International Journal of Agricultural Sciences ISSN 2167-0447 Vol. 8 (2), pp. 1404-1427, February, 2018. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Study on ethnobotany and phenotypic diversity in anchote (*Coccinia abyssinica* (Lam.) Cogn.) Landraces in Western Ethiopia

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Accepted 18 December, 2018

Among the major root and tuber crops, anchote is a potential crop produced in Western parts of Ethiopia. In addition to food source, it takes wide portion in socio-economic, cultural and medicinal value for the farming communities. To study the indigenous knowledge on utilization and conservation of anchote, ethno-botanical survey was conducted in 2012 for continuous three months (February, March and April) in Western part of Ethiopia. The landraces were also collected during survey. Forty nine anchote landraces were tested in 7x7 Simple Lattice Design at Wayu Tuqa District of East Wollega in 2012/013. The survey results showed that most of the respondents had sufficient experiences of growing *Coccinia abyssinica* (Lam.) Cogn. Socio-economic status of the households and ecological requirements was found to be an important factor affecting the use, management and conservation of the crop. The difference in level of education had no impact on conservation and use of *Coccinia abyssinica*. It was also observed that the older informants were more knowledgeable than the younger ones, as they knew much more about the different local cultivars and values of use. Data of the mean values of all experimental units were subjected to analysis of variance for RCBD. Flower width (61.22%) showed high heritability and medium heritability was recorded for flower length (52.24%), indicated that such characters were least affected by environmental modifications so that; selection based on phenotypic performance would be reliable. Low heritability were recorded for traits like root length (33.72%), Leaf width (21.53%), total root yield (20.6%), leaf length (17.19%), root diameter (8.33%) and low heritability were recorded for other to indicate environmental effect that constitutes a major portion of the total phenotypic variation signifying that management practice is better than selection to improve those traits. Genetic advance as percentage of the mean ranged from 2.45% for leaf length to 77.08% for flower width. Within these range a relatively high genetic advance as percent of the mean was observed for flower length (57.72%) and flower width (77.08 %). High value for heritability and genetic advance of the characters in current study provide information for the existence of wider genetic diversity among anchote landraces which offers high chances for improving several traits of the crop through simple selection. Cluster analysis showed that four divergent groups were formed. Each cluster known by their highest and lowest mean value and it is helpful for easy selection of parents with the desired traits for hybridization or selection program.

Key words: *Coccinia abyssinica*, anchote, ethno-botany, heritability, landraces.

INTRODUCTION

Anchote (*Coccinia abyssinica*) is the root crop of the *Curcubitacae*of the Genus: *Coccinia* Specific epithet: *abyssinica Cogn* (Candolle, 2007). It is found both as cultivated and wild in Ethiopia (Edwards, 1991). Although the genus in Ethiopia is not well studied, there are about ten species of Coccinia in Ethiopia. However, only *Coccinia abyssinica* is cultivated for human consumption

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(Endashaw, 2007). Some of the species are highly resistant to drought (FAO, 1996). The most widely used vernacular name of *Coccinia abyssinica* is Anchote spelt *Ancootee* in Afan Oromo, *Ushushu* in Welayita, *Shushe* in Dawuro and *Ajjo* in kafigna (Demel *et al*., 2010). It is adapted well to south and western parts of the country between 1300 to 2800 m above sea level. It prefers soil pH of 4.5 to 7.5, mean minimum and maximum temperature of 12 ^{o}C and 28 ^{o}C and rain fall ranging from 800 to 1200 mm/year (Amare, 1973; BARC, 2004).

Anchote dish, owing to its contribution to good health is getting popular and demand is increasing. In addition, because of its attachment to customs and tradition of the people in the region, the revival in the society is affecting and will continue to influence anchote culture (Habtamu, 2011). It is mainly grown for its storage root yield and leaf also used as a vegetable among the growers. As a food, it is a rich source of carbohydrate, vitamins, minerals, protein and calcium as compared to other root crops (Amsalu et al., 2008; Habtamu, 2011). Nutritionally, 100 gram of anchote contains moisture 74.93g, crude protein 3.25g, CHO 92.11g, crude fat 0.19g, total ash 2.19g and crude fiber 2.58g with a total gross energy of 382.78 Kcal/100g. In addition, anchote contains 119.5Ca, 5.49 Fe, 34.61 P, 79.73Mg and 2.23 mg of Zn in 100g of anchote (EHNRI, 1997; Bradbury and Holloway, 1988); USDA, 2002; Esayas Ayele, 2009).

Habitually, its storage root is served as a side dish with cereals as; 'kitifo', 'lankata' (finely grounded tuber), 'wot', soup, and 'murmura' (boiled tuber cut in pieces). Similarly, the leaf also primed as 'Wot' and served as a side dish with bread or 'injera' (Abera, 1995). Moreover, traditional practitioners use anchote to treat different type of diseases such as diabetes, gonorrhea, tuberculosis, asthma and cholesterol lowering (Amare, 1973).

Abera (1995) reported that a farmer in Western parts of Wollega usually allocate 400 to 600 square meters of land for anchote production mainly for home consumption. Its productivity show a discrepancy based on genotypes, soil fertility level, location and cultural practices used. Under farmers condition it can yield 20 - 30 tha^{-1}(Abera, 1995; BARC, 2004). However, under research condition it has a potential to yield up-to 73 tha^{-1}(Desta, 2011) and 76.45 tha^{-1}(Daba *et al*., 2012). The total yield of anchote is 150-180 quintals/hectare, which is in the range of total yield of sweet potato and potato (IAR, 1986).

The estimation of genetic parameters is needed to understand the genetic architecture of yield and yield contributing components. Besides, an information about the mode of inheritance, type of gene action and heritability of the yield contributing components helps immensely for plant breeder to decide about the proper breeding procedure to be adopted and the characters on which the selection has to be made so that selection is effective (Chandrasekhar, 2006). In spite of the long history of cultivation and consumption, anchote have not been taken up for systematic research work in order to understand the genetic architecture and manipulation in an improvement program. Due to the lower attention given to the research and development of anchote, there is no variety so far developed and released.

There are traditional selection practices being followed by farmers to have anchote types of desirable qualities, such as larger tuber size (Desta, 2011). According to a report (Abera et al., 1995), women usually do the selection and maintenance of good quality anchote root and discard the undesirable ones. Farmers have their own experience by which they maintain seeds for the next planting. Among the quality attributes the farmers take in to account are cooking quality, durable quality and time taken for tuber formation.

Beyond the traditional experience, there is no scientific research done on the selection of more yielder and better adaptive varieties of this crop. Though it is a major root crop of the south and western regions, it is less known to other world. Efforts to conserve the traditional root and tuber crops of the country are short of what is desirable. Demissie (1998) reported that enset (*Ensete Ventricosum*), anchote (*Coccinia abysinica*), Oromo potato (*Plectranthus edulis*), *Amorphophallus abyssinica* and *Abelmoschus esculentus* are some of the little known but potentially useful crop species in Ethiopia. They, however, have received little attention by research and development activities so far.

Anchote is for a long time with its practices on farming and utilization being passed from generation to generation in the course of oral tradition, with very little recorded information (Gemeda, 2000).

It is one of the many underutilized crops with less emphasis given in terms of investigation and preservation practices. Thus, the study was conducted with the following objectives:

- To study the indigenous knowledge on the utilization and conservation of anchote
- To estimate the heritability (broad sense) and genetic advance
- To study the extent of diversity among landraces and cluster them into different groups

LITERATURE REWIEW

Origin and Distribution of Anchote

Ethiopia is the country in the world where crop domestication started, and considered as a primary gene centre for several crop plants (Vavilov, 1951). Other scientists (Harlan, 1969; Frankel, 1973) reported the existence of many cultivated crops in Ethiopia which show considerable genetic diversity. According to IBCR (2001), at least 7000 vascular plant species occur in

Ethiopia, of which 12% are believed to be endemic. It is also stated in ENBSA (2005) that crops such as tef (*Eragrostis tef* (Zucc.) Trotter), noog (*Guizotia abyssinica* (L.F.) Cass.), gesho (*Rhamnus prinoides* (L'Hér.), kosso (*Hagenia abyssinica* (Bruce) J. F. Gmel), Ethiopian mustard (*Brassica carinata* (A.Br.), enset (*Ensete ventricosum* (Welw.) Cheesman), chat (*Catha edulis* (Vahl.) Endl.), Oromo potato (*Plectranthus edulis* (Vatke) Agnew), anchote (*Coccinia abyssinica* (Lam.) Cogn.) and Coffee (*Coffea arabica* L.) have great diversity and believed to have originated in Ethiopia. The genus Coccinia is made up of 30 spp. of which eight are reported to occur in Ethiopia. The species recorded in flora of Ethiopia since 1995 include C. abyssinica (Lam.) Cogn., C. *adoensis* (Hochst. Ex. A. Rich.) Cogn.), C. *grandis* (L.) Voigh (Syn. C. *indica* wight and Arn.), C. *megarhiza*, C. Jeffrey and C. *schliebenii* Harms. The remaining three species have not yet been described (Abera et al., 1995).

According to Westpal (1974), anchote is one of several root and tuberous crops (Yam, Taro, Oromo Potato, Irish Potato, Sweet potato and Enset) grown in west and southwestern parts of the highlands. According to Edward (2001) anchote is grown as a root crop only in the west, south west and southern regions of Ethiopia. Anchote is cultivated in areas between 1300-2800 m above sea level where the annual rainfall ranged between 762-1016 mm (Amare, 1973).

Ethiopia has 18 agro-ecological zones which are endowed with suitable climatic and edaphic conditions for quality and quantity production of various kinds of root and tuber crops (EIAR, 2008).

