Chickpea (*Cicer arietinum* L.) Fabaceae Landrace Diversity in Ethiopia

Senait Berhanu Wordofa

Addis Ababa University

Addis Ababa, Ethiopia

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Senait Berhanu Wordofa

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GRADUATE PROGRAMES

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5.	Dr. Berhanu Amsalu (Co-Advisor)	_____	_____
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Abstract

Chickpea (*Cicer arietinum* L.) Fabaceae Landrace Diversity in Ethiopia

Senait Berhanu Wordofa, MSc. Thesis

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This study was conducted on chickpea growing in farmers' fields with the help of farmers' knowledge. The main focus of the field study was the main production areas of Ethiopia that include areas in 32 districts distributed in five regions (Amhara, Oromia, Tigray, Southern Nations Nationalities and Peoples (SNNP) and Addis Ababa) during 2014-2015 cropping season. The main objective of this study was to assess the diversity of chickpea landraces and to know the current status in Ethiopia in addition to ethnobotanical value of the crop. The field study was carried out between November 2014- Feburary 2015. The field data were collected by using purposive sampling and simple random observation technique by researcher from farmers' fields, threshing ground, home gardens, store and market places. Ethnobotanical data collections were semi-structured interview, field observation, guided field walk and market survey. Descriptive statistics informant consensus and simple preference ranking were employed to analysis data's. The findings are presented in the form of charts, tables, graphs and words. A total of 41chickpea landrace seed samples and 27 voucher specimens were collected, then dried and stored in National Herbarium (ETH) of Addis Ababa University. Chickpea phenotypic diversity was recorded on different flower and seed colors, anthocyanin content in the leaf and stem, average number of pods per plant, number of primary branches per plant and number of leaflets per leaf. The most frequently reported food recipes were SHIRO WET, KIK WET next to NIFRO and KOLO, besides agroecological and market value of the crop. The observed variation might have resulted from environmental factors including precipitation, temperature, soil characteristics, photoperiod and genetic variation as influenced by the diversity in socio-cultural factors of the areas studied. Therefore, germplasm conservation, education, resources and further research needed in order to maintain the landrace diversity of chickpea.

Key words: Chickpea landraces, Ethiopia, diversity, farmers' knowledge, cultural practices

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Acronyms

CSA:	Central Statistics Agency
EIB:	Ethiopian Institute of biodiversity
ESE:	Ethiopian Seed Enterprise
FAO:	Food and Agricultural Organization of the United Nations
GIS:	Geographical information system
IBC:	Institute of Biodiversity Conservation (former name now changed to EIB)
IBPGR:	International Board for Plant Genetic Resources
ICARDA:	International Center for Agricultural Research in Dry Areas
ICRISAT:	International Crops Research Institute for the Semi-Arid Tropic
MOA:	Ministry of Agriculture
NGO	Non-Governmental Organization
SNNPR:	Southern Nations Nationalities and Peoples Region
SSA:	Sub-Saharan Africa
WHO:	World Health Organization

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Ethiopia is endowed with diverse ecosystems, edaphic and climatic conditions. As the result, the country is inhibited by amazingly great diversity of plant, animal and microbial genetic resources (FAO, 2001). Diversity in crop plants is conditioned by geographic, climatic and edaphic factors, cultural and ethnic differences, farming practices, and religious and cultural beliefs (Hawkes, 1983). It is also reported that the genetic diversity found in the Ethiopian landraces are being used worldwide for developing new crop varieties and addressing different production constraints (Yeshitila Mekbib, 2007). Landrace diversity is an essential source of adaptive traits that can be incorporated into new crop varieties. Many plant breeding centers conduct regular inventories of landrace diversity within their region, and collect specimens in the hopes of locating advantageous traits for their breeding objectives.

In today's world, parallel to population growth, nutrition problem is also growing increasingly. Especially productions of high-range protein foods have been important for solving nutrition problem. Legumes play an important role in the agriculture and diet of many developing countries and are a major source of dietary nutrients for many people (Dejene Dida, 2010). Chickpea (*Cicer arietinum* L.) is the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.) (Gaur *et al*., 2010; Hajibarat *et al.*, 2014). It is cultivated mostly in the Mediterranean basin, the Near East, Central and South Asia, East Africa, South America, North America and, more recently, in Australia (Rubio *et al.,* 2004). It accounts for 12% of the world's pulse crop production. The Asian region contributes 70% to the total world's chickpea production. These chickpea types are grown throughout the world with different names, Chickpea (UK), Garbanzo (Latin America), Bengal gram (India), Hommes, Hamaz (Arab world), Shimbra/Shumbura (Ethiopia) and Nohud and Loblebi (Turkey) (Gul *et al.,* 2013).

Based on differences in seed types, the cultivated chickpeas are distinguished as desi and kabuli types. The desi types have small darker multicolored seeds with a rough seed coat while the

kabuli types have larger beige to white colored seeds with smoother seed coat. Existence of a pea-shaped third type characterized by medium to small seed size and creamy color has also been recognized which may be the result of intercrossing between desi and kabuli types that has resulted in a sort of intermediate group types (Gemechu Keneni *et al*., 2012). Globally, chickpea is adapted to black soils in the cool semi-arid areas of the tropics, sub-tropics as well as the temperate areas (Menale Kassie *et al*., 2009). Currently, about 75% of the area all over the world is covered by the desi type and the remaining 25% by the kabuli type. The main farmers of the desi type are India, Pakistan, and Ethiopia, while Mexico, Iran, Afghanistan, Spain, and Chile are main producer of the kabuli type (Gemechu Keneni *et al*., 2012). As noted in Menale Kassie *et al*. (2009), about 95% of chickpea cultivation and consumption is in the developing countries.

The national average yield of chickpea in Ethiopia under farmers' production condition remains less than 1.5 tons per hectare. On the other hand, the potential of the crop under improved management condition is more than 3 tons per hectare. (Legesse Dadi *et al*., 2005). It is one of the most important pulses grown widely over an area of 208,388.6 ha across the highlands and semi-arid regions of the country (CSA, 2011). According to Melese Dadi (2005), there are few studies on diversity analysis of Ethiopian chickpea landraces. Feven Workeye (2002) studied morphological and isoenzyme diversity of Ethiopian chickpea, Yadeta Anbessa and Geletu Bejiga (2002b), had also evaluated and screened 482 chickpea accessions collected from different regions for their tolerance to drought. Yadeta Anbessa and Geletu Bejiga (1994 a) had also evaluated chickpea genotypes for drought tolerance.

There are 1122 in chickpea accessions collected and conserved in Ethiopian Biodiversity Institute (EIB, 2014 unpublished database) but the distribution and diversity of chickpea in Ethiopia is not yet well known in publish documents. This study particularly focuses on the extent and status of farmers' varieties of chickpea currently cultivated in Ethiopia. Thus, the findings of this study will be very significant for identifying and documenting the local diversity of the crop with the help of farmers and the wild relatives of the crop found in the country. In addition, it will enhance farmers' access to a wide range of varieties of chickpea instead of using introduced varieties in research and allows the natural processes of evolution to take place by using and conserving locally available varieties. Furthermore, the study will

contribute to generate new knowledge on diversity of chickpea for those who want to conduct further research on this crop.

1.2. Statement of the Problem, Research Questions and Objectives

1.2.1. Statement of the problem

There are only limited studies done on diversity analysis of Ethiopian chickpea landraces. Farmers cultivate two types of the crop namely, desi and kabuli types as the researchers identified. However, there are no studies that describe and identify chickpea varieties considering farmers' nomenclature and identification as well as the diverse local uses and management systems. Thus, the main purpose of this study is to assess, identify, document and analyze the diversity of chickpea in Ethiopia focusing on farmers' criteria. The results will contribute to enhance farmers' access to a wide range of varieties of chickpea while the research programs also make effective use of the wide genetic material found with farmers instead of purely relying on introduced chickpea cultivars.

1.2.2. Research questions

- How many chickpea landraces are found in Ethiopia?
- How do farmers call these landraces?
- What are the uses of these farmers' varieties of chickpea?
- What are the problems associated with the production of chickpea landraces in Ethiopia?
- How do farmers mange and conserve chickpea landraces?

1.2.3. Objectives

1.2.3.1. General objective

The general objective of this study is to assess the diversity of chickpea landraces and know the current status in Ethiopia.

1.2.3.2. Specific objectives

- To identify chickpea landraces that are cultivated and used in different parts of Ethiopia
- To check the distribution of chickpea varieties across five regions (Oromia, Amhara, Tigray, SNNP and Addis Ababa Special region (Akaki) of the country
- To understand the diversity of chickpea
- To document ethnobotanical information of landrace by considering farmers' knowledge on cultivation, production, management and use of chickpea
- To study the problems associated with the production of chickpea in Ethiopia.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Landrace

Many definitions are given for the term landraces some of them are mentioned here. Landraces are defined here as being ‘‘variable plant populations adapted to local agroclimatic conditions which are named, selected and maintained by the traditional farmers to meet their social, economic, cultural and ecological needs’’ (Awgechew Teshome 2007).

Banga’s (1944) cited in Zeven, (1998): ‘a landrace is a population which naturally developed in a certain region under the influence of the regionally prevailing conditions of climate, soil and management, without or with only little mass selection.’ Harlan (1975) cited in Zeven, (1998): ‘Landraces have a certain genetic integrity. They are recognizable morphologically; farmers have names for them and different landraces are understood to differ in adaptation to soil type, time of seeding, date of maturity, height, nutritive value, use and other properties. Most important, they are genetically diverse. Such balanced populations – variable, in equilibrium with both environment and pathogens, and genetically dynamic – are our heritage from past generations of cultivators. Brown (1978) cited in Zeven, (1998): also described landraces as geographically or ecologically distinctive populations which are conspicuously diverse in their genetic composition both between populations [i.e. between landraces and within them]. They differ from their wild relatives because they have evolved under cultivation upon which most of them have come to rely for their survival. They differ from the cultivars developed by modern scientific plant breeding in that they have not been deliberately intensively selected to a predetermined reduced level of genetic heterogeneity.

2.2. Origin and Geographic Distribution

Chickpea is not known in a wild state, but in some regions is found as an escape (Westphal, 1974). Its origin is believed to be in south-eastern Turkey and adjoining Syria and Iran. The earliest remains of chickpea seeds date back to around 7000 BC (Syria and Turkey) (Van der Maesen, 1987). According to Ladizinsky (1975), it is believed to have been

domesticated in Turkey from *Cicer reticulatum* Ladizinsky, a closely related wild species. After its domestication in the Middle East, the crop spread throughout the Middle East, the Mediterranean region, India and Ethiopia. Chickpea cultivation is expanding where it has been recently introduced, e.g. in Australia, New Zealand, the United States and Canada. In tropical Africa, it is mainly cultivated in East Africa (Sudan, Eritrea, Ethiopia, Kenya, Tanzania) and in Malawi; where it is grown particularly in areas with a marked cool season (Geletu Bejiga & van der Maesen, 2006).

According to Van der Maesen (1972), as cited in Redden and Berger (2007), recognized the primary center of diversity is in the Fertile Crescent where the crop was originally domesticated, and with the geographic spread of chickpea secondary centers of diversity developed, some older than 2000 years in Mediterranean Europe, the Indian subcontinent and north-east Africa, and some more recently in Mexico and Chile with post-Colombus introduction. According to the same authors, the distribution of old landraces and wild relatives of chickpea occurs in three main regions from 8° to 52°N latitude and 8°W to 85°E longitude: (i) western Mediterranean, Ethiopia, Crete and Greece; (ii) Asia-minor, Iran and Caucasus; and (iii) Central Asia, Afghanistan and the Himalayan region. The geographic distribution differs for these two types, with the kabuli tending to be restricted to the western Mediterranean where the desi are mainly absent. The desi range more widely from the eastern Mediterranean to central Asia and the Indian subcontinent (Moreno and Cubero, 1978).

In Ethiopia, archaeological evidence from Lalibela caves dated seed samples as over 2500 years of age (Mitiku Demissie, 2011). The country is also a secondary diversity for chickpea (Yadeta and Geletu, 2002). It is widely grown in different agro-ecological zones falling between 1400 to 2300m above sea level where the mean annual rainfall ranges from 700 to 2000mm (Geletu Bejiga and Million Eshete, 1996). Although chickpea is widely grown in Ethiopia, the major producing areas are concentrated in the two regional states - Amhara and Oromia. These two regions cover more than 90% of the entire chickpea area and constitute about 92% of the total chickpea production. The top 9 chickpea producing zones (North Gonder, South Gonder, North Shewa, East Gojam, South Wello, North Wello, West Gojam, (Gonder Zuria) belong to the Amhara region and account for about 80% of the country's chickpea production. In the Oromia

region, the major producing zones are in West Shewa, East Shewa and North Shewa, which account for about 85% of the total area and production in this regional state. In line with this idea, Menale Kassie *et al.* (2009), noted that Tigray, Southern Nation Nationalities and peoples of Ethiopia and other regions contribute 7.1%, 1.3% and 0.7 % average cultivated chickpea area and chickpea production share of 6 %, 1%and 1%, respectively during 1999-2008.

2.3. Botany

2.3.1. Taxonomy

The genus *Cicer* L. (Leguminosae, *Cicereae*) comprises 9 annual and 35 perennial species that have a centre of diversity in south-western Asia, with remote, endemic species found in Morocco and the Canary Islands (van der Maesen, 1987). The genus is the member of the monogeneric tribe *Cicereae* Alef., subfamily *Papilionoideae*, family *Leguminosae*. It was historically included in the legume tribe *Vicieae* Alef (Van der Maesen *et al*., 2007). Of the 9 annual species, chickpea (*Cicer arietinum* L.) is the only cultivated species. The eight other annual species of chickpea are wild and include: *Cicer reticulatum*, *Cicer echinospermum*, *Cicer pinnatifidum*, *Cicer judaicum*, *Cicer bijugum, Cicer cuneatum, Cicer chorassanicum and Cicer yamashitae* (Singh *et al*., 2008).

