



**Cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) Landrace
Diversity in Northern Ethiopia**

Mulugeta Alemu Molla

Addis Ababa University

Addis Ababa, Ethiopia

July 2015



**Cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) Landrace
Diversity in Northern Ethiopia**

Mulugeta Alemu Molla

A Thesis Submitted to

The Department of Plant Biology and Biodiversity Management

Presented in Partial Fulfillment of the Requirements for the Degree of Master of
Science (Plant Biology and Biodiversity Management)

Addis Ababa University

Addis Ababa, Ethiopia

July 2015

ADDIS ABABA UNIVERSITY
GRADUATE PROGRAMES

This is to certify that the Thesis prepared by Mulugeta Alemu Molla, entitled: *Cowpea (Vigna unguiculata (L.) Walp.) (Fabaceae) Landrace Diversity in Northern Ethiopia* and Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science (Plant Biology and Biodiversity Management) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by Examining Board:

Name	Signature	Date
1. _____ (Examiner)	_____	_____
2. _____ (Examiner)	_____	_____
3. Prof. Zemedede Asfaw (Advisor)	_____	_____
4. Prof. Zerihun Woldu (Advisor)	_____	_____
5. Dr. Berhanu Amsalu (Co-Advisor)	_____	_____
6. Dr. Beth A. Medvecky (Co-Advisor)	_____	_____
7. _____ (Chairman)	_____	_____

ABSTRACT

Cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) Landrace Diversity in Northern Ethiopia

Mulugeta Alemu Molla, MSc Thesis

Addis Ababa University, 2015

*The study was carried out to identify and document the landrace diversity and ethnobotany of cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) in northern Ethiopia. Ethnobotanical data were collected using semi-structured interview, field observations (guided field walk) and market surveys. A total of 54 germplasms and representative voucher specimens were collected from different geographical locations ranging in altitude from 1260 – 2140 m.a.s.l. Of these, 45 were local farmers' varieties (83%) and nine were commercial varieties (17%) introduced by Melkassa Agricultural Research Centre. The majority of farmers (75%) preferred the erect type of cowpea (*Vigna unguiculata* subsp. *cylindrica* (L.) Verdc. farmers' variety KIMITE and subsp. *cylindrica* (L.) Verdc. farmers' variety CHEKELE) because of many reasons such as ability of the crop to be harvested before the cereal crops are ready, high grain and straw yield, organoleptic character, early maturity, feed value, adaptability to all types of soil, disease resistance, drought tolerance and market value. The spreading type of cowpea (subsp. *unguiculata* farmers' variety JERGADIE) produced much more leaves than grains and mainly the farmers use it for improving soil fertility. These local farmers' varieties contribute to smallholders' income as a higher-value crop like cereals and to diet as a cost effective source of protein intake especially in Central Tigray, South Wello and Oromia Special Zones of northern Ethiopia. In Amhara Region, cowpea is mainly used for human food in the form of boiled grain (NIFRO), baking bread (KITA) and sauces (SHIRO WET). There is high potential area for cowpea production; but the actual production by local farmers is restricted to some areas. Therefore, the responsible body (Ministry of Agriculture and Ethiopian Institute of Agricultural Research) needs to enhance and/or distribute the important cowpea landrace varieties to the areas where the crop can be suitably grown.*

Key words: Cowpea, Ethiopia, ethnobotany, farmers' knowledge, landrace

ACKNOWLEDGMENTS

First and foremost, I would like to express my deepest gratitude and heartfelt appreciation to my major advisors Prof. Zemedu Asfaw and Prof. Zerihun Woldu and co-advisors Dr. Berhanu Amsalu and Dr. Beth A. Medvecky for their valuable guidance, suggestions and provision of related study materials in both proposal development and this final research writing. Moreover, I would like to express my thanks to the McKnight Foundation for funding the research expenses and Nefas Silk Polytechnic College is also acknowledged for sponsoring my study at Addis Ababa University. I also thank Mr. Demeke Mekonen for his technical support in mapping the study area. I would like also to thank all management and staff members of Tanqua Abergelle, Kola Temben, Wereie Leke, Abergelle, Sekota, Lasta Lalibela, Bati and Kalu weredas governmental administrative offices of agriculture for giving important information on production and utilization of cowpea by local farmers. I am also indebted to my friends Dereje Mengist, Eyerusalem Tesfaye, Martha Nigussie and Halefom Tesfaye for their constant encouragement and help rendered to me. I am also thankful to Yirsaw Demeke, Tibebu Alemu and Meaza Kassahun for their valuable comments, constant encouragement and moral support during the research work. My sincere acknowledgment goes to the peoples of northern Ethiopia for devoting their valuable time during the interview. Finally, I would like to thank many other persons and organizations who have supported me in accomplishing and collecting the primary data and secondary data for my final work.

DEDICATION

I dedicate this piece of work to my parents Alemu Molla and Aregu Bikes and my uncle Ayene Faris for being the inspirational force behind my studies.

Table of Contents

List of Figures.....	i
List of Tables	ii
List of Appendixes.....	iii
Acronyms.....	iv
CHAPTER ONE	1
1. INTRODUCTION	1
1.1. Background of the Study.....	1
1.2. Statement of the Problem.....	2
1.3. Research Questions, Hypotheses and Objectives.....	3
1.3.1. Research questions.....	3
1.3.2. Research hypotheses	3
1.3.3. Research objectives.....	4
CHAPTER TWO	4
2. LITERATURE REVIEW	5
2.1. Taxonomy of Cowpea.....	5
2.2. Origin, Domestication and Distribution.....	5
2.3. Cowpea Varieties in Ethiopia	6
2.4. Botanical Characteristics of Cowpea	7
2.5. Environmental Requirements.....	8
2.5.1. Climatic requirements.....	8
2.5.2. Soil requirements	10
2.6. Adaptability of Cowpea for Drought Stress.....	10
2.7. Growth Habit	11
2.8. Germplasm Collections and Conservation.....	11
2.9. Socio-economic Importance of Cowpea	12
2.10. Nutritional Value of Cowpea	13

2.11. Production System	14
2.12. Production Constraints	15
2.12.1. Biotic stress	15
2.12.2. Abiotic stress	17
CHAPTER THREE	18
3. MATERIAL AND METHODS	18
3.1. Description of the Study Area	18
3.1.1. Geographical location	18
3.1.2. Topography and agro-ecological zone	18
3.1.3. Climate	20
3.1.4. Demography and livelihood	22
3.1.5. Land use	22
3.2. Material Used in the Research	24
3.3. Methods	24
3.3.1. Site selection	24
3.3.2. Informant selection	25
3.3.3. Ethnobotanical data collection	25
3.3.4. Voucher specimen collection and identification	27
3.3.5. Germination Data Collection	28
3.4. Data Analysis	28
3.4.1. Descriptive statistics	29
3.4.2. Preference ranking and informant consensus	29
CHAPTER FOUR	30
4. RESULTS	30
4.1. Cowpea Landrace Diversity in Northern Ethiopia	30
4.1. Germination Potential of Cowpea Landraces	33
4.2. Vernacular Names of Cowpea	34

4.3.	Farmers' Knowledge and Utilization of Cowpea.....	35
4.4.	Farming System and Practices	37
4.5.	Gender Roles for Maintaining the Landrace Diversity of Cowpea.....	40
4.6.	Market Value of Cowpea	41
4.7.	Production Constraints	42
CHAPTER FIVE		43
5.	DISCUSSION, CONCLUSION AND RECOMMENDATIONS	43
5.1.	Discussion	43
5.1.1.	Cowpea landrace diversity in northern Ethiopia.....	43
5.1.2.	Farmers' knowledge and perceptions.....	44
5.1.3.	Crop uses and purpose of production.....	45
5.1.4.	Cropping systems and management practices.....	46
5.1.5.	Seed supply, selection and storage.....	47
5.1.6.	Qualitative and quantitative traits	48
5.2.	Conclusion	49
5.3.	Recommendations.....	50
REFERENCES		52
APPENDICES		60

List of Figures

Figure 1: Map of Ethiopia showing Regional States and the study areas	19
Figure 2: Climate diagram of the study areas	21
Figure 3: Map of Ethiopia showing Regional State and collection zones for cowpea landrace	31
Figure 4: Agronomic practices for cowpea production in northern Ethiopia	39
Figure 5: Farmers' seed source	40
Figure 6: Market price of cowpea landrace varieties in the study areas	41

List of Tables

Table 1: Major crops grown in the study areas.....	23
Table 2: Regions, zones, weredas and kebeles used in the study	25
Table 3: Cowpea germplasm collection in northern Ethiopia.....	30
Table 4: Diversity of cowpea landraces cultivated in northern Ethiopia as revealed by seed morphology ..	32
Table 5: Representatives of cowpea landrace accessions subjected to germination percentage evaluation .	33
Table 6: Vernacular names and interpretation of cowpea landraces in northern Ethiopia.....	34
Table 7: Preference ranking value for uses of cowpea in northern Ethiopia	36
Table 8: Major local foods prepared from cowpea and other uses in northern Ethiopia	37
Table 9: Cowpea production season in northern Ethiopia	38

List of Appendixes

Appendix 1: Checklist of questions to be used as basis for discussion and interview with informants	60
Appendix 2: Cowpea germplasm collection in northern Ethiopia	63
Appendix 3: Ecological requirement and range of suitability for cowpea production	65
Appendix 4: Major crops grown in the study area.....	65
Appendix 5: Qualitative and quantitative traits of collected cowpea landrace specimens	69
Appendix 6: Photographs.....	72

Acronyms

ANRS: Amhara National Regional State

AFF: Agriculture, Forestry and Fisheries

CSA: Central Statistical Agency

EIAR: Ethiopian Institute of Agricultural Research

EBI: Ethiopian Biodiversity Institute

FAO: Food and Agricultural Organization

GAOA: Governmental Administrative Offices of Agriculture

GIS: Geographical Information System

GP: Germination Percentage

GPS: Geographical Positioning System

IBPGR: International Board for Plant Genetic Resources

IITA: International Institute of Tropical Agriculture

ILRI: International Livestock Research Institute

MARC: Melkassa Agricultural Research Center

MoA: Ministry of Agriculture

NMSA: National Meteorological Service Agency

NPHC: National Population and Housing Census

TFAP: Tigray Forestry Action Program

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Pulses have been recognized as a major source of proteins (20 - 35%) with required minerals and vitamins (Fall *et al.*, 2003; Girma Abebe *et al.*, 2005). Among the pulses, cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) is an important food legume growing in tropical and subtropical regions of Africa, Asia, and Central and South America (Pasquet, 1996; Lemma Gebremariam *et al.*, 2009; Singh *et al.*, 1997). According to Thulin (1989), in Ethiopia cowpea is cultivated primarily for its edible seeds and also the leaves are sometimes used as a green vegetable for human food. In addition to its importance for human food, the crop is also useful for soil fertilization through symbiotic nitrogen fixation and can be a major animal feed due to the quality of its leaves. Its world annual production is estimated at 5,249,571 tons of dried grains of which over 64% is produced in Africa. Nigeria produces about 850,000 tones and reputed to be the highest producer of cowpea in the world (Ogbemudia *et al.*, 2010). On the African continent, West Africa represents the largest production zone (Pottorff *et al.*, 2012; Gbaguidi *et al.*, 2013), but also cowpea is an important grain legume in East Africa (Sariah, 2010).

According to Pottorff *et al.* (2012), cowpea is a multipurpose crop; the entire plant can be used for either human or livestock consumption. Islam *et al.* (2006) emphasized that all parts of the plant used as food are nutritious providing protein and vitamins, immature pods and seeds are used as vegetables while several snacks and main dishes are prepared from the grains (Agbogidi and Egbo, 2012). Cowpea young leaves, pods and seeds contain vitamins and minerals which have

fuelled its usage for human consumption and animal feeding and the scorched seeds are occasionally used as a coffee substitute (Ogbemudia *et al.*, 2010). The species has a unique ability to fix atmospheric nitrogen with its nodules and performs well even in poor soils with more than 85% sand, less than 0.2% organic matter and low levels of phosphorus (Bilatu Agza *et al.*, 2012). Integration of cowpea with the prevailing farming system using native cowpea variety could have significant importance in improving soil fertility and productivity, improving feed quality and withstands the impact of climate change (Ayana Etana *et al.*, 2013).

According to EBI (2014), presently a total of 94 germplasms of cowpea were collected by Ethiopian Biodiversity Institute for conservation and subsequent utilization. Therefore, the major goal of this study was to identify and document the landrace diversity and the ethnobotanical uses of cowpea in northern Ethiopia. The important morphological traits and the germination potential of cowpea landrace varieties were also investigated.

1.2. Statement of the Problem

The pulses as a group in Ethiopia constitute considerable number and diversity of crop species (Million Fikreselassie, 2012). Cowpea is a tropical grain legume which plays an important nutritional role in Ethiopia. Cowpea young leaves, pods and seeds contain vitamins and minerals which have fuelled its usage for human consumption and animal feed (Westphal, 1974). Although Vavilov (1951; as cited in Westphal, 1974) indicated that Ethiopia is a secondary center of diversity for cowpea, there is limited information regarding the genetic resource, major production challenges and social factors related to cowpea production in the country. In addition, there is no published document regarding with cowpea landraces and the status of diversity in Ethiopia. Therefore, collecting and documenting ethnobotanical information on cowpea landrace diversity is a fundamental urgent task. Hence, documenting and conserving cowpea landrace diversity and

ethnobotanical information of the crop in northern Ethiopia would be crucial. For this reason, this study was initiated to gather record and document the landrace diversity and ethnobotanical information of cowpea in northern Ethiopia.

1.3. Research Questions, Hypotheses and Objectives

1.3.1. Research questions

The objectives of the study were achieved by way of seeking answers to the following questions:

1. What are the cowpea (*Vigna unguiculata*) landraces found in northern Ethiopia and which ones are most commonly used?
2. Which is more in the farmers' fields? (landraces or commercial varieties of cowpea?)
3. What are the important values of cowpea in northern Ethiopia?
4. What are the production methods and agronomic activities for cowpea production in northern Ethiopia?
5. What are the problems associated with the production of cowpea in northern Ethiopia?
6. What are the similarities and differences among the landraces of cowpea in northern Ethiopia in terms of morphological traits and germination potential?

1.3.2. Research hypotheses

It was hypothesized that:

1. The landrace diversity of cowpea in northern Ethiopia is higher than the currently cultivated improved variety of cowpea.
2. There are no modern cultivars of cowpea released to local farmers in northern Ethiopia.
3. There are variations among local farmers of different geographical areas of northern Ethiopia in their familiarity and utilization of cowpea.

1.3.3. Research objectives

General objective

- ❖ The general objective of this study was to identify and document the landrace diversity and traditional uses of cowpea (*Vigna unguiculata*) in northern Ethiopia.

Specific objectives

1. Make an inventory of cowpea landraces currently cultivated in northern Ethiopia;
2. Collection of seed samples for description, germination tests and germplasm conservation;
3. Collection, identification and documentation of voucher specimens of cowpea landraces;
4. Gather, record and document indigenous knowledge of the people on the ethnobotanical uses of cowpea and
5. Test and document the germination potential of cowpea landrace varieties.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Taxonomy of Cowpea

Cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) is an important pulse crop in many areas of the world (Ouédraogo *et al.*, 2002). According to Ogbemudia *et al.* (2010), cowpea is one of the world's dicotyledonous (leguminous) food crops and a major food crop of millions of people in the developing countries. All cultivated cowpeas are grouped under the species *Vigna unguiculata*, which is subdivided into four cultivar groups (cv. gr.) (1) Unguiculata, grown as a pulse (the common cowpea), (2) Biflora, mainly used as a forage (the catjang), (3) Sesquipedalis (the yard-long bean), grown as a vegetable and (4) Textilis (used for fibers) (Westphal, 1974; Maréchal *et al.*, 1978; Perrino *et al.*, 1993; Singh *et al.*, 1997).

2.2. Origin, Domestication and Distribution

Cowpea plays a critical role in the lives of millions of people in Africa and other parts of the developing world (Timko *et al.*, 2007). However, a lack of archaeological evidence has resulted in contradicting views supporting Africa, Asia and South America being favored its primary center of origin. Some literature sources indicate that cowpea was introduced from Africa to the Indian subcontinent approximately 2000 to 3500 years ago, at the same time as the introduction of sorghum and latter reached to Europe and possibly North Africa from Asia (AFF, 2011). However, the centers of diversity have been identified in both Africa and Asia. The exact region of cowpea domestication is still under speculation. Speculations are that the northern part of the Republic of South Africa (former Transvaal region) was the center of speciation of *Vigna*

unguiculata, owing to the presence of most primitive wild varieties (Timko *et al.*, 2007). They further hypothesized that the species moved northwards from the Transvaal to Mozambique and Tanzania, where the subspecies *pubescens* evolved (Kabululu, 2008; AFF, 2011). According to Sariah (2010); Kabululu (2008); Nwosu *et al.* (2013), based on morphological and cytological evidence, information on its geographical distribution and cultural practices the determination of the origin and domestication of cowpea had been suggested to be southern Africa, while domestication is also believed to have taken place in Africa. Recently, Asia has been questioned as a center of domestication due to the lack of wild ancestors. By reasons of having the highest genetic diversity of the crop and the presence of the most primitive form of wild and cultivated cowpea species abound in the region, southern Africa is the most probable center of domestication (Kabululu, 2008). The crop was introduced from Africa to the tropical Americas in the 17th century by the Spanish in the course of the slave trade. It has been grown in southern USA since the early 18th century (Padulosi and Ng, 1997). Cowpea production has spread to East and Central Africa, India, Asia, South and Central America (AFF, 2011).

