can continue up to 200 days after planting amongst climbers that are used in cooler upland elevations (Gomez2004).

In Africa, common bean crop cultivation is concentrated at altitude above 1000 metres above sea level, with adequate amounts of precipitation (> 400 mm of rain) during crop growing season and soil pH above.5.5

2.4 Phosphorus and Nitrogen fertilizers on common been production

Application of fertilizer in a recommended amount is essential for high yield and quality of grains (Morgado, 2003). The use of fertilizer is considered to be one of the most important factors to increase crop yield per unit areaswever, the response to the type and rateof fertilizer application varieswidely with location, climate and soil type (Khan et al., 2003; Marshner, 2002). Nitrogen deficiency occurs almost everywhere unless nitrogen is applied as a fertilizer or manure (Des2888). It has been reported that there was increased yield responses of pulse for nitrogen fertilizer (Morgado, 2003).

2.4.1 Phosphorus (P) use efficiency of Common bean

Phosphorus is a critical nutrient element for plant growindore it is involved in daular energy transfer, respiration and photosynthesis. Phosphorus is also a structural component of the nucleic acids of genes and chromosomes and of many coenzymes, phosphe proteins and phosphilopids. Plants need P throughout their life cycle butstmo importantly during early growth stages for cell divis (behavlin et al., 1999). Phosphoruss among the principal nutrient elements needed for growth of many legumes in arid and semi arid agriculture regions due to low available P in the soils and advantageous effects of (Rathju et al., 1987; Frizzone, 1982) Amos et al. (1998, 1999) also indicated that P application is key to enhance bean yiel **barom**er, sfield in their study on the low fertile Orthic Acrisols of western Kenya. The researchers also indicated that P significantly enhanced the establishment of beans, number of pods pearnplant, the bean grain yields. Similarly, Dadson and Acquaah (1984) also reported that the formation of nodes and pods was promoted with the application of P in P deficient soil. Thus, P application from external sources/fertilizers/ becomes very essert **bardatato** optimum yield.

2.51 rrigation and its advantage in Ethiopia

Water scarcity became a common in Ethiopia with droug mequency of at least once in three yeawshile the country owns a large irrigation optimized that should be exploited sustainably. Various national animiternational institutions are currently engaged in developing small scale irrigation here for poverty alleviation. Monitoring and evaluation exercise was nducted in 2004 and in 2006 in four administrative regions fo Ethiopia, namely Tigray, Southern regions, Oromia and Amhara, to assess the benefits an exosociated environmental effects sofnall scale irrigation investments of the International Fund for gricultural Development (IFAD). Inefficient water management the rainfed agriculture coupled with accelerated land degradation plays an important role aggravating the recurrent food insecurity time country (NRMD, 2011)

In the recent years, droughtecame a common phenomenon, happeininagy part of the country at any time of theyear, with a frequency of at least oncethinee years. Four different drought scenarios were identified in the mixed crelipvestock systems of Ethiopia namely, terminadrought, intermittent drought, foreseeable ught and definite drought (Amedeet al., 2004). In situations where agricultural roduction is operating under these various drought scenarios, with annual rain fadinability of 40 to 50%, supplementary irrigation became a necessity for forest for a structure of the sector of the

intensifying systems through high yielding and inpretsponsive varieties and breeds. Currently, the growth in food production in Ethiopia parimarily due to expansion of agriculturalland while production per unit of investmeretmainedstagnant

On the other hand, Ethiopia owns a wide range of irrigation opportunities with about 9.85 million ha of potentially irrigable arable land, while only 3 to 5% of the potential is currently under irrigation (alew et al., 2011) accounting for approximately 3epcent of total food crop productiorCurrent yield from rairfed land is only about 50% of the irrigated land, given all other inputs remain the same, thanks to the recurrent drought and limited adoption of water management practices. If the country **acchie**eve its stated aims of food selfsufficiency and food security, the current production shortfalls call for drastic measures to improve production efficiency of both irrigated andferatin agriculture. In response, the governmentEthiopia asstated in its Poverty Reduction Strategy Paper (PRSP) emphasized the importance improved water resource development anits utilization to achieve food securitly rough enhanced use of small scaleirrigation. Since the early 1990s, the federated regional governments of Ethiopia, with financial assistance from donors, have bettermpting to upgrade traditional small scaleschemes, built small scale dams, diversiond water harvesting ponds to respond to these environmental calamitie (alexed al., 2011)

However, the performance of the irrigation systemas been poor. There exists a substantial/yield gap in irrigated farms betwearchievable and actual yield both in terms of yield per unit of land but also yield per unit water depletedThe positive effect was more visible with horticultural crops. There habeen also a shift towards improved varieties with access to irrigation. Farmers replaceearly maturing but low yielding varieties with high yielding varieties. Cropoliversification increased significantly, in some sites from three to about 15 specalets, ough this decision making process diot favour legumes Yalew et al., 2011).

To mitigate the effect of drought several strategies can be employed including irrigation and drought tolerant varieties. Drought tolerant varieties are not a viable option for most small scale farmers due to the cost factors, while the use of irrigation preferred option (Kilasi, 2010). The main advantage of irrigations that it maximizes the roductivity of water. Although a certain reduction in yield observed, the quality of the yield (e.g. sugar content, grain size) and to be equal or even support to rainfed (Zhanget al., 2006; Spreeret al., 2007).

2.6 Improved Common bean Varieties

Farmers in Eastern and Central Africa grow bean cultivars of wide range of seed types, often in phenotypically diverse mixtures. The genetic diversity expected to give stability to bean production, buffering it against biotic and abiotic stresses. But, as higher yielding varieties become available, traditional cultivars are lost with a resultant decline in genetic diversity. Frequently, breeders have seed vpromising lines of similar seed type and face the choice of either releasing and promoting only thevalues type (s) (CIAT, 2011).

The choice of one technology and/paractice over others is greatly influenced by the balance between its positive annelegative characteristicsNSIA, 2010. Any new technology presented to farmers will either improve or substitute for the technologic options they currently havet is fundamental to identify these options and understand perceptions about the advantages disadvantages of each onfethem. Theresearchers are be able to assess the appropriateness of potential new technologies or practices, evaluate the likelihood that they will be adopted, and if necessary modify them to suit farmers, needs betteTable 1).
Table1 List of improved Haricot bean varieties and their characteristics. 2011).

| | | Туре | | | |
|--------------|----------|------|----------|------|-------------------------------|
| | Released | Ex | | | |
| Variety name | year | port | Domestic | Both | Recommended Agrocology |
| | | | | | In all haricot beamproduction |
| Awash Melka | 1998 | † | | | area |
| Mexican 142 | | † | | | In all areas |
| | | | | | In all haricot bean productio |
| Gofta | 1990 | | † | † | area |
| Fedis | 1998 | | † | | Southern rift valley |
| KatB-9 | ** | | † | | ** |
| Seer125 | ** | | | † | ** |
| Hawasa dume | 2001 | | † | | Southern Ethiopia |
| | | | | | In all haricot bean productio |
| Nasir | 2003 | | | † | area |
| | | | | | In all haricot bean productio |
| Dinkenesh | 2003 | | | † | area |
| Gebisa | | | | | |
| | | | † | | In all areas |
| Ibado | 2003 | | | † | Southern Ethiopia |
| Loko | 2003 | | | † | Southern Ethiopia |
| KatB-1 | | | † | | In all area |
| Durstu | | | † | | Southern Ethiopia |
| | | | | | In all haricot bean productio |
| Deme | 2008 | | | † | area |
| Ramada | ** | ** | ** | | ** |
| Waju | ** | ** | ** | | ** |
| Haramaya | 2006 | food | Export | | In cold area of Harer |
| Omo-95 | 2003 | food | | | South rift valley |
| | | | | | |

** =Not accessed by this study

2.7 Heritability, genetic advance and association of major quantitative traits

Heritability interests plant breeders primarily as a measure of the value of selection for a particular character in various types of progenies and as an index of transmistfibilit the percentage is high, the character is heritable but if it is small, the environment is correspondingly prominent in the character expression (Hetyels 1955). Allard (1960) indicated that the heritability values for quantitative traits are **noav**inly due to their sensitivity to environmental factors. Moreover, heritability should be used along with genetic advance in predicting the efficiency of selection. High heritability values could be obtained with genotypes having small or large genetic ance but genetic progress would be larger witharger genotypic variance (Allard, 1960).