As described in Westphal (1974) three varieties: var. *vulgare,* var. *rytidospermum* and var. *macrocarpum* are distinguished within *Cicer arietinum*. According to this author, the Ethiopian chickpeas belong to proles *abyssinicum* of subspecies *orientale.* They are small plants, with few branches, arching at the top; seed shape angular (ram's head), sometimes globular (pea-shape) or rounded (owl's head), mainly dark colored; flowers pinkish-red, rarely white; anthocyanin present and within the proles *abyssinicum,* found eight varieties: *Abyssinico-albescens, Abyssinicum roseum, Abyssinicum fulvum, Abyssinicum brunneum, Abyssinicum nigrum, Abyssinicum nigritum, Abyssinicum lutescens, Abyssinicum rubidum.* From a practical point of view this classification is difficult and therefore of limited use. Van der Maesen (1972), as cited in Redden and Berger (2007), proposed to regard the subspecies as races, the proles as subraces. In the Ethiopian Flora (Thulin, 1998), only one cultivated and one wild species, without infraspecific categories, have been described.

2.3.2. Biology and plant growth habit

It is a self-pollinated, diploid (2n = 16), annual grain legume crop (Bharadwaj *et al*., 2010), though 14 has been reported for some landraces, the species *Cicer songaricum* and for some accessions of *Cicer anatolicum* (van der Maesen, 1972), and cross-pollination is a rare event; only 0-1% is reported (Singh, 1987) with a small genome (Aggarwal *et al*., 2013) and winter- grown legume that stands between 20 cm and 1 m tall (Muehlbauer and Abebe Tullu, 1997). Pollination is completed in the flower bud stage, before bees visit open flowers in the field (van der Maesen, 1972). Usually only one seed per pod is set (Van der Maesen *et al*., 2007).

2.4. Climate and Growth Conditions

Chickpea is grown under wide agroclimatic conditions around the world. It is grown between 20◦N and 40◦N in the northern hemisphere and is also cultivated on a small scale between 10◦N and 20◦N in India and Ethiopia at relatively higher elevations (Berger *et al*., 2006). In the Southern hemisphere, where chickpea is relatively recent introduction, it is grown between 27°S and 38°S (Imtiaz *et al*., 2011). Growing regions of chickpea can be broadly divided into two, non-tropical dry areas and semiarid tropics (SAT) (Imtiaz *et al*., 2011). Chickpea is grown usually as a rain-fed cool-weather crop or as a dry climate crop in semi-arid regions, with relative humidity of 21 to 41% as optimum for seed setting (Muehlbauer and Tulu, 1998). The time available for chickpea crops to produce adequate vegetative structures and then grain yield is often limited by hot or cold temperatures, rainfall distribution, or competition for use of land by other crops in rotation (Roberts *et al.*, 1985; Smithson *et al*., 1985).

2.5. Major Limiting Factors for Chickpea Production

Chickpea production is exposed to different biotic and abiotic constrains which reduces seed yields. The major biotic stresses which lead to yield reduction and instability are those caused by fungal, bacterial and viral diseases, insect pests, parasitic nematodes (Ranalli and Cubero, 1997) and parasitic weeds of chickpea (Cubero *et al*., 1986). Some of the diseases caused by biotic stresses are described below.

Ascochyta blight, caused by *Ascochyta rabiei*, is a highly devastating foliar disease of chickpea. It occurs mainly in areas where cool, cloudy and humid weather prevails during the crop season (Singh *et al*., 2008). Fusarium wilt, caused by *Fusarium oxysporum*, is the most important root disease of chickpea, particularly in the semiarid tropics where the chickpea growing season is dry and warm. Viral diseases have been reported to cause sporadic but significant yield loss in some areas. Major symptoms include discoloring (yellow, orange or brown) of foliage, browning of phloem and stunting of growth. Many viruses have been identified that can cause stunt disease. Insects especially the gram caterpillar or gram pod borer (*Helicoverpa armigera* Hubner) can cause problems (Winch, 2006). According to the same author, the insect is highly polyphagous and sources with high levels of resistance are not available in chickpea germplasm. Furthermore, seed beetle or bruchid (Callosobruchus spp.) is the most important storage pest of chickpea. Cyst nematode (*Heterodera ciceri*) is another major biotic stress to chickpea (Singh *et al.,* 2008). As with most weeds in a particular crop, weeds affecting chickpea have a similar ecology and biology. Generally, cool-season broadleaf weeds are the most difficult to control in chickpea (Yenish, 2007).

The most common abiotic stresses affecting chickpea production are drought (particularly terminal drought), salinity heat, frost and cold. Resistance or tolerance to these stresses is more complex. Chickpea, an important food legume grown in the arid and semi-arid tropical regions, suffers substantial yields loss due to water deficit at the end of the growing season (Khamssi, 2011).

2.6. Mechanism of Drought Tolerance in Chickpea

A common reason for failure to obtain satisfactory stands of many legumes is the inability of the seedling plants to become established quickly under unfavorable environmental conditions including drought, and other abiotic stresses (Katerji *et al*., 2001). Drought is one of the main risks associated with global warming. Under severe drought, plants activate several molecular, biochemical and physiological pathways (Keskin, 2012).

Under water-limiting conditions, the morphology of crop root systems is a crucial determinant for the capacity for nutrient uptake and water extraction by crop plants (Fageria, 2004), influencing aboveground growth and biomass yield. A root that has developed during the early growth stages of the plant can effectively exploit the water in the soil, especially in semiarid areas in which plant

establishment is often limited by low water availability. Roots with a longer length or more tips increase the nutrient supply to the plant to a greater extent than those with shorter roots or fewer root hairs (Dong *et al*., 1995). Several key attributes of chickpea roots, such as their high water absorption efficiency per unit root length density, their ability to change the rooting pattern across soil depths to efficiently access the available soil moisture and their ability to produce a larger root surface area per unit root biomass, seem to make chickpea the best choice for dryland cropping systems compared with other legumes or cereals (Tilahun and Schubert, 2003).

2.7. Importance of Chickpea

2.7.1. Nutritional value of chickpea

Adequate nutrition via food is a necessity of human life. There is a well-known proverb that healthy agriculture produces healthy people and healthy people belong to healthy nations. Pulses are primary sources of nourishment and, when combined with cereals, provide a nutritionally balanced amino acid composition with a ratio nearing the ideal for humans. Chickpeas are an ancient crop usually grown for their seed which is nutritionally of a very high quality (Saxena, 1990). The main use of chickpea is for human consumption and the seed provides an excellent source of protein, especially for vegetarians or vegans. The seeds may be eaten as whole; split into halves after removing the seed coat processed into flour or the young shoots may be eaten as a vegetable (Muehlbauer and Tullu, 1997). Due to their good balance of amino acid, high protein bioavailability and relatively low levels of anti-nutritional factors, chickpea seed have been considered a suitable source of dietary proteins. Ranging among varieties, the seeds contain approximately 12.4-31.5 % crude protein, 3.8-10.2 % fat, 52.4-70.9 % total carbohydrate and 1.7-10.1 % crude fiber. True digestibility, biological value and net protein utilization of chickpea seed ranges from 85-89 %, 83-85 % and 92-97 % respectively (Williams and Singh, 1987). Nutritionally, kabuli chickpeas are very slightly higher in protein content and fat, however, desi chickpeas provide more than three times the dietary fiber (Petterson, 1997).

2.7.2. Medicinal value of chickpea

Legume seeds contain large number of compounds that are qualified as phytochemicals with significant potential benefits to human health (asanticarcinogenic, hypocholesterolemic or hypoglycemic agents) (Muzquiz and Wood, 2007). Chemical composition is subject to

fluctuations, depending on various factors, e.g. cultivar and maturity stage, environment (mostly weather conditions), and agrotechnics. As Paolini *et al.,* (2003), indicated that these variations can be either due to intrinsic factors (mainly genetics, which are partly responsible for differences between cultivars and varieties) or to extrinsic factors, such as storage, type of soil, agronomic practices, climatic factors and technological treatments. On the medicinal side, chickpea is known to be a nutraceutical (or health benefiting food) because of its high nutritional value and near absence of anti-nutritive components (Williams and Singh, 1987). Desi chickpea have a very low 'glycemic index' making them a healthy food source for people with diabetes (Walker and Walker, 1984). As described in Muzquiz and Wood (2007), chickpea does not contain any specific major antinutritional factors; the only negative factor ascribed to its consumption is more flatulence due to a higher concentration of raffinose family oligosaccharides (RFOs) than other dry edible legumes. Seeds are mainly used for the treatment of bronchitis, leprosy, skin diseases, blood disorders and biliousness (Muehlbauer and Tullu, 1997).

2.7.3. Nodulation and nitrogen fixation

Legume crops are economically important in cropping systems because of their ability to assimilate atmospheric nitrogen. Biological nitrogen fixation occurs inside the root nodules of legume species as a result of a symbiosis between the host plant and bacteria (Thavarajah *et al*., 2005). The fertility benefits are derived from the N-rich legume residues remaining after grain harvest and from the higher levels of nitrate that are often found in the root-zone of legume crops at the end of growth. The origin of this nitrate is contentious (Unkovich, 1997). Unkovich and Pate (2000) suggested that the nitrate most likely originates from mineralised rhizodeposits, legume roots, and nodules. Soil in which nodulated legumes are growing often contains more nitrate nitrogen (N) than soil in which unnodulated legumes or non-legumes are growing (Turpin *et al.,* 2002). N_2-fixing legumes use less soil nitrate than an adjacent non-N_2-fixing crop, resulting in nitrate conservation.

2.8. Seed System and Chickpea Production Practice in Ethiopia

In Ethiopia, the two seed systems (sectors) are operational. The informal seed systems (self-saved seed or farmer-to-farmer seed exchange) accounts for 90 % of the seed used by smallholder farmers. These are cost-effective systems and are fully adequate in many cases,

especially in hard-to-reach areas. This local production and distribution facilitates maintenance of crop bio-diversity by preserving in situ locally adapted varieties and by broadening the genetic base of production with multiple varieties adapted to specific micro-climates and production system. Despite its vital contribution this sector is not adequately linked into institutional sources for improved seed (Menale kassie *et al*., 2009). According to the same author the formal seed system was and still is used as a major source for disseminating new varieties (technology transfer channel) obtained from the Ethiopian Institute of Agricultural Research, International Agricultural Research Centers and a number of regional research centers and higher learning institutes in the form of basic (foundation) seed or breeding lines. The ESE produces, processes, distributes, and markets improved seed including chickpea based on the official demand projection of the regional bureaus of agriculture.

In Ethiopia, the desi type chickpea accounts for more than 90 percent of production and is grown across a wide range of ecologies. It covers over 160 000 ha with a total production of 160000 tones which accounts for 12 percent of the total grain legume production (IBC, 2007). Improved varieties of chickpea, which were released for production, were selected from the Ethiopian chickpea collections. Currently, there is considerable interest in the kabuli type for export. Six varieties have been released and are in various stages of multiplication by the Ethiopian Seed Enterprise (IBC, 2007).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of the Study Areas

The study was conducted between November 2014- Feburary 2015 in the four major chickpea growing regional states of Ethiopia (Oromia, Amhara, Tigray, SNNP and Addis Ababa Special region (Akaki); 12 zones and 32 districts (Figure 1). Geographically located in latitude 7^0 25' 54.2'' – 14^0 07' 36.2'' (N) and longitude 37^0 46' 54.1'' – 41^0 05' 57.7'' (E) (Appendix 5).

Regional States were selected based on; major production areas of chickpea by taking the work of Menale Kassie *et al*. (2009), and a Global Positioning System (GPS) based survey sheet and distribution map of chickpea constructed following FAO (1984).

