

Mungbean (*Vigna radiata* (L.) Wilczek) (Fabaceae) Landrace Diversity in Ethiopia

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Mungbean (*Vigna radiata* (L.) Wilczek) (Fabaceae) Landrace Diversity in Ethiopia

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This is to certify that the thesis prepared by Tensay Ayalew Asegie entitled Mungbean (*Vigna radiata* (L.) Wilczek) Landrace Diversity in 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.

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ABSTRACT

Mungbean (*Vigna radiata* (L.) Wilczek) (Fabaceae) Landrace Diversity in Ethiopia

Tensay Ayalew Asegie "MSc. Thesis"

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The general objective of this study was to assess and document the landrace diversity and ethnobotanical information of mungbean (Vigna radiata (L.) Wilczek) in Ethiopia. Ethnobotanical information of the crop was collected by using semi-structured interview, field observation and market survey. The study areas were covered in Amhara Region (South Wollo, North Shewa and East Gojjam), Gambella Region (Agnwaa), Oromia Region (West Shewa) and SNNPR (Gamo Gofa and Segen Hizboch) zones of Ethiopia. Data analyzed by using descriptive statistics and informant consensus tools. Totally, 25 accessions of mungbean germplasm were collected from local markets, farmers' field and home from September to October 2014. Among all study sites, from Amhara Region more accessions while from Oromia Region less accession were collected. According to the informants, 100% of the accessions were landrace varieties. The collected specimens of mungbean belong to Vigna radiata var. radiata farmer variety MASHO(Amharic), farmer variety OGODA (Agnwaa) and farmer variety NEKEYDA(Konso). In this finding, local farmers use of mungbean as food and fodder (36.8%), income generation, food and fodder (32%), food, fodder and improve soil fertility (22.4%), food, fodder, improve soil fertility and income generation (8.8%). Poorly organized marketing system, less availability of seed during sowing season, less management are causes for limitation. Other factors like disease, insect and drought stress are the key problems of mungbean productivity as described by informants. Awareness raising, effectively managing and making farmers direct beneficiaries will increase production of mungbean by farming communities

Key words: Diversity, ethnobotany, farmers' knowledge, landrace, management, mungbean.

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List of Acronyms

AAU	Addis Ababa University
^{0}C	Degree Celsius
EIB	Ethiopian Institute of Biodiversity
ECXA	Ethiopia Commodity Exchange Authority
GI	Germination index
GMT	Germination mean time
GP	Germination percentage
IBPGR	International Board for Plant Genetic Resources
Kg/ha	kilogram per hectare
m.a.s.l	meter above sea level
NMSA	National Metrological Services Agency
SNNPR	Southern Nations Nationalities and Peoples Region
subsb.	sub-species

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Mungbean is one of the most important pulse crops, grown from the tropical to sub-tropical areas around the world (Kumari *et al*., 2012; Khan *et al*., 2012). It is an important wide spreading, herbaceous and annual legume pulse crop cultivated mostly by traditional famers (Ali *et al.*, 2010). The crop is characterized by fast growth under warm conditions, low water requirement and excellent soil fertility enhancement via nitrogen fixation (Yagoob and Yagoob 2014). Fertilization of this crop occurs through self-pollination without requirement of other pollinators like insects, water and wind (Rashid *et al*., 2013).

Among legumes, mung bean is noted for its protein and lysine-rich grain, which supplements cereal-based diets (Khan, 2012; Minh, 2014). The crop is utilized in several ways; seeds, sprouts and young pods are all consumed and provide a rich source of amino acids, vitamins and minerals (Somta and Srinives, 2007). The grain contains 24.2% protein, 1.3 % fat and 60.4 % carbohydrate (Hussain *et al*., 2011). It is also known to be very healthy and packed with a variety of nutrients such as vitamin B, vitamin C, protein, manganese and a lot of other essential nutrients required for effective functioning of the human health. Mungbean has low in calories and rich in fiber and easily digestible crop without cause flatulence as happens with many other legumes (Minh, 2014).

Mungbean has good potential for crop rotation system, for crops under drier farmland cultivation areas (Ashraf *et al.*, 2003) and ability of growing on dry and irrigated conditions (Rahim *et al*., 2010). Sowing of mungbean mainly occurs during summer when sufficient rain is available for growth but it is sensitive to waterlogging. It is grown in several types of cultivation systems, including sole cropping, intercropping, multiple cropping and relay cropping, where it is planted after cereals using residual moisture (Rehman *et al*., 2009).

Nutrient management is one of the most important factors that greatly affect the growth, development and final product of this crop. Like other legumes, mungbean require phosphorus, potassium, calcium, magnesium and sulfur for grow and development (Arain, 2012). Micronutrients increase the nodulation and nitrogen fixation of mungbean plant. Phosphorus application along with other micronutrients can also increase the biological activity, which can result in improvements to plant height, number of nodules per plant, number of pod per plant and enhanced straw quality (Kumar *et al.,* 2012). As Hussain *et al*. (2011) reported, potash (K) is vital for mungbean and, if applied in soils where it is otherwise deficient, it can increase growth and yield of the crop on average by 90kg/h.

According to Asfaw *et al*. (2012), the optimum temperature range for good production of mungbean ranges from 27^{o}C- 30^{0}C. The temperature necessities always stay above 15^{0}c and the crop requires from 90–120 days for maturity. Dry seed of mungbean is well known to exhibit problems with dormancy. Temperature and relative humidity are common phenomena relating to the development of hard seed of this crop. Factors like temperature and low relative humidity are cause for dormancy of mungbean seed during growth (Lawn and Rebetzke, 2006). This hard seededness is a major problem in producing mung bean sprouts but is useful in protecting dry stored seed from moisture, insect and weather damage (Somta and Srinives, 2007).

Production of mungbean is influenced by biotic and abiotic limiting factors. Water stress, drought stress, salt stresses are among abiotic factors that influence mungbean growth and development. Negative impacts of the stress can be seen in the production of leaves, pods and flower parts at key growth stage of mungbean crop. Thus, depending on the growth stage when the stress occurs, it can significantly reduce final grain yield (Ranawake *et al*., 2011).

As Asfaw *et al.* (2012) reported, in Ethiopia mungbean is mostly grown by smallholder farmers under drier marginal environmental condition and the production capacity is lower than other pulse crops. For resource poor farmers in Ethiopia, mungbean is mainly used as food, but growing it for income generation can also be important. The varieties used for income generation may be different than those which can give a stable yield under harsh environmental conditions. Result from farming practice used as food, medicine, economic, ecological, socio-cultural,

religious and cultural needs. Mungbean is cultivated for its edible seeds, income generation and fodder for livestock's.

The study areas were selected based on the combination of climatic requirements outlined by FAO; these mainly include rainfall, temperature and altitude (FAO, 1984). Accordingly, areas ranging from highly suitable, moderately suitable and not suitable climatic zones were identified. This study focused on areas considered highly suitable for mungbean growth. In Ethiopia no published documented information on diversity and ethnobotanical information of mungbean landrace. So, this study addresses that gap.

1.2. Statement of the Problem

Ethiopia is both a center of origin and diversity of many crops. Mungbean has ecological and socio- economic importance to those local consumers who are highly dependent on it. There are a number of biotic and abiotic factors that lead to decrease in crop quality and productivity. Abiotic factors include water stress, drought stress, salinity stress, while biotic factors include diseases, insect pests and weeds. Insufficient management of the crop, due to farmers' attitude toward it, also results in low productivity of mungbean in the study areas. In Ethiopia, mungbean the prevalence of traditional crop production methods, such as ox-plowing, direct sowing at field and hand weeding also contribute to low productivity. The crop is mostly used for domestic consumption (food for humans and fodder for animals), to improve soil fertility and for income generation through national markets. This study was focused on collecting ethnobotanical information on the diversity and distribution of mungbean landraces cultivated by local farmers. It also involved mungbean germplasm and specimen collection and identification, as well as germination tests. The main limitation of the study was limited accessibility of the crop in the study sites with farmers' and local markets.

1.3. Research Questions, Hypotheses and Objectives

1.3.1. Research Questions

This research was designed to answer the following questions

- What is mungbean landrace diversity and distribution?
- What are the major limiting factors of mungbean production in Ethiopia?
- What are the use values of mungbean in the areas of production?
- How do local farmers' cultivate and manage mungbean landrace?

1.3.2. Objectives

General Objective

- The main objective of this study was to assess and document the diversity and ethnobotanical information of mungbean (*Vigna radiata* (L.) Wilczek) landrace in Ethiopia.

Specific Objectives

- To study diversity and distribution of mungbean landraces.
- To identify factors that constrain the productivity of mungbean across study sites
- To assess the importance of mungbean landrace varieties across study sites.
- To study the cropping system in which mungbean is being cultivated and the traditional methods of management.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Origin of Mungbean

The center of origin of cultivated mungbean is Asia. As Sangsiri *et al.* (2007, 2009) reported, mungbean originated in the India-Burma region of Asia because evidence provided by archaebotanical findings and literary records showed that mungbean was domesticated in India where wild mungbean is widely distributed. Specifically, it has been found at Neolithic sites in southern India where wild mungbean exists. The findings also point to both south-eastern and western Himalayan foothills as likely places where domestication could have taken place. Altaf (2009) also suggested that the primary gene diversity center for mungbean was the central Asian region with India having the widest diversity of domesticated varieties of the crop.

