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Review Article

Review on Sesame (*Sesamum indicum L.*) Production Challenges and Opportunities in Ethiopia

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Abstract

Sesame (*Sesamum indicum L. Pedaliacae*) is an important crop produced in Ethiopia for oilseed production. The objective of this paper is to review the importance of Ethiopian sesame seeds and to indicate the gaps, opportunities and set future recommendations. The crop grows in different regions across the different agro-ecologies in Ethiopia. The production is concentrated in Southwestern and northwestern parts of Ethiopia. Sesame production in most areas is carried out under traditional production systems which results in low production and productivity. Small scale farmers use oxen driven plow and broadcasting in different areas. Due to the variation in climatic conditions, the national productivity of sesame is varying from year to year ranging 7-8 Qt/ha. Application of high seed rate, weeds, insect pests and diseases, moisture stress during critical growth stages, late harvesting which shattering incur high grain loss, poor storage facility, grain loss on field at and before harvesting, and during threshing, cause considerable yield and quality loss. Therefore, to increase yield potential and quality of sesame crop and achieve better profit necessitates improving production techniques, application of improved crop protection techniques, development of high yielding widely adapted cultivars with better resistance to pests, development of improved agronomic and managemental practices and capacity building for experts on sesame crop improvement and post harvest handling, across the sesame growing areas; will have vital role in providing modern sesame production systems in Ethiopia.

Keywords: Sesame; Production; Opportunity; Challenges; Ethiopia

Introduction

Sesame (*Sesamum indicum L. Pedaliaceae*) is one of the oldest oilseed crops cultivated in tropical and subtropical regions of Asia, Africa and South America [1] and thought to have originated in Africa [2,3]. Ethiopia ranks among the top six world producers of sesame and linseed. The Ethiopian government has indicated that the oil seeds such as sesame, niger and safflower seeds as high priority export crops and ranks the second biggest export earner. Thus, production growth and quality improvement of oilseeds can substantially contribute to the economic development at national, regional and at family level. Sesame is the third most important oil crop in Ethiopia and occurs both as cultivated and wild. In Ethiopia, it shows a high phenotypic diversity for number of days to maturity, plant height, pod shape and size, and for seed size and color. Sesame production is increasing in Ethiopia especially in southwest and northwestern parts of the country which is driven by high market value and suitability of environmental conditions [4]. In spite of the growing demand for sesame seeds and oil in Ethiopia, the productivity and production methods are traditional. Though Ethiopia is among the top sesame producers in the world, the potential benefit that could be obtained is below the optimum due to various factors. As indicated by [5], lack of new technology and improved varieties, and inappropriate use of fertilizers and pesticides by the producers are the major production constraints of sesame production and productivity in the country. Hence, the objective of this paper is to review the status of production and

productivity and importance of Ethiopian sesame seeds, and to indicate the gaps, opportunities and set future directions.

Ecology, Composition and Importance of Sesame

Sesame is an annual plant which can grow well in many ecological regions of tropical and subtropical climates. It grows on a wide range of soils; however, well-drained, loose, moderately fertile and sandy alluvial soils that have a pH value between 5.5 and 8.0 are very suitable for sesame production and is quite resistant to moisture stress [6]. Due to its tap roots, the plant is highly resistant to drought and can provide good harvests even when only stored soil water is available [7]. However, moisture levels before planting and flowering have great impact on the seed yield. Sesame requires a minimum of 300-400 mm of rainfall per growing season but is sensitive to wet condition and has a very low salt tolerance character [8]. Depending on the climate, sesame can be cultivated at altitudes up to 1600 m [7]. Planting sesame is the most critical phase of its management and successful establishment of sesame requires careful seedbed preparation and close attention to soil moisture. Once established, sesame is capable of withstanding a higher degree of water stress than any other cultivated plants. However, it requires adequate moisture during germination and early growth for reasonable yields [9].

Sesame seed comprises 50-60% oil and 40% protein [2,10]. It has been found that sesame oil is unique among vegetable oils because of its high contents of natural antioxidants such as sesamin, sesamol and sesamolin. The antioxidants make the oil very stable and it has, therefore, a long shelf life [11]. In sesame oil, oleic and linoleic acids are the predominant fatty acids and make up more than 80% of the total fatty acids. The high levels of unsaturated and polyunsaturated fatty acids increase the quality of the oil for human consumption [12]. Moreover, high level of fatty acid in sesame oil is claimed to reduce blood cholesterol, high blood pressure and plays an important role in preventing atherosclerosis, heart diseases and cancers [13,14]. Ethiopian sesame oil contains a significant amount of fatty acids, mainly linoleic (39.3-59%) and oleic (32.7-53.9%) acid, and palmitic (9-11%) and stearic (5-10%) acid [15].