2.3. Cowpea Varieties in Ethiopia

According to Thulin (1989), in Ethiopia there are five subspecies of *Vigna unguiculata* subsp. *unguiculata* and *V. unguiculata* subsp. *cylindrica* are mainly cultivated in Harerge Region at altitudes up to 2000 m.a.s.l. for its edible seeds and also the leaves are sometimes used as a green vegetable. *V. unguiculata* subsp. *sesquipedalis* is mainly cultivated in northern Ethiopia and *V. unguiculata* subsp. *dekindtiana* also cultivated in Tigray, Gonder and Ilubabor regions of Ethiopia. Lastly, *V. unguiculata* subsp. *mensensis* is mainly cultivated in Kefa and Gamo Gofa zones of Ethiopia up to 1500 m.a.s.l. The last subspecies according to Thulin (1989) does not have

much difference from *V. unguiculata* subsp. *dekindtiana* while Westphal (1974) did not recognize this subspecies.

2.4. Botanical Characteristics of Cowpea

According to Timko *et al.* (2007), all cultivated cowpea farmers' varieties are considered warm season crops that exhibit a wide range of growth habits and adapted to heat and drought conditions. Thulin (1989), described cowpea as an annual or perennial, erect to climbing herb and reaching heights of 15 - 80 cm with a strong tap root and many spreading lateral roots in the surface soil (Sariah, 2010; Sheahan, 2012). Root depth has been recorded at 22.5 cm depth 8 weeks after planting (Timko *et al.*, 2007). According to Sariah (2010), growth forms vary and many are erect, semi-erect, prostrate or climbing. The stems are striate, smooth or slightly hairy and sometimes tinged with purple (Sheahan, 2012). Sariah (2010), described cowpea leaves are alternate and trifoliate with one terminal and two lateral leaflets. The first pair of leaves is simple or unifoliate and opposite while the second and subsequent leaves are alternate. Leaves exhibit considerable variation in size (6-16 x 4-11 cm) and shape (linear, lanceolate to ovate) and they are usually dark green. The leaf petiole is 5-25 cm long. The shapes of the leaves are mostly hastate, ovate, lanceolate, sub-hastate and rhombic (IBPGR, 1983; Sariah, 2010; Sheahan, 2012).

Flowers and pods arise at the terminal end of peduncles. Flowers have the typical leguminous standard, keel and wings. Usually 2-6 flowers are found per peduncle. The flowers are arranged in racemose or intermediate inflorescence at the distal ends of 5-60 cm long peduncles. Flowers are borne singly or multiples in alternate pairs, with usually only two flowers per inflorescence (Sheahan, 2012). Flowers are conspicuous, self-pollinating, borne on short pedicels and the corollas may be white, dirty yellow, pink, pale blue or purple in color (Thulin, 1989). Flowers open in the early day and close at approximately midday. After blooming (opening once) they wilt

and collapse. The stamens are diadelphous (9 forming a tube of filaments and 1 free). The ovary is straight with a bent style, which is hairy along the inner side and a globular, glandular stigma.

Fruits are dehiscent pods, which usually shatter when dry and vary in size, shape, color and texture. It is pendulous, mostly linear although curved and coiled (crescent-shaped) forms occur. The pod is green at early stage and when maturing it becomes usually yellow, light brown, pink or purple. The pod length may vary ranging from 5.5 – 90 cm (Thulin, 1989).

Seeds vary considerably in size, shape and color. They are relatively large (2-12 mm long) and weigh 5-30 g/100 seeds. Seed shape is correlated with that of the pod (Timko and Singh, 2008). According to Sariah (2010), there are usually 10-20 seeds per pod. Seeds of cowpea cultivar vary considerably in color (such as brown, purple, white and speckled), shape (reniform or kidney shaped, ovoid, rhomboid etc.) and sizes ranging between 0.4 cm to 1.2 cm in length and 0.3cm to 1.0 cm in width. Weigh 5-30 g/100 seeds. Seed coat texture (testa) can be smooth, rough, wrinkle white, green, red, brown, black, speckled, blotched and hilum white surrounded by a dark ring (IBPGR, 1983; Sariah, 2010).

2.5. Environmental Requirements

2.5.1. Climatic requirements

Cowpea is a warm season crop well adapted to many areas of the humid tropics and temperate zones (Timko *et al.*, 2007). According to AFF (2011), cowpeas can grow under both irrigated and non-irrigated systems. The crop responds positively to irrigation but will also produce well under heat and dry land conditions, but intolerant of frost. Drought resistance is one reason that cowpea is such an important crop in the world (Timko *et al.*, 2007). If irrigation is used, more vegetative growth and some delay in maturity may result. Application rates should insure that the crop is not

overwatered, especially in more northern latitudes, as this will suppress growth by lowering soil temperatures (Dugje *et al.*, 2009).

The base temperature for germination is 8.5 °C and for leaf growth 20 °C. Cowpea is a heat-loving and drought-tolerant crop (Timko *et al.*, 2007). The range of minimum and maximum temperatures is between 20 and 30 °C for growth and development (FAO, 1984; Dugje *et al.*, 2009; AFF, 2011). Varieties differ in their response to day length, some being flowering within 30 days after sowing when grown at a temperature around 30 °C. The time of flowering of photosensitive varieties is dependent on time and location of sowing and may be more than 100 days (AFF, 2011).

Cowpea performs well in agro ecological zones where the rainfall range is between 500 and 1200 mm per annum (Dugje *et al.*, 2009) and the altitude range is between 350 and 2000 m.a.s.l. (FAO, 1984). In Ethiopia, cowpea can also grow at mean annual rain fall ranging from 400 - 1500 mm (FAO, 1984; Bilatu Agza *et al.*, 2012). Adequate rainfall is important during the flowering stage. Cowpeas react to serious moisture stress by limiting growth (especially leaf growth) and reducing leaf area by changing leaf orientation and closing the stomata. Flower and pod abscission during severe moisture stress also serves as a growth restricting mechanism (AFF, 2011). According to AFF (2011), cowpeas are also having a great tolerance to waterlogging. Well distributed rainfall is important for normal growth and development of cowpeas. The frequency and unreliability of rainfall pose problems to cowpea growth and development.

2.5.2. Soil requirements

Cowpea performs well on a wide variety of soil conditions, but performs best on well-drained sandy loams or sandy soils where soil pH is in the range of 5.5 to 8.3 which tend to be less restrictive on root growth (FAO, 1984; Bilatu Agza *et al.*, 2012). It is more tolerant to infertile and acidic soils than many other crops. This adaptation to lighter soils is coupled with drought tolerance through reduced leaf growth, less water loss through stomata, and leaf movement to reduce light and heat load under stress (AFF, 2011).

Cowpea like all legumes, form a symbiotic relationship with a specific soil bacterium (*Rhizobium* spp.). *Rhizobium* makes atmospheric nitrogen available to the plant by a process called nitrogen fixation. Fixation occurs in root nodules of the plant and the bacteria utilize sugars produced by the plant (Timko *et al.*, 2007). Although cowpea *Rhizobium* is normally widespread, seed inoculation with *Rhizobium* specific to cowpea would be beneficial in areas where it is not present. Excess nitrogen (N) promotes vegetative growth, delays maturity, may reduce seed yield and may suppress nitrogen fixation. The plant will perform well under low N conditions due to a high capacity for N fixation (Gbaguidi *et al.*, 2013).

2.6. Adaptability of Cowpea for Drought Stress

Cowpea is grown extensively in the low lands and mid altitude regions of Africa sometimes as sole crop but more often intercropped with cereals such as sorghum and maize (Agbogidi, 2010). It is now grown worldwide, especially in the tropics. It is a warm season crop that can be produced in semi-arid regions and dry savannas. It is better adapted to sandy soils and under drought conditions (Sheahan, 2012). It is often grown in rain fed agriculture receiving at least 300 mm annual rainfall and adapted to a temperature range of 20 to 35⁰C and a wide extreme of moisture conditions. In a good drainage condition, cowpea grows in a wide range of soil textures,

from heavy clays to sands, growing best in slightly acid to slightly alkaline soils (Bilatu Agza *et al.*, 2012).

2.7. Growth Habit

Cowpea is a warm-season, annual and herbaceous legume. Plant types are often categorized as erect, semi-erect, prostrate or climbing (Timko *et al.*, 2008; Timko and Singh, 2008). Most cowpea plants are indeterminate in growth habit. However, some of the newly developed early maturing varieties have a determinate growth phenotype. Early flowering cowpea genotypes can produce a crop of dry grain in 60 days, while longer season genotypes may require more than 150 days to mature, depending on photoperiod (Timko and Singh, 2008).

2.8. Germplasm Collections and Conservation

Cowpea germplasm is maintained in collections around the world with varying levels of accessibility and documentation. The largest collections are held by the IITA with more than 14,000 accessions (Timko *et al.*, 2007). The United States Department of Agriculture (USDA) maintains a collection with ca. 8,000 accessions. Access to this collection is through the USDA Germplasm Resources Information Network or GRIN system (www.ars-grin.gov). The University of California-Riverside has a collection with ca. 5,000 accessions accessible on a Microsoft Access database. There is also a large collection of Mediterranean and African landraces (ca. 600 accessions) held at the Istituto di Genetica Vegetale at Bari, Italy (www.ba.cnr.it) (Timko and Singh, 2008). The collection mission is done yearly and the number of accessions is expected to rise with time (Sariah, 2010). According to EBI (2014) data base, a total of 94 accessions of cowpea germplasm were collected by Ethiopian Biodiversity institute.

2.9. Socio-economic Importance of Cowpea

Cowpea is one of the most economically and nutritionally important indigenous African grain legumes produced throughout the tropical and subtropical areas of the world (Lowenberg-DeBoer and Ibro, 2008). Cowpea is a multifunctional crop, providing food for human and feed for livestock, as concentrate for farm animals, hay, silage, pasture, soil cover and green manure (Westphal, 1974) and it is a cash generating commodity for farmers, small and medium-size entrepreneurs (Timko and Singh, 2008).

Although cowpea is mostly utilized as a dry grain and animal fodder crop, cowpea leaves are also used as a high-protein pot herb in many countries of Africa (Pottorff *et al.*, 2012). It can also be used as cover crop (Timko and Singh, 2008). The very early maturity characteristics of some cowpea varieties provide the first harvest earlier than most other crops during production period. This is an important component in hunger fighting strategy, especially in the Sub-Saharan Africa where the peasant farmers can experience food shortage a few months before the maturity of the new crop (Sariah, 2010).

Cowpea grains are consumed as food and feed to livestock as a nutritious fodder (Singh *et al.*, 2003). The young leaves and shoots are consumed as spinach or vegetable and provide one of the most widely used pot herbs in tropical Africa; they are often dried and stored for dry season use (Westphal 1974; Zia-Ul-Haq *et al.* (2013).

Its drought tolerance, relatively early maturity and nitrogen fixation characteristics fit very well to the tropical soils where moisture and low soil fertility is the major limiting factor in crop production (Timko and Singh 2008). Cowpea is among the dominating grains legumes traded almost in all local markets especially in the Sub-Saharan Africa.

Cowpeas are usually resorted to as hay or grazing crop when a too low rainfall or lack of irrigation water does not permit the production of fine-stemmed and easily cured fodder. The best stage for cutting is when the first pods turn yellow. At that stage the leaves and pods still contain over 60% of the original quantity of crude protein and then loss of leaves during drying and handling of the hay is lowest (Westphal, 1974). In Ethiopia cowpea seeds are used in "WET", or ground into flour for the preparation of various foods. The CHAKO in south-west Ethiopia eat the leaves as spinach (Westphal, 1974).

2.10. Nutritional Value of Cowpea

Many researchers have examined and reported on the nutritional quality of cowpeas. Grain legumes are important source of proteins for food and can therefore validly replace animal protein in the regions of the Third World where plant production is by far more important than animal production (Nielson *et al.*, 1997; Sariah, 2010). Cowpea can be used at all stages of growth as a vegetable crop and the leaves contain significant nutritional value. The tender green leaves are an important food source in Africa and are prepared as a pot herb, like spinach (Westphal, 1974; Timko *et al.*, 2007). Dry grain for human consumption is the most important product of the cowpea plant, but fresh or dried leaves (in many parts of Asia and Africa) (Nielsen *et al.*, 1997; Timko *et al.*, 2007) and fresh green pods may be the most important in some local situations (Ehlers and Hall, 1997). Cowpea hay plays a particularly critical role in feeding animals during the dry season in many parts of West Africa (Westphal, 1974; Singh and Tarawali, 1997; Timko *et al.*, 2007).

Cowpea seeds possess high nutritive value in terms of minerals and vitamins (Ghalmi *et al.*, 2010). It has been reported that folic acid, a vitamin B necessary during pregnancy to prevent birth defect in the brain and spine content is found in higher quantity in cowpea compared to other

plants (Hall *et al.*, 2003; Timko and Singh, 2008). Total seed protein content in seed ranges from 23% - 35% of the seed weight (Westphal, 1974; Sariah, 2010). The total crude protein in foliage ranges from 14-21% and in crop residues it is 6-8%. This crop has no any toxicity effect (Sariah, 2010). Fat contents of 100 advanced breeding lines of cowpea from IITA showed a range in fat contents from 1.4 to 2.7% and fiber content is about 6% (Phillips *et al.*, 2003; Timko *et al.*, 2007).

2.11. Production System

In agriculture, cowpea has traditionally exceptional importance for dry savannas of Africa because it requires relatively little water, which is a big limiting resource in these areas (Kabululu, 2008). The majority of cowpea is grown by subsistence farmers in west and central sub-Saharan Africa, where its grain and leaves are highly valued for food and forage (Timko and Singh, 2008). The area along the coast covers eastern and southern parts of Africa including countries like Somalia, Kenya, Tanzania and Mozambique.

According to Timko *et al.* (2008), about 70% of cowpea production occurs in the drier Savanna and Sahelian zones of West and Central Africa, where the crop is usually grown as an intercrop with sorghum (*Sorghum bicolor* (L.) Moench). It is normally grown alone as pure crop in the coastal regions and as mixed crop with maize (*Zea mays* L.) (Blade *et al.*, 1997; Timko and Singh, 2008).

In Eastern Africa most of the farmers prefer to grow a dual purpose cowpea, which is a type where both leaves and grains are the final important products. In addition, it is common that many growers who are actually engaged in producing a dual purpose cowpea sequentially harvest leaves along the growing period followed by seed harvest at the end of the season (Kabululu, 2008).

2.12. Production Constraints

In the developing world most of the cowpea is grown without the use of fertilizers and plant protection measures such as pesticides and herbicides (Singh, 2005; Timko *et al.*, 2007). Both abiotic and biotic stresses can result a significant yield reduction in cowpea (Hall *et al.*, 1997; Timko *et al.*, 2007; Sariah, 2010). Despite cowpea being more drought tolerant than many other crops, still moisture availability is the major constraints to growth and development, especially during germination and flower setting. Erratic rainfall affects adversely both plant population and flowering ability resulting into tremendous reduction of grain yield and total biomass in general (Timko and Singh, 2008; Sariah, 2010).

The biotic factors that cause yield reduction include a wide range of insect pests, parasitic flowering plants, as well as viral, fungal and bacterial diseases (Emechebe and Lagoke, 2002; Timko and Singh, 2008). Under proper insect pest management the yields are as high as 2.0 t/ha compared to the low average yields (1.0 t/ha) normally experienced in subsistence farming in West and Eastern Africa (Timko and Singh, 2008). The abiotic factors include poor soil fertility, drought, heat, acidity and stress due to intercropping with cereals (Singh and Tarawali, 1997).

2.12.1. Biotic stress

Diseases

Cowpea is susceptible to a wide variety of pests and pathogens that attack the crop at all stages of growth (Timko *et al.*, 2007). For many bacterial, fungal and viral diseases, effective screening techniques have been developed that allow researchers to identify cultivars with potential sources of resistance (Ehlers and Hall, 1997). For instance cowpea wilt caused by *Fusarium oscysporium*, cowpea root rust caused by a nematode (*Meloidogyne ssp*) and cowpea bacterial blight caused by

Xanthomonas vignicola. Losses due to pest attacks or diseases can be as high as 90% (IITA, 2000). Cowpea is attacked by over 35 major diseases caused by viruses, bacteria, fungi, and nematodes (Lin and Rios, 1985; Patel, 1985). The occurrence, severity, and yield loss due to each disease and mixed infections vary from place to place, but some diseases occur and cause significant damage across the cowpea growing regions of the world (Emechebe and Florini, 1997).

In general, good progress has been made using conventional breeding techniques to move resistance to various bacterial, fungal, and viral diseases, parasitic weeds (*Striga gesnerioides* and *Alectra vogelii*) (Sariah, 2010), and root-knot nematodes into farmer-acceptable germplasm. Resistance to these pathogens and parasites is usually governed by single genes that are often effective only in a restricted region due to pathogen/parasite variability and may be overcome in a relatively short period of time. Marker-assisted selection can be helpful in assembling more durable resistance by incorporating an array of resistance genes from other regions as discussed below (Timko and Singh, 2008).