2.2. Taxonomy of Mungbean

The family Fabaceae is classified into three sub-families: Papilionoideae, Caesalpinioideae, and Mimosoideae and each sub-family is identified by its flowers. Sub-family Papilionoideae mainly consists of edible legume crops (Allaire and Brady, 2009). Mungbean belongs to the Asian *Vigna* in the sub-family Papilionoideae and subgenus Ceratotropis, based on agromorphological character of the crop, such as flower color and size of its parts, plant height, pod arrangement, branching of stems and growth habit, seedling characteristics and habitat of the crop (Sangsiri, 2009; Seehalak *et al*., 2009). Subgenus Ceratotropis is divided into three sections Ceratotropis, Angulares and Aconitifoliae which consists of 21 species of which eight are domesticated including moth bean (*V. aconitifolia*), azukibean (*V. angularis*), black gram (*V. mungo*), mungbean (*V. radiata*), creolebean (*V. reflexo-pilosa* Hayata var. *glabra*) jungli bean (*V. trilobata*), toapee (*V. trinervia*) and rice bean (*V. umbellata*) (Sangsiri 2009; Seehalak *et al*., 2009). As Chattopadhyay *et al.* (2008) studied, mungbean has morphological similarity with other genera and species like *Phaseolus* but taxonomically they are different (Sangsiri, 2009). It also has a close relationship to black gram.

Mungbean is botanically described as *Vigna radiata* (L.) Wiczek, syn. *Phaseolus aureus* Roxb, *Phaseolus radiata* (L.) *V. radiata* consists two subp. These are *V. radiata* ssp. *sublobata* wild mungbean and *V. radiata* subp. *radiata* cultivated (Thulin, 1989). Commonly *V. radiate* is called as mungbean/ green gram/ golden gram/ mash bean and green soy.

2.3. Distribution of Mungbean

Although native to India, mungbean is also widely cultivated in Africa, Asia and America. The wild mungbean (*Vigna radiata* var. *sublobata*) is widely distributed from tropical Africa and through west, south and Southeast Asia to Papua New Guinea and Australia (Angsiri, 2009). According to Shanmugasundaram (2009), there is widespread cultivation of mungbean throughout south and Southeast Asia, including India, Pakistan, Bangladesh, Sri Lanka, Myanmar, Thailand, Philippines, Laos, Cambodia, Vietnam, Indonesia, Malaysia, South China, Taiwan, West Indies, South America and North America. As Sangiri *et al*. (2007) reported the cultivated germplasm spread from south Asia to both west and Southeast Asia at a similar time. It was introduced into Africa more than once. Currently, mungbean is one of the most important grain legumes produced for income generation, agricultural improvement, soil conservation and nourishment. Wild relatives of the crop species possess greater genetic diversity than the cultivated forms (Sehrawat *et al*., 2013).

2.4. Historical Perspectives of Mungbean in Ethiopia

According to ECXA (2014), mungbean is being cultivated as a recently introduced crop in Ethiopia. It is also grown in few areas of North Shewa and hence its consumption is not widespread like the other pulses. Farmers used mungbean in bordering areas to make soil fertile without providing fertilizer on the land. So, farmers regard mungbean as traditional crop. Mungbean in Ethiopia were landraces which are similar from one village to another and cultivated by traditional farming. The recently introduced mungbean is also grown in limited areas in smaller quantity.

2.5. Morphological Description of Mungbean

Mungbean is an annual crop cultivated mostly in rotation with cereals (Rashid, 2013). As Imrie (1995) reported, the growth habit can be dwarf, erect, determinate and non-branching or indeterminate and semi-prostrate to tendrilious. The leaves are trifoliate with large, ovate, entire leaflet that are rarely lobed, membranous leaflets with densely pubescent on stems, peduncles and petioles. Pods are born at or above the leaf canopy with sub cylindrical, straight or slightly curved shape (Nawale, 2001). Mostly, mungbean is characterized by broader stipules, pale yellow flowers to greenish yellow with axillary or terminal raceme, more ovules per pod, a spreading pod with short brown hairs (Sangsiri, 2009). It is characterized by an upright habit and relatively synchronous flowering (Paudel, 2008). As Rashid (2013) reported, the mungbean seed coat has two layers containing an outer columnar layer that may contain deep blue or black pigment and a green parenchyma layer, which contains various concentrations of chloroplasts. The germination of mungbean is epigeal with the cotyledons and stem emerging from the seedbed (Arain, 2012).

2.6. Climate Requirements of Mungbean

Mungbean is an important food legume cultivated in many tropical and sub-tropical parts of the world (Iqbal, 2010). It is also cultivated in semi-arid condition of the tropical and warm regions of the world (Rahim *et al*., 2008; Sangsiri, 2009). It is a warm season crop requiring 90-120 days with optimum temperature ranges form 27^{o}c-30°c; the time from sowing to maturity depends on variety of the crop. Adequate rainfall is required from flowering to late pod filling to achieve high grain yield (Zare *et al*., 2013). It is mostly grown during summer season when the temperature and light irradiance fluctuate frequently. In some mungbean growing areas of the tropics, the early summer is characterized by high temperature more than 30^{0}c, while the late summer has high temperature and bright sunlight (Karim *et al*., 2003). Among the ecological requirements for mungbean, temperature and light intensity influence the photosynthetic effectiveness of the leaves of the critical stage of growth (Karim *et al*., 2003).

2.7. Cropping System of Mungbean

Mungbean is cultivated mostly in intercropping and sole cropping systems. Intercropping is a practice of growing two or more crops simultaneously in the same field in a particular growing season. It has probable advantages for increasing sustainability in crop production and producing two or more crops in particular cropping season for cultivars. According to Onuh *et al*. (2011), intercropping mungbean with other crops confers advantages such as improved soil fertility through nitrogen fixation, shading of the soil surface and protection against erosion. It is also reduces the risk of damage due to biotic and abiotic factors. The morphological or physiological differences of the crops' root systems and canopy structure help to increase productivity of the crop (Shahbazi and Sarajuoghi, 2012). Maize and mungbean intercropping is popular with farmers (Mobasser *et al*., 2014). Other mungbean intercropping systems include patch cropping, relay cropping and alley cropping (Mobasser *et al*., 2014).

Growing a single species of a crop in a field at a time is termed as sole cropping or monoculture. Some authors claim that mungbean is more effective in sole cropping than intercropping system in terms of total yield and products of the crop (Lertmongkol *et al*., 2011; Onuh *et al*., 2011); this was due to bigger plants, more numerous leaves per plant and abundant shoot branches. The sole crop also had more root nodules and a deeper roots system, which enabled it to absorb water from greater soil depths; this encouraged better photosynthetic activity for mungbean due to free from competition with others.

2.8. Crop Rotation System of Mungbean

Crop rotation increases both land and crop productivity particularly and is important for sustainable agriculture. Annual crop legumes grown in rotation with cereals contribute to total amount of nitrogen in the soil and improved yield of cereals (Ahmad *et al*., 2001). But some rotation systems can be problematic. For example, poor soil physical conditions limits successful cropping of mungbean after rice. If seeds are sown too early after rice harvest, anaerobic conditions may reduce crop establishment and decrease yield potential (Kirchhof and So, 2005). As it is a short duration legume, it is mainly cultivated between rice-rice, rice-wheat, rice-potato-

wheat, maize-wheat, cotton, and other cash crop to increase both land and crop productivity (Ebert, 2014).

Mungbean has the capability of accumulating large amounts of vegetation in a short period of time. So it also could be used as compost for the soil improvement and by combining its remains into the soil after pods have been harvested at maturity. This can increase soil productivity for succeeding crops (Lertmongko *et al*., 2012). But in other places, such as Ethiopia, these residues are more highly valued as fodder and are thus fed to animals instead. Adding mungbean to the cereal cropping system has the potential to increase farm income, improve human health and soil productivity, save irrigation water, and promote long-term sustainability of agriculture (Chadha, 2010).

2.9. Use Values of Mungbean

Among pulses, mungbean is the most important cash crops in the world (Somta and Srinives, 2007; Pandey *et al*., 2011). It is a vital crop in developing countries where it is consumed as dry seeds, fresh green pods or leaves due to its high protein, vitamin and mineral content. It is also consumed as forage or green pods and seeds as vegetables (Tang *et al*., 2014; Das *et al*., 2014). Primarily, the purposes of this crop are for its protein rich edible seeds and fresh sprout. The seed of mungbean mainly used for making soups, bread and biscuits (Sehrawat *et al*., 2013). Other than food it is importance to assistance in normal use of land, water resource and enrichment of the soil through nitrogen fixation (Nawale, 2001).

Adaptation to short growth duration, low water requirement, ability to increase soil fertility and usefulness in crop rotation practices are also another significances of mungbean (Das *et al*., 2014). Capacity of forming important ecological relationships with majority of invisible soil microbes for the achievement of limiting macro and micronutrients especially in the nutrient poor ecosystems increase productivity of crop and land (Yasmeen *et al*., 2012). Ability of improving soil fertility by fixing atmospheric nitrogen into available form with the help of rhizobia species for plant's growth and development are characters of mungbean (Singh *et al*., 2014; Jat *et al*., 2012). Symbiotic relation of mungbean is mainly affected by soil type, pant growth rate, plant signals, root geometry, mineral elements level in the soil, shade, light and

temperature occurrence result loss of crop final yield (Yasmeen *et al*., 2012). Precisely symbiotic relation has also a very good ability to enhance the physical, chemical and biological properties of soil, therefore, it is considered as an important component of sustainable agricultural production (Lertmongko *et al*., 2012). Bio-organic fertilizer used as foliar spray for improving quantitative aspects of root and shoots parts growth of mungbean (Khalilzadeh *et al*., 2012).

Those who can benefit most from mungbean are the poor, especially children and women whose diets lack much-needed protein and iron (Shanmugasundaram, 2009). As Minh (2014) reported, mungbean also contains a lot of minerals like calcium and potassium, which are essential for enhancing the strength of bones and teeth. Taking mungbean us food helps in preventing the loss of nails, hair and breast cancer for women (Gwag, 2010). Mungbean contain rich in lecithin which reduces the liver fat and regulates the normal functioning of the liver. It also used to decrease the absorption of toxic substances, reduce the risk of hypercholesterolemia and coronary heart disease and prevent cancer (Tang *et al*., 2014). Other properties like easy digestibility and low proportions of flatulence factors also add to its value among the pulse crops (Das *et al*., 2014). Not only dry seed but also mungbean sprouts are an important food with excellent source of protein, calcium and vitamin C (Gwag, 2010).