In addition, Namiki M [16] reported that the use of sesame products is proposed for relief of conditions such as arthritis, and for skin problems such as eczema, and psoriasis. Therefore, the oil is broadly exploited in paints, cosmetics, soap manufacturing, perfumes, pharmaceuticals, insecticides, and cooking and bakery products. Sesame oil also contains significant amount of important carbohydrates, fibers and some minerals viz., potassium, phosphorus, magnesium, calcium and sodium [17]. Sesame seeds are not only used for culinary purposes but also in traditional medicines for their nutritive, preventive and curative properties. The cake produced after the extraction of oil from un-hulled seeds is an excellent protein feed for poultry and ruminants [18]. Apart from these, sesame is a good catch crop and performs well in pure and mixed stand in residual soil moisture [19].

Sesame Production

World production of sesame seed gradually increased from 1.5 million tons per year in the 1960s to 3.2 million ton from 2.7 million ha in 2005, due to an increasing demand for sesame oil worldwide [20]. Over this period, annual international trade in sesame seed increased from 150,000 tons to 800,000 tons. Africa produced an estimated 25% of the total world production over this period and contributed nearly 40% of world exports [20,21].

The oilseed sector in Ethiopia is one of the fastest growing sectors in the country. It is the second largest source of foreign exchange earnings after coffee [22] and sesame is the main oilseed crop in terms of production value. Ethiopia is one of the sesame growing and exporter countries in Africa exporting huge produce to the world market and it is the major oil seed in terms of exports, accounting for over 90% of the values of oil seeds exports following coffee. These crops are primarily used as sources of oil for local consumption and also contribute to the national economy through import substitution by helping save scarce foreign currency spent for importing cooking oil. The major sesame seed producing regions are situated in the North West and South West Ethiopian in Humera, North Gondar and Wollega [4,23,24]. However, a small amount of sesame is currently produced in SNNPR. Tigray, Amhara and Oromia have a total share of 92.7% of 2007/08 production. The practice of sesame production is also expanded to many new areas, including Benishangul, Illubabor and many other places [21]. Somali Regional State also played good role in sesame production and is suitable for sesame production with productivity of about 1.3 tons/ha [6].

Sesame production trend shows that in 2010, a total of 400000 ha were estimated to have been under sesame production. By 2012, the area under sesame cultivation shrunk to below 200000 ha [25]. As indicated by [26] the major reason for the reduction in production is that the areas under large scale sesame production was dramatically decreased as the state and private farms specialized on this crop became nonfunctional or operating at minimum scale primarily due to the lack of labor at harvest, drought and other management and social problems specially in 1980s. However, drastic improvements have been observed since 2013 in area coverage and total production. For example, in 2013/14 production year, nationally sesame scored 700000 ha land coverage and 400000 tones production were recorded [25]. However, due to many biotic and abiotic factors the productivity of sesame is decreasing from year to year (Figure 1).

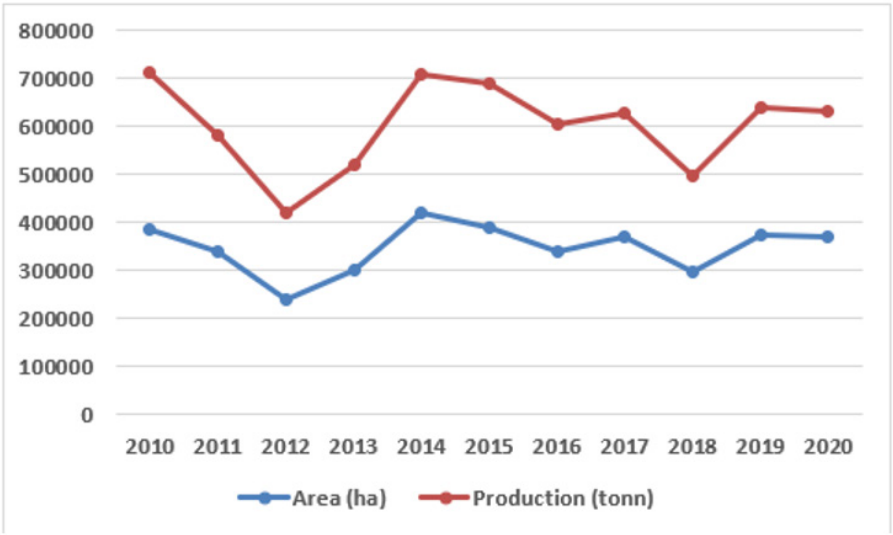

Figure 1: Area coverage and production trend of Sesame over the past 10 years (2010-2020).