High heritability associated with high genetic advance is chiefly due to the additive gene effect but if heritability is mainly due to dominance and epistasisgenetic gain would be low (Panes, 1957). In general, genetic variability, heritability and genetic advance are prerequisites for a breeding program and provide opportunities to breeder to select high yielding genotypes or to combine or transfer geneeing desirable traits (Philip2013). Pandey and Tiwari (1983) indicated the importance of estimating heritability to know the inheritance of quantitative traits as it indicates the genetic gains that may be achieved through selection.

Acquaah (2012)Seedyield is an important and priority trait for plant breeders and other crop researchers. However, seed yield is a complex character and is considered the ultimate product of its components. Hence, selection of superior genotypes based on grain yield is diffcult due to the integrated structure of a plant in which most of the characters are interrelated and being governed by a larger number of genes. This necessitates a thorough knowledge on the nature of the relationship prevalent between the contributory claracters and grain yield and the extent of genetic variability.

2.8 Agronomic Practices on Common bean Production

Improved agronomic practices are used to increase crop yield and are recommended by researchers after testing on the research field **lso**db**a** farmer field.

Seeding rate

Ethiopian farmers, in general, use lower seed rate than research recommendations which result in lower grain yields (Aliet al., 2003). The seed yield of bean is the result of many plant growth processes which ultimatelingfluence the yield components such as pods/plant, seeds/pod, and unit weight of seed. The highest seed yields were obtained when all the above got maximiz (Bessboet al., 2004).

The spatial distribution of plants in a crop community is an importated reference of yield (Egli, 1988) and many experiments have been conducted to determine the spacing between rows and between plants that maximizes yield. Two general concepts are frequently used to explain the relationship between row, spacing, plant **density**ield. First, maximum yield could be obtained only if the plant community produced enough leaf area to provide maximum light interception during reproductive growth (Testsbo al., 2004). Secondly, equidistant spacing between plants affected interceptanetition (Pendleton and Hartwing, 1973). Hence, it will be very important to adjust the spatial distribution of the recommended population in order to have maximum yield.

To avoid nutrient competition sufficient spacing between plants and rows is vital to get maximum yield in a given plot of land. Appropriate spacing enables the farmer to keep appropriate plant population in his field. Hence, a farmer can avoid over and les population in a given plot of land which has negative effect on yield.

Harvesting

Timely harvest is important to reduce mold, bird and insect damage and also to decrease losses due to shattering and wet weather **(Ai**l, 2003). Crops may be harvest when

they are physiologically mature. Common bean is harvested when the foliage of the crop is turned to yellow and before starting shattering (Setegne and Leggese, 2003).

2.9 Evaluation of Improved Crop Varieties by Farmers

Farmers' criteria vary **gately** between households, depending on the productive resources controlled by the household. However, the criteria also vary within a household. Farmers identify and select the type of crops most likely to do well in their areas and selection is normally peceded by extensive discussions both within the farm family and with neighbors (Getinet et al., 2001). Characteristics of the varieties play a vital role in adoption of improved crop varieties (accordingly, if the characteristics of the varieties satisfy the need and interest of the farmers they eventually adopt threvierth crop varieties (Gebre gziabeheet al., 2014). Farmers, technology evaluation criteria include growth habit, yield, color of grain, ease of threshing main uses in the diet, storage, qualities, marketability (Farrington and Martin, 1988), cost, ease of sale, desirability for home consumption, compatibility with existing practices, taste, nutritional value, cooking quality and resistance to pest (Abebeal, 2013).

The choice of one technology actice over others is greatly influenced by the balance between its positive and negative characteristics (Danielet al., 2014). Depending on the preferences, resources, and constraints that individual farmers face, a iblenefic characteristic for one farmer may be a negative one for another, or the balance between positive and negative traits may be acceptable for one farmer but not for another (Bunderset al., 1996). Any new technology presented to farmers will either imepoorv substitute for the technological options they currently have. It is fundamental to identify these options and understand perceptions about the advantages and disadvantages of each one then will researchers be able to assess the appropriateness multiplomew technologies or practices, evaluate the likelihood that they will be adopted, and if necessary modify them to suit farmaeneeds better (Acquaa2012).

2.10 Overview of Technology Adoption

Adoption is a mental process through which an individual passes from first knowledge of an innovation to the decision to adopt or reject and to confirmation of this de(Raign 2001)

According to Federet al. (1985) adoption refers to the decision to use a new technology, method, practice, etc by a farmer or consumference al., (2006) indicate that the decision to adopt an innovation is not normally a single instantaneous act, it involves a process. The apption is a decision making process, in which an individual goes through a number of mental stages before making a final decision to adopt an innovation.

Decision making process is the process through which an individual passes from first knowledge of a innovation, to forming an attitude toward an innovation, to a decision to adopt or reject, to implementation of new idea, and to confirmation of the decision (Ray, 2001). However, as emphasized by Delmer (2))@adoption does not necessarily follow the suggested stages from awareness to adoption; trial may not always be practiced by farmers to adopt new technology. Farmers may adopt the new technology by passing the trial stage. In some cases, particularly with environmental innovations, farmers may hold awareness and knowledge but because of other factors affecting the decision making process, adoption does not occur (FAO, 2)01

3. Materials and Methods

3.1 Description of the Study Area

The experiment was conducted at Bako on model fafieler under irrigated conditions in 2014/2015Bako Tibe district is located about 251 and 125 km west of Addis Ababa and Ambo, respectively. The total area of the district is about 644.94 indenthe total population size was estimated 65,299 n and 68,21 women of totally 133,584 Bako is located at 3709‡E and 916‡N and an altitude of 650m.a.sThe major agroecological zone of the study area is humid to **stub**mid with unimodal rain fall characteristic The mean annual rain fall is 1217 mm. Itsha warm humid climate with mean minimum, maximum and average temperature of 0C4 28 °C and 21°C, respectively. The soil is nitosol specifically clay loam soil. This location was purposely selected as it is among the potential areas for both irrigation common bean production.

Figure 1 Map of the study area(BakoTibe Woreda Land Use Management and Environmental Protection office)

3.2 Experimental/Plant Materials

Twenty improved common bean varieties which were released the different Agricultural Research Centers such as Awasa, Bako, Haramaya and Melkasta??@m to 2009 were used (Appendi).1

3.3 Experimental Designs and Treatmentarrangements

The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications. Each plot consisted of three rows of 1.8 m long and 0.4m between rows. The spacing between plants within row was 10cm.

3.4 Phenological and growth parametes recorded

Ten individual plants were selected randomly per plot, marked before flowering and used as samples for the measurable quantitative traits. The following parameters were recorded following common bean descriptors

Date of emergence (DE)It was recorded when 50% of plants in the plots emerged, and will be used to calculate days to flowering and days to maturity. It is the data at which about 50% of the seedling expected from the plot have emerged outgood time or become visible above the guind.

Days to 50 % flowering (DF) it was recorded ashte number of days from planting the time when 50% of the plants in the plots started flowering(in case of dry sowing) or it is the number of from sowing (if sowing is done when the soil is weetigen to initiate germination).

Days to 95 % maturity (DM): days to physiological maturity was recorded when 95% of the plants in a plot turns their leaves to yellow. It is the number of days from day of sowing to day of 95 % physiological maturity.

Plant height (PH) (cm): was measured from above ground to top of apex once at physiological maturity on ten randomly selected sample plants.

Number of seeds per pod (SPP) it is the number of seed in each pod. It was determined by dividing the total number of seeds fitemsampled plants by the total number of pods.

Number of mature pods per plant (PPP): It is the average number effective pods on a plant. It was determined as the average number of viteled pods often randomly taken plants divided by the plant sampled

Seed yield per plant () (SYPP): Recorded as the average ght of seeds obtained from ten sampled plants divided by the number of sample plants.

Pod filling period: Calculated as the number of days from flowering to physiological maturity (days to maturity minus days to flowering).

Harvest Index: Calculated as:

HI $\tilde{O} = \frac{\text{Grainyield}}{\text{BiomassYikel}} \times 100 \text{WhereHI is harvest Index, GY is grain yield per plot and BY is biomass yield per plot.}$

100-seed weight (g) (HSW):Recorded as the weight of 100 seeds of a variety after it was dried to optimum level **st**orage moisture.