2.10. Constraints of Mungbean Production

The productivity of pulses is very low as compared to cereals, which have been selected for high grain yield under high input conditions. Productivity of mungbean is decreased through biotic and abiotic stresses including diseases, insect pests, drought stress, water stress, extreme high temperature, salinity stress as well as heavy metals (Waniale *et al*., 2012; Das *et al*., 2014).

CHAPTER THREE

3. MATERIAL AND METHODS

3.1. Description of the Study Area

This study was conducted in different parts of Ethiopia based on the ecological requirement of the crop (FAO, 1984). A total of four regions (Amhara, Gambella, Oromia and SNNPR), 8 zones and 11 weredas were purposively selected for the study (Figure 1).

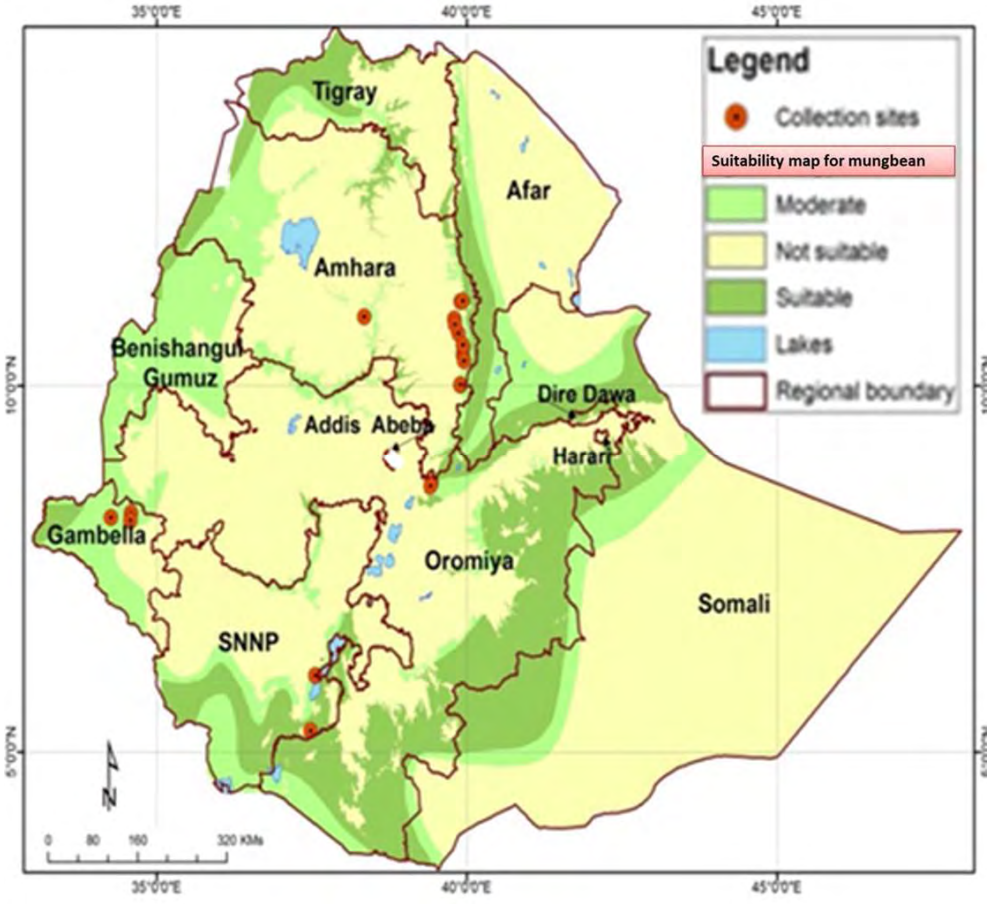


Figure 1: Map of Ethiopia showing the study areas

3.1.1. Geographical Location

This study was conducted in four regions of Ethiopia namely Amhara, Oromia, Gambella and SNNP Regions. Zones and weredas with in each of the four regions together with geographical location are given in (Table 1).

Table 1: Geographical location of the study areas

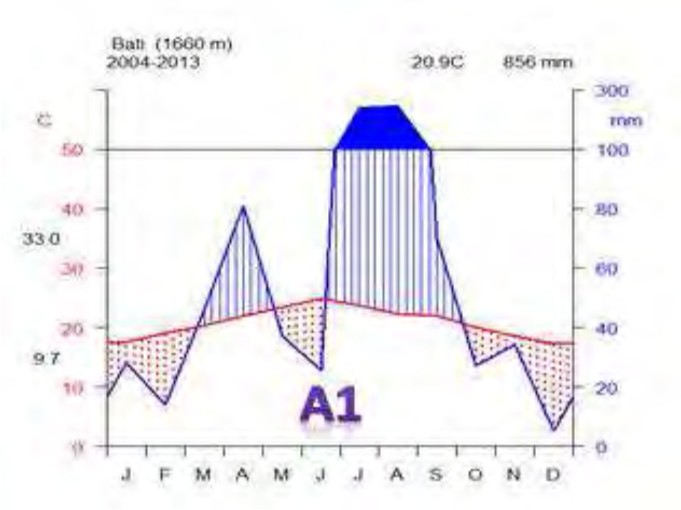
Region	**Zone**	**Wereda**	Altitude (m.a.s.l.)	Grid Reference	Distance from Addis Ababa (km)
Amhara	East Gojjam	Enabsae Sarmider	2217	$10^0$56’41.0’’N 038^{0}20’56.1’’E	364
	North Shewa	Efratana Gedim	1462	$10^0$20’32.6”N 039^{0}57’11.9”E	229
		Kewot	1287	$10^0$00’45.1’’N 039^{0}53’35.4’’E	222
	Oromia Special Zone	Bati	1544	09^{0}02’09.9”N 038^{0}46’06.6”E	412
		Kemsae	1430	$10^0$42’52.5”N 0390 51’56.8”E	328
	South Wollo	Kalu	1462	$10^0$20’32.6”N 039^{0}57’11.9”E	375
Gambella	Agnwaa	Abobo	450	08^{0}09’03.4’’N 034^{0}34’49.4’’E	821
		Itang	524	08^{0}15’14.2’’N 035^{0}34’22.2’’E	821
Oromia	West Shewa	Boset	1461	08^{0}37’11.8’’N 039^{0}23’31.5’’E	92
SNNPR	Gamo Gofa	Arebaminche	1200	05^{0}17’01.0’’N 037^{0}26’29.1’’E	505
	Segen Hizeboch	Konso	1200	05^{0}20’29.8’’N 037^{0}29’07.0’’E	610

3.1.2. Topography

Agro-ecological zones of Ethiopia are traditionally classified into different categories on the base of altitude and temperature these are: pastoral rangelands (*bereha* (below 500 m), lowlands (*Kola*) (500-1500 m), midlands (*woina dega*) (1500-2300 m), highlands (*dega*), (2300-3000 m), ighlands Wurch (3000-3700 m) and highlands (*Kur*) (above 3700 m) (MoA, 2000).

3.1.3. Climate

The climate of the sites of study has been represented using the maximum and minimum temperature, rainfall based on the data obtained from National Metrological Service Agency of Ethiopia for the last ten years. The climate conditions of each collection site are depicted in climadiagrams (Figure 2).



