Traditional Production and Utilization of Cowpea in Ethiopia: A Showcase from Two Regional States

Selamawit Ketema[1, 2], Bizuayehu Tesfaye[2], Gemechu Keneni[3], Berhanu Amsalu[1], and Bedru Beshir [1]

[1]Ethiopian Institute of Agricultural Research, Melkassa Research Center, Melkassa, Ethiopia, [2]School of Plant and Horticultural Science, Hawassa University, Hawassa, Ethiopia, [3]Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia; E-mail yeabselam1998@gmail.com

Abstract

Ethiopia is believed to be the possible center of genetic diversity for cowpea but little is known about its production and utilization across diverse agro-ecologies and cultures. This paper is aimed at documenting cowpea production, utilization, variety preference criteria and production challenges. The data were collected using semi-structured questionnaire from 240 farm households in two major cowpea growing regions of Ethiopia, namely South Nations Nationalities and Peoples and Gambella regional states. The results showed that cowpea landraces are predominantly produced for food, market and feed. Preferences for cultivars grown were based on leaf texture, short cooking time, grain texture, early maturity, seed color, high yield and seed availability. Grain, leaves and green pods of cowpea are used as human food and the straw as animal feed. Despite multiple constraints faced by cowpea farmers, the level of technological intervention was minimal. Only 3% of the interviewed farmers responded to receive any information and training about improved cowpea production. Pests, drought, shortage of improved technologies, and limited extension services were among the major production bottlenecks that deserve research and development focus. Besides, to boost the production and productivity of cowpea for achieving household food and nutritional security, research and development endeavors need to capitalize on farmers' indigenous production and utilization experience.

Keyword: Cowpea, farmers' perception, constraints, selection

Introduction

Cowpea (*Vigna unguiculata (L.*) Walp.) is an economically important indigenous African legume crop contributing to food security of millions of small-scale farmers in Africa and maintenance of the environment (Tarawali *et al.*, 2002; Langyintuo *et al.*, 2003). It is a very versatile African crop. It is cultivated around the world primarily as a pulse but also as a vegetable (for its leaves as well as the green peas), as a cover crop and for fodder.

Cowpea is a highly nutritious grain legume well adapted to the stressful growing conditions of tropical Africa,

Asia, Latin America and Southern USA (Singh and Jackai, 1985; Matsui and Singh, 2003; Phillips *et al*., 2003; Singh *et al*., 2003; Trinidad *et al.*, 2010). It plays a critical role in the lives of millions of people in Africa and other parts of the developing world where it is a major source of dietary protein that nutritionally complements staple low protein cereal and tuber crops (Langyintuo *et al*., 2003). It is not only rich in nutrients, but also nutraceuticals such as dietary fiber, antioxidants, and polyunsaturated fatty acids and polyphenols (Shetty *et al*., 2013). As a nitrogen-fixing legume cowpea improves soil fertility, and consequently helps to increase the yields of cereal crops when grown in rotation (Tarawali *et al.*, 2002). Cowpea grows in a wide range of soil pH and temperatures, tolerant to drought, shade, and low fertility and acid soils (Akyeampong, 1986; Badiane *et al*., 2012).

Cowpea grows in almost all administrative regions of Ethiopia; however, the Southern Nations, Nationalities and People and the Gambella Regional States are known for the utilization of the multipurpose nature of the crop (Bedru *et al*., 2019; Sisay *et al*., 2019). From the research system so far six varieties have been released for use in the country as grain (MoA, 2018) and all were introductions. So far, local collections (landraces) haven't been started for cowpea varietal development for grain or dual purpose legume. Despite its tremendous benefits, little attention has been given by research and development especially as a multipurpose legume. In order to ascertain the extent of these problems and propose a way forward for cowpea improvement, it was necessary to assess the production and utilization of the crop in the major cowpea production areas of Ethiopia. Information on cropping systems, cultural practices, production constraints, utilization, and benefits are pertinent to improve farmers' preferred varieties and production technology packages. Therefore, the objective of this study was to assess farmers' perceptions and experiences on production, utilization, preference criteria, and production challenges in intervention areas.

Material and Methods

Study area and data collection

The survey was conducted in two regional states of the Ethiopia (Figure 1). Since there was no sub-national or national data on cowpea production and area coverage, the study area was selected based on the discussion with the respective Ministry of Agriculture and Natural Resource (MANR) experts at national, regional, zone and wereda levels (Weredas are the third-level administrative divisions of Ethiopia, which are equivalent to district). Based on the discussions; 'Southern Nations, Nationalities and People Regional state' (SNNPRS) and Gambella Regional states were

selected based on production and consumption practice both as vegetable and grain crops. Accordingly, three zones from SNNPRS and two zones from Gambella were selected. Ten to twenty individuals that consisted of elders, women, and youth were interviewed from each *Kebele* (local lower level administrative structure in Ethiopia), making the total number of respondents 240 (Table 1).

Table 1. Number and distribution of respondents by regions

Regional state	Zone	District	Kebele	Number Respondents
Gambella	Anuak	Abobo	Kire	20
			Pinykew	20
		Itang	Dorong	20
			Bazyel	20
SNNPRS	Segen people	Dirashe	Agrobatena	19
		Konso	Jarso	20
			Nalya Segen	20
	South Omo	Bena Tsemay	Chali	20
			Goldia	20
		South Ari	Keyesa	21
	Wolaita	Humbo	Abela Forecho	20
			Ela Kebela	19
	Total			240

The survey was conducted using a semi-structured questionnaire completed as a personal interview with experienced and trained enumerators. A preliminary questionnaire was prepared, pretested with a group of farmers and modified before the actual data collection. The data were complemented with information obtained from focus group discussion, key informants comprised of cowpea growers from each Kebele, including local agricultural experts.

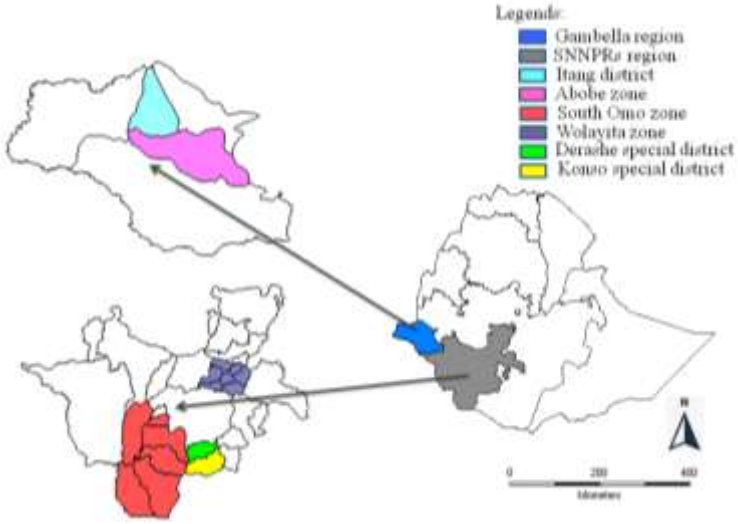


Figure 1. Map of cowpea survey areas in Ethiopia

The required socioeconomic information, production and consumption related information, cropping and seed systems, service delivery such as extension system and input usage as well as use of varieties, variety selection criteria for different traits and status of the crop in the society were collected using survey and focus group discussion. The interview was conducted in October 2017 by trained and experienced enumerators under the close supervision after pre-test of the questionnaire.

Data analysis

The collected data were coded, entered and analyzed using Statistical Package for Social Sciences (SPSS) software version 20. Data were cleaned before analysis. After data cleaning, 217 respondents were used for data analysis. Data analyses were carried out using descriptive statistics namely frequency, percentages and mean.

Result and Discussion

Socio-economic characteristics of sample households

Cowpea farmers were male-dominated but the participation of women were sufficiently high (38%) as compared to their participation in other field crops, for example, maize (14%) (Bedru and Nishikawa, 2017). The percentage of female-headed households' participation in cowpea production was high in Gambella (51%) than SNNPRS (29%) (Table 2). Cowpea here is mainly used as a vegetable mainly managed by women and used for home consumption and marketing in small amount.