Insect pests

Insect pests belong to the major biotic stresses in cowpea growing regions in both developing and developed countries (Timko and Singh, 2008). In East Africa cowpea production is mainly constrained by insect pests such as aphids, thrips, cowpea weevil, parasitic weed and a multiple of sucking bugs and leaf eating beetles (Sariah, 2010). One of the major insect pests in East Africa is cowpea aphid (*Aphis craccivora* Koch) (Obopile and Ositile, 2010). Cowpea crop has been reported to be infested with two species of thrips, *Sericothrips occipitalis* and *Megalurothrips sjostedti* (Thripidae) (Ezueh, 1981). According to Omo-Ikerodah *et al.* (2009), yield losses ranging from 20 to 80% are due to thrips infestation. The cowpea weevil (*Callosobruchus*

maculatus (Fabricius)) is the most important postharvest storage pest of cowpea. The weevils occur wherever the cowpea is grown. The adult beetles are small (3 mm long) and orange-brown with dark markings (Sariah, 2010). The parasitic weed (*Striga gesneriodes*) also poses a major threat to cowpea production in Africa (Timko and Singh, 2008; Sariah, 2010).

2.12.2. Abiotic stress

Environmental Stress

While cowpea is inherently more drought tolerant than other crops, water availability is still among the most significant abiotic constraints to growth and yield. Erratic rainfall at the beginning and towards the end of the rainy season adversely affects plant growth and flowering resulting in a substantial reduction in grain yield and total biomass production. The use of early maturing cultivars helps farmers escape the effects of a late season drought, but plants exposed to intermittent moisture stress during the vegetative or reproductive stages will perform very poorly (Timko and Singh, 2008).

CHAPTER THREE

3. MATERIAL AND METHODS

3.1. Description of the Study Area

3.1.1. Geographical location

The research was conducted in two regions of northern Ethiopia, namely Tigray and Amhara regions. The study area lies between 10° 00' to 14° 00' North latitude and 38° 00' to 40° 00' East longitude with an altitudinal range from 1260-2140 m.a.s.l. These study areas were located purposively in areas found to be suitable for cowpea based on the FAO (1984) and MoA (2000). In Tigray Region, the study was conducted in three weredas, namely Kola Temben, Tanqua Abergelle and Werie Leke which are found in the Central Tigray Zone of the Region. In Amhara Region the study was carried out in five weredas, namely Bati (Oromia Special Zone), Kalu (South Wello), Lasta Lalibela (North Wello), Sekota and Abergelle found in Waghimra Zone of Amhara Region (Figure 1).

3.1.2. Topography and agro-ecological zone

Amhara and Tigray regions have topographic setups of very diverse nature. Lowland, midland and highland plains, mountains, rugged lands, undulating landforms, chains of plateaus are common land features in the regions (ANRS, 2013). Agro-ecological zones of Ethiopia are traditionally classified into six categories with traditional names assigned to each zone, based on altitude and temperature: Bereha or hot lowlands (below 500 m), Kola or lowlands (500-1500 m), Weinadega or midlands (1500-2300 m), Dega or highlands (2300-3000 m), Wurch or highlands (3000-3700

m) and Kur or highlands (above 3700 m) (MoA, 2000). In terms of the traditional agro-ecologic classification, Amhara Region is composed of Bereha (3%) Kolla (22%), Woinadega (44%) Dega (27%), Wurch (3.6%) and high Wurch or Kur (0.4%) (ANRS, 2013). Tigray Region generally falls mainly into four major agro-ecological zones, namely arid-lowlands in the extreme Eastern part; semi-arid in the North-western part; tepid to cool sub-moist in the central part; and hot-warm sub-moist in the South-western part (TFAP, 1996). Hence, the study area falls in three climatic zones of Kolla, Weinadega and Dega which correspond to the arid areas of low lands, the mid altitude with mild climate and the high altitude with cold climate respectively.

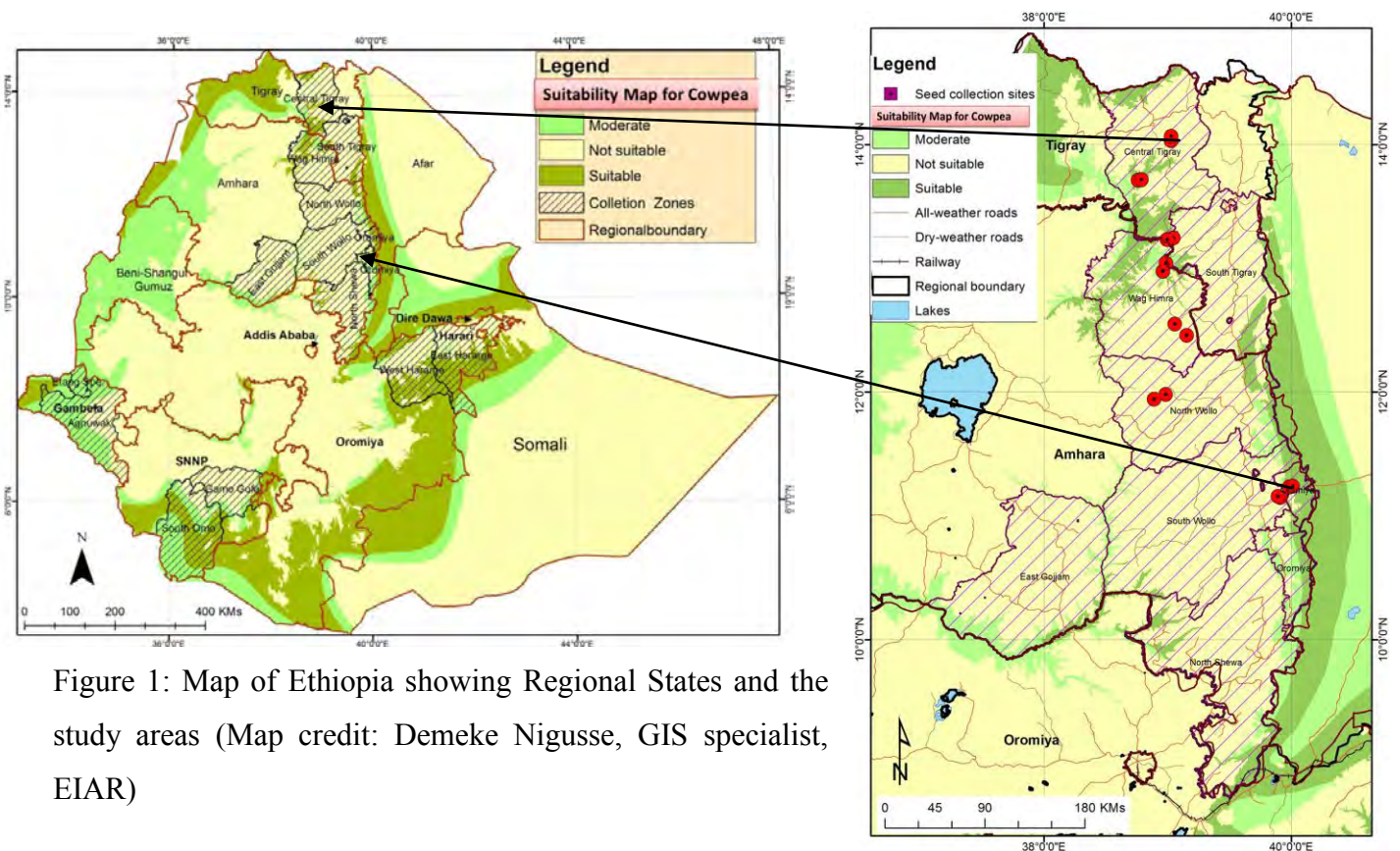


Figure 1: Map of Ethiopia showing Regional States and the study areas (Map credit: Demeke Nigusse, GIS specialist, EIAR)

3.1.3. Climate

Based on the data collected by the National Meteorological Service Agency (NMSA) of Ethiopia, the mean annual maximum and minimum temperatures of the study area for the last ten years were ranging from 27.6 – 33.2 °C and 11.2 – 18.1 °C respectively. The maximum temperature of the area is generally high in April, May and June but relatively lower in the months of November, December and January. According to the information obtained from the NMSA of Ethiopia, the average annual rainfall of the study area ranges from 562 – 1257 mm. The distributions of rainfall in all study areas remain similar with a long dry season from the beginning of September to the end of June. The study areas obtain high amount of rain during the months of July and August whereas the lowest mean annual rainfall was recorded in December, January and February. The detail description on climatic condition of the study area is displayed in Figure 2. From the study areas, Bati and Kalu appear to have a slightly bimodal rainfall pattern whereas all the areas are unimodal. Most of the study areas are characterized by a short growing season (about three months of wet period) and a long (8-9 months) dry season.

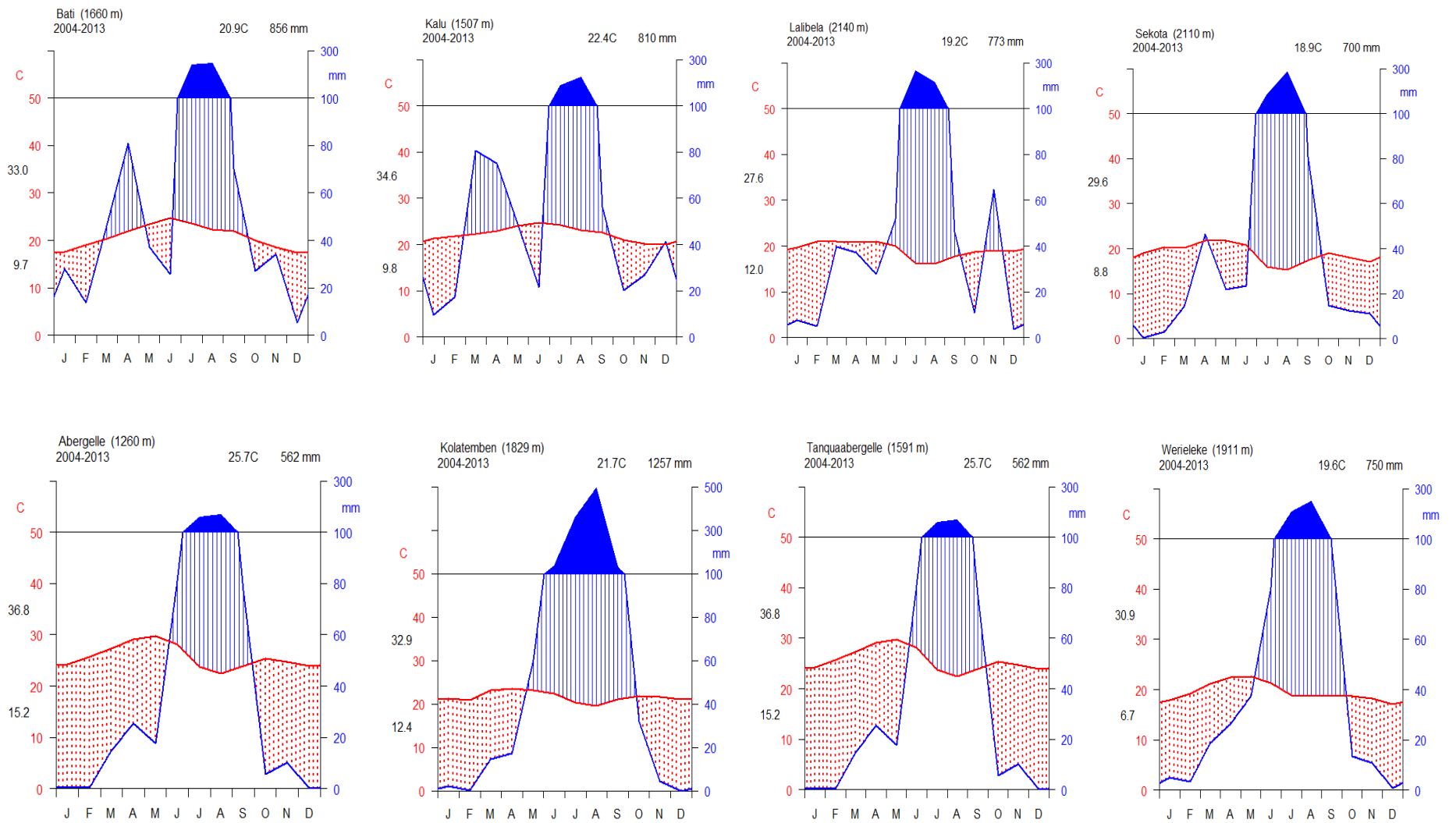


Figure 2: Climate diagram of the study areas (Data source: NMSA)

3.1.4. Demography and livelihood

In the study areas, the main economic activities of the people are rain fed crop cultivation mixed with animal production and petty trading. Amhara, Oromo, Agew and Tigre communities with different religions (Christians, Muslims, and others) live together in the study areas (ANRS, 2013). Amhara Region is large but it's a highly populated Region in Ethiopia, the total number population in the study areas was estimated by Central Statistical Agency of Ethiopia for the year 2012 to be 118,176 (Bati), 203,494 (Kalu), 129,464 (Lasta Lalibela), 121,030 (Sekota), 46,509 (Abergelle), 149,346 (Kola Temben), 104,686 (Tanqua Abergelle) and 164,986 (Werie Leke). Males constituted 50.01% of the population while females made the remaining 49.99%. The population projection figures in this issue are based on the results of the May 2007 National Population and Housing Census of Ethiopia CSA (2011).

3.1.5. Land use

It is rather difficult to obtain reliable statistics on major crops grown and production area coverage from each wereda due to lack of maintaining separate records on crops produced. Based on information available from Governmental Administrative Offices of Agriculture (GAOA) and via correspondence with extension experts of forage department some data were described in the Appendix 4 except for Sekota Wereda. The major crops grown in the study area are described in Table 1. Different crop types are cultivated in the study areas, as the local people lead their life based on crop production and livestock rearing. Individual farmer production is for household consumption and local markets. Agricultural production is based on rain fed cultivation and few irrigation activities are found around Werie Leke Wereda. Accordingly, six species of cereals, six species of pulses and six species of oil crops are cultivated. Major cereal crops cultivated in the study areas include sorghum, teff, maize, wheat, finger millet, oat, sesame, barley, flax and lentil.

Cereal crop coverage in the study area is highest for sorghum, teff and maize in that order. Legumes cultivated are cowpea, faba bean, field pea, chickpea and mungbean. Consequently, cowpea is grown as a major crop in Tanqua Abergelle and Bati weredas while in other weredas of the study areas it is grown as a minor crop.

Table 1: Major crops grown in the study areas

Crop category	Scientific name	Family	Common name
Cereals	<i>Eleusine coracana</i> (L.) Gaertn	Poaceae	Finger millet
	<i>Eragrostis tef</i> (Zucc.)Troteer	Poaceae	Teff
	<i>Hordeum vulgare</i> L.	Poaceae	Barley
	<i>Sorghum bicolor</i> .L.	Poaceae	Sorghum
	<i>Triticum aestivum</i> L.	Poaceae	Wheat
	<i>Zea mays</i> L.	Poaceae	Maize
Pulses	<i>Cicer arietinum</i> L.	Fabaceae	Chikpea
	<i>Phaseolus vulgaris</i> L.	Fabaceae	Haricot beans
	<i>Pisum satium</i> L.	Fabaceae	Field pea
	<i>Vicia faba</i> L.	Fabaceae	Horse beans/ Faba bean
	<i>Vigna radiata</i> (L.) Wilczek	Fabaceae	Mungbean
	<i>Vigna unguiculata</i> (L.) Walp.	Fabaceae	Cowpea
Oil crops	<i>Linum usitatissimum</i> L.	Linaceae	Flax/ Lin seed
	<i>Sesamum orientale</i> L.	Pedaliaceae	Sesame

3.2. Material Used in the Research

Representatives of cowpea landrace accessions collected from different geographical origins of northern Ethiopia were used for germination testing and materials like petri-dish, alcohol, distilled water and tissue paper were used to conduct the experiment. Voucher specimens of cowpea landraces were used for identification based on morphological characteristics. In addition, the materials such as plant press, GPS, plastic bag, note book, secateurs and digital photo camera was used during the field work.

3.3. Methods

3.3.1. Site selection

Based on the ecological requirements of the crop (Appendix 3) and the help of wereda agricultural office workers; a total of five zones comprising eight weredas with 16 kebeles were purposively sampled for the study. In order to have valuable information on landrace diversity, use and traditional production systems, it was decided to sample from those kebeles where cowpea is highly produced. Hence, 16 kebeles were selected purposely for the study i.e., two kebeles from each wereda. Whenever a wereda was found to contain more than two kebeles, the two considered most significant cowpea production areas by local farmers were selected for the study. The other selection criterion was accessibility of the area and the final reason was due to time constraint. The zones, weredas, kebeles and the total number of informants used in the study are listed in Table 2.

