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Genetic erossion of anchote *(Coccinia abyssinica)* in Ethiopia: a Review

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ABSTRACT

Ethiopia is the birthplace and diversification hub for several cultivated crops and wild relatives including anchote. Farmers use, protect and manage these different genetic resources to satisfy their livelihood requirements using indigenous knowledge. Due to the changing nature of agricultural production, Ethiopia's anchote genetic diversity, notably that of landraces, is today facing major genetic degradation and irreversible losses. Currently, indigenous crop genetic resources and farmers' traditional knowledge are critically threatened and vulnerable to rapid genetic erosion. Natural disasters, population pressure, change in farming system, market preferences, agricultural modernizations, urbanization, cost of stake, biotic factors, and changing cropping patterns as a result of climate change and environmental degradation are the main factors that have greatly influenced the magnitude of crop genetic diversity in the country. If this tendency continues, the crop genetic resource gene pool may be depleted in the near future. As a result, assessing Ethiopian genetic resources, estimating the pace of loss, and identifying main variables that cause genetic erosion are critical for conservation and long-term utilization of Anchote.

Keywords: Crop, Genetic diversity, Erosion, Land race and Utilization.

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Anchote [(Coccinia abyssinica (Lam.) Cogn.] is the only tuberous cucurbit belonging to the family Cucurbitaceae in the genus Coccinia (Girma and Hailu, 2007). The genus Coccinia comprises 27 species, all of which are confined to sub-Saharan Africa where it is diversified into various habitat types (Holstein and Renner 2011). A total of eight species of Coccinia are found in Ethiopia (Jeffrey, 1995). Among these species, C. abyssinica is the only species cultivated for its edible tuberous roots and the young shoots used as leaf vegetables (Fekadu, 2011). It is mostly cultivated in backyards and grows in the south, south west and western parts of the country (EIAR 2008). The crop has high nutritional values as well as a great potential for medicinal, economic and socio-cultural use (Hora, 1995). It is rich in carbohydrate, vitamins, minerals, protein and calcium as compared to other root crops (Fekadu, 2011). According to local farmers, it helps in fast mending of broken bones and displaced joints.

Due to its good vitamin A content, consumption of anchote may also help to reduce the problem of vitamin A deficiency. Traditionally, it is also believed that anchote makes lactating mothers healthier and stronger. Flour made from the tuber may be used as a supplementary food for infants and young children. Furthermore, juice prepared from anchote tubers has saponin as an active substance and is used to treat gonorrhea, tuberculosis, and tumors.

Anchote is adaptable to a variety of agro-ecological zones, with an altitudinal range of 550 m above sea level in the Gambela area to 2800 m above sea level in the Kelam Wollega zone, and an annual rainfall range of 950 to 2000 mm (Amare Getahun, 1973). It grows well on soils with pH ranging from 4.5 to7.5, mean minimum and maximum temperatures of 12 ^{o}C and 28 ^{o}C, respectively, and annual rainfall ranging from 800 to 1200 mm. (Bekele 2017).

Anchote production and use in Ethiopia is unusual in that the crop is cultivated in such a wide range of environments, encompassing altitude, rainfall, soil, and farming systems. Despite their major contributions to food security, income production, dietary energy provision, and resource base conservation, the food potential of root and tuber crops has not yet been completely tapped and used (EIAR, 2008). Low agricultural productivity, recurring drought, and socio-political factors have all contributed significantly to critical food shortages in Ethiopia, as has over-reliance on a few cereal crops; thus, root and tuber crop integration into the people's food system should be given serious consideration.

The loss of variability from crop populations in diversity centers, i.e. areas of domestication and secondary diversification, is referred to as genetic erosion (Brush, 1999). It was defined roughly by Hammer *et al.* (1996) as the loss of specific local landraces expressed as the ratio of the number of landraces now accessible to their previous number. The term "genetic erosion" is often used narrowly, referring to the loss of genes or alleles, and generally, referring to the loss of variety (FAO, 1998). It is a process that affects both wild and domesticated species. It is also both natural and artificial or manmade. Naturally, it occurs when there is inbreeding between members of small population that will reveal deleterious recessive alleles. It causes a population "bottleneck" by shrinking the gene pool or narrowing the genetic diversity available. This natural process could be the cause for the losses of heterozygosity that reduces the adaptive potential of every population (Caro and Laurenson, 1999). Genetic erosion in cultivated plants is the loss of population diversity, that is, the loss of heterogeneity of alleles and genotypes with their accompanying morphotypes and phenotypes. The problem of genetic erosion in crops was originally recognized by American plant explorers (Harlan and Martini, 1936).

