International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Cassava (*Manihot esculenta* Crantz) Production and Field Management in Ethiopia

Adera Sisay Wassie

Department of Plant Science, College of Agriculture, Wolaita Sodo University, Ethiopia, P.O.Box:138

Abstract: ***Cassava (Manihot esculenta Crantz) is a perennial woody shrub with an edible root, which grows in tropical and subtropical areas of the world. It is believed to have been originated in north-eastern and central Brazil and introduced into Africa in the Congo basin by the Portuguese around 1558.Then, it introduced to drought prone areas of southern part of Ethiopia primarily to fill food gap. Cassava is the fourth most important crop for farmers in tropics after rice, wheat and sugar, consumed by up to a billion people globally. It accounts for about 30% of all staple foods produced in sub-Saharan Africa. However, cassava production in Ethiopia is limited to some areas of southern regions. In these areas, farmers usually grow cassava in small irregular scattered plots either sole or intercropped mainly with taro, "enset", maize, haricot beans or sweet potato. This indicates the crop is negligible in Ethiopia and has not been the focus of agriculture policy and extension service despite its ability to provide yield in marginalized land and serving as a buffer against drought shocks. Beside, cassava is becoming increasingly important food crop in declining soil fertility and worsening drought situations. Therefore, this review is intended to show existing field management practices and extension service gap that need to be filled in order to promote the potential of this crop for food security.***

Keywords: Cassava production, field management, Ethiopia

1. General Description about Cassava

1.1. Origin, Distribution and Botanical Description

The origin of cassava is South America and introduced to the African continent by Portuguese traders, first into West Africa via the Gulf of Benin and the Congo River during the second half of the 16th century; then after distributed into East Africa towards the end of the 18th century (Christopher, 2008). But specifically it introduced to Ethiopia by the British and currently cultivating in south west, and western part since its introduction (Amsalu, 2003). In these areas, farmers usually grow cassava in small irregular scattered plots either sole or inter cropped mainly with taro, enset, maize, haricot bean and sweet potato. The average total coverage and production of cassava per annum in southern region was 4942 ha and 53,036.20 tones, respectively (SNNPRS BoA, 2002).

Cassava is a dicotyledonous plant of the family Euphorbiacea and the genus Manihot. The Manihot has about 100 species, among which Manihot esculenta is the only one commercially cultivated. It is widely grown in the tropics and subtropics for its tuberous starch-filled roots (Benesi, 2005).

Cassava is a perennial herbaceous shrub up to 4 m high. Also the tuber is long and tapered with a firm homogenous flash encased in detachable rind, about 1mm thick, rough and brown on the outside. Commercial varieties can be 5 to 10 cm in diameter at the top, and round 15 cm to 30 cm long. Also woody cordon runs along the roots axis. Meantime the flash can be white or yellowish (Burns and Devendra, 2010). The mature cassava plant (12 months old) contains 6% leaves, 44% stem and 50% tuber. The leaves are fingerlike, deeply indented, palmate 3-7 lobed, attached to a slender stem by long petioles. The flowers are small, greenish-yellow occurring in panicles. The seeds are formed in capsules, which explode upon ripening to distribute their load (Aye, 2010).

1.2. Agro-ecologic Requirement

Cassava is cultivated throughout the lowland tropics, typically between 300 N and 300 S of the equator, in areas where the annual mean temperature range 25-30 ^{0}C (MoARD, 2011). Also it grow poorly in cold climates and growth ceases at temperatures below 10 ^{0}C (Alve, 2010). The plant grows best when rainfall is 1000-1500 mm per year, but it can also survive when rainfall is as low as 500 mm per year (El- Sharkawy, 2003). When moisture availability is low, cassava plant ceases growth and sheds some of its older leaves. However, it resumes growth and produces new leaves when moisture becomes available. Cassava grows best on light, sandy loam soil of medium fertility with good drainage (MoARD, 2011). On clay or poorly drained soil, growth is generally poor.

Cassava tuberous root formation is controlled by photoperiod. Under short day conditions tuber formation occurs readily, but at a day length of 12 hours its growth is delayed and yield reduced (Williams and Gazhali, 1969).

The crop is a perennial crop, the storage roots can be harvested from 6 to 24 months after planting, depending on cultivar and the growing conditions. In the humid lowland tropics the roots can be harvested after 6 to 7 months. In regions with prolonged periods of drought or cold, farmers usually harvest cassava after 18 to 24 months. Moreover, the roots can be left in the ground without harvesting for a long period of time, making it a very useful (El-Sharkawy, 1993).

1.3. General Classification of Cassava

The cultivar of the Cassava crop is generally classified as bitter and sweet cultivars. Meantime cassava varieties are categorized based on the amount of cyanide content. For instance cultivars can produce as little as 20 milligrams of cyanide (CN) per kilogram of fresh roots; whereas bitter ones may produce more than 50 times more cyanide content (Dufour and Wilson, 2002).

In similar way Mkumbira *et al.* (2003), suggested that cassava cultivars are generally classified based on taste and concentration of total cyanide. The sweet cultivars are those with less than 100 ppm total cyanide fresh weight. Cultivars based on mg CN- per kilogram edible fresh weight can be also classified as innocuous (<50 ppm), moderately poisonous (50 – 100 ppm) and dangerously poisonous (>100 ppm) (Bourdoux *et al.*, 1982).

1.4. Importance of Cassava

Cassava is a major staple tuber crop in many tropical and subtropical developing countries, especially in West Africa. Grown in more than 90 countries, it ranks as the 4th supplier of energy after rice, sugar, and corn/maize (Heuberger, 2005). Cassava is a nutritionally strategic famine crop and could support food security in areas of low rainfall. Mature tubers are able to survive for a long time without water and still retain nutritional value. Also tubers are a valuable source of calories, whereas cassava leaves are a valuable source of protein, minerals, and vitamins (Dufour and Wilson, 2002).

Cassava tubers contain 80% to 90% carbohydrate on a dry weight (DW) basis of which 80% is starch (Gil and Buitrago, 2006) with small quantities of sucrose, glucose, fructose, and maltose (Tewe and Lutaladio, 2004). Additionally cassava leaves are rich in iron, zinc, manganese, magnesium, and calcium; vitamins B1, B2, and C; and carotenoids (Wobeto *et al.*, 2006). However, cassava tubers and leaves have a huge deficit of methionine and cysteine, and nutrients are not well allocated in the plant. Tubers have very low quantities of lipids, minerals, proteins, and vitamins compared to the leaves. Hence, a cassava meal can provide complete dietary needs in terms of calories, protein, minerals, and vitamins only if cassava leaves are added to tuber meal along with another source of essential sulfur-containing amino acid-rich protein. All of these benefits made a crop to be preferred as food and fodder, and cash crop (Gil and Buitrago, 2002).