Biomass yield (BM): was measured from net plot by harvesting close to ground level and kept separately; sun dried to a constant weight and then tied in to small bundle and weighted.

Grain yield/plot (g) (GY/PLOT): This was recorded by eighing seeds obtained from the net plot area after sun drying for one week. The data was used to calculate seed yield per hectare

3.5 Data analysis

3.5.1 Analysis of variance

3.5.2 Cluster analysis

Hierarchal clustering of the average linkage method with squared Euclidian distance was performed using/MINITAB14 (MINITAB, 2003). It is used forsmall varieties tes(i.e., less than 30). Data for all quantitative traits were standardized to mean of zero and variance of one before clustering to avoid any bias that may have arisen due to differences in measuremenThecales. distances between cluess were calculated using average linkage method of squared Euclidian distance.

3.5.3 Principal component analysis (PCA)

Principal component analysis for standardized quantitative traits was computeinby MINITAB14 (MINITAB, 2003) software to identify the most important traits contributing to the total variations observed among the accessions, countries/regions of origin and altitude classes. As suggested by Johnson and Wichern (1988), principal components with Eigenvalues variancegreater than one were considered.

3.5.4 Estimation of correlation coefficient

The Pearson,s correlation coefficients between all possible pairs of quantitative traits were tested for their significance usion Software (SAS, 20)2

3.5.5 Phenotypicand Genotypic coefficient of variation

The variability of each quantitative trait was estimated by simple statistical measures such as mean, range, phenotypic and genotypic variances and coefficient of variation. Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (CV) values below 10%, 10%-20% and above 20% were considered to be low, intermediate and high, respectively (Khorgadeet al., 1985). The phenotypic and genotypic variation and coefficient of variations were calculæd following the formula suggested by Singh and Chaundhary (1985) and Allard (1960) as follows;

$$^{2}_{p} = ^{2}_{g} + ^{2}_{e}$$
 where, $^{2}_{p} =$ phenotypic variance,
 $^{2}_{g} =$ genotypic variance and
 $^{2}_{e} =$ environmental variance
 $^{2}_{g} = (MS_{g}, MS_{e})/r$ where, $MS_{e} =$ mean square of genotype,
 $MS_{e} =$ mean square of error and
 $r =$ number of replications

 $PCV = \frac{\sqrt{d^2 p}}{\bar{x}} \times 100 \quad \text{where, PCV} = \text{phenotypic coefficient of variation,} \\ \hat{x}^2 = \text{phenotypic variance and} \\ \frac{2}{\bar{x}} = \text{population mean for the trait considered} \\ GCV = \frac{\sqrt{d^2 g}}{\bar{x}} \times 100 \quad \text{where, GCV} = \text{genotypic coefficient of variation,} \\ \hat{x}^2 = \text{genotypic variance and} \\ x = \text{population mean for the trait considered} \\ \end{array}$

3.5.6 Estimate of Broad sense heritability

Broad sense heritability was estimated according to the suggestion of Allard (1960) by dividing genotypic variaces by phenotypic variance: $H\check{S} \stackrel{2}{=}_{g} (\stackrel{2}{}_{p}) \times 100$, where $\stackrel{2}{}_{g} =$ genotypic variance and $\stackrel{2}{}_{p} =$ phenotypic variance. Expected genetic advance under selection assuming a selection intensity of 5% was computed following the formula developed by Allard (1960) as:

 $GA = (K) (\hat{p}) (H^{2}), \text{ where } GA = \text{expected genetic advance}$ K = selection differential that varies depending up on the selectionintensityand standsta2.056 for selecting 5% of the monotypes. $\hat{p} = \text{phenotypic standard deviation and}$ $H^{2} = \text{heritability (in broad sense)}$ Genetic advance as percent of mean (GA as % mean =) × 100%: where, GA = geneticadvance and

 \overline{x} = population mean for the trait considered

3.5.7 Estimation Shannonweavers diversity index (H€) for qualitative traits

Genetic diversity indexwas estimated to measure the diversity fixed qualitative traits such as seed colorseed shape, seed size, flower color and pod color everpteoyed in this study. The amount of genetic variation as determined using Shannow eaver diversity index (Shannon and Veaver, 1949)

4. Result and Discussion

4.1 Mean, range and standarddeviation for quantitative characters

Mean, range and standard deviation agronomic traits are widely used to determin variations between varieties the mean, minimum, maximum, range, deviation from the mean and standard error of mean for 20 released to be varieties are presentined Table 2.

As can be seen from table 2, wider ranges of variation were observed between the tested common bean varieties for most of quantitative traits. Days to floweringged afrom 37 (for variety Gofta) to 50 (for Deme). Common bean variety Naswias earlymaturing (83 days), but Demteook the highest number of days to mature (109). The higheest height recorded for Waju (172cm) and the lowest for KatB1(46.3cm). Pod per plath ranged from 10.93 for Hwasadumeto 33.07 for Dinkinesh

Extremely wider range of variation was noted for grain yield per heotalek(g to 5767 kg). Of all tested common bean varieties, the highest grain yield per h(5767 kg) was noted forRamadareleased fromMelkasa Agricultural Research Center, but the lowest (772 kg) forHawassa dummeleased fromHawasa Agricultural Research Center

The descriptive analysis for major quantitative traits showed the existence of wide range of variation among the released commonarberarieties. The wide range in the extreme values of each of the traits studied offers broad opportunities for further utilization in the breeding program to develop varieties suitable for different-agotogies of the country and for different purposes

The broad range of variation for phenologies such as days to flowering, days to maturity and grain filling period offer great flexibility for developing improved varieties suitable for various agreecologies of the country which have variable lengthgrowing period and also to use in various cropping systems. The wider variation in number of pods per plant, seeds per pod, hundred seed weight and seed per plant among the varieties implied the possibility to create a variety with higher grain yiehtd/or other biological yields. Early flowering and maturity is the most important mechanism to escape terminal drought stress in raifed condition. The highest plant height in Waju (1072) indicates that this traitis less influenced by environmental fluctutions and also attributed to the semi-climbing nature of the genotypethe findings in this studyare in agreement with Win, (2011); Nielson and Nelson, (1998); and Philips, (2013) in common bueater irrigated condition They all reported that, the difference can be attributed to genetic variability among the genotypeticate (1993) found similar results in soybeans.

| Variable | Minimum | Maximum | Range | StDev | Mean ±SEM |
|--------------------------|---------|---------|---------|---------|-------------|
| Plant height | 46.27 | 172.13 | 125.86 | 31.91 | 104.9±7.13 |
| Days to flowering | 37.33 | 49.80 | 12.47 | 4.10 | 42.54±0.916 |
| Days to maturity | 82.67 | 109.33 | 26.66 | 8.51 | 95.15±1.9 |
| Grain Filling Period | 40.67 | 65.00 | 24.33 | 6.80 | 52.75±1.52 |
| Pod per plant | 10.93 | 33.07 | 22.14 | 5.23 | 21.35±1.17 |
| Seed per pod | 3.08 | 6.20 | 3.12 | 0.96 | 4.67±0.215 |
| Seed per plant | 33.37 | 154.63 | 121.26 | 37.21 | 101.85±8.32 |
| Hundred seed weight | 20.67 | 52.53 | 31.86 | 10.88 | 35.25±2.43 |
| Grain yield per plant | 9.18 | 61.81 | 52.63 | 11.92 | 34.25±2.66 |
| Grain yield per plot | 144.40 | 1093.60 | 949.20 | 252.60 | 515.10±56.5 |
| Grain yield per hectare | 772.00 | 5767.00 | 4995.00 | 1362.00 | 2779±305 |
| Biomass weight per plant | 1.40 | 3.10 | 1.70 | 0.48 | 2.2±0.108 |
| Harvest index | 0.11 | 0.36 | 0.25 | 0.07 | 0.23±0.015 |

| Table2 Descriptive statistics on y | vield and 1y3eld | related parameters |
|------------------------------------|------------------|--------------------|
|------------------------------------|------------------|--------------------|

sourcemodel

4.2. Pearson correlation coefficient analysis

Correlation coefficients were computed to assess the relationships between yield and yield related components office 20 released common bearvarieties in Ethiopia under irrigated condition in the study area. Takesociation yield and yield related attributes was based on the mean of 20 released mmon bearvarieties for 13 quantitative traits The resultshowed that about 9.23% of the total traits howed positive correlation and 30.77% showed negative correlation (Table The yield per plant exhibited significant positive correlation (P < 0.05) with most of yield related traits indicating relative utility of these traits for selection the positive correlation could be resulted from the presence of common genetic elements or micro environments (or both) that controls the characters

to the same directionSimilarly, Khan and Qureshi (2001) have reported that number of podsper plant is psitively correlated with seed yieper plantin chickpea. Also, Guler et al. (2001)informed that the direct effect of the number of pods per plant on seed yield in chickpea was significanPositive significant correlation due to effect of genes can be the result of strong linkage between their genes or the characters may be the result of pleiotropic genes that controllese characters in the same directione(beet al., 2013). Similar results were reported by Ludeal, (2012) for finger millet and Ayana (2001) for sorghum. The is a small and non significanceorrelation(r= 0.0930) between grain yield (kg/ha) and plant heightThismay be due to lodging and canopy effect.

