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# DOCUMENTATION OF SORGHUM (*Sorghum bicolor* L. Moench) LANDRACES: PRODUCTION, UTILIZATION AND CHALLENGES IN ERITREA

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**ABSTRACT**

Grain Sorghum (*Sorghum bicolor* (L.) Moench) is the most important staple food crop in Eritrea. A study conducted in four sub regions (Hamelmalo, Segeneyti, Tesseney and Goluj) of Eritrea to determined farmers' perceptions on sorghum diversity, utilization, post harvest and production problems and their management practices using a semi-structured questionnaire and focused group discussions. A total of 190 sorghum growing farmers were randomly selected for this study. Results from the study showed that about 22 sorghum landraces were in active cultivation in the four sub regions, though there is a possible duplication in the naming of landraces. The naming of landraces was based on maturity dates, grain color, plant height and uses. Grain sorghum was used for home consumption in the form of injera (90%), bread (5%) porridge (5%) and local alcoholic beverages (13%). Varieties with white and red grains were used mainly for injera and porridge while those with brown grains were used for local alcoholic beverages. Storage pests were the leading post harvest constraint in all the sub regions. Farmers reported various traditional pest management options which included treatment with ash and herbs; washing with water, sun dry and winnowing methods. Low yields (less than 1.0 t $ha^{-1}$) were reported by farmers in all the sub regions. Drought was reported to be the leading production constraint (71%) followed by striga and diseases (17.9%) and access to labour (3.2%). Post flowering drought was the key yield reducing factor on farmers' field. The use of early maturing landraces and good adaptation to marginal areas coupled with some agronomic practices are the main options used by the farmers to mitigate drought. The results also indicated that 85.8 % of the farmers used their own saved sorghum seed for planting. The main criteria for seed selection were panicle and seed size, grain color and maturity dates. The panicles to be used as seed were selected when the sorghum plants reached physiological maturity.

**Keywords:** *Sorghum bicolor*, landraces, diversity, household survey, participatory rural appraisal.

## INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is an important staple food crop in Eritrea. The crop is commonly grown under rain fed conditions by resource-poor subsistence farmers with very little or no capital inputs, such as fertilizers, pesticides, or irrigation. It is widely grown in the lowland and mid highland regions of the country where rainfall is low for the cultivation of other cereals. The most commonly grown sorghums are the local landraces that have diverse plant structure, panicle orientation, seed color and maturity ranges. Local landraces have been chosen by farmers on the basis of their grain and stalk qualities and adaptation to specific ecologies (Mann *et al*., 1983). However, some sorghum landraces have disappeared from the farmers fields due to climatic variabilities. Though sorghum is well adapted to drought prone environments some late maturing varieties have been neglected due to their inability to cope with erratic rainfalls and short growing season of the country.

The basis why farmers prefer growing sorghum landraces over improved varieties is their ability to adapt to various temperatures, rainfall, soil type, and ecological settings (Mekbib, 2006). In general, research efforts to breed improved varieties have primarily concentrated on more favoured and high-potential environments in which the increase in productivity and yield response to harmonizing inputs is high (Bellon, 2006). In contrast to improved varieties landraces are generally the product of farmer selection for adaptation to specific environments (FAO, 1998; Mekbib, 2006). High genotype-environment interactions can result in higher performance from landraces compared with improved varieties (Ceccarelli *et al*., 2001).

The Eastern African region, to which Eritrea belongs, has been described as one of the centers of diversity and a possible area of domestication for sorghum (Vavilov, 1992). Although, some landraces have been collected from the country, very little information on these landraces is available. Some of the local landraces which were once widely cultivated in Eritrea are now grown only in some restricted areas or are extinct. The farmers' indigenous knowledge on sorghum landraces has not been well documented. Moreover, a previous similar study conducted in the country concentrated on general cereal production of the country and gave little attention to the sorghum sub-sector. Information specific to sorghum production systems, utilization and challenges was not documented and hence, this study was conducted. The objectives of the study were to document sorghum production systems, utilization and challenges as well as farmers' preferences and criteria for selection of the landraces to meet different needs.