Table 2. Socio-economic characteristics of the households

Characteristics	SNNPRS				Gambella Regional state			
	South Omo n=60	Wolaita n=29	Segen People n=48	Mean	Anuak n=40	Itang n=40	Mean	Total N=217
Sex (%)								
Female	32	21	35	29	58	45	52	38
Male	68	79	65	71	43	55	49	62
Year of cowpea growing experience (years)								
Less than 5 years	8.30	55.2	4.2	23	20.0	2.5	49.0	18.0
5-10	25.0	27.6	16.7	23	27.5	32.5	11.3	25.9
10-15	16.7	6.9	18.8	14	7.5	-	30.0	10
15-20	15.0	3.4	12.5	10	5.0	-	7.5	7.2
Above 20 years	35.0	6.9	47.9	30	40.0	65.0	5.0	39
χ^2=65***								
Landholding (ha)								
Total land size	1.38	1.76	0.66	1.27	1.35	1.30	1.33	1.29*
Over all cultivated land	1.25	1.68	0.64	1.19	1.27	1.21	1.24	1.21*
Own land cultivated	1.44	1.47	0.62	1.18	1.27	1.21	1.24	1.20
Rent in land	0.05	0.16	0.03	0.08	-	-		0.05*
Shared land	-	0.28	-	0.28	-	-		0.06**

*significant at p<0.05, **at p<0.01, ***at p<0.001

There was a significant ($p \leq 0.05$) difference in total land size and overall cultivated land size among zones (Table 2). The average landholding in Gambella regional was 1.16 ha (SD=0.27) whereas in SNNPR zones were 1.18 (SD=0.47). The average land holding of cowpea growing farmers in Wolaita zone in SNNPRS was higher than the other zones. In this zone, cowpea is produced by renting and sharing in land. The result of this study revealed that, cowpea growers have fairly enough land to cultivate different crops including cowpea, in both regions.

Of the total sample households, 35-65% has experience of cultivating cowpea for more than 20 years for all study area except Wolaita zone (Table 2). These shows a large number of respondents are well experienced showing the crop is one of the oldest crop in their farming system and the information obtained from the respondents would be reliable.

Farmland allocated to cowpea production

Overall farmland allocated to cowpea production was 0.10–0.27 ha or 20% of the total cultivated land. There was a difference in cowpea areas planted among the zones in 2017 growing year (Table 3). Relatively larger area was allocated to cowpea production in Gambella (0.20 ha) while relatively smaller area (0.18 ha) was allocated to the crop in SNNPRS (Table 3). This might be due to relatively large land holding and the importance of the crop in Gambella region.

There was also a difference among zones in the allocation of their land for cowpea production. Based on the perception of the respondents, they classified their land as fertile, medium fertile and poor or marginal land (Table 3). Accordingly, the result of the analysis of farm allocated revealed that, in Gambella regional state higher proportion (83%) of cowpea growers produce in fertile soil and the remaining 17% produce in medium fertile land. While in the SNNPRS only 25% of farmers allocated their fertile land for cowpea while 52% and 23% of the farmers produce in medium fertile and marginal land, respectively. The reason of allocating fertile soil in Gambella region could be due to availability land and/or the land is less explored. Additionally, Bena Tsemay, South Ari, and Dirashe districts from SNNP allocated fertile soil which may be attributed to intercropping or mixed cropping systems practiced in the area. While in the Humbo district, a high proportion of land for cowpea production was allocated from medium and marginal land. This might be due to high population pressure and degraded soil (Meseret and Dawit, 2019).

Table 3. Farmland allocation for cowpea

Characteristics	SNNPRS			Gambella Regional state		
	South Omo n=60	Wolaita n=29	Segen People n=48	Anuak n=40	Itang n=40	Total n=217
Cowpea planted in 2016/2017 (ha)						
2016 main season	0.19(0.22)	0.25(0.15)	0.19(0.18)	0.24(0.13)	0.22(0.15)	0.22(0.18)
2017 belg season	0.10(0.13)	0.12(0.18)	0.17(0.22)	0.22(0.18)	0.10(0.12)	0.14(0.17)
2017 main season	0.13(0.14	0.27(0.21	0.24(0.22)	0.23(0.13)	0.23(0.20)	0.22(0.19)
Perceived Soil fertility (%)						
Fertile	37.7	20.7	17.0	97.5	67.5	48.1
Medium	55.7	51.7	48.9	2.5	32.5	38.3
Marginal	6.6	27.6	34.0	0.0	0.0	13.6

Values in parentheses are standard deviation

Cropping system

Cowpea production was practiced under varying cropping systems. These include sole cropping, intercropping, mixed and relay cropping. The majority (60%) of cowpea growing households practices sole cropping while 15% of farm households practiced intercropping mainly with maize and sorghum (Table 4). Mixed cropping of cowpea was practiced to a lesser extent. There is variation on production system across the regional states. Cowpea was planted using sole cropping in Gambella regional state where both intercropping and sole cropping were used in SNNPRS. Intercropping of cowpea was usually done with cereals such as maize and sorghum though a few farmers in Gambella region reported intercropping cowpea with groundnut, linseed, tomato, and okra. In SNNPRS, the proportion of the number of farmers using mixed cropping was relatively small. A small proportion of farmers in South Omo (1.7%) and Segen people (8.3%) zone reported cowpea planted mixed with maize, sorghum, common bean, and mung bean. In both regions, small proportions of farmers practice relay cropping. Some farmers in Wolaita zone (10.3%) sow cowpea when the maize mature and in Itang (2.5%) when the sorghum mature. In both regions maize, common bean and sorghum are the major crops (CSA, 2018).

Table 4. Cowpea cropping system n SNNPRS and Gambella regions

	Administrative regions and zones (%)					Total (%)
	SNNPRS			Gambella regional state		
	South Omo N=60	Wolaita N=29	Segen People N=48	Anuak N=40	Itang N=40	
Cropping system (%)						
Solo cropping	46.7	58.6	45.8	82.5	75.0	59.9
Intercropping	18.3	24.1	31.3	0	0	15.3
Mixed	1.7	0	8.3	0	0	2.3
Rely cropping	0	10.4	0	0	2.5	1.8
Sole and Intercropping	33.3	6.9	14.6	17.5	22.5	20.7
Sum	100	100	100	100	100	100
Cowpea intercropping with cowpea (%)						
Maize	54.8	100.0	69.2	28.6	77.8	64.6
Sorghum	38.7	0	30.8	28.6	22.2	29.4
Tef	3.3	0	0	0	0	1.2
linseed	3.2	0	0	0	0	1.2
Groundnut	0	0	0	14.3	0	1.2
Tomato	0	0	0	14.3	0	1.2
Okra	0	0	0	14.3	0	1.2
Sum	100	100	100	100	100	100

Though sole cropping is the major cropping system in both regions, farmers also practiced intercropping manly with maize and sorghum. Thus, researchers should develop cowpea varieties that fit for both cropping systems. For intercropping the cowpea varieties should fit with the crop intercrop with such as with maturity time and growth habit.

Cowpea landraces and variety selection criteria

Almost all (99%) of cowpea grower farmers in the study area grow landraces. The name of the crop is different from area to area depending on the local languages, morphological characteristics, appearance, seed color and names of places where it is being produced. In South Omo zone they call it '*Zaka*,' '*Woqa'* and '*Aeqa',* in Wolaita also call it '*Aeqa',* in Segen People '*Ohoda'*, '*Alita'* and '*Elida'*, in Gambella regional state *Boho*, *Rapo* and '*Wenu*'. Often, farmers do not grow a single type of variety in a season. For example, they grow medium to long maturing varieties with good leaf and, grain yield mixed with the early maturing grain type varieties with market preferred seed color and texture (white, creamy and pink color and smooth textured). They indicated that in good season the late maturity type give better yield and if there is interruption of rain or in drought season the early maturing type escape the drought and gives better yield.