Polygenic traits such as of per plant, biomasyield, and seedper pod hundred seed weight and harvest index showed positionerrelation with grain yield. This inlined the possibility to combat the low yielding ability of mmon bean varieties improving and selecting for these important agronortrigits. Similarly, GebreEgziabheret al, (2014) found positive correlation for grain yield with number of post plant, number of seeds per plant and hundred seeds weight. Supportive results to the present study were also reported for common bean Mesfin et al. (2014) Kebereet al., 2006 Abebe et al., 2013 and Daniel 2012; for bread wheat T(arekegn 1994 Salado Navaro et al., 1993 and Karmakerand Bhatnagar, 1996 or linseed (Worku, 2005), and for tef Assefaet al., 2002) and for sorghum (yang 2001). Plant heighthas negative correlation with grain yield and mosof yield related traits (Table)3Similarly, GebreEgziabheret al. (2014) found negative correlation between plant height and rain yield in some released common bean varieties Vin, (2011) also found negative correlation between plant height andpod per plant, seed per plant avield per plant in chickpea under similar condition. Negative correlation between grain yield and plant height in the present study was in contrary with the finding of Riggset al., (1981) which reported positive association in wheat.

However, number of pods per plant was negatively correlated with days to 50% flowering, and days to maturityThis may be due to flower suppression during irrigated condition. Those results indicated that prolong reproductive phase in such environment may lead to

decrease in yieldNegativecorrelation betweenumber ofpodper plant and days to 50% flowering, anddays to maturity in the present study was in contrary with the finding of Win (2011) which reported positive association dinickpea under ain fed condition.

Therefore, from the present correlation study are were strong correlations between some trais (Table 3), which allows for simultaneous selections and use the frelated traits interchangeably in selection. The program of the same genes or pleiotropic effections, 2008). Practically, during be improvement, if two strongly correlated traits desired, they can both be selected simultaneously basing on one of the traits

For examplegiving emphasis to number pods/plant, number of seeds/pod and number of seeds /plant is a paramount importanic improving seed yield of common bean genotypes through indirect selection in high moisture stress area like Bako. Such studies are useful in disclosing the magnitude and direction of relationships between the different characters and seed yield as well as among the characters (Sharma and 19776).

| Traits | PH | DF | DM | GFP | PPL | SPPOD | SPPL | HSW | GYPPL | GYKgh | BIO | HI |
|-----------------------|--------|--------|--------|---------|--------|---------|---------|--------|--------|--------|--------|----|
| DF | 0.150 | | | | | | | | | | | |
| DM | 0.429* | 0.645* | | | | | | | | | | |
| GFP | 0.414* | 0.187 | 0.862* | | | | | | | | | |
| PPL | -0.003 | -0.067 | -0.152 | -0.207 | | | | | | | | |
| SPPOD | -0.050 | 0.207 | -0.088 | -0.281 | 0.430 | | | | | | | |
| SPPL | -0.021 | -0.008 | -0.174 | -0.263 | 0.828* | 0.819* | | | | | | |
| HSW | -0.142 | 0.434* | 0.362 | 0.208 | -0.269 | -0.442* | -0.469* | | | | | |
| GYPPL | -0.062 | 0.407* | 0.253 | 0.010 | 0.533* | 0.361 | 0.468* | 0.499* | | | | |
| Gy kg hā ¹ | 0.093 | 0.384 | -0.076 | -0.368 | 0.098 | 0.549* | 0.338 | 0.140 | 0.435* | | | |
| BIO | -0.147 | 0.405 | 0.062 | -0.225 | 0.181 | 0.570* | 0.391 | 0.139 | 0.547* | 0.802* | | |
| HI | 0.082 | 0.216 | -0.305 | -0.532* | 0.195 | 0.564* | 0.410* | 0.002 | 0.331 | 0.913* | 0.577* | |

Table3. Correlations coefficient of yield and yield related components of othemon beangenotypes

Key: * = significantat5% levelof significance. 4.3. Principal component analysis

Principal component Analysis for 13 stand**aed** quantitative traits were computed by using MINITAB14 softwareMINITAB(2003) to identify the most important traits contributing to the total variations observed among th**eo200**mon bearvarieties PCA results illustrated he overall picture of the pattern of genedicersity of the common germplasm based of a quantitative traits. As speculated or suggested by Johnson and Wichern (1988), principal component willingen-values greater than one was considered.

The first four principal components having Eigeentue greater than one were extracted from the mean of 13 nominized quantities traits of 20 improved mmon bean varieties (Table 4). A variance of 39.2, 22.1, 14.6 and 10.6% were extracted from the first to fourth components, respectively. Agronomic and phenotypic characters such as grain yield per plot, grain yied kg/ha, harvest index, biomass yield, seeds per pod, number of seeds per plant and grain yield per plant were the major contributors for the variation observed in the first principal components. The variation in the second principal were mainly due to dasy to maturity, days to 50% flowering, hundred seed weight and grain feeling period. Likewise pod per plant, seed per planating periods and hundred seed weight were the major contributors to the variation in the third components. Plant height, gain yield per plant, hundred seed weight pod per plant, seed weight and harvest index were the major contributors for the variation observed in the fourth components. The variation is the fourth components. Plant height, gain yield per plant, hundred seed weight pod per plant, seed weight and harvest index were the major contributors for the variation observed in the fourth components. The above traits arbight recommended for use in common beamaracterization conservation and breeding imilar result was alsoeported by Atilla et al., (2001).

| Traits | PC1 | PC2 | PC3 | PC4 |
|-----------------------------|--------|--------|--------|--------|
| Plant height | 0.029 | 0.196 | 0.263 | 0.589 |
| Days to flowering | -0.134 | 0.453 | -0.002 | 0.010 |
| Days toMaturity | 0.088 | 0.517 | 0.277 | 0.096 |
| Grain filling period | 0.219 | 0.371 | 0.325 | 0.117 |
| Number ofPodsPer plant | -0.208 | -0.154 | 0.475 | -0.317 |
| N umber ofSeedsPer Pod | -0.353 | -0.086 | 0.248 | 0.124 |
| N umber ofSeedsPer Plant | -0.312 | -0.177 | 0.446 | -0.091 |
| Hundred seed weight | 0.033 | 0.411 | -0.313 | -0.418 |
| Grain yield per plant (g) | -0.261 | 0.262 | 0.167 | -0.468 |
| Grain yield per plot (g) | -0.408 | 0.066 | -0.178 | 0.173 |
| Grain yield per hectare (kg | -0.388 | 0.134 | -0.222 | 0.193 |
| Biomass yield per plot (g) | -0.362 | 0.168 | -0.108 | -0.041 |
| Harvest index (%) | -0.377 | -0.015 | -0.208 | 0.206 |
| Eigenvalue | 5.0942 | 2.8706 | 1.9003 | 1.3779 |
| Proportion | 0.392 | 0.221 | 0.146 | 0.106 |
| Cumulative | 0.392 | 0.613 | 0.759 | 0.865 |

Table 4 Principal Component Allysis of 13 quantitative traits of 20 improvedmmon beangenotypes

PC: Principacomponents

4.4. Cluster analysis

At 80% similarity level, all the 20 released varieties were grouped into five clusters based on 13 standardized quantitative tra(Fsig. 1). Common bean varieties such as Gofta, Seer125, KatB-9, KatB-1, Fadis, Awash Malka, Mexican142, Seer119, Dursitu, Dinkinesh and Gebisa were grouped together in the first cluster (Fighits).cluster recorded the least in plant heigh@c(cm) and days to grain filling period (42 da)@/aju, Ebado and Loko were grouped in the sectorluster.This cluster showed the highest in average number of pods per plant (25.32), hundred seed weight (46.7 g) and grain yield per plant (48.5 g) but the least in number of seeds per pods and harvest index. The third cluster comprised of two variest (Deme and omm@5) and this cluster showed the highest average plant height (132 cm), days to flowering (49 days), days to maturity (109 days) and days to grain filling period (61 days). Haramaya and Awash Dume were grouped in the fourth cluster duther relatedness for plant height, pod per plant and seed per pod. Besides, the fourth cluster portrayed the least in number of pods per plant (18.8), seeds per plant (78) hundred seed weight (27.8) and biomass weight per plant (1.9 g). The fifth cluster of two varieties such as Ramada and Nasir, and those varieties showed the highest in seed per pod (5.8), seed per plant (126) and grain yield per hectare (5.01 tons).

