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Sesame production constraints, utilization and cultivation opportunities in Eritrea

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ABSTRACT

Sesame (*Sesamum indicum* L.) is a high value and important oilseed crop owing to its dietary uses, health benefits, and industrial applications. Sesame oil maintains a balanced fatty acid composition with more or less equal and higher percentages of unsaturated fatty acids. Despite its several merits, it is behind in genetic improvement as compared to other field crops in Eritrea. This paper aims to identify the major sesame production constraints and document sesame utilization and cultivation opportunities as well as farmer- and market-preferred varieties and traits, in Eritrea. The documentation of the paper will serve as a guide for large-scale sesame seed and oil production and breeding programs. A participatory rural appraisal (PRA) study was conducted in three selected sesame-growing sub-regions and seven villages and sites of Gash Barka region in Eritrea. Data were collected from 90 sesame farmers through semi-structured questionnaires and 50 in focused group discussions. Sesame is grown by all respondent farmers in the study areas for food and as a source of cash. The result of the survey indicated that most of the respondent farmers reported cultivating sesame using seeds of local landraces of their own. About 47.5% of the respondents reported moisture stress/drought as the most important production constraint, followed by low and unstable market outlets (45.7%). Other production constraints included seed shattering, diseases and insects (31.4%), and lack of improved seeds and inputs (14.3%). The above constraints were attributed to the absence of dedicated crop management practices, lack of improved seed and a formal seed sector, poor extension services, and underdeveloped pre- and postharvest infrastructures. With regards to input utilization and crop rotation; 95% of the farmers responded that they don't use fertilizer and 82% said no herbicide and pesticide applications. Besides, 97.4% of the farmers responded that they have grown sesame for crop rotation. The most important market-preferred traits of sesame included white seed colour (26.0%), followed by bold with big seed size (20%) and clean seed (17%). To improve the low yield of sesame there is a need for a dedicated sesame genetic improvement program by integrates thekey production constraints and market- and farmer-preferred traits to develop and deploy new generation varieties to enhance the production, productivity, and adoption of sesame cultivars in Eritrea.

KEYWORDS

Farming Practices, Production Constraints, Oil Content, Sesame Production, Survey

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Sesame (*Sesamum indicum* L.) is an ancient and important oleaginous crop that is grown mainly in the tropical and subtropical regions of Asia, Africa, and South America. It belongs to the Pedaliaceae family, the genus of *Sesame* and adapted to hot areas (Weiss, 2000, Stevens, 2012). Sesame is a significant crop farmed in almost all nations in North and Central Africa, with Sudan and Ethiopia being the top producers.

It serves as an alternative cash crop that generates income for smallholders, especially women (Dossa *et al.*, 2017). Sesame seed demand is rising quickly all over the world and North Africancountries. Sesame seed is particularly valued because it is produced largely without pesticides. Sesame has grown to be a significant agricultural export good, affecting millions of farm households (Dossa *et al.*, 2016).

Sesame cultivation has recently increased due to its drought resistance and easy growing circumstances, but most crucially due to farmers' need to diversify their sources of income (Sadiq *et al.*, 2020). The need is brought on by climate change, which has worsened the agrarian environment, reduced production of food crops (millet, sorghum and maize), and decreased production of the main cash crop (peanut). In addition to its economic, pharmaceutical and food interests, sesame farming has agronomic advantages in the crop rotation system (Verma *et al.*, 2016).

Given the critical importance of agriculture for rural livelihoods in the North African region where Eritrea is found, it is crucial to prioritize and encourage the production of crops that can survive and give high yields sustainably under adverse environment precipitated by climate change (Langham, 2007). In this context, sesame (*Sesamum indicum* L.) is undoubtedly one of the resilient crops best suited to the Eritrea's semi arid and arid climate. Sesame is cultivated in marginal lands and under privileged areas during frequent severe droughts in Eritrea and Ethiopia (Ayana, 2015). Sesame is a crop that is attracting more attention from developers in the agricultural sector and is, therefore, a crop of interest (Sene *et al.*, 2018).

However, compared to other crops, the sesame production is still very low (Girmay, 2018). In addition, research on sesame has been limited worldwide in general and in Eritrea in particular, which may have resulted in its being produced under traditional management practices (Girmay, 2018). In terms of world production, countries like India, China, Burma, Sudan, Ethiopia, Uganda, and Nigeria dominate sesame production with Asia and Africa being the leading continents that are growing fair percentages of the world's sesame crop. World sesame production was estimated at 6.1 million Mt in 2016 (FAOSTAT, 2018). Africa was the top sesame production continent in 2019 with (61%) followed by Asia and America (FAOSTAT 2020). Globally, a total of 2,211,339 tons of sesame grain was traded with a monetary value of 3.4 trillion USD in 2019. In 2019, sub Saharan African countries exported about 1,465,493 tons of unprocessed sesame with a cash value of 1.9 trillion USD (FAOSTAT 2019). In terms of global total sesame production, the top 10 sesame producing countries are Sudan (981,000 tons), Myanmar (769,000 tons), India (746,000 tons), Nigeria (573,000 tons), Tanzania (561,000 tons), China (433,000 tons), Ethiopia (301,000 tons), South Sudan (207,000 tons), Burkina Faso (206,000 tons), and Uganda140,000 (table 1).

