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Pineapple research and development in Ethiopia a review

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Abstract

Pineapple ranked third in production of tropical fruit after banana and citrus. It is a tropical fruit widely cultivated in world which can be consumed fresh or processed into various food products. The pineapple sector has enormous technological potential in both local and international trade. In this review, the status of pineapple production in Ethiopia, agro ecological adaptation areas, genetic improvement, agronomic practice such as propagation, fertilization, mulching, irrigation, planting density, earthing up and maturation and harvesting of pineapple have been discussed.

Breeding pineapple is time consuming because of hetrozygosity, self-incompatibility and need to improve two or more traits at same time. During 2008 to date, in pineapple breeding program about two improved pineapple varieties were released with various desirable characteristics for the low and mid altitude areas of Jimma, Agaro, Metu, Haru, Mugi and Tepi areas of south western and southern Ethiopia. However, pineapple breeding in Ethiopia is still in its infant stage. Because the use of biotechnology in agricultural development is limited, the reviewer recommended that future pineapple improvement through advanced breeding technology should be considered.

Keywords: Ethiopia, pineapple, production, propagation, variety

Introduction

Pineapple (*Ananas comosus* (L) Merr.) is an important tropical fruit in the world. Mature fruit contains sugar, a protein digesting enzyme bromelin, citric acid, vitamin A and Vitamin B (Joy, 2010) [20]. It can be used as supplementary nutritional fruit for good health with an excellent source of vitamins and minerals and considerable calcium, potassium, fiber and vitamin C. Pineapple is the third most important tropical fruit in the world after banana and citrus (Hemalatha and Anbuselvi, 2013; Rohrbach *et al.*, 2003) [35, 11].

Besides, wastes from processing of pineapple fruit are now further processed into sugar, wines, vinegar, animal feed during the dry season. The leaves of pineapple have high quality fiber, manufacture of luxury clothing, making rope, fishing nets and pulp in the paper industry. The suitability of pineapple as food stores on ships and medical ingredients greatly facilitated their distribution throughout the world (Spronello *et al.*, 2004; Sun, 2011) [17]. The five leading pineapple producing countries are Costa Rica, Philippines, Brazil, Thailand and Indonesia (FAO STAT, 2018) [16]. These countries produce the fruit primarily for fresh fruit markets and the processing industry.

Origin and distribution of Pineapple

The Pineapple is originated in Brazil and Paraguay in the Amazon basin where the fruit was first domesticated (Collins, 1949) [9]. Worldwide production started by 15th century. Pineapple was distributed in Europe and the tropical regions of the world. The most spread variety is Smooth Cayenne (Cayena lisa), which was first introduced in Europe from French Guyana (Medina and Garcia, 2005) [25]. Pineapple production is concentrated in the tropical regions of the world. It is grown in over 82 countries with over 2.1 million acres under the fruit (Ndungu, 2014) [27]. The smooth Cayenne cultivar is extensively cultivated in many tropical countries like Hawaii, Philippines, Australia, South Africa, Puerto Rico, Kenya, Mexico, Cuba and Formosa (Azevedo *et al*., 2007) [37].

Other important producers include India, Nigeria, Kenya, Indonesia, México and Costa Rica and these countries provide most of the remaining fruit available (50%) (Medina and Garcia, 2005) [25]. There exists several hundred varieties, but the most widely grown are Smooth Cayenne, Queen and in the past decade introduced variety called MD2 which commands 80% of the global trade in pineapples (Ndungu, 2014) [27].

Pineapple production in Ethiopia

In Ethiopia, the major pineapple production sites are located in the southern and southwestern part of the country owned by private farmers and state farm. The farmers produce in small-scale on fragments of lands, whereas the state farm of Coffee Plantation Development Enterprise produces pineapple var. smooth cayenne along with their coffee and/or maize plantation (Edossa, 1998) [12]. Pineapple production in Ethiopia during 2012 constituted more than 8400 tons (Figure 1). During 2016/17 cropping season, the total area under pineapple plantations is about 645.19 hectares of land and the production estimated to be 1275.83 tons (MoALR, 2017) [26]. Currently, pineapple successfully grows in South and Southwestern parts of Ethiopia as small scale farming and the average yield of the crop is low about 45 tons/ha (Wondifraw *et al.*, 2006) [34] as compared to global average fruit yield of 67.5 t/ha (FAO, 2000) [14]. This low yield is partly due to: low fertility status of the soil, resulting from depletion by proceeding crops, lack of improved pineapple technologies for diverse environmental

conditions, longer maturity, poor marketing system, presence of diseases and insect pests, and lack of improved post-harvest handling technologies are a few to mention (Tewodros *et al.*, 2014) [33].