1. Distribution and importance of Anchote

The plant is known by many vernacular names in Ethiopia, including anchote (Afaan Oromo) (Amare Getahun,1973), ushushe (Welayita), wushish (Tigrinya), shushe/ushushe (Dawuro), and ajjo (Kefinya) (Wolde Michel, 1987). This implies that anchote is indigenous to Ethiopia, where where it is found as both cultivated and wild (Amare Getahun, 1973; Edwards and colleagues, 1995). Because Ethiopia has such diverse agro–ecologies, the genus Coccinia may be found in a wide range of areas, including the western, central, southeastern, and northern parts of the country (Edwards et al., 1995). However, in western and southwest Ethiopia, the well-known species for its food, medicine, and other socio-cultural benefits is simply anchote [Coccinia abyssinica (Lam.) Cogn.] (Amare Getahun, 1973). However, the crop is also found growing even in cooler and higher altitudes such as Inango Dambal (2820 m a.s.l) in West Wollega (Amare Getahun, 1973) and Walal Mountain in Kellem Wollega (Abera Hora *et al*., 1995). Presently, the collections of C. abyssinica specimens in the Natural Herbarium of Ethiopia at Addis Ababa University (AAU), representing different agro–ecological zones of the Flora region, indicates that anchote is growing, even, in more wide altitudinal range, i.e., from lowest 550 m a.s.l (in Gambela region) to 2500 m a.s.l (in Debre Libanos monastery).

Root and tuber crops provide food for millions of people and play an essential role in global agriculture. Anchote is an important root and tuber crop cultivated in Ethiopia's western and southern regions (Daba *et al*., 2012). Its high keeping quality is one of its desirable attributes as a tuber crop. As other crops fail, the tubers may be stored in an underground trench and recovered when required, giving food security. Although there is less information on the nutritional and anti–nutritious contents of anchote's leaf and seed, the root has been well examined and claimed to have a greater nutritional content than other common and widespread root and tuber crops (Habtamu and Kelbessa, 1997).

Particularly compared to other tuber crops, anchote has a strong nutritious content with a good supply of vitamins and minerals, and it is recognized as a leading protein root crop. (Habtamu, 2011; Tekilu, 2019). When compared to other tuberous crop plants, the raw Anchote tuber includes organic (carbohydrate, crude protein, crude fiber) and inorganic compounds (calcium, magnesium, iron) as well as low amounts of antinutrients (Oxalate, tannin, and cyanide) except phytate, according to Fekadu (2011). Anchote has been recommended to treat individuals suffering from bone fracturing, displaced joints and other diseases such as gonorrhea, tuberculosis, and cancer (Dawit and Estifanos, 1991; Dandena, 2010). This might be due to its high calcium and protein content, which helps to mend broken bones; however, peeling anchote while cooking decreases its nutritious richness (Habtamu and Kelbessa, 1997). Calcium is the major component of bone and assists in tooth development. Calcium concentrations are also necessary for blood coagulation and for the integrity of intracellular cement substances. Anchote was a fibrous material while the fiber is most important to reduce colon cancer, diabetes, heart diseases and the level of low - density lipoprotein cholesterol in blood and other numerous health benefits (Viuda-Martos, 2010). It also ensures smooth bowel movements and thus helps in easy flushing out of waste products from the body, increase satiety and hence impacts some degree of weight management. High fiber content increases the utility of Anchote flour in various food products. However, emphasis has been placed on the importance of keeping fiber intake low in the nutrition of infants and weaning children because high fiber levels in weaning diet can lead to irritation of the gut mucosa (Bello *et al*., 2008).

2. *Genetic Diversity of Anchote in Ethiopia*

Ethiopia is an important center of domestication and genetic diversification centers of crop species and their wild relatives (Vavlov, 1951; Purseglove, 1968; Mooney, 1979). Center of diversity is defined as geographical area where a wide genetic diversity is found for particular crops and related species (Almekinders and Louwaars, 1999). Genetic diversity can be measured by counting the number of different genes in a gene pool, but genetic variation can only be expected to occur and cannot be measured. Genetic variability thus, can be considered as the building blocks of genetic diversity. Genetic diversity is the base for survival of plants in nature and for crop improvement. Diversity in plant genetic resources provides opportunity for plant breeders to develop new and improved cultivars with desirable characteristics, which include both farmer-preferred traits and breeder-preferred traits. Genetic variability is the occurrence of differences among individuals due to differences in their genetic composition and/or the environment in which they are raised (Allard, 1999). Genetic variability, which is due to the genetic differences among individuals within a population, is the core of plant breeding because proper management of diversity can produce permanent gain in the performance of plant and can buffer against seasonal fluctuations (Sharma, 1998). These genetic variations can be enumerated at three levels: species, populations and individual levels. Since Ethiopia is the only centers of origin and diversifications of anchote [(*Coccinia abyssinica* (Lam.) Cogn.], there is a high genetic diversity, which is mainly attributed to its diverse ecological features (Fekadu D., 2011; Fekadu H., 2011; Abreham *et al.,* 2014; Tilahun *et al.*, 2014).