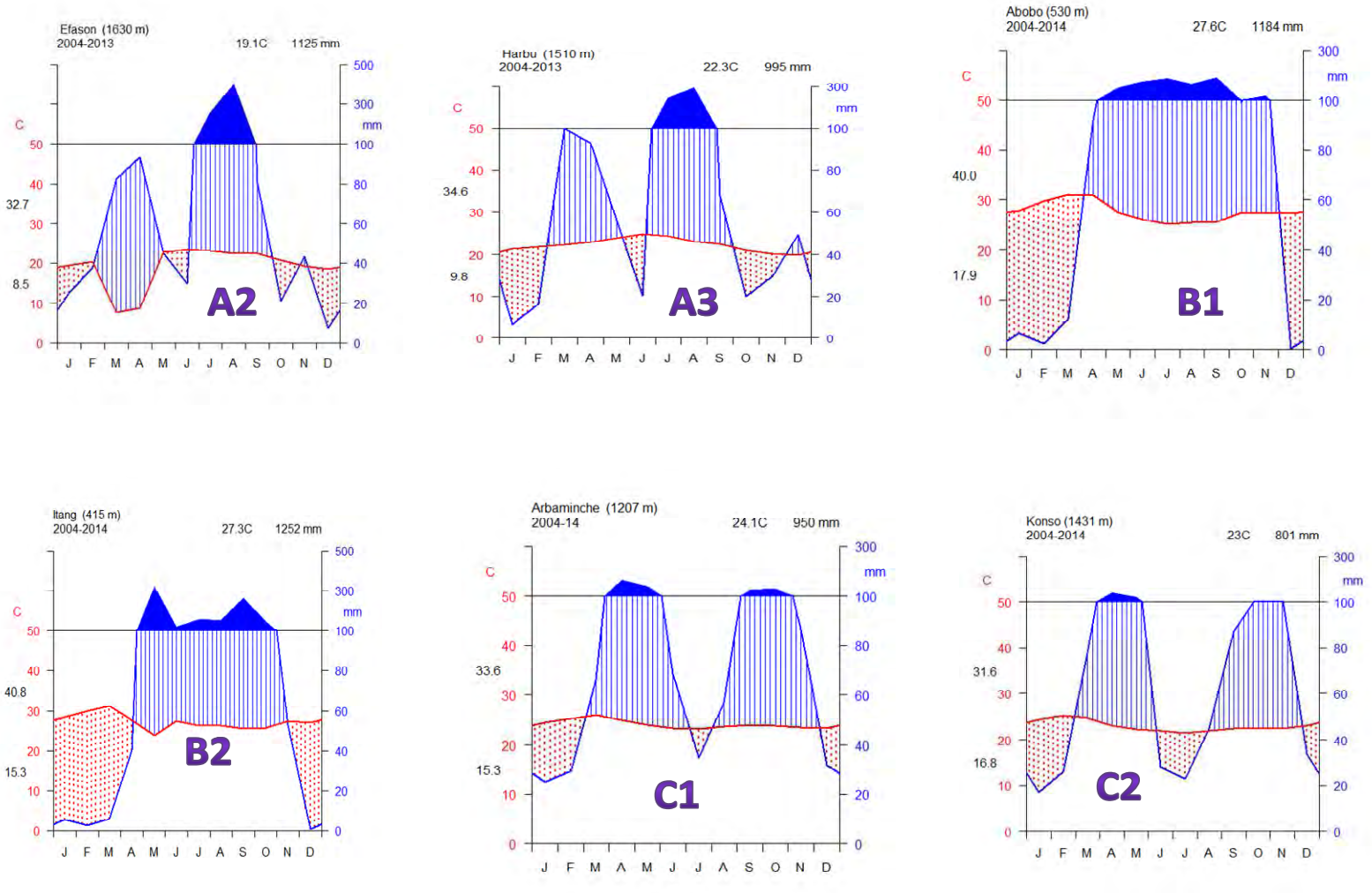


Figure 2: Climadiagram of the study sites

Where; Amhara (A1- A3), Gambella, (B1-B2) SNNPR (C1-C2)

Materials

Materials used during data collection were GPS (Global positioning system device), digital camera, notebook, scissors for cutting plant specimen, plastic bag (holding specimen taken from field) pressing materials like ventilator, wooden frame straps cardboard, blotter for pressing and draying specimens.

3.2. Data Collection Methods

3.2.1. Ethnobotanical Data Collection

The required research data were collected from September 2014 – January 2015. Ethnobotanical information of mungbean landrace was collected by following Martin (1995) and Cotton (1996) procedures. The collected specimens with necessary ethnobotanical information were recorded. Local name of the crop, altitude, latitude, longitude, collection sites and other necessary data were collected as botanical information of mungbean landrace from the study areas.

3.2.2. Field Data Collection

The field study was conducted from beginning of September to end of December, 2014. Data were collected using purposive sampling of the study areas and the ecological requirements of the crop /appendix 4/ (FAO, 1984) suitable wereda lists for mungbean cultivation were prepared. Simple random sampling techniques were used for informants. Therefore, information was collected from zone agricultural experts about which werda's produce this crop. Primary source of data were collected from the farmers' fields (on-farm data collection).

3.2.3. Sampling of Informants

A total of 125 informants (male 86 and female 39) aged between 20 -70 were selected using simple random sampling technique from 4 regions, 8 zones and 11weredas. But key informants (model farmers) were selected purposefully who have good experience in mungbean cultivation. 74 informants from Amhara, 20 informants from Gambella, 12 informants from Oromia and 19 from SNNP regions were used for interview.

3.2.4. Semi-structured Interview

In order to acquire information on mungbean landrace distribution, face to face interviews with informants was done (Appendix 1). The interview was conducted at farmers' fields, homes and at local markets. A questionnaire was used to gather ethnobotanical information on mungbean landraces, such as local name of the crop, time of cultivation and harvesting, traditional management practices, cropping system, use and value of the crop, cost and home consumption purpose, production constraints, attitude and perception of the farmers' towards the crop. General impressions about mungbean production, utilization and management were recorded.

3.2.4.1. Field Observation

The field observations were conducted from September – December, 2014. Guided field walk was done walking with local farmers' in their mungbean cultivated farm land. The data were also conducted with the support of local guides, language translators and informants to obtain the necessary oral information about mungbean from the study site. Local farmers' activity like harvesting, threshing and selling at local market places were observed during the field work and guided walks. Then, the voucher specimens were pressed and taken to the National Herbarium of Addis Ababa University. The specimens were identified using (IBPGR, 1985) and Flora of Ethiopia and Eritrea (Thulin, 1989) in AAU Herbarium.

3.2.4.2. Market Survey

During this study, market survey was done at local market in which mungbean landrace varieties were sold. Information on market values of mungbean was gathered from both mungbean seller and buyer at local market of study site. This helps one to understand and examine local market value of mungbean across the study sites. Some general information about the crop was collected by oral interviews from sellers and buyers to record the local market value or income generation ability of mungbean for local farmers'.

3.2.5. Laboratory Data Collection

Germination test was experimentally conducted at laboratory of Ethiopian Institute of Biodiversity (EIB) during December 2014. The experimental material consisted of mungbean germplasm collected from study site. Materials like petri-dish, distilled water, forceps, dray oven and filter paper were used to conduct this experiment. Before germination, soaking of seed for 24 hour was done to form imbibition and facilitate germination time of the crop.

For the germination test the method and procedures used (Agrwal, 1980)

The experiment was done by applying the following procedures

- Seeds of mungbean were soaked for 24 hours at room temperature.
- All the petri dishes were washed by water.
- The petri dishes were arranged randomly on the table.
- Filter paper was placed on each petri dish.
- Ten imbibed seeds were placed on each petri dish.
- The distilled water was watered on each petri dish
- All petri dish were placed under dry oven equipment by arranged 30^0C.
- The germination ability data were recorded for seven respective days starting from sowing of seeds.

3.3. Data Analysis

Both qualitative and quantitative analytical tools were used for data analysis method. Descriptive statistics and informant consensus tools were used for analyzing ethnobotanical data by entering in to the excel spreadsheet. Descriptive statistics, preference ranking and informant consensus tools were used to analyze the quantitative data. To determine management system limiting factors, parts used method of preparation and others. The informant consensus values were calculated from data collected during interviews. The ethnobotanical data was entered into a Microsoft excel spreadsheet and was analyzed for common characters of the crop like, use and value of the crop, parts used, management practice done by farmers', cropping system and limiting factors of the crop to obtained scientific and tangible results from farmers description.

Then, the results were presented in graphs, figure and tables as well as in text. Climatic diagram of study area were analyzed by R Environmental and Ecological data analysis software (R Core Development Team, 2013) following (Zerihun Woldu, 2012).

CHAPTER FOUR

4. RESULTS

4.1. Mungbean Landrace Diversity in Ethiopia

The cultivated variety of mungbean found in the study areas belongs to the *Vigna radiata var radiata*. Mungbean landrace varieties are cultivated in some parts of Amhara, Gambella, Oromia and SNNP regions of Ethiopia. The 8 zones and 11 weredas belong to the regions. During this study, a total of 25 germplasms of mungbean farmers variety (*Vigna radiata* farmers' variety MASHO (Amharic), *Vigna radiata* farmers' variety OGODAE (Agnwah) and *Vigna radiata* farmers' variety NEKEYDA (Konso)) were collected (Appendix 3). Based on respondants result, mungbean cultivated in the eleven weredas were identified by farmers and the user community as well as by the agricultural research staff as 100% landraces.

Except in three weredas in Itang, Abobo and Konso special wereda all the local varieties are known by the popular name, MASHO. The observed specimen result showed that, mungbean had good morphology in warm areas than in colder environments. The cultivated mungbean landrace found in Gambella Region characterized by semi- erect growth habit, long pod length, many seeds inside per pod, small seed size, green in color and broad leave size. But in Amhara, Oromia and SNNPR mungbean is characterized by small pod length, few numbers of seeds per pod and small sized leaf compared to specimens collected from Gambella. Collection areas, local name of the crop and its language, use values of the crop in each study site and morphological features of mungbean landrace as described by the local farmers and user communities across the study areas are given (Table 2).

Table 2: The local name, languages of crop, used and status of mungbean

Region	Zone	Wereda	Local name of landrace	Language	Morphology	Status	Use
Amhara	East Gojjam	Enabsae Sarmider	MASHO	Amharic	Small pod and small leaf size	Landrace	Food, fodder, cultural ceremony and soil fertility
	North Shewa	Efratana Gedim	MASHO	Amharic	Many grain per pod	Landrace	Food, soil fertility and fodder
		Kewot	MASHO	Amharic	Long pod and many grain per pod	Landrace	Food, soil fertility and fodder
	Oromia Special Zone	Kemise	MASHO	Amharic	Medium pod with medium grain per pod	Landrace	Income generation, food, soil fertility and fodder
		Bati	MASHO	Amharic	Medium pod little grain per pod	Landrace	Income generation, food, soil fertility and fodder
	South Wollo	Kalu	MASHO	Amharic	Medium pod, little grain per pod	Landrace	Income generation, food, soil fertility and fodder
Gambella	Agnwaa	Abobo	OGODAE	Agnwaa	Long pod, many grain per pod, and broad leaf	Landrace	Soil fertility, food and fodder
		Itang	OGODAE	Agnwaa	Long pod, many grain per pod, and broad leaf	Landrace	Soil fertility, fodder, food
Oromia	West Shewa	Boset	MASHO	Afan Oromo	Medium pod length, little grain per pod	Landrace	Income generation, food, soil fertility and fodder
SNNPR	Gamo Gofa	Arebaminch	MASHO	Gamo	Medium pod length	Landrace	Food, soil fertility and fodder
	Segen Hizeboch	Konso	NEKEYEDA	Konso	Medium pod length, and small leaf size	Landrace	Food soil fertility and fodder

4.1.1. Germination Test

Based on germination testing result, all representatives of seed samples were germinated greater than 90%.