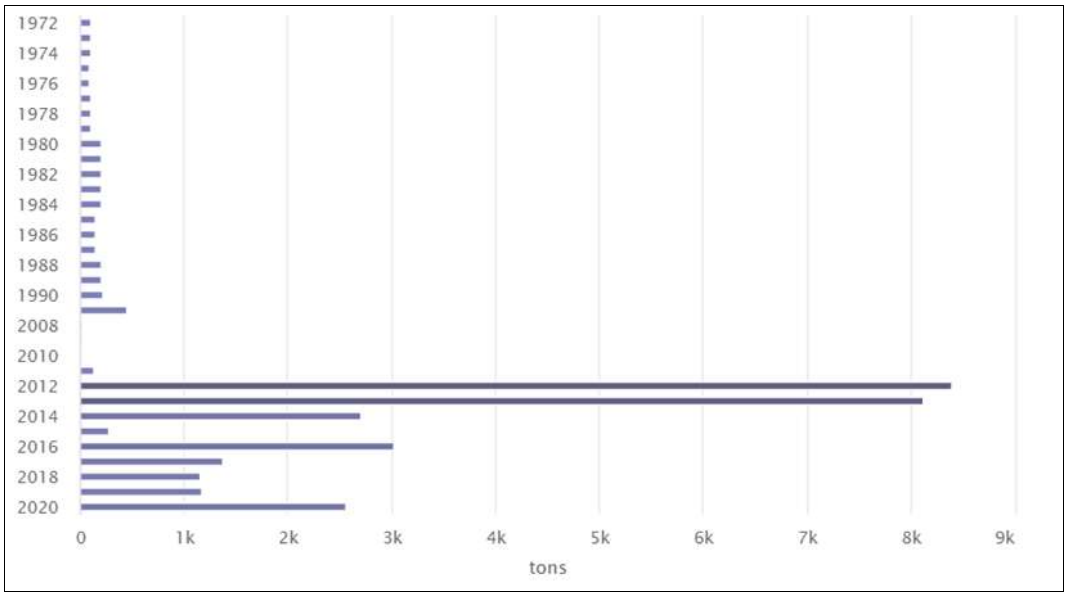

Fig 1: Pineapples production quantity (tons) in Ethiopia

Agro-Ecological Adaptation

Pineapple grows in warm and humid climate. It grows well in tropical and subtropical climate ranging from mild costal climate up to an altitude of about 1000 meters provided the area is free from frost (Malezieux *et al.*, 2003) [13]. When the pineapple is grown at high altitude smaller fruits with elevated tartness are produced and the pulp is less attractive in color and flavor (Purseglove, 1968) [30]. The optimal growth temperature lies between 20 to 30 ºC and more specifically at 23-24 ºC (Neild and Boshell, 1976) [36]. When ambient temperature drops between 10 to 16 °C, fruit growth is constrained. Plants may stand sub-freezing temperatures for very short periods. Conversely, with exposure to temperatures well over 30 °C heat damage may occur due to increased respiration rate and metabolism and impaired nutrient absorption (Bartolomew and Kandzimann, 1987) [5]. During periods of intense sunlight and high temperature above about 35 °C, the fruit is susceptible to sunburn damage. Good fruit quality is attributed to growing sites having a combination of relatively cool night temperatures, sunny days and day temperatures ranging from 21 to 29.5 °C ◦but not exceeding 32 °C. It can be grown in areas that have a relatively high atmospheric humidity and an average rainfall of 760-1,000 mm (Hossain, 2016) [18].

The best soils for pineapple production are well drained non-compacted loams, sandy loams and clay loams with no heavy clay or rock within one meter of the surface. A soil pH in the range of 4.5-5.6 is optimal for pineapple production. Slopes between 2-6% are best for pineapple growing. Below this range, it may be hard to achieve adequate drainage (Bartolomew and Kandzimann, 1987) [5]. Acidic soil rich in organic matter and potassium is desirable to pineapple cultivation. The flavor and quality of fruit grown on light soils is considered to be superior. The plant is particularly sensitive to waterlogged soil conditions. On the hills it can be grown successfully provided the soil depth is at least 45 to 60 cm (Hossain, 2016) [18].

Genetic improvement

There are around 30 varieties of A. comosus var. comosus that are commercially produced. However, the popular commercial varieties of pineapple are; Pernambuco, Queen Victoria, Giant kew, Mauritius, Smooth Cayenne and Red Spanish. The international pineapple industry is dominated by cv. 'Smooth Cayenne', which is used mostly for processing, and which has been the backbone of the industry for more than a century (Chan *et al*., 2003) [8].

