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Review paper on diversity, management practices and genetic erosion of enset (*E. Ventricosum* (Welw) Chessman) in South and Southwest Ethiopia

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Abstract

Ethiopia is the home of diversity for different crops. Of these crop enset is the only domesticated and serve as food security in South Nation Nationality People Regional State of Ethiopia. This region is well known by its broad enset genetic bases on which more than 75% of residents depend on. Though the plant is the endemic and source of food security crop for Ethiopian, compiled document on its diversity, production constraints, its agronomic and management practices as well as farmers' perception on its future fate were little reviewed and organized. The objective of this paper is so, to review existed enset diversity, production status, related challenges and their management practices in Ethiopia. The review of different articles revealed that there were more than 220 enset clones in producing regions. These all clones varied morphologically as well as biochemically. Additionally, study conducted by different authors on molecular characterization also indicated that there were great variations among few studied clones. Different sources undertaken on production of enset noted that the cultivation of enset was started decreasing gradually every year due to biotic (disease, pig, porcupine and mole rat) and abiotic (drought, climate change) factors as well as lack of labor forces which caused by emigration and lack of interest of young generation in enset cultivation, shifting from enset farm to cash crop. But, elder farmers in producing area tried different mechanism against these factors to sustain their dependable crop which include using steel trap and digging out, flooding, poisoning, smoking for mammalian enemies and discarding of infected enset, soil fertility improvement by manure application and using traditional believe for disease.

Keywords: Diversity, Enset production threats, Management practices.

Introduction

Ethiopia is the home of diversity for different crops. Of these crop enset is the only domesticated and serve as food security in South Nation Nationality People Regional State (SNNPR) of Ethiopia.

Enset (*Ensete ventricosum* (Welw.) cheesman) belongs to order *Scitamineae,* family *Musaceae,* and genus *Ensete.* It is a plant native to Ethiopia often called false banana because of its morphological resemblance to common banana (Genet, 2004).

Enset is an important food crop, after cereals and pulses, with coverage of 25% of arable land in the region (Awol *et al.,* 2014). It is one of the most important food crops in south, southwestern and western parts of Ethiopia supporting about 20% of Ethiopia's population as staple and co- staple food (Almaz and Anke, 2004). It is believed to be one of the most dependable and strategic crop as it can withstand short period of drought, heavy rain, and flooding which ordinarily devastate other crops for the attainment of food self-sufficiency and food security, especially in densely populated and in areas very prone to adverse climatic conditions (Awol *et al*., 2014).

There are different enset clones available in different agro-ecologies of Ethiopia. For example as cited by Zerihun *et al*. (2014) in his survey study undertaken in eight zones of SNNPR of Ethiopia that 218 different enset clones were recorded with their vernacular name. However, the production and productivity is low due to biotic and abiotic factors (Tewodros and Tesfaye, 2014). Besides, there is little information documented regarding available enset genetic diversities and their management practices. This might be due to lack of systematic way to study on diversity, distribution and management of the crop. Moreover, currently, enset genetic resources in Ethiopia are becoming seriously endangered owing to the high rate of genetic erosion resulting from extensive substitute of genotypes by high value crops (Coffee, Species and Chat) in major Enset growing areas of the country. Different report showed worlds including Ethiopia in the near future are facing serious overlap of population growth and

detrimental weather condition unfortunately unsustainable food system. For example, FAO (1999) states that genetic resources in developing countries in general are being eroded through the rapid transformation of the agricultural system, in which the main cause of the loss of genetic resources in the indiscriminate introduction of exotic genetic resources, before proper characterization, utilization and conservation. In addition to substitution by high value crop, change in production systems, market preferences, environmental hazards, natural catastrophes and the availability of very limited funds for conservation activities have reduced the diversity of Enset genetic resources in the country. Taking these problems under consideration this review paper was planned with the objectives to review existed enset diversity, production status, related challenges and their management practices in Ethiopia.

Basic Research Finding and Concepts: Diversity within plant species can be studied by morphological which includes quantitative and qualitative traits, genetic or molecular methods (Bizuayehu and Luddes, 2003).

Enset quantitative and qualitative traits as measure of genetic diversity:

In Ethiopia where enset used as staple and co-staple food, there are broad genetic bases. There were numerous experiments conducted on diversity analysis of enset based on indigenous knowledge characterization using surveys at different locations in Ethiopia.