Table 2: Regions, zones, weredas and kebeles used in the study

Region	Zone	Wereda (Wereda)	Kebele	Number of informants
Amhara	Oromia Special Zone	Bati	Melka Lugo	10
			Bira	
	South Wello	Kalu	Abecho	10
			Arabu	
	North Wello	Lasta Lalibela	Gelesot	10
			Shumshuha	
	Waghimra	Sekota	Hamusit	10
			Weleh	
		Abergelle	Maernet	10
			Saka	
Sub total				50
Tigray	Central Tigray	Kola Temben	Derene Tseb	10
			Newi	
		Tanqua Abergelle	Hadnet	10
			Lemlem	
		Werie Leke	Enda Chewa	10
			Zongi	
Sub total				30
Grand total				80

3.3.2. Informant selection

After selection of the study sites, a total of 80 informants (61 males and 19 females) aged 21 to 71 were randomly selected. Ten individuals from each wereda i.e. from each kebele 4-6 persons were used for interview. The selection of key informants and information regarding the knowledge of local farmers about cowpea was first gathered with the local guide and local agricultural extension experts of each wereda.

3.3.3. Ethnobotanical data collection

The required research data were collected from September 2014 – January 2015. Semi structured interview, field observations and market surveys as described by Martin (1995) and Alexiades

(1996) were used for both botanical and ethnobotanical data collection. Voucher specimens were collected from farmers' fields as described in IBPGR (1983) descriptor list for cowpea. The botanical information (passport data) of the crop were collected using GPS. Colored photos of cowpea accessions were also used for ensuring the understanding of farmers and local guides to show where cowpea is growing as well as to know the local name of the crop before starting the interview. The field data were collected using primary and secondary data sources. Primary data to obtain a representative idea of the crop (plant specimens, seed samples and ethnobotanical information) were collected from farmers' field, threshing grounds, home gardens and local market places. Secondary data also were collected both from offices of governmental and non-governmental organizations including agriculture and development offices and the National Meteorological Service Agency. Additional data were sourced from local communities and researchers.

Field observation (guided field walk)

During guided field walk, the interview was conducted while walking through the study sites to collect the data on cowpea landraces. Field observation was supported by local guides, language translators (when necessary) and participating informants to obtain the necessary information on how cowpea is cultivated, intercropped, used and marketed and the resulting data were recorded. Voucher specimen and germplasm collections were conducted in the farmers' field, threshing grounds and local markets of the study area. The local perspectives on major crops produced and soil type of the study areas were identified by the researcher through personal observation and discussion with local experts.

Semi-structured interview

The checklists of semi-structured questions (Appendix 1) were employed for discussion and interviewing the informants to record and collect the required information based on the objectives of the research. The methods, procedures and techniques were used according to Martin (1995) and Alexiades (1996). Group discussion was also conducted with individual local resource users and informants to record their general impressions about cowpea production, utilization and management.

Market Survey

During data collection, market survey was undertaken in the markets of the different weredas to record the cowpea landraces that are sold in the market together with information on market values. This is especially a good method to conserve landraces of cowpea that have high economic value. Therefore, local markets in the study areas were visited and observations on use and market value of the crop were conducted with cowpea producers and/or sellers at the market to record and determine the value or income generated from such practices.

3.3.4. Voucher specimen collection and identification

In order to identify and describe cowpea landraces at subspecies and local variety levels by using qualitative and quantitative traits, specimen collection was carried out between 20th September and 10 October, 2014. The voucher specimens of cowpea landraces were identified by local and/or scientific names and then pressed, dried and brought to the National Herbarium (ETH), AAU, for further identification, confirmation and characterization. Hence, both qualitative and quantitative traits of collected specimens were identified and categorized based on similarity of morphological traits. Identification of voucher specimens collected from the study areas was

attempted in the field while doing observations and confirmed at the National Herbarium using taxonomic keys in the Flora of Ethiopia and by comparison with already identified herbarium specimens. Further confirmation of the accuracy of the identification was made with the assistance of taxonomic experts. Finally, the identified specimens were stored at the National Herbarium as reference material for educational and research purposes.

3.3.5. Germination Data Collection

The germination experiment was carried out at the laboratory of Ethiopian Biodiversity Institute (EBI) following Amador and Dieguez (2000) procedures. Homogeneous (in size, shape and color) cowpea landrace seeds were selected and subjected to germination percentage evaluation. The experiment was conducted using nine treatments replicated four times and ten seeds per petri dish were imbibed by soaking in water for 24 hours at room temperature. After these procedures, all the petri dishes were sterilized using alcohol and washed with distilled water; the petri dishes were arranged randomly on the table; filter papers were placed on each petri dish and ten imbibed seeds were placed on each petri dish; distilled water was applied equivalently on each petri dish and seeds were germinated at 30⁰C. Germination counts were taken for eight respective days starting from sowing of seeds. Germination for each treatment was calculated as germination percentage (GP), considering the number of germinated seeds as a percentage of the total number of tested seeds ($GP = \text{germinated seed}/\text{total tested seed} \times 100\%$).

3.4. Data Analysis

Ethnobotanical data were summarized in tables and figures and analyzed using both quantitative and qualitative methods as recommended by Martin (1995), Cotton (1996) and Phillips (1996). Descriptive statistics, preference ranking and informant consensus tools were used to analyze the

quantitative data. MS Excel 2010 was used to quantify and sort data, determine proportions, and draw bar graphs and tables. Climate diagrams of study areas were analyzed using R environmental and ecological data analysis software.

3.4.1. Descriptive statistics

Both qualitative and quantitative analytical tools of ethnobotany were used for data analysis following the relevant approaches of Phillips (1996) and Cotton (1996). Ethnobotanical data were analyzed by entering into the excel spreadsheet and summarized using descriptive statistics to identify the most common widely used cowpea landrace in the study areas. To determine proportions of different landraces, growth forms, source of collection, degree of scarcity, plant parts used, method of preparation and others, such as various ethnobotanical scoring and ranking methods, percentage frequency methods and inferential statistics was employed in order to test the consistency of respondents' information and to obtain scientifically more reliable results. Then the results were presented using graphs, charts and tables as well as in text form.

3.4.2. Preference ranking and informant consensus

Preference ranking was the simplest analytical tool used for this study. This method allows the calculation of a numerical index which gives an estimate of factors for a given crop species. In preference ranking, each informant was asked to arrange a group of items according to a given criterion such as personal preference or importance of cowpea. Each item is then assigned a value, with the most important ranking highest, while the least important one is assigned a value of lowest number (Cotton, 1996). In addition, for ethnobotanical data analysis informant consensus method was employed (Phillips, 1996). The informant consensus values were calculated from free listing data collected during interviews and summarized in tabular form.

CHAPTER FOUR

4. RESULTS

4.1. Cowpea Landrace Diversity in Northern Ethiopia

A total of 54 cowpea germplasms were collected in the 16 surveyed kebeles. Among these, 45 were local varieties (83%) and nine were commercial varieties (17%) introduced by MARC (Appendix 2). Phenotypic diversity were observed in terms of growth habit, seed color and seed size (Table 4 and Appendix 5). In northern Ethiopia, there is production of cowpea in Amhara Region mainly at Bati, Kalu, Lasta Lalibela, Sekota and Abergelle weredas and in Tigray Region cowpea is highly produced at Kola Temben, Tanqua Abergelle and Werie Leke weredas (Table 3). In addition to the study areas, the collection was also carried out in the market place of Haik, Raya Kobo, Abi Adi, Desse, Shewarobit, Ataye and Enebse Sarmidir weredas (Figure 3).

Table 3: Cowpea germplasm collection in northern Ethiopia

Place of collection (Administrative weredas)	Agro ecology (Traditional zone)	Altitude range (m.a.s.l.)	Number of collection		Total number of collection
			Landrace variety	Improved cultivar	
Abergelle, Efratanagidem, Raya Kobo, Tanqua Abergelle, Kalu, Shewarobit	Kolla (lowlands)	500 - 1500 m	10	3	13
Kola Temben, Tanqua Abergelle, Werie Leke, Abergelle, Kalu, Bati, Abi Adi, Lasta Lalibela, Sekota, Haik, Enebse Sarmidir	Woina Dega (midlands)	1501 - 2300 m	35	6	41
Total number of collection			45	9	54
Percentage			83%	17%	100%

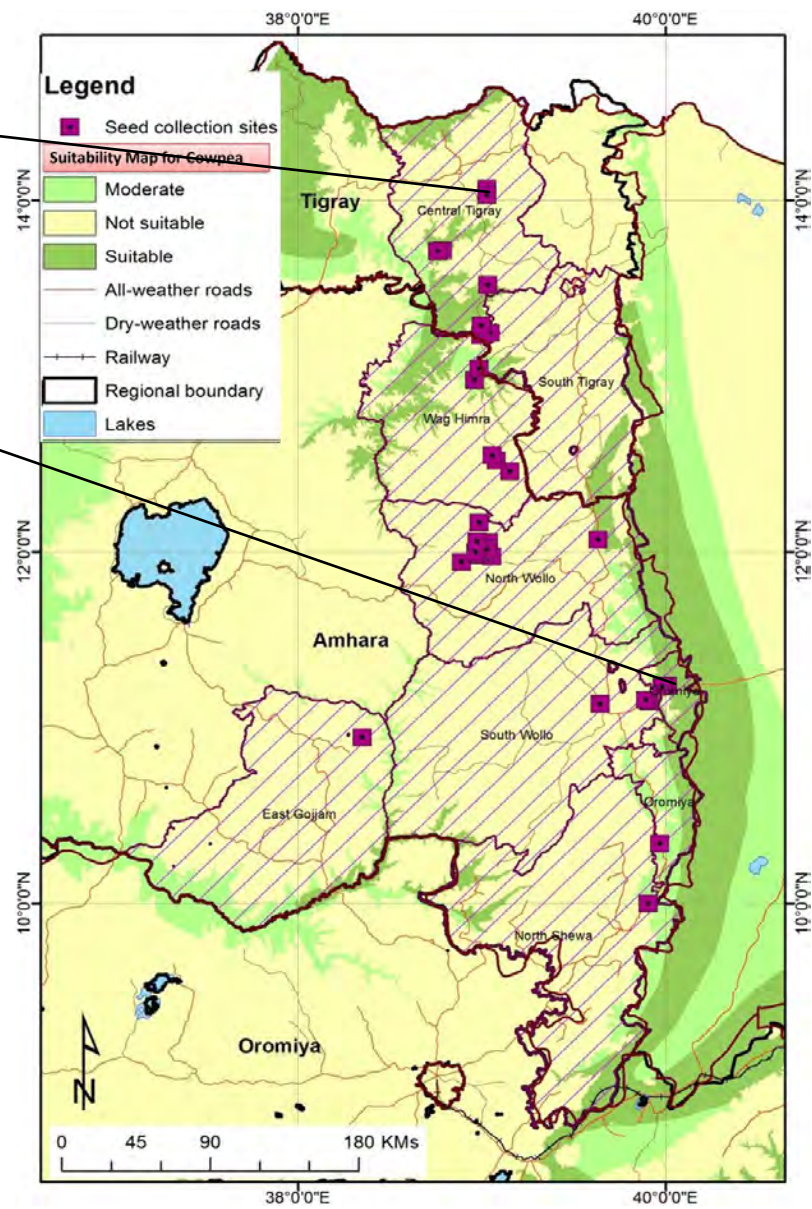
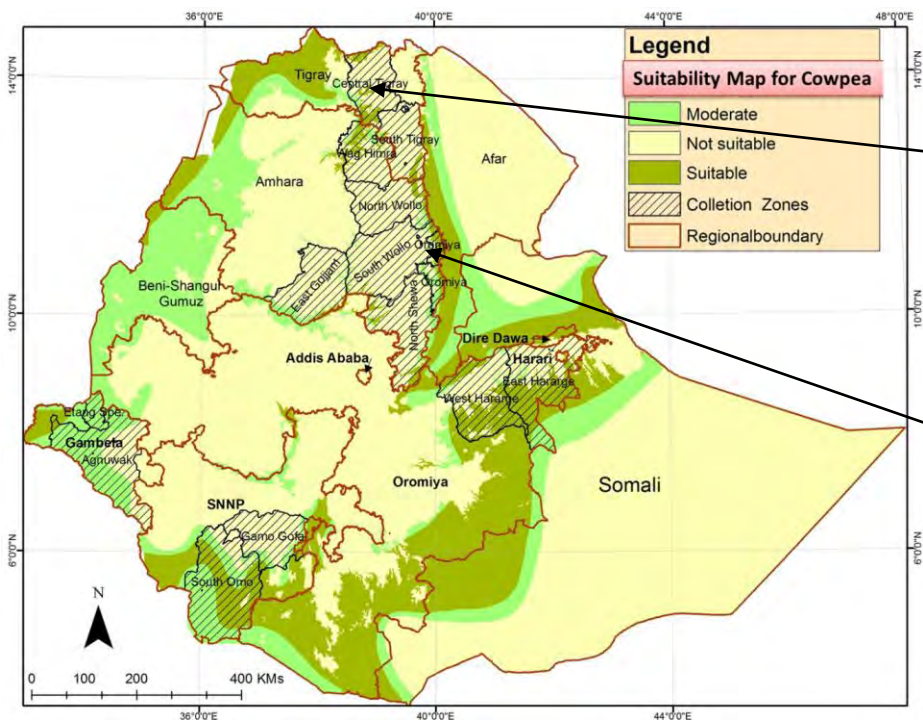











Figure 3: Map of Ethiopia showing Regional State and collection zones for cowpea landrace (Map credit: Demeke Nigusse, GIS specialist, EIAR)










Table 4: Diversity of cowpea landraces cultivated in northern Ethiopia as revealed by seed morphology

Seed sample of cowpea landraces	Local name	Language	Place of collection
	ADENGOR, ADAGURA, DEKAK ADAGURA, ADENGUARIE and DEKAK ADAGURA	Tigreña	Tanqua Abergelle and Kola Temben
	TEKEMICHE, KIMITE and SEREKULA	Amharic	Bati and Kalu
	TEKEMICHE, KIMITE and SEREKULA	Amharic	Bati and Kalu
	CHEKELE, EGOYLA	Amharic and Agewgna	Lasta Lalibela, Sekota, Abergelle and Enebse Sarmidir
	ADENGOR, ADAGURA, DEKAK ADAGURA, ADENGUARIE and DEKAK ADAGURA	Tigreña	Tanqua Abergelle, Kola Temben and Werie Leke
	JERGADIE		Bati and Kalu
	ADENGOR, ADAGURA, DEKAK ADAGURA, ADENGUARIE and DEKAK ADAGURA	Tigreña	Werie Leke
	CHEKELE and KIMITE	Amharic	Bati and Enebse Sarmidir
	JERGADIE	Amharic	Bati and Kalu

4.1. Germination Potential of Cowpea Landraces

The experiment results showed that the germination percentage of representative cowpea landraces namely, CTW 01, DBK 03, DBG 04 and NWL 09 were absolutely germinated (100%) and CTRLR 02, AK 06 and DBW 07 were germinated between 92 – 95% within five days. Consequently, two cowpea landrace varieties (DBB 05 and CTR 07) collected from Bati and Central Tigray showed lower germination percentage (72% and 75% respectively). This means that there is no germination problem within cowpea landraces. But numerically they showed considerable difference from each other (Table 5).

Table 5: Representatives of cowpea landrace accessions subjected to germination percentage evaluation

Accession Code	Sources of collection	Germination Percentage (%)
 CTW 01	Central Tigray	100
 CTRLR 02	Central Tigray	92.5
 DBK 03	South Wello and Oromia Special Zone	100
 DBG 04	South Wello	100
 DBB 05	East Gojam and Oromia Special Zone	72.5
 AK 06	South Wello	95
 DBW 07	Oromia Special Zone	95
 CTR 08	Central Tigray	75
 NWL 09	North Wello, Waghimra and East Gojam	100

4.2. Vernacular Names of Cowpea

Local farmers are generators and information base for modern taxonomy since indigenous knowledge's are adaptive skills of the local farmers that are acquired informally through interaction with the natural environment. Accordingly, cowpea had different names in different areas of northern Ethiopia by local farmers based on multipurpose and unique characteristics of the crop (Table 6).

Table 6: Vernacular names and interpretation of cowpea landraces in northern Ethiopia

Vernacular name of cowpea farmers variety	Language	Meaning of the name	Agro ecology	Source of collection
TEKEMICHE, KIMITE and SEREKULA	Amharic	Drought resistant herb	Woina Dega and (midlands)	Kalu and Bati
JERGADIE	Amharic	A climber which has big size seed		
ADENGOR	Tigregna	Green pulse crop	Kolla (lowlands)	Abergelle
EGOYLA	Agewgna	A crop which is mainly used during shortage of food	Woina Dega (midlands)	Sekota
CHEKELE	Amharic	Drought tolerant herb and can grow in dry season	Woina Dega (midlands) and Dega (highlands)	Lasta Lalibela
ADENGOR, ADAGURA, DEKAK ADAGURA, ADENGUARIE	Tigregna	A pulse crop with small size grain mainly used for animal feeding	Woina Dega (midlands)	Kola Temben and Tanqua Abergelle
LAHIM ATER	Tigregna	A pulse crop mainly used for animal feeding	Woina Dega (midlands)	Werie Leke

4.3. Farmers' Knowledge and Utilization of Cowpea

All eighty farmers' that were interviewed from northern Ethiopia in eight weredas claimed to know modern agricultural production system especially in pre and post-harvest technology. The majority of the farmers interviewed (75%) grew the erect type of cowpea in North Wello, Central Tigray and Waghimra zones. A reasonable number of farmers (25%) grew both erect and prostrate or spreading types of cowpea mainly in Kalu and Bati weredas. This is because in Bati and Kalu local farmers grew cowpea when the soils are more degraded and/or livestock more important. The majority preferred the erect type because they perceived the ability to produce grains during famine season because of the early maturing habit of the crop. Furthermore, local farmers preferred the erect types of cowpea for different reasons such as, high grain and straw yield, disease resistance, drought tolerance, adaptability to all types of soil, early maturity, market value, food quality, feeding value and the multiple purpose of the crop. The spreading type of cowpea produced much more leaves than grains and mainly the farmers used this type for improving soil fertility. Both grains and leaves or straw were the expected products of cowpea for all of the farmers who participated in the interview.