Table 1. Ten Top Sesame producing countries in 2020

S. N.	Country	Area ('000' ha)	Production ('000' MT)	Productivity (ton/ha)	Production Contribution (%)
1	Sudan	3,480	981	0.28	16.3
2	Myanmar	1463	769	0.53	12.8
3	India	1,730	746	0.43	12.4
4	Nigeria	539	573	1.10	9.5
5	Tanzania	800	561	0.70	9.3
6	China	311	433	1.39	7.2
7	Ethiopia	415	301	0.73	5.0
8	South Sudan	618	207	0.33	3.4
9	Burkina Faso	321	206	0.64	3.4
10	Uganda	210	140	0.67	2.3
11	Eritrea	43	23	0.53	0.4
12	Other countries	1,813	1,076	0.50	17.9
	World	11,743	6,016	0.51	

Source: FAOSTAT Report 2020

Sesame is a warm season annual crop which is primarily adapted to areas with long growing seasons and well drained soils.

Sesame prefers slightly acid to alkaline soils (pH 5-8) with moderate fertility. Clay soils are more prone to water logging.

Sesame will not withstand water over the stem because it limits oxygen presence to the roots and suffocates the plants. Even if the plants do not die, they will be more susceptible to root rots and will yield less, whereas it is a heat tolerant crop (Langham *et al.*, 2010). So, sesame will perform best on fertile and well-drained soils such as silt loams. It is adapted to sandy loam soils provided there is adequate moisture during seedling establishment and it has been grown satisfactorily on silty clay loam soils. Planting sesame is the most critical phase of its management. Successful establishment of sesame requires careful seedbed preparationand close attention to soil moisture. Sesame will not emerge from soils that are even slightly crusted and needs fairly warm soil temperatures of 21^0C or more.

The objective of this study was to document sesame production and productivity trends assess opportunities and constraints and identify farmer and market-preferred varieties and traits in the major sesame growing areas of Eritrea. The result of the assessment can serve as a guide for large-scale production and breeding programs of sesame.

Material and Research Methods

Description of the Study Areas and Survey Form

The study was conducted in 2023 in Gash Barka Region, within three sub regions: the sub regions surveyed are Goluj, Tesseney and Lailai Gash. The study areas are among Eritrea's major sesame growing belts (fig 1).

Figure 1. Map showing the Sesame growing and surveyed areas of Eritrea (☆Tesseney, ★ Goluj and ★ Lailay Gash and Shambuko areas).

Goluj and Lailay Gash have a predominantly Vertisolsand clay loam soil that is ideal for sesame production. In the last three years, the annual average rainfall was ranging between 450-650 mm, 400-650 mm and 350-550 mm in the sub regions Lailay Gash, Golujand Tesseney respectively, during the primary cropping season (June to September).

Questionnaire Design and Sampling Procedures

A semi-structured questionnaire and focused group discussions (FGDs) were used to collectd attain the study areas. Data collected from FGDs were used to support and validate the information obtained from the formal questionnaire. A purposive sampling procedure was employed to select three sesame-growing regions: namely sub regions Tesseney, Goluj and Lailay Gash.

A total of 96 farmers were participated in the survey from seven administration area/ villages. The administration villages include Tokombia and Augaro from sub region Lailay Gash; Fanco and Tesseney from sub zoba Tesseney and Goluj, Gergef, and Omhager from sub zoba Goluj (table 2). The farmers were selected with the assistance of the agricultural extension offices of the sub region and administration village. Besides, three groups of focused group discussion conducted in the three sub regions in which the groups containing 15-20 people. The composition of the FGD includes farmers, extension experts, researchers, sub region and village administrators. The FGDs were used to support and validate the interview data obtained from the semi structured questionnaire.

The data collected from the FGDs included information on improved varieties, seed sources, sesame seed utilization, market information and challenges, and production constraints.

Data Collection

Both primary and secondary data were recorded. Primary data were collected through interviews using a semi structured questionnaire and focus group discussions. The responses of the selected farmers and FGD were based on sesame farming experience. The data were entered into an Excel spreadsheet and the gathered information from the above methodologies has been compiled, organized, and cleaned using appropriate data handling methodologies.

Table 2. Number of households sampled in the study areas

Region	Subregions	Sites/ Villages	Number of Households	Sub Region Total Farmers	Total Number of Participants in FGD
Gash Bark	Tesseney	Tesseney	12	24	15
		Fanco	12		
	Lailay Gash	Tokombia	14	28	15
		Augaro	14		
	Goluj	Goluj	14	44	20
		Gergef	15		
		Omhager	15		
Gash Barka Region Total			96	96	50

Data Analysis

The analysis was calculated using descriptive statistics thatsummarized into averages, percentages, and frequencies. The data analysed were presented in the form of texts, tables, charts graphs, and figures.