Varietal selection criteria of farmers were different from place to place mainly based on the use of cowpea part and marketability. Cowpea varieties are preferred on the bases of their leaf texture, short cooking time,

grain texture, early maturing, seed color, high yielding and accessibility of the seed (Table 5). These indicate the need for site-specific research and breeding approaches. Except for Wolaita zone, leaf quality (texture) was as important as grain yield in other locations. Thus, focus should be given to develop dual-purpose cowpea varieties.

Short cooking time was an important trait in all areas. Cooking time, an indication for cooking quality, is one of the most important factors responsible for consumers' choice for a particular food especially in grain legumes. Like other legumes, longer cooking time makes cowpea uneconomical and unacceptable to consumers (Demooy and Demooy, 1990; Bhokre and Joshi, 2015; Hamid *et al*., 2016). Often, women change their food consumption patterns (reducing food items that have long cooking times) when firewood supplies are limited. The changes can further compromise families' nutritional intakes. Short cooking time is one of the important criteria mentioned by the respondents for choosing a specific variety. Therefore, for maximum utilization of seed by food-insecure consumers, it is essential to address the long cooking times required to make seed palatable.

Ethiopia, as possible center of diversity for cowpea, understanding of their selection criteria is essential to understand the diverse need and challenges of farmers and, thus, to develop a sustainable cowpea breeding and management strategies.

Table 5. Farmers' variety selection criteria

	SNNPRS (percent)			Gambella Regional state (percent)			
Preference criteria	South Omo n=60	Wolaita n=29	Segen People n=48	Anuak n=40	Itang n=40	Total n=217	Over all Rank
Leaf texture	21.0	0	26.2	32.5	30.0	21.9	3
Seed texture	1.7	7.3	0	20.0	25.0	10.8	4
Seed color	6.7	10.3	2.1	5.0	7.0	6.2	5
Seed size	1.7	0	2.1	0	0	0.8	10
Short cooking time	21.7	30.4	29.3	22.5	15.5	23.9	2
Drought resistance	1.7	15.2	0	2.5	0	4.4	6
Early maturing	10.0	5.4	4.2	0	0	3.9	7
Disease resistance	3.3	0	0	5.0	5.0	2.7	8
High leaf yield	3.3	0	0	2.5	0	1.2	9
High grain yield	29.0	31.2	36.3	10.0	15.0	24.3	1
Sum	100	100	100	100	100	100	

Cowpea production constraints

Cowpea grower households in both regions face various production challenges. A household face one or multiple constraints in cowpea production. Insect, disease, weed, input availability (improved seed and pesticide), storage and moisture stress were the production constraints stated by the respondents (Figure 2). In SNNPRS, 77% of the respondents agreed as both field and storage insect were their number one constraint, while 45% of respondents in Gambella region indicated diseases as the number one production challenge. This might be due to the agro-ecological difference between the two regional states. Anuak and Itang zones in the Gambella regional state are characterized by a hot humid climate that favors the development of pathogens (Velásquez *et al*., 2019) whereas the selected zones in SNNPRS are hot dry area that creates conducive environment for insect pest multiplication (Jaworski and Hilszczański, 2013).

As perceived by the farmers, from the major constraints, damage by insect pests was moderate (52%), sever (31%) and mild (7%). The respondents mentioned different types of symptoms when the cowpea attacked by insect. The major symptoms were shrinking of leaf, holes in the pod and grains, reduced pod size and no grain filling, discoloration of grain, drying of leaf and pods, yellowing of leaves and shedding, deformation of leaf and pods, cutting of leaf, stem, and pod. To reduce the insect attack 84% of cowpea farmers use cultural practices such as mixed cropping, intercropping, crop rotation, and removal of infected leaves. Only 16% of farmers use insecticide and those farmers were from Segen people and Wolaita zone of SNNPRS. Several reports indicated that insect pest attack is a major constraint to cowpea production worldwide (Jackai and Daoust, 1986; Togola *et al*., 2017; Mishra *et al*., 2018). Yield losses of up to 70%, from insect pests alone, have been reported (Livinus *et al*., 2012). Different reports have listed at least 20 major insect pest species in various cowpea producing regions of the world in which the number varies from region to region (Singh and Jackai, 1985; Jackai and Daoust, 1986). The most damaging of all the insect pests are the flowering and post-flowering insect pests. The major flowering and post-flowering insect pest of cowpea in tropical Africa are the flower bud thrips, (*Megalurothrips sjostedti* Tryb.), cowpea pod borer (*Maruca spp.*) and a complex of pod sucking bugs out of which *Clavigralla tomentosicollis* Stal is the dominant species (Jackai and Daoust, 1986). This result indicated the need to identify the major insect peats of cowpea in Ethiopia to devise control option for the growers.

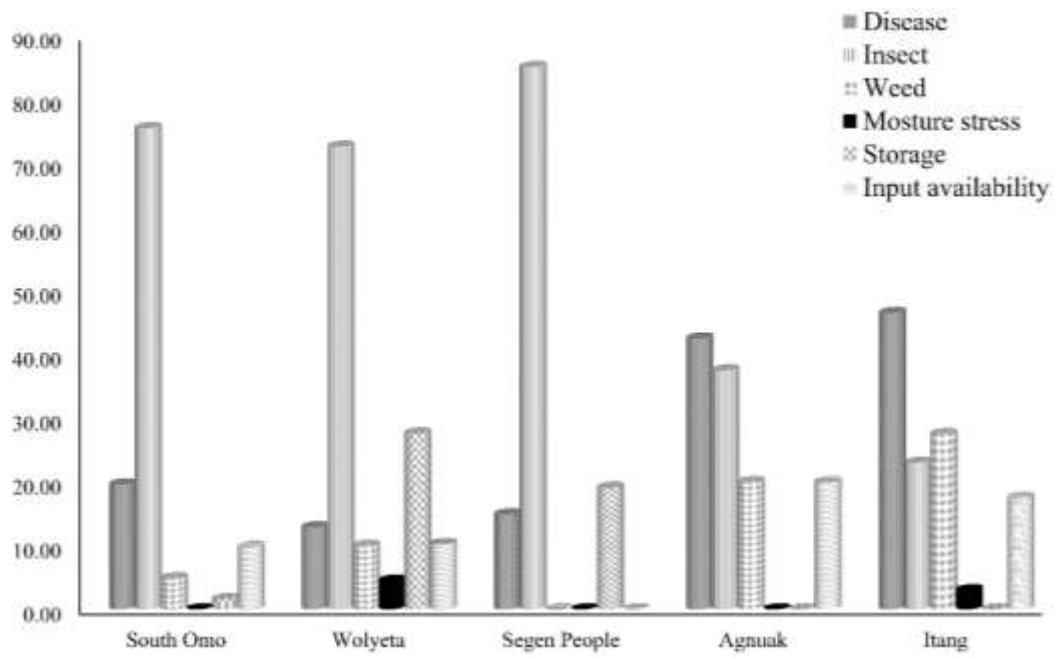


Figure 2. Constraints of cowpea production in Ethiopia by percentage of respondents

Farmers used different practices to control storage pests. Fifty percent of the farmers mix the grain with ash and 10% mix with small cereals (tef and/or millets), and 34% use chemicals (in Konso and Humbo district). The remaining 6% use different traditional practices namely hanging of dry pods around areas it can get smoke, keeping in cooler places, keeping in airtight containers such as plastic bottles, bag and sealed clay pots. Losses of up to 30-70% have been recorded on stored cowpea in the absence of insect pest control measures (Livinus *et al*., 2012). Cowpea bruchids (*Callosobruchus spp*.) are the most common and widespread insect pests in storage. Bruchid attack starts at the field and continued in storage. Bruchids damage might cause seed weight loss, reduce marketable seed quality and germination. At a small farming scale, grains are stored traditionally in different styles of containers, depending on the farmer's socio-economic status and environment. Thus, controlling this storage pest is indispensable.