Based on results of the primary data, cowpea contributes to smallholders' income as a higher-value crop like cereals and to diet as a cost effective source of protein intake especially in Central Tigray, South Wello and Oromia Special zones of northern Ethiopia. While in Amhara Region, cowpea is mainly used for human food in the form of boiled grain (NIFRO), baked or thin bread (KITA) and sauces (SHIRO WET) (Table 8). The seeds are a major source of plant proteins and vitamins for human, feed for animals and also a source of income. The immature pods are occasionally eaten as raw vegetable in South Wello and Oromia Special zones. Moreover, cowpea also plays an important role in improving soil fertility for cereal crops (such as sorghum

and maize) when grown via intercropping and crop rotation. Therefore, informants were asked to explain the use of cowpea as food, income source, forage, medicinal use and improving soil fertility. Table 7 gives detailed information provided by eight key informants, where again the best use of cowpea for a given wereda receives the highest ranking value five (5), while the least useful is assigned a ranking value of two (2).

Table 7: Preference ranking value for uses of cowpea in northern Ethiopia

Sources of collection	Ranking value for each wereda			
	Food	Income generation	Forage	Improving soil fertility
Bati	5	3	4	2
Kalu	5	4	3	2
Kola Temben	5	4	3	2
Taqua Abergelle	5	4	3	2
Werie Leke	3	4	5	2
Abergelle	5	2	4	3
Sekota	5	3	4	2
Lasta Lalibela	3	2	4	5
Total score	36	26	30	20
Ranking	1 st	3 rd	2 nd	4 th

Table 8: Major local foods prepared from cowpea and other uses in northern Ethiopia

Sources of collection	Local name	Major recipes prepared	Other use
Bati	KIMITE, SEREKULA	NIFRO and WET (Amh.)	Forage, income source and improving soil fertility
Kalu	KIMITE, JERGADIE	NIFRO and SHIRO WET (Amh.)	Forage, income source and improving soil fertility
Abergelle	ADENGOR	NIFRO, WET and KITA (Amh.)	Forage and income source
Sekota	EGOYLA	NIFRO, WET and KITA	Forage and income source
Lasta Lalibella	CHEKELE	NIFRO and KITA (Amh.)	Forage, income and improving soil fertility
Kola Temben	ADENGOR, ADAGURA, DEKAK ADAGURA, ADENGUARIE	NIFRO , WET, KITA and INJERA by mixing with sorghum (Amh.)	Income source and forage
Tanqua Abergelle	ADENGOR, ADAGURA, DEKAK ADAGURA, ADENGUARIE	WET, KITA and NIFRO (Amh.)	Forage and income source
Werie Leke	LAHIM ATER	NIFRO (Amh.)	Commonly used for animal feed and improving soil fertility

4.4. Farming System and Practices

The farmers in northern Ethiopia gave a description of the farming system and practices. They underlined that the rainy season commences in May and ends in October. They prepare the land between the months of March and May. Land preparation is mainly done by oxen plough and weeding activity is done by manual hand weeding and handheld hoeing. Planting commences

towards the end of May right after the first substantial rains have fallen through to July and early August. By the end of November, all farmers harvested cowpea from the field (Table 9).

Table 9: Cowpea production season in northern Ethiopia

Location	Time of planting	Time of harvesting
Bati	Mid July – Early August	Mid September – Mid October
Kalu	July	Middle September – End October
Abergelle	July	Mid September
Sekota	July	Mid September
Lasta Lalibela	Mid July	Mid September – Mid October
Kola Temben	End May – June	September – October
Tanqua Abergelle	Mid June – Early July	October – November
Werie Leke	Mid July – Early August	Mid September – Early October

Traditional cropping systems reported by farmers in northern Ethiopia showed that cowpea is mostly intercropped with cereals. Common combinations are: sorghum with cowpea and maize with cowpea using different planting methods such as broadcasting, row planting and both broadcasting and row planting methods (Figure 4). Furthermore, farmers produce cowpea in sandy and marginal soil conditions since the crop has the ability to withstand drought and poor soil fertility conditions. Farmers produce this crop in their entire farms (main field, home garden, and border farm field) during the rainy season except farmers from Central Tigray (Werie Leke) where they use irrigation. The majority of farmers (60%) used their home saved seed (Figure 5) for the next growing season except in Werie Leke Wereda where they use mostly seed obtained from agricultural office and sometimes they used their own home saved seed the next growing season.

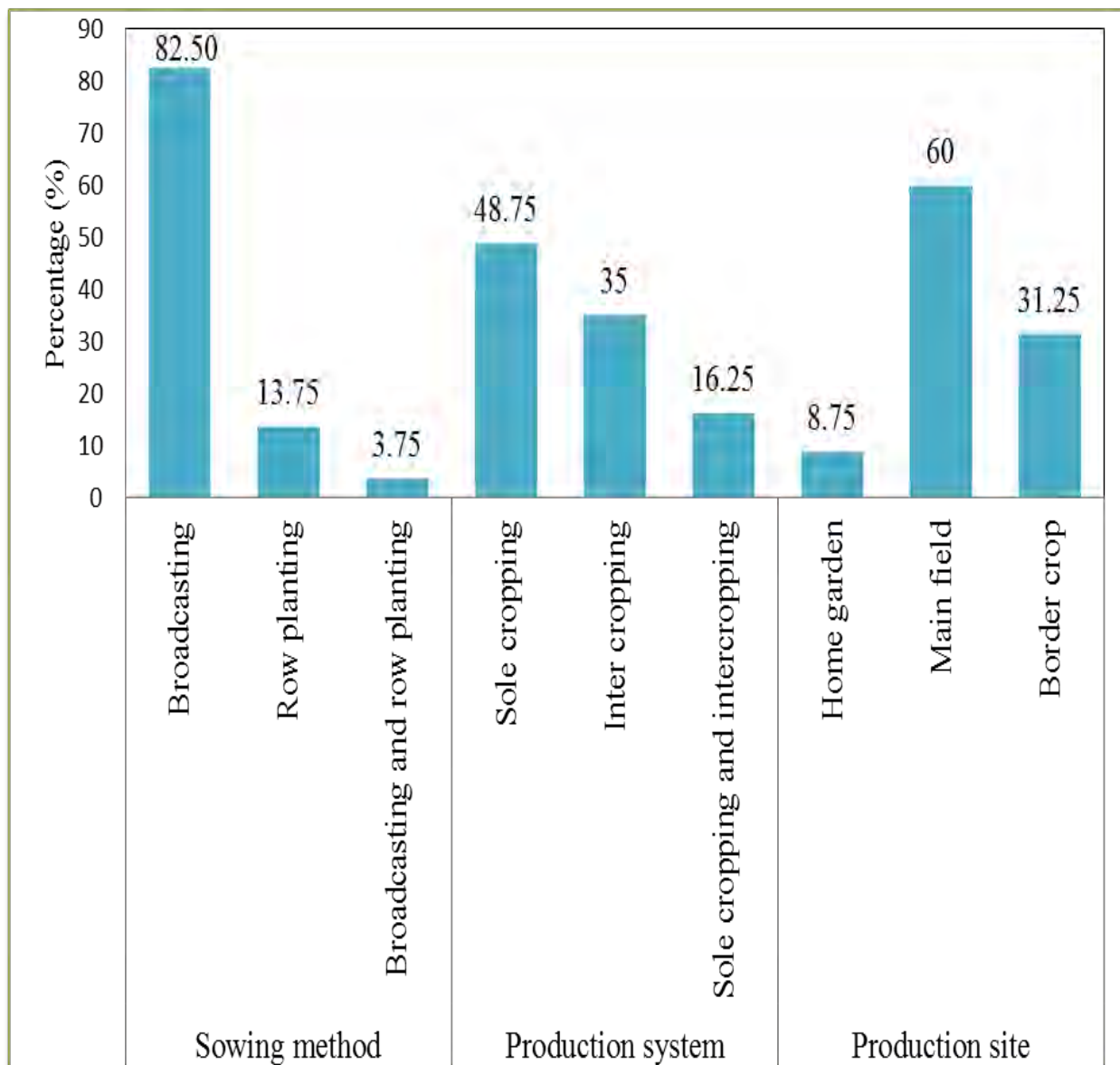


Figure 4: Agronomic practices for cowpea production in northern Ethiopia

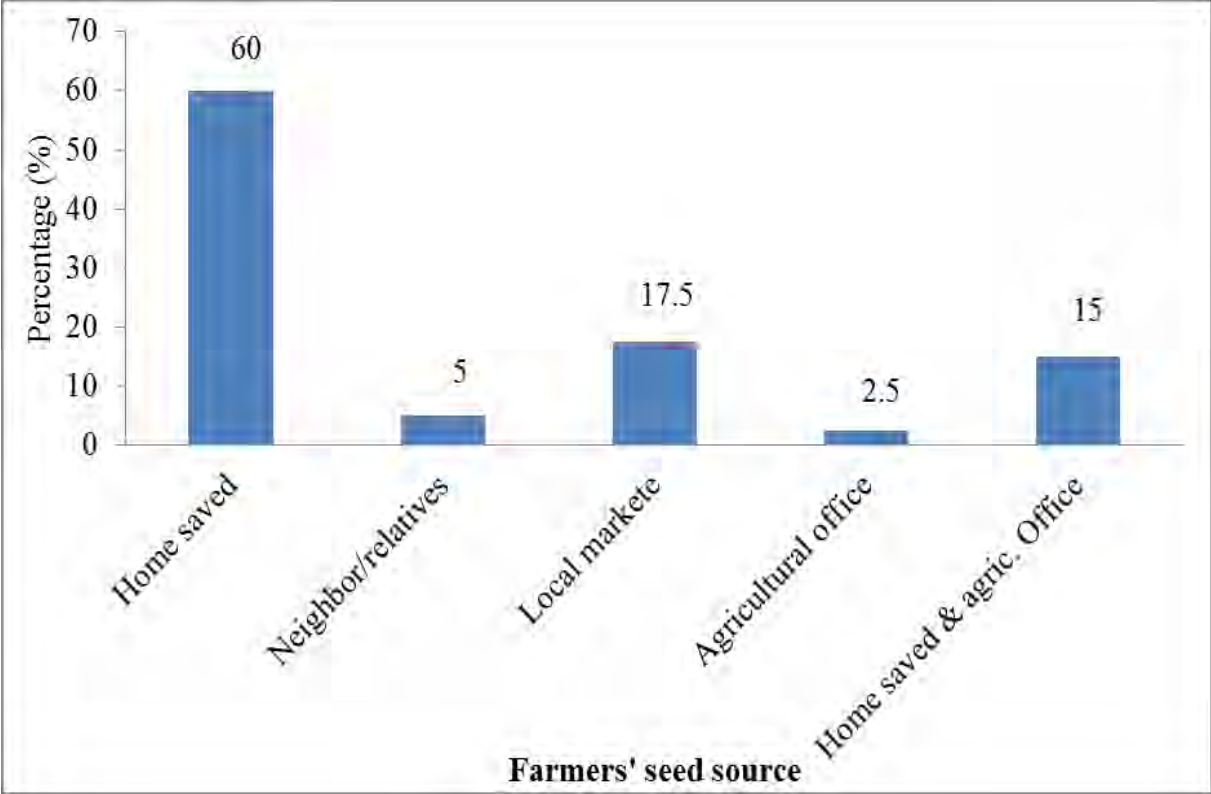


Figure 5: Farmers' seed source

4.5. Gender Roles for Maintaining the Landrace Diversity of Cowpea

Traditionally, in northern Ethiopia cowpea cropping is mostly done by men including the agronomic activities such as land preparation, planting, weeding, harvesting, threshing and drying. Women also participate in many activities to support their husbands together with children. The major responsibilities of women are preparing processed product of cowpea in the form of local recipes. Agronomic activities such as variety selection, weeding, processing, and hoeing, harvesting, post-harvest treatment (during storage), marketing of the grain, processing for food and animal feed are the major activities of women in the household share of farming activities.

4.6. Market Value of Cowpea

In addition to its food and forage value, cowpea has economic importance as income source by selling the grain in the local markets. The crop has a price variation as gathered from different weredas of the study area (Figure 6). In Lasta Lalibela Wereda the crop is mainly used as ground cover and income generation. This is because the agro ecology of the area and the local farmers' perception were primarily focused on other legumes (faba bean, chickpea and field pea) and unpleasant organoleptic character of the crop. In Werie Leke Wereda, cowpea has higher market price than other weredas. This is because, in Werie Leke there is scarcity of forage for livestock feed and the local farmers grew cowpea via intercropping with maize for livestock feed and marketing. The cowpea value chain consists of local exchanges and markets that ensure a movement of grain from producers to consumers. Therefore, exchange begins with the production of cowpea by small scale farmers. In northern Ethiopia, farmers typically sell their cowpea grains directly to consumers or some times to rural assemblers, who in turn sell it directly to consumers.

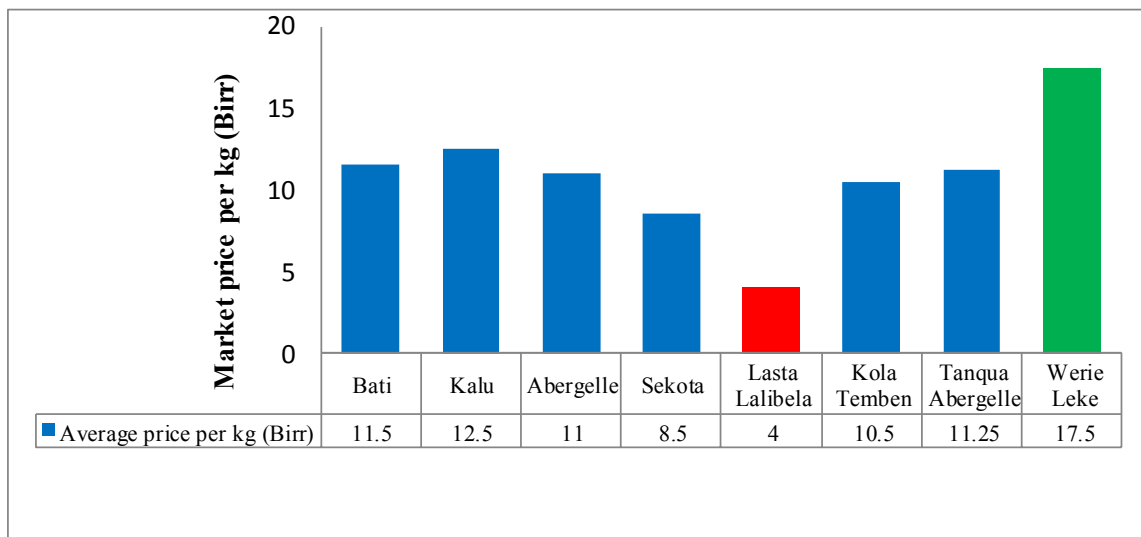


Figure 6: Market price of cowpea landrace varieties in the study areas

4.7. Production Constraints

In northern Ethiopia, small holder farmers are facing different constraints on cropping, storage and consumption of cowpea such as storage pests, field insects, parasitic weeds and diseases, though they could not identify the names of the pests and diseases. However, the descriptions they provided showed that aphids and pod borers are the most important problems for farmers. The primary insect pest causing losses to stored cowpeas in northern Ethiopia is storage weevil (*Callosobruchus maculatus*) locally called NEKEZ. *Striga spp.* locally called AKANCHIRA is a parasitic weed typically found in the study area and causes yield losses.