Overall, the aggregation those 20 released common begremotypebased onplant height days to flowering days to maturity grain filling period, pod/plant, seed/pod, hundred seed weight, grain yield/ plant, grain yield/plot, grain yield/ha, biomass yield/plot and harvest indexinto five clustersat 80% similarity level having2-11 varieties per cluster indicated a morphological diversity between the tested materials. generally agreed that genetically diverse parents will exhibit maximum heterosis and offer the best chance of isolating transgressive segregalities,(2008). The result of hierarchal clustering of the maturing and long plant height cultivars in cluster three could result in several new lines with heterotiar actersLikewise, it is possible to generate a diverse parental line for hybridization from distantly related clusters with diverse functional traits as observed of the parchical clustering (Fig) 2

The clustering pattern indicated that varietiesclinsters 3 to 5 were genotypildy more divergent from the other collections for they formed single genotypic clusters. This method of clustering germplasm collections can also be used in the elimination of the duplicated and genetically redundant accession with other relevant information and documents of the germplasm (Greene and Peder20001). Hence, they recommended the elimination of duplicates as an effective way of reducing germplasm maintenance cost without losing valuable genetic resoulcides wise, it is possible to generate a diverse parental line for hybridization from distantly related clusters with

diverse functional traits as observed from hierarchical clustering (FigEnte) present study was confirmente finding of Malicet al., (2004). He reported that teaster analysis using dendrogramind out genetic variability amongommon beamgenotypes.



Figure 2 Dendrogram showing genetic similarity and differences between 20 improved common bean genotypes evaluated for 13 major phenotypic traits at 80% similarity level for standardized data

4.5 Phenotypic and Genotypic coefficient of variation

The estimates of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient variation (GCV) for all the characters under considera@comparatively maximum PCV values were observed for grain yield per plot (47.8%), grain yield per plant (39.09%), number of seed per pod (37.5%), harvest in 25%)(hundred seed weight (29.94%), plant height (22.29%), and pod per plant (26.5%), and biomeiget per plot (23.19)Intermediate PCV values were observed for grain feeling period only. However, days to 50% flowering and days to maturity exhibit very low PCV values, 9.64% and 8.56%, respectively. Estimates of genotypic coefficient of variation (GCV) were lowest for traits such as days to maturity and days to 50% flowering. Intermediate

GCV values were observed foliays tograin feelingperiod and biomass yield per plot. The highest genotypic coefficient of variation (GCV) was obtailinged grain yield per plot (46.16%), number of seed per plant (33.9%), grain yield per plant (31.56%), hundred seed weight (29.12%), harvest index (25.2%) and number of pod per plant (22.5%) (Table 5). Similar results have also been reported Abgmayehuet al. (2014) for yield per plant and pods per plant 2009 for yield per plant, pods per plant, plant height and 100 seed weight; Panelegil. (2013) for pods per plant.

The PCV and GCV values for most of the traits considered in this study were folged to high (Table 5). High GVC and PCV for number of podrpedant and number seeds per plant were earlier reportedly Fikre et al. (2012). The large percentage of both GCV and PCV values were due to their respective large variances sourced mean, as shown in table 5 In other words, traits that had relatively ge genetic variances also showed higher genotypic coefficient of variation, suggesting that selection for these characters might be more effective than the remaining ones since they had less environmental influences. Genotype Nassir and Ramada can be ideened as the best variety and be recommended fouse under irrigated condition in the study abea ause the umulative effects of the 13 quantitative traits make them well adapte of earlier and the table of the table of the table table table to the table table

4.6. Broad sense heritability (H2) and Genetic advance

A fair measure of efficiency of selection for any quantitative traits can be derived from the estimates of heritability for the characters under consideration. But reliability of selection depends not only on heritability but it should also be accomplayileigh genetic advance (Johnson al, 1955). High heritability coupled with high genetic advance indicated that genetic progress can be made through selection as it suggests the presence of additive gene effects (Panse, 1957).

In the present studyestmates of heritability H²) ranged from 51.88% for harvest index to 97.99% for days to maturity (Table).5Hence, the highest heritability estimates were observed for days to maturity (97.99%), grain feeling period (97.4%), plant height

(96.7%), hundred **seet** weight (94.9%), grain yield per plot (93.14%), days to 50% flowering (85.76%) and number of seed per plant (81.8%).

According to Win (2011) eritability estimate for canopy height was higher under irrigated condition than non-irrigated condition. It indicated that genetic variation for canopy height of these tested genotypes was high underwater stress condition. Similar finding was reported by ohn (2006). High estimates of heritability on plant heights were also reported by, Sharetaal (1990), Asefa et al., (2002) and Gebre Egziabheret al., (2014). All of the traits considered in the current studyowed heritability percentage greater than 50%. However, the heritability value was not accompanied by genetic advance. Genetic advance was least for days to flowering (17.01%) and highest for grain yield per plot (91.6%). Relatively higher heritability followed by higher genetic advance were recorded for grain yield per plant, grain yield per plot, number of seed per plant, number of pod per plant and harvest index. Days to maturity and days to 50% flowering ortraved lower percentage of genetic advance. Broad sense heritability was high for grain yield, pod per plant, seeds/plod and hundred seeds weigh(Alemayehu 2014). Similar observations were reported by Sieghal (1994) for yield per plant, and pods per plattbebe, (2013) for yield per plant, podsept plant, plant height and 100 seed weight.

High broad sense heritability was indicating a significant contribution for traits evaluated and the additive effects played a greater role in the total genetic va**(iAtian** Klynger da Silva habatoet al., (2014).So, this result suggests that selecting for traits with high H ² value could lead to better progress than those with lowerds the latter were more influenced by environment than the former. On the other hand, characters wittHowe may have poor response to selection due to substantial effect of the environment. Generally, in this study, yield per plant, pod per plant yield per plotgaaid yield per hectare showed relatively high genotypic coefficient of variability, heritability and genetic advance. Therefore, these traits need to be given more emphasis in phenotypic selections. Thus selection for these traits is likely to accumutate additive genes leading to further improvement of their performance and these traits may be used as selection criteria in common bgan breedin program under irrigated condition.

Table 5. Estimation of the different variances arameters, heritability and genetic advance10 major quantitative traits of 20 released varieties.