The second challenge for cowpea production was a disease. Leaves and other parts of this crop disease are important production constraints, especially in the Gambella regional state. Cowpea is known to be affected by several fungal, viral and bacterial diseases. The diseases found on cowpea are mainly fungal diseases incudes anthracnose, ascochyta blight, black leaf spot, leaf smut, brown blotch, cercospora leaf spot, powdery

mildew, pythium stem rot, septoria leaf spot, spbaceloma Scab, and web blight are the common one (Emechebe and Florini, 1997; Nahunnaro and Ayuba, 2012). Thus, prioritizing the main diseases at cowpea growing areas is crucial to devise target control option for the growers.

The third challenge is both broad leaves and grass weeds. Weed is devastating in cowpea production since cowpea is a weak competitor of weed at the early stage and harbors insect pests which reduce the grain quality, and grain and fodder yield (Dugje *et al*., 2009).

In general, detail of insect pests, disease and weed species assessment including the level of damage, has to be done by competent experts since the oral interview hasn't given these detail information. This will help to devise integrated pest management options for the growers.

The fourth challenge is input unavailability (fertilizer and pesticide) shortage as part of cowpea production challenges. The fifth challenge was storage for keeping the seed of cowpea for a long time for keeping for next season planting and for long period of consumption. Moreover, some farmers reported as moisture stress is also one of production constraint. Although cowpea is considered a relatively drought-tolerant crop, previous reports also indicated its productivity is negatively affected by prolonged drought and high temperatures (Agbicodo *et al*., 2009; Hall, 2012).

Most of the farmers in the survey area use own saved seeds (Figure 4). Though seed unavailability and insufficiency were not reported as an issue in the study area, collecting the available landraces, evaluating based on their preference for different purpose and traits, and improving for different stresses and disseminating the improved variety is vital to improve productivity of the cowpea. In addition, despite its potential it hasn't been got research and development attention and it is still one of orphan crops in most African countries including Ethiopia. The Central Statistic Authority (CSA) of Ethiopia also does not generate data about the amount produced, area coverage, productivity, the number of household who produce cowpea and so on. Extension service of cowpea needs attention since the crop is nutritious and a climate smart. Moreover, extension service might need to pack holistic information (from production to consumption).

Cowpea management practice

To obtain high yield and quality product, effective crop management practices are important. Concerning tillage frequency in cowpea production, only 6.5% of cowpea grower households practice one-time tillage while about 87 percent of the farmers plow their cowpea plots two to three times. Only 7% of farmers plow more than three times (Table 6). Land preparation for cowpea production by

the majority of farmers falls within the research recommendation of 2–3 times tillage. Proper land plowing is important to break the soil to loosen it for easy penetration of roots, soil aeration, and water percolation and create a suitable medium for microbial activities within the soil. The result is in agreement with plowing frequency of farmers in Ethiopia, for other major crops (two to six times per planting depending on the crop) (Aune *et al.*, 2001). Cowpea yield increases with good land preparation *(Boukar et al*., 2019). Among the major reasons for practicing intensive tillage are to prepare the seedbed, conserve soil moisture, reduce weed infestation and increase productivity (Temesgen *et al*., 2008). Hence the frequency of land tillage is one of an indicator how cowpea is an important crop for the farm household in the study area. Thus, it is possible to say as cowpea is one of the main crops at the study areas.

Planting method is an important agronomic practice in food crop production. Half (51%) of the farm households primarily plant cowpea in broadcasting while the remaining half (47%) grow the crop in row planting (Figure 3). There was a difference among the administrative regional states in their adoption of row planting. The higher proportion (78%) of farm households in Gambella regional state grows cowpea using row planting. In SNNPRS, still the majority (58%) of the household plant in broadcasting. Farmers who planted cowpea in broadcasting reported that they do so because it is a long-held tradition (23%), or because they are not familiar with other planting methods (54%) while 23 percent reported that row planting is time-consuming, labor-intensive and land extensive. Some farmers from South Omo zone mentioned broadcasting distribute seeds better than broadcasting. In the group discussion in Wolaita zone, the participant mentioned that the reason for the use of row planting for cowpea in the area was due to the adoption of row planting of common bean through training and demonstration. Row planting of cowpea is recommended since it facilitates crop management practices during hoeing, weeding, fertilizer application, and harvest. In both regional states planting is mainly done in broadcasting which usually demand higher seed per unit areas.

Table 4. Cowpea management practices in the SNNPRS and Gambella regional state

	Administrative regions and zones (%)					Total (%)
	SNNPRS			Gambella regional state		
	South Omo n=60	Wolaita n=29	Segen People n=48	Anuak n=40	Itang n=40	
Tillage frequency (%)						
One time	6.7	0	14.6	7.5	0	6.5
Two times	23.3	20.7	79.2	62.5	82.5	53.5
Three times	65.0	51.7	6.3	22.5	15.0	33.2
More than three times	5.0	27.6	0	7.5	2.5	6.9
χ^2=102***						
Harvesting frequency for leaf yield (%)						
Less than 7 days	38.6	0	57.1	56.4	74.4	54.7
8 to 15 days	56.1	0	42.9	23.1	17.9	37.1
Throughout growing season	5.3	0	0	20.5	7.7	8.2
Crop stage to stop leaf harvest (%)						
Before flowering	29.8	-	5.7	84.6	56.4	43.5
At flowering	31.6	-	57.1	0	18.0	26.5
At mid pod filling stage	35.1	-	34.3	15.4	25.6	28.2
At maturity	3.5	-	2.9	0	0	1.8

The average seeding rate used for cowpea was 22 kg/ha with a range of 19 to 28 kg/ha. This is within the range of seeding rate of 12–25 kg/ha which is recommended by the International Institute of Tropical Agriculture–IITA (Dugje *et al*., 2009). The seed rate difference among zones was due to the difference in planting methods and cropping systems. Although row planting and intercropping needs relatively lower seed rate, in the study area for these cropping systems they use more amount of seed.

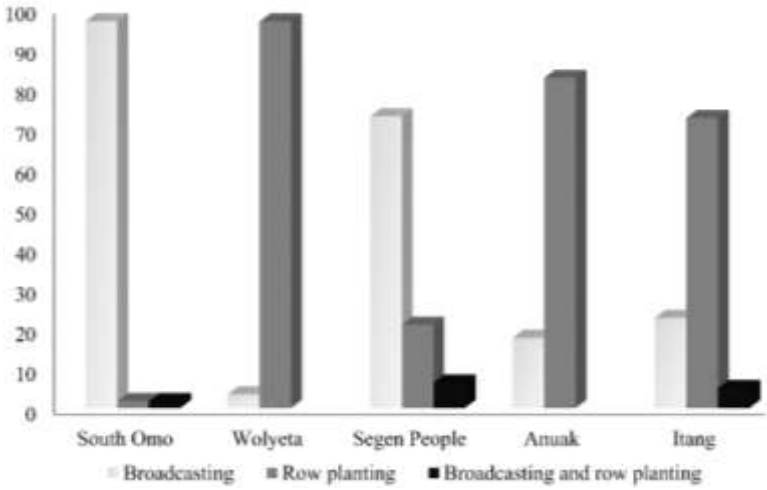


Figure 3. Planting methods of cowpea in different area of Ethiopia.

Cultivation and weeding are other management practices that affect the productivity of the crop. The survey result revealed that 92% of cowpea growers do hoeing and 97% do weed up their cowpea field. Twenty percent of the farmers weed once in the growing season, more than half of the grower weed twice and 25% of them said more than three times. These show how the farmers use gives attention for cowpea production.