## METHODOLOGY

### Study locations

The study was conducted in four sub regions of the country namely; Goluj, Tesseney, Hamelmalo, and Segeneyti, where sorghum is a major crop (Figure-1). Important information on location and climatic conditions for the sub regions are given in Table-1. The cultivated areas in Goluj and Tesseney are flat with altitudes ranging from 500 to 700 m above sea level while those in Hamelmalo and Segeneiti are undulated with altitudes of 1280 and 2171 m above sea level, respectively (Table-1). The soils in Goluj and Tesseney plains were dark clay loamy vertisols. Soils of Hamelmalo areas ranged from sandy to sandy loamy lithosol while those in Segeneyti were sandy and loamy leptosols with dark brown soils. All the sub regions have a short, single rainy season from June to September, followed by a long dry season. The total amount and distribution of the annual rainfall is highly variable from one year to another and crop production is, to a great extent, dominated by small-scale or resource poor farmers.

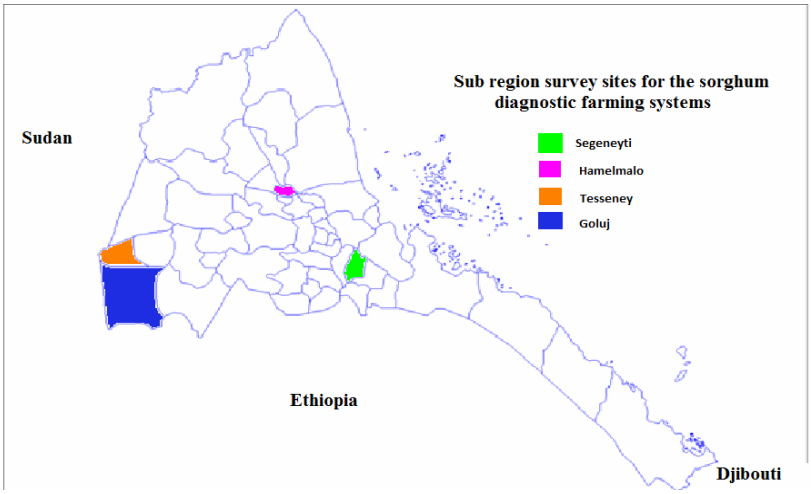


**Figure-1.** The locations of the survey sub regions.

**Table-1.** Agro ecology, location, and mean annual rainfall and soil types of the surveyed sub regions.

| Sub region | Agro ecology zones | Location | | | Mean annual rainfall (mm) | Soil type |
|---|---|---|---|---|---|---|
| | | Altitude (m) | Latitude | Longitude | | |
| Hamelmalo | North western lowland | 1280 | $16^0$ 01' N | $38^0$ 20' E | 479.2 | Sandy and sandy loam with low water retention capacity |
| Segeneyti | Central highland | 2171 | $15^0$ 05' N | $39^0$ 19' E | 451.5 | Sandy and loamy, leptosols |
| Tessenei | South western lowland | 600 | $15^0$ 11' N | $36^0$ 66' E | 318.7 | Dark clay loam, Vertisols |
| Goluj | South western lowland | 678 | $14^0$ 74' N | $36^0$ 72' E | 759.3 | Dark clay loam, Vertisols |

### Research approach and sampling size

### Formal survey

Three villages from each of the four sub regions, giving a total of twelve villages, were selected for the study. The villages were selected with the assistance of extension officers on the basis of growing sorghum as a major crop. A total of 190 sorghum growing households were randomly selected from the four sub regions. The number of households that were sampled from each village is given in Table-2. A semi-structured questionnaire was used to collect information from these households on sorghum production, utilization and major constraints affecting production.