Results and Discussion

Overview Oil Crops and Sesame Production and Productivity in Eritrea

The main oilseeds crops grown in Eritrea include Linseed (*Linum usitatissimum*), Sesame (*Sesamum indicum* L.) Niger seed (*Guizotia abyssinica)* and Groundnut (*Arachis hypogaea*). Sesame is Eritrea's most crucial oil crop that has the potential for local and export values. The percentage and contribution of sesame production reaches to about 60% of the total oil crops cultivated in the country.

The area allocated for sesame varies from year to year depending on rainfall availability. In 2022, the area allocated for sesame production was 32,489 hectares producing 19,609 metric tons. Accordingthe Ministry of Agriculture 11 year's data information, average of all oil crops production is about 11,572 tons which is produced from an estimated average area of 22,474 hectares (table 3). According to the MoA experts in Gash Barka Region, Sesame covers more than 70% of the area cultivated and about 60% of the entire oilseed crop produced in the country. In Eritrea, sesame is mainly produced for household food and as a source of cash. It is predominantly grown by small holders (95.5%) and medium-to-large commercial farmers (4.5%) under rainfed conditions. Sesame production is primarily localized in the lowland areas of the country, where drought and heat stresses are common events.

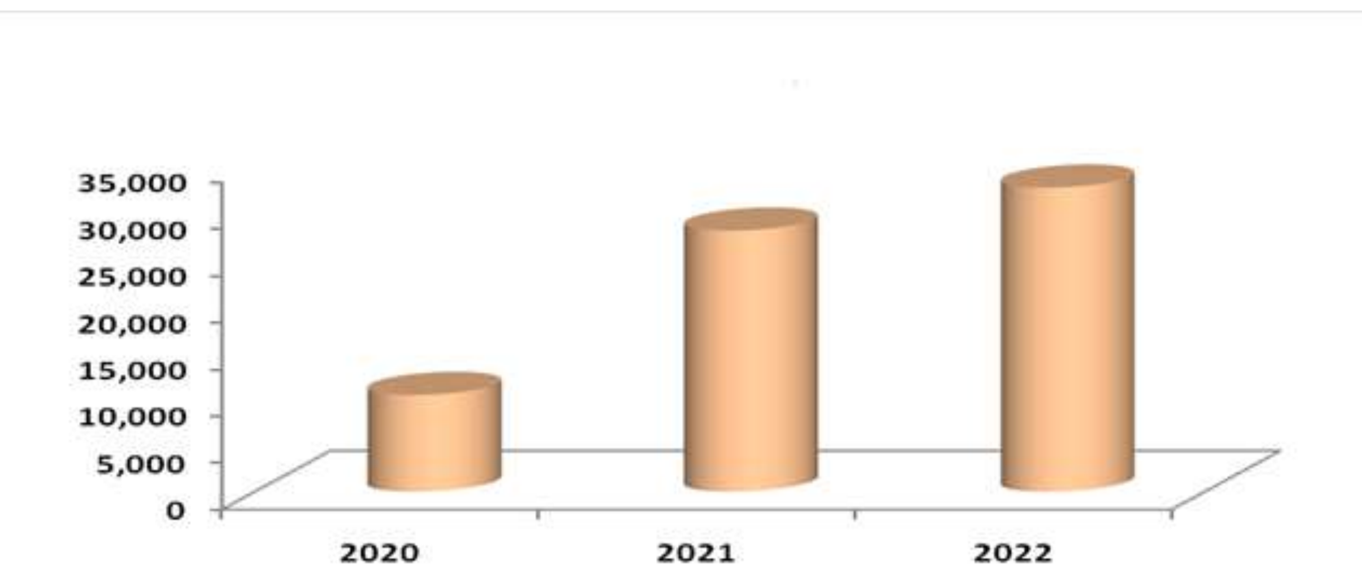
Based on MoA statistics of crop production during the 2012 - 2022 production seasons, the total area and volume of sesame production under medium-to-large commercial farming conditions was mainly concentrated in zoba Gash Barka which is 99.4% of area cultivation and production. The production and productivity of oil crops in general and sesame in particular fluctuate from year to year which is highly dependent on the amount and distribution of rainfall patterns. Data information of three years (2020-2022) from MoA of Gash Barka indicated that sesame cultivation area is at increasing trend (fig 2).

Based on the survey, the productivity of sesame is low and stagnant in sesame growing areas of Gash Barka when compare with other major sesame growing regions in SSA which is less than 0.50 t/ha because of many production constraints. According to the FGD the low yield of sesame is attributable to a lack of high-yieldingandwell-adaptedvarieties, susceptibility to capsule shattering, the prevalence of biotic and abiotic stresses, and a lack of modern production technologies such as optimal agronomic managing practices, row planters, harvesters, and storage facilities.