1.4.1. Nutritional value

The nutritional benefit of the cassava crop is not only dependent on the root part, but the whole biomass of the crop is composed with 6 percent leaves, 44 percent stem and 50 percent storage roots contribute for nutrition. Especially the roots and leaves of the plant are the two nutritionally valuable parts, which offer potential as a feed source (Tewe, 2004). Meantime the peels of cassava can represent 5 to 15% of the root (Aro, 2008). Therefore, at the time of discussing about the nutritional benefit, it must be focus on each components of the crop.

1.4.1. 1. Cassava root

The cassava plant has 5 to 20 starchy elongated tubers and may be 20-80 cm long and 5-10 cm in diameter (Kuiper *et al.*, 2007). The root is rich source of carbohydrate. Its composition shows 60-65% moisture, 20-31% carbohydrate, 0.2-0.6% ether extracts, 1-2% crude protein and a comparatively low content of vitamins and minerals. However, the roots are rich in calcium and vitamin C and contain a nutritionally significant quantity of thiamine, riboflavin, nicotinic acid, sucrose, maltose, glucose and fructose in limited levels (Tewe, 2004).

1.4.1. 2. Cassava leaf

The foliage of the cassava has significant contribution as fodder in our country. Cassava leaves can be harvested within 4 to 5 months of planting without adversely affecting root production and yielding up to 10 tons of dry foliage per hectare (Khajarern and Khajarern, 1992).

The nutritional value of the cassava leaf showed different results. For instance, Nnaji *et al.* (2010) conducted research to screen leaf meals and found that cassava leaf meal had the highest crude protein content (26.3%). Similarly, Seng and Rodriguez (2001) reported, crude protein (CP) content of cassava leaves is in the range of 21–24 % of dry matter in the foliage.

Generally the leaves contained crude protein 348.0 g/kg DM, crude fiber 121.0 g/kg DM, ash 69.0 g/kg DM and gross energy 47.0 MJ/kg (Fasuyi, 2005). Also cassava leaves are good sources of minerals and vitamins like calcium, magnesium, iron, manganese, zinc, ascorbic acid, vitamin A, and riboflavin. But considerable losses of vitamins, particularly of ascorbic acid, occur during processing (Borin, 2005).

1.4.1.3. Cassava peel and fiber

The processing of cassava tubers yields like, peels and fiber are valuable livestock feeds (Aro, 2008). According to the previous researcher, cassava peel was obtained after the tuber have been water-cleansed and peeled off mechanically. The solid fibrous residue (up to 17% of the tuber) that remained after the flour or starch content has been extracted; it contains high amounts of cyanogenic glycosides and has higher protein content than other tuber parts (Tewe, 2004).

Generally cassava is mainly cultivated in the tropics for its starchy tuberous root. The root is rich in energy and low in fiber, protein, ash and ether extract. The fresh edible fleshy portion of the tuber contains 60-65% water, 30-35% carbohydrate, 1-2% protein, 0-0.2% fat, 1-2% fiber and 1-1.5% minerals (Nassar and Ortiz, 2007). According to Garcia and Dale (1999), the tuber of cassava is a rich source of energy with high starch content of about 60-70%.

The tuber had a higher content of metabolizable energy (2990 kcal/kg) and low level of protein of 2.2-2.5% (Garcia and Dale, 1999). Meantime the tuber is composed of fiber 3.0-3.7%, ash 3.1-4.1%, lysine 0.08-0.09%, methionine 0.03%, methionine + cystine 0.04-0.06%, calcium 0.20%, phosphorous 0.09- 0.15%, sodium 0.01-0.03%, potassium 0.40-0.73% (Garcia and Dale, 1999). Nweke *et al.*, (2002) also reported 36 mg/100 g and 0.7 mg/100 g of vitamin C and iron content of cassava root, respectively. But cassava is deficient in carotene and other coloring carotenoids (Cock, 1985; Nweke *et al.*, 2002).

1.4.2. Income generation

Cassava is widely cultivated in many parts of the world to filling the food needs in moisture stress area. Especially it's rich in carbohydrate but low in protein storage. Hence, tubers serve as important energy source and are a staple foodstuff for more than 500 million people throughout tropical Africa, Latin America and parts of Asia (Yeoh *et al.*, 1998).

The importance of cassava for food security and income generation in resource poor areas is remarkable. For instance, cassava played significant role to poverty reduction in China (Huang *et al.*, 2006). Also cassava is in Thailand's second most important food crop and third largest agricultural export crop (FAOSTAT, 2009). Uniquely in Thailand; cassava is grown as an industrial rather than a staple crop. The Thai cassava industry is very export oriented, with up to two-third of total production exported in 2008 (TTSA, 2009). It consists of two value chains: the dried cassava and the starch value chain from the sale they can generate a large household income (Tijaja, 2010).

Hence, stating of cassava production cue for poverty reduction, through increasing agricultural production, increasing income, and reducing of food price. This helps very poor households meet the basic needs associated with improvements in household overall economic welfare, protection against risks of crop loss due to erratic, unreliable or insufficient rainwater supplies, promotion of greater use of yield enhancing farm inputs and creation of additional employment, which together, enable people to move out of the poverty cycle (Lipton *et al.*, 2004).

In Africa over two-third of the total production of cassava is consumed in various forms by human beings. Though, the majority of cassava produced (88%) is used for human food and some is exported to Europe. (Westby, 2002); Cassava provides about 45% of all calories consumed in Africa (Nweke *et al.*, 2006) and about 70% of the daily calories intake of over 50 million Nigerians. Cassava has advantage over other crops when compared; it generates income for the largest numbering households (FAO, 2002).

According to Nweke *et al.* (2002) cassava plays significant role in African development through serving as famine reserve crop, staple food, cash crop and raw material for feed and chemical industries. Cassava is also one of the richest fermentable substances for the production of crude protein. These benefits enable the crop to fetch maximum economic income (Westby, 2002).

Generally cassava serves as cash crop, because alcohol/ ethanol, starch and other starches ingredients such as molasses processed by the crop. Similarly cassava starch has thickening and binding qualities. It is used as binder and thickener in convenience foods including bouillon cubes and baby foods. In the textile industry, cassava starch is considered preferable to corn starch as the latter gives a dull finish and may change the color (Grace, 1977).