### Focussed group discussion

A focused group discussion with stakeholders was organized in each of the sub regions. A total of 25 participants that comprised of farmers, extension experts, researchers and local administrators participated in the group discussions. In addition, field observations and secondary data reviews were used to enrich the study.

**Table-2.** Number of households sampled in the study sites.

| Region/ Zoba | Sub regions | Sites/ villages | Number of households | Sub region total |
|---|---|---|---|---|
| Anseba | Hamelmalo | Gizgiza | 19 | 47 |
| | | Fledareb | 16 | |
| | | Hamelmalo | 12 | |
| South | Segeneyti | Hadida | 12 | 40 |
| | | Adi Hadid | 13 | |
| | | Akrur | 15 | |
| Gash Barka | Tesseney | Tesseney | 30 | 51 |
| | | Aligidir | 11 | |
| | | Thalata Ashir | 10 | |
| Gash Barka | Goluj | Goluj | 18 | 52 |
| | | Gergef | 17 | |
| | | Omhager | 17 | |

**Data analysis**

The primary data collected in this study was entered into an Excel spread sheet and analyzed using XLSTAT 2012. The data were summarized into averages, percentages and frequencies. The data analyzed was presented in the form of Tables, pie charts and graphs.

**RESULT AND DISCUSSIONS**

**Landholding and production status of sorghum**

Results from both the household survey and the group discussion indicated that about 95% of the farmers in sub regions Segeneiti and Hamelmalo had land holdings of 0.5 to 2.5 hectares while in Tesseney and Goluj land size ranged from 1.3 to 8 hectares. Five percent of the farmers in the study were commercial farmers who owned land between 40 to 100 hectares in sub region Goluj. The average land holding of all farmers in this study was 2.5 hectares (Table-3). These results were in agreement with those of Bekuretsion (2005) who reported that the average land holding size in the South and Anseba regions was 0.25 to 4 hectares while in Gash Barka it ranged from 1.3 to 40 hectares. The average proportion of farm land allocated to sorghum cultivation in the study area was 96%.

Results from this study showed that the size of land holding was not proportional to family size and therefore, household food security was not guaranteed for the majority of the families. Consequently, most of the households were dependent on allied agricultural activities, such as animal rearing, wage earning and trading.

**Table-3.** Landholding and area allocation for sorghum in the study sites.

| Sub region | Village administration | No. of household (No.) | Total HH landholding size (ha) | Average landholding (ha) | Land allocated for sorghum (ha) | Sorghum area share to total land holding (%) |
|---|---|---|---|---|---|---|
| Hamelmalo | Gizgiza | 19 | 19.25 | 1.0 | 19.25 | 100.0 |
| | Fledareb | 16 | 32.00 | 2.0 | 29.75 | 93.0 |
| | Hamelmalo | 12 | 33.75 | 2.8 | 27.25 | 80.7 |
| Segeneyti | Hadida | 12 | 12.75 | 1.1 | 10.25 | 80.4 |
| | Adi Hadid | 13 | 18.00 | 1.4 | 15.25 | 84.7 |
| | Akrur | 15 | 16.00 | 1.1 | 9.75 | 60.9 |
| Tesseney | Tesseney | 30 | 139.00 | 4.6 | 137.00 | 98.6 |
| | Aligidir | 11 | 27.00 | 2.5 | 24.00 | 88.9 |
| | Thalat Ashir | 10 | 12.50 | 1.3 | 12.00 | 96.0 |
| Goluj | Goluj | 18 | 84.00 | 4.7 | 82.00 | 97.6 |
| | Gergef | 17 | 547.00 | 32.2 | 547.00 | 100.0 |
| | Omhager | 17 | 142.00 | 8.4 | 131.00 | 92.3 |

The area under sorghum cultivation in Eritrea is increasing but the yield levels are stagnant (MoA, 2012.). Based on a review of secondary data, 33% of the total sorghum area of cultivation and 26% of total national production comes from the four surveyed sub regions (Table-4). Sub region Goluj is a leading sorghum producer and covers the highest area of sorghum cultivation in the country. Sorghum productivity in this region was 0.6t $ha^{-1}$, a Figure that is similar to the national average. Sub region Hamelmalo had the lowest sorghum productivity (0.35 t $ha^{-1}$). Sub region Segeneyti recorded the highest value for sorghum productivity (1.0t $ha^{-1}$).