Table 3. All oil crops and sesame area of cultivation and production in Eritrea (2012-2022)

Year	Total Area Oil Crops (ha)	All Oil Crops Production (tons)	Productivity of All Oil Crops (ton/ha)	Sesame Area (ha)	Sesame Production (tons)	Sesame Productivity (ton/ha)
2012	21,654	10,830	0.50	16,655	7,272	0.5
2013	9,795	4,590	0.47	4,411	813.0	0.2
2014	27,501	19,747	0.72	22,200	14,011	0.6
2015	13,295	1,807	0.14	8,290	1,061	0.1
2016	10,326	6,170	0.60	5,274	1,601	0.3
2017	7,837	2,256	0.29	4,441	754	0.2
2018	16,797	6,817	0.41	16,797	2,682	0.2
2019	48,793	29,991	0.61	42,690	23,370	0.5
2020	17,099	8,775	0.51	10,308	3,357	0.3
2021	34,302	12,663	0.37	27,895	7,455	0.3
2022	39,810	23,650	0.59	32,489	19,609	0.6
Mean	22,474	11,572	0.47	17,405	7,453	0.35

Source: Annual Report, MOA, 2023



Source: MoA, Annual Report of Gash Barka, 2023

Fig 2. Area of Sesame Cultivation (ha) in Gash Barka, 2020-2022

Source of Seed and Farmers Preferred Traits in Sesame Production in Eritrea

The current survey conducted by HAC and MoA in 2023 indicated that mostof the farmers used local sesame varieties. The sesame growing farmers have identified the most popular sesame varieties grown in the last five years of 2018-2022. Different sesame varieties were reported across the sub zobas and villages cultivating sesame in Gash Barka.According to the farmers' description the landraces are highly valued for having farmer-preferred attributes such as unique taste, aroma, and adaptation to grow under low-input farming systems and marginal agricultural lands. Consequently, these production constraints have yet to be systematically studied, prioritized, and documented in Eritrea to guide research and development of this crop.

The local land races that have identified within the farming system with local names are indicated in (table 4) and it seems that the landraces are similar across zoba Gash Barka. Farmers also indicated that no improved varieties so far were available for this crop and farmers urged to supply with diversified improved sesame varieties for better productivity of sesame. It has been also observed the existence of wild sesame varieties that in the surveyed areas that could be a good source and raw material for sesame improvement. According to the information gathered from the sesame growers, the white sesame seed colour (26%) and bold and large seeds (23%) are considered characteristics of a good sesame seed. Besides high germination capacity (20%) and clean seed (17%) are also considered as a good attributes of sesame seeds (fig 3). According to the study, farmers selected sesame cultivars for production based on better adaptation, early maturity, and good for utilization.

Sesame Farm Size and Production Status

The farm sizes of sesame cultivation were variable to a certain extent that ranging from 0.5-25 hectares across the different sub zobas and villages. The majority of farmers interviewed had farm size ranging 0.5-2 hectares which is about 60.0%. On the other hand, from the farmers interviewed, 37.1 % assigned more than 4.0 ha for sesame production which is relatively at the higher side (table 5).

In general, sesame is produced on an average area of 2.0 hectares, with the largest sesame production area being 100 hectares for one commercial farmer during the interview time. Even though the area of cultivation of sesame increased from year to year, the productivity of this crop was at decreasing trend which was mainly attributed to a lack of improved varieties, abiotic and biotic stresses. This was also supported by the FGDs where the majority of the participant households reported the trend that sesame production areas had increased but productivity was decreased for the last five years.

Sesame Seed Utilization in Eritrea

Survey conducted in 2023 by researchers indicated that the sesame produced by the farmers is utilized for different purposes such selling as seed, keeping as own seed for the next planting season, and for edible oil extraction and home consumption. Majority of the sesame growing farmers indicated that the sesame seed produced is used for sell to the market (68.7 %) while for edible oil extraction and home consumption accounted for 25.0% (table 6). On average about 6.3% of the sesame produced by the farmers retain the crop for its own seed source to grow for the next planting season. The survey study also indicated that sesame seed is used primarily for cash earning by selling seed and edible oil preparation for home consumption. Sesame seeds are not only used for selling as a cash source and for edible oil extraction purposes but also in traditional medicines for their nutritive, preventive, and curative properties. According to the interviewed farmers, majority of them agreed that white seed colour is better for oil extraction followed by red-seeded sesame.

Rationale for the Importance and Utilization of Locally Produced Sesame Oil as Compared to Imported Oils

The survey report indicates that most of the imported cooking oils sold in Eritrean super markets and shops are of different nature with variable quality due to the possession saturated issuethat associated with human health effects. The desk review study also showed that cooking oil is typically a liquid at room temperature, although some oils that contain saturated fat, such as coconut oil, palm oil and palm kernel oil are solid.