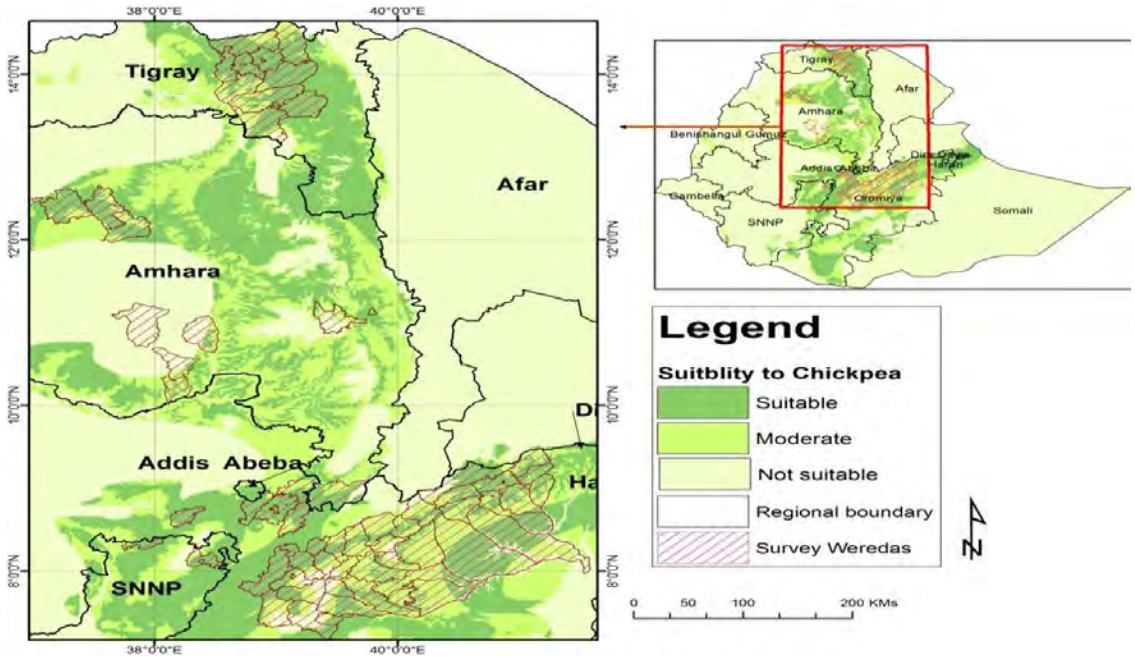


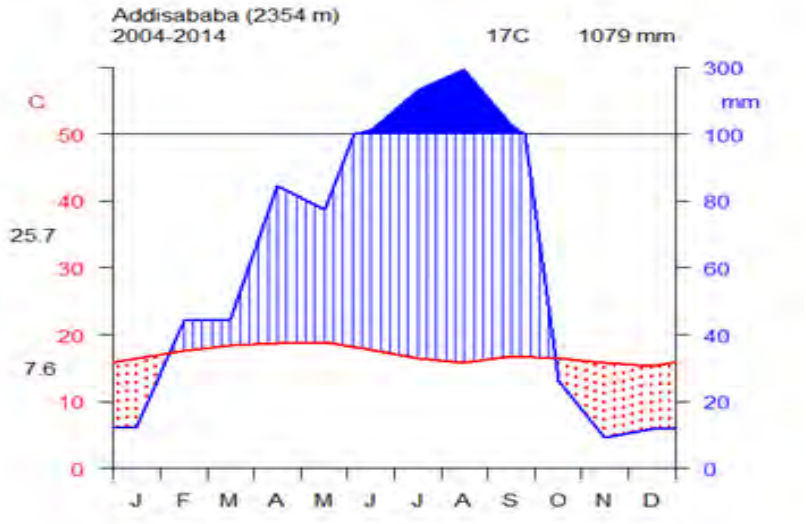
Figure 1: Distribution map of chickpea in Ethiopia

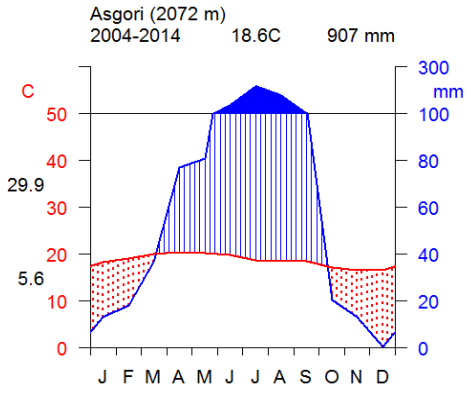
3.1.1. Soil characteristics of the study areas

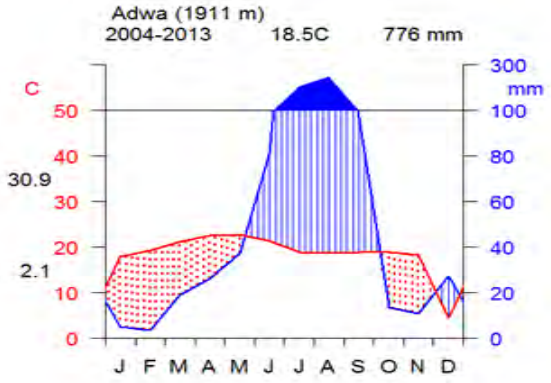
The major soil types of the surveyed areas were classified by FAO (1984) which belong to Vertisols, Leptosols, Cambisols, Luvisols and Andosols where, the agroecological zones fall in the tepid sub-moist mid highlands, cool humid mid highlands and warm sub-moist lowland.

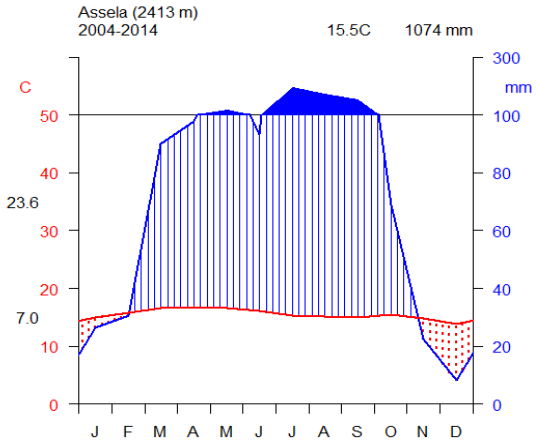
3.1.2. Climate

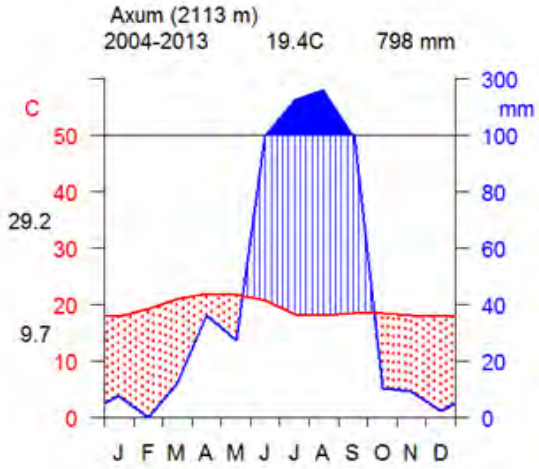
The multitude of agro-ecological zones (AEZs) is traditionally classified into five categories with traditional names assigned to each zone, based on altitude and temperature: *Bereha*, *Kola*, *Weinadega*, *Dega* and *Wurch*. However, the amount of rainfall and its distribution are also important in classifying common agro-ecological zones (MoA, 2000) going from hot day lowlands to cold, wet highlands. Sample of ten years monthly rainfall data and monthly minimum and monthly maximum temperature data were acquired from the National Meteorological Service Agency. Sampling the current climatic condition of the areas help to show how the climate is changed over years and its current impact on the production status of desi type chickpea. However, it is difficult to conclude only by using ten years data but helps as a starting point and as accurate evidence for the information that is collected from the interviewees (Figure 2).

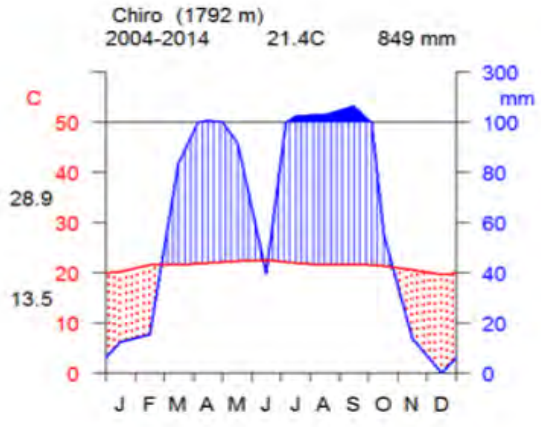


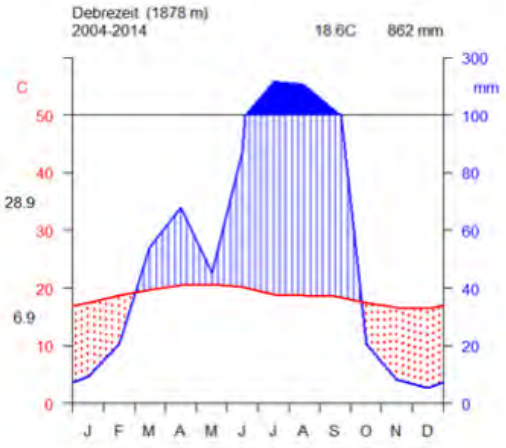

Asgori (2072 m)
2004-2014 18.6C 907 mm
C
mm
29.9
5.6
J F M A M J J A S O N D


Adwa (1911 m)
2004-2013 18.5C 776 mm
C
mm
30.9
2.1
J F M A M J J A S O N D


Assela (2413 m)
2004-2014 15.5C 1074 mm
C
mm
23.6
7.0
J F M A M J J A S O N D


Axum (2113 m)
2004-2013 19.4C 798 mm
C
mm
29.2
9.7
J F M A M J J A S O N D


Chiro (1792 m)
2004-2014 21.4C 849 mm
C
mm
28.9
13.5
J F M A M J J A S O N D


Debrezeit (1878 m)
2004-2014 18.6C 862 mm
C
mm
28.9
6.9
J F M A M J J A S O N D

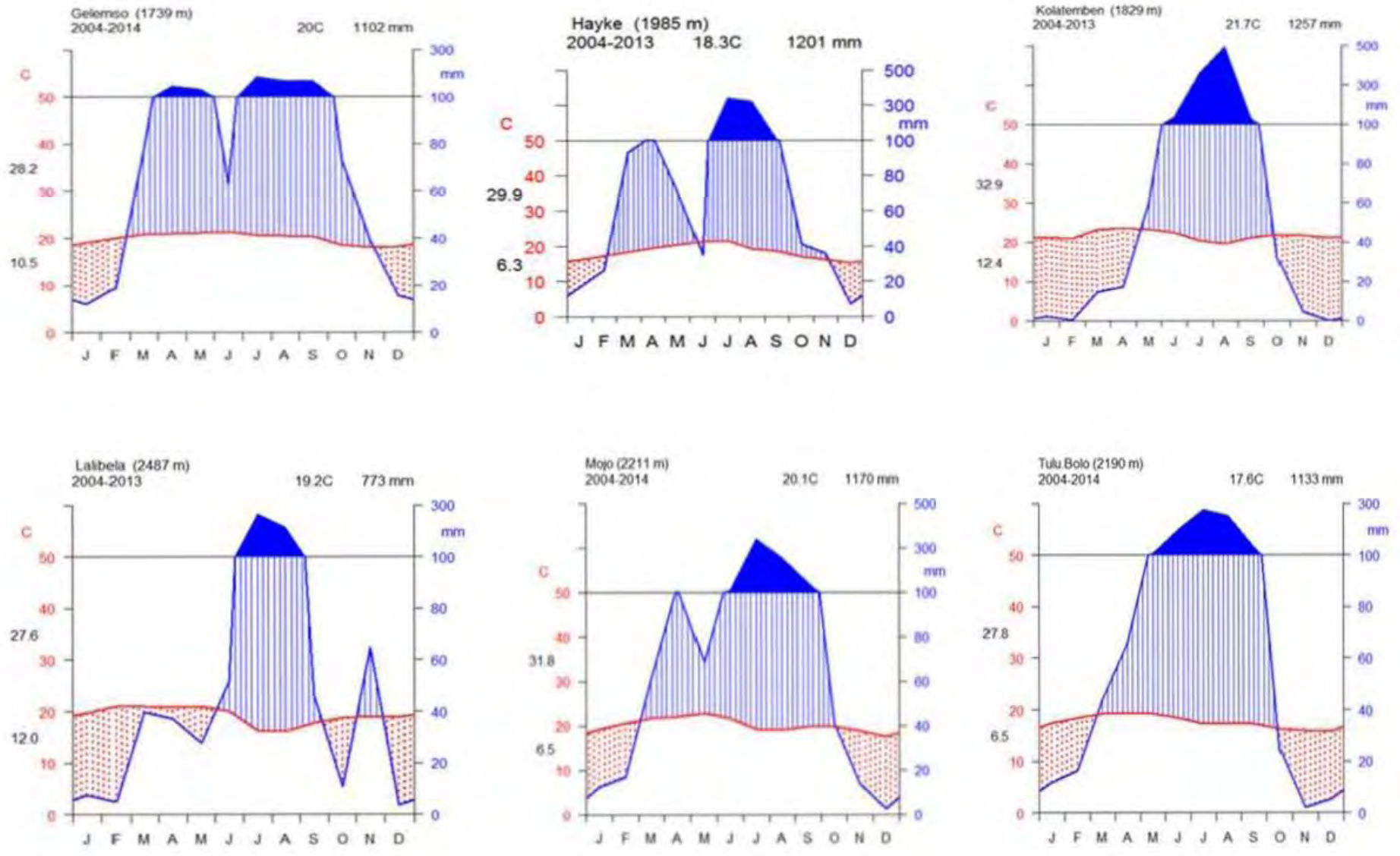


Figure 2: Climatic diagram of studied areas

3.2. Methods of Data Collection

The required data were collected by using purposive sampling and simple random observation technique by researcher.

3.2.1. Field data collection

In order to characterize landrace diversity within a region, sampling strategies are needed that help to maximize the amount of diversity encountered. For example, sampling along known gradients (elevation, rainfall, soil type/fertility) is appropriate for identifying landraces adapted to different environmental conditions. Strategic agroecogeographic sampling for landrace diversity using Global positioning system (GPS) based survey sheet was prepared to address the study objectives. Primary source of data were obtained from the farmers' fields (on-farm data collection), threshing ground, home gardens, store and market places.

3.2.2. Plant material and plant observations

Forty one chickpea landrace accessions from different geographical locations of Ethiopia were collected for the study of chickpea landrace diversity. Some of the accessions were kindly provided by the farmers and others bought from nearby markets. Origin/collection site of the landrace chickpea accessions used in the present study are shown in (Appendix 5).