The survey result conducted in Kembata Tembaro zone by Melesse *et al.* (2014), detected enset clones diversity and the uses of clones were portrayed. Accordingly, total of 111 different enset clones were characterized by farmers, of which 21 of them have medicinal uses. Suggestion depicted the highest number of enset diversities were recorded at higher altitude of more than 2500m asl where it serve as staple food and conducive enset growth condition. People of the area classified enset in to two based on sex; male and female based on quality required by them. Hence, the female enset is characterized by ease of scrapping, early maturity and fermentation, edibility, susceptibility to disease in addition to yield quality fiber and small in size where as the male has the opposite traits (Melesse *et al.,* 2014).

In parity with the above suggestion, Admasu (2002) characterized 146 different enset clones from three zones; (52 clones from Sidama, 55 clones from Wolaita and 59 clones from Hadiya. Totally, in these districts, 218 enset diversities were identified. Additionally, Genet (2004) identified 111 enset clones from nine growing area of Ethiopia and Tesfaye (2013), described 79 clones from the Sidama Zone of southern region. Similarly, Zerihun *et al.* (2014) conduct assessment in southern part of Ethiopia in Wolaita, Kembata, Hadiya, Gamo Gofa, Gurage, Sidama and Dawro to study enset diversity and distribution. From the result, the highest clone richness were recorded in Hadiya with total enset clones of 53, followed by Kembata (43), Dawro (41), Wolayita (39), Gamo Gofa (34) and Gurage (31), and the lowest clones observed in Sidama. This report was supported with the observation of Temesgen *et al.* (2014), who recorded 67 enset clones under cultivation in Wolaita using 11 descriptors related to agro-morphological traits, cooking quality and perceived places of origin. He also cited that, folk classification of enset is based on its domestication status, 'gender', agro-ecological adaptability and clone suitability for different food and other uses (fiber, feed, medicinal). Beside the above suggestions, Abraham *et al.* (2012) under took survey in four Kebeles from highland and midland area of southern Ethiopia. The result revealed in each kebele enset clones were very diverse ranging from 2 to more than 50 clones. Each farmer in each kebele had various number of enset varieties. In supporting with the idea of the above authors, Yemane and Fasil (2006), under their survey conducted at Keffa Zone in two districts namely, Chenna and Decha 42 different enset varieties were identified based on eleven morphological traits qualitative characters like leaf color, midrib color, petiole color, pseudostem color, pigmentation, corrugation and quantitative like petiole length, pseudostem length, girth circumference, crude fat, crude fibber, crude protein, Nitrogen, mineral ash and total carbohydrate. Based on these traits varieties were grouped under six clusters. Also genetic distance among clusters were calculated and the maximum distance was recorded to be (d^2 =91.4) followed by 82.8, 54.9, 28.2 and 1 9.5. This result detected the distinctness of enset varieties grouped into different clusters. This opportunity helps in cross breeding for varieties improvement.

Enset molecular markers based genetic diversity:

The use of molecular markers and genomic tools i.e DNA markers such as Inter Simple Sequence Repeats (ISSR), Random Amplified Polymorphic DNA (RAPD) and Amplified Fragment Length Polymorphism (AFLP) have been used to assess intra-specific genetic diversity of enset clones (Temesen *et al.,* 2015). Tobiaw and Bekele (2011), conducted experiment to investigate genetic variation using molecular marker on leaf samples of 71 enset plants

that collected from Assera and Keficho. Accordingly, six primers were tested on 71 enset accessions and four of them gave relatively clear banding pattern and two primers were selected. ISSR analysis using two primers produced a total of 26 scorable bands which composed of 12 polymorphic bands generated by primer 834 and 14 bands with 826 with size of bands amplified using the two primers ranged from 250bp to 2.5 kb in which number of polymorphic loci were 12 for primer 834 and 14 for primer 826. 86.54% out of the total loci scored was observed to be polymorphic. Among all enset population subjected to analysis, Assera populations were found to have higher percentage of polymorphism (92.31%) as compared to Keficho population (80.7%). But, Keficho population had showed higher genetic diversity (0.32) than Essera population (0.22).The mean overall genetic diversity of enset population was found to be 0.27.