Taxonomy and Name of Anchote Species

The scientific classification of Anchote (*Coccinia abyssinica (Lam.) Cogn*) has the following pattern (Candolle, 2007).

Domain: *Eukaryota;* Kingdom: *Plantae;* Subkingdom: *Viridaeplantae;* Phylum: *Tracheophyta;* Subphylum: *Euphyllophytina;* Class: *Magnoliopsida;* Subclass: *Dilleniidae;* Superorder: Violanae; Order: *Cucurbitales;* Family: *Cucurbitaceae;* Subfamily: *Cucurbitoideae;* Tribe: *Benincaseae;* Genus: *Coccinia;* Specific epithet: *abyssinica* Cogn. Botanical name: *Coccinia abyssinica* (Lam.) Cogn.

Biology of Anchote

Anchote is both a tuber crop and leafy vegetable. It is a leaf vegetable in that when the plant is in its new flush or growth, it produces tender young leaves from the new growing bud. The tender leaves and top growing buds are plucked together like leaves tea, and cooked to be served with other especial food. In the top growing point areas, anchote is considered as delicious dish in Dambi Dollo area (personal experience). Anchote is a storage tuberous root perennial with trailing annual shoots that climb up a support by means of simple tendrils. Anchote leaves are heart-shaped to palmate lobed with slightly toothed margins and arise singly at each node. The stems and leaf stalks are solid and not hollow like most other cultivated cucurbitaceous crops.

Cultural Practices

Propagation

Vegetatively, it is achieved by planting either the whole tuber or by slicing it in two or more pieces, each pieces, having rootlets and an external covering. This is usually done to establish "Mother" plants, called "Guboo" to serve as a seed source for further plantings while seeds are extracted from fully mature red-ripe fruits, which are harvested before they start rooting. Such fruits are macerated or sliced to separate the seeds from the fleshy juicy part (Ambecha, 2006). The seeds are then mixed with an equal quantity of wood ash and dried in sun. The moisture content of the seeds for storage is based on the desired level. During this storage period the seeds are usually kept in either clay or wooden pots or wrapped in a sheet of cloth (Ambecha, 2006).

Sowing Methods

The existing practice is to sow the seeds by broadcasting. After broadcasting the seeds are covered either by ploughing with oxen or more commonly using a digging hoe (Qonfaro) with or without metal (Personal experience). When broadcasting farmers prefer a narrow spacing of about 20 cm than a wider spacing. According to (Girma and Hailu, 2009), intra-row spacing highly affect root yield while inter –row spacing affected root yield and average root weight per plant. The reduction of intra-row spacing from 30 cm to 10 cm resulted in increase of total tuberous root yield by 137%. Reduction of inter-row spacing from 100 cm to 40cm resulted in high total tuberous root yield by 37.4%. Therefore, 40-60cm inter row and 10cm intra- row spacing are recommended for the western sub-humid zones of Oromia, Ethiopia.

Fertilization

Anchote responds strongly to soil fertility, particularly to wood ash and produces large sized tuber of good shape very rapidly when grown in fertile soils. Growers know this from their long practical experience and hence prefer to grow anchote close to the home garden where a cattle pen can be put up and rotated. This makes cow dung available as organic manure. Other areas within the reach of the family can also be made suitable for anchote through the use of other waste as organic manure in addition to that from cow dung (Amare, 1973). According to Girma and Hailu, 2009, 5-8 t ha^{-1} farm yard manure

(FYM) or 46/20 kg ha^{-1} N/P are recommended for high yield of anchote production and enhancement of soil structure and its nutrient for the western sub-humid zones of Oromia, Ethiopia.

Ecological requirements

The general lack of information on the crop holds true for the lack of information on suitable soils for anchote cultivation. Westpal (1974) based on climate, altitude and soils classified the country into many agro ecological regions between which two regions have special connections with anchote. The south eastern part of the Ethiopian high lands: these areas are situated at altitude of 1800 m a.s.l. and have Afisols as a major soil type. They receive 950-1500mm average annual rainfall. The south western part of the Ethiopian high lands including Wollega, Illubabor and Jimma has oxisols, ultisols and vertisols as major soil types.

The southwestern part of the Ethiopian/Oromia high lands is situated at 1500-2400m a.s.l. and receives an annual rainfall about 1500mm to over 2000mm per year. According to Amare (1973) anchote is cultivated in areas between 1300-2800m where the annual rainfall is 62-1016mm.

Medicinal Importance

Root and tuber crops have good nutritive value and phytochemical contents which are beneficial to the human health. In addition to major food staff (proteins, carbohydrates, fats and mineral vitamins) anchote contains phytochemicals such as alkaloids, tannins, phenols, flavonoids and saponins (Okwu and Ukanwa, 2007). Fufa and Urga (1997) reported traditionally, it is believed that Anchote heals broken or fractured bones, helps sick people to recuperate and makes lactating mothers healthier and stronger, this may be due to the high calcium contents of the tuber. Dawit and Estifanos (1991) also reported that juice prepared from roots of anchote has been used in Ethiopian traditional medicines. They indicated that the juice has saponin as an active substance and is used to treat gonorrhea, tuberculosis and cancer.

Economic and Social Importance

Seedling of anchote tuber and leaves for current use and anchote seeds for propagation generate income to growers. The price for anchote tuber varies with tuber size, time of the year, supplies amount and market location. In the western parts of the country tubers of anchote are boiled and prepared with local butter for Meskel holiday in September, which commemorated the finding of the true cross. It is also a current experience that' lanqaxaa' a finely prepared anchote dish, is commonly served during ceremonies marking weddings, betrothals, birthdays, and religious celebrants, new year and thanks giving day for the harvest as well as on other occasions (Ambecha, 2006).

Anchote and Oromo Women. The role played by Oromo women in anchote culture is manyfolds. They work as:' *Breeders*' by selecting a desirable quality of anchote and growing it, '*Growers*' as they plan, plant and weed the plants,' *Harvesters'* as they determine the maturity stage that gives anchote of the type and how to harvest it properly, *'Processor'* as they prepare, process and taste for it quality both physically and behavioral'; and finally as '*Marketers and distributors'* (Abera et al., 1995).

The benefits that the Oromo women derive from anchote the existing experience is that they can decide or convince their husbands in family forums, to reach decisions on the many affairs concerning anchote. This includes site selection (the decision on where to grow), what size of land area to use for anchote, variety selection, buying or selling of anchote products and for what purposed to use the money in return. What is encouraging and should be appreciated is that besides their right to decide on the many affairs of anchote, Oromo women have experience in exercising this right. They have stood on their own feet and decided freely and fairly what they think is should be done in cultivating and using anchote. It is the advantage that exceeds the monetary benefits (Ambecha, 2006).

Tuber Qualities

There are traditional selection practices being followed by farmers to have anchote types of desirable qualities as larger tuber size. The following are the attributes farmers are considering while selecting anchote types with desirable qualities. The women usually do the selection and maintenance of good quality anchote tubers and discarding of the non-desirable ones. According to (Desta, 2011) there are traditional selection practices being followed by farmers to have anchote types of desirable qualities, such as larger tuber size. Farmers harvest selectively and observe the size of the tubers. If it is big, they maintain some of the crop and collect their seeds for future propagation from these plants. If the tubers remain quite small, the farmers will not maintain that types as seed source.

Some anchote types are fibrous while others have low fiber content. Farmers harvest and test the crop quality by cooking and eating some tubers. Keep yield and other quality factors constant, if the tuber has high fiber content the farmers will not keep that type for seed production. Even if seed is produced they nearly harvest from a fibrous types. Here, it should be understood that some anchote types are generally fibrous even from very beginning while for others the fiber content only increase with age. Also farmer will abandon those with poor cooking quality and maintain seeds of anchote types with general desirable qualities. Similarly, there are types preferred for their taste over the others.

Production Constraints

Crop Protection

Farmers usually grown anchote near dwelling areas. This land gives an equal right for weeds to grow luxuriously. Hence, anchote needs early weeding and better land preparation (Amare, 1973). Incidence on tubers is rare and thus protection from disease and minor pests is not common. Fruit fly bores into the fruit and pre-disposes it to decay. Wild animals, particularly wild pig, Porcupine and Wart-hoge; domestic animals; sheep, goat, cattle and donkeys are on the list. The wild animals eat the anchote tuber by digging into the soil and are terrible pests of anchote. The roots have to be protected by fencing the anchote field properly and also by guarding the crop at night when these pests come out and attack the crop (Abera, 1995).

MATERIALS AND METHODS

Survey in western Ethiopia

A study was conducted in Sayo and Hawa Galan district of Kellem Wollega; Gimbi and Haru district of West Wollega and Sibu Sire and Wayu Tuka district of East Wollega Zone of Western Ethiopia (Figure. 1). A total of six districts were selected following discussion and based on available secondary data. Eventually, after discussion with agricultural experts two kebele in each district, Babo and Moyi of Hawa Galan district; Walgahi Bubuka and Ifa Galano of Sayo district; Wara Sayo and Kombo Mika'el of Gimbi district; Ganat Abo and Warra Baro of Haru district and Bikila and Cafe Jalale of Sibu Sire district; Gida Basaka and Gute Badiya of Wayu Tuka district were selected. During the survey kebele managers and agricultural experts working in each kebele assisted the researcher in creating the list of farmers growing anchote. From the list informants were selected randomly. Six households selected from each kebele a total of seventy two informants were interviewed. In addition, respondents selected based on their willingness and practical knowledge on production and use. To ensure the reliability of their information repeated asking were performed.