The survey result revealed that only 11% of cowpea growers use fertilizer either organic or inorganic or both. Cowpea claimed to fix between 20 and 100 kg N ha^{-1} with an estimated N fertilizer replacement value ranging from 10 to 80 kg N ha^{-1} (Sanginga *et al*., 2000*;* Carsky *et al.,* 2002). This contributes to soil fertility improvement particularly in smallholder farming systems where little or no fertilizer is used. However, nitrogen fixation in legumes can be limited or enhanced by P availability and utilization (Vance *et al*., 2003; Waluyo *et al*., 2004). Because of its multiple effects on plant nutrition, P fertilizer is recommended to increase yields. The crop often responds favorably to phosphorus, because of its multiple effects on plant nutrition, a phosphorus fertilizer is recommended to increase yields. Hence, to improve the productivity of the crop, research should also give attention to select varieties with high phosphorus efficiency and determine optimum P and other important fertilizers for different soil types.

Leaf harvesting was done from the same plant that planted for grain. The majority of farmers stop leaf harvesting before flowering (43.5%), 26.5% and 28% of the farmers stop at flowering and at mid pod filing, respectively. Only 2% of farmers harvest up to maturity as long as there is young leaf in the plant. During group discussion farmers mentioned that leaf harvesting hasten maturity of the crop otherwise the plant stay long for maturity. This opinion needs further investigation.

Availability of inputs

Seed unavailability and insufficiency were not reported to be issues in the cowpea seed supply system in the study area. For instance, 55% of farmers use home-saved seed, 5% home saved and local market, 9% from neighbors or relatives and 25% get it from the local markets (Figure 2.4). Seventy-three percent of farmers get access within less than 30-minute walking distance and 15% farmer access seed from 30 to 60-minute walking distance (Table 7). Similarly, the majority (74.6%) reported that sufficient cowpea seed is obtained for their annual cowpea production. Seventy-three percent of respondents have access to their preferred (familiar) varieties of cowpea. Likewise, the majority of cowpea producers (78%) obtained cowpea seed fairly easily when the landraces are concerned. However, the farmers lack information about improved varieties of cowpea. This was a piece of clear evidence from farmers' heavy

reliance on the landraces for easy accessibility of their seeds.

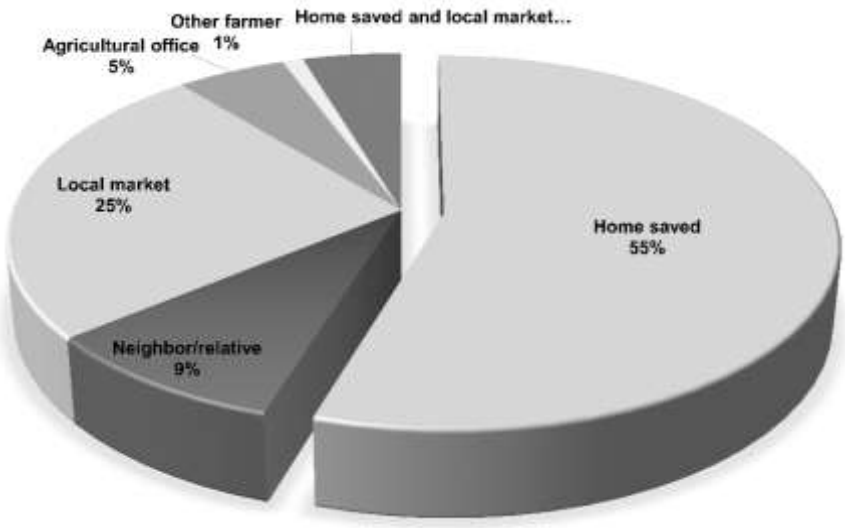


Figure 4. Cowpea seed source in selected zone of cowpea grower areas

Table 5. Distance to the major seed source and estimated price of cowpea in 2016 main season

	SNNPRS			Gambella regional state		Mean
	South Omo n=60	Wolaita n=29	Segen People n=48	Anuak n=40	Itang n=40	
Distance to the market (minute)						
Less than 30	55	72	79	85	73	73
30 to 60	34	24	13	8	0	15
more than 60	10	3	9	8	27	12
Seed price (Birr/kg)						
Seed price*	13.2	18.9	14.6	24.0	24.1	19.0
SD	4.3	6.7	4.2	5.5	4.4	5.0

*Estimated price of seed in 2016 main season, **SD=standard deviation

The price of seed in the local market is different from location to location. The overall mean price for 2016 was 19 birr (1birr=0.036 USD) (SD=5 birr) for one kilogram of cowpea seed. Seeds of cowpea in Gambella regional state was higher with the average price of one kilogram of seed with 24 birr (SD= 4.55 birr) whereas at SNNPRS the average price was 15.6 birr (SD=5.6 birr).

There was no difference in the use of fertilizer (organic or inorganic) to grow cowpea in both regional states. Only 10.6 percent of the respondent says they use fertilizer. Even though, pests are the major problem in cowpea production, in both regional states recommended pesticides were not available.

Purposes and consumption of cowpea

Ninety-two percent of cowpea grower households plant cowpea every year. Though they grow cowpea for a different purpose, the main purpose was food and income (Figure 5). To a lesser extent, they grow for animal feed and medicinal values. Grain and leaves were used significantly higher proportion in both regional states. From the selected zones, the grain harvest is the driving reason for growing cowpea in the Wolaita zone. Parts of cowpea and ways of consumption differ across regional states and across districts. Grain, leaves and green pods were used across all the study areas except Wolaita. Consumption of green pods was not important in itself as its use is related to growing cowpea for other purposes.

Growing cowpea as a feed was reported to be more significant in the Wolaita zone. As we understand from key informant in group discussion, in Wolaita zone of Humbo district cowpea was introduced to the area by Ministry of Agriculture for animal feed as forage crop. As reported by farmers, cowpea performed better than common bean in adaptation of poor soil and moisture stress condition; they started to grow cowpea using the package demonstrated for common beans.

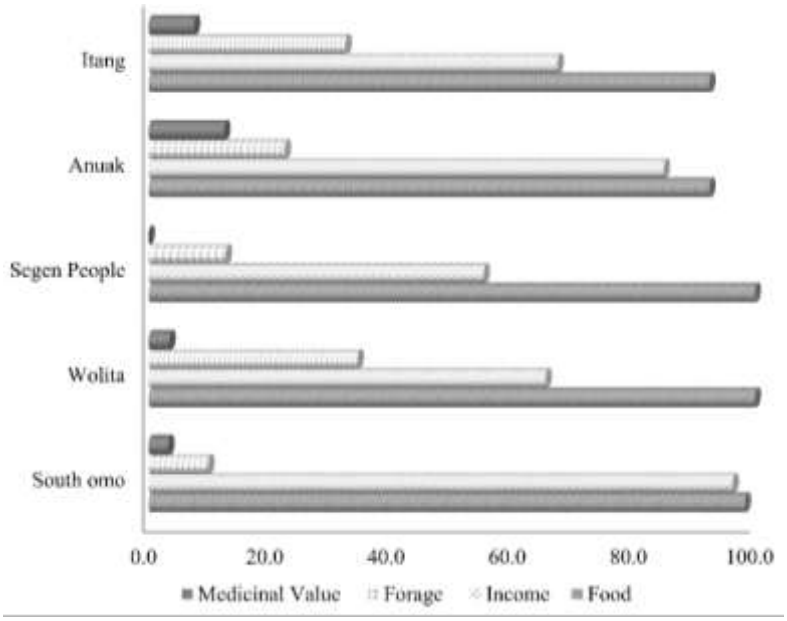


Figure 5. Major reasons for the production of cowpea (percent of the respondent)

Popular cowpea based recipes include stews, soups, and porridges consumed with other cereals like maize and sorghum. Others recipes are

'*fosese'* and '*kurkufa*; which is a cowpea-based product prepared by steaming. *Fosese* prepared by steaming maize or sorghum flour, mixed with cowpea grain and leaf whereas *kurkufa* only use the seed. '*Nefero'* is a popular nutritious food prepared from boiled whole grain cowpeas or mixed with maize grain. 'Kollo' is prepared from roasted cowpea fresh pea or dry grain while '*kita'* is prepared from cowpea flour like chapatti. The leaf is also cooked like any other leafy vegetable or mixed with meat and boiled seed. The roasted and milled cowpea grain flour or split-grain is also used to make stew ('*shero'* in Amharic). In other African countries, cereals are fortified with cowpea in weaning foods formulations (Elemo *et al*., 2011).