| Variables | Mean | MSg | MSe | ^2g | ^2e | ^2p | GCV% | PCV% | H 2% | GA | GA% |
|----------------------|---------|-----------|----------|----------|----------|-----------|-------|-------|-------|--------|-------|
| PH | 104.90 | 3054.25 | 31.12 | 912.99 | 31.12 | 944.11 | 28.80 | 29.29 | 96.70 | 61.09 | 58.24 |
| DF | 42.53 | 50.10 | 2.40 | 14.44 | 2.40 | 16.83 | 8.93 | 9.65 | 85.76 | 7.23 | 17.01 |
| DM | 95.15 | 217.07 | 1.33 | 65.03 | 1.33 | 66.36 | 8.48 | 8.56 | 98.00 | 16.41 | 17.25 |
| GFP | 52.75 | 138.59 | 1.08 | 41.45 | 1.08 | 42.53 | 12.21 | 12.36 | 97.46 | 13.07 | 24.77 |
| PPL | 21.35 | 81.96 | 8.86 | 23.17 | 8.86 | 32.04 | 22.55 | 26.51 | 72.33 | 8.42 | 39.43 |
| SPPOD | 4.65 | 1.54 | 0.681 | 0.49 | 0.681 | 1.17 | 15.1 | 23.3 | 41.9 | 0.93 | 20.05 |
| SPPL | 101.85 | 4154.00 | 265.8 | 1193.3 | 265.80 | 1459.05 | 33.92 | 37.50 | 81.78 | 64.23 | 63.06 |
| HSW | 35.24 | 355.23 | 5.70 | 105.63 | 5.70 | 111.33 | 29.17 | 29.94 | 94.88 | 20.58 | 58.41 |
| GYPPL | 34.25 | 426.01 | 62.38 | 116.90 | 62.38 | 179.28 | 31.57 | 39.09 | 65.20 | 17.95 | 52.41 |
| GYPPLO | 515.14 | 191426.3 | 4162.8 | 56549.6 | 4162.8 | 60712.4 | 46.16 | 47.83 | 93.14 | 471.7 | 91.60 |
| Gykgha ^{⁻1} | 2772.49 | 3223809.9 | 360024.4 | 954595.2 | 360024.4 | 1314619.6 | 35.2 | 41.3 | 72.6 | 1711.4 | 61.73 |
| BIO | 2.21 | 0.70 | 0.07 | 0.19 | 0.07 | 0.26 | 19.84 | 23.19 | 73.17 | 0.77 | 34.89 |
| HI | 0.23 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 25.21 | 35.00 | 51.89 | 0.08 | 37.34 |

4.7 Agronomic Performance of some (20) Released Common bean Varieties

There were significant flierences (p < 0.0)5 among genotypes with respect to yield and yield attributes, which demonstrates high genetic variance amonthmem that enabled to screemigation tolerant genotypes (Tabl6). The analysis of variance indicated

significant differences among theariveties for all traits alsoevealing that the varieties tested were highly variable. The mean values for grain yield ranged from 1,947 to 4,519 kg/ha with an average yield of 3,400 kg/ha (data not shown).

Number of pods per plant: Significant differences (P<0.05were exhibited among common bearvarieties for number of pods per plant. More numbers of predsplant were recorded from the varieties Ramada and Nassir with respective 33.07 and 27.6 pods per plant. Online other hand, the variety Awasame had the lowest number of pods per plant (10.93). The data ranged from 10.93 to 33.07 for this param(Freeble 6). These finding confirmed the study of Abebeet al., (2013).

Number of seeds per podCommon beam arietieswere exhibited variation (P<0.)06 or number of seeds per pod. The Ramada Natassir produce more number of seeds per pod (6.20 and 6.10) respectively compared to the other varieties. On the other Hawada Dume produces the lowest number of seeds per pod (3.06) emaining varieties were in the range of 6.10 to 3.53 for the character not (Dable 6). The variation in yield components and seed yield among traveicot beangenotypes were also repred by Daniel et al., (2012).

Number of seed plant Significant differences (P<0.) Swere exhibited amongommon beanvarieties for number of seeds per plant. More numbers of seeds /plant were recorded from the varieties Nassir and Mexica 42 with respective 152.10 and 147.33 seeds per plant. On the other hand, the variety Awash Dume had the lowest number of Seeds per plant with seed number/plant of 33.37 he data ranged from 38.33 to 140 for this parameter(Table 6). Significant variability in seeds per pod in chickpea was also observed by Ahmaet al (2003).

Plant height: Highly significant variation (P<0.0)5was observed among the studied varieties for plant height. The variety Waju (172.13 cm) was the longest variety while the variety KatB1 (46.27cm) was the shortest variety (Tab)eHigh variability in plant height of chickpea genotypes was absoported by Win, (2011).

Days to flowering and Days to maturity Days to 50% flowering and days to maturity had significant differenceP(<0.05) among the varieties. Days to flowering and days to maturity were maximum for Deme (50, 109 days) and minimum for Gofta8(33days), respectivelyFrom this result, one can conclude tthat line with early phenology (early flowering and early maturity) would be less vulnerable to terminal drought and hence suited as drought escaping genotypes in-freathconditionand this asociated with high initial growth vigour Sabaghpouret al. (2003) who found that early flowering and maturity was the most important mechanism to escape terminal drought Streitar result was found by Beaver and Rosas (1998) in their studgrfroinal drought tolerance in common beans, where selection for early flowering in red beans permitted the identification of the genotype with short reproductive perio8imilar results were reportedby Guaret al. (2008) on chickpea

According to Win 2011) generally observations on days to maturity underigated conditions revealed that there wasslelay of 816 days in maturity in all genotypes under irrigated condition. The reason may be the fact that the moisture stress creates internal stress ordifferent parts, which quickens flowering and maturity. Similar observations were recorded by Dhimaret al., (2006) who reported that there was delay in maturity under irrigated condition

Total biomass weight: Significant differences (P<0.) Svere exhibited amongommon beanvarieties for total biomass reight perplot. The highest was recorded from O. (3.1kg/plot) followed by Nassir (3.03kg/plot). The least biomass was ded doy Awasa dume (1.4kg/plot) (Table 6). Win (2011) reported that increased biomass eight in chickpea can contribue to higher seed yield in the present study hese high seed yielding genotypes could produce the highest value of biomy and under irrigated condition. These genotypes can be assumed vas agematuring genotypes, which caraccumulate large amount of total plant biomass due et duced total photosynthetic period compared to the relatively longer maturing an et al.

Hundred seed weight: The common beanvarieties tested had significant variation (p<0.05) among each other for hundred seed weight. The variety Loko produces the highest hundred seed weight (52.53 gm) followed by Deme(52.07gm). The variety Dursitu was the least in seed weight (23.33gm) (T**6**) lies imilar results were reported by Fikru (2007).

However, he results of present study showed that the decrease in HI by irrigation. Pandeyet al., (2001 and 2003) found that the decrease in HI by irrigation was due to suppression of flowering and numberpoolds. This led to a decreased requiremending matter and N in reproductive sink. Consequently, more of dry matter is retained in vegetative tissues. The results of present study showed that reduction in HI highs of magnitude inAwasa dume (0.11) and Gebisa (0.15) Similarly, Dhiman et al. (2006) reported that HI was reduced under irrigated condition

Gain feeling period Common bearvarieties were exhibited vation (P<0.05) for grain feeling period per plot. Awash Dume an embe had long grainfeeling period (65 and 61 days) respectively compared to the other varieties. On the other hand, Nassir and Dinkineshrevealed the shortest number of days per plot (and 44), respectively(Table 6).

Grain yield per plant: A significant variation (p0.05) was observed amongpmmon beanvarieties for grain yield per plant. The highest yield was recorded from the varieties Ramada and Ebado with the values of 61.81g/plant and 58.53g/plant, respectively. On the other hand Awash Dume was the lowest yield (0.18 g/plan): Table 6 The higher yield of these two genotypes was dute the production of higher number of pods per plant which was supported by the results of figure ater number of generative study was inagreement with the results of (2011).

Grain yield/plot: A significant variation (p<0.0)5was observed amongpmmon bean varieties in their response to grain yield. The highest yield was recorded from the varieties Ramada and Nassir with the values of 1093.63 and 1086.6g/plet;tikestp. AwasaDume on the other hand was the lowest yielder with the value of 144.4 g/plot (Table6).

Grain yield potential (kg/ha): Ramada (5767.15 Kg/haand Nassir (5674.82 Kg/ha) out yielded the remaining varieties. Although this result is a single year and single location trial, the two varieties could be better recommended for production under irrigated conditionese two varieties are so superior to most of the varieties studied for traitssuch as number of pods per plant, number of seeds per pod, grain yield per plant, grain yieldplot, total biomass yield per plot and harvest index. This result is in agreement with the finding ofeGebr Egziabheret al (2014); Kebereet al (2006); Abebe et al., (2013) for common bean who stated that the seed yield of some released mon bear is the result of many plant growth processes which ultimately influence the yield components such as pods per plant, seeds per pod and unit weighseed.