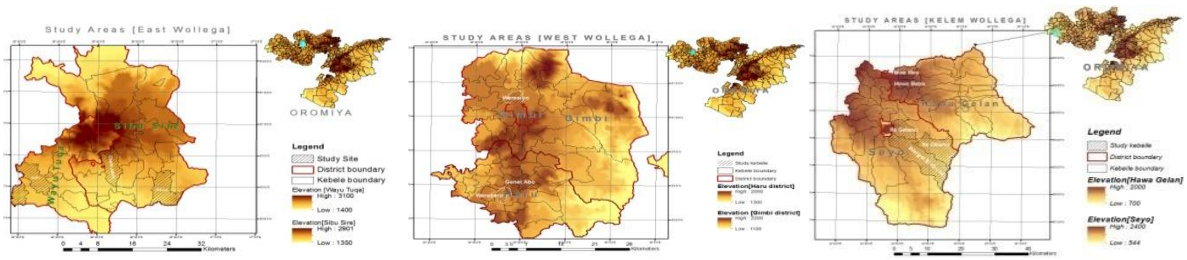
Data were collected from November to December 2011, using interview prepared in English translated to Afan Oromo. Before starting the interview session, time was devoted to introduce them the subject and the purpose of the study. The questionnaire covered different topics such as information about the study area, landholding, root crops commonly grown and specific information on the use and management of *Coccinia abyssinica.* The detailed information was focused on cultural practices, the effect of distance on cultivation, movement of planting materials, agricultural inputs, the parts and types of food prepared, and traditional use values of *Coccinia abyssinica.* The respondents were also asked about the storage and associated problems, especially conservation practices, which provided information on the importance of the crop and its future utilization and conservation.

Farmers were also asked to differentiate the local cultivars known in the field with their typical characteristics such as original source, date of planting, maturity days, shelf life, taste, market price, production per hectare, response to disease and insect pest. Local cultivars that were once cultivated by farmers were asked about the meaning of local names in cases where special attributes were associated with the names. Finally, they were asked about their opinion on the production status of *Coccinia abyssinica.* A gender-specific question within individual farmers was raised to see whether there were differences in the participation of the household in management and use of *Coccinia abyssinica,* and if a particular management function, such as seed tuber selection, was related to gender. In the end, farmers were also asked whether there is extension system applied recently relating to production *Coccinia abyssinica,* significance and role to household food security.

The survey work took 90 days. Some respondents were sometimes taken up by the subject and spent much time in sharing their views, especially elders' on significance of anchote, which made the time longer. Financial scarcity of the researcher also influenced to keep a while to collect and return to work prolong the time of study. Only the researcher participated in data collection. A digital camera was used to document the different local cultivars of *Coccinia abyssinica* seed and tuber (Guboo) identified during the survey. During survey seed were also collected specific to the area of collection. To ensure the viability of the seed for planting, having large quantity, mix with ash and enclosed with cloth were done.

Description of the experimental site for morphological characterization

The experimental part of the study was conducted in Wayu Tuka District of East Wollega Zone, Oromia Regional State of Ethiopia. This zone contains seventeen woreda with its own subkebele division. It is surrounded by West Shewa from East, West Wollega from the West, Jimma and Illu Abbabora from the North and Amahara Regional State and Horo Guduru Wollega from the South. It receives annual rainfall ranges from 1200-2400mm and 23^{o}c mean temperature (East Wollega Zone Agricultural Office, 2011). It has a total population of 1.3 million out which Wayu Tuka District with total population of 74,020 (East Wollega Zone Agricultural Office, 2011). This district is located at 318 km west from



(A) (B) (C)

Figure 1. Map of study areas (A - East wollegazone; B- West Wollega zone and; C - Kellem Wollega zone). (Source: Wollega University Department of Geography, 2011).

Addis Abeba and 12 km Northeast of Nekemte. The altitude of the area ranges from 1400 to 3162 m a.s.l. Its climate covers 37.66% of highland, 49.22 % of mid land and 13.12 % of lowland (WTLEPO, 2011).

The mean temperature of the area is 22^{o}cand the area receives maximum rainfall from April and lasts to October. Total annual rainfall ranges from 1200 - 1800mm. The dominant soil type of the district includes 60 % of clay loam, 35 % of sand 5 % clay (WTAO, 2011).

Among these cultivable land 33735.87 ha, cultivated land 35, 382.38 ha, forest land 1825.4ha, pasture land 1214.78ha and 1,651.646ha were others. Common agricultural practices of the area included mixed farming system (WTLEPO, 2011). For practical reasons, the study villages were selected as a representative and approximate. Preliminary field visit was made prior to the actual field work in the selected kebele in order to make known with the area and development agents working there.

Planting materials, experimental design and data management

The experiment was conducted in 2011/12 cropping season. A total of 49 landraces of (*Coccinia abyssinica* (Lam.) Cogn.) collections were planted in 7x7 simple lattice design (Table 2). The sizes of each plot were 4m^2 and inter-row and inter-block distances were 0.7m. There were five rows per plot. Spacing between row and plants were 45cm and 10cm, respectively. There were 17 plants in each row and totally 85 plants/plot. During the study period normal agronomic practices such as weeding, ridging up, staking and fertilization were applied as appropriate. DAP and Urea were applied at the rate of 20/46 kg/ha respectively (Girma and Hailu, 2009).

In addition to guard, experimental plots were fenced using wire to prevent the entrance of both domestic and wild animals.

Data collection

A descriptor list for characterizing *Coccinia abyssinica* is so far not available. Therefore, the descriptor list developed for other root crops by IPGRI (1991) and ECPGRI (2008) was used with slight modification for the study. Field data were collected from randomly selected ten plants on a plot. Nine quantitative and eleven qualitative morphological characters were measured respectively (Tables 2 and 3). Most of the data were collected at 50% flowering stage. Rulers, sensitive balance, polyethylene bags and other special equipment were used for data collection.

Data analysis

Coding and verification of data were made carefully in order to ensure the quality of the collected data. All gathered data coded in various ways depending on their nature. Ethnobotanically gathered interview was presented using descriptive statistics, percentage and tables. Data for quantitative morphological traits were subjected to analysis of variance (ANOVA) using randomized complete block design since the efficiency of simple lattice design was in some cases less than RCBD. The estimation of various genetic parameters is easier and standardized in RCBD especially to estimate correlations and path coefficient analysis and simple lattice being flexible (Cochran and Cox, 1957).The difference between treatments means was compared using LSD at 5% probability level.

The ANOVA for simple lattice design is given in Table 5 below and stated as: ***Yil(j)=μ+ti=rj=rl(j)+eil(j)***.

Where, Yil(j) is the observation of the treatment i(i=1,…v,k2), in the block l (l=1,..k) of the replication j(j=1,..,m); μ is constant common to all observations; ti is the effect of the treatment i; rj is the effect of the replication j; rl(j) is the effect of the block l of the replication j; eil (j) is the error associated to the observation Yil(j), where eil(j)≈N(0,S) independent.

Estimate of genotypic and phenotypic coefficient of variation

The phenotypic and genotypic variances and coefficient of variations were estimated as per the pro-

Table 1. Anchote (Coccinia abyssinica) landraces and its collection site.

S/no.	Landraces/accessions code	Collection site/District and Zone
1	Babo 1	Hawa Galan- Kellem Wollega
2	Babo 2	Hawa Galan- Kellem Wollega
3	Babo 3	Hawa Galan- Kellem Wollega
4	Babo 4	Hawa Galan- Kellem Wollega
5	Babo 5	Hawa Galan- Kellem Wollega
6	Bikila 1	Sibu Sire - East Wollega
7	Bikila 2	Sibu Sire - East Wollega
8	Darabata 1	Wayu Tuka - East Wollega
9	Darabata 2	Wayu Tuka - East Wollega
10	Darbata 3	Wayu Tuka - East Wollega
11	Gute Badiya 1	Wayu Tuka - East Wollega
12	Gute Badiya 2	Wayu Tuka - East Wollega
13	Haro 1	Wayu Tuka - East Wollega
14	Haro 2	Wayu Tuka - East Wollega
15	Haro 3	Wayu Tuka - East Wollega
16	Haro 4	Wayu Tuka - East Wollega
17	Haro 5	Wayu Tuka - East Wollega
18	Ilfata 1	Wayu Tuka - East Wollega
19	Ilfata 2	Wayu Tuka - East Wollega
20	Ilfata 3	Wayu Tuka - East Wollega
21	Ilfata 4	Wayu Tuka - East Wollega
22	Jalale 1	Sibu Sire - East Wollega
23	Jalale 2	Sibu Sire - East Wollega
24	Jalale 3	Sibu Sire - East Wollega
25	Jalale 4	Sibu Sire - East Wollega
26	Kichi 1	Wayu Tuka - East Wollega
27	Kichi 2	Wayu Tuka - East Wollega
28	Kichi 3	Wayu Tuka - East Wollega
29	Kichi 4	Wayu Tuka - East Wollega
30	W/B/Migna 1	Wayu Tuka - East Wollega
31	W/B/Migna 2	Wayu Tuka - East Wollega
32	W/B/Migna 3	Wayu Tuka - East Wollega
33	W/B/Migna 4	Wayu Tuka - East Wollega
34	W/B/Migna 5	Wayu Tuka - East Wollega
35	W/B/Migna 6	Wayu Tuka - East Wollega
36	Kombo Michael 1	Gimbi - West Wollega
37	Kombo Michael 2	Gimbi - West Wollega
38	Tinfa 1	Guto Gida - East Wollega
39	Tinfa 2	Guto Gida - East Wollega
40	Tinfa 3	Guto Gida - East Wollega
41	Tinfa 4	Guto Gida - East Wollega
42	Tinfa 5	Guto Gida - East Wollega
43	Tinfa 6	Guto Gida - East Wollega
44	Wara Sayo 1	Gimbi - West Wollega
45	Wara Sayo 2	Gimbi - West Wollega
46	Wara Sayo 3	Gimbi - West Wollega
47	Wara Sayo 4	Gimbi - West Wollega
48	Wara Sayo 5	Gimbi - West Wollega
49	Wara Sayo 6	Gimbi - West Wollega

cedure suggested by Burton and De Vane (1953) as follows:

$$\sigma^2 g = \frac{(\sigma^2 e + r\sigma^2 g) - \sigma^2 e}{r} = \frac{MSg - MSe}{r}$$