3.2.3. Agronomic data collection

Agronomic data were collected from randomly selected five plants mostly based on the descriptor developed by IBPGR (1985), records taken both on quantitative and qualitative agronomic traits (Appendix 2). Quantitative agronomic traits include: days to 50% flowering, days to maturity, plant height, canopy height, number of primary branches, pod number per plant and seed number per pod were determined. The above agro-morphological traits were undertaken when seeds begin to change color inside the uppermost pods or when the pods are straw yellow. Qualitative agronomic traits include: stem/foliage pigmentation, seed color, seed testa texture and flower color of chickpea. The number of fields visited per district was small because some chickpea fields were far apart, resulting in a smaller number of sites visited in such districts. A total of 27 plant specimens were collected in the field with the help of local people and subsequently pressed, dried, checked and stored at the National Herbarium (ETH), Biology Department of the Addis Ababa University Ethiopia.

3.2.4. Ethnobotanical data collection

The methods used for ethnobotanical data collection were semi-structured interview (Appendix 1), field observation, guided field walk and market survey following (Martin, 1995) and Cotton (1996) procedures.

3.2.4.1. Semi-structured interview

Prepared checklist of semi-structured questions were employed for discussion and interviewing informants to record and collect information as given in Appendix 1.The methods and techniques for these were those recommended by Alexiades (1996). Questions used in the interviews are shown in Appendix 1. Prior to the interview, with the assistance of local farmer's association representatives, all informants were briefed about the objective of the study, which is chickpea landrace diversity in Ethiopia. They were also informed that this study directly or indirectly enhance farmers' access to a wide range of varieties of chickpea in research and allows the natural processes of evolution to take place by using and conserving locally available farmers' varieties. Most semistructured interviews were conducted with a single person at a time so as to make individuals speak freely and express personal view point and discuss disagreements in the community as recommended by Martin (1995).

The reason why an interview was decided to be done is because it is the easiest and simplest way to communicate. Sometimes it is difficult to find all the materials that are needed in the form of hard copy; it is easier to communicate through speech than in writing. Most of the interviews with the targeted group of the community were carried out in Amharic official language of Ethiopia and some of them in their local language and local farmers expressed their on how. The impression of informants was observed and recorded during the interview.

3.2.4.2. Informants selection

A total of 73 informants were interviewed. The number of informants to be interviewed was decided based on production status of the regions. Half of the informants were from Oromia (32), and Amhara (22), Tigray (12) and SNNP (7). Of these, 50 were male and 23 were females (aged 19 - 75), who were selected using simple random sampling techniques with the help of local agricultural extension experts. The informants were with different cultural background,

language, economic status, gender and age. The reason for having the number of female informants lowered is due to cultural influence, shyness and the dominance of male household heads. Most of the questions are open ended to make it easy and save time.

3.2.4.3. Field observation and guided field walk

Field observation was supported by local guide, language translators and participating informants to obtain the necessary data in the study area. Mainly as the observation continues, all the necessary information was recorded on how chickpea is cultivated, intercropped, managed, used and marketed.

3.2.4.4. Market survey

A market survey was made to record the chickpea landrace varieties that are sold in the market with information on market values of chickpea landrace as described by sellers and buyers. This approach is especially a good method to consider the conservation of landrace varieties of chickpea that are of high economic value. Therefore, local markets in the study areas were visited and semi-structured interviews were conducted with sellers and buyers at the market to record and determine the value or income generated from such practices and seeds were bought from nearby markets in addition to accessions that were kindly provided by the farmers.

3.2.4.5. Laboratory data collection

The germination test was conducted in Ethiopian Biodiversity Institute germination laboratory. Seeds were incubated in 5 cm petri dishes on one layer of filter paper and kept moist with distilled water throughout the experiment. Germination was assessed by placing four replicates of 10 seeds each in petridish at room temperature by determining the germination percentage which is recorded for six days consequently. The data was collected using simple observation and counting techniques by the researcher.

3.3. Data Analysis

Both qualitative and quantitative analytical tools were used for data analysis as recommended by Alexiades (1996) and Cotton (1996). Accordingly, descriptive statistics and informant consensus techniques were used to analyses ethnobotanical data. Quantitative data were analyzed by entering in to the excel spread sheet and summarized using descriptive statistics to identify the most common popularly used chickpea landrace varieties and other attributes of chickpea in the

study area. To determine proportions of different landrace varieties, growth forms, source of collection, plant parts used method of preparation and others; ethnobotanical percentage, informant consensus and simple preference ranking methods were employed in order to test the consistency of respondents' information and to obtain scientifically more tangible results. MS Excel 2010 was used to quantify, sort data and determine proportions using R environmental and ecological data analysis software. Then, the results were presented with graphs, charts and tables as well as in texts.

3.3.1. Informant consensus

During the survey, informants were asked to determine landrace varieties, growth forms, and source of collection, plant parts used, method of preparation and others. The informant consensus is helpful to see how frequently particular information is mentioned. It can also be used to confirm the authenticity of information by comparing it with other information given by other informants.

3.3.2. Preference ranking

In this analysis method, key informants were involved to give information on use value of landrace chickpea. Thus, five use values were short listed and ranked by the key informants based on their personal preference or perception following the procedure explained by Martin (1995) and Cotton (1996).

CHAPTER FOUR

4. RESULTS

4.1. Chickpea Landrace Diversity in Ethiopia

In this study, a total of 41 chickpea accessions were collected from five regions of Ethiopia (Amhara, Oromia, Tigray, SNNP and Addis Ababa special Region) (Figure 2). Accession was collected with local name of SHUMBURA and SHIMBRA from Addis Ababa Special region(Akaki), 16 accessions were collected from Oromia Region (18 weredas); they identified it as farmers' variety with the name of SHUMBURA (SHUMBURA DIMA, SHUMBURA GURACHA) while, they identified the improved chickpea (kabuli) with the name SHUMBURA ADDI/DUBAE. In Amhara Region 5 weredas were surveyed and a total of 10 chickpea accessions were collected. The local name of the landraces in this region were SHIMBRA (KEYE SHIMBRA), TIKUR SHIMBRA and NECH SHIMBRA for the improved type. A total of eight accessions were collected from Tigray Region (6 weredas). The accessions were locally named as KEY ATER or ATER and 5 accessions were collected from SNNP Region (2 weredas), the accessions are locally named SHIMBERE. The collected specimens belong to the desi type chickpea which had about four farmer landraces and one kabuli type called DUBAE. The agromorphological characteristics of the collected specimens, which are the representatives of the collected accessions, showed a considerable difference. This variation on growth and development is might be due to environmental differences in photoperiod, temperature, and precipitation and wide variation in longitude and the time of sowing also varies from one region to another.

4.1.1. Agro-morphological characters

4.1.1.1. Qualitative character

Qualitative characters of 41 chickpea landrace accessions are presented in Table 1. Similar traits for all specimens were not used to differentiate landraces like; growth habit, seed shape and others. Plant pigmentation was no anthocyanin, stems and leaves green for 9 accessions where low anthocyanin, stems and leaves partly light purple were observed for 14 accessions, high anthocyanin, stems and leaves predominantly purple for 4 accessions.

Seed color was light orange for 11 accessions, brown for 7 accessions and orange for 9 accessions. Black with light orange for 6 accessions, black with reddish brown for 4 accession black with orange for 4 accessions (Figure 3). Flower color was pink for 5 specimens and light pink for 22 accessions.

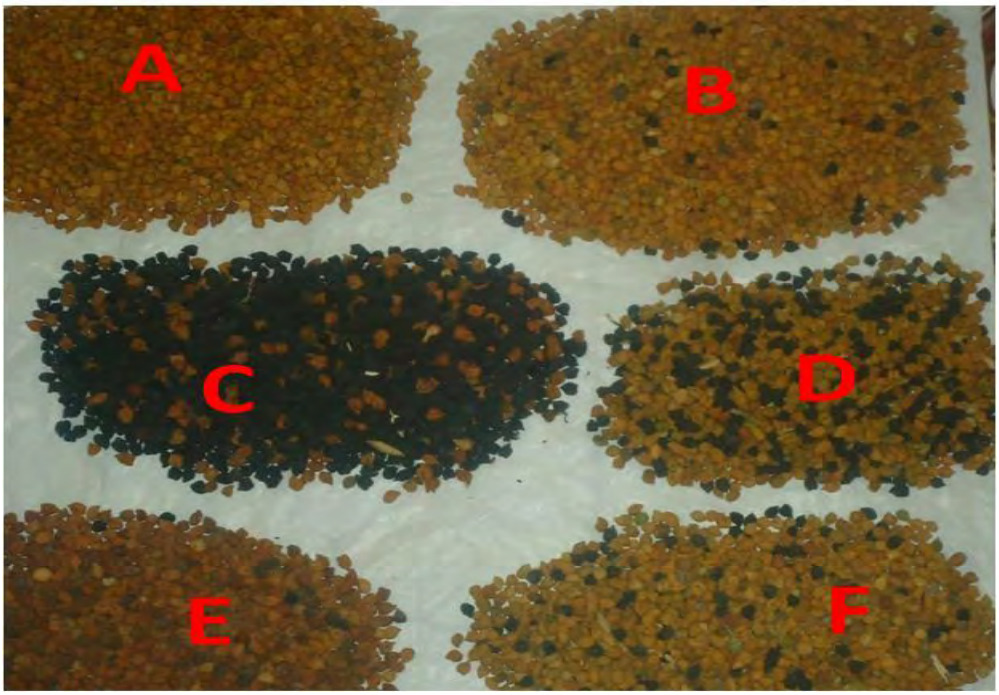


Figure 3: Seed color of chickpea landraces (where **A** and **C**: dominated in Amhara, **B** and **E**: Oromia region, **D**: Tigray and **F**: SNNP Region)

4.1.1.2. Quantitative characters

Data were recorded for days to flowering, plant canopy height (cm), number of pods per plant, number of seeds per pod, days to maturity in addition to common characteristics observed and recorded. Leaflet number 5-10 for 5 specimens, 11-15 for 9 specimens and 16-21 for 13specimens. Days to 50 % flowering 60-74 for 10 specimens, 75-90 for 10 specimens and 90-100 for 7 specimens. Number of pod per pant 21-50 for 7 specimens, 51-80 for 9 specimens and 81-120 for 11 specimens. Number of primary branches 1-2 for 11 specimens and 3-4 for 16 specimens. Plant canopy height recorded 14.5 cm to 63.7cm (Table 1).

Table 1: Quantitative Agro-morphological data

Character	**Number of leaflets per leaf**		
Number of leaflets per leaf range	5-10	11-15	16-21
District	Lume-ejere, Enqelo wabi, Adea, Shirka, Enbse sar midr	Tyo, Akaki, Betcho, Lalibela, Gemechis, Hitosa, Hirna, Liben chquala, Tahitay michew	Dese zurya, GiQuantitambichu, Tefki, Zeway dugda, Habro, Laelay michew, Degua-temben, Minjar shenkora, Eilu, Sodo, Kola-temben, Chiro, Kebena
Character	**Days to 50% flowering**		
Days to 50% flowering range	60-74	75-90	90-100
District	Akaki, Adea, Gimbichu, Betcho, Lalibela, Hitosa Hirna, Tahitay michew, Laelay michew, Tyo	Minjar shenkora, Enbse sar midr, Sodo, Zeway dugda, Dese zurya, Lume-ejere, Tefki Eilu, Gemechis	Habro, Degua-temben, Liben chquala, Kebena, Kola-temben, Shirka, Chiro, Enqelo wabi
Character	**Average number of pods per plant**		
Average number of pods per plant range	21-50	51-80	81-120
District	Liben chquala,, Zeway dugda, Laelay michew, Gemechis, Akaki, Tahitay michew, Hitosa	Tyo, Minjar shenkora, Adea, Betcho, Enqelo wabi, Habro, Tefki, Kola temben, Sodo	Chiro, Kebena, Shirka Hirna, Lume-ejere, Enbse sar midr, Degua-temben, Dese zurya, Gimbichu, Lalibela Eilu
Character	**Number of primary branches**		
Number of primary branches range	1-2		3-4
District	Gemechis, Akaki, Enqelo wabi, Hitosa, Tyo, Zeway dugda, Lume-ejere, Liben chquala, Tefki, Kola-temben, Tahitay michew		Minjar shenkora, Enbse sar midr, Lalibela, Dese zurya, Shirka, Gimbichu, Eilu, Chiro, Habro, Hirna, Sodo, Adea, Betcho, Kebena, Laelay michew, Degua-temben