About 5% of farmers use cowpea for a medicinal purpose. Especially in the Gambella regional states, farmers used leaves and grain to control diarrhea, malaria, yellow fever and to enhance digestion. Sisay *et al*. (2019) also documented the medicinal value of cowpea ranked fifth in cowpea utilization whereas a quarter of the farmers were reported as they are using leaves and grains of cowpea for the treatment of gastric discomfort, malaria and liver diseases.

Table 6. Consumption of cowpea made food and preference among family members

	Percentage of users by Region					
	SNNPRS (%)			Gambella regional state (%)		
	South Omo N=60	Wolaita N=29	Segen People N=48	Anuak N=40	Itang N=40	Total (%)
Frequency of using cowpea food						
Daily	15	7	13	85	20	27
More than one per week	60	59	60	5	33	45
Once on two weeks	3	10	-	-	3	3
Once per week	17	21	25	10	35	21
Some times	5	3	2	-	10	4
χ^2=115***						
Family member that consume more cowpea (%)						
All family member	71.7	55.2	60.4	97.5	100.0	77.0
Children under 5	5.0	3.4	20.8	2.5	0.0	6.9
Breast feeding mothers	1.7	0.0	0.0	0.0	0.0	0.5
Sick family member	8.3	6.9	2.1	0.0	0.0	3.7
Children under 5,Pregenant mother and breast feeding mother	8.3	0.0	0.0	0.0	0.0	2.3
Children under 5 and pregnant mother	0.0	34.5	16.7	0.0	0.0	8.3
Children under 5 and breast feeding mother	5.0	0.0	0.0	0.0	0.0	1.4
χ^2=97***						

Cowpea was one of the most consumed crop in all study areas (Table 8). In Gambella regional state significant number (53%) of farm households consumes cowpea daily (Table 8) where as in SNNPRS region 60% of households consume more than once per week. There was also a significance difference in consumption of cowpea among family members but about 77% of the respondent said it is consumed by all members of the family (Table 8).

In SNNPRS, 38% of the respondents said there was a difference in consumption of cowpea based foods among the family members while in Gambella regional state 99% of the household said there was no difference. The reason indicated for the difference in consumption among family members was bloating of the stomach and taste preference. Reports elsewhere also indicated the major constraints associated with cowpea utilization are its long cooking time that increases opportunity cost for women's time and fuel wood consumption, flatulence factors and storage chemical residues (Phillips *et al*., 2003).

Cowpea leaves are among the top indigenous leafy vegetables that are marketed and consumed across the entire Africa continent (Barrett, 1990; Smith and Eyzaguirre, 2007). The production of cowpea as a leafy vegetable appears to have increased markedly in many areas in recent years as farmers shift to more drought-tolerant vegetable crops in light of repeated droughts facing many parts of Africa (Saidi *et al*., 2010). But consumption of cowpea as a leafy vegetable is not popular in Ethiopia as the other African countries (Saidi *et al*., 2010*;* Owade *et al.*, 2019). However, the study areas are known for the use of cowpea for both grain and leaf except Wolaita zone. Moreover cowpea ranks among the top 5 leafy vegetable next to Ethiopian kale (*Brassica carinata*) and moringa (*Moringa oleifera*) leaf except in the Anuak zone, where cowpea leafy vegetable is the leading vegetable (Table 9).

Sixty-three percent of farmers have more than ten years' experience of eating cowpea leaves as a vegetable (Table 9). Unlike leaves of other grain legumes, cowpea leaves may be more valuable than the seed because of its protein content and protein productivity exceed that of the seeds on a dry weight basis (Dube and Fanadzo, 2013). Protein concentrations of 29 to 43 % have been reported for cowpea leaves but only from 21 to 33 % in seed (Nielsen et al., 1997; Ahenkora et al., 1998).

The harvesting interval of cowpea leaves was different from farmers to farmers but almost half (49%) of farmers harvest the leaves within less than five days intervals. Harvesting leaves at a 7 days interval gives the highest leaf vegetable yields, but grain yields are depressed and harvesting leaves at a 14 days interval, on the other hand, minimizes grain yield reduction due to leaf harvesting (Saidi *et al*., 2010). Though farmers harvest within less than 5 days interval they might not be harvested from the same plant.

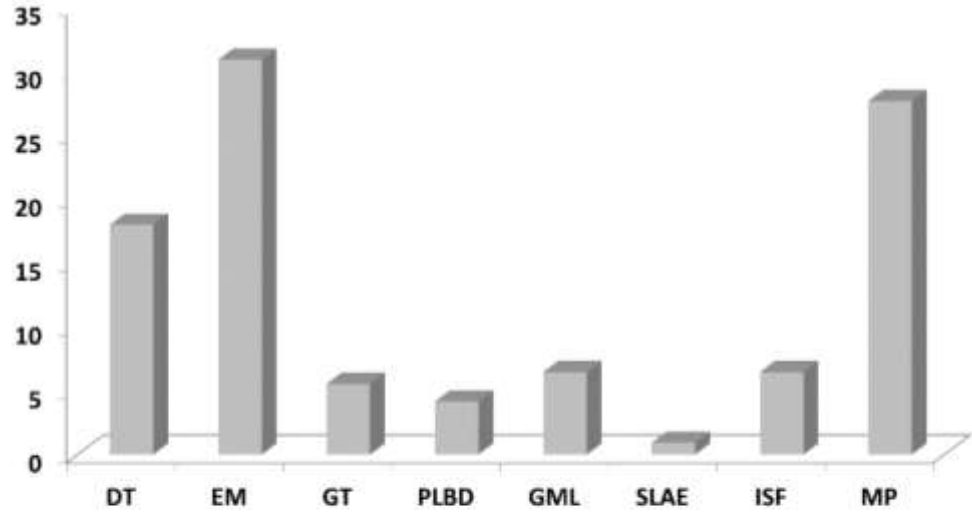
Table 7. Rank of cowpea among leafy vegetables and frequency of consumption of cowpea made food in selected areas of two regional states of Ethiopia

	Percentage of users by Regional states					Total (%)
	SNNPRS (%)			Gambella (%)		
	South Omo N=60	Wolaita N=29	Segen People N=48	Anuak N=40	Itang N=40	
Rank of cowpea leaf with other leafy vegetables (%)						
First	17	-	10	55	23	24
Top 3	77	-	90	33	73	70
Top 5	7	-	0	13	5	6
χ^2=191***						
Number of years consumed cowpea leaf						
1-5 years	17	-	21	23	20	20
6_10 years	15	-	10	25	23	18
11_15 years	22	-	13	8	8	13
16-20 years	17	-	13	5	20	14
Above 20years	30	-	44	40	30	36
χ^2=204***						
Harvesting frequency of leaf (%)						
Less than 5 days	29	-	51	54	69	49
5 to 10 days	61	-	37	46	31	46
11 to 15 days	11	-	11	0	0	6
Stage of cowpea to stop harvesting of leaf (%)						
Before flowering	30	-	6	85	56	44
At flowering	32	-	57	0	15	26
after flowering	0	-	0	0	3	1
At mid pod filling stage	35	-	34	15	26	28
At maturity	4	-	3	0	0	2

The majority of farmers stop leaf harvesting before flowering (44%) and 28% of farmers stop at mid pod filling stage. Another report also suggested that leaf harvesting is carried out before flowering (Dube and Fanadzo, 2013). Farmers in Zimbabwe start leaf harvesting at three weeks after the emergence and terminated harvesting once cowpea started podding, due to reduced leaf quality and not to affect seed yield (Matikiti *et al*., 2012).