**Table-4.** Average area of sorghum cultivation and production in the study sites for the period 2006-2011.

| Sub regions | Area and production of sorghum | | | |
|---|---|---|---|---|
| | **Area under sorghum** (ha) | **Production** (Tons) | **Productivity** (Tons/ha) | **Remarks** |
| Hamelmalo | 2, 197.7 | 790.1 | 0.35 | |
| Segeneyti | 1, 257.6 | 1, 369.2 | 1.0 | |
| Tesseney | 23, 398.0 | 9, 487.5 | 0.4 | |
| Goluj | 60, 120.8 | 30, 516.0 | 0.6 | |
| Sub regions total | 86, 974.1 | 42, 162.8 | 0.5 | |
| Average National Total | 264, 144.0 | 157, 492.0 | 0.6 | |
| Surveyed sub regions contribution (%) | 33.0 | 26.7 | | |

Source: Ministry of Agriculture (2012)

**Sorghum utilization and preferences**

The majority of the farmers in the surveyed area produced sorghum both for home consumption (98.9%) and seed for the next growing season (85.8%). About 41% of the farmers produced sorghum for sale in smaller quantities when they have excess as grain and 10.5% as seed (Table-5). Some farmers (16.8%) use sorghum for exchange with their neighboring farmers or relatives. The farmers often do such seed exchange when there is a variety they want to grow but not in their hands or for modern improved varieties.

Sorghum grain in Eritrea is used primarily in the home to prepare local foods such as 'injera', thick porridge (*Geat*) and bread (*kicha*) and any other dietary functions. *Injera* is a leavened, round and flat pancake which is national dish of Eritrea. The type of grain sorghum used for injera, bread and porridge significantly differed from region to region and sub regions. White-grained sorghum generally is preferred for food in the highlands such as in sub region Segeneyti because it gives the desired color, while Red and Brown grains are preferred for brewing a local alcoholic beer called '*siwa'*. In the lowlands areas such as sub regions Hamelmalo, Tesseney and Goluj the White and Red grain sorghum are equally important for injera, bread and porridge making while Brown grain for the preparation of homemade drinks.

**Table-5.** Frequencies of main purpose for growing local sorghum varieties.

| Sub zoba | Sell as grain | Sell as a seed | Exchange as a seed | Keep as own seed | For home consumption | For animal feed |
|---|---|---|---|---|---|---|
| Goluj | 30 | 6 | 17 | 46 | 52 | 0 |
| Hamelmalo | 9 | 13 | 5 | 32 | 46 | 0 |
| Segeneyti | 3 | 1 | 8 | 38 | 39 | 0 |
| Tesseney | 37 | 0 | 2 | 47 | 51 | 1 |
| Utilization % | 41.6 | 10.5 | 16.8 | 85.8 | 98.9 | 0.5 |

The red grain sorghum was preferred for injera (45.8%), local alcoholic beverage (13.2%) while brown sorghum was preferred for local alcoholic beverage preparations and has longer storage life after harvest. The home made drink siwa is only prepared by Christian household (Table-6). In general households are slightly inclined to use Red sorghum for injera and bread in the lowlands. More importantly farmers both in the household interviewed and group discussion confirmed that they don't use sorghum only for one specific form of food preparations