Table 2: Local nomenclature of chickpea landrace and type of cultivated material

Region	District	Local name of chickpea landrace	Language	Status	Type of cultivated material
Addis Ababa	Akaki	KEYE and TIKUR SHIMBRA	AMHARIC	Landrace	Landrace and introduced
	Dese Zurya	KEYE and TIKUR SHIMBRA	AMHARIC	Landrace	Landrace
	Enebise-sarmidir	KEYE and TIKUR SHIMBRA	AMHARIC	Landrace	Landrace
	Lalibela	KEYE and TIKUR SHIMBRA	AMHARIC	Landrace	Landrace
	Minjar Shenkora	KEYE and TIKUR SHIMBRA	AMHARIC	Landrace	Introduced
	Shewarobit	KEYE SHIMBRA	AMHARIC	Landrace	Neither landrace nor introduced
Oromia	Assela	SHUMBURA DIMMA and GURACHA	AFAN OROMO	Landrace	Landrace and introduced
	Enqelo-wabi	SHUMBURA DIMMA and GURACHA	AFAN OROMO	Landrace	Landrace
	Hitosa	SHUMBUR DIMMA and GURACHA	AFAN OROMO	Landrace	Landrace and introduced
	Shirka	SHUMBURA DIMMA and GURACHA, SHIMBRA	AFAN OROMO	Landrace	Landrace and introduced
	Tyo	SHUMBURA DIMMA and GURACHA	AFAN OROMO	Landrace	Landrace and introduced
	Zeway Dugda	SHUMBUR DIMMA and GURACHA	AFAN OROMO	Landrace	Landrace
	Adea	SHUMBURA DIMMA and GURACHA	AFAN OROMO	Landrace	Landrace and introduced
	Gimbichu	SHUMBURA DIMMA and GURACHA	AFAN OROMO	Landrace	Landrace and introduced
	Liben-chquala	SHUMBURA DIMMA and GURACHA	AFAN OROMO	Landrace	Landrace
	Lume-ejere	SHUMBURA DIMMA and GURACHA	Afan Oromo	Landrace	Landrace and introduced
	Betcho	SHUMBURA DIMMA and GURACHA	Afan Oromo	Landrace	Landrace and introduced
	Eilu	SHUMBURA DIMMA and GURACHA	Afan Oromo	Landrace	Landrace and introduced
	Tefki	SHUMBURA DIMMA and GURACHA	Afan Oromo	Landrace	Landrace and introduced
	Chiro	SHUMBURA DIMMA and GURACHA	Afan Oromo	Landrace	Landrace and introduced
	Gemechis	SHIMBRA DIMMA and GURACHA	AMHARIC	Landrace	Landrace and introduced
	Habro	SHIMBRA, SHUMBURA DIMMA and GURACHA	AMHARIC Afan Oromo	Landrace	Landrace
	Meiso	SHUMBURA DIMMA and GURACHA	Afan Oromo	Landrace	Landrace and introduced
	Hirna	SHUMBURA DIMMA and GURACHA	Afan Oromo	Landrace	Landrace and introduced
SNNPR	Kebena	SHIMBERE	GURAGEGNA	Landrace	Landrace and introduced
	Sodo	SHIMBERE	GURAGEGNA	Landrace	Landrace
Tigray	Adwa	KEYE ATER	TIGRGNA	Landrace	Landrace
	Axum	KEYE ATER	TIGRGNA	Landrace	Landrace
	Degua- Temben	KEYE ATER	TIGRGNA	Landrace	Landrace
	Kola- Temben	KEYE ATER	TIGRGNA	Landrace	Landrace
	Lailay-Mayichewu	KEYE ATER	TIGRGNA	Landrace	Landrace and introduced
	Tahitay-Maychew	KEYE ATER	TIGRGNA	Landrace	Landrace and introduced

4.2. Chickpea Landrace Distribution in Ethiopia

Chickpea landrace is grown under wide agroclimatic conditions in the surveyed areas. It is grown between latitude 7^0 25' 54.2'' – 14^0 07' 36.2'' (N) and longitude 37^0 46' 54.1'' – 41^0 05' 57.7'' (E) with 1278 -2599 m.a.s.l altitudinal range. The landraces are distributed in areas, where annual temperature ranges from 15.5^0c -21.7^0c and rainfall 773-1979mm. Chickpea specimen and accession collection zones and weredas of study site is presented in (Figure 4).

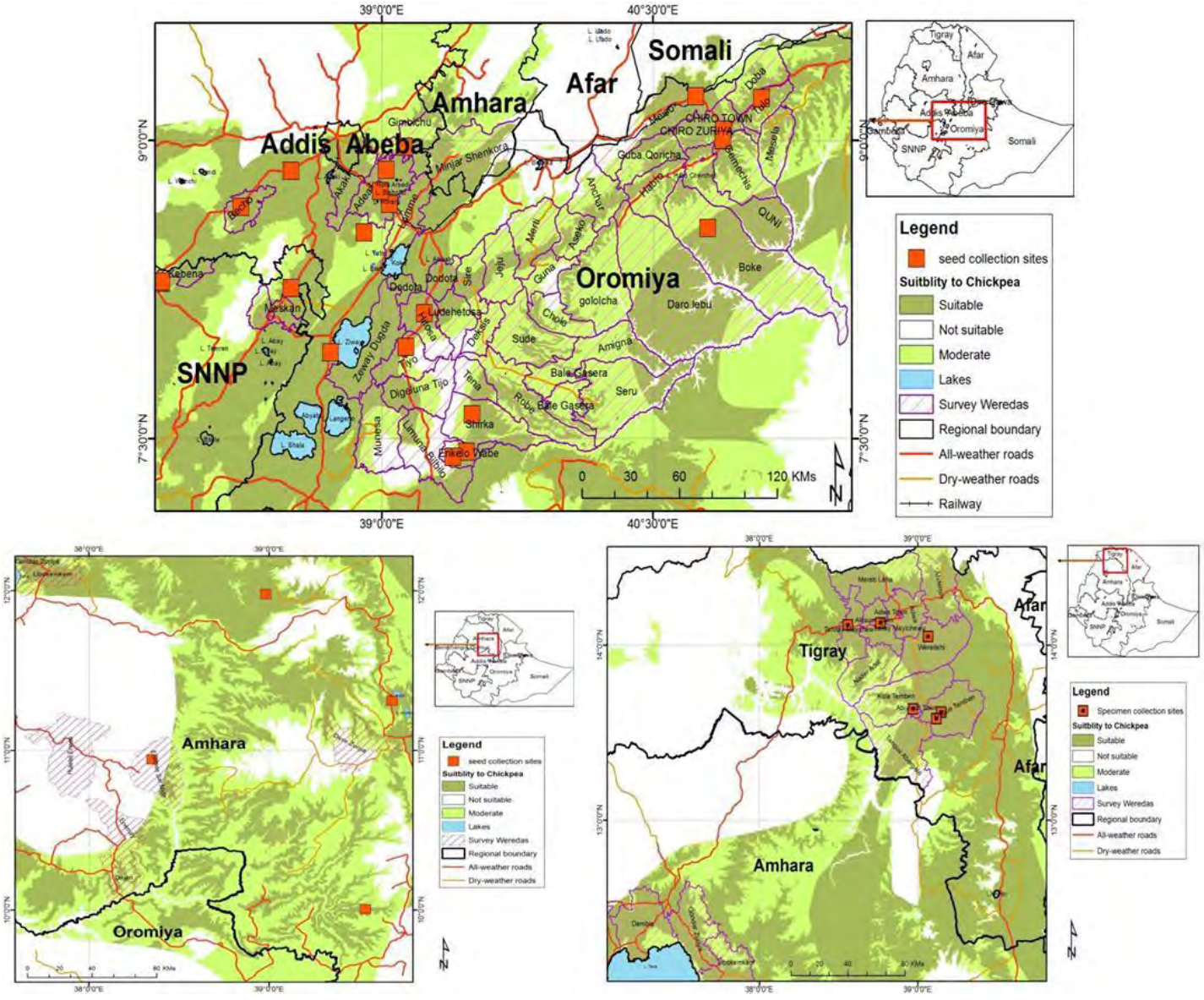


Figure 4: Map of Ethiopia showing collection areas of specimens and accessions of chickpea landraces

Table 3: Collected landraces and localities

Region	Place of collection	Altitude range (m.a.s.l.)	Number of sample collected
Amhara and Oromia	Shewarobit and Zeway dugda	1278-1676	2
Oromia	Liben-chquala, Lume-ejere, Habro, Meiso and Hirna	1729-1788	5
Amhara and Tigray	Minjar-shenkora and kola-temben	1803-1838	2
Amhara, Oromia, SNNPR and Tigray	Dese-zurya, Adea, Chiro, Gemechis, Kebena, Sodo and Adwa	1902-1965	8
Oromia and Tigray	Eilu, Tefki and Laelay-michew	2065-2087	5
Addis Ababa, Oromia and Tigray	Tahitay-michew, Axum, Betcho, Hitosa and Akaki,	2112 - 2493	3
Amhara and Oromia	Enbsesar-midr, Lalibela, Enqelo-wabi and Tyo	2217 - 2273	11
Oromia	Shirka and Gimbichu	2308-2362	2
Oromia and Tigray	Degua-temben and Assela	2413-2599	3
	Total number of collection		**41**

4.3. Importance of Chickpea in Ethiopia

4.3.1. Use values of chickpea

Traditionally, the local people have their own way of categorizing important value according to the value they provide. Informants were asked to express their impression on how chickpea production is efficient in improving their livelihood; food, fodder, medicinal uses, in addition to socio-economic and agroecological value of the landrace (Table 2).

A majority of farmers (59%), used seed in the form of mature dry seeds after parching as a popular soaked and roasted (KOLO or snacks) and boiled seeds (NIFRO) (Amharic language). 31% of respondents used seeds at the raw green and tender stage (unripe stage), called ESHTE, and livestock feed. As female respondents reported, chickpea seed is used as sauce (SHIRO WET, KIK WET and SHIMBRA ASA) (Amharic language) and bread (KITA) (Amharic language) preparation from the flour of the seed in some part of Amhara Region. The most frequently reported recipes were SHIRO WET, KIK WET next to NIFRO and KOLO (Table 4). Crop residue was used as a fodder for animals like chickens and donkeys. Only 5.5% of respondents mentioned the seed had medicinal values. In spite of a good medicinal property, reasonable number respondents (22%) explained that

consuming the raw green cause thirst and burning sensation because of sour substance on the whole parts of plant.

Table 4: Chickpea use values

Sources of collection/Region	Major recipes prepared (Amharic Language)	Common English name
Addis Ababa	SHIRO WET, KIK WET AND SHIMBRA ASA , NIFRO, KOLO	Stew, boiled grain and roasted grain
Amhara	SHIRO WET, KIK WET AND SHIMBRA ASA , NIFRO, KOLO, KITA	Stew, boiled grain, roasted grain and local bread
Oromia	SHIRO WET, KIK WET AND NIFRO, KOLO	Stew, boiled grain and roasted grain
SNNP	SHIRO WET, KIK WET AND NIFRO, KOLO	Stew, boiled grain and roasted grain
Tigray	SHIRO WET, KIK WET AND SHIMBRA ASA , NIFRO, KOLO	Stew, boiled grain and roasted grain

4.3.2. Agroecological value of chickpea

Chickpea, like other annual legumes in a rotation, offers several cropping advantages for the farmers. Among the respondents 42.5% of them answered rotation will sometimes increase cereal crop yields when planted after legumes like chickpea.

The major crop rotations practiced by the farmers are:

- Teff –chickpea– teff
- Wheat- chickpea-wheat
- Barley -chickpea -barley
- Maize- chickpea-maize
- Sorgum-chickpea-sorghum

Most farmers (78.1%) think that starting the rotation with teff or other cereals and then planting chickpea or vetch improves crop productivity more than rotations based solely on cereals (Figure 5). They think the swelling on the root might have an advantage to increase the fertility of their soil and the crop secretes vinegary substance that plays an important role in protecting the plant against insect-pests. However, 5.5% of them noted that chickpea has a moderately deep rooting

system which is effective at extracting subsoil moisture, and because little stubble remains after harvest to trap snow and minimize evaporation, available crop water can be extremely limited following chickpea. They believe that, it often leaves the soil drier at harvest compared to other crops due to its late maturity and utilization of late-season rainfall and depletes the soil profile of moisture for subsequent crops. They concluded that, this is why cereal yields tend to be lower following a chickpea crop, compared to other legumes.

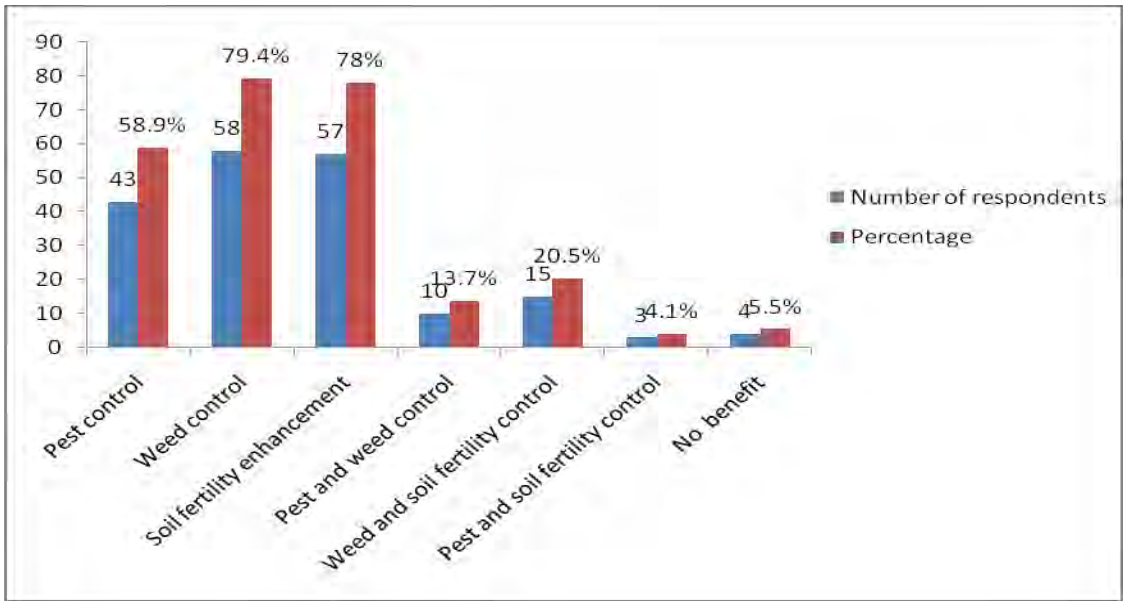


Figure 5: Advantage of crop rotation of chickpea with other crops

4.3.3. Preferences of Farmers'

The preference ranking of importance of chickpea by key informants showed that it is more preferred as fodder next to as a food. But different ranking was observed among studied regions (Table 5). All the farmers and local community uses chickpea for food but the degree of preference is more for the improved chickpea.