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

5.1.1. Cowpea landrace diversity in northern Ethiopia

Landraces are the result of several years of natural and artificial selections by farmers for better adaptation to local growing conditions (Hegde and Mishra, 2009). Cowpea landraces collected from both Tigray and Amhara regions of northern Ethiopia did not show much variation for plant growth pattern and growth habit. All local farmers grew determinate types with prostrate to erect growth habit. Such types are preferred by farmers because of their better performance under marginal conditions of rain fed environments where cowpea is commonly grown. Thulin (1989), reported that, *Vigna unguiculata* subsp. *sesquipedalis* and subsp. *dekindtiana* are mainly cultivated in northern Ethiopia. In the present study, landraces belonging to *Vigna unguiculata* subsp. *unguiculata* and *Vigna unguiculata* subsp. *cylindrica* are still cultivated as components of different cropping systems under marginal rain fed conditions in northern Ethiopia. The local landraces (83%) are more popular than the released commercial varieties (MAARC 19, MAARC 20, MAARC 21, MAARC 22, MAARC 23, MH 06, MSRC 01, MSRC 01A and MSRC 01B) because of farmers' preference, multi-purpose nature of the crop, organoleptic character and higher market price. The majority of landraces collected from Bati and Kalu weredas of Amhara region (MBB 35A, MBB 35B and MD 05) belonged to *Vigna unguiculata* subsp. *unguiculata* farmers' variety JERGADIE having prostrate (climbing) nature with higher green leaves and long pods as compared to the erect type of cowpea. The collected landrace accessions were found

both in mixed and uniform seed colors. Similar result was reported by Sariah (2010), where landrace accessions are mostly found both in mixed and uniform seed colors. From farmers' perceptions, they grow cowpea for home consumption, animal feed, income source and improving soil fertility. Thus, almost all collections from each wereda were found to be uniform in seed color except in some areas where accessions with mixed seed colors were found ranging from white to black, with cream and light red colors dominating mainly in Bati and Kalu weredas and these were described as big sized JERGADIE. The crop is mainly produced in Tanqua Abergelle and Bati as a major crop. Cowpea is an important component of diets in northern Ethiopia. Therefore, cowpea is widely cultivated in Central Tigray (Tanqua Abergelle, Kola Temben and Werie Leke), Waghimra (Abergelle), South Wello (Kalu) and Oromiya Special Zones (Bati). In North Wello Zone (Lasta Lalibela), farmers said cowpea is predominantly grown for income generation, contingency of land use (ground cover) and sometimes for food. The reverse is true for Central Tigray local farmers where cowpea has an equal value with sorghum in terms of price value and major uses for home consumption primarily grown for food, income generation and forage.

5.1.2. Farmers' knowledge and perceptions

Cowpea is a versatile food crop that contributes to food culture in many parts of Africa (Timko and Singh, 2008) and referred to as the "hungry-season crop" given that it is the first crop to be harvested before the cereal crops are ready (Carlos, 2004). The same is true for Waghimra and Central Tigray zones of northern Ethiopia where the crop is used as hungry-season crop and obviously known and grown by all farmers. This reflects the importance of cowpea in the day to day life of farmers in northern Ethiopia, which might probably be due to the fact that cowpea has the ability to withstand the existing dry conditions in the study areas. In every growing season,

almost all farmers grow cowpea by intercropping with sorghum and maize except Sekota and Lasta Lalibela weredas where the farmers mainly use sole cropping system at their main and boarded farm fields. Both climbing and erect types of cowpea were grown in northern Ethiopia to exploit the advantages provided by each type. As described by Carlos (2004), the fast growth and spreading habit of traditional cowpea farmers' varieties suppress weeds, and soil nitrogen is increased which improves cereal growth. Farmers' responses on the selection criteria based on multipurpose of the crop being used for human consumption, animal feed, income source and improving soil fertility. Cowpea also contributes to the sustainability of cropping systems and soil fertility improvement on marginal lands through nitrogen fixation, provision of ground cover and plant residues, which minimize erosion and subsequent land deterioration.

5.1.3. Crop uses and purpose of production

As mentioned by many authors (Westphal, 1974; Thulin, 1989; Gbaguidi *et al.*, 2013), vernacular names traditionally attributed to varieties vary more often across administrative weredas and kebeles (village) even sometimes between farmers within a single village. Similar result was reported by Singh *et al.* (2003) and Timko and Singh (2008). Cowpea is a multi-purpose crop and it is used for food, forage, income generation and improving soil fertility as asserted by all respondents. In addition, Moa Megersa *et al.* (2013) reported that, cowpea is traditionally used by smashing and rubbing on affected part of body to treat tinea corporis disease. The present study results did not indicate uses of cowpea in medicine. Almost all parts of the crop such as seeds, pods, leaves/ stems and straw are used for various purposes as reported by Singh *et al.* (2003); Pottorff *et al.* (2012) and the present study. As reported by Carlos (2004), in southern Africa, cowpea is grown primarily for fodder, although it is also used for grain production, green manure, weed control in forestry plantations and as a cover or anti-

erosion crop. In this study, cowpea uses vary considerably between regions and some uses reported from other countries were not recorded in northern Ethiopia. Cowpea green leaves and immature pods were found to be used for traditional food as green vegetables is found in southern and eastern Ethiopia (Westphal, 1974). As reported by Timko *et al.* (2007), the tender green leaves are an important food source in Africa and are prepared as a pot herb, like spinach. Immature green pods are used in the same way as snap beans, often being mixed with cooked dry cowpea or with other foods. Nearly mature “fresh-shelled” cowpea grains are boiled as a fresh vegetable were not mentioned in this study. The study results showed that, seeds are a highly valued part of the crop for home consumption in the form of NIFRO, KITA and WET. Sometimes the green mature pods were eaten by children in Bati and Kalu weredas. As stated by Singh and Tarawali (1997), in northern Ethiopia cowpea foliage is an important source of high-quality hay for livestock feed.

5.1.4. Cropping systems and management practices

As reported by Blade *et al.* (1997) and Timko *et al.* (2007), cowpea is usually grown as an intercrop with sorghum (*Sorghum bicolor* (L.) Moench) and less frequently as a sole crop or intercropped with maize (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), or cotton (*Gossypium* sp.). In the present study, cowpea is mainly grown as a rain fed crop and sorghum is the major cereal crop with which cowpea is intercropped (95%) in all surveyed areas, except in Werie Leke Wereda where maize is the major cereal in which cowpea is intercropped (5%). Carlos (2004) and Dugje *et al.* (2009) described a rather similar intercropping system in West and Central Africa under similar semi-arid conditions, where cowpea was also intercropped with cereal crops (maize and sorghum) with the recommended spacing of 75 cm x 50 cm. Dugje *et al.* (2009) and AFF (2011) reported that fertilizer application in cowpea production depends on

anticipated yield and soil fertility. As a legume, cowpea does not require too much nitrogen fertilizer because it fixes its own nitrogen from the air using the nodules in its roots. Based on the result, the majority of farmers (60%) indicated that they never used fertilizer and/or chemicals in the surveyed areas especially in Tanqua Abergelle, Abergelle, Sekota and Lasta Lalibela weredas. On the other hand, reasonable number of the farmers (40%) used organic matter as fertilizer and chemicals for plant protection in Bati, Kalu, Kola Temben and Werie Leke weredas.

5.1.5. Seed supply, selection and storage

The reliance of local farmers mainly on sources of home saved seed and exchanging with their neighbors support in maintaining and conserving the distinct types, but at the same time there is little driving force to create new types and maintain a high level of diversity (Munisse *et al.*, 2011). The present study result also showed that, the majority of farmers relied on their own home saved seeds, buying from local market, exchanging with neighbor or relatives, buying from agricultural office (only landraces) and sourced from both home saved and agricultural office. The most important criterion for selection is tolerance to drought, good taste, high grain yield, early maturity, feeding and market value of the grain. For example, some farmers in Bati and Kalu weredas prefer once cowpea having climbing habit (JERGADIE) for its high leaf yield for improving soil fertility via nitrogen fixation and livestock feed value as compared to cowpea with erect growth nature (KIMITE and CHEKELE).

Cowpea suffers terribly from its natural enemies (insects and storage pests). There are published data (Carlos, 2004; Dugje *et al.*, 2009) providing evidence that insect pests cause devastating losses in cowpea yields and weevils (post-harvest pest) can destroy a granary full of cowpeas within two or three months. In northern Ethiopia, some farmers store the seed with special

treatment using chemicals (malatine) and botanicals (ash) for the next growing season to escape storage pest problem. As a result, all farmers claimed that, the loss of product after harvesting is totally reduced due to storage pest problem. As reported by Dugje *et al.* (2009) insect pests are major constraints to cowpea production in West Africa and damage by insect pests on cowpea can be as high as 80–100% if not effectively controlled. The most important storage pest of cowpea is the weevil (*Callosobruchus maculatus*) and severe infestation can lead to total grain loss in storage (Carlos, 2004; Dugje *et al.*, 2009; Sariah, 2010). The storage life of cowpea depends on its moisture content before storage and the lower the moisture content, the better the quality of seeds in storage (AFF, 2011). In developed countries, one alternative is the use of cold storage and that exposure to minus 18 °C during 6 to 24 hours reduced pest numbers by more than 99% (Carlos, 2004).

5.1.6. Qualitative and quantitative traits

Earlier studies on cowpea using morphological traits have been carried out by many researchers. These traits were all found to be of great importance to distinguish genetic variability. As in previous studies (Hegde and Mishra, 2009; Sariah, 2010; Gbaguidi *et al.*, 2013), this study also found that morphological traits (quantitative and qualitative) are still valuable tools for cowpea genetic diversity studies. For example, some of the morphological traits such as growth habit, terminal leaflet length, terminal leaflet width, seed length, twining tendency, terminal leaflet shape, pod length, number of seeds per pod and seed shape had the uses for morphological identification and characterization. The results showed that landraces collected from Bati and Lasta Lalibela locally called CHEKELE and KIMITE were more similar to each other. Similarity for some characters also observed between JERGADIE and KIMITE and CHEKELE. As for the qualitative traits, the existence of genetic diversity among the collections for most of the

morphological traits studied CHEKELE and KIMITE were more varied than JERGADIE. A high level of similarity was also observed among the collection of CHEKELE and KIMITE for most of the traits studied.

5.2. Conclusion

Traditional knowledge related to the cultivation and use of cowpea particularly the local landraces are still persisting in northern Ethiopia. The present study has brought some facts about the crop. It will be of interest to study the diversity of the landraces further to be able to apply the local conservation strategies in a modern context and to identify potential genetic resources, to enhance food security, nutrition and income generation. Cowpea contributes to smallholders' income generation as a higher-value crop like cereals and to diet as a cost effective source of protein intake especially in Central Tigray, South Wello and Oromia Special Zones (Amhara Region) of northern Ethiopia. In Amhara Region, cowpea is mainly used for human food in the form of boiled grain (NIFRO), thin bread (KITA) and sauces (SHIRO WET). Additionally, cowpea also plays an important role in improving soil fertility making it suitable for cereal crops (such as sorghum and maize) when grown via intercropping and crop rotation. In addition to its food and forage value, cowpea has economic importance as income source from selling the grain in the local markets. The cowpea market chain consists of local exchanges and markets that ensure a movement of grain from producers to consumers. Landraces provide a valuable source of new variation for the genetic improvement of economically important characters such as use value, grain and straw yield, organoleptic character, early maturity, feed value, adaptability to any types of soil, disease resistance and drought tolerance. A total of 54 cowpea accessions (45 were local landraces and nine were commercial varieties both in mixed and uniform seed color) were collected and identified. These accessions are now maintained at Ethiopian Institute of

Agricultural Research, Melkassa Agricultural Research Centre, National Pulse, Oil and Fiber Crops Research Program. A range of observations was made in the current analyses on cowpea landraces both in qualitative and quantitative traits. High level of dissimilarity exists between JERGADIE group compared to CHEKELE and KIMITE group for some of the characters studied. For example, *Vigna unguiculata* subsp. *unguiculata* farmers' variety JERGADIE (MMLG 01 and MKAG 02) were different from the other varieties (CHEKELE and KIMITE) for some important characters such as high number of seeds per pod, pod length, seed length, twinning tendency and other characters. Therefore, morphological variation of local landraces can be used for cowpea improvement programs through cross breeding. In addition, it may also be supportive to carry out local participatory variety selection and breeding within the material to further enhance the yield and attributes of some the genotypes present.

5.3. Recommendations

Based on the research findings, the following recommendations are given:

1. National Pulse, Oil and Fiber Crops Research Program and other partners need to enhance and/or distribute the important cowpea landraces to the areas where cowpea can be grown.
2. Ethiopian Biodiversity Institute would need to do more collection and conserve farmers' varieties of cowpea.
3. The local agriculture experts should make the local farmers aware of integrated pest management technique to prevent a series problem of insect and pest damage using a combination of good hygiene, aeration, drying, treating storages and equipment and mixing chemicals with the grain.

4. Further research should be conducted on diversity, use, conservation and genetic aspects of cowpea in Ethiopia and evaluate value of landraces in breeding.
5. Expanded this study to the entire country for a full documentation of cowpea landrace varieties in Ethiopia is necessary for scientific research and development programs.

REFERENCES

- Agbogidi O.M. (2010). Screening six cultivars of cowpea (*Vigna unguiculata* (L.) Walp) for adaptation to soil contaminated with spent engine oil. *Journal of Environmental Chemistry and Ecotoxicology* **7**: 103 - 109.
- AFF (Agriculture, Forestry and Fisheries) (2011). Production guidelines for cowpeas. Directorate Agricultural Information Services, Department of Agriculture, Forestry and Fisheries Private Bag X144, Pretoria, Republic of South Africa. Web: www.daff.gov.za. Pp. 1-6.
- Agbogidi O.M. and Egho E.O. (2012). Evaluation of eight varieties of cowpea (*Vigna unguiculata* (L.) Walp.) in Asaba agro-ecological environment, Delta State, Nigeria. *European Journal of Sustainable Development* **1** (2): 303-314.
- Alexiades M.N. (1996). Collecting ethnobotanical data: An introduction to basic concepts and techniques. **In:** Alexiades M.N. and Sheldon J.W. (Eds.). Selected guidelines for ethnobotanical research; a field manual. New York Botanical Garden (NYBG), Bronx, New York. Pp. 53-80.
- ANRS (2013). Annual report on agricultural development efforts and lessons of a decade in the Amhara National Regional State, Ethiopia. Amhara National Regional State, Bahir Dar, Ethiopia.
- Amador B.M. and Dieguez E.T. (2000). Effect of salinity on the germination and seedling characteristics of cowpea (*Vigna unguiculata* (L.) Walp.). *Australian Journal of Experimental Agriculture* **40**: 433-438
- Ayana Etana, EstefanosTadesse, Ashenafi Mengistu and Abubeker Hassen (2013). Advanced evaluation of cowpea (*Vigna unguiculata*) accessions for fodder production in the central rift valley of Ethiopia. *International Journal of Plant Anatomy and Physiology* **1** (1): 4 - 9.
- Ba F.S., Pasquet R.S. and Gepts P. (2004). Genetic diversity in cowpea (*Vigna unguiculata* (L.) Walp.) as revealed by RAPD markers. *Genetic Resources and Crop Evolution* **51**: 539–550.

- Bilatu Agza, Binyam Kasa, Solomon Zewdu, Eskinder Aklilu and Ferede Alemu (2012). Animal feed potential and adaptability of some cowpea (*Vigna unguiculata*) varieties in North West lowlands of Ethiopia. *Wudpecker Journal of Agricultural Research* **1** (11): 478 - 483.
- Blade S.F., Shetty S.V.R., Terao T. and Singh B.B. (1997). Recent developments in cowpea cropping systems research. **In:** Singh B.B., Mohan Raj D.R., Dashiell K.E. and Jackai L.E.N. (Eds.). *Advances in Cowpea Research*. International Institute of Tropical Agriculture and Japan International Research Center for Agricultural Sciences.
- Carlos G. (2004). Cowpea post-harvest operations. INPhO- Post-harvest Compendium, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. Pp. 2-64.
- Cotton C.M. (1996). *Ethnobotany: Principles and application*. John Wiley and Sons Ltd., Baffins lane, Chichester, West Sussex Po19 1UD, England.
- CSA (2011). Federal Democratic Republic of Ethiopia (FDRE), Central Statistical Agency (CSA), Statistical Abstract, 2011, Addis Ababa, Ethiopia.
- Dugje I.Y., Omoigui L.O., Ekeleme F., Kamara A.Y. and Ajeigbe H. (2009). Farmers' guide to cowpea production in West Africa. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Pp. 1-17.
- EBI (2014). Cowpea germplasm collection database. Ethiopian Biodiversity Institute (unpublished data)
- Emechebe A.M. and Lagoke S.T.O. (2002). Recent advances in research on cowpea diseases. **In:** Fatokun C.A., Tarawali S.A., Singh B.B., Kormawa P.M. and Tamo M. (Eds.). *Challenges and opportunities for enhancing sustainable cowpea production. Proceedings of the World Cowpea Conference III held at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria*. Pp. 94-123.
- Ehlers J.D. and Hall A.E. (1997). Cowpea (*Vigna unguiculata* L. Walp.). *Field Crops Res.* **53**: 187-204.
- Ezueh M.I. (1981). Nature and significance of Pre-flowering damage by thrips to cowpea. *Entomol Exp Appl* **29**: 305.