Table 4. List of local sesame landraces in sub zoba Lailay Gash, Tesseney and Goluj

S. N.	Sub zoba	Landraces name	Status
1	Tokombia/ Augaro	Hirhir, Abu Sanduk or Abu Sita, Tegil, Kefif, Deda and Baria	All these landraces exist in good condition except the red-seeded sesame (Baria cultivar)
2	Goluj/ Gergef	Abuleben, Abusita, Abunaam, Hirhirand Tagil,	
3	Omhager	Abuleben, Abusita, Abunaam, Hirhir, Tagil and mixed seeds	

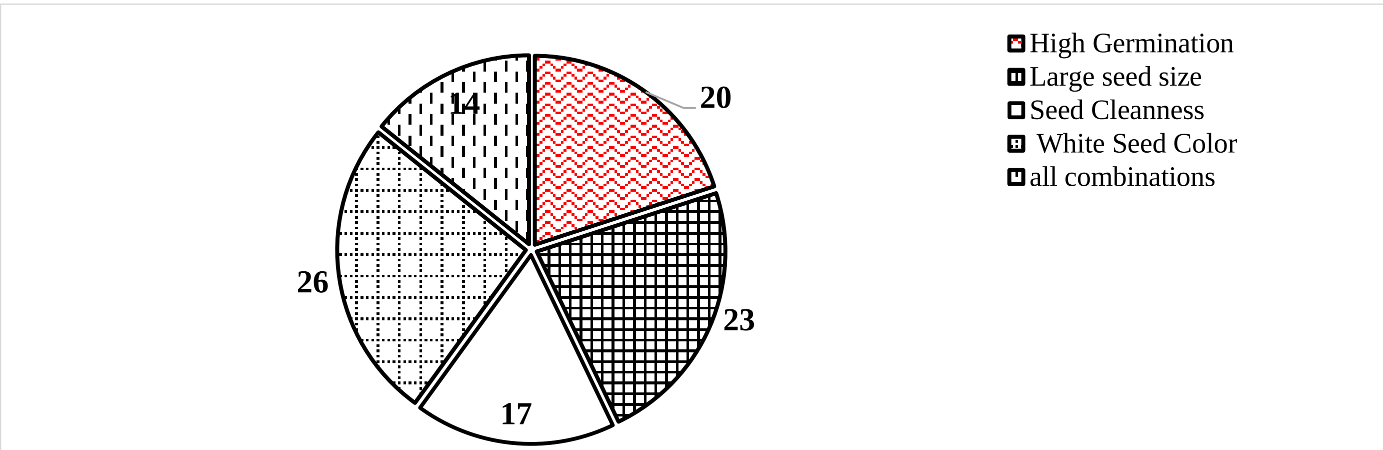


Fig 3. Farmers' response on characteristics of a good sesame seed (%), MoA-FAO, 2023

Table 5. Sesame farm size, production status and production in good and bad seasons

Variable	Class	Sub zoba/ Villages			Average (%)
		Tokombia/ Augaro	Goluj/ Gergef	Omhager	
Sesame farm size of interviewed farmers	0.5-1.0	92.9	23.1	12.5	48.6
	1.5-2.0	7.1	7.7	25.0	11.4
	2.1-3.0	0.0	7.7	0.0	2.9
	> 4.0 ha	0.0	61.5	62.5	37.1

Table 6. Purpose of sesame varieties cultivation in selected subzobas/ villages of Eritrea

Sub zoba/ village	Aim of Sesame Cultivation and Production by Small-Scale Farmers		
	Sell as Seed	Keep as Own Seed for Next Planting Season	Use for Oil Extraction and Home Consumption
Tokombia/ Augaro	50.0	2.0	48.0
Goluj/ Gergef	76.0	8.0	16.0
Omhager	80.0	9.0	11.0
Average Utilization %	68.7	6.3	25.0

Source: FAO Eritrea, 2023 report on constraints of sesame production and productivity

There are a wide variety of cooking oils from plant sources such as sesame olive oil, palm oil, soybean oil, canola oil (rapeseed oil), corn oil, peanut oil and other vegetable oils, as well as animal-based oils like butter. The recommended daily calories are about 10% or fewer from saturated fat, and 20-35% of total daily calories should come from polyunsaturated and monounsaturated fats.

Research studies found that a significant correlation between high consumption of saturated fats and blood LDL concentration, a risk factor for cardiovascular diseases. Those having lower amounts of saturated fats and higher levels of unsaturated (preferably monounsaturated) fats like olive oil, peanut oil, canola oil, sesame and cottonseed oils are generally healthier.