The highest seed yields were obtained when all the abraxies got maximized. According to this study, Rama, data medium red variety and Nassir, a small pure dark red variety are the most favored and most commercially accepted varieties within the red bean types. These two improved varieties were released in Ethiopia **comat** on bean production areas. These foty ope varieties (Ramada and Nassir), released in 2003, were

found potential for smalholder farmers. The varieties were good yielder in research stations (up to 2500kg/ha) compared foormerly releasedones and also have short maturity cycle (80 to 95 das). They pose an opportunity for the farmers who at times hardly wait too long to feed the famility, improve soil fertility as it is a legume crops, to grow multiple crops per plots per season

Similarly, Alemayehu 2014) reported thatof the variation among common bean genotype vere significant for grain yield and yield related traits under both sole and intercropping system. Overall, the present study revealed that significant variations were recorded among the common bean varieties for grain yield yield related traits under irrigated conditionimplying the presence of substantial variability among the studied genotypes This irrigated condition may influences economic characters such that is mostly controlled by many genes and haspetex inhertance. Highly significant yield differences, earliness good grain (not shown) and adapted to the agro climatic condition of this particular area indicates the need to develop genotypes that adapted to specific environmental condition. Maximizing seed yield through simultaneously increasing biomass yield aortbler important yield related traits area worthwhile strategy (Wallace, 1985; Wallace al, 1993), especially for production regions likeBako.

| Genotypes | PH | DF | DM | GFP | PPL | SPPOD | SPPL | TSW | GYPPL | GYPPLO | GYkgha | BIO | HI |
|-------------|----------------------|----------------------|----------------------|---------------------|-----------------------|--------|---------------------|-----------------|----------------------|-----------------------|----------------------------------|--------------------|-----------------------|
| Gofta | 107.50 ^E | 37.33 | 88.67 ^J | 51.33 [™] | 21.20 ^E | 3.53 | 74.80 ^{HG} | 37.7 7 F | 28.27 ^{EDG} | 403.60 ^{¯GH} | 2157.49 ^F | 1.93 ^{GF} | 0.21 ^{FECDG} |
| Awash melka | 109.47 | 44.33 ^{DE} | 90.67 | 46.33 | 24.03 ^{CEBD} | 5.45 | 117.00DEC | 20.97L | 24.60FEG | 443.77FG | 2378.3 [†] [₽] | 1.73GHF | 0.27BCD |
| Fadis | 76.27 ¹ | 47.00 ^{BC} | 96.33 | 49.33 ^{HG} | 18.47 ^{HG} | 4.07 | 74.53HG | 46.73CB | 34.80FCEBDG | 556.90DE | 2967.5 ^{4 DAC} | 2.67BAC | 0.21FECDG |
| Mexican142 | 114.40 ^{ିଁ} | 38.00 ^{ll} | 87.00 ^{KJ} | 50.67 ^G | 21.47 ^E | 5.35 | 147.33BA | 20.67L | 23.63FG | 427.33FG | 2279.8Í | 1.80GHF | 0.24FBECD |
| KatB9 | 54.23 | 41.67 ^{9F} | 86.67 | 48.33 [#] | 14.57 ^{1JI} | 4.20 | 60.37IH | 43.37CD | 26.20FEG | 557.50DE | 2967.22 ^{BDFC} | 2.10EGDF | 0.27BC |
| Seer 125 | 54.23 | 39.00 ^{iHI} | 89.67 [∺] | 50.67 ^G | 21.50 ^{FE} | 4.66 | 99.57FEG | 31.13GH | 30.98FCEDG | 422.00FG | 2223.03BDAC | 2.13EDF | 0.21FECDG |
| Deme | 137.50 [₽] | 48.67 ^{8A} | 109.33 | 61.00 ് | 16.23 ^{HGI} | 4.23 | 68.77H | 52.07A | 35.83FCEBD | 611.33DC | 4921.67 ^{BDAC} | 2.40EDC | 0.30BA |
| Ramada | 111.63 [₽] | 49.67 ^A | 96.67 | 46.67 ^{ll} | 21.03 ^{EG} | 6.10 | 129.10BDAC | 48.07B | 61.81A | 1093.63A | 5767.15A | 3.03A | 0.36A |
| KatB- 1 | 46.27 | 39.00 ^{iKi} | 84.67 | 46.00 | 18.53 ^{FHG} | 3.56 | 66.13H | 45.37CB | 30.00FCEDG | 350.17IGH | 1868.77EF | 1.97EGF | 0.18FEHDG |
| Waju | 172.13 | 40.00 ^{9HI} | 98.6 7 | 59.00 ^{°D} | 27.20 ^{°DB} | 3.95 | 106.80FDE | 39.93ED | 42.62CB | 401.27FGH | 2305.65F | 1.67GH | 0.25BCD |
| Nassir | 125.93 | 40.00 ^{GHI} | 82.67 ^M | 40.67 [∟] | 22.43 ^{ED} | 5.50 | 122.87BDEC | 27.10IKJ | 33.28FCEBDG | 1086.63A | 5674.82BA | 2.90BA | 0.36A |
| Seer-119 | 89.03 ⁹ | 38.67 ^{HI} | 90.67 [⊮] | 51.67 ^E | 22.83 ^{CEBD} | 6.20 | 140.80BAC | 29.57IH | 40.95CBD | 674.27C | 3416.14BAC | 2.73BAC | 0.25BECD |
| Haramaya | 134.00 ^{°D} | 43.00 ^{DEF} | 96.00 ⁶ | 53.00 € | 13.53 ^{ll} | 3.53 | 38.33IJ | 34.57GF | 22.37G | 315.17IH | 1671.25EBDF | 2.03EGDF | 0.15FHG |
| Dursitu | 84.30 ^{HG} | 41.33 ^{GHF} | 93.67 ^{8A} | 52.33 [™] | 27.50 ^{°D} | 5.60 | 154.63A | 23.33LK | 36.45FCEBD | 583.33DC | 3076.99 | 2.40EDC | 0.24FBECD |
| Omo 95 | 126.30 | 48.33 ^{BA} | 108.67 | 60.33 ^{св} | 22.67 ^{CED} | 5.76 | 130.00BDAC | 25.57KJ | 33.18FCEBDG | 856.00B | 3826.87A | 3.10A | 0.24FBECDG |
| Awasa Dume | 143.83 | 37.67JI | 102.33 | 65.00 ⁴ | 10.93 | 3.08 | 33.37J | 27.70IHJ | 9.18H | 144.40J | 771.66EF | 1.40H | 0.11H |
| Gebisa | 110.27 ^E | 45.00 ^{°C} | 102.67 | 57.67 | 21.00 ^{FEG} | 5.67 | 115.53DEC | 26.40IKJ | 30.90FCEDG | 265.431 | 1404.20EDFC | 1.80GHF | 0.15FHG |
| Ebado | 89.57 ⁹ | 42.00 ^{GEF} | 105.67 ^{°C} | 63.67 ^A | 27.60° | 4.40 | 121.13BDEC | 47.60B | 58.53A | 363.77FIGH | 1940.64FBDAC | 2.47BDC | 0.15H |
| Loko | 106.43 ^E | 48.67 ^{8A} | 107.0ď [∟] | 57.67 | 21.17 ^E | 3.87 | 83.87FHG | 52.53A | 44.23B | 286.471 | 1537.65EDF | 1.83GHF | 0.16FEHG |
| Dinkinesh | 104.77 | 41.33 | 85.33 | 43.67 | 33.07 | 4.60 | 152.10A | 24.33LKJ | 37.21BD | 459.83FE | 2432.98ECD | 2.10EGDF | 0.22FBECDG |
| Mean | 104.9 | 42.53 | 95.15 | 52.75 | 21.35 | 4.65 | 101.85 | 35.24 | 34.25 | 515.14 | 2779.49 | 2.21 | 2.0244 |
| CV(%) | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 | 2.0244 |
| LCD(%) | 9.221 | 2.559 | 1.908 | 1.719 | 4.921 | | 26.945 | 3.947 | 13.055 | | | 0.439 | 0.0908 |
| F-value | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |

Table6. Grain yield (kg ha¹) and other major agronomic traits of 20 released mon beavarieties under irrigated condition, 2015, Bako

Source: Model result** = significantat 5%significant level.

4.8 Morphological diversity

Results from the Principatomponents analysis (PCA) and ShankWeeaver diversity index (H) values for the5 phenotypictraits studied are presented in TableThe PCA wasused to show the traits which accounted for significant riation in the common bean germplasm. It reduced the data to a few dimensional explained 64% of total phenotypic variation in the germplasm. The first two principal components with Eigen value (latent roots) greater than was contributed most of the total variation in the germplasm.