- Fall L., Diouf D., Fall-Ndiaye A.M., Badiane F.A. and Gueye M. (2003). Genetic diversity in cowpea (*Vigna unguiculata* (L.) Walp.) varieties determined by ARA and RAPD techniques. *African Journal of Biotechnology* **2** (2): 48–50.
- FAO (1984). Land evaluation: Part Three. Crop environmental requirements. assistance to land use planning, Ministry of Agriculture, Addis Ababa, Ethiopia.
- Gbaguidi A.A., Dansi A., Loko L.Y., Dansi M. and Sanni A. (2013). Diversity and agronomic performances of the cowpea (*Vigna unguiculata* (L.)Walp.) landraces in Southern Benin. *International journal of Agronomy and Plant Production* **4** (5): 936-949.
- Girma Abebe, Hattar B., Adel-Rahman M. and Tawaha A. (2005). Nutrient availability as affected by manure application to Cowpea (*Vigna unguiculata* L. Walp.) on calcareous soils. *Journal of Agriculture and Social Sciences* **1** (1): 1–6.
- Ghalmi N., Malice M., Jacquemin J.M., Ounane S.M., Mekliche L. and Baudoin J.P. (2010). Morphological and molecular diversity within Algerian cowpea (*Vigna unguiculata* (L.) Walp.) landraces. *Genet Resour Crop Evol* **57**: 371-386.
- Hall A.E., Cisse N., Thiaw S., Elawad H.O.A., Ehlers J.D., Ismail A., Fery R., Roberts P., Kitch L.W., Murdock L.L., Boukar O., Phillips R.D. and McWatters K.H. (2003). Development of cowpea cultivars and germplasm by the Bean/Cowpea CRSP. *Field Crops Res* **82**:103–134.
- Hegde V.S. and Mishra S.K. (2009). Landraces of cowpea (*Vigna unguiculata* (L.) Walp.) as potential sources of genes for unique characters in breeding. *Genet Resour Crop Evol* **6**: 615–627.
- IBPGR (1983). Descriptors for cowpea. International Board for Plant Genetic Resources (IBPGR), Rome. Pp. 14-28.
- IITA (2000). Research highlights. International Institute of Tropical Agriculture, Ibadan. Web: <http://www.iita.org/crop/cowpea.htm>
- Islam S., Cowmen R.C. and Ganer J.O. (2006). Screening for tolerance of stress temperature during germination of twenty-five cowpea (*Vigna unguiculata* (L.) Walp.) cultivars. *Journal of Food, Agriculture and Environment* **4** (2): 189 - 191.

- Kabululu M.S. (2008). Cowpea (*Vigna unguiculata*) variety mixtures for stable and optimal leaf and seed yields when intercropped with maize in Central Tanzania. MSc thesis at Georg-August-Universität, Göttingen, Germany. Pp.5-9.
- Kristjanson P., Tarawali S., Okike I., Singh B.B., Thornton P.K. Manyong V.M., Kruska R.L. and Hoogenboom G. (2002). Genetically Improved Dual-Purpose Cowpea: Assessment of Adoption and Impact in the Dry Savannah of West Africa. Impact assessment series 9. ILRI (International Livestock Research Institute), Nairobi, Kenya. Pp. 68.
- Lemma Gebremariam, Worku W. and Woldemichael A. (2009). Moisture and planting density interactions affect productivity in cowpea (*Vigna unguiculata* (L.)Walp.). *Journal of Agronomy* **8** (4): 117 – 123.
- Lin M.T. and Rios G.P. (1985). Cowpea diseases and their prevalence in Latin America. **In:** Singh S.R. and Rachie K.O. (Eds.). Cowpea research, production and utilization. John Wiley and Sons, Chichester, UK. Pp. 199-204.
- Lowenberg-DeBoer J. and Ibro G. (2008). A study of the cowpea value chain in Kano State, Nigeria, from a pro-poor and gender perspective. **In:** USAID report on the potential effect of economic growth and technological innovation on women's role in the cowpea value chain in Kano State, Nigeria. U.S. Agency for International Development or the United States Government. Pp. 11-18.
- Mashi D.S. (2006). Genetic studies on seed coat texture and cooking time in some varieties of cowpea (*Vigna unguiculata* (L.) Walp.). PhD. Thesis at University of Jos.
- Martin G.J. (1995). Ethnobotany. A methods manual. Chapman and Hall, Royal Botanical Gardens, Kew, London, UK.
- Maréchal R., Mascherpa J.M. and Stainer F. (1978). Etude taxonomique d'un group complexe d'especies des genres *Phaseolus* et *Vigna* (Papillionaceae) sur la base de donnees morphologiques et polliniques traitees par l'analyse informatique. *Boissiera*. **28**: 1–273.
- MoA (2000). Agro ecological zones of Ethiopia. Ethiopian Ministry of Agriculture. Web: <http://awm-solutions.iwmi.org>
- Moa Megersa, Zemedede Asfaw, Ensermu Kelbessa, Abebe Beyene and Bizuneh Woldeab (2013). An ethnobotanical study of medicinal plants in Wayu Tuka Wereda, East Welega Zone of Oromia Regional State, West Ethiopia. *Journal of Ethnobiology and Ethnomedicine* **9**: 68.

- Million Fikreselasie (2012). Variability, heritability and association of some morpho-agronomic traits in field pea (*Pisum sativum* L.) genotype. *Pakistan Journal of Biological Science* **15** (8): 358-366.
- Munisse P., Andersen S.B., Jensen B.D. and Christiansen J.L. (2011). Diversity of landraces, agricultural practises and traditional uses of watermelon (*Citrullus lanatus*) in Mozambique. *African Journal of Plant Science* **5**(2): 75-86.
- Nielson S.S., Ohler T.A., Mitchell C.A (1997). Cowpea leaves for human consumption: production, utilization, and nutrient composition. **In:** Singh B.B., Mohan R.D.R., Dashiell K.E. and Jackai L.E.N. (Eds.). *Advances in Cowpea Research*. Co-publication of International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS). Sayce, Devon, UK. Pp 326–332.
- Nwosu D.J., Aladele S., Adeosun J.O., Nwadike C. and Awa E.N. (2013). Cross-compatibility and F1 reproductive potential of cultivated cowpea varieties and a wild relative (Subsp. *Unguiculata* var. *spontenea*). *Greener Journal of Agricultural Sciences* **3** (5): 391-395.
- Obatolu V.A. (2003). Growth pattern of infants fed with a mixture of extruded malted maize and cowpea. *Nutrition* **19**:174-178.
- Obopile M. and Ositile B. (2010). Life table and population parameters of cowpea aphid, *Aphis craccivora* Koch (Homoptera: Aphididae) on five cowpea *Vigna unguiculata* (L. Walp.) varieties. *J Pest Sci* **83**:9-14.
- Ogbemudia F.O., Denise E.M., Ogie-Odia E.A. and Omonhinmin A.C. (2010). Comparative germination studies of Cowpea (*Vigna unguiculata* L. Walp.) and Soy bean (*Glycine max* L. Merr.) on whole and water saturated fractions of hydrocarbon (hexane). *Annals of Biological Research* **1** (4): 34 - 40.
- Omo-Ikerodah E.E., Fatokun C.A. and Fawole I. (2009). Genetic analysis of resistance to flower bud thrips (*Megalurothrips sjostedti*) in cowpea (*Vigna unguiculata* L. Walp.). *Euphytica* **165**:145-154.
- Ouédraogo J.T., Gowda B.S., Jean M., Close T.J., Ehlers J.D., Hall A.E., Gillaspie A.G., Roberts P.A., Ismail A.M., Bruening G., Gepts P., Timko M.P., and Belzile F.J. (2002). An

- improved genetic linkage map for cowpea (*Vigna unguiculata* L.) Combining AFLP, RFLP, RAPD, biochemical markers, and biological resistance traits. *Genome* **45**: 175–188.
- Padulosi S. and Ng N.Q. (1997). Origin, taxonomy, and morphology of *Vigna unguiculata* (L.) Walp.) **In:** Singh, B.B., D.R. Mohan Raj, K.E. Dashiell, and L.E.N. Jackai (Eds.). Advances in cowpea research. Co-publication of International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS). UTA, Ibadan, Nigeria. Pp. 1-13.
- Pasquet R.S. (1996). Wild Cowpea (*Vigna unpidata*) evolution. **In:** Pickersgill B. and Lock J.M. (Eds). Advances in Legume Systematics 8: Legumes of Economic Importance, Royal Botanic Gardens, ICew. pp. 95-100.
- Pasquet R.S. (1998). Morphological study of cultivated cowpea (*Vigna unguiculata* (L.) Walp.) Importance of ovule number and definition of cv gr Melanophthalmus. *Agronomie* **18**: 61-70.
- Perrino P., Laghetti G., Spagnoletti-Zeuli P. L. and Monti L.M. (1993). diversification of cowpea in the Mediterranean and other centers of cultivation. *Genetic resources and crop evolution* **40**: 121-132.
- Patel P.N. (1985). Fungal, bacterial and viral diseases of cowpeas in the USA. **In:** Singh S.R. and Rachie K.O. (Eds.). Cowpea research, production and utilization. John Wiley and Sons, Chichester, UK. Pp. 205-213.
- Phillips O. L. (1996). Some quantitative methods for analysing ethnobotanical knowledge. **In:** Alexiades M.N. and Sheldon J.W. (Eds.). Selected guidelines for ethnobotanical research: A field manual. The New York Botanical Garden (NYBG). Pp. 171-190.
- Phillips R.D., McWatter K.H., Chinnan M.S., Hung Y., Beuchat L.R., Sefa-Dedeh S., Sakyi-Dawson E., Ngoddy P., Nnanyelugo D., Enwere J., Komey N.S., Liu K., Mensa-Wilmot Y., Nnanna I.A. Okeke C., Prinyawiwatkul W. and Saalia F.K. (2003). Utilization of cowpeas for human food. *Field Crops Research* **82**: 193–21.
- Pottorff M., Ehlers J.D., Fatokun C., Roberts P.A. and Close T.J. (2012). Leaf morphology in Cowpea (*Vigna unguiculata* (L.) Walp): QTL analysis, physical mapping and identifying a candidate gene using syntonic with model legume species. *BMC Genomics* **13**: 234.

- Purdom D. and Trese A.T. (1995). Morphological and molecular characteristics of host-conditioned ineffective root nodules in cowpea. *Plant Physiol.* **109**: 239-244.
- Sariah J.E. (2010). Enhancing cowpea (*Vigna unguiculata* L.) production through insect pest resistant line in East Africa. PhD thesis, University of Copenhagen, Faculty of Life Sciences, Department of Agriculture and Ecology. pp. 5 – 9.
- Sheahan C.M. (2012). Plant guide for cowpea (*Vigna unguiculata*). USDA-Natural Resources Conservation Service, Cape May Plant Materials Center, Cape May, NJ.
- Singh B.B., Chambliss O.L. and Sharma B. (1997). Recent advances in cowpea. **In:** Singh B.B., Mohan-Raj D.R., Dashiel K.E. and Jackai L.E.N. (Eds.). Advances in cowpea research. Co-publication of International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS), Ibadan, Nigeria. Pp. 30-49.
- Singh B.B. and Tarawali S.A. (1997). Cowpea and its improvement: key to sustainable mixed crop (livestock farming systems) in West Africa. **In:** Renard C. (Ed.) Crop Residues in Sustainable Mixed Crop/Livestock Farming Systems. CAB in Association with ICRISAT and ILRI, Wallingford, UK. Pp. 79–100.
- Singh B.B., Ajeigbe H.A., Tarawali S.A., Fernandez-Rivera S. and Abubakar M. (2003). Improving the production and utilization of cowpea as food and fodder. *Field Crops Research* **84**: 169-177.
- Singh B.B. (2005). Cowpea [*Vigna unguiculata* (L.) Walp. **In:** Singh R.J. and Jauhar, P.P. (Eds.). Genetic Resources, Chromosome Engineering and Crop Improvement. Volume 1, CRC Press, Boca Raton, FL, USA. Pp 117–162.
- Thulin M. (1989). Fabaceae (Leguminosae). **In:** Hedberg I. and Edwards S. (Eds). Flora of Ethiopia Vol. 3 Pittosporaceae to Araliaceae. Addis Ababa and Asmara, Ethiopia, Uppsala, Sweden. Pp.49-174.
- Timko M.P., Ehlers J.D. and Roberts P.A. (2007). Cowpea. **In:** Kole C. (Ed.). Genome mapping and molecular breeding in plants, Vol. 3. Pulses, Sugar and Tuber Crops. Springer-Verlag Berlin Heidelberg. Pp. 49-67.

- Timko M.P., Rushton P.J., Laudeman T.W., Bokowiec M.T. Chipumuro E. Cheung F., Town C.D. and Chen X.F. (2008). Sequencing and analysis of the gene-rich space of cowpea. *BMC Genome* **9**:103.
- Timko M.P. and Singh B.B. (2008). Cowpea, a multifunctional legume, **In**: Moore P.H. and Ming R. (Eds.), *Genomics of Tropical Crop Plants*. Springer, New York. Pp. 227-257.
- Vavilov N.I. (1951). The origin, variation, immunity and breeding of cultivated plants. *Chron Bot* **13**:1-366.
- Verdcourt, B. (1970). Studies in the Leguminosae-Papilionoideae for the flora of tropical East Africa. IV. *Kew Bulletin* **24**: 507-569.
- Westphal E. (1974). Pulses in Ethiopia, their taxonomy and agricultural significance. Centre for Agricultural Publishing and Documentation, Wageningen. Pp.213-232.
- Zia-Ul-Haq M., Ahmad S., Amarowicz R. and Feo V. D. (2013). Antioxidant activity of the extracts of some cowpea (*Vigna unguiculata* (L) Walp.) cultivars commonly consumed in Pakistan. *Molecules* **18**: 2005-2017.

APPENDICES

Appendix 1: Checklist of questions to be used as basis for discussion and interview with informants

General Information

Informant's Name _____ Age _____ Sex _____ Date _____

Location: Region _____ Zone _____ Wereda _____ Kebele _____

Local name of the crop _____ Meaning of the local name _____

Soil type _____ Cropping season (Meher (Main season), Belg, or others)

Altitude _____ Latitude _____ Longitude _____

I. Ethnobotanical Information

1. Is it improved or local variety? _____ If it is local variety what is the name of the variety? _____ meaning of name _____.
2. How do you use this crop? A. food B. fodder C. Medicinal use D. Cultural use. E. Other
3. Which parts of cowpea you are used? A. Grains B. Leaves C. Grain and Leaves D. Green pod E. Other
4. Uses and values of the crop other than food. A. Income generation, B. Improving soil fertility C. Forage D. Alcoholic beverage (specify) E. Medicinal F. Ritual G. Myths and beliefs associated with the crop H. Any sayings, songs and poems
5. What is the most commonly used cowpea (*Vigna unguiculata* (L.) Walp.) landrace varieties in the your area? _____, (list most important first)
Is there any wild relative? _____ What is it called? _____ How is it used? _____
6. How do you cultivate and manage your cowpea field to improve productivity of the crop?
A. Using fertilizer B. Using compost C. Using green manure D. Just grow without any treatment
7. What is your planting method for your cowpea?

- A. Broadcasting B. Row planting C. Both broadcasting and row planting
8. If it has medicinal values describe the medicinal value (kind of disease and method of application)._____
 9. Which varieties of the crop are said to have medicinal value?
 - 9.1 What is the local name of the variety used as a medicine in your area?
 - 9.2 What part/parts of the crop are used for medicinal purpose?
 - 9.3 What are the common diseases that can be treated by this crop?
 - 9.4 What are the methods of preparation to use as a medicinal plant?
 - A. Preparation form: crushed, powder, chewed etc.
 - B. Used alone, mixed with water or other etc.
 - C. Condition: dried, fresh, both.
 - 9.5 Could you tell me the amount or dosages that are used for disease treatment?
 10. Suitable soil types for the crop to grow _____
 11. Cultivation time? _____
 12. Do you use cowpea in your crop rotation system? -----, If yes sequence of the crop types _____
 13. Use in crop rotation sequence _____
 - A. To eliminate pest infestation B. To eradicate problem of weed
 - C. To replenish soil fertility D. Others _____
 14. Where do you grow cowpea? A. Home garden B. Main field C. Boarder crops
 15. How do you grow this crop / in what cropping system do you grow cowpea? A. Monoculture /sole cropping B. intercropping C. Sole and intercropping D. Relay cropping E. Mixed/multiple cropping
 16. If intercropping, for what reasons?
 17. If intercropping, which crops do you grow in association with cowpea?
 18. If Multiple cropping, which crops do you grow in association with cowpea?
 19. What do you think about the area of production in terms of coverage?
 20. How do farmers maintain the fertility of their farmland? Do they use artificial or natural fertilizer?
 21. In case of seed shortage; where does a farmer obtain seed?

A. Home saved seed B. Neighbor/relatives C. Local market E. Research station F.
Other? _____

22. Are there any traditional varieties that are no longer cultivated? A. Yes B. No
23. If yes, why it is no longer cultivated?
24. Do you think improved varieties have replaced the landrace? Yes/No? If yes, how many landraces has been replaced so far?
25. How long hasn't seen since the landrace has been replaced in the area?
26. Does the community prefer landrace or released ones? A. Landrace B. Improved
27. What are the common insect pest affecting this crop?
28. What are the common weeds attacked this crop?
29. How do farmers culturally manage disease/insect pest/weeds?
30. What is the common environmental factor (drought, heat) that affects this crop?
31. What are the main threats to the traditional variety in your area?
32. What measures should be taken to overcome the problems?
33. Do you grow any landraces here on your farm that perform noticeably better than others under difficult conditions
34. Are certain varieties you grow here on your farm notably more tolerant to important pest and disease problems
30. Do you grow any varieties here that have a particular advantage, such as....?
 - a. Soil fertility enhancing
 - b. Reduce soil erosion
 - c. Really good for intercropping
 - d. Always yields something no matter how bad conditions (Yield stability)
 - e. Produce food over an especially long period of time
 - f. Easy to process compared to other varieties
 - g. Other advantages that we may have forgotten to mention

II. Socio- Cultural Significance of Crops

31. If cowpea used as food and fodder which variety do you use and for what purpose?
32. Which varieties of these crops are said to have better nutritional value?
33. What special tasks do women contribute to maintain genetic diversity?
34. What are your parameters of selection for better varieties of the crop?