Sesame both unrefined and semi-refined possess 44% mono-unsaturated and 43% poly-unsaturated with 41% of Omega-3 and Omega-6 with smoking point of 232 °C which is good for deep frying. Farmers during the FGD also indicated that the nutrient-rich seed is popular in alternative medicine, from traditional massages and treatments. Sesame oil is approximately equal in monounsaturated (oleic acid) and polyunsaturated (linoleic acid) fats, totalling together 80-85% of the fat content. Despite sesame oil's high proportion (41%) of polyunsaturated (Omega-6) fatty acids, it is least prone, among cooking oils with high smoke points, to turn rancid when kept in the open. This is due to the natural antioxidants, such as sesamol, present in the oil. Sesame is produced in the form of organic farming practice in Eritrea. Organic farming is regarded as the use of fertilizers of organic origin such as compost manure, green manure, and places emphasis on techniques such as crop rotation and companion planting. Organic farming is integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity while by prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones".

Organic food is food produced by methods complying with the standards of organic farming. Opposite to the conventional farming, sesame growers in Eritrea don’t use inorganic fertilizers and a pesticide that makes the extracted oil is safer for use. The trend of input utilization and rotation in the surveyed area is indicated in (table 7). 97.4% of the farmers indicated that they have grown sesame for crop rotation. Sesame generally comes at the head of rotation (e.g., sesame–sorghum–sesame or Sesame-pearl millet - Sesame). Another advantage of sesame oil is its heat and smoking resistance nature during cooking. Heating oil’s during cooking changes its characteristics. Oils that are healthy at room temperature can become unhealthy when heated above certain temperatures, so when choosing a cooking oil, it is important to match the oil's heat tolerance with the cooking method. Sesame oil is suitable for high-temperature frying above 230 °C because of their high smoke point. In a cool, dry place, sesame oil has greater stability. To minimize the degrading effects of heat and light, oils should be removed from very cold storage just long enough for use.

Farmers indicated that traditionally sesame oil is used for massaging as it is believed to relieve the body of heat due to its viscous nature upon rubbing. It is also used for hair and scalp massage and in many cosmetic applications. Research studies indicated that nutritionally for a 100-gram serving, dried whole sesame seeds are rich in calories (573 kcal) and are composed of 5% water, 23% carbohydrates, 12% dietary fiber, 50% fat and 18% protein. The cake that remains after oil extraction from sesame seeds is 35-50% protein and contains carbohydrates. This cake, also called sesame meal, is a high-protein feed for poultry and livestock in Eritrea. Based on the FGD, the use of sesame oil internally processed and refined is another advantage instead of using of different type of imported oils that are not known their sources and the way these oil crops produced. Besides, establishing or revitalizing the existing cooking oil refinery can save hard currency from importing edible oils. The oil qualities of varieties currently under production are relatively good and encouraging. The use and supplying of raw sesame seeds for oil processing from locally cultivated are more advantageous in terms of health as well as economic benefits.

Major Constraints of Sesame Production and Productivity

Even though sesame is moderately drought tolerant crop, prolonged dry spells during its early growth stages affect growth and development. Cessation of rainfall during the flowering and seed setting (post flowering) is major constraint in the study areas. Lack of improved and high yielding varieties for the different agro-ecologies with desirable agronomic qualities *viz*. non-shattering, disease/pest resistance is other production constraints. About 45.7% of households reported that moisture stress (drought) was ranked as a leading constraint of sesame (fig 4). The other sesame constraints are a combination of both abiotic and biotic factors. Drought and seed shattering (17.1%); diseases and insects (14.3%), and lack of improved seeds and farm machinery (14.3%) are production and productivity constraints in sesame (fig 4). Farmers also reported a combination of all constraints contribute to the reduction of sesame production in the surveyed sites. Diseases and insects are causing significant yield loss in sesame.

Table 7. Trends of input utilization (%) as reported by sesame growing farmers in the selected sub zobas of Gash Barka, 2023

Variable	Responses to the practices (Yes/ No)		Sub zoba			Average (%)
			Lailay Gash	Tesseney	Goluj	
Trends of input used for sesame production	Fertilizer application	Yes	14.3	0	0	4.8
		No	85.7	100	100	95.2
	Herbicide Application	Yes	7.1	20.5	25	17.5
		No	92.9	79.5	75	82.5
	Crop rotation	Yes	100	92.3	100	97.4
		No	0	7.7	0	2.6