To understand the position of cowpea as a dual-purpose crop, farmers were asked to mention the main reason why they are interested in this crop. The major reason mentioned was early maturity (31%), multipurpose nature of the crop (28%) and drought tolerance (18%) (Figure 6). The result support earlier research that described cowpea as one of the most important tropical dual-purpose legumes (Chweya and Eyzaguirre, 1999) and drought-tolerant crop (Agbicodo *et al*., 2009). Farmers also ascertained the high productivity of cowpea on marginal land and its advantage for soil fertility enhancement. Moreover, the farmers also stated as the leaf of cowpea can be preserved and used when there is shortage of food and the food made of cowpea stay long after eating. It shows the high potential of cowpea leaves for these purposes and, thus, more research, breeding, and promotion activities are necessary.

As we observed from interviewed farmers and in the focus group discussion, farmers were very much aware of health benefits in consuming cowpea grain and leaves, though they did not indicate as it is reach in vitamin, mineral, protein or fiber. They believed as cowpea helps for growth and maintenance for human body and also uses to treat gastric discomfort as well as serves as medicinal purpose. These results indicate an existing awareness about the value of cowpea by the farmers'. Nevertheless, further promotion activities are needed to enhance the knowledge of health benefits by consuming cowpea leaves.



DT= Give yield in drought season; EM= Early maturity; BT= Good taste; PLBD= Preserve the leaf by drying and use for long time; GML=Grow in marginal land; SLAE= Stay for long time after eating; ISF=Improve soil fertility; MP= It is a multipurpose crop

Figure 6. Advantage of cultivation of cowpea as perceived by farmers in selected areas of Ethiopia

Marketing

Marketing is a prime mover and stimulator of production. There was a difference in perception and practice among the two regional states concerning the cowpea parts to be marketed (Table 10). In Gambella regional state, 85% of farmers sell their cowpea in a different form while in SNNPRS grain is the only commodity for sale and only 36% of farmers sell the grain. In Wolaita zone cowpea leaves are not known as a vegetable, they produce for grain or forage purposes (Table 10). In South Omo and Segen people cowpea leave well known as leafy vegetables but it is not commercialized. Ninety-seven percent of cowpea growing farmers sell their cowpea products in local

markets. From these farmers who sold cowpea, 77% of them got market price information from their neighbors. Most of the farmers (61%) appreciated market prices (value) of cowpea and 35.5 % responded as cowpea has a modest market price value.

Table 8. Parts of cowpea marketed in the study area

Part marketed	Administrative Zones				
	South Omo N=60	Wolaita N=29	Segen People N=48	Anuak N=40	Itang N=40
Whole grain (%)	32	48	27	15	35
Fresh leaves (%)	—	—	—	52.5	30
Split grain (%)	—	—	—	2.5	2.5
Whole grain and fresh leaves (%)	—	—	—	20	10

Extension and training services

Only about 3 percent of cowpea growing households have participated in a cowpea demonstration or field days or received training relating to cowpea production. Extension service provides technical advice in crop production activities of the family farm and provides information to assist farmers in making sound production decisions. This can be information about improved varieties, agronomic practices, prices, and markets or about the availability of credit and inputs. At the study area however, the cowpea growers get information from experienced other fellow farmers. Practical extension works such as demonstration plot or field days are important to establish a farmer-to-farmer link and technology promotion. Although the farmer have enkowlage and experience on the traditional farming sytem, their skill and knowlage can be enhanced through extenstion servise and training.

Conclusions and Recommendation

Cowpea production in the selected regional states of Ethiopia is characterized by the widespread cultivation of landraces with differing preferred attributes among locations and farmers. Farmers' selection criteria for cowpea have implications for breeding activities in Ethiopia. Cowpea is used as multipurpose legume crop consumed as a vegetable or dry seed. It can also be prepared in different forms for consumption. Additionally, different parts of the crop are also use as animal feed. The present study provided insights on production constraints, preferred traits,

and utilization and farming systems of cowpea in the two regional states of Ethiopia. Breeding for high grain yields, resistance to field and storage pests and farmers-preferred cowpea varieties are the most important strategies to increase cowpea production and productivity by subsistence farmers in the regional states. Furthermore, the availability of improved seeds and production input need to be improved to boost cowpea productivity in the country. Hence, breeding efforts need to look at the area-specific needs of the user beyond focusing on seed yield. Breeding for high leaf and seed yield and farmers-preferred traits such as short cooking time is crucial to enhance the use of cowpea as dual purpose crop. Availability of seed and production input are issues that worth consideration to increase cowpea production, productivity and utilization by subsistence farmers in the selected regional states of Ethiopia.

Acknowledgement

The authors are greatful for the grant support The McKnight foundation a grant No. 15-534 and EIAR for financial support.

References

Agbicodo, E.M., Fatokun, C.A., Muranaka, S., R. G. F. Visser, A., Der, C.G.L. van, 2009. Breeding drought tolerant cowpea: constraints, accomplishments, and future prospects. Euphytica 167, 353–370.

Ahenkora, K., Adu Dapaah, H.K., Agyemang, A., 1998. Selected nutritional components and sensory attributes of cowpea (Vigna unguiculata [L.] Walp) leaves. Plant Foods Hum. Nutr. 52, 221–9.

Akyeampong, E., 1986. Some response of cowpea to drought stress, in: Haque, I., Jutzi, S., Neate, P. (Eds.), Potentials of Forage Legumes in Farming Systems of Sub-Saharan Africa. Proceeding of a Workshop Held at ILCA. 16-19 September 1985. Addis Ababa, Ethiopia, p. 141.

Aune, J.B., Bussa, M.T., Asfaw, F.G., Ayele, A.A., 2001. The OX Ploughing System in Ethiopia: Can it be sustained? Outlook Agric. 30, 275–280.

Badiane, F.A., Gowda, B.S., Cissé, N., Diouf, D., Sadio, O., Timko, M.P., 2012. Genetic relationship of cowpea (Vigna unguiculata) varieties from Senegal based on SSR markers. Genet. Mol. Res. 11, 292–304.

Barrett, R.P., 1990. Legume Species as Leaf Vegetables, in: Simon, J.J. and J.E. (Ed.), Advances in New Crops. Timber Press, Portland, OR, pp. 391–396.

Bedru, A., Nishikawa, Y., 2017. Understanding smallholder farmers' access to maize seed and seed quality in the drought-prone Central Rift Valley of Ethiopia. J. Crop Improv. 31.

Bedru, B., Berhanu, A., Mulugeta, T., Dagmawit, T., Bezawit, Y., Selamawit, K., 2019. Cowpea: Production, marketing and utilization in Ethiopia. Research Report 121. Addis Ababa, Ethiopia.

Bhokre, C.K., Joshi, A.A., 2015. Effect of soaking on physical functional and cooking time of cowpea , horsegram and mothbean. Food Sci. Res. J. 6, 357–362.

Boukar, O., Togola, A., Chamarthi, S., Belko, N., Ishikawa, H., Suzuki, K., Fatokun, C., 2019. Cowpea [Vigna unguiculata (L.) Walp.]. Breeding. Volume 7, in: Al-Khayri, J.M., Jain, S.M., Johnson V., D. (Eds.), Advances in Plant Breeding Strategies: Legumes. Springer Nature Switzerland AG, Switzerland, pp. 201–243. https://doi.org/10.1007/978-3-030-23400-3

Carsky, R.J., Vanlauwe, B., Lyasse, O., 2002. Cowpea rotation as a resource

management technology for cereal, in: Fatokun, C.A., Tarawali, S.A., B.B. Singh, Kormawa, P.M., Tamò, and 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, 4–8 September 2000. IITA,. Ibadan, Nigeria., pp. 252–266.

Chweya, J.A., Eyzaguirre, P.B. (Eds.), 1999. The biodiversity of traditional leafy vegetables. International Plant Genetic Resources Instit. (IPGRI), Rome, Italy.

CSA, 2018. The Federal Democratic Republic of Ethiopia. Agricultural Sample Survey. Report on Area and Production of Major Crops for Meher Season. 2017/18 (2010 E.C). Statistical Bulletin No 586. Addis Ababa, Ethiopia.

Demooy, B.E., Demooy, C.J., 1990. Evaluation of cooking time and quality of seven diverse cowpea (Vigna unguiculata (L.) Walp.) varieties. Int. J. Food Sci. Technol. 25, 209–212.