Table 5: Preference ranking for use value of chickpea

Data collection area (region)	Use value ranks based on (number of key informants who cited the use)				
	Food	Fodder	Enhance soil fertility	Income generation	Medicinal value
Amhara	5	4	4	4	3
Oromia	5	5	3	4	2

SNNP	5	4	5	5	0
Tigray	5	3	1	1	0
Total score	20	16	13	14	5
Rank	1st	2nd	4th	3rd	5th

4.4. Production constraints of chickpea

Small living organism buried either in the soil or live on the air can limit the production of the crop as local farmers' described and mentioned; foliar disease: (discoloring (yellow, orange or brown) of foliage and leaves become yellow followed by defoliation, root disease (SERE ABESBSE in Amhara region), (HUNDESA KAGNATU in Oromia region), pod diseases (by insects, worms and bird perches) and storage pests locally called NEKEZE. Defoliation and yellowing of leaf was the major problems of landrace production in all the studied areas next to worm attack and weeds. The informants identified the type of weeds as grassy and broad leaf weeds. The common weeds were annual (*Argemone mexicana, Chenopodium album*) and perennials were *Cyperus rotundus, Cynodon dactylon.* Perennial species of weeds that have been observed during field observation include those of the Polygonaceae, Convolvulaceae, Asteraceae, Poaceae and other families.

Farmers' explained that most common stresses affecting chickpea production are those factors that are directly or indirectly caused by continuous change of the surrounding environment which are frost and drought (particularly terminal drought). In addition, there are other abiotic stresses specific to some regions such as water logging and nutrient deficiencies of land in some part of Oromia region. Chickpea landrace is identified by its drought resistance ability because of deep root system and chemicals on the leaves and pods and a saying was listened in Amhara region Dese Zurya, SETNA SHIMBRA TSHAY YWDALU. 43(58.9%) of informants indicated that frost is one of environmental factor for production while, 20 (27.4%) of them mentioned that both extremes of temperatures lead to flower drop and reduced pod set. However, 13.1% of respondents mentioned that landrace chickpea is drought resistance as compared to the introduced chickpea; sometimes it grows with moisture it absorbs during the first week of sowing and continues its vegetative and reproductive stages without requiring additional moisture. The other limitations identified by farmers were shortage of land and poor management practices for chickpea farms. Currently, because of urbanization programs farmlands are needed for construction of buildings, this causes shortage of land for farming. In addition to this farmers are more interested to cultivate other staple and cash crops like teff,

wheat, barley, sorghum and chat, thus more of their land is covered by this crops and a little concern is given to chickpea because of its supplementary use in consumption.

4.5. Chickpea Seed Source, Cultivation and Management Practices

4.5.1. Chickpea landrace seed source

Farmers' who produce the landrace type chickpea are dependent on informal seed source. In surveyed areas, 70 percent of the farmers rely on farm-saved seed, while the rest through exchange of seed with other crop seeds and from local market. The informal seed system is characterized by lack of functional specialization and quality control. In order to minimize losses due to low quality of seeds both male and female farmers apply traditional and modern methods during harvest, processing and storage.

4.5.2. Chickpea landrace cultivation

In the areas where this study was conducted, farmers' explained chickpea is mainly (82%) grown on deep black soils, whereas 15% and 2.7% is grown on red and sandy soil respectively. Deep black soils are known for excess water and drainage problem during the main rainy period (June - August). Thus, to overcome this problem farmers plant chickpea late in the season (September - October) commonly on residual moisture after harvesting preceded crops (Figure 6).

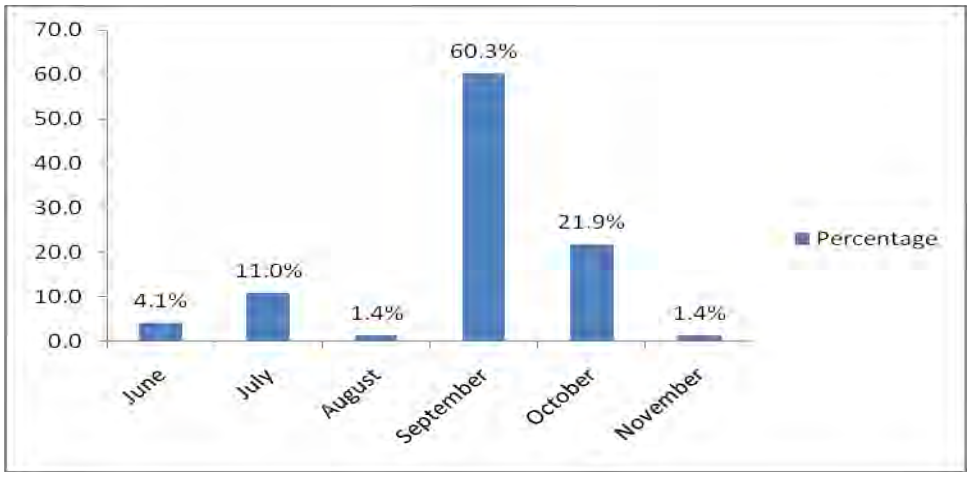


Figure 6: Cultivation time of chickpea

Most chickpea growing farmers (90.4%), cultivate chickpea as main crop on main farm (Figure 7), because the crop starts its growth after the rainy seasons where, harvesting of other crops took place. Cultivating chickpea in home garden is practiced in South Welo in Amhara region, Arsi,

East Shewa and West Harege zone in oromia region. Gurage zone (Sodo wereda) and South East and some part of Central zone of Tigray region.

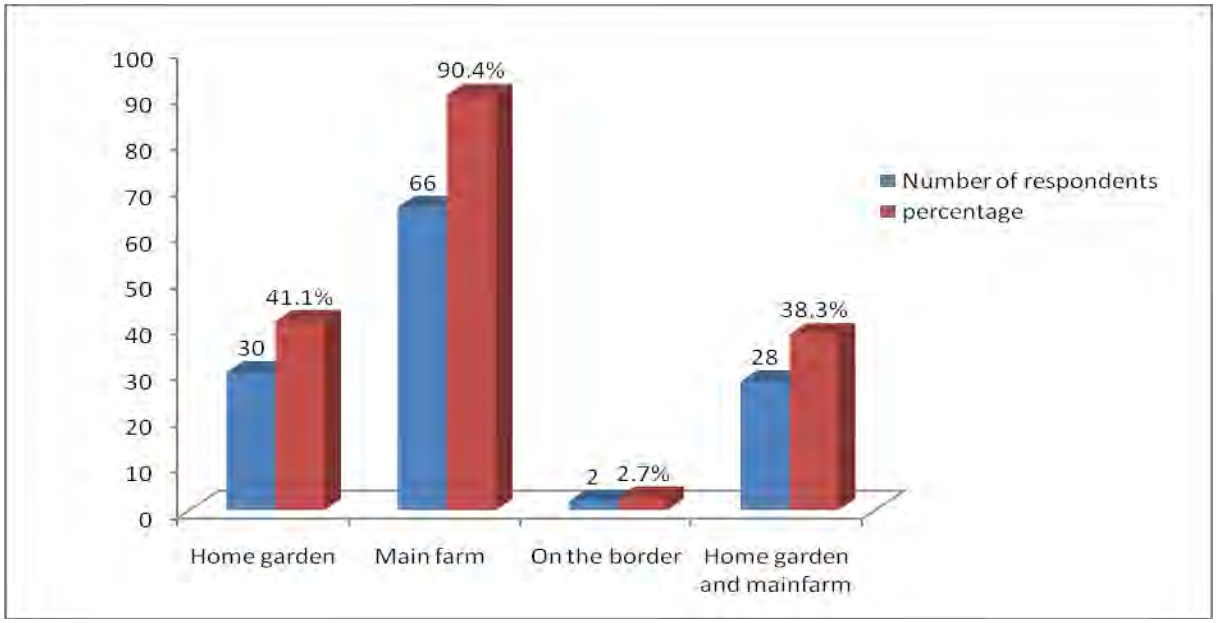


Figure 7: Cultivation site of chickpea landrace

Two type of cropping system was practiced in the areas, monoculture in all locations and intercropping with chat (*Catha edulis*) and sorghum (*Sorghum bicolor*) in Oromia region particularly in West Harerge zone (Figure 8).

Figure 8: Intercropping of chickpea with chat and sorghum in West Harerge (Photo by Senait Berhanu, 2014).

Harvesting time was extended from December to Feburary in areas where, large number of days to maturity was recorded from Enqelo-wabi (127) and Shirka (123) in Oromia region Arsi zone, Kebena (122) in SNNP region and Eilu, Tefki and Betcho (128-132) from South Shewa Oromia

regions compared to the other areas. This is might be due to late sowing practices of farmers of the area or environmental factors.

4.5.3. Chickpea landrace management practices

In order to solve production limiting factors that limit the production of landraces in huge amount, farmers in the studied areas have discussed their techniques. The majority of farmers rely on their own saved seed sources, thus to overcome problems associated with seeds controlling quality before harvesting was done by males, the crop is harvested when leaves start to senesce and start shedding, pods turn yellow, plants are dry, and seed feels hard within the pod. After harvest, the plants are dried in the sun for a few days to ensure that seeds get dried well. The dried seeds are cleaned to remove the undesirable contaminants such as plant parts, soil particles, stones, weed seed, other crop seed, and shriveled, broken, or damaged seed. The cleaning and grading of seeds is first achieved by winnowing and then through a set of mechanical sieves by women's. Thus seed for the next growing season is prepared then stored based on the size, color, thickness, degree of damage and health.

Fertilizer used in chickpea was relatively much less than its use in wheat, teff and other cereals. It is used mainly in waterlogged and low fertility areas. Local communities cultivate and manage chickpea farm mainly with the fertility of the land itself without application of fertilizers, manure and herbicides. The reasons behind are high cost of fertilizer and ability of the crop to grow effectively without application of either manure or fertilizers. In some part of area fertilizer requirements depend on the nutrient status of the field, and thus, vary from field to field. Manure application is also common especially in Lume-Ejere and Minjar-Shenkora districts to enhance the fertility of chickpea farmland.

Chickpea is weeded at least once throughout the production season. Its harvesting is done by manual labor, either for green pod consumption or for dry seed. Most farmers in the study area do not weed their fields at the right time because of labor bottlenecks. Chickpea is weeded at least once throughout the production season. A few farmers have started using herbicides to control weeds. Farmers usually look after the farm of chickpea to protect wild and domestic animals in addition to human's damages in searching of unripe pods. In order to alleviate shortage of land for cultivation, they had started diversifying the type of crops to cultivate instead of farming only cereals.

4.6. Production Status of Chickpea Landraces

The desi chickpea varieties currently grown by farmers in Ethiopia are not able to satisfy the quality attributes required by diverse markets. It has been above twenty years for the introduction of improved chickpea called kabuli as 5.5 percent of respondents answered. While, 16.4 and 57.5 percent of them responded that it has been above and below ten years for the introduction of it respectively. However, 21.9 percent respondent indicated that still now there is no new variety of crop introduced in their area, but they have the information about it. 87.7% grow both improved and desi. Large seeded kabuli type chickpeas are in high demand in export markets and bring considerably higher prices than desi types. 5.5% of farmers' remind that it has been more than 27 year for the introduction of improved type of chickpea, while the majority of them 57.5% remind it was recently introduced less than 10 year. The rest were not sure to guess the year exactly.

4.7. Germination Performance

All the accessions were started germination on the third day and finished on the sixth day. Among the ten seed samples tested for germination performance all of accessions; above 95% of them had showed greater germination capacity. This implies that the collected seeds are exposed to different environmental conditions and this test does not demonstrate the same efficiency in estimating seed performance after sowing, since seeding field emergence results are frequently lower than those observed in laboratory. Thus commonly used standard germination test cannot predict field emergence.

CHAPTER FIVE

5. DISSCUSSION, CONCLUSIONS and RECOMMENDATIONS

5.1. Discussion

5.1.1. Chickpea landrace diversity in Ethiopia

There are two distinct types of chickpea, desi and kabuli cultivated in Ethiopia. The desi type is the farmer variety (landrace), while the very large seeded kabuli domestic types appear to have evolved from the smaller seeded desi types (Moreno and Cubero, 1978). Various methods are available for use in estimating the landrace diversity of crops. The use of morphological and agronomic traits is a standard way of assessing landrace variation for many species including chickpea.

The collected accessions and specimens of chickpea landraces had shown similar characteristics in some agronomic and morphological characteristics. According to McKay *et al*. (2002), the plant is erect with primary and secondary branching; resembling a small bush and similar phenomenon was observed and recorded from the collected specimens. The 'fern' leaf like leaf type with multiple leaflets attached to a leaf stem while, single or 'unifoliate' leaf is like leaf type with multiple leaflets attached to a leaf stem while, single or 'unifoliate' leaf is present on some kabuli varieties. The plant flowers plentifully and has an undetermined growth habit, continuing to flower and set pods as long as climatic conditions are favorable growth habit, continuing to flower and set pods as long as climatic conditions are favorable, days to flowering ranged from 60 days in East Shewa zone to 97 days in Arsi zone in oromia region. Similarly, days to maturity ranged from 75 days in East Shewa zone to 127 days in Arsi zone in Oromia region.