2. Cassava Production in Ethiopia

2.1. Production Status

The importance of cassava is both for food of human and fodder of livestock. This is true in the most developing countries like Ethiopia. However, Tewe (2004) indicated that cassava usage as feed in Ethiopia is not significant. Cassava was introduced in Ethiopia around 1960's and currently the plant is being distributed throughout the country as a tool to tackle food insecurity (Aweke *et al.*, 2012).

But the area distribution is not as such appreciable. It produced for longer period of time in southern part of the country to filling the critical periods of household food insecurity. Nowadays, it is also being promoted in food insecure northern areas of Ethiopia (Aweke *et al.*, 2012). However, processing methods, storage experience and modes of consumption in Ethiopia are not yet customized unlike other African countries (FAO, 2012).

Even cassava potential production areas farmers usually grow cassava in small irregular scattered plots. The production system is either sole or inter cropped mainly with taro, enset, maize, haricot bean and sweet potato (SNNPRS BoA, 2002). Among potential production areas in southern Ethiopia, the contribution of Wolaita zone is noticeable. The crop was first introduced and dominantly grown in Wolaita which is known as "Mita Boyiya" Yenchet Boye meaning tree yam (Eyasu, 2010). In 2010, annual cassava production yield and productivity estimates of Wolaita Zone was 22, 216.7 tone and 21.7 tone/ha, respectively. However, the figure of maize in the same season in the Zone was 867.45 tone and 7 tone/ha, respectively (Bizuneh *et al.*, 2011). This figure indicates that the production and productivity of cassava was by far higher than maize. This means cassava has a great potential in Wolaita Zone both as source of food and feed as compared to maize. These indicates, if the crop is adopted the remaining part of the country, our food need will be very soon.

2.2. Production Constraints

The numerous factors are challenge in crop production, and the constraints are categorized under natural and socio-economic factors. The natural factor which is challenge for crop production classified as physical/environmental and biological factors. The improved production in cassava mainly achieved through proper agronomic practices and most production constraints are related with poor management practice. Hence, the determinants of cassava productions are included in land and water related management factors like, water availability and quality, fertility status and timing of water application (Tsedeke *et al.*, 2002). Beside this, the following cumulative factors effects are big challenge for productivity:-

Climatic factors:- The major climatic factors which are constraint for cassava production is related with rainfall, temperature, sunshine or light, frost, drought and other related.

The effects of climate change on cassava production determine the quality, quantity and productivity of cassava which, leads to food security for a given household (Ayoade, 2012). Therefore, it must be done on adaptable variety selection and varietal development to mitigate problems: like agro-ecological factors, rain fall, temperature, humidity and wind, which are related with climate changes (Ntawuruhunga and Dixon, 2010).

Agronomic factors: - The cassava production determinant agronomic factors directly linked with quality, quantity and timing of input application. Also the cutting sizes, quality and planting position are fundamental importance for obtaining greater yields (Toro *et al.*, 1984). The quality of cassava stalks depends on stem age, thickness, number of nodes per stalk and size. Controlling of these factors is essential for sprouting of vigorous plants and maximizing tuber yield (Lazo-Casteleanos, 1985). Generally land preparation, time of planting and weeding practice is categorized under main constraints for cassava production (Garcia and Rodriguez, 1983).

Pests and Diseases: - The two current viral pests and diseases, which are spread by a whitefly vector (Bemisia tabaci) and the movement of planting materials, now pose a severe threat to cassava culture in many areas in the cassava producing regions. According to researchers at the National Agricultural Research Organisation (NARO), Uganda, there has been a significant increase in the density of whitefly populations in recent years. Due to the radical increment in the number of population, it has become a crop pest causing damage to cassava leaves as well as being a disease vector. These have the same effect on different cassava producing countries (FAO, 2010).

Socio-economic factors: - These factors interconnected with farmers' health, education, experience in farming, family size, occupancy terms, gender issues, availability of credit and marital status. Also the farm management factors (i.e. adoption of modern production technologies, farm planning and management practices, etc.) are also production constraints (Naiken, 2002).

3. Major Agronomic Practices for Cassava Production

Cassava is the most important vegetative propagated food crop and the second most important food staple in terms of calories per capita for more than 500 million people in Africa (Nweke *et al.*, 2002). It provides 50% of the calorie requirement of over 200 million people in sub-Saharan Africa (Osiru *et al.*, 1996). The main nutritional component of cassava is carbohydrate, which is derived from starch accumulated in the tuberous storage roots. This is processed into various food forms. The tender shoots and leaves are eaten as vegetables in many parts of Africa and it provides protein with a high content of lysine, minerals and vitamins (7 g protein per 100 g edible portion) (Benesi, 2005). The seed is processed for oil and seed cake, used for formulating feed for livestock. The seed is also processed into a medicinal product to cure skin diseases (Popoola and Yangomodou 2006).

Sayre *etal.*, (2011) reported that an adult's daily recommended allowance for energy can be provided by cassava by about 80%, while providing an average of 10-20% for vitamin A, iron and zinc. An exceedingly increasing current price of tef in Ethiopia could be a good opportunity to utilize cassava flour as a supplement to tef.

In the present situation of our country where by the price of cereals increased from five to six folds higher than their last year's price. Cassava producing farmers at Gofa and Woliata areas of the southern region consider cassava as an important source of cash for household. So that it can be sold at a reasonable price and its dried chips are suitably mixed with tef, wheat and sorghum to prepare injera (Yared, 2012). Even though the cassava has maximum productivity and nutritional values, the production in Ethiopia is limited in few specific areas. Even cassava potential production areas farmers usually grow cassava in small irregular scattered plots (SNNPRS BoA, 2002). Therefore working on to adopting other regions of Ethiopia and to maximizing the productivity through improved agronomic practices is not assignment for tomorrow.

3.1. Land Preparation

The most important and the first thing to have better yield in any crop is land preparation. The land preparation involves plowing, harrowing, and leveling the ground to make it suitable for crop establishment. When the first rains have softened the ground, farmers loosen the soil in individual planting holes with a hoe or sharp spade, and plant cassava cuttings. For continuously grown cassava, as soon as one cassava crop has been taken out, the land can be tilled and preparations can be started for the next cropping season (Osiru *et al.*, 1996).