Table 5 Mean value of GP, GMT and GI

Treatment	Parameters		
	GP (Mean)	GMT	GI
Tm1	97.50	2.920	4.35
Tm2	100	1.875	6.975
Tm3	100	2.775	4.1
Tm4	92.50	2.853	3.950
Tm5	75	3.262	2.505
Tm6	95	2.765	3.728
Tm7	85	3.885	2.507
Tm8	85	4	2.780
Tm9	100	3.4	3.398
Tm10	90	3.990	2.605
F value	1.91	1.76	3.79
P value	0.089	0.119	0.003

4.2. Mungbean Landrace Distribution

In this study the area of mungbean landrace distribution ranges between altitudes 420 to 1800 m.a.s.l, and temperature ranges between 15^{o}c to 40^{o}c. But insufficiently mungbean were collected from altitude of 2217 in east Gojjam zone. In South Wollo and North Shewa zones of Amhara Region, mungbean is highly cultivated due to its multipurpose nature, since the crop can be used for food, income, improving soil fertility and fodder. The early maturity of the crop is considered an important attribute In Gambella Region mungbean landraces were produced at Agnwah zone, Itang and Abobo weredas. Mungbean specimen and germplasm collection zones and weredas of study site (Figure 1).

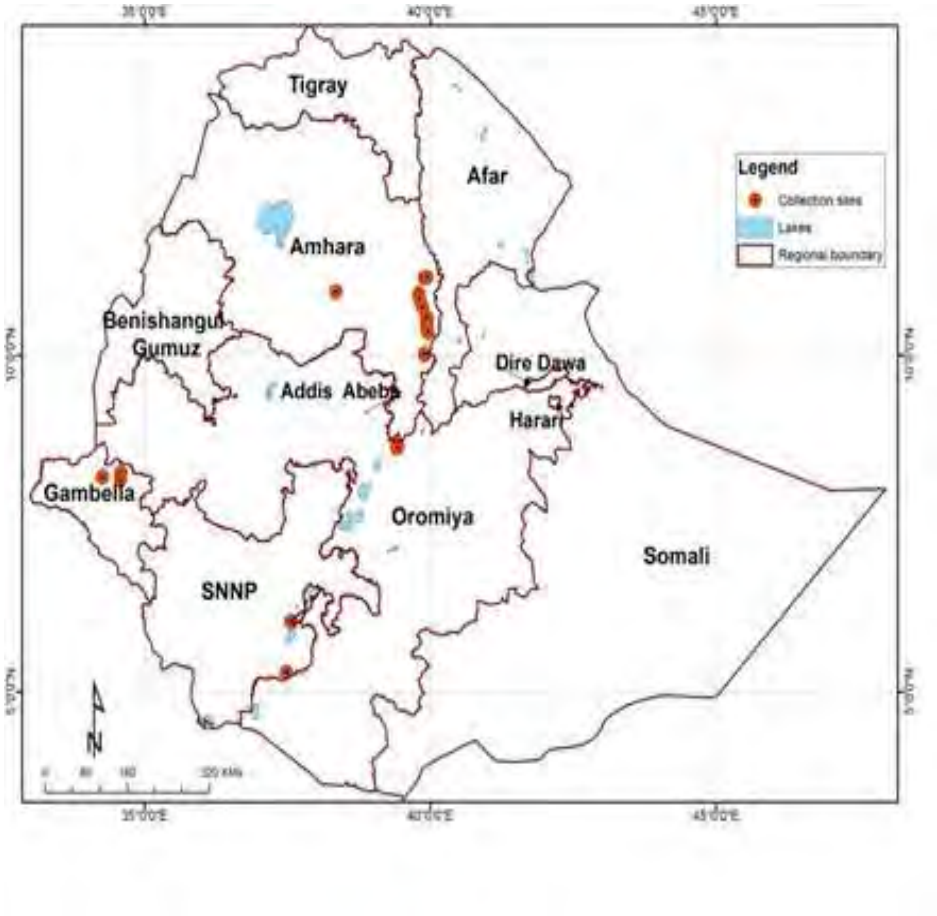


Figure 3: Map of Ethiopia showing the areas of collection of voucher specimens and germplasm

4.2.1. Environmental Suitability for Mungbean Cultivation

According to farmers' response show that, for growth and productivity of mungbean (82%) respondents under warm temperature while, (18%) moderate temperature. Because temperature accelerates maturation time of the crop also if the temperature is warm, the crop mature too quickly while, if the environment is cool, the crop maturity was too slow. Cultivation of the crop in Gambella occurred in the hottest and driest season. In Amhara, Oromia and SNNP Regions, mungbean were cultivated under warm season but these areas are cooler compared to Gambella.

4.2.2. Limiting Factors for Mungbean Production

Biotic Factors

According to farmers, biotic factors that limit mungbean productivity included weeds leave diseases, flying insects on pod and leave at any growth stage. Pest (weevils) also among biotic factors described by informants occurred on stored seeds of mungbean. Parts of mungbean attacked by insects were mostly leaf and pods of crop plant at field before harvesting and seeds after storage. Furthermore, result from local farmers indicated that destruction of pods by flying insect was the most serious problem (Figure 4). According to the data, storage problems were less severe.

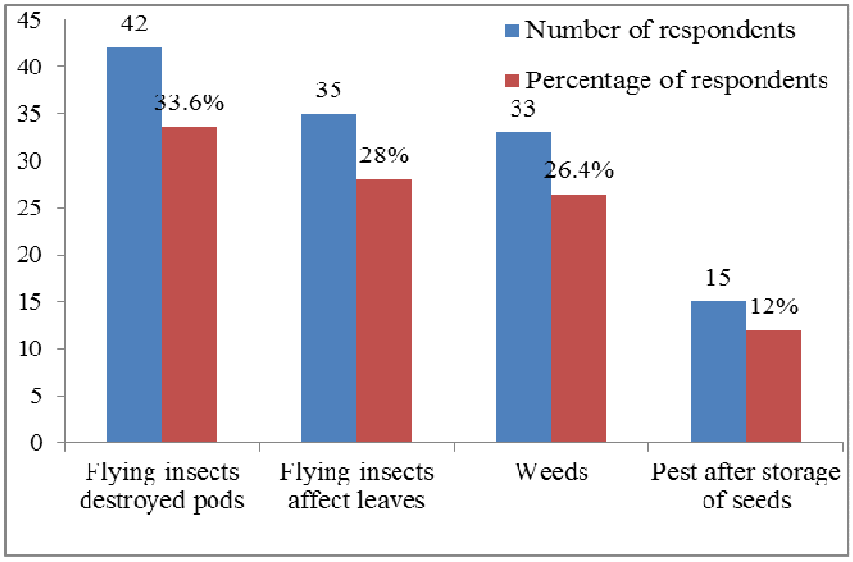


Figure 4: Biotic limiting factors for mungbean landrace by farmers' in the study areas

Abiotic Factors

According to this study informants, the abiotic factors limiting yields of mungbean-- in terms of both quality and quantity are extreme drought 34 (27.2%), cold weather 24 (19.2%), untimely rain (rain after pod filling) 28 (22.4%) and type of soil used for cultivating it 19 (15.2%). From the above factors, extreme drought is described by farmers as greatly influenced factors for mungbean crop productivity. In addition to biotic and biotic factors shortage of land, less management practice and less availability of germplasm during sowing time were among limiting factors affecting mungbean.

4.3. Use Values of Mungbean Landrace Varieties

Results from the local community on the importance of mungbean showed that mungbean has multiple socio-economic values, including its use for food and fodder as well as soil fertility. Thus, local farmers' uses of mungbean as food and fodder 46 (36.8%), income generation, food and fodder 40 (32%), food, fodder and soil fertility 28 (22.4%), food, soil fertility and cultural ceremony 11 (8.8%). Among the respondents the highest percentage (36.8%) proportion gives priority for food and fodder value of mungbean. Seeds of mungbean in all study areas have related purpose like house consumption as food locally called NIFRO, KIK WOET and soup (SHORBA).

4.3.1. Preferences of Farmers'

The total results of the responses showed that mungbean is more preferred as food by local farmers. But this preference is vary between the study areas. Hence; in Amhara region mungbean is primarily preferred for income source (Table 2). Landraces varieties of mungbeans have been selected by farmers and consumers based on different aspects, including adaptation to harsh condition, crop quality, ability to enhance soil fertility, source of income generation and intercropping characteristics

Table 3: Farmers preference ranking of mungbean in the study areas

Data collection weredas	**Food**	**Fodder**	**Improve soil fertility**	**Income generation**
Abobo	5	4	2	-
Arebaminch	5	4	3	-
Bati	3	2	4	5
Boset	4	3	1	2
Efratana Gedim	5	4	3	5
Enabsae Sarmider	5	4	2	-
Itang	5	4	3	1
Kalu	3	4	2	5
Kemsae	3	5	1	3
Kewot	4	2	3	5
Konso	5	4	2	1
Total score	47	40	26	27
Rank	**1st**	**2nd**	**4th**	**3rd**

4.4. Local Perceptions of the Community about Mungbean

Majority of informants in this study described mungbean that, early maturing crop, disease resistance, drought tolerance, adaptability to any types of soil and good market value. Result from local farmers showed that, cultivation practice of mungbean in study areas was not sufficient. Its cultivation practice also varies within regions based on environment conditions and farmers' awareness and choice on crop use values. This difference among regions can be due to difference in awareness level regarding the importance of mungbean, cultural difference or due to differences in altitude as well as temperature between the regions. Farmers practice for mungbean cultivation in the study sites is noteworthy. Soil preferred by local farmers to grow mungbean landrace in the study areas was mostly marginal and stony black soil types.

4.5. Cropping System and Management Technique for Mungbean Production

4.5.1. Cultivation of Mungbean

The majority of local farmers' grew mungbean at main field 59 (47.2%), home garden 34 (27.2%) and border of the crops 32 (25.6%). In the study sites, mungbean was cultivated in the main field, border of crop and home garden but this varied based on amount of crops cultivated (Figure 4).