2.1. *The significance of genetic diversity*

Genetic diversity is essential for plant survival in nature and crop enhancement. Plant genetic resource diversity allows plant breeders to create new and improved cultivars with desired qualities such as farmer-preferred traits (high yield potential, big seed, etc.) and breeder-preferred traits (pest and disease resistance and photosensitivity, etc.) (Allard, 1999). The presence of genetic diversity in the form of wild species, related species, breeding stocks, mutant lines, and so on may serve as a source of favorable alleles and help plant breeders develop climate adaptable cultivars. To develop climate adaptable cultivars, unique features like as tolerance to possible new insect pests and diseases, high heat, extreme cold, and diverse air- and soil-pollutants are required. Different genes must be reserved in cultivated and cultivable crop species as germplasm resources for ever-changing breeding aims. The presence of genetic variation within and across agricultural plant species allows breeders to choose superior genotypes for use as new varieties or as parents in hybridization programs. Genetic diversity between two parents is required to achieve heterosis and transgressive segregants. Breeders can develop varieties for particular characteristics like as quality enhancement and tolerance to biotic and abiotic stresses due to genetic diversity. It also makes things simpler to develop new lines for non-traditional purposes, such as biofuel variants. Diversity is also significant in terms of crop plant adaptation to various environments, particularly changing climatic circumstances.

3. *Genetic Erosion of Anchote in Ethiopia*

The loss of variability from crop populations in diversity centers, i.e. areas of domestication and secondary diversification, is referred to as genetic erosion (Brush, 1999; Loko *et al.,* 2015). It implies that the normal addition and disappearance of genetic variability in a population is altered, so that the net change in diversity is negative (Tsegaye and Berg, 2007). Guarino (1998) defines genetic erosion as a permanent reduction in the richness or evenness of common localized genes or alleles, or the loss of allele combinations through time in a given region. In Ethiopia, crop genetic diversity is critically endangered due to a high rate of genetic erosion caused by natural disasters, population pressure, market preferences, agricultural modernization, urbanization, high pest and disease pressures, and changing cropping patterns caused by climate change and environmental degradation (Hildebrand *et al.,* 2002; Megersa, 2014). If this scenario continues, the gene pool of crop genetic resources may be depleted in a short period of time. Furthermore, on-farm genetic resource conservation is receiving less attention, and agricultural extension in the nation has been focusing on improved varieties to boost productivity (Yifru and Karl, 2006). For many decades, government agricultural policy ignored the function and contribution that indigenous crop genetic resources may provide (Tamiru, 2006; Tsegaye and Berg, 2007). This is due in part to a lack of appreciation for the significance of indigenous agricultural genetic resources, and in part to a desire to close national food security shortages (Mulualem, 2017). Furthermore, knowledge on Ethiopia's traditional agricultural method and crop genetic a resource is limited (Teshome, 2006). Because of human meddling, the rate of genetic degradation of crops and their wild cousins is growing at an alarming rate (Sadhan and Dipak, 2016). Drought has degraded a significant amount of biodiversity in the nation during the last few decades. Furthermore, the causes, consequences, and extent of genetic erosion on local landraces, as well as the list of varieties/species lost in various sections of the nation, remain unclear. Furthermore, the causes and consequences of agricultural genetic resource genetic degradation are poorly recognized in Ethiopia (Megersa, 2014).