Since soil physical and chemical conditions influence the growth of cassava plants and their root yields, proper tillage is required for sustainable cassava production. Therefore, appropriate land preparation is one of the most important agronomic practices for successful cultivation. Various different methods of land preparation had a highly significant effect on the fresh root yield of cassava but not on the root starch content (Jongruyasuk *et al.*, 2007). However, timely land preparation is also needed and the best time of tillage is required to achieve its maximum benefits. Soil should be cultivated when moist, but not too wet or too dry. Cultivation of very dry or very wet soil can break up the soil structure, leading to poor drainage and aeration, surface crusting, and greater susceptibility to erosion. The land should be adequately prepared prior to planting of the cassava stakes (Dufour and Wilson, 2002).

Good land preparation involves the removal or incorporation of crop residues and any weeds or other vegetation that may compete with the cassava crop, either manually or through mechanical tillage. Tillage aims to turn over and loosen the topsoil and the compacted soil below, in order to achieve a good tilth for forming the mounds or ridges, and provides a uniform medium where storage root growth is not obstructed (Nweke *et al.*, 2002).

After initial land preparation, soil samples can be collected for analysis, especially in the case of commercial large-scale cassava plantations. The soil analysis will determine the need for any soil amendments that must be incorporated before planting. The following land preparation should aim to incorporate any soil amendments, manure or chemical fertilizers that need to be applied before planting; and, depending on the location, may also incorporate residues remaining from the previous crop, which contribute to the buildup of soil organic matter and provides nutrients for the following crop (El-Sharkawy, 2003**)**.

Generally the good land preparation can be achieved by thorough plowing and harrowing done a number of times, depending on soil conditions. It should incorporate all crop residues and weeds and create a soil structure that allows the cassava stakes to emerge rapidly and uniformly, and provide the young plants ready access to the vital resources of nutrients, water and oxygen. Also zero tillage followed by direct planting in small holes reduced yields and slightly increased erosion (Osiru *et al.*, 1996).

3.2. Time of Planting and Harvest

The best time of planting would be after the on-set of rains (pre-monsoon) under rainfed conditions, but the crop can be planted year-round under irrigated conditions. Many researchers found that cassava yields are seriously reduced if either low rainfall or low temperatures are limiting growth during the period of 3-5 months after planting. Meantime the best time to plant cassava not only depends on the climatic conditions at time of planting but also on climatic as well as marketing conditions at time of the expected harvest (Howeler, 2001).

3.2.1. Time of planting for tropical regions

In tropical regions with distinct dry and wet seasons and a mono-modal rainfall distribution, the best time to plant is early in the wet season. Because enough soil moisture allows for adequate germination of planted stakes. For instance in Thailand similar with Ethiopia, the right time of planting in May, at the starting of the first rainy season (Aye, 2010). In those areas with a bimodal rainfall distribution, such as in Kerala, India, planting at the start of the second rainy season, i.e. in August or September, will also result in high yields (George *et al*., 2001).

3.2.2. Time of planting for subtropical regions

Cassava is also grown in subtropical regions which, are characterized by cold and dry winters (with occasional frost at higher latitudes) and hot and wet summers with relatively long daylight. Because cassava yields is little affected by date of planting when cassava is harvested at12 months. But the yields markedly declined when planted in late summer (Aug-Nov) and harvested after 8 months in April to July. Whereas, harvested at 8 month after planting, both root yields and starch content will be minimized (Howeler, 2001). Therefore, equal focus must be given for the time harvesting when planting to planting of cassava.

Generally highest yields are obtained when cassava is planted as early as possible in the wet season, while starch contents are highest when plants are harvested in the middle of the dry season. At planting time there should be enough soil moisture to get at least 80-90% germination, while soils should not be so wet as to prevent adequate aeration and root formation (Popoola and Yangomodou 2006). Hence, cassava should be planted as early as possible because early planted stakes sprout and establish well, and receive sufficient moisture during the growth period. In areas where very low temperatures are possible, the cuttings are planted as soon as danger of frost has past. Therefore, delayed planting may lead to reduced yield of cassava (Benesi, 2005).

3.2.3. Planting Methods

The method of planting varies place to place. Based on rainfall distribution pattern and soil type cassava producing farmers are use horizontal, inclined (slanted at 45^{o} to 60º) and vertical (at 90^{o}) planting positions (Toro *et al.*, 1984).

Horizontal planting method: The entire stake is placed horizontally and buried at a depth of 5 to 20 cm (usually about 10 cm) in the ground. This method produces shallower roots than slanted and vertical planting.

Inclined planting method: The stake is placed 2/3 of its length in the ground and at an angle ranging from about 45º to 60º.

Vertical planting method: The stake is pushed vertically and about 1/2 of its length into the ground. This enable to stake sprouts quicker than with the other two methods, but it produces deeper roots than the horizontal or inclined planting methods. Whereas, soil is loose and friable, stakes can be planted vertically or slanted method by pushing the lower part of the stake about 5-10 cm into the soil. Stakes can also be planted horizontally at 5-7 cm depth by digging individual holes, or by making a long furrow, laying the stakes down and covering with soil. Planting vertically or slanted generally produces higher yields than planting horizontally, especially during periods of drought. Meantime, vertical planting method is suitable in sandy soils and under erratic rainfall (Howeler, 2001). Whereas, in sandy clay loam soils in planting vertically or inclined produced significantly higher root yields than planting horizontally. This could be true when stakes is planted in the early dry season (November), when horizontal planting resulted in a significantly lower rate of germination (Tongglum *et al.*, 2001).With vertical planting callus formation around the cut surface developed more uniformly, which resulted in the uniform distribution of roots around the base of the cassava plant (Ravindran, 2006).

Generally the orientation of the cuttings influences several growth characteristics of the plant. Moreover, cuttings from different sections of the stem have a varying influence on subsequent growth and yield of cassava (Garcia and Rodriguez, 1983). Planting material should be prepared for any planting method from long, moderately thick stalk which, taken from the basal part of the plant suggestible for higher root yield (Lazo-Casteleanos, 1985). Planting stakes horizontally is common in heavy clay soils or with zero- or minimum-tillage methods of land preparation. When the soil is well prepared and friable, planting vertically or slanted is faster than planting horizontally, but care should be taken that the eyes or buds on the stakes face upward; with horizontal planting this is of no concern (Sopheap *et al.*, 2010).

3.4. Plant Spacing

The plant spacing depends mainly on variety, climatic conditions, soil fertility and cultural practices. However, there is no universal recommendation for the plant spacing of cassava. Branching and vigorous cassava varieties will need wider spacing compared to less branching and less vigorous varieties. Also cassava grown on very fertile soils will need wider spacing compared to cassava grown on infertile soils (Howeler, 2001).

Generally in case of Ethiopia the cuttings should be planted on ridge at a spacing of 1mx1m and no fertilization is required (EARO, 2004).