Landrace chickpea (desi) are short, crown length ranging from14.5 cm to 63.7 cm from the soil surface, introduced (kabuli) types often slightly taller than desi types. The collected accessions showed identical angular ram shape with smooth surface. Mean number of seeds per plant in some part of Eastern Shewa and Arsi zone had 1 and 3 seeds per pod was recorded in South West Shewa and Arsi zone. The flower color of collected specimens belongs to light pink (red-purple) and pink in some chickpea landrace farms (Akaki, Adea (Denkaka kebele), Lume-ejere, Enqelo-wabi, Habro and Dese Zurya weredas. Single pod per peduncle was recorded in all the

studied areas except those collected from Betcho wereda (Wereherso and Buti kebele) had showed two pods per peduncle.

The phenotypic diversity was observed in farmers' fields is considerable, particularly in flower and seed color, anthocyanin in the leaves and stems, average number of pods per plant, number of primary branches and number of leaflets per leaf (Appendix 3). This slight difference is might be due to environmental in photoperiod, temperature, and precipitation, and genetical differences, all of which have significant effect on growth and development.

5.1.2. Chickpea landrace distribution

The crop is widely grown in more than 24 districts of Ethiopia with preference to areas with deep black soils and is highly preferred by cash-constrained farmers who cannot afford to buy commercial fertilizers for cereals that are rotated with chickpeas. It is usually well suited for cultivation in cooler areas with low rainfall (Bekele Shiferaw *et al.,* 2007). The landraces are highly distributed on the selected areas of the study, but area of coverage is becoming less and less from year to year because, new kabuli type varieties have been developed and released in Ethiopia in recent years. Local desi remains the most widely grown variety among chickpea growing farmers. Desi is mostly cultivated in areas where there are no nearby research centers and NGOs. Areas which are located in a few kilometer distances from cities and research centers, mainly cultivate kabuli. From the surveyed areas the following districts; Liben-chquala, Degua-temben, Adwa, Dese-zurya, and Enqelo-wabi are cultivating desi chickpea in large amount than kabuli in this cropping season (2014-2015).

5.1.3. Importance of chickpea

5.1.3.1. Food and medicinal value of chickpea

It has a major role in the daily diet of the rural community and poor sectors of urban population and its straw is used for animal feed. Chickpea seeds may be used for feeding domestic animals. Seeds are usually consumed at the raw green and tender stage (unripe stage), called ESHTE, or in the form of mature dry seeds after parching as a popular soaked and roasted (KOLO or snacks), boiled seeds (NIFRO), KIKWOT and flour (SHERO) and BREAD for human consumption. Old aged informants responded that soaking the seed in pure water for 48 hours and eating, while the seeds start to germinate in the morning before breakfast will relieve gastric related diseases (dyspepsia

and flatulence) because of its digestibility. In spite of a good medicinal property, consuming the raw green cause thirst and burning sensation because many are glandular and secrete a highly acidic substance on the whole parts of plant. In line with this idea eating too much of either roasted or raw green will cause flatulence. Both introduced and local chickpea seeds are used for some religious ceremonies, but no information was collected on other cultural values.

5.1.3.2. Agroecological value of chickpea

Being a leguminous crop, chickpea fixes atmospheric nitrogen through symbiosis, thereby improving soil fertility and the productivity of the subsequent cereal crop, particularly in dry lands by fixing atmospheric nitrogen (Saxena, 1990). The most common cereals preferred for rotation with this crop are teff (*Eragrostis tef)*, wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*), maize (*Zea mays*). Many are glandular and secrete a highly acidic substance containing malic, oxalic and citric acids and reduce the occurrence of weeds and pests in addition to enhancement of the fertility of the soil for the next crop due to the following considerations:

- Cereal pest cycles have been disrupted
- Alternative herbicides to cereal crops can be used to clean up grassy weeds
- Improvement of soil fertility

Farmers choose which crops to grow in rotation according to how they adapt to the soil and the rainfall pattern. Personal preference and economic considerations such as the price of the crop also influence the farmers' choices. The major crop rotations practiced by the local farmers are Teff, Wheat, Barley, Maize and Sorghum. Most farmers think that starting the rotation with teff or other cereals and then planting chickpea or vetch improves crop productivity more than rotations based solely on cereals.

5.1.3.2. Market value of chickpea

Most of the farmers lead subsistence life; they produce to cover their daily consumption. Chickpea is cultivated in small hectare of land as a supplementary food because of a lot of land is allocated to produce other staple foods like teff and cash crops. Only few farmers produce and sell their products either to nearby local or primary markets (buyers who buy directly from the producers include rural retailers, rural assemblers, brokers, and primary cooperatives) with

variable prices ranging from 9-11 ETB (0.5 dollar) per kilo gram. The price of the crop becomes low during harvesting time of the new chickpea and high after harvesting period.

Through secondary markets (buyers who purchase products primarily from originators) include wereda retailers, wereda wholesalers, and farmers unions and tertiary markets include urban wholesalers, urban retailers, processors, supermarkets, and grain exporters, and are located in larger cities such as Addis Ababa and Nazereth (Adama) and capital cities of the surveyed areas the crop reaches to domestic and international market. The local landraces grown by farmers do not meet the quality and quantity requirements preferred to some extent by domestic but especially international markets because desi type chickpea produces smaller seeds with a thick often irregular-shaped seed coat. Desi chickpeas require a specialized process called decortication, to remove its seed coat if it is used for human food. The kabuli types produce seeds that range from white to a pale cream tan color. If the seed is dark or discolored the processors will not accept it. The desi chickpea varieties currently grown by farmers in Ethiopia are not able to satisfy the quality attributes required by diverse markets. Large seeded kabuli type chickpeas are in high demand in export and local markets and bring considerably higher prices than desi types.

5.1.4. Production constraint and local management practices

The major biotic stresses which lead to yield reduction and instability are those caused by fungal, bacterial and viral diseases, insect pests, parasitic nematodes (Ranalli and Cubero, 1997) and parasitic weeds of chickpea (Cubero *et al*., 1986). The common diseases observed in the studied areas caused by biotic factors attacks economical part of the crop such as; leaf, pod and seed. The diseases on the leaf locally named as ADERKRE in some part of Amhara region and GOGOGSISA in Oromia region. Insects especially the gram caterpillar or gram pod borer can cause problems (Winch, 2006). As described in McKay *et al*. (2002), insect pests in chickpeas are usually minimal since its stems, leaves and seedpods are covered with small hair like glandular structures that secret malic and oxalic acids which deter insect pests as compare from other crops. It has been observed that some grasshopper species are reluctant to feed on chickpea vegetation. However, aphids were observed in some part (East Shewa zone Adea wereda Oromia region, cause damage to chickpeas. Furthermore, seed beetle or bruchid is the most

important storage pest of chickpea (Singh *et al.,* 2008). Bruchids locally called NEKEZE are important post harvest problems. To protect seeds from bruchids attack, the seed is either stored in polythene bags or in safe storage structures (metal bins or clay made containers). The bags are kept if possible in a rodent free place to save pure seeds for the next growing season. Women's use traditional methods of protecting the seed from insect damage (NEKEZE) by mixing with ash and salt. For large scale storage farmers use commercially available fumigants (ethylene dibromide or phosphine) to protect seed from storage pests. But large scale production of chickpea is not common in the areas they produce in small amount less than a hectare because of less use of the crop for consumption as compared to other cereals. Farmers prefer to allocate their land to other staple and cash crops like teff, wheat, sorghum and chat and traditional management practices are not yet practiced to overcome the major diseases which attacks (leaf, root and pod) of the landrace.

According to Kebede Desta (2000), farmers of chickpea in Ethiopia commonly lose up to 30% of their crops because of weed infestations. Weeds deprive crop plants of nutrients and water, and often serve as hosts to insects and other pests detrimental to the crop. Most farmers in the study area do not weed their fields at the right time because of labor bottlenecks. Hand weeding is the most common weed control method used by small-scale farmers. It usually requires no capital outlay. This is a major advantage when cash is not readily available and labor is provided from the farmer's immediate family or through non-cash exchange. It may be the only feasible method for weeding broadcast crops when herbicides are not available, but also good agricultural practices such as increased plowing, delayed planting and crop rotations. However, herbicides have been found to be less effective than hand-weeding, as they require specific conditions which may be more limiting than other control methods. The correct herbicide must be selected for the particular crop and weed spectrum present.

The results indicated the existence of mismatches between crops and their growing environments either because of environmental differences or management practices (late planting such as chickpea) are most common abiotic stresses affecting chickpea production. In addition, there are other abiotic stresses specific to some regions such as salinity, water logging and nutrient deficiencies. Resistance or tolerance to these stresses is more complex. Chickpea, an important food legume grown in the arid and semi-arid tropical regions, suffers substantial yields loss due

to water deficit at the end of the growing season (Khamssi, 2011). Water deficit is one of the most serious problems for germination, a crucial phase of plant life (Gan *et al*., 2003). Frost which is locally called KORA is the major problem in all the studied area. Wilting in chickpea was the major problem in the areas. The disease appears at seedling and reproductive stages of the crop under field conditions as the farmers reported. The main symptoms of the disease are drying and yellowing of leaves from the base to upward and wilting of plants.

5.1.5. Chickpea cultivation

Under the main season, due to its sensitivity to water logging, it is sown starting from about mid to late September, at which time the water logging problem has receded (Amare Girma, 2013). Deep black soils are known for excess water and drainage problem during the main rainy period (June - August). Thus, to overcome this problem farmers plant chickpea late in the season (September - October) commonly on residual moisture after harvesting preceded crops. Because of the short, open canopy of the crop, plants are poor competitors, farmers prefer to cultivate the crop alone on a farm and broadcast seeds on prepared land. Thus, monoculture is practiced in most parts of chickpea producing areas in order to reduce plant competition for nutrients, space, and solar radiation and to maximize profit from growing of a single crop on main farm and they use mixed type of intercropping with no district row arrangement to diversify the amount of income per unit area than sole cropping as well to maintain soil fertility. Cultivation is practiced in home garden as well to protect and look after the pods during ripening (pod setting) stage from wild and domestic animals, including human's attacks and manure application is common as compared to cultivation on main farm which is far from home of growers. Chickpea which is sown in Oromia (Arsi and South West Shewa zone) and SNNP (Kebena) region were harvested on Feburary but from October to January in the rest zones.

5.1.6. Preferred traits of chickpea landrace

Yield is an obvious consideration within a market class. However, other characteristics such as disease tolerance or maturity can quickly overshadow potential yield gains if the plant is limited in reaching its full potential. There are many agronomic and market factors to consider when choosing a variety. Desi is characterized by its small size while, the kabuli one is characterized by its large size; affect directly or indirectly the market value.

Desi is fairly drought tolerant, adapted to low rainfall areas and is of shorter height. Kabuli is a late-maturity type with a thin, white seed coat and is found mainly in areas of rainfall and is relatively taller in height. Kabuli has larger seeds with a smoother coat. The desi type chickpea produces smaller seeds while kabuli produces large pods contain 2-3 peas these cause a yield difference. Market demand for a particular class or variety can change over time. The overall score for kabuli variety was the highest for both men and women chickpea farmers. When examination is conducted based on specific traits, female chickpea farmers prefer desi variety for its taste and better water uptake properties while, kabuli for its shorter cooking time. Whereas male farmers prefer kabuli variety for high price in the market, grain size, grain color and grain yield. The preferred traits for desi variety by both male and female farmers are early maturity and low cost of production. Generally, kabuli varieties are highly preferred for their high economic return in addition to their grain color and size. Most of the chickpea production is used for domestic consumption. Communities use both types especially desi flour for SHERO or WOT and kabuli for roasted (KOLO or snacks) and boiled seeds (NIFRO) for human consumption.

5.1.7. Farmers' knowledge and perceptions

In this study, local farmers expressed their impression on how chickpea production is efficient in improving their living. Based on farmers' perception, the majority of them need to produce chickpea for home consumption and as a fodder. Farmers perceive desi chickpea has high drought resistance and better performance than other crops under difficult conditions such as adaptability to high temperature, poor soil fertility and unusual rain fall pattern but the crop is highly sensitive to frost. The farmers concluded that existing native chickpea (desi) have lower yield, small seed size and poor quality as a result they have lower return. Thus, to scale up their return they prefer to produce the improved chickpea variety which is donated by agricultural research centers. Farmers have also lack of knowledge in the socio economic importance of the crop, they use it as a supplementary food with the perception of having a low mineral and nutrients as compared to cereals, again poor knowledge on nitrogen fixing ability of the crop instead some of them believe that it has deep root system which enables it to absorb much of the water under the soil. This and other negative perceptions on the crop by the farmers lead to poor management of the crop.

5.1.8. Germination potential

Similar germination percentage was obtained among collected accessions within six days. Chickpea seeds germinate at an optimum temperature (28-33°C) and moisture level in about 5-6 days. Germination begins with absorption of moisture and swelling of the seed (Qasim *et al*, 2010).

5.2. Conclusion

Even though Ethiopia is considered as the secondary center of genetic diversity with a large germplasm holding for chickpea, the landrace diversity is not yet well known. Knowing the diversity will enhance farmers' access to a wide range of varieties of chickpea instead of relying on introduced varieties in research.

Chickpea has a major role in the daily diet of the rural community and poor sectors of urban population and its straw is used for animal feed as reported by farmers'. A little medicinal value was recorded in the studied areas. Chickpea, like other annual legumes in a rotation, offers several cropping advantages for the producer. They contribute to crop rotations because of their ability to fix nitrogen and provide a disease and weed break for cereal crops and used as a means of income generation.

This study used characters, which included both quantitative and qualitative traits that were identified as important traits in distinguishing local (desi) chickpea landraces found in different geographic locations Fourty one sample of chickpea landrace accessions were collected from the studied areas. A total of four landraces diversity in farmers' nomenclature of the crop (Shimbra, Shumbura, Shimber and Ater) and a considerable phenotypic diversity were recorded. Thus, the findings of this study with local farmers' knowledge have shown some distinct local varieties with specific local names and high phenotypic variation.