$\sigma^2 g$= Genotypic variance, $\sigma^2 e$= environmental variance, r= number of replication, MSg= mean square due to genotype (landraces) MSe= mean square for error (environmental variance)

$$\sigma^2 P = \sigma^2 g + MSe$$

σ^2P= Phenotypic variance, **σ^2g=** Genotypic variance and **MSe=** mean square for error

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV)

$$GCV = \frac{\sqrt{\sigma^2 g}}{\bar{x}} \times 100$$

$$PCV = \frac{\sqrt{\sigma^2 p}}{\bar{x}} \times 100$$

Where; x =population mean of the character being evaluated (grand mean)

Estimate of broad sense heritability (H^2) and genetic advance

Heritability in the broad sense for quantitative characters was computed using the formula suggested by Singh and Chaudhary (1985):

$H^2 = \frac{\sigma^2 g}{\sigma^2 p} \times 100$

Where, H^2= heritability in broad sense (in percentage)

Expected genetic advance (GA)

The genetic advance (GA) for selection intensity (K) at 5% was calculated by the formula suggested by Allard (1999) as: **GA= K*σp*H^2** Where; GA= expected genetic advance, K= selection differential (2.06 at 5% selection intensity), σp= phenotypic standard deviation

Genetic advance as percent of mean (GAM) was computed to compare the extent of predicted genetic advance of different characters under selection using the formula

GMA= $\frac{GA}{X}$ *** 100**

Where GA= Genetic Advance, X= population mean for the trait considered

Divergence and cluster analysis

Cluster analysis is a multivariate statistical analysis technique involving partitioning a set of objects into groups so that objects within a group are more similar and objects in different groups are more dissimilar (Crossa et al., 1995). The qualitative characters were quantified by using appropriate scale (descriptors) of cucurbits (ECPGR, 2008) and descriptors of sweet potato (IBPGR, 1991).

The associations among the 49 anchote landraces for eleven qualitative characters were examined by hieratical agglomerative cluster analysis of observations using proc clusters of SAS with average linkage method of clustering strategy (SAS institute, 2008).

Cluster analysis for genetic divergence among the genotypes was estimated by D^2 (Mahalanobis, 1936). The analysis was based on all yield contributing characters influencing yield. The generalized distance between any two set of population will be defined as

$D^2 ij= (\bar{A}i-\bar{A}j)\ S^{-1}(\bar{A}i-\bar{A}j)$

Where D2ij= total generalized distance between class i and j (Āi-Āj)= the difference in the mean vectors of i^{th} and j^{th} germplasm accessions; S^{-1}= the variance-covariance matrix of pooled error. The distance obtained was tested using tabulated F table at 5% level significance.

RESULTS AND DISCUSSION

Ethno botany

The ethno botanical survey was aimed to study the indigenous knowledge on the utilization and conservation of anchote in the study area. The sampled households varied considerably in resource endowments, demographic and geographic factors.

Household Characteristics

A total of 72 respondents were interviewed at farm level, out of which 57 and 15 were men and women farmers, respectively. Most of the respondents had lived in the area and involved in farming activities for more than 12 years. Similarly, 59.7% of the respondents in the study area had grown the crop for more than 12 years. The average household size was 6.2 members (Appendix 1).

Land Holding and Level of Education

Increase in population, loss of land fertility and land holdings per family has become very big dilemma. Over 55.5% of the households have land holdings between 0-1 hectares of land (Table 5). According to farmer's statement, land shortage possessed a big challenge not only to the type of crops they grow but also to the total area allocated to each crop. The average land holding was 1.81hectares (Appendix 1) and farmers have no way to expand their land holdings. Poor households who have small plots of land are therefore, forced to plant near homestead on very small plot of land for family consumption or they plant in far distance from the home were anchote tuber highly attacked by wild animals (Abera, 1995). The majority of the respondents were in elementary and secondary school only very few out of the total had received diploma.

Agricultural Practices

The study sites are located in altitudes ranging from 544 to 3100 meters above sea level. The agricultural systems of these areas include a wide variety of crops. Root and tuber crops, cereals, coffee and spices are commonly cultivated. The cultivated landscapes include both home gardens and main fields. In some place main fields are situated far from the houses. The major root and tuber crops produced were sweet potato (*Ipomoea batatas*.), Irish potato (*Solanum tuberosum*), enset (*Ensete ventricosum*), taro (*Colocasia esculenta*), and yam (*Dioscorea spp*.). Other root crops such as carrot (*Daucus carota*), beet root (*Beta vulgaris*) and onion (*Allium cepa*) are cultivated as sources of income (ENBSA, 2005).

Due to shortage of cultivable land farmers often prioritize their main fields to major crops. They use commercial fertilizers for production of major crops because of the ever

Table 2. Quantitative traits with their respective codes and description.

No	Trait	Code	Scoring methods
1	Germination type	GE	1= Epigeal and 2= hypogeal
2	Leaf length	LL	Measured from the base of lamina to the tip of large vein
3	Leaf width	LW	The width of middle lamina will be measured
4	Tuber length	RL	Root length will be measured for 10 samples from top to bottom using ruler.
5	Tuber diameter	RD	Width of the 10 samples root will be measured using caliper
6	Number of sepal and petal	NS and NP	Counted from the flowers
7	Flower length (cm)	FL	Fully opened flowers measured for 10 samples from top to bottom using ruler.
8	Flower width(cm)	FD	Width of the fruit 10 sampled fruit will be measured using ruler
9	Total tuber yield (t/ha)	TRY	Total weight from 10 plants from three middle rows

Table 3. Qualitative traits with their respective codes and description.

S/no	Trait	Code	Description
1	Leaf color/foliage color	1-3	1=light green, 2 = green, 3= deep green
2	Plant growth type	1-2	1= determinate (main stem distinct with shortened internodes), 2= indeterminate (long main stem)
3	Sepal color	1-7	1=Green, 2=Green With Purple Edge, 3=Green With Purple Spots, 4= Green With Purple Areas ,5= Some Green Others Purple ,6=Totally Pigmented Pale Purple ,7=Totally Pigmented Dark Purple
4	Flower color	1-6	1= white, 2= white limb with purple throat, 3= white limb with pale purple ring and purple throat, 4= pale purple limb with purple throat, 5= purple, 6= yellow.
5	Growth habit/Vine spreading nature	1-2	1= bushy, 2= runner
6	Root shape	1-9	1= round L/B ratio 1:1, 2= round elliptic L/B ratio not >2:1, 3= elliptic L/B ratio not>3:1, 4= ovate-resemble longitudinal section of an egg(broadest at distal end), 5= obovate-inversely ovate(broadest at proximal end), 6= oblong – almost rectangular outline L/B ratio about 2:1, 7= long oblong – L/B ratio >3:1, 8= long elliptic- elliptic outline with L/B ratio of more than 3:1, 9= Long irregular or Curved
7	Root formation	1,3,5,7	1= closed cluster, 3= pen cluster,5= medium number of cracks, 7= very dispersed
8	Root cracking	0,3,5,7	0= absent, 3= few cracks, 5= medium number of cracks, 7= many cracks
9	Root size and variability	3,5,7	3= uniform, 5= slightly variable, 7 = moderately variable
10	Predominant root skin color	1-9	1= white, 2= cream, 3= dark cream, 4= orange, 5=pink, 6= red, 7= purple red, 8= purple, 9= dark purple
11	Secondary root skin color	0-9	0= absent, 1= white,2= cream, 3=yellow, 4= orange, 5=pink 6= red, 7=purple red, 8= purple, 9= dark purple

increasing prices of commercial fertilizer they didn’t apply for anchote production.

But the study showed there are more practices to apply this technology in East Wollega zone while in Kellem Wollega were not practiced at all (BARC, 2004; Desta, 2011). The farmers use small plots of lands efficiently and practice different soil conservation measures. Since rain-fed farming is dominant in the study area, rainfall variability is crucial in the farmers’ decisions as to plant the desired variety. Farmers usually begin planting Cocci-

Table 4. The structure of ANOVA table for RCBD.

Source of variation	Degrees of freedom	Mean square	Expected mean square
Replication	(r-1)	Msr	
Genotypes	(g-1)	Msg	$r\sigma^2_g + \sigma^2_e$
Error	(g-1) (r-1)	Mse	σ^2_e
Total	rg-1		

Where r and g represent number of replications and genotypes, msr= mean square for replication, msg= sum of square due to genotypes, mse= error sum of square.

nia abyssinica early in May to June.

Management Practices of Coccinia abyssinica

Coccinia abyssinica needs a relatively fertile land in contrast to other root crop species in the study area. Most farmers responded that the cultivation technique of *Coccinia abyssinica* is laborious, since it required continuous management practices in the very beginning of land preparation up to harvesting (Desta, 2011).

Propagation

All the respondents reported that Anchote is propagated exclusively from seeds collected from mother plant called “Guboo” which is achieved by planting either the whole tuber or by slicing it in two or more pieces, each pieces having rootlets and an external covering. “Guboo “can stay more than 2 and above years in the soil and mostly found near homesteads. Seeds are extracted from fully mature red- ripe fruits. Such fruit are macerated to separate the seeds from the fleshy juicy part and mixed with an equal quantity of wood ash and dried in the sun. All respondent agreed this experience increases the viability of the seed for the next planting time.