Challenges for Sesame Production in Ethiopia

Sesame yields are highly variable depending upon the growing environment, cultural practices and the type of cultivar. It is a low yielder and worldwide average yields are low [27]. Despite of its nutritional and high value crop, the existing production system suffers from traditional farming practices, unimproved seed, lack of fertilizer use, etc. This situation has caused productivity of the crop per hectare to be far below the estimated FAO potential, which is about 16 quintals/ha [4]. According to MoARD master plan, during 2000 the average productivity of sesame was 4.58 quintals/ha. However, CSA report of 2005-06 indicates that the crop's productivity level is 7.07 quintals/ha countrywide. As reported by [28], lack of wider adapting cultivars, shattering of capsules at maturity, nonsynchronous maturity, poor stand establishment, lack of fertilizer responses, profuse branching and low harvest index are the major constraints in sesame production worldwide. However, in Ethiopia, lack of appropriate storage facilities and mechanical mixtures of different variety seeds has been reported as a problem inhibiting sesame production and productivity. In addition, various biotic stresses, such as weeds, insect pests and diseases cause severe yield losses in the country.

Weeds

Numerous weed species affect the growth and development of sesame through competing for resources such as light, moisture and nutrients in the soil, which can decrease the crop quality, higher the production costs due to increased cultivation and hand weeding, and considerably reduce crop yields. They also serve as alternate hosts of insect pests and diseases. In the major sesame growing areas of Ethiopia, more than 98 weed species from 31 families causing damage to sesame crop have been identified; with grasses, sedges, bind weeds and broadleaf weeds dominantly growing in different regions around the country [15].

Among weed species, grasses are the most abundant weeds in the northwest part of the country. For instance, in Metekel Zone of Benishangul gumuz regional state, *graminaceae* species are the most dominant ones, 22%, followed by Compositae (17%).

Sesame is a poor competitor of weeds. Crop yields often depend on the amount, size, and proximity of weeds present after crop emergence. Sesame yield loss due to weeds on the other hand may vary based on several factors such as management options practiced, weed species, pre and post emergence herbicide application, and growing conditions. As indicated by [15], over all yield loss due to weed infestation in Metekel, Humera and Werer under irrigation recorded 42, 83 and 92%, respectively. As a thumb rule, not weeding sesame may result in 100% yield loss depending on soil type, weather conditions and weed species [15].

Insect pests

Sesame yields are seriously affected by insect pests. Out of which [15] indicated that sesame webworm (*Antigstra catalaunalis*), sesame seed bug (*Elasmolomus*), sesame gall midge (*Asphondilia sesami*), green vegetable bug (*Nezara viridula*), grasshoppers, African bollworm (*Helicoverpa armigera*) and crickets are the major pests of sesame in Ethiopia. Insect pests of minor importance such as termites, aphids, jassides and whitefly also affect sesame in Ethiopia.

Sesame seed bug (*Elasmolomus*): Sesame seed bug was reported long ago in Ethiopia, however, its prevalence and damage were restricted to the northwestern part of the country, and it is so important only in years of outbreaks. Seed bug is considered as a

local pest that appears in large numbers at harvest time. Currently, however, infestation of seed bug is increasing from year to year depending on climatic conditions like rainfall and humidity.

In Humera, bugs were found feeding on many species of weeds, trees and vegetable crops. Sesame is usually attacked in the field during drying and in warehouses by nymphs and adults, which suck the entire seed contents. The nymphs and adults incur damage by sucking the seed oil and its content, causing qualitative and quantitative losses, Weight loss of more than 50% was recorded after only 10 days of storage on open and bug infested ground, if left long losses could be as high as 100%. The quality loss resulting due to bug feeding is expressed in color and taste change that makes the seed bitter and dark/unmarketable [15].