III. Economic significance of crop varieties

35. Which varieties of the crop are more preferred for its better production?
36. Which varieties of the crop are used for consumption?
37. Which varieties of the crop are used for market?
38. Are there special landrace varieties of cowpea which are marketable in your area?
39. Are there limitations in the cultivation, utilization and marketing of cowpea in the locality?
40. What are the solutions to constraints for cowpea species?
41. Could you kindly list crop species that are cultivating in your area?
42. Do you have anything else?

Appendix 2: Cowpea germplasm collection in northern Ethiopia

Collection code	Latitude (dd mm ss)	Longitude (dd mm ss)	Altitude (m.a.s.l.)	Sources of collection	Status of collection
MAARC 19	N13 37 32.7	E38 59 59.0	1650 m	AARC (Abi Adi)	Improved
MAARC 20	N13 37 32.7	E38 59 59.0	1650 m	AARC (Abi Adi)	Improved
MAARC 21	N13 37 32.7	E38 59 59.0	1650 m	AARC (Abi Adi)	Improved
MAARC 22	N13 37 32.7	E38 59 59.0	1650 m	AARC (Abi Adi)	Improved
MAARC 23	N13 37 32.7	E38 59 59.0	1650 m	AARC (Abi Adi)	Improved
MAS 42	N12 58 38.7	E38 57 37.6	1260 m	Saka (Abergelle)	Landrace
MBB 35	N11 14 28.5	E40 00 27.4	1770 m	Bira (Bati)	Landrace
MBB 35A	N11 14 28.5	E40 00 27.4	1770 m	Bira (Bati)	Landrace
MBB 35B	N11 14 28.5	E40 00 27.4	1770 m	Bira (Bati)	Landrace
MD 04	N11 08 58.4	E39 54 30.0	1460 m	Arabu or Degan (Kalu)	Landrace
MD 05	N11 08 58.4	E39 54 30.0	1460 m	Arabu or Degan (Kalu)	Landrace
MDRM 07	N11 08 09.1	E39 38 27.5	Unknown	Desse Robit Market	Landrace
MDT 29	N13 42 57.2	E38 47 10.9	2130 m	Derene Tseb (Kola Temben)	Landrace
MEA 37	N10 20 25.9	E39 57 51.4	1420 m	Ataye (Efratanagidem)	Landrace
MEG 38	N10 56 41.0	E38 20 56.1	2000 m	Enebse Sarmidir (East Gojam)	Landrace
MEG 38A	N10 56 41.0	E38 20 56.1	2000 m	Enebse Sarmidir (East Gojam)	Landrace
MH 27	N13 13 56.9	E38 59 34.7	1633 m	Hadnet (Tanqua Abergelle)	Landrace
MH 06	N11 16 48.8	E39 40 51.0	2050 m	Haik (North Wello)	Improved
MHT 24	N13 31 09.7	E39 01 49.6	1490 m	Hadash Tekli (Tanqua Abergelle)	Landrace
MHT 24A	N13 31 09.7	E39 01 49.6	1490 m	Hadash Tekli (Tanqua Abergelle)	Landrace
MKA 36	N11 09 31.2	E39 53 23.9	1580 m	Abecho (Kalu)	Landrace
MKA 36A	N11 09 31.2	E39 53 23.9	1580 m	Abecho (Kalu)	Landrace
MLB 15	N12 10 02.4	E38 59 06.4	1990 m	Bilbala (Lasta Lalibela)	Landrace

Appendix 2 continued

Collection code	Latitude (dd mm ss)	Longitude (dd mm ss)	Altitude (m.a.s.l.)	Sources of collection	Status of collection
MLG 18	N11 56 33.2	E38 53 21.6	2050 m	Gelesot (Lasta Lalibela)	Landrace
MLM 17	N12 03 18.6	E39 02 05.9	2040 m	Medage (Lasta Lalibela)	Landrace
MLS 08	N11 58 48.8	E38 58 53.1	1960 m	Shumshuha (Lasta Lalibela)	Landrace
MLS 09	N11 58 23.4	E39 03 08.5	2070 m	Berta (Lasta Lalibela)	Landrace
MLS 10	N11 59 25.4	E39 00 57.9	2140 m	Godu Memder (Lasta Lalibela)	Landrace
MLS 11	N11 59 21.5	E38 59 11.0	2000 m	Tinchoy (Lasta Lalibela)	Landrace
MLS 12	N12 00 37.4	E39 00 08.8	2090 m	Lawober (Lasta Lalibela)	Landrace
MLS 13	N12 00 54.1	E39 01 38.7	2100 m	Yohans Amba (Lasta Lalibela)	Landrace
MLS 14	N11 59 53.6	E38 58 01.1	2000 m	Enkuay Beret (Lasta Lalibela)	Landrace
MLSM 16	N12 03 30.3	E38 58 19.0	2030 m	Segno Gebeya (Lasta Lalibela)	Landrace
MM 25	N13 16 11.7	E38 59 47.7	1560 m	Maerey (Tanqua Abergelle)	Landrace
MM 25A	N13 16 11.7	E38 59 47.7	1560 m	Maerey (Tanqua Abergelle)	Landrace
MML 34	N11 14 04.6	E39 58 47.3	1750 m	Melka Lugo (Bati)	Landrace
MML 34A	N11 14 04.6	E39 58 47.3	1750 m	Melka Lugo (Bati)	Landrace
MML 34B	N11 14 04.6	E39 58 47.3	1750 m	Melka Lugo (Bati)	Landrace
MN 29A	N13 42 37.9	E38 45 28.8	2100 m	Newi (Kola Temben)	Landrace
MRKA 28	N12 04 09.2	E39 37 48.2	1470 m	Aradum (Raya Kobo)	Landrace
MSAN 33	N13 02 33.9	E38 59 01.7	1350 m	Maernet (Abergelle)	Landrace
MSH 32	N12 27 31.8	E39 09 08.1	2030 m	Hamusit (Sekota)	Landrace
MSRC 01	N10 00 22.5	E39 53 42.7	1290 m	Shewarobit	Improved
MSRC 01A	N10 00 22.5	E39 53 42.7	1290 m	Shewarobit	Improved
MSRC 01B	N10 00 22.5	E39 53 42.7	1290 m	Shewarobit	Improved
MSRM 02	N10 00 04.0	E39 54 09.5	1270 m	Shewarobit	Landrace
MSRM 02A	N10 00 04.0	E39 54 09.5	1270 m	Shewarobit	Landrace
MST 31	N12 31 13.0	E39 04 43.1	2110 m	Tiya (Sekota)	Landrace
MSW 30	N12 32 56.7	E39 03 19.5	2040 m	Weleh (Sekota)	Landrace
MTAL 41	N13 14 39.3	E39 02 36.3	1610 m	Lemlem (Tanqua Abergelle)	Landrace
MWEC 39	N14 03 59.6	E39 01 33.4	2070 m	Enda Chewa (Werie Leke)	Landrace
MWZ 40	N14 01 45.0	E39 01 37.4	2020 m	Zongi (Werie Leke)	Landrace
MY 26	N13 17 13.1	E38 59 39.6	1560 m	Yechilla (Tanqua Abergelle)	Landrace
MY 26A	N13 17 13.1	E38 59 39.6	1560 m	Yechilla (Tanqua Abergelle)	Landrace

Appendix 3: Ecological requirement and range of suitability for cowpea production (FAO, 1984).

Ecological Requirement	Range of Suitability		
	Highly suitable	Moderate to Marginally Suitable	Not Suitable
Altitude (m.a.s.l)	350 – 1500	1500 – 2000	Over 2000
Temperature (°C)	22.5 – 30	20 - 22.5	Below 20 Above 30
Rainfall (mm)	500 – 1000	400 – 500 1000 - 1500	Below 400 Above 1500

Appendix 4: Major crops grown in the study area

Location	Major crops grown		Cowpea production system		Place of cowpea occupy in household farming system of the wereda
	Common name	Area coverage (ha and/or %)	Sole-cropping	Intercropping	
Bati	Sesame Cowpea Maize Other crops	40% 30% 20% 10%	30 – 40%	60 – 70% with Sorghum	Major crop
Kalu	Sorghum Teff Maize Mungbean Cowpea and other haricot beans Faba bean Chickpea Oat	65% 12% 7% 4% 4% 3.5% 3% 1.5%	20%	80% with Sorghum	Minor crop
Lasta Lalibella	Teff Wheat Barely Oat Figure Millet Cowpea	4,986 ha 4,627 2,893 ha 187 ha 106 ha 44 ha	95%	5% with Sorghum	Minor crop

Sekota	-	-	-	-	No information
Abergelle	Sorghum Teff Sesame Cowpea	6,253 ha - 2,408 ha 58 ha (Total area of cultivated land is 35,116.6 ha)	90%	10% with Sorghum	Minor crop
Lasta Lalibella	Teff Wheat Barely Oat Figure millet Cowpea	4,986 ha 4,627 2,893 ha 187 ha 106 ha 44 ha	95%	5% with Sorghum	Minor crop
Kola Temben	Sorghum Maize Teff Figure millet Barely Wheat Cowpea	12,848 ha 10,285.5 ha 2,382.75 ha 979.5 ha 708 ha 590 ha 313.13 ha	40%	60% with Sorghum	Minor crop
Tanqua Abergelle	Sorghum Maize Sesame Teff Cowpea Flax	15,858 ha 8,320 ha 2424.75 ha 772.5 ha 735 ha 180.75 ha	50%	50% with Sorghum	Major crop
Werie Leke	Teff Sorghum Maize Wheat Figure millet Barley Field pea Flax Cowpea	No information	5%	95% with Maize under irrigation	Minor crop

Note: The information's of the above table were gathered from the annual report data of each weredas of agricultural office particularly from agricultural extension experts.

Appendix 5: Qualitative and quantitative traits of collected cowpea landrace specimens

Qualitative and quantitative traits	Specimens code					
	MMLG 01 (Subsp. unguiculata farmers' variety JERGADIE, collected from Bati)	MKAG 02 (Subsp. unguiculata farmers' variety JERGADIE, collected from Kalu)	MKAK 03 (Subsp. cylindrica farmers' variety KIMITE, collected from Kalu)	MKAbK 04 (Subsp. cylindrica farmers' variety KIMITE, collected from Kalu)	MLLC 05 (Subsp. cylindrica farmers' variety CHEKELE, collected from Lasta Lalibela)	MSC 06 (Subsp. cylindrica farmers' variety CHEKELE, collected from Sekota)
Growth habit	Climbing	Climbing	Erect	Erect	Erect	Erect
Growth pattern	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate
Twinning tendency	Intermediate	Intermediate	None	None	None	None
Terminal leaflet shape	Sub-globose	Sub-globose	Globose	Globose	Hastate	Hastate
Plant hairiness	Glabrescent	Glabrescent	Glabrescent	Glabrescent	Glabrescent	Glabrescent
Raceme position	Throughout canopy	Throughout canopy	In upper canopy	In upper canopy	In upper canopy	In upper canopy
Pod attachment to	30-90 ⁰ down from	30-90 ⁰ down from	Erect	Erect	Erect	Erect

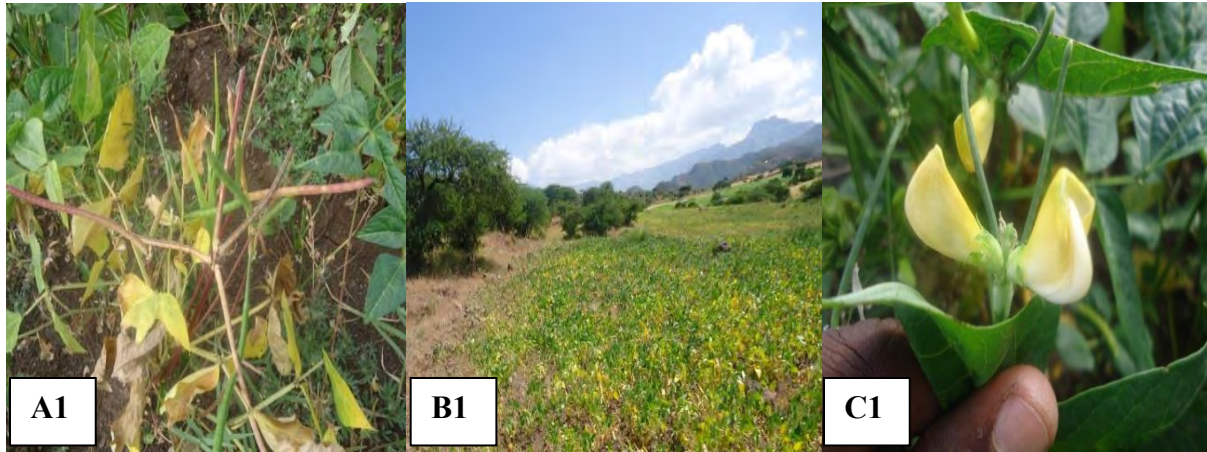
peduncle	erect	erect				
Pod curvature	Straight	Straight	Slightly curved	Slightly curved	Straight	Straight
Seed shape	Ovoid	Ovoid	Rhomboid	Rhomboid	Rhomboid	Rhomboid
Testa texture	Smooth	Smooth	Smooth to rough	Smooth to rough	Smooth	Smooth
Leaf color	Intermediate green	Intermediate green	Pale green	Pale green	Pale green	Pale green
Leaf marking	Absent	Absent	Absent	Absent	Absent	Absent
Splitting of testa	Absent	Absent	Absent	Absent	Absent	Absent
Terminal leaflet length (mm)	90	87	72	76	74	76
Terminal leaflet width (mm)	54	58	48	44	30	33
Number of pods per peduncle	2	2	3	3	3	3
Number of seeds (locules)per pod	18	17	12	13	10	10

Seed length (mm)	8	8	5	5	6	5
Seed width (mm)	6	5	2	3	3	3
Pod length (cm)	18	19	9.5	7.4	8.1	8.5
Pod width (mm)	9	8	5	4	5	5

Appendix 6: Photographs



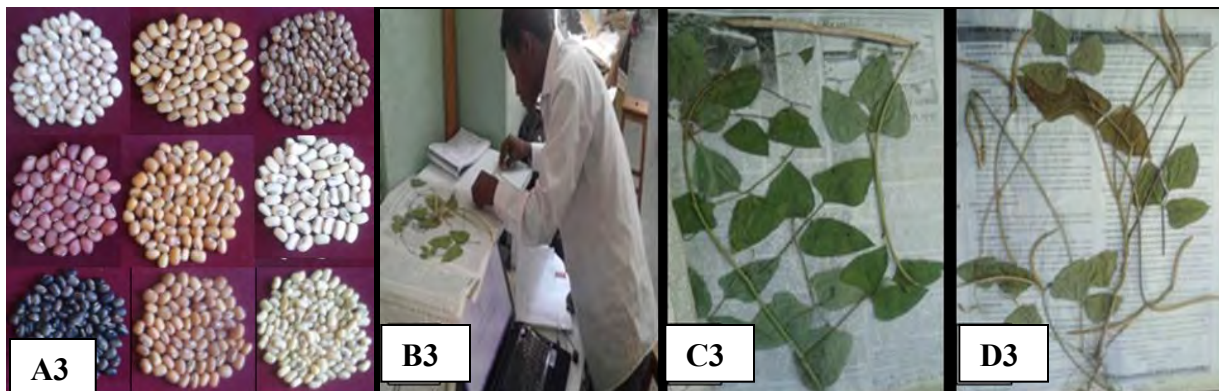
Description: A, B and C represents collecting germplasm and gathering information at farmers' field and local market. D and E shows dried mature pods of cowpea locally called Jergadie and Kintie respectively. F and G interviewing local farmers' in their village (Map credit: Mulugeta Alemu)



Description: A1, B1 and C1 shows cowpea landrace varieties in the farm field



Description: A2, B2 and C2 represents collecting cowpea landraces varieties at market place



A3) Collected cowpea landrace varieties in northern Ethiopia; Sample photos of the voucher specimens of cowpea landraces: B3) Voucher specimen identification at the National Herbarium; C3) *Vigna unguiculata* subsp. *unguiculata* farmers' variety JERGADIE D3) *Vigna unguiculata* subsp. *cylindrica* (L.) Verdc. farmers' variety KIMITE) (Photo credit: Mulugeta Alemu)

DECLARATION

I, Mulugeta Alemu, author of this thesis titled “Cowpea (*Vigna unguiculata* (L.) Walp.) (Fabaceae) Landrace Diversity in Northern Ethiopia”, do hereby declare that apart from the references of other people’s work which has been duly and appropriately acknowledged. The research work presented in this thesis was done entirely by me in Addis Ababa University, Graduate Programs, College of Natural Sciences, Department of Plant Biology and Biodiversity Management (PBBM) from September 2013 to July 2015. This thesis is my original work and it has never been presented and submitted in other universities, colleges, institutes or elsewhere for a degree or other purpose.

Name: Mulugeta Alemu Molla Signature: _____ Date: _____

This work has been done under my supervision.

Name: _____ Signature: _____ Date: _____

_____ Signature: _____ Date: _____

_____ Signature: _____ Date: _____

_____ Signature: _____ Date: _____