Land Preparation

Majority of the respondents reported that land preparation usually start around the month of April to June before the onset of rainy season. All most all respondent stated that land need to be ploughed three times in order to increase water retention, weed control and to facilitate germination of the seed. Mostly the land is prepared for planting in May throughout June. All farmers used traditional ploughing system for the cultivation of Anchote.

Sowing Method

The existing practices is to sow the seeds by broad casting and covering the seed using simple tools like digging hoe etc. Most farmers agreed this practice require large quantity of seed and difficult in harvesting time. Row planting considered necessary to be advised in the future. During survey no such planting considerations were followed.

Sowing Date

Farmers interested to plant seed from April to May in the study area but due to erratic delay rainy season they are persuaded to plant in the beginning of June.

Fertilizer Application

In the study area, 13.9 % farmers used commercial fertilizers to maintain the productivity of *Coccinia abyssinica*, mainly restricted to Sibu Sire and Wayu Tuqa. None of the farmers used pesticide application. Most farmers are subsistence farmers and cannot afford to buy commercial fertilizers and even for the other major crops. Few farmers reported that *Coccinia abyssinica* is highly responsive to commercial fertilizer. Awareness creation needs to be performed in the use of commercial fertilizer for minor crop in the rest of study site. Most farmers use organic fertilizer for anchote production in the study area which is appreciated if devoted to prepare it.

Weeding and Cultivation

More than 95% of the respondents reported that they carry out weeding activities three times. The remaining farmers weed even more often than this. Weeding is done at all stages of crop development and hand-weeding is the common practice employed. None of the farmers mentioned associated weed during the interview. Hilling up takes place one times, but the main building up is carried out only once during the final weeding. The hilling up is mainly carried out so as to cover the soil at the base of the stem which finally end up producing tubers. Ridging up will enable farmers to increase yield per unit area, and harvest relatively larger tubers. All most all respondents except one not involved in practice of intercropping in the study area.

Table 5. Land holdings of respondents (Source: Survey data, 2011).

District	Kebele	Land holding (ha)		
		0-1	≥1	Total
Sibu Sire	Bikila	4	2	6
	CaffeJalale	-	6	6
Wayu Tuka	Gute Badiya	1	5	6
	Gida Basaka	1	5	6
Gimbi	Warra Sayo	2	4	6
	Kombo Mika'el	2	4	6
Haru	Ganat Abo	2	4	6
	Warra Baro	2	4	6
Sayo	Ifa Galano	1	5	6
	Walgahi Bubuka	3	3	6
Hawa Galan	Hawa Moyi	1	5	6
	Warra Babo	4	2	6
	Total	***23***	***49***	***72***

Figure 3. Anchote (mother plant) attacked by rodents (photograph taken by the researcher, Gimbi, Warra Sayo, 2011).

Figure 2. Anchote tuber aged more than ten years and color of tubers (photograph taken by the researcher).

Pests and Diseases

Coccinia abyssinica is not seriously attacked by disease and pests, but fruit decay result prematurely due to certain kind of wasp and fruit fly effect. Some respondent mentioned lack of seed to collect; due to cholera (*Vibrio cholera*) have an effect on the mother plant result premature falling down of fruit. Few respondent stated grass hopper effect on seedling. Most respondent agreed anchote liked by domestics animals vis sheep, goat and cattle. Over 50% of respondents reported that the tubers are rarely attacked by rodents if, and only if, other root crops are harvested early.

Distribution of Local Cultivars

In all study sites, *Coccinia abyssinica* is grown in monoculture on a small plot of land. All respondent interviewed grow local cultivars of the crop. They reported that earlier they had been growing two different (White and Red) local cultivars for various reasons but during homestead survey yellow type mother plant over 15 years also recorded in Gute Badiya. More than 98.62 % of farmers selected to grow the white type. They said this type has more advantage like less fiber content, quickly prepared, soft, attractive and less out ward rootlets than red type. On the other hand red type has medicinal value than white one (Tables 6 and Fig 3). Some of the respondent believes that red color is associated with the age of anchote tuber (Mother Plant) in the soil. But the study revealed that color and the age of tuber is unrelated and it is due to the genetic diversity between the landraces (Figure 3). High demand requirement and dominant availability in the market increases people preference for white type only. Farmers restricted to grow only the white type to fulfill the people need too. This shows that farmers mainly relied on selecting the dominantly available white one while on the other way the use of red type is currently decline rapidly. These days they have specialized on few cultivars. There is evidence of ongoing genetic erosion, which has resulted in the complete loss of some local cultivars. Despite the fact, most farmers in the study area are not well aware of the meaning of the local name; they can simply

Table 6. Characteristics of the common local cultivars in the study area.

Characteristics	Red (Ancootee Diimaa)	White (Ancootee Adii)
Fiber content	More	Less
Preparation /During Boiling/	Difficult	Easy
Consumption	Hard	Soft
Rootlets	More	Less
Medicinal Value	More	Less
Marketability	Less	More
Tuber color	Red	White
Taste	Poor	Good
Yield performance	Intermediate	Good

Table 7. Mean squares for the 7 characters of 49 anchote landraces.

Source of variation	Df	LL	LW	FL	FW	RL	RD	TRY
Rep	1	0.54	1.735	0.339	1.577	2.907	22.723	473920.66
Genotypes	48	0.433ns	0.429ns	0.663**	1.339***	1.974**	7.926ns	402905.15ns
Error	48	0.307	0.277	0.208	0.322	1.978	6.707	265272.23
Mean		8.77	9.11	1.230	1.491	9.316	18.67	2153.26
C.V (%)		6.31	5.77	37.07	38.07	10.62	13.87	23.92

Df = degrees of freedom, **, p< 0.01; ns = not significant.
LL= Leaf length, cm; LW= Leaf width, cm; FL= Flower length, cm; FW= Flower width, cm; RL= Root length, cm.

distinguish them by their distinct characteristics.
*Data are based on farmer's perception of the performance of landraces collected during interviews.

Sources and diffusion of planting materials

Sources of planting materials in the study areas include own savings and market. The traditional seed supply systems are the only means of seed supply in the study area. Most farmers obtain seed from the market. In the low land of study area most farmers incapable to keep seed for next planting time due to predispose of fruit containing seeds by cholera (*Vibrio cholera*) and other insect pest infestation. They buy from the market. Those farmers who save seed often select red-ripe fruit from the mother plant in the homestead to be used as source of planting material. Women actively participate in preparing seed for market and for next planting time. The amounts to be prepared were different in the study area.

Selection of local cultivars

Women actively participate in the selection of local cultivars and they take a leading role in production activities (Abera et al., 1995). Even most respondent said anchote production belongs to women. A few of them stated they both participated in the production. Three main selection criteria for local cultivars were identified by them during the survey: productivity, household requirements and market demand are discussed below.

Productivity

Availability of the land and labor influence the production of *Coccinia abyssinica* in the study area. They had grown mostly for household consumption. The distance of farm field from homestead critically influence farmers at different place due to difficult in transportation. But most farmers seek to maximize their total house hold production in the future which may require technology transfer.

Household uses

Most respondent agreed having good appearance, taste; white color and larger one are the most preferred candidates. Time requirement needed for cooking is another important parameter when selecting for home consumption.

Market demand

Market demand is another selection criteria used by farmers in the study area. The farmers usually sell their produce during the beginning of the new year (September) and at different holyday time. Seed collected mostly sold before the onset of rainy season. Most farmers leave anchote tuber in the soil to wait for increase in price. They sell anchote tuber in time they want without a significant reduction in their food qualities often get better price.

Harvesting and seed storage

The crop is harvested 4-5 months after planting. The harvesting time stretches from September to November. Bulk harvesting can be done but the crop is more often harvested as needed. The process involves completely digging out the tuber. The tubers are different in shape and size. Farmers store their produce (whether for consumption, sale) in the production beds (Abera et al., 1995). This is the only traditional storage technique used until the predetermined objective will meet. Some respondent state wild animal damage may happen if other root crop is not available nearby. At times when the dry spell is longer than normal, farmers take out the tubers from the soil and immediately used it. Farmers reported that seed were collected from the mother plant that is why they all prefer to consume or sale what is produced from their small plots of land.

According to Abera et al. (1995), seed collected by most farmers usually dried in the sun and mixed with ash and stored in structure like sacks, sheet of cloth and vessels of clay pot to keep the viability of the seed for next planting time Seed stored mostly affected by mouse that is why most of them willing to use vessels of clay pot with protective covering on opening hole.

Due to difficult in preparing the seed and falling down of premature fruit most farmers prefer to buy from the market.

Use value

Most of the farmers in the study site reported that the crop has been under cultivation since long time. All the respondents underlined that *Coccinia abyssinica* is important to the medicinal, cultural, social and economic life of the households.

It is particularly important in cultural diets mainly between September and November. It is highly valued for its contributions to food security in these periods since other food crops will not be ready for consumption. The primary product of *Coccinia abyssinica* is obviously the tubers and four different type of food is can be prepared from the tuber. This include Lanqaxaa (finely prepared dish of anchote tuber), boiled anchote, Qori anchote (anchote tuber cut in to granulated after boiled and mixed with butter and other ingredient required) in other place called Shisho and wot. The tubers are boiled with or without peeling and eaten during 'Maskale Festival', the popular religious festival in Ethiopia, as one component of the diversified dishes prepared to celebrate holiday (Habtamu, 2011).