Sesame webworm (*Antigastra catalaunalis*): Sesame webworm or leaf roller is an important, well-established and widely distributed insect pest of sesame in Ethiopia [29]. It is a sporadic pest that causes greatest damage during seedling and flowering stages, and may continue until harvest, feeding on mature seeds hidden inside capsules. Generally, webworm can cause 25-35% yield losses and damaged capsule may inflict up to 100% seed loss.

Sesame gall midge (Asphnodylia sesami): Sesame gall midge was minor pest of sesame in Humera area, but nowadays, it became key pest mainly due to mono cropping system of sesame production. Where it occurs, the gall midge causes extensive damage and the larvae are the damaging stage. Eggs are laid in ovaries of flowers and the gall begins to develop before the petals wither or become twisted and stunted and do not develop into flower or capsules.

Even though not yet quantified, estimated yield reduction could reach more than 30% in heavy infestation years.

Insect pests of minor importance: A number of insect pest species with minor economic importance infest sesame. Aphids and Whiteflies: Nymphs and adults of both species pierce the plant tissues and feed on sap. Heavy feeding of both species on leaves cause crinkling and cupping, induce production of honeydews that serve as the substrates for the growth of black sooty molds, and result in reduces photosynthesis and stunted growth. Heavily infested sesame plants will turn yellow, eventually wilt because of excessive sap removal, and finally die off. These insects are also known to transmit virus diseases of many crops.

Termites

Termite is an important pest of sesame in the field and storages in drier areas, especially in places with low and poor rainfall distribution. Field attack may start from seedling stage and continue to harvest and shocks. Infesting stacked sesame causes severe economic damage as termites build soil on shocks and contaminates the seed during trashing. So far, yield loss from termite damage is not quantified in sesame however; farmers' may bear up to 100% loss in severe cases. Pests attack the crop in all stages of its development. The most important storage pests of sesame in Ethiopia are the red flour beetle (*Tribolium confusum*) and rice moth (Corcyra cephalonica). These are cosmopolitan insect pests that attack a range of stored products.

Diseases

Sesame is the crop most intolerant to leaf diseases. It is affected by several diseases in Ethiopia. As reported by [30], bacterial blight, phyllody (Mycoplasma), Fusarium wilt, powdery mildew, Alternaria leaf spot and Cercospora leaf spot are the common sesame diseases registered in Ethiopia. Currently, bacterial blight in humid and phyllody in drier areas are very important, while powdery mildew and wilt are sporadic and minor economically.

Bacterial blight (*Xanthomonas campestris pv. sesami*): Bacterial blight is very common disease in humid and high rainfall areas, transmitted by infected seeds and while phyllody is a highly destructive disease. Its incidence and severity varies depending on topography, altitude, and weather conditions. Disease incidence may reach up to 100% in areas such as Wellega, Pawe and Gambella where high humidity persists for longer time while it is about 10-50% in semi-arid areas like Werer and Humera. It affects the plant at any stage of development.

It is found that the disease was devastates and often instigates remarkable damages to the crop. Under favorable conditions, i.e. soil moisture (30-40%) and relative humidity (75-85%), and during months when the average temperature is about 29oC acute losses have been reported [31]. It is known to cause losses of about 60% in capsule and 25-40% seed yield in Egypt [32], 21-27% seed yield loss in India [33] and up to complete yield loss under rainy and humid areas of Sudan and Ethiopia [34,35].

Phyllody: Phyllody is most destructive disease of sesame in drier areas like Werer, Babille, and Bisidimo and partly in the north-west. It is transmitted by jassids and whiteflies, and causes deformation of leaves and flowers, which remain green with the calyx and corolla, sometimes stiff, forming a half-open hood. Phyllody infected plants do not bear capsule, if does they are deformed and crack before maturity and seeds are shriveled.

Other Factors

Besides the biotic factors, there are also many other factors inhibiting sesame production and productivity. This includes:

Drought: unpredictable onset and cessation of rainfall in Ethiopia affect production, productivity and quality of sesame. Even though sesame is highly drought tolerant crop, prolonged dry spells during its early growth stages affect growth and development. Cessation of rainfall during the mid-growth stages (flower initiation and grain filling) deter pollination and seed set.

Lack of improved and high yielding varieties for different agro-ecologies with desirable agronomic qualities viz. non-shattering, disease/pest resistance: Naturally, sesame is a low yielder crop but the productivity of sesame varieties in Ethiopia is very low when compared with other countries'. Sesame capsules crack and shed seeds when they reach maturity and harvesting is late and leads to considerable amount of yield loss from shattering. Besides, poor fertilizer response of sesame and lack of varieties which respond to inorganic fertilizers.