3.5. Weed Control

Weeds can significantly affect crop yields by shading and smothering the crop as well as by competing for plant nutrients and water. The competitiveness of weeds varies both between species and at different times of the year. Some crops are also more affected by weed competition than others; whereas the yield of cassava can markedly reduce by weed competition. It has been reported that yields may be reduced 25-50% if weeds are not controlled, particularly at the early growth stage (Tirawatsakul, 1983).

However, the negative effect of weeds on cassava yields depends on the weed population in any particular location, on the cassava variety and plant population used, and on the type of weed control. For instance, traditionally one to two hand weeding is used (Benesi, 2005).

Higher crop densities will compensate for the effects of weed competition when the weed control system is not sufficiently intensive. By keeping the crop totally weed-free, especially during the early growth stages, fewer plants per hectare were needed to achieve maximum production. If weeds are not controlled at all, yields will be extremely low; nevertheless, yields increased as plant density increased (Tongglum *et al*., 1992).

3.6. Harvesting Methods

Traditionally, cassava is harvested by cutting off the top growth about 20 cm from the ground and then pulling on the remaining stump of the stem until the roots come out of the ground. In heavy or very dry soils this may require some digging around the roots with a spade, shovel, or hoe. Most of Ethiopian farmers used <<Zapi>> which is a metal tool attached to a wooden stick used easily pull the roots out of the ground (Aweke *etal.,* 2012).

4. Processing Techniques and Reduction of Cyanide Levels in Cassava

Cassava plays a significant role as a food security crop in water stress areas of the world; because, it has a number of physiological adaptations that allow it to tolerate extended periods of water stress (Alves, 2002). This made cassava tuber more preferable for human food and animal feed in large number of different products. There are various processing methods used to produce different food products, depending on locally available processing resources, local customs and preferences (Hillocks, 2002). Cassava tubers are traditionally processed by a wide range of methods, which reduce its toxicity, improve palatability, increase shelf-life, facilitate transportation and convert the perishable fresh tuber in to stable products (Nweke, 1994). These methods consist of different combinations of peeling, chopping, grating, soaking, drying, boiling and fermenting. While all these methods reduce the cyanide level, the reported loss in cyanide content differs considerably due to analytical methods, the combination of methods and extent to which the processes are carried out (Cooke and Maduagwu, 1978).

4.1. Boiling

Boiling is used in the processing of cassava roots in almost all countries where cassava is used as food. Boiling is not an efficient method for cyanide removal. The inefficiency of this processing method is due to the high temperature. At $100^{O}C$ linamarase, heat-labile, β-glucosides, is denatured and linamarin cannot then be hydrolyzed into cyanohydrins. According to Cooke and Maduagwa, (1978) bound glucosides are reduced to 45 % to 50 % after 25 min boiling. Free cyanide and cyanohydrine in boiled cassava tubers are found at very low concentrations. Cyanohydrins and free cyanides are volatilized during boiling, which reduced the content in boiled cassava tuber (Oke, 1994).

4.2. Drying

Drying is the simplest method of processing. It reduces moisture, volume and cyanide content of tuber, thereby prolonging product shelf life. This process is practiced primarily areas in with less water supply. Total cyanide content of cassava chips could be decreased by only 10-30 percent through fast air drying, however, produces grater loss of cyanide. Sun-drying the peeled cut pices of tuber gave a HCN concentration lower than 10mg/100g and loss was more effective than oven drying (Mahungu *et al.*, 1987). Generally drying is not an efficient means of detoxification especially for cassava varieties with high initial cyanogenic glucoside content. However, sun-dried products are the most common type of cassava processed products in Africa (Westby, 2002).

4.3. Fermentation

Fermentation by lactic acid bacteria is processing method commonly used in Africa. This is done with grated or soaked cassava tubers and results in a decrease in pH value. The fermentation of grated cassava tuber is efficient at removing cyanogenic glucosides.

The process enables to remove 75 % of linamarin within 3 hour of grating (Westby and Choo, 1994). In addition to other cassava processing, microorganisms play a great role in cyanogens reduction and are responsible for linamarin hydrolysis (Vasconcelos *et al*., 1990). In most case, Lactobacillus plantarum plays an important role in the fermenting process, and the grated cassava tubers are allowed to ferment in sacks for 3-7 days, which encourages lactic acid fermentation. The pH after 3 days decreases from 6 to 4 and the fermentation is dominated by lactic acid bacteria (Westby and Twiddy, 1992). Fermentation also prevents the tubers from rapid spoilage after harvest since cassava tubers are more perishable than other tuber crops, such as yam and sweet potato (Poulter, 1995). The process of fermentation conducted by soaking of cassava tubers under water, followed by sun drying and finally cyanogens free product achieved (Westby, 2002, Cardoso *et al.*, 2005).

4.4. Dewatering the Fermented Cassava

During or after fermentation of tubers for gari production, the grated pulp is put in sacks (jute or polypropylene) on which stones are placed or jacked-wood plat forms are set to drain or press off the excess liquid from the pulp. Then the cassava pulp is taken out and heaped up on the rocks in the sun for further fermentation and draining of the excess moisture. In this way, much of the cyanide is effectively lost with the liquid. Since cassava tuber contains about 61% water coupled with the solubility of its cyanogenic glucoside component, the dehydration (dewatering) process results in a substantial reduction in the content of this toxin in the pressed pulp (Tefera, 2013).

4.5. Peeling

Many methods of processing cassava tuber commence with the peeling of the tubers. Generally the cassava peel contains higher cyanide content than the pulp. Removal of peels therefore reduces 50 % the cyanogenic glucoside content considerably. Peeling, therefore, can be an effective way to reduce the cyanide content (Zemach, 2013).

4.6. Grating

This process takes place after peeling and is sometime applied to whole tubers. Grating of the whole tuber ensures the even distribution of the cyanide in the product, and also make the nutrients contained in the pulp available for use. The fermentation of grated cassava tuber is efficient at removing cyanogenic glucosides (Westby and Choo, 1994). Grating also obviously, provides a grater surface area for fermentation to take place.

4.7. Soaking

Soaking of cassava root normally preceded by cooking or fermentation; it provides a suitable larger medium for fermentation and allows for grater extraction of the soluble cyanide into the soaking water. The process remove about 20% of the cyanide in fresh root chips after 4 hours, although bound cyanide is only negligibly reduced. Bound cyanide begins to decrease only after the onset of fermentation (Cooke and Maduagwa, 1997). A very significant reduction in total cyanide achieved if the soaking water is routinely changed over a period of 3-4 days. The fermentation of soaked tubers in water is much more effective than that of grated tubers in terms of cyanogens reduction. Indeed, more than 90% of total cyanogen removed after 3 day of fermentation and about one-third of initial linamarin is found in the water (Westby and Choo, 1994).