Highly specialized systems of production and processing have been developed almost exclusively for this cultivar (Chan *et al*., 2003) [8], but these have since been adapted for cultivar 'MD-2', a complex hybrid bred in Hawai'i, which was officially released in 1996, and which is now the world's principal fresh fruit for export cultivar (Bartholomew *et al*., 2012) [3]. Cultivar 'Pérola' (considered to be drought tolerant) is important in parts of South America, including Brazil, where it is grown on 80% of the planted area (Matos and Reinhardt, 2009) [24]. These three cultivars, together with 'Queen' (a cultivar that produces small fruit), include 90% of pineapples grown in the world. Cultivars often have local names as well as their generic names (Chan *et al*., 2003; Coppens d'Eeckenbrugge and Leal, 2003) [8].

Currently in Ethiopoia two varieties of pineapple Tafache (MD2) and Smooth cayenne released/registered by Jimma agriculture research center. Thus varieties grows well in low and mid altitude (1000-1750 m A.S.L.) areas of Jimma, Agaro, Metu, Haru, Mugi and Tepi areas of south western and southern Ethiopia (MoALR, 2017) [26].

Agronomic practice

Pineapple production in Ethiopia is small in scale and labor-intensive. Only a few pineapple growers in Ethiopia manage large scale pineapple production. Planting density of Tafache is about 44,444 plants per ha, depending on the fruit size demanded by different markets. The average yield of pineapple is 84 tone ha^{-1} on research field and 63.4 tone

ha^{-1} on farmers' field (MoALR, 2017) [26].

Propagation

Pineapple is propagated asexually from crowns, slips and sucker plant parts. Suckers arising in the axils of the leaves on the main stem forms root and can be used for propagation. Even the crown of leaves above the fruit and parts of the stem itself can be used. Another method of propagation is by slips, which are the suckers, arising immediately below the fruit. Suckers and slips should be preferred for planting as they come to bearing earlier than the crown and produce larger fruits. Plant tissue culture technique is applied for mass production of clonal pineapple within a shorter period compared to conventional propagation.

Before planting, suckers are sorted out into larger, medium and small to avoid competition between plants of different sizes. Too large suckers or slips should not be used for planting. Suckers weighing 400-500 g or slips of 350-450 g are considered suitable as planting material. Prior to planting curing of slips and suckers for 8-10 days in shade is necessary as fresh suckers planted in moist soil begin to decay. Before planting some of the lower leaves are removed from the sucker to facilitate the formation and entry of roots into the soil. After removing scaly leaves, planting material should be treated with Monocrotophos (0.15%) and Carbendazim (0.1%) solution to protect against mealy bugs and heart rot, respectively (Hossain, 2016) [18].

Tissue culture has been successfully applied to pineapple. It has the potential to produce millions of plantlets per year. *In vitro* micro propagation of pineapple plantlets has many advantages over conventional methods of vegetative propagation. For instance, this technique allows an efficient and rapid increase of selected elite pineapple varieties. Many authors have reported successful production of pineapple via micro propagation system during the last few years (Ayelign *et al.*, 2013; Firooozabady and Gutterson, 2003; Be and Debergh, 2006; Danso *et al*., 2008) [1, 15, 6, 10].

Fertilization

Pineapple has high requirements for nitrogen (N), potassium (K), and iron (Fe), while relatively low requirements for phosphorus (P) and calcium (Ca). Potassium is usually applied to the soil before planting and later as side dressing. Other nutrients sometimes including K are applied as foliar sprays or through the drip irrigation system, or by both methods, during the growth cycle. Phosphorous and Ca are usually banded in the plant line during bed preparation. Less fertilizer is required during the first five months after planting but requirements increase sharply afterward and peak at two to four months before floral initiation (Hossain, 2016) [18].

According to Tewodros *et al.*, (2018) [32], for high yield and good quality of Pineapple fruits, nitrogen should not be applied beyond 108 kg N ha^{-1} rate. Apply treatments beyond 108 kg N ha^{1}, the TSS content declined by 1.95%. The economic analysis also revealed that the highest net benefit of 61,600.0 Ethiopian Birr/ha (ETB/ha) with marginal rate of return of 237.0% was obtained by the application of 281 kg N ha^{-1}. Likewise, the net benefit of 12,320 ETB/ha with marginal rate of return of 507.0% were obtained by the application of 134.8 kg P2O5 ha^{-1}. The application of 281 kg N ha^{-1} and 134.8 kg P2O5 ha^{-1} had significantly increased the fruit yield of pineapple. The economic analysis reveals that further application of NP fertilizer is not economical. Thus, application of 281 kg N ha^{-1} and 134.8 kg P2O5 kg ha^{-1} is economical and recommended for pineapple production under Jimma and its vicinity of Southwest Ethiopia (Tewodros *et al.*, 2018) [32].