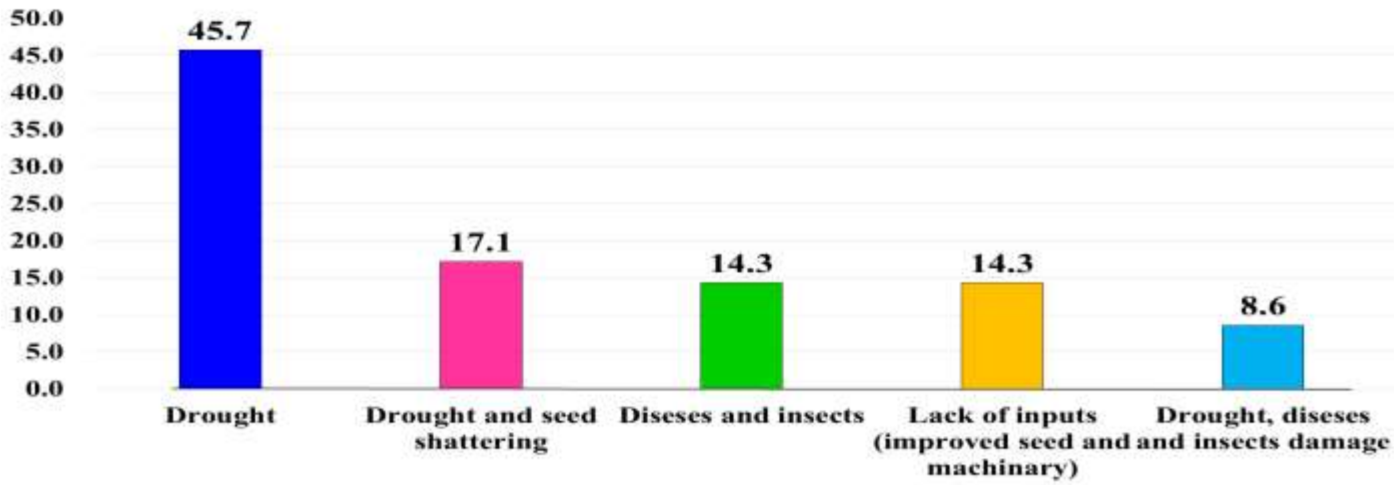


Fig 4. Sesame production and productivity constraints (%) in sesame growing sub zobas of Gash Barka, 2023

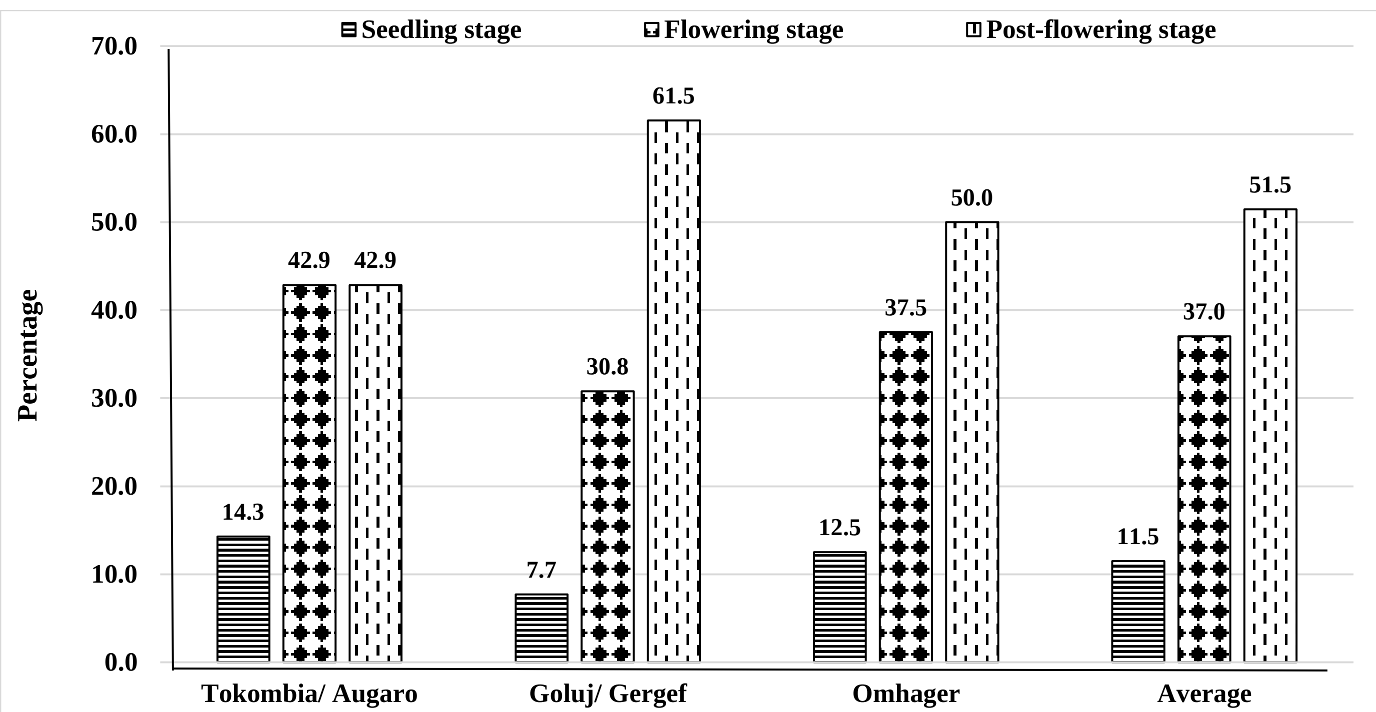


Fig 5. Sesame stage of growth affected by drought in different sub zobas

Table 8. Sesame market constraints (%) as reported by sesame growing farmers in selected sub zobas of Gash Barka, 2023/24