4.8. Steaming, Baking, and Frying

The loss of cyanide resulting from steaming, baking or frying is small due to processing temperature of over 100 ^{O}C and to the stability of linamarn in neutral or weak acid conditions (Nambisan and Sundaresan., 1985).

Generally cassava is processed by various methods to reduce toxicity and improve palatability and storage characteristics. Processing practices vary considerably from region to region, but all seek to reduce the toxic cyanoglucosides to a safe level. The processing techniques for cassava tubers include peeling, boiling, steaming, roasting, fermenting, and sun drying. Sun drying is the most popular practice to reduce cyanide in many tropical countries. Because the time of linamarase contact with the glucosides is higher with sun drying. This method eliminates the cyanide more effectively than oven drying. Thinner chips may retain more cyanide than thicker chips because the latter dry more slowly. Before sun drying, crushing the tubers to proper size increases the contact surface and can almost totally eliminate cyanide (Khdarern and Kbjarem, 1991).

5. Summery

Cassava (*Manihot esculenta* Crantz) is a dicotyledonous perennial woody shrub with an edible starchy tuber, belonging to the family Euphorbiaceae. It's a perennial crop and native to tropical America with its center of origin in north-eastern and central Brazil, and first introduced into Ethiopia by the British. Potentially cassava growing area farmers of Ethiopia usually grow cassava in small irregular scattered plots either sole or intercropping.

The most important feature of cassava is its adaptability and produce yield in various ecological and agronomic conditions and it often grows where most other crops fail. In Ethiopia, the crop has been found to have an excellent adaptation and performance far greater than the global average tuber yield of 10.5t/ha. So it has high significant contribution to serving as food during inadequate rain.

Internationally there are several thousand varieties of cassava and about 100 related wild species with hydrogen cyanide (HCN) contents of their roots ranging from 1-1550 parts per million (ppm). However, nationally two recently released cassava cultivars named 44/72 NW (Kello) and 44/72 NR (Qule) in the year 2006 known for their high quality yield (tuber yield 36t/ha).

Cassava is cultivated throughout the lowland tropics, typically between 300 N and 300 S of the equator with annual mean annual temperature and rainfall ranges 25-30 ^{0}C and 1000-1500 mm respectively; but it can also survive when rainfall is as low as 500 mm. It grows best on light, sandy loam soil of medium fertility with good drainage.

Cassava is a nutritionally strategic famine crop and tubers are a valuable source of calories, whereas cassava leaves are a valuable source of protein, minerals and vitamins. Its tubers contain 80% to 90% carbohydrate on a dry weight (DW) basis of which 80% is starch with small quantities of sucrose, glucose, fructose, and maltose. Additionally cassava leaves are rich in iron, zinc, manganese, magnesium, and calcium; vitamins B1, B2, and C; and carotenoids. Generally the whole part of the plant has its own nutritional contribution.

The importance of cassava for food security and income generation in resource poor areas is remarkable. Hence, cassava plays significant role in African development through serving as famine reserve crop, staple food, cash crop and raw material for feed and chemical industries.

The improved production in cassava mainly achieved through proper agronomic practices and most production constraints are related with poor management practice. The major factors effecting on productivity are related with climate change (rain fall, temperature, humidity and wind), Agronomic factors related with (land preparation, time of planting and weeding practice), pests and diseases caused by spread by a whitefly and movement of planting materials and socio-economic factors.

Even though the cassava has maximum productivity and nutritional values, the production in Ethiopia is limited due to poor agronomic practices. So to maximizing the productivity it must be focused on improved agronomic practices such as, land preparation, time of planting and harvesting, planting methods, plant spacing and harvesting methods.

Generally cassava is a relatively easy crop to grow. It can grow and give reasonable yields in low fertility soils and in drought-prone areas with little risk of complete crop failure. However, to obtain better root yields and have sustainable production systems, the crop should be well-managed. The crop should be planted and harvested at an optimum time of the year. The important factors to consider when planting cassava are time of year, suitable land preparation and tillage methods, planting methods, optimum plant spacing and adequate weed control during the first 2-3 months after planting.