Temesgen *et al.* (2015), collected leaf tissues from 60 enset clone and six wild individual from Areka research center which were collected from different regions which found in southern Ethiopia to investigate their diversities. From the total analyzed enset clones, 34 of enset SSR marker revealed 202 alleles. The allelic richness per locus varied widely among the markers ranging from 2 (Evg-52) to 12 (Evg-12) alleles with an average of 5.94 alleles with frequency < 0.05 comprises 43%, intermediate (with frequency 0.05-0.5) were 48 and frequency > 0.5 comprises 9% respectively. Suggestion indicated that small genetic variation between regions. The average genetic distance of 0.42 and ranged from 0.00 to 0.70 was observed based on the 34 markers among accessions. Some clones did not differ in their SSR profile for the tested marker such as Arisho, Arikia, Sanka. On the other hand, two clones named as Gena in Wolaita and Sidama showed different SSR profiles, with genetic distance of 0.60.

Experiment on genetic diversity and cluster analysis of enset was done on 279 enset accession and six qualitative and 22 quantitative traits were considered. Consequently, morphological variability was observed based on qualitative traits as well as significant variation in all the 22 quantitative characters (Mikias, 2014). Hence, the maximum inter-clusters distance noticed to be D^2 =256.45 and the minimum was genetic distance of (D^2) =206.10 indicating diversity between the group. This suggests inter-mating among these accessions may give high heterosis. On top of this suggestion, Genet (2004) studied distinction between wild and cultivated enset using random amplification polymorphism DNA (RAPD) and found that there were no gene flow between wild and cultivated ensets. This suggested that there are genetically different between these which serve in genetic improvement of cultivated enset varieties.

Enset production, constraints and its management s ystem in Southwest Ethiopia: Enset production coverage in southern region of Ethiopia was reported to be 65% of the total crop production (Genet, 2004). Zerihun (2014) portrayed that about 300,000 hectare of land were estimated to be covered with enset. It is grown as a sole or intercropped with different annual or perennial crops. It intercropped with annual crops like beans, haricot beans, taro, yam and maize or perennial crops such as coffee, avocado and guava.

Production and productivity as well as diversity of enset seriously endangered in Ethiopia due to different mammalian such as porcupine, mole rat, and pig (Brandt *et al*., 1997), insect pests and diseases leading to genetic erosion and yield losses (Tewodros and Tesfaye, 2014). Diseases such as bacterial wilt (Xanthomonas campestris pv.), pests (enset root mealy bugs, leaf hopper, mole rat and porcupine) and soil nutrient depletion are some of the production constraints encountered in the south western Ethiopian. Enset is well grown on fertile soil. So, farmers add cattle manure while in some household with sufficient capitals started using inorganic fertilizers. In southern part of Ethiopia, farmers' per capita land holding on average was found to be 0.71 hectares. Enset, wheat, food barley, irish potato, faba bean and field peas were in the major crops cultivated by smallholder farmers with different degree of crop mix. However, enset ranks first in total land area coverage, where 25% of the total arable land is occupied by enset, which is considerably greater than other competing crops (Temesgen *et al,*, 2014).

According to CSA (2009/10), the area covered by enset is more than 300,000 ha. Enset is accredited for its tolerance to drought with high productivity and consequently, considered as top priority food and cash security crop in the country.

Enset cultivation occupies a central core in the agricultural systems of the Wolaita, and every farming household cultivates enset in its home garden. It is considered as repository of enset clone diversity in their home garden.

It is reported that up to 80% of enset farms are currently infected by EXW (Zerihun, 2014). According to Tewodros and Tesfaye (2014), bacterial wilt, mealy bug and nematodes are the most disease and pest identified and the way of their transmission is through animal trampling, flooding, wind and cutting

materials. In agreement with this, in different districts of South and Southwestern part of Ethiopia enset is being devastated with Enset root mealy bug and the average of 64, 51 and 76 adult enset root mealybug per plant were recorded in Dilla, Gedeb and Wonago districts (Habtamu *et al*., 2014).

Enset transplanting and leaf pruning effect on fresh weight of fermented kocho were tested by Tsegaye and Struik (2001). Transplanting was done at one, two and three years respectively and each transplanted enset were flowered at 104, 130 and 260 weeks after transplanting. Thrice transplanted enset decreased in 15% yield. Transplanting effect on fresh weight of kocho was significant at all date except at 260 weeks after first transplanting and until 156 weeks after transplanting plants gave highest fresh weight of fermented kocho. Additionally, pruning at these stages showed significant decreasing kocho yield at the first transplanting and slight increasing in the other transplanting.