Variable	Class	Sub zoba			Total	Rank
		Lailay Gash	Tesseney	Goluj		
Major market constraints of Sesame	Low quality and seed impurity	11.4	14.3	5.7	31.4	2
	Strong competition with imported oils	2.9	2.9	0.0	5.7	4
	Low and Unstable (fluctuation) market prices	22.9	11.4	11.4	45.7	1
	Lack of capital and labour shortage	2.9	8.6	5.7	17.1	3

During the FGDs, farmers have identified a number of insects and diseases. Out of which they indicated sesame webworm (*Antigstracata launalis*), sesame seed bug (*Elasmolomus*), sesame gall midge (*Asphondilia sesami*), grasshoppers, African bollworm (*Helicoverpa armigera*) and crickets are the major pests of sesame during growth and post-harvest time. Sesame is also affected by several diseases in the surveyed areas. As reported by the farmers' bacterial blight, phyllody (*Mycoplasma*), fusarium wilt, powdery mildew, *alternaria* leaf spot and *cercospora* leaf spot are the common sesame diseases. Drought being as the major sesame constraint, however, the stage of plant growth in which sesame is affected by drought varies from sub zoba to sub zobas. On average, results across the surveyed villages indicated that drought that happened at the post-flowering stage of growth was the most important in influencing farmers' production (53.5%). Besides 37.0 % of the interviewed farmers indicated that moisture stress occurred at the flowering stage affected sesame production (fig 5). Farmers in sub Goluj (61.5%) expressed that the occurrence of moisture stress at post flowering stage was the most common phenomenon when compared with the other sub zoba Lailay Gash (Tokombia and Augaro) (42.9%) (fig 4). MoA report indicated that seed loss due to total sesame crop failures by drought has been observed once in every 3-4 years.

Sesame Market Constraints and Seed Type Preferred in the Market

Based on the current survey finding, there are different marketing problems such as the production of low-quality produce, limited access to market informationand delivery systems, and low selling price at the market and seed type that leads to low profit for the farmers.

About 45.7 % of the farmers reported low and unstable domestic market price as the first major constraint of sesame producers followed by low quality and sesame seed impurity (31.4 %) that affects market price and lack of capital and labour shortage (17.1%) (table 8). Farmers' low purchasing capacity and shortage of required credit results discourage farmers to grow sesame. In addition, lack of timely and sufficient market information; low price of the product at harvest time; weak market linkages among value chain actors were the minor marketing constraints faced by sesame farmers growers. Besides, the market demand for sesame seeds also does not remain the same throughout the year. During the FGDs, farmers also stated that the middlemen engaged in market price fixing without the farmer's involvement. This indicates that there are no price regulations favouring the small-scale framer's involvement in sesame market systems in the study areas. Farmer's identified white seed colour, increased seed size, and high oil content as the most critical sesame market-preferred traits in the study areas. Farmers in all the sub zobas ranked white seed first market-preferred trait, followed by high oil content and a combination of white and large seed size.

Future Opportunities and Prospects of Sesame Cultivation in Eritrea

The current production of sesame seed is highly dependent on high marketable value and suitability of environmental conditions especially in the south western low lands of sesame growing areas of Eritrea. The suitability of environmental condition for sesame crop production and the presence of rich genetic diversity of sesame in Eritrea would give better possibility or potential for improvement. The proximity of the country to international market and the high market demand for Eritrean sesame seed can be considered as another opportunity.

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 researchers' centres in Eritrea 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 Eritrean economy and health benefits.

Conclusion

Farmers' identified moisture stress as the most critical production constraint, followed by low yield gains, diseases, and low market price. Other production constraints included insect pests, lack of market information. These constraints were attributable to the absence of a dedicated breeding programme, lack of a formal seed sector, poor extension services, and underdeveloped pre- and postharvest infrastructures. The essential market-preferred traits of sesame included true-to-type seed, white seed colour, and high seed oil content. The vital farmer-preferred attributes included reasonable market price, resistance to crop diseases, drought tolerance, resistance to crop insectpests, high seed yield, white seed colour, early maturity, and good oil quality in areas such as aroma and taste. Therefore, there is a need for a dedicated sesame genetic improvement programme that would integrate the above key production constraints and market- and farmer-preferred traits to develop and deploy new-generation varieties to enhance stable production, productivity, and adoption of sesame cultivars in Eritrea.

Recommendation

Sesame production in Eritrea faces numerous challenges. To solve the different challenges, it is important to consider the following points for implementation on improving sesame production and productivity in Eritrea:

- Collaborative efforts of all concerned stakeholders including government organizations, researchers, CBOs, private investors and farmers…etc, is needed in the improvement of this crop.
- Capacity building on sesame crop improvement and post-harvest handling to maintain the quality of produce.
- 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.
- Environmental clustering for high oil quality as oil quality is influenced by environmental factors.
- Attention should be given to start refining processes for oil seeds in Eritrea than importing refined edible oil with comparable value that is being obtained from expert earnings from oilseeds.

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