Mulching

Mulching is an important practice in pineapple production. Based on the research conducted on different mulching materials by Neim *et al.*, (2021) black polythene (Fig 2) and coffee husk mulch inhibited weed growth in best manner and highest pineapple yield was obtained. Additionally, a film mulching can modify the microclimate, reduce water evaporation from soil and maintain the soil humidity (Bartholomew *et al*., 2003) [13]. It can also efficiently inhibit the growth of weeds, promote the plants growth and increase the yield and quality of crops (Joy, 2014) [37]. Film mulching could also increase some physiological properties, such as contents of chlorophyll, soluble sugar, and protein of pineapple leaves and roots (Liu *et al*., 2008) [23].

Fig 2: Black polythene (Plastic) mulching during pineapple planting.

Irrigation

In general, pineapple requires a minimum monthly rainfall of 50-100 mm. If the annual rainfall is less than 500 mm, irrigation is essential (Carr, 2012) [7]. Pineapple plants are drought tolerant, therefore, the schedule for irrigation at the time of planting and thereafter should be intermittent. The growth of pineapple plant is retarded due to seasonal drought and water shortage. Available water for irrigation is recommended in drier areas and is useful in planting, and at 8-12 weeks before harvesting. Pineapples are sensitive to saline water (Bartolomew and Kadzimann, 1987) [5].

Planting density

The recommended pineapple planting density in Ethiopia 44444 plants per hectare (Fig. 3) a double-row system taking into account distances between plants, rows and ridges 30cm, 60cm and 90cm, respectively (Jarc, 2017) [19].

An adequate sowing density depends, among other factors, on the type of crop, product target, level of mechanization, use of irrigation, or precipitation (Malezieux *et al*., 2003) [13]. Importantly, high sowing densities of up to 70000 plants per hectare ensure a higher tonnage per unit area; conversely, lower densities generally allow larger fruits with higher market prices (Malezieux *et al*., 2003; Genefol *et al*., 2016) [13, 29]. In addition, plant spacing in pineapple cultivation can influence plant growth, fruit development, and performance as a result of competition for nutrient,

water, and light sources.

Nuri *et al.* (2021) [21] results of their study show that increasing plantation densities (up to 55500 plants ha^{-1}) did not have significant effects on the weight (-crown) or diameter of pineapple fruits. The TSS contents and pH values of the harvested fruits varied due to the interaction of the cultivars and the sowing density, but in general, the fruits met the standards required for the market. Based on the results, it is recommended that farmers in the area increase their planting densities up to 55500 plants ha^{-1} (30 cm x 40 cm x 80 cm), since it improves the yield of fruits ha^{-1} but without affecting the quality of the harvested fruit (Nuri *et al.*, 2021) [21].

Fig 3: Double row planting system of Pineapple

Earthing up

Earthing up is a very important operation in pineapple cultivation and involves pushing soil to the base of the plant from the periphery or into the trench from the ridge, where trench planting is common. Due to its shallow root system and weak stem pineapple plants are prone to lodging (Joy, 2014) [37]. Earthing up gives better anchorage to the plants and should be done after each application of fertilizers and also after weeding, hoeing and harvesting of crops. This becomes more important in ratoon crops (Hossain, 2016) [18].

Maturation and harvesting

Pineapple plants that are vegetative propagated will bear fruit in 15-22 months (Kerns *et al*., 1936) [22]. More than three months are necessary from flowering to fruit maturity in pineapple. Fruits for canning are acceptable at a more advanced stage. Over-ripe fruits are highly perishable. Therefore, for optimum fruit sweetness, pineapple fruit should be harvested when 1/3 to 2/3 or more of the peel color has turned from green to yellow. Harvesting of fruits can be manual or semi-mechanized.

Conclusions

Ethiopia has an immense potential for production of pineapple in small scale as well as in large scale. However, pineapple is only cultivated on a small quantity of land in Ethiopia, and the production is low. The pineapple cultivation areas range from 162 to 906 hectare with a total production 137 tons to 8400 ton within this decade. South and South western parts of Ethiopia are the main pineapple cultivation areas. The yield is low and the industrial competitive potential is in adequate in comparison to other major producing countries in the world due to a lack of cultivation technologies and low attention given to research. Furthermore intensive research and development focusing on pineapples should be implemented in a variety of fields such as mechanization, agronomy, variety development, disease and pest management, and post-harvest handling and management. New discoveries are required to extend the niche and market for pineapple food based and waste processing goods. Because it is accessible all year, it has enormous economic value potential.

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