Most respondent in Kellem Wollega state the tip vegetative growing part of anchote is delicious dish. But farmer in east and west Wollega has no idea on the consumption as well as ways of preparing dish from tip growing part. They farmers in Kellem Wollega prepare dish similar to as leaf vegetable like kale. The medicinal value and other ingredient in the leaves are not far mentioned and desirable to be studied. They also further explained that it is the most preferred food with porridge and often served to esteemed guests who visit a certain family.

It is now becoming more use of anchote tuber as a family consumption and means of respecting new guest. Most farmers state Guboo (mother plant more than 2 year old) has a medicinal value. People with bone fracture, difficulty in pain/ tiredness/, birth giving women can recover from all illness and difficulties (Okwu and Ukanwa, 2007).

Even farmer in West Wollega, Wara Sayo Kebele reported that anchote can be a means to solve divorce/conflict/ since it can be possible to maintain wishes between husband and wife by keeping the tip benefit of both requirements. Regarding household food security, most farmers reported anchote is also liked by domestic animals (goat, sheep and cattle) are the repeatedly mentioned.

From the observations made in this study it can be argued, however, that it plays a major role in filling gap where there is shortage of food until other crops mature. As such its contribution to food security is considerably high. It has also been observed that there is a wide knowledge gap between young and old respondents about the cultural values. The new generations have limited knowledge in this regard. As a result, the loss of cultural values associated with the use and management of this traditional root crop is considerable.

Gender and effect of distance from residence on cultivation of C. abyssinica

Friis-Hansen (2000) noted that there are clear gender differences in plant genetic resources management at the local scale. The present study also revealed that there was a clear gender difference in management of *Coccinia abyssinica*. Women farmers play a dominant role in the production cycle especially on seed collection, extraction and storage. They also highly participate on management practices to obtain good quality tuber (Abera et al., 1995). In addition to this they perform a range of end-use criteria relating to the household food requirements, e.g. palatability, taste, cooking time and market demand. Male farmer assist them through land preparation after final discussion to where to plough. It was observed that farmers grow *Coccinia abyssinica* both in home garden and agricultural fields. Those farmers grow in the field face transportation problem and wild animal attack on the crop.

They often give as priority crops such as enset, seasonal vegetables, coffee, spices and other species that can be used in daily basis close to the residential places. As compared to other root crop species they often grow *Coccinia abyssinica* in monoculture fields. Only one farmer mentioned intercropping with coffee can be possible in a way it helps in improving soil condition, weed control and increase water percolation.

Threats and loss of local cultivars

The demand for land has been increasing in the study area as the farm population is increasing from time to time. This has resulted in redistribution of land among the household members. Consequently, the proportion of land holdings of farmers has decreased. Similarly, reduction in soil fertility, population growth and eucalyptus coverage over the agricultural fields result scarcity of cultivated land. Due to this, farmer's preference to the type of root crop they grow has been changed to major crop species. Most farmers prefer to grow only the white type of anchote tuber and avoid using the red type. The later type is not easily available now days due to continuous selection pressure by farmers contributed which may later result the loss of cultivars that do not correspond to their preferred characteristics.

Rijal et al (2000) reported that raising awareness is the first step towards promoting conservation and use of local plant genetic resources. This is because it adds value to the local crops and encourages consumers (both rural and urban) to make use of them. Furthermore, farming communities would be encouraged to conserve and make continued use of these crops. Thus, so as to keep *Coccinia abyssinica* as a major source of food for farmers, who grow it, awareness creation has to be carried out by district and zonal, agriculture and rural development offices, and research and conservation institutions.

Morphological characterization and phenotypic diversity

Qualitative Morphological Traits

All landraces follow epigeal germination type in which cotyledon comes above the ground. All of the landraces of *Coccinia abyssinica* investigated had runner vine spreading nature, yellow flower and green sepal color. All the landraces investigated had indeterminate plant growth habit.About 20% of tuber had round root shape while 60% and 20% are ovate and long irregular or curved respectively. All the landraces had single root formation and possessed 90% of absent and 10% of few root cracking. Predominant root skin color is white in all investigated plants while secondary root skin color is 90% white and 10% cream. Sampled plants possessed five numbers of sepals and petals.

Higher variability between landraces was observed in leaf color followed by that of tuber skin color. The dominant colors of the leaves were: deep green (20%), green (25%), and light green (20%). The dominant colors of tuber skin were: cream (35%), cream white (15%), cream with some purple (15%) and purplish red (35%).

Quantitative Morphological Traits

Analysis of variance

The results of analysis of variance for different characters are presented in Tables 7 for RCBD. The analysis of variance showed that the genotypes differed significantly for flower length ($p< 0.01$), flower width ($p<0.01$) and root length (($p<0.01$) and the other parameters are non-significant.

RD= Root diameter, cm; TRY= Total root yield, g/plot.

Genotypic and phenotypic coefficient of variations

Genotypic and phenotypic variances were ranging from 0.0635 for leaf length to 688116 for total root yield and 0.353 for leaf with to 334089 for total root yield, respectively (Table 8). Thus, both high phenotypic and genotypic variance value were noted for total root yield. Low phenotypic and genotypic values were recorded for all other traits. Genotypic and phenotypic coefficients of variation were ranged from 2.87 for leaf length to 47.82 % for flower width and 6.52 % for leaf width to 61.12 % for flower width, respectively. GCV greater than 20% was

Table 8. Phenotypic and genotypic variances, heritability and genetic advance as a percentage of mean for 7 characters of 49 anchote accessions.

Traits	Mean	σ^2g	σ^2p	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
Leaf length (cm)	8.77	0.0635	0.3695	2.87	6.93	17.19	0.2152	2.45
Leaf width (cm)	9.11	0.076	0.353	3.03	6.52	21.53	0.2635	2.89
Flower length (cm)	1.230	0.2274	0.4352	38.77	53.64	52.24	0.7099	57.72
Flower width (cm)	1.491	0.5084	0.8304	47.82	61.12	61.22	1.1492	77.08
Root Length (cm)	9.316	0.4977	1.4761	7.573	13.04	33.72	0.8439	9.059
Root diameter (cm)	18.67	0.6096	7.3167	4.182	14.49	8.33	0.4643	2.49
Total root yield (g/p)	2154	68816	334089	12.179	26.83	20.60	111.31	5.17

σ^2g- Genotypic variance; σ^2p- Phenotypic variance; GCV- Genotypic coefficient of variation; PCV- Phenotypic coefficient of variation, H^2- Heritability; GA- Genetic advance; GAM- Genetic advance as a percentage of mean.

Table 9. Cluster means for the 7 traits of 49 ancote genotypes studied.

Traits	C1 (15)*	C2 (26)	C3 (5)	C4 (3)
Leaf length	8.80	8.88	8.45	8.40
Leaf width	9.10	9.20	8.86	8.92
Flower length	1.36	1.28	0.86	0.95
Flower width	1.62	1.54	1.05	1.33
Root length	9.56	9.26	9.37	8.45
Root diameter	19.99	19.19	17.00	15.42
Total root yield	2707.4	2192.82	1668.58	1181.83

*Figures in parenthesis are the number of genotypes in each cluster.

observed for flower length and flower width, PCV greater than 20 % were recorded for flower length, flower width and total root yield. According to Deshmukh et al. (1986) phenotypic and genotypic coefficient of variation values greater than 20% are considered as high whereas, values less than 10% are low and values between 10 and 20% as medium. Accordingly, high phenotypic coefficients of variation were noted for characters like flower width (61.12 %), flower length (53.64 %) and total root yield (26.83%). Root diameter (14.49%) and root length (13.04%) showed medium phenotypic coefficient of variation.

Other characters showed low phenotypic coefficient of variation which leaf length and leaf width recorded (6.93%) and (6.52%) respectively.

High genotypic coefficients of variation were recorded for the character like flower width (47.82%) and flower length (38.77%) signifying the existence of high genetic variability among anchote landraces. Lowest genotypic coefficient of variation is expressed by leaf width (3.03%), leaf length (2.87%), and root diameter (4.182%). These lower genotypic coefficient of variation values (<10%) traits indicates selection is not effective for such traits because of their narrower genetic variability.

Generally, the current finding revealed that, for all characters, estimates of phenotypic coefficients of variation were higher than genotypic coefficient of variation , indicating the apparent variations in the landraces were not only genotypic but also environmental influence. This observation agrees with the earlier finding of Aina (2007) in cassava. However, phenotypic coefficients of variation and genotypic coefficients of variation in this study were close to one another for most characters, indicating the high contribution of genotypic variance to the expression of these characters than environmental variance and favors greater possibilities of improvement through selection.

Heritability and Genetic Advance

According to Singh (2001) heritability values greater than 80% are very high, values from 60-79% are moderately high, values from 40- 59% are medium and values less than 40% are low. Accordingly, high heritability values was noted for flower width (61.12), while flower length (52.24%) showed medium heritability suggesting such character was least affected by environmental modifications so that, selection based on phenotypic performance would be reliable and low heritability were recorded for other (Table 8). The other characters had low heritability values. The environmental effect constitutes a major portion of the total phenotypic variation indicating management practice is better than selection to improve those traits. Genetic advance as percent of the mean ranged from 2.45 % for leaf length to 77.08 % for flower width.

Within these range, a relatively high genetic advance as percent of the mean was observed for flower length (57.72%) and flower width (77.08 %). Selection based on those traits with a relatively high heritability and GAM values will result in the improvement of performance of genotypes for the traits. The low GAM arises from low estimate of phenotypic variance and heritability.

Estimate of genetic advance is more useful as a selection tool when considered jointly with high genotypic coefficients of variation and heritability values (Johnson et al.,1995). For traits with high heritability value but moderate value of genetic advance needs careful selection for such traits. Similarly, characters with high heritability values but low value of genetic advance may be governed by non-additive gene action or high genotype by environmental interaction and used for development of hybrid varieties.