Traditional production system: Poor management practices by farmers and investors. Farmers use traditional plowing system, oxen or donkey or camel driven plow; which is labor intensive incurring high cost of production, shallow till and difficult for row plantation and fertilizer application.

- Lack of adequate knowledge of farming and post-harvest crop management
- Lack of improved technologies/facilities (planting, harvester)
- majority of sesame growers are farmers whom cannot afford modern planting and harvesters and threshing machines.
- Less attention to sesame research when compared to other crops like maize and wheat though it is major export commodity next to coffee.
- Lack of collaboration among breeding institutes and food industries

Despite the high potential for increased production of sesame and the rapidly growing demand in the international market for Ethiopian sesame, it has been observed that the supply chain of sesame also suffers from different challenges including the adulteration or mixing of sesame with different sources of varying quality. Thus, it is believed that selecting and grading sesame according to its quality and clearly specifying its characteristics can create higher market prices as well as fulfill buyer expectations in the end market [36]. This necessitates the coordination of different stakeholders at any stage in production, post-harvest handling and processing to obtain better quality.

Future Opportunities for Sesame Production in Ethiopia

The existing production system of sesame seed is highly dependent on high marketable value and suitability of environmental conditions especially in the lowlands of Northwestern and Southwestern areas. Environmental suitability for sesame production and the presence of ample genetic diversity of sesame in Ethiopia would give better possibility or potential for improvement. The opportunities and future prospectus of sesame production in Ethiopia is indicated as follows. There is also an enormous potential to expand sesame seed production in the country through cultivation of additional new land, through transfer of technology and the provision of inputs, the increment of production and yield will be achieved strongly. The diversified agro-ecology and availability of huge area in different regions of Ethiopia is suitable for sesame production, availability of virgin fertile new areas which can be cultivated on large scale and cheap and abundant labor source for the peak periods (planting, weeding and harvesting) are the key indicators of the future potential. There are few varieties under research and verification in different research centers across the country, and disseminating these varieties to farmers and growers will be encouraging, promoting sesame research and development, giving attention with the contribution of the crop to the country will help improve production and productivity of the crop, there is good demand for Ethiopian sesame in the world market due to its proximity, yet, the crop has got less emphasis regardless of its foreign currency. The oil qualities of varieties currently under production are relatively good and encouraging but needs to improve further. Though there is an effort by some research centers in Ethiopia in variety development and agronomic research but yet it is not enough to bring impact in increasing production and productivity of sesame. Diseases and insects are causing significant yield loss in sesame crop. The research attention that has been given to improve this crop is not comparable with the contribution of this crop in Ethiopian economy.

Conclusion and Recommendations

Sesame has high agronomic importance as it has the ability to adapt to harsh environments. Hence, in many sesame growing regions the crop is indispensable not only for its economic importance but also for its suitability in such harsh areas. Therefore, developing improved cultivars and production technology is required to increase sesame yields and establish stability in different growing areas. More productive sesame cultivars that have been adapted by breeding are expected to be the major strategy for increasing yield and establishing stability in Ethiopia. However, it is understood that the current productivity level of sesame in Ethiopia is far below the expected average, and therefore there is room for improvement by means of a better farming system and the implementation of improved inputs. Moreover, since there is still land available in the northwestern, western and southwestern areas of the country, the potential for increasing production volume is great. Therefore, to solve the prevailing challenges and improve production potential as well as quality of sesame, the use of improved technologies in general is highly recommended. Thus, it is important to focus on the following points:

- Developing improved cultivars and production technology is required to increase sesame yields and establish stability in different growing areas,
- More productive sesame cultivars that have been adapted by breeding are expected to be the major strategy for increasing yield and establishing stability in Ethiopia,

- Introduction and identification of better adaptable cultivars with better resistance to important diseases and pests,
- Development of high yielding potential variety with improved quality traits through application of modern breeding techniques,
- Development of improved agronomic and managemental practices and the implementation of improved inputs,
- Capacity building on sesame crop improvement and post-harvest handling to maintain the quality of produce,
- Attention should be given to strengthen the collaborative efforts of all concerned stakeholders in the improvement of the crop.

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Conflict of interest

No conflict of interest.

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