Enset production threats and its management systems in southwest Ethiopia: Farmers of enset growing area use different management methods against different mammals, insects and diseases. Wealthier farmers uses steel trap to catch porcupine and mole rat, burning coal and dumping into tunnel and digging pit around enset farm so that it is difficult for animal to get in to farm (Brandt *et al*., 1997).

Enset cultivation requires careful nurturing. There is a very intimate relationship between the whole household and the enset plant in the homesteads. According to study conducted in Kembata Tembari detected, though the region is the center of origin and diversity of enset diversity, there were challenges that influence sustainability of enset agriculture. Production in this area was highly affected by diseases like bacterial wilt, pests, and vertebrates like mole rat, porcupine, pig (Tewodros and Tesfaye, 2014). Besides, report suggested that clones such as Gena and Mazia are replacing previously grown clones due to their resistance to Xanthomonas wilt. Several enset clones previously known by farmers have disappeared in recent years due to disease, extended drought and wild animals, causing genetic erosion of enset clones (Zerhun *et al.,* 2014).

Melesse *et al.* (2014) during his survey undertaken at Kembata Tembaro identified these challenges as wild animal, pests, enset diseases and replacement by high value and cash crops.

In Borana zone which found in southern part of Ethiopia, survey was conducted by Desalegn and Addis (2015) on bacterial wilt disease of enset. In line with this, symptoms were observed in majority of inspected enset field but the disease prevalence and incidence varied among district surveyed. In Kembata Tembaro in ojojia water shade in Doyogena district seven major cause of enset constraints were isolated. These include use of the same cutting materials like knife, environmental change by flooding, infected planting materials, farm equipment, animal track and wind movement which serve as means of enset bacterial wilt, root rot, nematodes and other pests (Tewodros and Tesfaye, 2014). The same achievement by Awol *et al.* (2014), also listed the enset constraints to be enset xanthomonus wilt, purcopine, Amicho rot, mole rat, enset root millibug, drought and swine. Different cultivars have different resistance to disease. With similar concept cultivar Nobo, Mezya and Henewa tolerates somewhat the bacterial wilt additionally Tewodros and Tesfaye (2014), suggested cultivar torora, bedadeda, woshamada and gariya were good tolerant to the bacteria. This indicated as farmers select and used resistant clones against enset disease.

Besides, in different enset growing areas, toward management of enset bacterial wilt disease, farmers used field sanitation, clean equipments and planting materials (Tariku *et al*., 2015).

Similar methods also practiced in Gurage societies toward controlling of enset wilt disease such as sanitary measures i.e uprooting, burning, material disinfecting, using clean planting materials and traditional beliefs (Mekuria *et al*, 2016).

Enset grow best on deep fertile with good drainage soil at backyard of house. Traditionally, farmers improve enset yield increasing soil fertility using animal manure and home wastages at garden. However, suggestion depicted that, application of inorganic fertilizer i.e nitrogen and phosphorus improve more productivity and shorten time of maturity. Twice application of 138 kg/ha N and 20kg/ha P in the life of the crop is better for yield improvement and early maturing escaping enset from disease as compared to traditional management (Abay and Mikias, 2011).

Conclusions

Enset diversity study includes phenotypic and genotypic variation within clone. Different evidence conducted on enset through survey as well as direct experiment depicted there were diversity of enset clones in Ethiopia. Survey study in Kembata Tembaro and other zones found in south and southwestern Ethiopia recorded more than 200 different enset clones. They researchers used morphological

variations, maturity periods, reaction against disease and drought and quantity and quality of end product of the clones as bench mark for study. Additionally, molecular based variation study of different clones witnessed the variation of available enset clones showing highest polymorphism of 92.31%. Especially between wild and domesticated type, author underlined as there were no gene flow due to great variations allowing cross breeding for required traits. Related to production status, enset production is the expression way of cultural and livelihood status of producing societies. It can grown as sole or intercrop with annual and perennial crops. Presently, different sources revealed that, the production and productivity of enset is in declining rates due to abiotic and biotic threats. But, farmers practiced different cultural practices to manage their enset from different threats. For example, manure application and discarding infected disease, using resistant varieties and burning and burying diseased plant; as well as steel trap method for animals. Additionally, soil fumigating and flooding are the way of killing animal like mole rat in soil. But, from the review of different literatures there were no adequate research conducted related to enset bacterial wilt management. Additionally, for mole rat control, there was no clear cut solution given except farmers knowledge based. So, it is better if future researchers gave deep attention on management methods of these threats and enset germplasm collection and conservation for future sustainability of this indigenous crop.

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