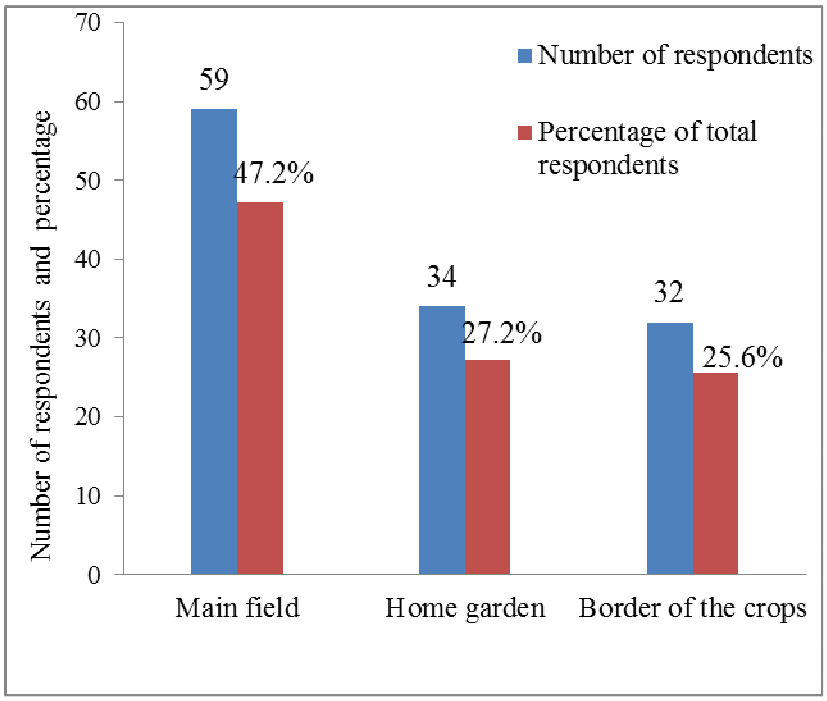


Figure 5: Farmers preferred farm land for mungbean cultivation across study site

A number of farmers described, importance of cultivating mungbean for farm land used as soil fertility improvement 62 (49.6%), for crop rotation 36 (28.8%) and to eliminate weeds from their farm lands 27 (21.6%).

4.5.2. Cropping System

In this study, two cropping systems were distinguished being practiced by farmers for mungbean cultivation. These are intercropping and sole cropping systems. Sole cropping is highly practiced in Gambella Region (100%) and Amhara Region (75 %) but slightly practiced in Oromia and SNNPR. As local farmers result showed that, mungbean is effectively in plant height, pods length, number of pods per plant and number of grans per pods under sole cropping system. Sole cropping of mungbean showed that, the plant having a lot of access to water and nutrients to send a larger number of pods and the plant also effective in growth and pod filing with long pod length (Figure 6).



Figure 6: Sole cropping of mungbean in Kewot wereda (Photo by Tensay Ayalew, 2014)

Mungbean is mainly grown as an intercrop with maize (*Zea mays)*, sorghum *(Sorghum bicolor)*, haricot bean (*Phaseolus vulgaris*) and barley (*Hordeum vulgare)* (Table 3). Accordingly, mungbean is highly intercropped with maize and rarely with barley.

Table 4: Farmers' ways of intercropping mungbean across the study site

Regions	Mungbean intercrop with other crops	Family	English name	Number of respondents	Percentage (%)
Amhara, Oromia and SNNPR	*Hordeum vulgare* L.	Poaceae	Barley	5	11.1
	Sorghum bicolor L.	Poaceae	Sorghum	9	20.0
	Zea mays L.	Poaceae	Corn	23	51.1
	Phaseolus vulgaris L.	Fabaceae	Kidney bean	8	17.8

4.5.3. Traditional Management Practices

Traditional mungbean management practices were assessed for land preparation, sowing, weeding, harvesting and storage. Land preparation for cultivation of mungbean was applied by of farmers' using ox plowing and digging systems. Sowing of mungbean was done from end of June to August by direct broadcasting method at prepared farm lands. Sowing of mungbean occurred by direct broadcasting method at farm land.

All types of weeds affect mungbean, particularly climber weeds, grass and other herbs. Weeding practice were done at vegetative growth stages, after 25 days of planting. Among respondents, 77 (61.6%) did not practice weeding but the rest 48 (38.4%) were practicing weeding to reduce competition of mungbean for nutrients, water and sun light. Based on local farmers perceptions, a majority of respondents could not give much care from planting to harvesting but reasonable number of informants used hand weeding practice.

Harvesting practice were done after maturity just above the ground level or when half of the pods turned to darker or black color and it was done from October to November (Table 5). As farmers' explained, mungbean was difficult to harvest by cutting the shoot, because of variation in maturity of the crop in one plant, rather it matures with weekly intervals per one mungbean crop plant. Once pods have dried, the seeds are removed by beating or crushing but the tip part may be at flowering stage. And after cutting the crop needed proper handling otherwise the pod will be broken, cracked or scarred and seeds fall out.

Table 5: Sowing and harvesting season of mungbean

Location	Time of planting	Time of harvesting
Amhara	Early June – End July	Early October – End November
Gambella	August	End November
Oromia	June- July	End September – End October
SNNPR	August	October -November

Proper storage practice is one effective management of the crop. Local farmers store seeds after proper drying in sunlight for 2-3 days. Sun dried and stored 40 (32%) mixing with cereals 35 (28%), adding chemical accounted for 25 (20%) cases and mixing with ash 25 (20%). Farmers' stored mungbean for few months as sowing purpose but if stored for more than one year it will have low germination capacity. Most of the farmers' just after harvesting and adequate drying, they selected seeds that are free from pests for next sowing season. But the seeds of mungbean have ability to resist pests if properly drayed and stored.

4.5.4. Gender Contribution and Seed Source

Women and men had different roles and responsibilities for management of mungbean production. Women farmers were exclusively involved in weeding, storage and processing for home consumption for food grain boiling (NIFRO), sauce (SHORBA) and (WOET). While plowing land preparation and threshing were the responsibilities of men farmers across the study sites. During sowing season, farmers source of seed are local market, storing at home and informal exchange with local communities.

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

5.1.1. Mungbean Landrace Diversity in Ethiopia

Mungbean variety collected from the study sites had slightly different in morphological features but it could be due to genetic difference or environmental factors. However, this needs to be verified through genetic studies. The specimen from Gambella region (*Vigna radiata* farmers' landrace variety OGODAE) has high number of pod per plant, long pod length, large leaf size and many numbers of grains per pod. On the other hand species collected from Amhara (*Vigna radiata* farmers landrace variety MASHO) particularly from Kewot and Efratana Gidem weredas crops has medium pod length, slightly brood leave size and few numbers of grain per pod compared to specimen collected from Gambella region (Itang and Abobo weredas). From SNNPR (*Vigna radiata* farmers variety NEKEYDA), the collected specimens were characterized by medium pod length, medium leaf size and less number of grain per pod, which was mostly similar from specimen collected from Kewot. Similar study conducted by Chadha (2010) mungbean seed of variable sizes, shapes and colors caused by difference in geography as well as climatic variables of growing areas.

5.1.2. Mungbean Landrace Distribution

Mungbean is distributed in different climatic and geographical regions of Ethiopia. In this study mungbeans were cultivated in Abobo, Arebaminch, Bati, Boset, Efratana Gedim, Itang, Enabsae Sarmider, Kalu, Kemsae, Kewot and Konso weredas of Ethiopia. In the study conducted by Thulin (1989), mungbeans were distributed in Shewa, Ilibabure, Gamo Gofa and Harerge areas of Ethiopia. This study was also conducted in some parts of the above areas, but presently in surveyed areas of Harerge, mungbean is not cultivated and replaced by other cereal crops. Mungbean distribution is effective in Amhara Region of South Wollo and North Shewa zones and production practice of farmers also increasing through time to time in those areas. In

Gambella Mungbean is produced in Itang and Abobo weredas but its distribution was limited. Reason for this may include its limited used as food and fodder for human and animals' respectively. Compared to other production sites it grows effectively, due to crop requirement for temperature and soil type of the locality. But the production status appears not to have changed through time.

In Oromia Region of West Shewa zone (Boset wereda) little mungbean production was observed. The main reason rised by local governmental employers' were less cultivation practice of the crop by farmers' and less awareness of farmers about the crop benefit via less consumption and market value. Farmers in that area characterized mungbean as susceptible to insect and diseases. Because of those reasons production of mungbean is decreasing through time. In SNNPR at Gamo Gofa zone of Arbaminch wereda and Segen Hizeboch zone of Konso special wereda mungbean cultivation practice is intermediate. Cultivation of this crop is limited for the purpose of home consumption as food, soil fertility and animals feed.

5.1.3. Environmental Factors Preferred by Farmers' for Mungbean Cultivation

In all the study areas, mungbean grew in warm temperature environments but not areas that experienced extreme drought. In a study conducted by Sangsiri (2009), mungbean was found to be mostly cultivated in semi-arid tropical, subtropical and warm regions. In addition to temperature soil also one important ecological requirement for mungbean production. The study informants felt that soil type does not greatly influence mungbean performance though they think it prefers to grow in black fertile soil. Farmers cultivate mungbean in black soil, red stony soil fertile and infertile soil. A higher proportion of the respondents agreed that mungbean does better in black fertile soil than in red soil.

In Amhara Region, farmers added natural fertilizer before sowing and at vegetation stage to increase crop quality and quantity. In contrast adding fertilizer was not practiced by farmers in , the Gambella Region. The reason Gambella farmers gave was that the temperature is high in the area and fertilizer makes the crop produce more leaf than pod and seed (they locally call it MEGASHEB). So the result indicates that farmers perceive that te use of natural fertilizer should go in accordance with local temperature. In Oromia Regions adding fertilizer was not practiced

because of less awareness of farmers. In SNNPR mungbean was fertilized because it is cultivated in the home garden and able to get natural compost.