References

[1] Adepoju, O.T., Adekola, Y.G., Mustapha, S.O. and Ogunola, S.I. 2010. Effect of processing
[2] methods on nutrient retention and contribution of cassava (manihot spp) to nutrient intake of Nigerian consumers. *Afr. J. Food Agric. Nutr. Dev*. 10(2): 20-21.
[3] Adesina, A.A. and JB, Forson, 1995. Farmers' perceptions and adoption of new agricultural technology: Evidence from analysis in Burkina Faso and Guinea. *West Africa. Agric. Econ.pp. 13-19.*
[4] Allem A.C. 2002. The origin and taxonomy of cassava.pp.191. in: R.J.Hillocks, M.J. Boulder (Eds.), CO, USA.
[5] Amsalu Nebiyu and Elfinesh Firidisa.2006. Effects of different proportions of Maize and soybean flours on cassava bread quality characteristics. In: Ethiopian horticultural science society (EHSS). 1: 153-156. Proceedings of the first conference, 23-24. Addis Ababa, Ethiopia.
[6] Amsalu Nebiyou. 2003. Characterization and Divergence Analysis of Cassava Accession at Jimma. Msc Thesis. School of Graduate Studies Jimma University Ethiopia.
[7] Aro, S. O. 2008. Improve in the nutritive quality of cassava and its byproducts through microbial fermentation. *African Journal of Biotechnology* 7: 89-97.
[8] Aweke Kebede, Beka Teshome, Asrat Wondimu and Aynalem Lakew, 2012. Detoxification and Consumption of Cassava Based Foods in South West Ethiopia. *Pakistan Journal of Nutrition 11* (3): 237-242. doi:10.3923/pjn.2012.237.242.
[9] Aye, T.M. and T.L. Oo. 2010. Cassava production and utilization in Myanmar. *In:* R.H. Howeler (Ed.). A New Future for Cassava in Asia. Proc. 8th Regional Workshop, held in Vientiane, Lao PDR. Oct 20-24, 2008. pp. 168-177.
[10] Benesi, I.R.M. 2005. Characterization of Malawian cassava germplasm for diversity, starch extraction and its native and modified properties. PhD Thesis.
[11] Bizuneh G/Medihin, Lemma Ayele and Mathewos Ashamo, 2011. Planned Agricultural Technologies Adaptation and Promotion For year 2011. Wolayta Zone Agricultural Department. Wolaita Sodo.
[12] Bourdoux, P, P. Seghers, M. Mafuta; J. Vanderpas, 1982. Cassava products: HCN content and detoxification processes. International Development Research Centre (IDRC): Ottawa, Canada, pp. 51-58.
[13] Borin , K., Lindberg, J.E. and Ogle, R.B., 2005.Effect of variety and preservation method of
[14] cassava leaves on diet digestibility by indigenous and improved pigs. CAB Abstracts. *Animal Science*, 80(3):1.
[15] Burns.M. and Devendra, C. 2010. Feeding and Nutrition. 56-115p.In: sheep production in the tropics. CAB (Commonwealth Agriculture Bureaux), London, UK.
[16] Cardoso, A.P. Mirione, E., Ernesto, M., Massaza, F., Cliff, J., Haque, M.R., Bradbury, J.H.2005. Processing of cassava roots to remove cyanogens. *Journal of Food Composition and Analysis* 18:451–460.
[17] Christina, H., M. Thomson, S. Jennifer and S. Anderson, 2001. Addressing food security in Africa via multiple livelihood strategies of women farmers. *Journal of food policy* 26:177-207.
[18] Christopher, C. O. 2008.Comparative analysis of enterprise combination costs and returns in cassava-based food crop farming Systems in delta state, Nigeria. *ARPN J. Agri. and Biol. Sci*. 3: 27-32.
[19] Cock J.H. 1985. Cassava New potential for a neglected crop. West view Press, R.J. Hillock, J.M. Thresh, A.C. Bellott (Eds), Cassava: Biology, Production and Utilization, CABI International, Oxford.
[20] Cooke, RD. and Maduagwu. E. 1978. The effects of simple processing on the cyanide content of cassava chips. *J. Food .Technol* .13:299–306.
[21] Dufour, D.L and Wilson, W.M. 2002. Why "bitter" cassava? The productivity of "bitter" and "sweet" cassava in a Tukanoan Indian settlement in the Northwest Amazon. *Economic Botany* 56(1): 49-57.
[22] EARO (Ethiopian Agricultural Research Organization).2004. Directory of released crop varities and their cultural practice. Addis Abeba.
[23] El-Sharkawy, M.A.2003. Drought-tolerant cassava for Africa, Asia and Latin America. *Bioscience* 43: 441-451.
[24] Eyasu.E, Soil fertility management and nutrient balance in Kindo koyisha farms: A case study in North Omo, Southern Ethiopia, FRP Technical Pamphlet No.15, Addis Ababa, Ethiopia, 2010.

[25] FAO (Food and Agriculture Organization of the United). 2012. Crop and food security assessment mission to Ethiopia. Special report, Rome.
[26] FAO, 2010. Food and agriculture organization of the United Nations Rome, Italy March, 2010; Cassava diseases in central, eastern and southern Africa (CaCESA
[27] FAO, 2003. The state of food insecurity in the World: monitoring progress towards the food summit and millennium development goals: Rome, Italy: pp. 24-26.
[28] Fasuyi, A.O. 2005. Nutrient Composition and Processing Effects on Cassava Leaf Ant nutrients. *Pakistan Journal of Nutrition.* 4 (1): 37-42. doi:10.3923/pjn.2005.37.42.
[29] Garcia M and Dale N. Cassava root meal for poultry. Review Article. *Journal of Applied Poultry Research* 8: 132-137. 1999.
[30] Gill, C and Buitrago,S .2006. Feed more profitable, but disease breeds' uncertainty, World feed panorama, *Feed international* 14:14-28.
[31] Grace, M. R., 1977. Cassava processing. FAO Plant Production and Protection Series, 3. RetrievedMarch14,2005,fromhttp://www.fao.org/docrep/X5032E/x5032E00.htmContents
[32] Heuberger, C. 2005. Cyanide content of cassava and fermented products with focus on ttieke. Dissertation submitted to the Swiss Federal Institute of Technology, Zurich, for the degree of Natural sciences.
[33] Hillocks, R.J. 2002. Cassava in Africa. J. M. Thresh, and, A. C. Bellotti (Eds), Cassava biology, production and utilization. CABI Publishing, Wallingford, UK. Holzafpel, W. H., 1997. Use of Starter Cultures in Fermentation on a Household Scale, *J. of Food Control* 8 (56):241-256.
[34] Huang, Q., S. Rozelle, B. Lohmar, J. Huang and J. Wang. 2006. Irrigation, agricultural performance and poverty reduction in Chin, Food Policy, 31, Issue 1: pp. 30-52
[35] Howeler, R.H. 2001. Cassava agronomy research in Asia: Has it benefited cassava farmers? In: R.H.
[36] Howeler and S.L. Tan (Eds.). Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Development Needs. Proc. 6th Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 345-382
[37] Khajarern, S. and Khajarern, J.M. 1992.Use of cassava products in poultry feeding. Roots, tubers, plantains and bananas in animal feeding. Pp. 141-156.
[38] Khdarern, S. and J.M. Kbjarem, 1991. Use of cassava products in poultry feeding. In: Processiding of the FAO Expert Consultation. Tubers, Tubers, Plantains, and Bananas in Animal Feeding, CIAT, Cali, Colombia. . P141-152
[39] Kuiper, L., Ekmecki, B. Hamelink, C. Hettinga, W. Meyer, S. and Koop, K. 2007. Bio-ethanol from cassava. Project number: PBIONL062937. Ecofys Netherlands BV, Utrecht.
[40] Lazo-Casteleanos. R, F.F Betancourt, Relationship between origins of cassava cuttings and yields in Camaguey-Tunas Penplane, Viandas Tropicales 8 (1985) 57-67.
[41] Lipton, M, J. Litchfield and JM. Figures, 2004. The effects of irrigation on poverty: A framework for analysis. *Water Policy Journal*, 5(5-6): pp. 413-427.
[42] Mahungu, N.M., Y.Yamaguchi, A.M. Alamazan, and S.K. Hahn. 1987. Reduction of cyanide during processing of cassava into some traditional African foods. *J. Food. Agric* 1:11-5
[43] Malawi: From farmers" perception to characterisation by molecular markers. Euphytica, 132: 7.
[44] Maduagwu.E, Cooke, RD. 1978. The effects of simple processing on the cyanide content of cassava chips. *J. Food .Technol* .13:299–306.
[45] MoARD (Ministry of agriculture and rural development). 2010. Household asset building Programme. Programme implementation manual: Addis Ababa, Ethiopia
[46] Naiken, L. 2002. Food and agriculture organization, methodology for estimating the prevalence of undernourishment and methods for the measurement of food deprivation and under nutrition: FAO, Rome Italy.
[47] Nambisan, B, and S. Sundaresan. 1985. Effect of processing on the cyanoglucoside content of cassava. *J. Sci. Food. Agric* 36:1197–203.
[48] Nassar, N. M. A, and R . Ortiz., 2007. A Review on Cassava improvement: challenges and impacts. *J. of Agri. Sci*. 145: 163–17. 73
[49] Nnaji, J., Okoye, F.C. and Omeje, V.O. 2010. Screening of leaf meals as feed supplements in the culture of oreochromis niloticus. *African Journal of Food Agriculture Nutrition and Development*. 10(2). (http://www.bioline.org.br/abstract?nd10015), Acceded on December.2017.
[50] Ntawuruhunga, P. and Dixon, A.G.O. 2010. Quantitative variation and interrelationship between factors influencing cassava yield. *Journal of Applied Biosciences*, 26: 1594 - 1602.
[51] Nweke, F.L., B.O. Ugwa, O.Ajabo and G. Okwor G, 2006. Collaborative research and studies on Cassava (COSCA) working paper 3.
[52] Nweke, F. L. 1994. Processing potentials for cassava production and growth in Africa. COSCA Working Paper No 3. Collaborative study of cassava in Africa: IITA, Ibadan, Nigeria.
[53] Oke.OL.1994. Eliminating cyanogens from cassava through processing: technology and tradition. *Acta Hortic* 375:163-167.
[54] Osiru.D.S., M.C.M.Porto and I.J.Ekanayake.1996. Morphology of cassava plant. IITA, Research Guide. Ibadan, Nigeria (CMD). Theoretical and Applied Genetics.
[55] Popoola, T.O.S and Yangomodou, O.D. 2006. Extraction, properties and utilization potential of cassava seed oil.
[56] Poulter.D., E. Agbor, A. Brauman, D. Griffon, and S. Tre'che. 1995. Cassava food processing. Orstom Edition. pp. 9-11
[57] Ravindran, C.S. 2006. Planting material production and agro-techniques. In: G. Byju (Ed.). Quality Planting Material Production in Tropical Tuber Crops. Central Tuber Crops Research Institute, Thiruvananthapuram, Karala, India. pp. 31-37.
[58] Sopheap U., O. Makara, R.H. Howeler and T.M. Aye. 2010. Enhancing cassava production and utilization