5.3. Recommendation

Based on the results of this study, the following recommendations are made for future consideration for some stakeholders like governmental and nongovernmental organizations and research centers.

- Creating strong institutional support to develop farmers' capacity for landrace type chickpea production.
    - To improve crop management, farmers may also require close and regular field supervision by technical support staff for an initial period.
    - Collaborative linkages need to be fostered among farmers, researchers, agro enterprise specialists, NGOs, and the formal seed industry.
    - Linkages between local agro-processing industries stimulate the use of better technology, creating demand for the use of the crop.
- Education, resources and further research needed in order to help control production constraints of landrace chickpea production.
    - Disease management is critical to success and it will be good to prepare and distribute a guide which teaches about diseases and its management in chickpea for a potential growers.
- Further research programs are needed for effective use of the wide genetic material found with farmers
- Government responsibility for conservation of those landraces

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APPENDICES

Appendix 1: Data collection format

Datasheet for collection of germplasm with farmer knowledge

Checklist of questions to be used as basis for discussion and interview for informants to collect ethnobotanical information on chickpea.

General Information

Informant's Name_____Age_____Sex _____

Location: Region_____Zone _____District_____Kebele____

Local name of the crop _____Soil type_ _____

Altitude _____Latitude _____Longitude _____

Meaning of the local cultivar name Language_____

Cropping season (Meher, Belg, or others)

Folk Taxonomy (characters used by the farmer for identification of the crop),

Quality, Diseases & pests identified by the farmer and Economic use of the crop

- **Ethnobotanical Information**

1. Is it improved or farmers' variety? If it is farmer variety what is the name of the variety_____
2. Uses and values of the Crop other than food

   A. Alcoholic beverage (specify) B. Medicinal C. Forage D. Ritual

   E. Myths and beliefs associated with the crop F. Any sayings, songs and poems
3. What parts of chickpea are used for food, vegetable, or feeding?
4. What is the most commonly used chickpea (*Cicer arietinum* L.) landrace varieties in

your area?

5. How do member of local community cultivate and manage the crop?

6. If it has medicinal value describes for what kind of disease it is used and method of application. _____
7. Which the varieties crop are said to have medicinal value?
   1. _____Purpose_____
   2. _____Purpose_____

- ✓ What is the local name of the variety used as a medicine in your area?
- ✓ What part/parts of the crop used for medicinal purpose?
- ✓ What are the common diseases that can be treated by this crop?
- ✓ What are the methods of preparation
- ✓ Preparation form: crushed, powder, chewed etc.
- ✓ Used alone, mixed with water or other etc.
- ✓ Condition: dried, fresh, both.
- ✓ Could you tell me the amount or dosages that are used for disease treatment?

8. Suitable Soil types for the crop to grow_____
9. Cultivation time?_____
10. Crop rotation programme/ Sequence of crop types_____
11. Use of crop rotation_____

i To eliminate pest infestation ii. To eradicate problem of weed

iii. To replenish soil fertility iv. Others_____

12. Do farmers use intercropping? Why? & How?

_____

13. Where do grow this crop? home garden _____main field _____boarder crops_____

14. How do you grow this crop? Monoculture _____Multiple cropping _____
15. If Multiple cropping, which crops do you grow in association with chickpea?

Crops grown in association	Farm land (main land or homestead)	Give reasons or uses of intercropping

16. What do you think the area of production in terms of coverage? Production per ha_____

Increasing	Decreasing	No change	Factors

17. How do farmers maintain the fertility of their farmland? Do they use artificial or n a t u r a l fertilizer?

_____

18. In case of seed shortage; where does a farmer obtain seed? Are there seed exchange mechanisms?

_____

19. Are there any traditional varieties that are no longer cultivated? Why not cultivated?

_____

20. Do you think improved varieties have replaced the landrace? Yes/No. If yes, how many landraces are replaced so far? _____
21. How long, since the replacement of landraces in the area?_____
_____
22. Does the community prefer landrace or released ones? Why?_____
23. How do farmers culturally manage such pest/weeds?_____
24. What are the main threats to the traditional variety in your area?_____
25. What measures should be taken to overcome the problems?_____

- **Socio- Cultural Significance of Crops**

26. How do you use this crop? A. food B. fodder C. others
27. Based on question no 26, which variety do you use and for what purpose? Variety of the crop purpose

_____

28. Which varieties of these crops are said to have better nutritional value?

1._____2_____

29. What special tasks do women contribute to maintain genetic diversity?

_____

30. What are your parameters of selection for better varieties of the crop?

Men women

- **Economic significance of crop varieties**

31. Which varieties of the crop are more preferred for its better production?_____
32. Which varieties of the crop used for consumption? _____
33. Which varieties of the crop used for market? _____
34. Are there special landrace varieties of chickpea which are marketable in your area?
35. Are there limitations in the cultivation and utilization of chickpea in the locality?
36. What are the solutions to constraints for chickpea species?
37. Would you mind to list any crop species that is cultivating in your area?
38. Do you have anything else to tell me?

Thank you for your willingness!!!

Appendix 2: Field data collection of chickpea genetic resources descriptors list format

This list consists of an initial set of characterization and evaluation descriptors for Chickpea genetic resources utilization.

1. Growth habit

The angle of the branches from the vertical axis at the pod filling stage

Prostrate	Spreading	Semi-spreading	Semi-erect	Erect

2. Days to 50% flowering

Number of days from sowing (or first rain sufficient for germination under rainfed conditions) until 50% of the plants have started to flower_____

3. Days to maturity

Number of days from sowing (or first rain sufficient for germination under rainfed conditions) until 90% of the pods have matured and turned yellow

4. Stem/foliage pigmentation

light green	green	partly light purple	predominantly purple	highly purple

5. Number of seeds per pod

Average number of 10 pods each from five representative plants. At maturity

6. Number of pods per plant

Average number of pods taken from five representative plants. At maturity

Seed shape

Angular, ram's head	Irregular rounded, owl's head	Pea-shaped, smooth round

7. Seed color

Black	Brown	Light-Dark brown	Reddish, Greyish Salmon brown	Grey	Yellow	Orange	Green	Light green	Ivory white

8. Seed testa texture

Smooth	Rough (pea-shaped)	Rough to wrinkled	Tuberculated (sticky surface)

10. Flower colour

Blue	Light blue	Dark pink	Pink	Light pink	White	White-pink striped

11. Abiotic stresses

Reaction to drought	Reaction to drought	Reaction to drought

12. Biotic stresses of chickpea (yellow) mosaic virus

Ascochyta blight *(Ascochyta rabiei)*

13. Number of primary branches

Average number of basal primary branches per plant taken from five representative plants

14. Plant canopy height [cm]. Average canopy height of five representative plants. Recorded at maturity Seed yield per plant [kg ha

Appendix 3: Qualitative morphological characteristics of collected specimens

District/Wereda	Plant pigmentation	Seed color	Flower color
Akaki	No anthocyanin	Light orange	Pink
Dese zurya	Low anthocyanin	Brown	Pink
Enbse sar midr	No anthocyanin	Brown	Light pink
Lalibela	Low anthocyanin	Light orange + black	Light pink
Minjar shenkora	No anthocyanin	Orange	Light pink
Zeway dugda	Low anthocyanin	Light orange + black	Light pink
Enqelo wabi	Low anthocyanin	Black +light orange	Pink
Tyo	No anthocyanin	Reddish brown+black	Light pink
Hitosa	No anthocyanin	Light orange	Light pink
Shirka	No anthocyanin	Reddish brown	Light pink
Adea	No anthocyanin	Light dark brown	Light pink
Liben-chquala	No anthocyanin	Light orange	Light pink
Gimbichu	Low anthocyanin	Grayish brown	Light pink
Lume-ejere	Low anthocyanin	Orange	Pink
Betcho	Low anthocyanin	Light orange	Light pink
Tefki	Low anthocyanin	Grayish brown	Light pink
Eilu	High anthocyanin,	Orange + black	Light pink
Chiro	High anthocyanin,	Light orange +black	Light pink
Gemechis	No anthocyanin	Orange	Light pink
Habro	Low anthocyanin	Orange	Pink
Hirna	High anthocyanin,	Orange	Light pink
Kebena	Low anthocyanin	Orange +black	Light pink
Sodo	Low anthocyanin	Orange	Light pink
Degua-temben	Low anthocyanin	Orange	Light pink
Kola-temben	Low anthocyanin	Light orange	Light pink
Laelay Michew	Low anthocyanin	Orange	Light pink
Tahitay Michew	High anthocyanin,	Orange	Light pink

Appendix 4: Quantitative morphological characteristics of collected specimens

Districts	Number of pods per peduncle		Number of primary branches	Number of leaflets per leaf	Days to 50% flowering	Average number of seeds per pod	Average number of pods per plant	Days to maturity	Average pant canopy height (cm)
Akaki	Single pod		2	12	60	2	46	82	44.6
Minjar shenkora	Single pod		3	19	75	2	52	105	49.2
Enbse sar midr	Single pod		3	10	75	2	89	96	57
Lalibela	Single pod		3	13	63	2	98	90	44.1
Dese zurya	Single pod		3	16	78	2	92	108	42.6
Enqelo wabi	Single pod		2	7	97	3	58	127	45.5
Hitosa	Single pod		2	14	65	1	48	90	39
Shirka	Single pod		3	8	93	3	82	123	33.2
Tyo	Single pod		2	11	68	1	51	93	41.2
Zeway dugda	Single pod		2	17	77	1	30	102	39
Adea	Single pod		4	7	60	2	52	80	30.6
Gimbichu	Single pod		3	16	60	2	94	112	39.8
Lume-ejere	Single pod		2	5	78	1	88	104	40.6
Liben chquala	Single pod		2	15	92	1	21	85	34.2
Betcho	Twin pods		4	12	60	2	52	80	30.6
Tefki	Twin pods		2	16	85	3	68	100	34.4
Eilu	Twin pods		3	19	90	3	118	110	63.7
Chiro	Single pod		3	21	95	2	81	110	57.2
Gemechis	Single pod		1	13	90	2	44	112	49.2
Habro	Single pod		3	18	91	2	59	106	54.5
Hirna	Single pod		3	14	65	2	86	95	61.1
Sodo	Single pod		3	19	75	2	79	95	38.2
Kebena	Single pod		4	21	92	2	81	122	51.9
Kola-temben	Single pod		2	20	92	2	69	107	38.8
Laelay michew	Single pod		4	18	67	2	42	97	49
Tahitay michew	Single pod		2	15	65	2	46	90	40.4
Degua-temben	Single pod		4	18	91	2	90	106	42.8

Appendix 5: Geographical information of collected accessions

Region	Zone	District	Seed and specimen collection code	Latitude (dd mm ss)	Longitude (dd mm ss)
Addis Ababa	06	Akaki	Cicer 001	N8 53 37.1	E38 49 18.7
Amhara	North Welo	Dese Zurya (Hayke)	Cicer 002	N11 19 29.4	E39 40 29.2
	East Gojjam	Enebise-sarmidir	Cicer 003	N10 33 50.4	E38 12 20.2
	South Welo	Lalibela	Cicer 004	N10 33 50.4	E38 12 20.2
	East- Shewa	Minjar Shenkora	Cicer 005	N8 55 13.8	E39 25 11.2
		Shewarobit	Cicer 006	N10 00 19.8	E39 31 59.9
Oromia	Arsi	Asela Town	Cicer 007	N7 34 19.6	E39 04 54.5
		Enqelo-wabi	Cicer 008	N7 25 54.2	E39 28 00.7
		Hitosa	Cicer 009	N8 07 49.0	E39 13 58.2
		Shirka	Cicer 010	N7 35 39.0	E39 30 53.7
		Tyo	Cicer 011	N7 52 32.3	E39 04 13.0
		Zeway Dugda	Cicer 012	N8 03 39.8	E38 59 18.0
	East Shewa	Adea	Cicer 013	N8 57 20.3	E40 50 17.7
		Gimbichu	Cicer 014	N8 58 04.0	E39 08 43.5
		Liben-chquala	Cicer 015	N8 32 29.0	E38 54 03.6
		Lume-ejere	Cicer 016	N8 35 29.4	E39 07 45.3
	South Shewa	Betcho	Cicer 017	N8 23 29.8	E38 07 20.3
		Eilu	Cicer 018	N8 52 50.3	E38 20 48.9
		Teffki	Cicer 019	N8 50 50.7	E38 30 10.2
	West	Chiro Town	Cicer 020	N9 03 23.5	E40 53 33.0
		Gemechis	Cicer 021	N8 57 20.3	E40 50 17.8
		Habro	Cicer 022	N8 48 27.0	E40 30 26.4
		Meiso	Cicer 023	N9 13 27.0	E40 44 11.7
		Hirna	Cicer 024	N9 12 56.3	E41 05 57.7
SNNP	Gurage	Kebena	Cicer 025	N8 17 33.6	E37 46 54.1
		Sodo	Cicer 026	N8 13 53.9	E38 30 49.8
Tigray		Adwa	Cicer 027	N14 02 59.7	E39 03 54.3
	Central	Axum	Cicer 028	N14 07 21.5	E38 43 03.6
	South East	Degua- Temben	Cicer 029	N13 37 04.3	E39 08 53.4
	Central	Kola- Temben	Cicer 030	N13 38 11.7	E38 58 07.9
		Laelay Michew	Cicer 031	N14 07 36.2	E38 45 49.2
		Tahitay Michew	Cicer 032	N14 06 57.5	E38 33 34.5