Lower heritability values and genetic advance for traits implies most of the variations for these traits were environmental and such traits requires management practice than selection to improve the traits performance. A trait with high heritability value but low GCV implies its improvement through early generation selection does not give the desired results. Under low GCV and heritability values direct selection for the trait may not be possible but through indirect selection of other secondary traits.

Cluster analysis of anchote accessions with quantitative traits

Forty Nine anchote landraces were grouped into four different clusters (Table 9 and Figure 4). Clusters I contained (15) cluster II (26), cluster III (5) and cluster IV contained (3). The clustering pattern of the landraces under this study revealed that the landraces collected from the same location were grouped into different clusters. The probable causes for the existence of related genotypes in different regions of origin were attributed to the open movement of anchote seeds from area to area by man as well as wild animals (Abera, 1995); the number of the characters studies were limited in number that might cause less differentiation of the genotypes into regions of origin and others. Anchote landraces collected from different areas such as East Wollega (Wayu Tuka, Guto Gida and Sibu Sire Districts), West Wollega (Gimbi District), Kellem Wollega (Hawa Galan District) were grouped in cluster I and II.

Cluster III and IV contain anchote landraces mainly collected from Kellem, East and West Wollega. The present study indicating narrow genetic base for within clustered landraces while wide genetic bases for between clusters and these is useful for hybridization and simple selection programs.

The cluster means of different characters of 49 landraces of anchote are presented in Table 9. Cluster I was characterized by highest flower length (1.36cm), flower width (1.62 cm), root length (9.56cm), root diameter (19.99cm) and total root yield (2707.4 g/p) and relatively medium leaf length (8.8 cm). Cluster II ranked second for total root yield (2192.82 g/p) and highest in leaf length (8.88cm) and leaf width (9.20cm) and contain large number of landraces collected. Cluster III have the second lowest cluster in number of landraces but possessed medium length of root length (9.37 cm) and leaf length (8.86 cm). For cluster IV the lowest mean value was recorded for all studied quantitative character except medium leaf length.

Each clusters known by their highest and lowest mean value and it is helpful for easy selection of parents with the desired traits for hybridization or selection program.

Similar to the distinct agro-ecological differences, cluster analysis reveals substantial genetic difference. Most of the accessions were grouped in different clusters irrespective of the collection region. This indicates that there was no significant relationship between phenotypic diversity and geographical origin. It could also be an indication that *Coccinia abyssinica* traditionally has been subjected to exchange that was conducted over long distances. Furthermore, the study also revealed that some of the landraces from the same district and currently maintained by producers are grouped in the same cluster. Thus, in order to identify whether these are duplicate landraces, further characterization work including molecular characterization should be carried out for effective conservation as proposed by Huaman (1992). The importance of such work to conservation has also been emphasized by Negash (2001).

The highest inter-cluster distance was between cluster C1 and C4 (1525.57) followed by C1 and C3 (1107.6). The lowest inter-cluster distance was between C3 and C4 (417.97). The others viz. C1 and C2, C2 and C3; and C2 and C4 inter cluster distances were 521.52, 586.09, and 1004.06, respectively.

CONCLUSION AND RECOMMENDATION

Among the major root and tuber crops, anchote is a potential crop produced in western parts of Ethiopia. In

Table 10. Distribution of landraces in to four clusters for 49 anchote landraces.

Cluster number	Number of landraces	Landraces
I	15	Babo 1, Ilfata 4, Haro 2, Migna 6, Darabata 1, Gute 1, Kichi 1, W/Sayo 2, Haro 3, Bikila 1, Jalale 1, Jalale 2, Ilfata 1, Ilfata 4, Kichi 1.
II	26	Babo 2, Jalale 3, W/Sayo 3, Babo 5, Ilfata 2, Jalale 4, Michael 2, Kichi 2, Haro 1, W/ Sayo 4, W/Sayo 5, W/Sayo 6, Tinfa 1, Tinfa 3, Tinfa 5, Tinfa 6, Bikila 2, Darabata 2, Darabata 3, Kichi 3, Migna 1, Migna 2, Migna 3, Migna 4, Migna 5, Michael1.
III	5	Babo 3, Babo 4, Haro 5, Kichi 4, Tinfa 2.
IV	3	Haro 4, Gute 2, W/Sayo 1

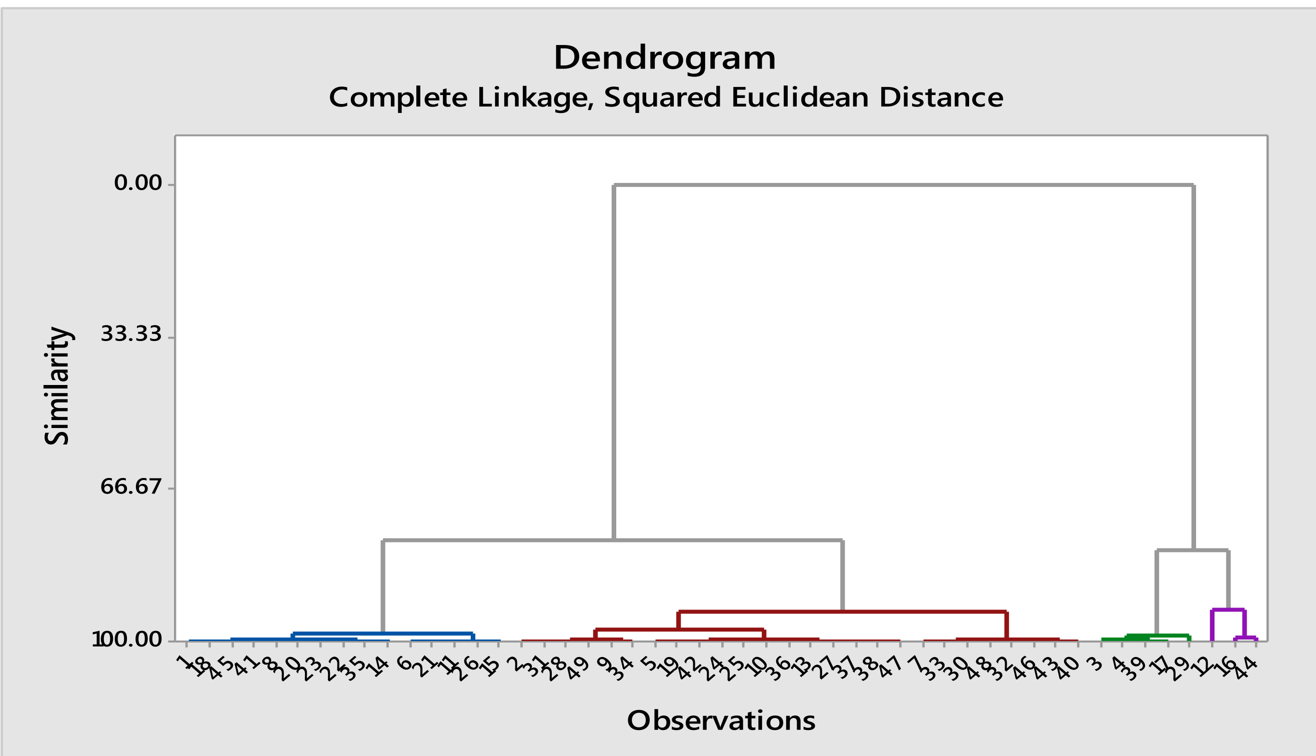


Figure 4. Dendrogram showing grouping of 49 anchote accessions in to 4 clusters based on seven quantitative characters.

addition, to food source it take wide portion in socio-economic, cultural and medicinal value for the farming communities. There is no adequate information on the clonal variations in coccinia abyssinica. The attempts made so far to collect, conserve and characterize coccinia abyssinica growing in different parts of the country, and document the indigenous knowledge related to the use and management of the crop is minimal. Since anchote is basically cultural food and has medicinal value in the study area further inquiry on use and conservation should be carried out. Advancement in technology transfer related to production should be applied. The experiment was carried out with the following objectives. To study the indigenous knowledge on utilization and conservation of anchote; and estimate the diversity of the landraces in the region. Ethnobotanical survey was conducted in 2012 for three months (February, March and April) in western part of Ethiopia. The landraces were also collected during survey. Forty nine anchote landraces were collected and tested for phenotypic variations in 7x7 simple lattice design at Wayu Tuqa District of East Wollega in 2012/013.

Socio-economic status of the households and ecological requirements was found to be an important factor affecting the use, management and conservation of the crop. The difference in level of education had no impact on conservation and use of *Coccinia abyssinica*. It was also observed that the older informants were more knowledgeable than the younger ones, as they knew much more about the different local cultivars and values of use. Ethnobotanical study reveals increased progress in anchote production need different disciplines to work cooperatively.

Estimate of genetic advance is more useful as a selection tool when considered jointly with high genotypic coefficients of variation and heritability values (Johnson et al.,1995). High value for heritability and genetic advance of the characters in current study provide information for the existence of wider genetic diversity among anchote landraces and this offers high chances for improving several traits of the crop through simple selection.

On the other hand, low value for heritability and genetic advance showed environmental effect constitutes a major portion of the total phenotypic variation indicating management practice is better than selection to improve those traits. For traits with high heritability value but moderate value of genetic advance needs careful selection for such traits. Similarly, characters with high heritability values but low value of genetic advance may be governed by non-additive gene action or high genotype by environmental interaction and used for development of hybrid varieties.

In the current finding revealed that, for all characters, estimates of phenotypic coefficients of variation were higher than genotypic coefficient of variation , indicating the apparent variations in the landraces were not only genotypic but also environmental influence.