5.1.3.1. Major Production Constraints of Mungbean

The result from informants showed that the most crucial abiotic factors sensitive for mungbean are extreme drought, waterlogging, unusual rainfall and cold weather. Among these, farmers felt water stress is the major limiting factor as it reduces final grain yield of mungbean in terms of seed quality and quantity. As Mohammed (2007), salinity, water stress, heavy metals, temperature and drought are the most abiotic (non-living) limiting factors for decrease mungbean productivity. Farmers in the study areas also described that; drought affects both quality and quantity of mungbean, if it occurs during pod filling. A study by Ranawake *et al*. (2011) showed that the occurrence of drought from flowering to maturity stage has serious effect on pod and fruit development of mungbean, seriously reducing its final yield.

There are pests that attack the crop at all stages, from seedling to maturity and these can cause serious yield loss. Similar study conducted by Chadha (2010) reported that all parts of crop plant including root, stem, branches, petiole, leaves, pods and seeds of the crops are vulnerable to disease and pest. Ashrar (2001) considered the low yield potential of mungbean is due to susceptibility to insect pests, diseases, undetermined excessive vegetation growth and small seed size.

Farmers' responses in this study showed that they felt the major biotic factor affecting mungbean landrace performances were flying insects; these affect leaves and pods parts of the crop during both the vegetative and reproductive periods. In some parts of the study area, mungbean is known to be resistant to pests compared to other crops.

Farmers' access to quality seed of mungbean landraces is constrained by insect, weeds and pests. Weeds affect the quality and quantity of mungbean crop. As reported by Yadollahi *et al*. (2014), mungbean yields are reduced due to weeds' abilities to outcompete crops for nutrients, water and sunlight. Thus, weeding management is an important practice for reducing mungbean weed and pest challenges. In addition to biotic and abiotic factors reported above, production of mungbean can also be limited by poor distribution of crop, improper time of sowing (sowing too early or

too late), inappropriate seed rates and lack of access to seed. Other important factors can include displacement by a cash or cereal crop, shortage of land, inappropriate management practices and poor marketing system.

5.1.4. Use value of Mungbean

Seeds of mungbean in most of the study areas were used for home consumption. The majority of informants preferred mungbean for food, fodder, soil fertility improvement and source of income generation. But we found that this varied by weredas (Table 2). In North Shewa and Oromia special zone (Bati and Kalu weredas) mungbean was more preferred for income generation. The crop trash (parts remaining after threshing and winnowing) is used as animal fodder. These were regarded as a nutritious grain and fodder for the farm animals in Amhara, Gambella, Oromia and SNNPR.

Major benefits of mungbean interims of agriculture includes soil fertility, crop rotation (increase both product of crop and productivity of land) and eliminate pest and weeds for the land are the most. Almost all farmers across study site had trend of cultivating mungbean just to enrich soil fertility. As farmers described, growing of mungbean rotationally was mainly done to eradicate weeds and soil fertility improvement. As Chadha (2010), adding mungbean to cropping system has the potential to increase farm income, save irrigation water, improve human health and soil productivity and promote long-term sustainability of agriculture. Crop rotation practice of mungbean was done mostly with cereals to increase both land and crop products. In addition, green mungbean is one of the products that has low local consumption yet has a high international demand (ECXA, 2014). In this research result also showed that, the local farmers used mungbean as income generation by selling in the local market.

5.1.5. Local Farmers' Knowledge and Perceptions on Mungbean

Farmers mostly preferred mungbean as food for home consumption purpose. Local farmers' valued for its yield, early maturity, ability to withstand harsh conditions and income generation value. Farmers in Enebsae Sarmider, Itang and Abobo weredas cultivated mungbean typically for food and crop rotation. Local farmers give less concern to crop sowing date (early and late sowing of the crop), planting pattern, way of weed control, unbalanced sowing of seed per given

area and others resulted in limited total yield of crop. On the contrary, farmers in North Shewa and South Wollo have better awareness and a positive attitude towards the crop, its market value and as a result they are the highest producers of the crop than the rest of the study sites.

5.1.6. Cropping System and Traditional Management Techniques

5.1.6.1. Cropping system

In the current study two types of cropping system were commonly implemented by the respondent these are sole cropping and intercropping systems. From the study areas Amhara, Oromia and SNNP regions farmers used both intercropping and sole cropping system. As result from informants, purpose of intercropping practice is to manage two or more crops simultaneously. For mungbean intercropping with different crops applied by local farmers were for the purpose of enhance soil fertility and gain more than one crop at particular time.

The respondents result showed that, mungbean intercropping with *Zea mays* has greater than other cereals (Table 3) hence; local farmers consider that, mungbean is more productive if intercropping with *Zea mays.* On the other hand intercropping of mungbean with *Phaseolus vulgaris* is less effective. Relative study reported by Khan *et al*. (2012), intercropping is more efficient, if it happened between morphological difference crops. Intercropping practice preferred by local farmers is because of its ability to increase both product in particular time and farm land. Comparative study conducted by Mobasser *et al.* (2014), intercropping practice provides increase soil fertility and agro-ecosystem conservation of ecosystem.

According to these findings sole cropping mostly practiced at Amhara and Gambella regions (Figure 5). Sole cropping of mungbean adapted in Gambella Region is because of mungbean nature of drought tolerance, ability to grow in any type of soil, productive with harsh condition. On the other hand cereals have no ability to productive under high warm condition. Due to this reason sole cropping of mungbean at Gambella Region is highly adapted by farmers. In Amhara region mungbean considered as source of income generation for local farmers and they cultivate on main field. As informants result showed that, for mungbean sole cropping has greatest advantage to increase its products and quality without competing with other crops. Similar study conducted by Lertmongkol *et al.* (2012), mungbean is more effective in sole cropping system,

because not much computation for nutrients, mineral and sun light with other crops for growth and productivity.

5.1.6.2. Traditional management

As local farmers' responses, pre and post harvesting management practice for mungbean landrace were increase quality and quantity of the crop. Management practices include timely sowing, weeding, harvesting and proper storing of the crop. Cropping season of mungbean is summer from the end of June to July. Therefore, land preparation and deep plowing particularly under rainfed conditions was done to conserve soil moisture and eradicate weeds before cultivation. Therefore, sowing of mungbean seed occurred by direct seed sowing (broadcasting) at field. It is easiest and cheapest way of crop technique done by farmers in the study site. Sowing of the crop done in home garden, main field and border but most of them were cultivate at main field and home garden but not much less cultivate at border.

Timely sowing seed at prepared farm land for mungbean play critical role for its product both in quality and quantity. As farmers expressed, too late sowed mungbean results in susceptible to insects on leave and pods, also early sowed of mungbean affected by unconditional rainfall. Study conducted by Chadha (2010), sowing time is one of the major factor affecting plant height, vegetation, reproduction, maturation time and yield of mungbean. Mungbean is effective in crop rotation but continuous cropping of mungbean can lead to plant growth inhibition, less quality production and decline total yield of the crop.

Main field cultivation of mungbean was done mostly in Amhara and Gambella regions. Also home garden cultivation was practiced mostly in East Gojjam and Gamo Gofa zones of study site. Home gardens cultivation method is important because of easily accessed of fertilizers and green manure to the growing plant. The composition of dung, weeds and other organic matter can increase soil fertility at home garden in the form of compost. Cultivation of mungbean in home garden may cause over growth of leave and steam than pod because of much compost decompose. So, if the soil is high fertile and increase in sprout (leave, shoot) product than seed. Cultivation in border was done in Boset and Konso weredas because of less attention given for this crop.

Hand weeding is an important traditional activity done by local farmer to reduce and remove unnecessary plants grown with crop. All types of weed affect and slightly reduce the crop plant particularly climber weeds, grass and herbs. Similar study conducted by Yadollahi *et al*. (2014), product of mungbean decreased due to competition ability of weed. Other way of management system done by farmers in the study areas were adding fertilizer. Majority of respondents mentioned that, sowing of mungbean was done without using fertilizer and few numbers of respondents told that cultivation was done by using natural fertilizer (compost). AS farmers in Gambella Region described mungbean cultivation in home garden was effective in sprout production than seed.

Harvesting management practices determine quality and quantity of the crop. Harvesting of mungbean by farmers was done when crop plant became mature. Early sowed of landraces mungbean were harvested at the beginning of October while late was harvested during November based on maturation and sowing times of the crop. Study conducted by Itefa Degefa *et al*. (2014), the main growing season of mungbean was from July to August and October was harvesting season in Ethiopia. The total result of the response showed that, mungbean was difficult to harvest by cutting shoot because of ununiformed maturity of the crop, rather it mature with weekly intervals per one mungbean crop plant. Once pods have dried, the seeds are removed by beating or crushing but the tip part may be at flowering stage. After collecting from field threshing done either by animals' leg or humans' hand based on its amount, but the pod is thin and hard when dry, so crushing by hand was not preferable by farmers.

Proper storage practice is one effective management of the crop. Most of the farmers just after harvested and adequate drying, they selected disease attacked seed of mungbean seed and store insect free seeds for next sowing season. Farmers prefer storage of seed was done by mixed with chemical cereals and ash to protect seeds from pest. But as farmers description, seeds of mungbean are pest resistance, if it properly sun dried before stored.