through the Nippon Foundation Project in Cambodia. In: R.H. Howeler (Ed.). ANew Future for Cassava in Asia. Proc. 8th Regional Workshop, held in Vientiane, Lao PDR. Oct 20-24, 2008. pp. 460-469

[59] Southern Nations Nationalities and People Region, Bureau of Agriculture (SNNPR, BoA). 2000. Basic AgriculturaInformation Planning and Programming Service, Awassa, Ethiopia

[60] Tefera Tadesse. 2013. Cyanide reduction, protein enhancement and improvement in palatability of cassava based foods through microbial fermentation. Thesis, Alemaya University, School of Graduate Studies.pp8-25.

[61] Tewe, O.O. 2004. Cassava for livestock feed in sub-Saharan Africa. The global cassava growth strategy. FAO, Rome Italy. Pp. 1-63.

[62] Tijaja, J. 2010. China's impact on commodity producing economies: lessons from the cassava value chains in Thailand China postgraduate network (CPN) UK 3rd Annual Conference, Conference Proceedings, 08 - 09 April 2010, the University of Oxford.

[63] Tongglum, A., P. Suriyapan and R.H. Howeler. 2001. Cassava agronomy research and adoption of improved practices in Thailand.Proc. 6th Regional Workshop, held in Ho Chi Minh city, Vietnam. Feb 21-25, 2000. pp. 228-258.

[64] Toro.J.C., Atlee. C.B. Agronomic practices for cassava production, in: Seminar on Cultural Practices of Cassava, Salvador, Anais Brasilia: Embrapa, 1984.

[65] Tsedeke Kocho and Endrias Geta, 2011. Agro-ecologic mapping in cassava production in smallholder crop-livestock mixed farming of Wolaita and Dawuro districts, Southern Ethiopia. *Livestock Research for Rural Development* 23(51). (http://www.lrrd.org/lrrd23/3/koch23051.htm) Accessed on December 22, 2017.

[66] TTSA (Thai Tapioca Starch Association), 2009. Thai ethanol industry: The opportunities and the challenges, http://www.tapiocathai.org, accessed 29 Dec 2009, TTSA: Bangkok.

[67] Welch, R.M. and R.D. Graham., 2004. Breeding for micronutrients in staple foods crops from a human nutrition perspective J. Exp. Bot. 55: 353-364.

[68] Westby, A., 2002 Cassava Utilization, Storage and Small-scale Processing, CAB International. Cassava: Biology, Production and Utilization pp. 281-190.

[69] Westby, A., BK. Choo., 1994. Cyanogen reduction during lactic fermentation of cassava. Abraka, Nigeria Acta. Hortic. 375:209-215.

[70] Williams, K.C. 1992. Some factors affecting albumen quality with particular reference to Haugh unit score. *Journal of World's Poultry Science*, 48: 5-16.

[71] Wilson, W.M. and Dufour, D.L. (2002). Why "bitter" cassava? The productivity of "bitter" and "sweet" cassava in a Tukanoan Indian settlement in the Northwest Amazon. *Economic Botany* 56(1): 49-57.

[72] Wobeto, C., AD. Corrêa, CMP. De Abreu, CD. Dos Santos, JR. De Abreu. 2006. Nutrients in the cassava (Manihot esculenta Crantz) leaf meal at three ages of the plant. Ciencia e technologia de alimentos, Campinas 26:865–9.

[73] Yared Dagne.2012. Demonstration and scaling up of improved cassava cultivars in moisture Stressed areas of the Southern region: Areka, Ethiopia.

[74] Yeoh, HH, T.Tatsuma, N. Oyama. 1998. Monitoring the cyanogenic potential of cassava: the trend towards biosensor development. Trends Analytical Chem 17:234–240.

[75] Zemach Lemecha.2013. Impact of cassava production in ensuring food security of farm households: the case of amaro woreda in southern nations, nationalities and peoples regional state of Ethiopia. Thesis, Alemaya University, School of Graduate Studies.16pp.