PCA results illustratedhe overall pictureof the pattern of genetidiversity of the common germplasm based on morphology The germplasm clustereid to two major groups with most variation attributed to seed color flower color, seed size, and seed shape The above traits are highly recommended for use in common bean characterization, conservation and breeding the Eigenvalue formed the basis Hence, selection of genotypes with high PCA and loware suitable for both streased nonstress environments (Golabade it al., 2006 and Shahryaze ind Molasadeghi, 2011) According to Koinangeet al. (1996), planttype and seed size important for preand post common bean crop, s domestication and were ployed logically to help interpretation of trait distributions among the genotypes in the PODA.

Results from the Shannok/Veaver diversity index (H) values for tbetraits studied are presented in Table. The H valueranged from 0249, 0.337, with a mean of 03.4±0.35. The mean Shannon diversity index (ets)timate of indicates that different lasses of traits and genotypes have a balanceptresentation of the collection. Yadæt al. (2010) used Shannok/Weaver diversity (H) analysis index on 1256 sweet potato accession g 20 morphological descriptors and reported an H of 0.71±0.03 and infred high diversity among the sweet potato clones from UganDate traits observed as critical for bean characterization in this study likeseed size and flower colour, were also found to important in beans from Ethiopia and Ker(yes faw et al., 2009), which indicates similar diversity manifestation in the East African regioBlair et al. (2010) observed

considerable variations in landraces in Central Africa, in seed size accolor predominated by the red mottled typeds was very frequent in thisus dy.

There is a broad genetic diversity of begen mplasm in Ethiopia The traits in Table 7 are highly recommended for use in common becara racterization, conservation and breeding. Blair et al. (2010) reported farmer, s preference for mage draces, where diversified bean types are used various agronomic and cultural reasons addition, varieties preferred for home cooking with unique second burs are selected for sale in the local markets hence, maintaining bean diversity in the tropics

Table 7 PCA and Shannon Weaver diversity index (H) estimates for the traits used to classify the 20 common bean germplasing Ethiopia

| Variable | PC1 | PC2 | Н | |
|--------------|----------|--------|-----------|--|
| Seed size | 0.423 | 0.208 | 0.334 | |
| Seed color | 0.565 | -0.055 | 0.331 | |
| Flower color | -0.509 | -0.112 | 0.337 | |
| Pod color | -0.067 | 0.671 | 0.249 | |
| Seed shape | 0.168 | 0.595 | 0.305 | |
| Eigenvalue | 2.4114 | 1.4281 | | |
| Proportion | 0.402 | 0.238 | | |
| Cumulative | 0.402 | 0.640 | | |
| Mean diversi | ty index | (H) | 0.34±0.35 | |

5. Conclusion and Recommendation

5.1 Conclusion.

Performance of some (20) improved haricot bean varieties and 13 yield related traits were considered in this analysis Polygenic traits such appod per plant, biomass yieldend seed per pod hundred seed weight and harvest index showed positivelation with grain yield. This implied the possibility to combat the low yielding ability of mmon bean varieties by improving and selecting for the se important agronomic traits gronomic and phenotypic characters such as grain yield per plot, grain yield kg/ha, harvest index, biomass yield, seeds per pod, number of seeds per plant and grain yield per plant were the major contributors for the variation observed time first principal components Overall, the aggregation of those 20 released common bean varieties into five clusters sind at yield a morphological diversity between the tested on the 13 quantitative traits indicated a morphological diversity between the tested on the best chance of isolating transgressive segregants

The study shows the existence of a broad range of genetic variability tested collections for grain yield and yield related traits based selection. This variability also confirmed by the analysis of principal components that explained the overall diversity by 13 eigenvectors. This studyyield/plant, pod/plant, anglield per plot, grain yield/ha showed relatively high genetic coefficients of variability, heritability, and genetic advance. Therefore, these traits need to be given more emphasis in phenotypic selections. The first four eigenvectors accounted about **%6.6** f the total variability among the tested genotypes. The principal component analysis showed that the main contributing characters were evenly distributed among the evaluated characters. Hogwaineryield per plot, grain yield kg/ha, harvest indexorbaiss yield, seeds per pod, number of seeds per plant and grain yield per plant were the most useful in distinguishing the tested haricot bean genotypes.

The presence of wide diversity among the 20 released haricot bean genotypes was confirmed by cluster malysis that grouped elm into five classesbased on the measurement of 13 agroorphological characters. The clustering pattern indicated that varieties inclusters 3 to 5 were genotypalby more divergent from the other collections for they formed singlegenotypic clusters This method of clustering germplasm collections can also be used in the elimination of the duplicated and genetically redundant accessions along with other relevant information and documents of the germplasm

The results of the ANOVAanalysis pointed out the relative variation of yield performance and different yield related traits of the 20 improved haricot bean varieties. Thus, grain yield potential and most of yield related parameters were found to have significant variation(p< 0.05) among the varieties investigateThe analysis of variance among the 20 tested genotypes alsohowed highly significant (p< 0.05 difference in terms of their yield performance under irrigated conditiThmere was also a wide range of difference between the maximum and the minimum values of the phrometric charactersThis considerable variability could be ascribed partly to the differences in the evaluated genotypes and partly to the genotypes and partly

The study measured birty parameters and the results revealed that all genotypes were different in grain yield potential and morphophysiological traits. The differences indicated presence of genetic variation for these traitsey factor in plant breeding and selection for bean crop improvement the trial sites are characterized with high moisture and medium soil fertility condition, hence varieties which tolerate these stresses perform best. Successful genotypes must have dgo ield and other essential agronomic characters. Besides, their performance should be reliable over a wide range of environmental conditions.

The overall performance of the test varieties was good in that particular area except Awasa Dumeunder irrigated growing condition i.e., this variety generally performs poorly under irrigated growing condition. Some genotypes like Ramada, Nassir, 2950 and Seer 19 were the best performed genotypes der irrigated conditions the study

area. However, Ramada and Nasser were the out yielded varietiesgreatest yield of thesefour varieties could be due to their inherent genetic potential. It could be also due to better local adaptation to the Western Ethiopia environmethesrefore, it is adviable to promote haricot bean as an irrigable crop in the study areas to improve production level, increase source of cash for farmers and foreign currency for the country as export crop.

5.2 Recommendation

- Some genotypes like Ramada, Nassir, O950 and Seer119 can be recommended for production under irrigated conditions. That means, these varieties could be the best choice for localities with better moisture condition or for irrigated growing condition. However, caution should be taken in the use of these results as the study was conducted only in one location and for one season. In order to validate the findings, the study should be conducted for a number of years and in many locations
- 2. The majority of Ethiopian farmers, however, are unable to affore thigh mineral fertilizer cost. Nitrogen derived from biological fixation is 5070 % more efficient than applied N because only 3050 % of the latter is recovered by plants (Bliss, 1993). Biological Mixation, a key source of N for poor farmers, constitutes a potentia solution and may have a lion sharefor sustainable bean production in Ethiopia. Therefore, all stakeholders who work in Ethiopian agriculture should not under estimate the importance rigitation using legumes crops as an alternativel source, and its role as a break crop in Maizend other cropsbased farming systems to reduce decline in soil fertility

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7. Appendices

| Variety | Rep 1 | Rep 2 | Rep3 | Remark |
|-------------|-------|-------|------|--------|
| Gofta | 1 | 32 | 54 | |
| Awash melka | 2 | 26 | 50 | |
| Fadis | 3 | 29 | 60 | |
| Mexican142 | 4 | 24 | 51 | |
| KatB9 | 5 | 27 | 59 | |
| Seer 125 | 6 | 21 | 42 | |
| Deme | 7 | 38 | 57 | |
| Ramada | 8 | 40 | 55 | |
| KatB- 1 | 9 | 22 | 41 | |
| Waju | 10 | 39 | 56 | |
| Nassir | 11 | 25 | 43 | |
| Seer-119 | 12 | 23 | 44 | |
| Haramaya | 13 | 33 | 45 | |
| Dursitu | 14 | 30 | 48 | |
| Omo- 95 | 15 | 34 | 58 | |
| Awasa Dume | 16 | 31 | 46 | |
| Gebisa | 17 | 28 | 47 | |
| Ebado | 18 | 35 | 53 | |
| Loko | 19 | 37 | 49 | |
| Dinkinesh | 20 | 36 | 52 | |

Appendices 1 list of common bean studied under irrigated condition with their randomization on the 60 plots

Appendices Field photo