**Table-6.** Preference of grain color of sorghum for injera, local drinks and storage life.

| | Sorghum seed color | | | | | |
|---|---|---|---|---|---|---|
| **Preference for use and storage length** (%) | **Red** | **White** | **Brown** | **Chalky white** | **Red, white, brown and chalky white** | **Total** |
| Injera making | 45.8 | 27.4 | 9.5 | 8.9 | 8.4 | 100.0 |
| Siwa making* | 13.2 | 15.8 | 14.2 | 7.9 | 6.8 | 57.9 |
| Better storage life | 45.3 | 15.3 | 36.3 | 3.1 | 0.0 | 100.0 |

*42.1% of the household do not prepare local alcoholic beverages

About 93 % of the households use sorghum in multiple ways (Figure-2). It is only 2.6% and 4.7% of the of the household farmers use sorghum for injera and porridge respectively.

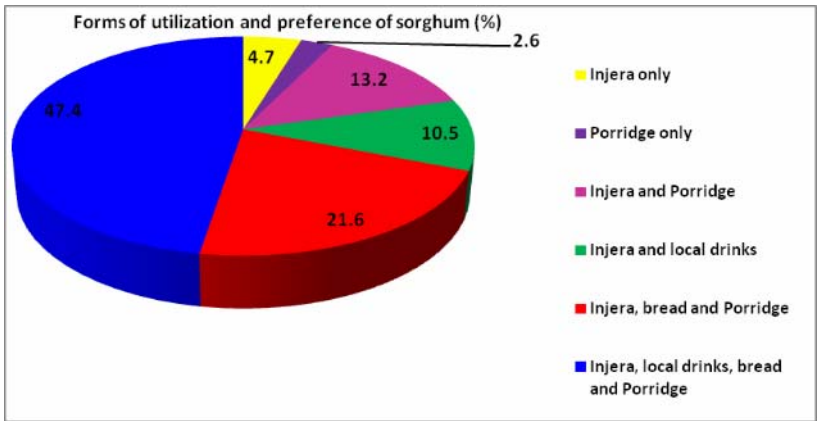


**Figure-2.** Forms of sorghum utilization by households.

**Agronomic practices and cropping calendar of sorghum**

The cropping patterns practiced in the surveyed sub regions included sole cropping, intercropping, and crop rotation. 'Fallowing' was not practiced in the surveyed sub regions due to shortage of farmland. The results indicated that intercropping was not common among the farmers except in sub region Hamelmalo (Table-7). However, inter-cultivation (*Gusia*) was generally practiced in all sub regions.

Majority of the households reported that they practiced crop rotation (Table-7). The pattern of crop rotation followed by farmers in all sub regions was cereals after pulses and oil crops or vice versa. For instance a field planted with one of the pulse crops (Chick pea, Faba bean or Grass pea) was allotted for growing sorghum or finger millet in the next season. The rotation cycle basically differs from one sub region to another based on the crop type and agro-ecology. The commonly used rotation cycles are: Sorghum-Ground nut-Pear millet (Hamelmalo), Finger millet-Sorghum-Taff-Fallow or Sorghum-Barley-Taff-Chick pea-Finger millet (Segeneyti) and Sorghum-Sesame-Pearl millet (Tesseney and Goluj).

Generally, the soils in Eritrea are poor in fertility and eroded by rain and wind. This is especially true in the highlands (Segeneyti) and mid lowlands (Hamelmalo) areas where the land holdings of the households are generally small. In these two sub regions the land is redistributed among the families of the village every 6-7 years, a land tenure system called 'diesa'. In this system farmers often do very little soil maintenance and cultivation is very intensive because of high population pressure leading the soils to become poorer and poorer. In the sub regions Tesseney and Goluj soil fertility is generally better.

In all sub regions commercial fertilizer is very rarely used by the farmers for sorghum cultivation (Table-7). However, some farmers in sub regions Hamelmalo and Segeneyti, applied farm yard manure (FYM) in their fields located near the homestead.