3.1. Causes of Genetic Erosion

In the current circumstances, several farmers mentioned crops that had ceased cultivation regions or had completely vanished and were no longer farmed by farmers in numerous growing areas. Other species had suffered significant declines throughout the decades (Anunda *et. al.*, 2014). Crop genetic erosion is a complicated process including various elements that have an impact on existing crop landraces either directly or indirectly (Mark van *et al.,* 2009). Some of these characteristics are associated with broad socioeconomic factors, while others are associated with biotic and abiotic issues (Loko *et al.*, 2015). In general, issues threatening biodiversity include habitat loss or change, over-exploitation, the introduction of alien species, disturbance, illness, and restricted ranges (Muchiru, 1985; WCWC, 1992). Through view of this, farm holding fragmentation, which allows farmers to keep landraces in at least one field; increased cultivation of marginal land, where landraces have an advantage over modern varieties; economic isolation, which creates market distortions that give landraces a competitive advantage; and cultural values and preferences for diversity are all important factors in preserving crop diversity. Any procedure that attempts to counteract this scenario may result in crop genetic erosion (Brush, 1993). Similarly, farmers' local knowledge of crops and agricultural diversity is being lost as a result of similar reasons (Kebebew, 1997).

Displacement of farmers' variations by new, genetically uniform crop cultivars, changes and development in agriculture or land use, degradation of habitats and ecosystems, and drought are the most important drivers for genetic erosion in the country (Worede, 1997). Furthermore, the hunger that lingered in some regions of Ethiopia prompted farmers to consume or sell their own seed in order to live. According to Mulualem (2017)'s survey report, farmers in Southwest Ethiopia verbally revealed several local names of agricultural landraces that were no longer found in their districts/regions and were deemed to be lost. Other agricultural landraces had seen significant declines in previous years (Megersa, 2014).

Changes in farming systems from tuber crops to cereals are another source of genetic loss. Different districts' agricultural extension staff are more informed and enthusiastic about cereals, particularly maize, and less familiar with root and tuber crops (Hildebrand *et al*., 2002). Because they grew grains in their previous location, most northerners dislike root and tube crops and only consume them when absolutely required (Mulualem, 2017). As a result, root and tuber crops have come to be seen as inferior to the grains cultivated by extension workers and newcomers.

Furthermore, growing of cereal grains is seen as upgrading of living conditions in several farming communities in Ethiopia. Similar findings were published by Zimmerer (1992), Charles and Weiss (1999), and FAO (1999), who indicated farmers' preferences in fulfilling diverse cuisines and earning revenue through time, in addition to the socio-cultural value that farmers retain (Loko *et al.*, 2015). However, in certain circumstances, farmers express contradictory requirements and make conflicting decisions owing to other economic or market-related considerations. Furthermore, because contemporary varieties have superior features (particularly higher yields and higher prices), farmers are rapidly replacing local agricultural landraces with modern kinds in many locations (Tsegaye and Berg, 2007).

Furthermore, dryness during the early phases of crop development is seen as a source of genetic erosion (Sadhan and Dipak, 2016). In Ethiopia, several crops, particularly root and tuber crops, are planted in October and November, and moisture stress was discovered to occur during emergence and succeeding months, causing the plants to become stunted and eventually perish. According to Arunachalam (1999), natural disasters such as floods, drought, and wild animal attacks are more likely to contribute to genetic degradation.
Worede (1997) observed in this respect that Ethiopian crop genetic resources are increasingly endangered by genetic erosion and extinction, owing mostly to habitat fragmentation and over-exploitation of natural resources. Staking is one of the most prevalent agronomic procedures in crop cultivation and contributes significantly to genetic erosion in particular crops, such as yams and tomatoes. This is strongly related to the high cost of the stake at important planting times. High market preference is also another factor for contribution of genetic erosion (Loko *et al.,* 2015).

4. *Conclusion*

Plant breeding has a difficulty in feeding an ever-increasing population on limited cultivable land. In this aspect, modern plant breeding has had considerable success. However, because of the narrow genetic base of cultivated variety in many crops, it has resulted in genetic vulnerability. As a result, there is a need for a paradigm change in plant breeding that focuses on varied genetic resources. Genetic diversity is currently recognized as a distinct field that can contribute to food and nutritional security. A better knowledge of genetic diversity will aid in choosing what and where to conserve. Crop plant genetic diversity provides the foundation for the long-term development of new cultivars.

Ethiopia is regarded as the birthplace and diversification center for several crop species including anchote. Farmers' indigenous knowledge manages this local crop genetic diversity in order to suit their livelihood demands. Currently, Ethiopian anchote genetic resources are under severe genetic erosion, owing to a lack of attention paid to crop value, early-stage drought, wild animal assault, scarcity of farm land, and displacement of crop/variety by high-value crops. Crop genetic resource erosion is more than just replacing a variety of crops with one or a few new varieties/cash crops; it also includes the loss of farmers' indigenous knowledge of and capacity to manage their own crop genetic resources.

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