5.2. Conclusion

From the study areas, mungbean accounts insufficient amount of cultivation practice for food and fodder. This research has been reported on diversity and ethnobotanical information of landrace mungbean cultivated in some parts of Ethiopia. Mungbean is edible legume crop cultivated by local farmers in Ethiopia. Its cultivation time ranges between June to July and harvesting was done from October to November based on maturity of the crop. Farmers' in the study areas preferred farm land for cultivation of mungbean were main field, home garden and boarder of other crops. Intercropping and sole cropping system were applied by local farmers for mungbean landrace cultivation. For intercropping system, crops that grown with mungbean in the farm lands were *Zea mays*, *Phaseolus vulgaris*, *Sorghum bicolor* and *Hordeum vulgare.*

Mungbean has considerable importance in economical, food, fodder and agricultural (green manure crop to improve soil fertility) aspects. In Ethiopia local community mostly prepared mungbean as boiled seed (NIFRO (Amharic)), split seed (KIK WET (Amharic)), seed powder (SHERO WET (Amharic)) and (SHORBA (Amharic)). In terms improving soil fertility, farmers are experienced on planting of mungbean as crop rotation system with other cereals. This crop is also one way of good income generation system for farmers even if the cultivation practice is less.

Farmers prefer mungbean were because of crop characters like, ability to resist harsh conditions (drought stress, less soil fertility), early maturing crop and good performance of pest and disease resistance. The crop is well adapted under warm and drought ecological areas of Ethiopia. Mungbean is mostly cultivated in Amhara regional state particularly in some areas of North Showa and South Wollo but insufficiently produced in some parts of Gambella, SNNPR and Oromia regions of Ethiopia. The yield of mungbean depends largely on weather conditions, soil type and management practices done by farmers. The main seed sources for cultivation of mungbean for local farmers' were storing at home, informal exchange by other crops and local farmers. Farmers across study site cultivate mungbean, at main field, home garden and border of the crops of farming lands.

There are biotic and abiotic factors that limit production of mungbean across study site. Among the factors drought stress, insect pest, disease, less management practice by farmers and less attitude of the crop by farmers' takes the greatest. Mungbean seeds were purchased at local market by farmers and local merchants. It is thus concluded that, there are opportunities for growers to enhance income from mungbean cultivation by getting potential yields. Mungbean is multifunctional and non-demanding required crop for production; cultivation, conservation and utilization of the crop are still lower. Therefore, this crop needs immediate attention given to its crucial importance as food, fodder, soil fertility improvement and source of income generation.

5.3. Recommendations

- Local governmental employers should do effective and efficient work on creating awareness regarding cultivation practice of mungbean and giving training for local farmers' on how to cultivate and manage the crop to increase its product.
- Creating awareness for local farmers on how to manage the crop effectively (sowing, weeding, harvesting and storing) and conserve the mungbean landrace.
- Local farmer also should apply the effective management practice that is necessary for the crop from preparation of farm land to storing the seed properly.
- The concerned body should increase availability and accessibility of mungbean landrace germplasm (seed) during sowing season for local farmers.
- More agricultural research should be conducted on the characters and requirement of the crop for various regions and environments to conserve landrace variety of mungbean.
- Institutions like, Melkasa Agricultural Research Center and Ethiopian Biodiversity Institute better to conserve landrace varieties of mungbean to prevent them threat.
- The government should create suitable economical as well as agricultural rules and policies for sustainable production and use of mungbean landrace for the community.
- Finally create marketing information networks that easily available by all farmers and easy to access cultivar in local area and make them direct economic user from mungbean.

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APPENDICES

Appendix 1: Interview data Collection Format for Mungbean landrace diversity

1. General Information

Informant's Name_____ Age_____ Sex _____

Location: Region_____Zone _____Woreda_____

Local name of the crop _____

Altitude _____Latitude _____ Longitude _____

Local variety name (Language) _____

Cropping season _____

Quality of mungbean in case of farmers' perception_____

Diseases and pests identified by the farmer_____

Economic use of the crop_____

2. Ethnobotanical Information

1. Is it improved or farmers' variety? If it is farmers' variety meaning of name_____ what is the name of the variety_____

2. Uses and values of the Crop other than food

A. Alcoholic beverage (specify)

B. Medicinal _____

C. Forage _____

D. Myths and beliefs associated with the crop_____

F. Any sayings, songs and poems_____

3. Which parts of mungbean are used for food or feed?

4. What are the most commonly used mungbean (*Vigna radiata*) landrace varieties in your area?

- Is there any wild relative? What is it called? How is used?

5. How do members of local community cultivate and manage?

6. Suitable environmental requirement for the crop to grow_____

7. Cultivation time?

8. Use of crop rotation_____

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

iii. To replenish soil fertility iv. Others_____

9. Do farmers use intercropping? Why? How?_____

10. Where do grow this crop? home garden _____main field_____boarder crops_____

11. How do you grow this crop? Monoculture _____Multiple cropping _____

12. If Multiple cropping, which crops do you grow in association with mungbean?

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

13. What do you think the area of production in terms of coverage?

Increasing	Decreasing	No change	Factors

14. How do farmers maintain the fertility of their farmland? Do they use artificial or natural fertilizer?_____

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

16. Are there any traditional varieties that are no longer cultivated? Why not cultivate?
17. Do you think improved varieties have replaced the landrace? Yes/No. If yes, how many landraces are replaced so far? _____
18. How long, since the replacement of landraces in the area?_____
19. Does the community prefer landrace or released ones? Why?_____
20. How do farmers culturally manage such pest/weeds?_____
21. What are the main threats to the traditional variety in your area?_____
22. What measures should be taken to overcome the problems?_____

3. Socio- Cultural Significance of Crops

23. How do you use this crop? A. food B. fodder C. others
24. Which variety do you use and for what purpose?

Variety of the crop	**purpose**

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

1._____ 2_____

26. What special tasks do women contribute to maintain genetic diversity?_____
27. What are your parameters of selection for better varieties of the crop? Men Women_____

4. Economic significance of crop varieties

28. Which varieties of the crop are more preferred for production?_____
29. Which varieties of the crop are used for consumption? _____
30. Which varieties of the crop are used for market? _____
31. Are there special landrace varieties of mungbean which are marketable in your area?

32. Are there limitations in the cultivation and utilization of mungbean in the locality?
33. What are the solutions to constraints for mungbean species?
34. Would you mind to list any crop species that is cultivated in your area?
35. Do you have anything else to tell me?

Thank you for your willingness!!!

Appendix 2: Spacemen photograph at field and during labeling with identification



Appendix 3: Morphological identification of specimen collected from the study areas

Characteristics	**Gambella**	**Showarobit**	**Degan**	**Konso**
Growth habit	Semi erect	Erect	Erect	Erect
Growth pattern	Determinate	Determinate	Determinate	Determinate
Leaf type	Compound (pinately trifoliate)	Compound (pinately trifoliate)	Compound (pinately trifoliate)	Compound (pinately trifoliate)
Leave arrangement	Alternate	Alternate	Alternate	Alternate
Lamina shape/Terminal leaflet shape/	Deltate	Deltate	Deltate	Deltate
Lamina base	Rounded	Rounded	Rounded	Rounded
Lamina margin	Entire	Entire	Entire	Entire
Lamina apex	Sub-acute	Sub-acute	Sub-acute	Sub-acute
Lamina venation	Reticulate	Reticulate	Reticulate	Reticulate
Lateral vein number	6-8	6-8	6-8	6-8
Lamina indumentums	Present	Present	Present	Present
Raceme position	Above canopy	Above canopy	Above canopy	Above canopy
Pod attachment to peduncle	$30\text{-}90^0$ down from erect	Sub erect	Sub erect	Sub erect
Pod curvature	Straight	Slightly down to the ground	Slightly down to the ground	Slightly down to the ground
Pod length	7-10 cm	7-8 cm	5.5- 6.5 cm	5-6 cm
Number of locules per pod	9-13	7-9 cm	6-7 cm	6-8cm
Leaf colour	Dark green	Green	Dark green	Dark green
Terminal leaflet length	2-2.5cm	3- 3.5 cm	2-2.5cm	3-3 cm
Terminal leaflet width	2-3 cm	2.5-3.5 cm	2-2.5 cm	2-3 cm
Primary leaf length	2-3 cm	4-5 cm	2-4 cm	2-3 cm
Primary leaf width	1-2 cm	2.5-4 cm	1-2 cm	2 cm
Peduncle length	3-3.5 cm	3- 4.5 cm	6- 12 cm	3-3.5 cm
Mature Pod colour	Dark purple	Dark purple	Brown	Dark purple
Seed length	4 mm	4 mm	4 mm	4 mm
Seed width	3 mm	3 mm	3 mm	3 mm
Seed thickness	2-2.5 mm	2-2.5 mm	2-2.5 mm	2-2.5 mm
Seed shape	Kidney	Kidney	Kidney	Kidney
Attachment of testa	Firmly attached to the seed	Firmly attached to the seed	Firmly attached to the seed	Firmly attached to the seed
Seed colour	Light green	Light green	Light green	Light green
Local name of landrace variety	OGODAE	MASHO	MASHO	NEKEYEDA
Scientific name	*Vigna radiata var radiata*	*Vigna radiata var radiate*	*Vigna radiata var radiata*	*Vigna radiata var radiata*

Appendix 4: Ecological requirement for mungbean cultivation (FAO, 1984)

Ecological Requirement	**Suitability Range of Mungbean**		
	Highly suitable	**Moderate to Marginally Suitable**	**Not Suitable**
Altitude (mater above sea-level)	400-1500	1500 – 2000 and 300-400	Over 2000 and Below 300
Temperature (^{0}C)	22.5 – 30	20 - 22.5	Below 20 Above 30
Rainfall (mm)	500 – 1000	400 – 500 1000 - 1200	Below 400 Above 1500

Declaration

I am, Tensay Ayalew Asegie the writer of this thesis on Mungbean Landrace Diversity in Ethiopia for Graduate Programs, Department of Biological Science from September 2013 to June 2015. The undersigned declare that, this thesis is my original work and it has not been presented in other universities, colleges or institutes for a degree or other purpose. All sources of the materials used have been duly acknowledged.

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This work has been done under my supervision.

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Prof. Zerihun Woldu Signature: _____ Date: _____

_____ Signature: _____ Date: _____

_____ Signature: _____ Date: _____