Most of the accessions were grouped in different clusters irrespective of the collection region. Some of the landraces from the same district and currently maintained by producers are grouped in the same cluster. Further description work is needed. Each clusters known by their highest and lowest mean value and it is helpful for easy selection of parents with the desired traits for hybridization or selection program. Therefore, promising landraces need to be studied further in aspects of breeding objective and way to support others.

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7. APPENDIX

Appendix Table 1. Respondent age, family size, level of education, land holdings, experience in farming and *Coccinia abyssinica* production

Respondent	Age	Family size	Level of education	Land holdings (ha)	Experience in farming (years)			Experience in anchote production (years)		
					<12	12	>12	<12	12	>12
1	28	3	EL	0.5	✓			✓		✓
2	40	7	Dip	2.5			✓			✓
3	45	4	BS	1.0			✓			✓
4	34	8	EL	3.5		✓		✓		
5	38	8	EL	1.0			✓	✓		
6	37	7	SD	10			✓			✓
7	30	4	EL	0.75		✓		✓		
8	47	8	SD	4.0			✓			✓
9	36	9	SD	1.0			✓			✓
10	40	4	SD	4.0			✓			✓
11	56	10	SD	3.5			✓			✓
12	32	5	Dip	1.0	✓			✓		
13	39	5	EL	0.125	✓			✓		
14	41	6	EL	0.5	✓			✓		

Appendix Table 2 cont.

15	**48**	**8**	**EL**	**3.0**			✓			✓
16	32	5	BS	0.5			✓	✓		
17	27	7	EL	6.0			✓			✓
18	21	3	SD	0.5	✓			✓		
19	35	8	EL	4.0			✓			✓
20	52	4	BS	1.0			✓			✓
21	35	7	EL	2.5			✓			✓
22	45	6	EL	4.0			✓			✓
23	29	5	EL	1.0			✓			✓
24	38	7	EL	2.0			✓			✓
25	35	6	SD	0.867			✓			✓
26	65	12	EL	1.5			✓			✓
27	38	7	EL	0.5			✓			✓
28	45	9	SD	1.25			✓			✓
29	50	8	EL	0.16			✓			
30	65	4	BS	0.16			✓	✓		
31	65	7	EL	2.0			✓			✓
32	40	7	BS	1.0			✓	✓		
33	65	8	EL	1.0			✓			✓
34	40	6	EL	0.5			✓			✓
35	25	5	EL	1.25	✓			✓		
36	38	6	EL	1.0			✓			✓
37	45	7	El	5.0			✓			✓
38	45	7	El	0.5			✓	✓		
39	60	4	EL	1.25			✓			✓
40	50	6	EL	0.75			✓	✓		
41	35	5	EL	0.5			✓	✓		
42	40	5	EL	4.0			✓			✓
43	32	9	EL	3.0			✓	✓		
44	35	6	SD	2.0			✓	✓		
45	49	7	EL	2.0			✓	✓		
46	22	2	SD	0.5	✓			✓		
47	60	8	BS	1.0			✓			✓
48	21	1	SD	1.0	✓			✓		
49	43	6	BS	1.0			✓			✓
50	35	8	SD	1.5			✓			✓
51	70	14	EL	10.0			✓			✓
52	22	5	EL	0.0625	✓			✓		
53	28	4	EL	0.5		✓			✓	
54	33	4	SD	1.5		✓			✓	
55	65	1	EL	1.0			✓			✓
56	35	6	SD	0.5			✓			✓
57	45	9	SD	2.0			✓			✓
58	30	6	EL	0.25	✓			✓		
59	25	8	EL	1.0			✓			✓
60	38	7	SD	1.0			✓			✓
61	47	5	BS	1.0			✓			✓

Appendix Table 3 cont.

62	36	7	EL	2.5		✓		✓		
63	40	9	EL	1.5			✓	✓		
64	38	5	SD	0.5			✓			✓
65	33	6	EL	0.75		✓		✓		
66	49	7	SD	4.0			✓			✓
67	55	9	EL	5.0			✓			✓
68	26	6	EL	0.0625	✓			✓		
69	31	4	EL	1.0		✓			✓	
70	35	5	SD	1.5		✓			✓	
71	60	1	EL	1.25			✓			✓
72	31	4	SD	0.5			✓			✓

***Key:** EL- Elementary school; BS- Basic education; SD- High school; Dip- Diploma holder

Appendix Table 2. Mean of seven quantitative traits

Genotypes	LEAF LENGTH	LEAF WDTH	FLOWER LENGTH	FLOWER WIDTH	ROOT LENGTH	ROOT DIAMETER	TOTAL ROOT YIELD
Babo 1	9.24	9.75	1.35	1.68	10.15	19.98	2638.50
Babo 2	8.93	8.82	2.08	1.40	9.55	17.93	2059.00
Babo 3	8.37	8.96	1.00	1.22	9.55	17.05	1554.00
Babo 4	8.72	8.98	1.05	0.99	9.63	15.57	1462.00
Babo 5	8.54	9.19	2.00	2.00	9.05	20.50	2217.50
Bikila 1	7.85	7.77	0.45	0.48	7.70	15.68	2569.00
Bikila 2	8.39	8.58	0.33	0.28	8.35	18.45	1927.00
Darbata 1	9.01	9.40	0.30	0.35	10.32	20.40	2721.00
Darabata 2	8.52	8.83	0.40	0.44	9.55	18.30	2155.50
Darabata 3	8.80	9.54	0.91	0.82	8.95	19.15	2332.50
Gute 1	9.72	9.90	1.39	1.80	9.00	20.65	2547.50
Gute 2	8.16	9.09	0.57	0.69	7.20	14.44	836.50
Haro 1	8.47	8.77	0.49	1.06	9.83	18.14	2313.50
Haro 2	8.96	9.22	1.38	1.05	10.53	20.75	2750.50
Harao 3	8.76	9.43	1.71	2.90	11.45	18.65	2489.50
Haro 4	8.72	9.02	1.11	1.52	9.35	16.58	1347.50
Harao 5	8.16	9.02	1.08	1.76	9.73	14.95	1469.50
Ilfata 1	8.64	8.90	1.52	2.07	9.70	17.00	2635.50
Ilfata 2	9.03	9.26	1.70	2.23	8.85	21.08	2221.50
Ilfata 3	8.51	9.01	0.86	0.98	8.60	19.83	2723.00

Appendix Table 2 cont.

Ilfata 4	8.86	9.65	1.71	1.61	9.65	21.83	2578.50
Jalale 1	8.38	8.40	1.45	2.18	10.08	18.95	2695.50
jalale 2	8.78	8.75	1.82	2.45	9.65	21.48	2723.00
Jalale 3	8.47	8.79	2.18	3.05	9.45	18.60	2200.50
Jalale 4	8.68	9.12	1.43	2.27	9.90	19.73	2193.00
Kichi 1	8.89	9.19	1.71	1.64	7.50	21.10	2529.50
Kichi 2	8.23	8.74	0.64	1.06	8.08	21.13	2302.50
Kichi 3	9.08	8.86	0.86	0.65	8.80	17.83	2057.50
Kichi 4	8.24	8.45	0.67	0.73	8.30	18.43	1697.00
Migna 1	9.03	9.33	1.13	1.34	10.75	16.65	1957.50
Migna 2	9.39	9.68	1.33	1.74	9.15	18.16	2060.00
Migna 3	9.64	9.47	0.40	0.39	10.35	16.95	1877.00
Migna 4	8.01	8.34	0.60	0.58	10.35	17.05	1941.50
Migna 5	8.87	9.50	0.68	0.72	9.25	19.53	2099.00
Migna 6	8.39	8.86	1.34	1.03	11.75	18.73	2706.00
Michael 1	8.32	8.64	0.56	1.05	8.15	19.40	2337.00
Michael 2	8.34	8.64	1.79	1.73	8.75	22.30	2296.00
Tinfa 1	9.51	9.59	1.92	2.89	9.40	20.40	2277.50
Tinfa 2	9.18	9.39	0.78	1.03	8.67	17.37	1461.50
Tinfa 3	9.20	9.44	1.18	1.02	7.90	18.48	1852.00
Tinfa 4	9.69	9.86	1.29	1.04	8.05	23.03	2604.50
Tinfa 5	9.70	9.94	1.38	1.20	8.50	18.80	2230.00
Tinfa 6	9.46	9.37	0.67	0.55	8.15	17.78	1904.00
W/Sayao 1	8.33	8.65	1.16	1.77	8.80	14.45	1148.50
W/sayo 2	8.32	8.47	2.13	3.06	9.28	17.82	2634.50
W/Sayo 3	8.71	9.64	2.03	2.83	10.00	17.48	1890.00
W/Sayo 4	8.79	9.49	2.51	3.31	10.47	20.58	2274.50
W/Sayo 5	9.03	9.38	2.11	2.66	10.90	17.75	1973.00
W/Sayo 6	8.92	9.46	1.25	1.88	9.45	18.05	2038.00
Mean	8.77	9.11	1.23	1.49	9.31	18.67	2153.26
CV (%)	6.31	5.77	37.07	38.07	10.62	13.87	23.92

Appendix Table 3. Soil chemical properties of the experimental site

S/No.	Soil chemical properties	Value
1	Electrical conductivity (EC) Ms/cm	0.208
2	PH H_2O 1:2:5	5.440
3	%OM	6.328
4	%TN	0.316
5	CEC (meq/100gm soil)	19.00
6	Available K^+(mg/kg soil)	35.700
7	Exchange able acidity (Al^{3+}+H^+)Meq/100gm soil	0.100
8	K^+(cmol$_c$ Kg/soil	1.290
9	Ca^{2+}(meq/100gmsoil	9.250
10	Mg^{2+}(meq/100gm soil)	5.050

Source: - Soil chemical properties of the research site, May 2012