Dube, E., Fanadzo, M., 2013. Maximising yield benefits from dual-purpose cowpea. Food Secur. 5, 769–779.

Dugje, I.Y., Omoigui, L.O., Ekeleme, F., Kamara, A.Y., Ajeigbe, H., 2009. Farmers ' Guide to Cowpea Production in West Africa. Ibadan, Nigeria.

Elemo, G., Elemo, B.., Okafor, J., 2011. Preparation and Nutritional Composition of a Weaning Food Formulated from Germinated Sorghum (Sorghum bicolor) and Steamed Cooked Cowpea (Vigna unguiculata Walp.). Am. J. Food Technol. 6, 413–421.

Emechebe, A.M., Florini, D.A., 1997. Shoot and pod diseases of cowpea induced by fungi and bacteria, in: Advances in Cowpea Research. Copublication of International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS).UTA, Ibadan, Nigeria, Ibadan, Nigeria, pp. 176–192.

Hall, A.E., 2012. Phenotyping Cowpeas for Adaptation to Drought. Front Physiol. 3, 1–8.

Hamid, S., Muzaffar, S., Wani, I.A., Masoodi, F.A., Bhat, M.M., 2016. Physical and cooking characteristics of two cowpea cultivars grown in temperate Indian climate. J. Saudi Soc. Agric. Sci. 15.

Jackai, L.E.., Daoust, R.A., 1986. Insect pests of cowpeas. Annu. Rev. Entomol. 31, 95–119.

Jaworski, T., Hilszczański, J., 2013. The effect of temperature and humidity changes on Insects development and their impact on forest ecosystems in the context of expected climate change. For. Res. Pap. 74, 345–355.

Langyintuo, A.S., Lowenberg-DeBoer, J., M.Faye, 2003. Cowpea supply and demand in West and Central Africa. F. Crop. Res. 82, 215–231.

Livinus, B., Oparaeke, Y., Mbonu, A., Joseph, A., 2012. Cowpea (Vigna unguiculata) Pest Control Methods in Storage and Recommended Practices for Efficiency : A Review. J. Biol. Agric. Healthc. 2, 27–34.

Matikiti, A., Chikwambi, Z., Nyakanda, C., Mashingaidze, A.B., 2012. The Impact of Leaf Harvesting on Cowpea of the Black eye beans: A Socio-Economic Survey of Mashonaland East Province of Zimbabwe. Sacha J. Environ. Stud. 2, 18–32.

Matsui, T., Singh, B.B., 2003. Root characteristics in cowpea related to drought tolerance at the seedling stage. Exp. Agric. 39, 29–38.

Meseret, M., Dawit, D., 2019. Evaluation of Soil and Water Conservation Measures on Physico-Chemical Properties of two Watershed in Humbo Woreda. Southern. Int. J. Nov. Res. Life Sci. 6, 54–61.

Mishra, S.K., Macedo, M.L.R., Panda, S.K., Panigrahi, J., 2018. Bruchid pest management in pulses : past practices, present status and use of modern breeding tools for development of resistant varieties. Ann. Appl. Biol. 172, 4–19.

MoA, 2018. Ministry of Agriculture: Plant Variety Release, Protection and Seed Quality Control Directorate. Crop Variety

Register Issue No.21. Addis Ababa, Ethiopia.

Nahunnaro, H., Ayuba, K., 2012. Response of some cowpea genotypes to cercospora leaf spot (Cercospora canescens) disease in Yola and Mubi, Nigeria. Ecisi.Com 2, 904–912.

Nielsen, S.S., Ohler, T.A., Mitchell, C., 1997. Cowpea leaves for human consumption: production, utilization, and nutrient composition, in: Dashiell, L.E.N., Jackai, B.B., Singh, D.R., Mohan, R. (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. 326–332.

Owade, J.O., Abong, G., Okoth, M., Mwang, A.W., 2019. A review of the contribution of cowpea leaves to food and nutrition security in East Africa. Food Sci. Nutr. 1–12.

Phillips, R.D., Mcwatters, 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., Saalia, F.K., 2003. Utilization of cowpeas for human food. F. Crop. Res. 82, 193–213.

Saidi, M., Itulya, F.M., Aguyoh, J.N., Mshenga, P.M., 2010. Yields and Profitability of a Dual-Purpose Sole Cowpea and Cowpea-Maize Intercrop as Influenced as Cowpea Leaf Harvesting Frequency. ARPN J. Agric. Biol. Sci. 5, 65–71.

Sanginga, N., Lyasse, O., Singh, B., 2000. Phosphorus use efficiency and nitrogen balance of cowpea breeding lines in a low P soil of the derived savanna zone in West Africa. Plant Soil 220, 119–128.

Shetty, A., Magadum, S., Kalmesh, M., 2013. Vegetables as Sources of Antioxidants Journal of Food & Vegetables as Sources of Antioxidants. J. Food Nutr. Disord. 2, 1–6.

Singh, B.B., Ajeigbea, H.A., Tarawali, S.A., Fernandez-Rivera, S., A., Abubakar, M., 2003. Improving the production and utilization of cowpea as food and fodder. F. Crop. Res. 84, 169–177.

Singh, S.R., Jackai, L.E.., 1985. Insect pests of cowpeas in Africa, their life cycle, economic importance and potentials for control, in: Singh, S., Rachie, K. (Eds.), Cowpea Research Production and Utilization. John Wiley, and Sons, New York, pp. 217–231.

Sisay, A., Alemu, M., Asfaw, Z., Woldu, Z., Berhanu, F.A., 2019. Cowpea (Vigna unguiculata (L .) Walp ., Fabaceae) landrace (local farmers ' varieties) diversity and ethnobotany in Southwestern and Eastern parts of Ethiopia. Afr. J. Agric. Res. 14, 1029–1041.

Smith, F.I., Eyzaguirre, P., 2007. African Leafy Vegetables: Their Role in the World Health Organization's Global Fruit and Vegetables Initiative. African J. Food, Agric. Nutr. Dev. 7, 1–17.

Tarawali, S.A., Singh, B.B., Gupta, S.C., Tabo, R., Harris, F., Fernández-Rivera, S., A. Bationo, V.M.M., Nokoe, S., And, K.M., Odion, E.C., 2002. Cowpea as a key factor for a new approach to integrated crop–livestock systems research in the dry savannas of West Africa, in: Fatokun, C.A., Tarawali, S.A., Singh, B.B., P. M. Kormawa, A., 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, 4–8 September 2000, Ibadan, Nigeria, pp. 233–251.

Temesgen, M., Rockstrom, J., Savenije, H.H.G., Savenije, W.B., Dawit, A., 2008. Determinants of Tillage Frequency Among Smallholder Farmers in Two Semi- Arid Areas in Ethiopia. Phys. Chem. Earth 33, 183–191.

Togola, A., Boukar, O., Belko, N., Chamarthi, S.K., Fatokun, C., Tamo, M., Oigiangbe, N., 2017. Host plant resistance to insect pests of cowpea (Vigna unguiculata L. Walp.): achievements and future prospects. Euphytica 213, 1–16.

Trinidad, T.P., Mallillin, A.C., Loyola, A.S., Sagum, R.S., Encabo, R.R., 2010. The potential health benefits of legumes as a good source of dietary fibre. Br. J. Nutr. 103, 569–574.

Vance, C.P., Uhde-Stone, C., Allan, D.L., 2003. Phosphorus acquisition and use : critical adaptations by plants for securing a nonrenewable resource. New Phytol. 157, 423–447.

Velásquez, A.C., Castroverde, C.D.M., Yang, S., 2019. Plant and pathogen warfare under changing climate conditions. Curr Biol 28, 619–634.

Waluyo, S.H., Lie, T.A., Mannetje, L., 2004. Effect of phosphate on nodule primordia of soybean (Glycine max Merrill) in acid soils in rhizotron experiments. Indones. J. Agri. Sci. 5, 37–44.