**Table-7.** Farmers responses to different sorghum agronomic practices.

| Sorghum agronomic practices | Responses for the practices (Yes/No) | Sub regions | | | | Household responses (%) |
|---|---|---|---|---|---|---|
| | | Hamelmalo | Segeneyti | Tesseney | Goluj | |
| Weeding | Y | 47 | 40 | 51 | 52 | 100 |
| | N | 0 | 0 | 0 | 0 | 0 |
| Inter cultivation (Gusia) | Y | 47 | 40 | 19 | 42 | 77.9 |
| | N | 0 | 0 | 32 | 10 | 22.1 |
| Fertilizer application | Y | 37 | 35 | 3 | 4 | 41.6 |
| | N | 10 | 5 | 48 | 48 | 58.4 |
| Intercropping | Y | 31 | 9 | 2 | 6 | 25.3 |
| | N | 16 | 31 | 49 | 46 | 74.7 |
| Crop rotation | Y | 45 | 40 | 29 | 44 | 83.2 |
| | N | 2 | 0 | 22 | 8 | 16.8 |

The operations and cropping calendar in the surveyed area is categorized into two forms, highland and lowland cropping calendars. Sub region Segeneyti represents the highland and Hamelmalo, Goluj and Tesseney for the lowlands. In the lowlands, land preparation and planting start in the middle of June, normally just after the first rains while in the highlands land preparation and planting for sorghum depends on the onset of rain normally between March to April (Table-8). The other activities normally coincide to each other and the same to all sub regions.

**Table-8.** Cropping calendar of farm activities for sorghum in the survey area.

| Survey regions | Cropping activities | | | | | | |
|---|---|---|---|---|---|---|---|
| | Land preparation | Sowing | Weeding | Cultivation | Bird scaring | Harvesting | Threshing |
| Highland | Mar.-Apr. | May | Jun.-Aug. | Jun-Aug. | Aug. | Oct.-Nov. | Nov.-Dec |
| Lowland | May –Jun. | Jun.-Jul. | Jun.-Aug. | Jun-Aug. | Sept. | Oct.-Nov. | Nov.-Dec |

Key: Lowland: Hamelmalo, Tesseney and Goluj, Highland: Segeneyti

**Seed sources, selection practices and criteria**

In each cropping season, the household head decides which variety and how much seeds of a given variety were to be planted. In most of the cases, farmers in the study area used their own saved seeds (unless unpredicted factors such as drought acts otherwise) although they may obtain seeds through exchange, gift or purchase. In the present study, 47.4% of the respondent farmers retained seed from their produce, while 9.5% obtained from the market, 7.9% from neighbors, and 1.6 from Ministry of Agriculture and the rest from a combination of the four sources (Figure-3). Very few respondent farmers used improved sorghum varieties provided by the Ministry of Agriculture. This was probably due to the absence or poor distribution of modern varieties or farmers were reluctant to use them and rather stuck to their own landraces.

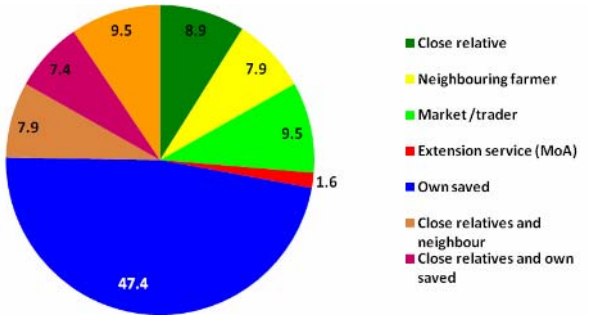


**Figure-3.** Sorghum seed sources of the households.

Majority of respondent farmers do seed selection before harvesting based on a number of traits such as big and long panicles, seed size and color, early maturing types and disease free plants.

**Post harvest constraints and management**

Majority of the farmers stored sorghum grain in containers such as sisal and polyethylene sacks. In


Segeneyti areas few farmers used the traditional store called 'Kofo'. Kofo is above ground raised structure made of clay and cow dung mixtures. About 63% of the farmers indicated that storage pests such as weevils (*Sitophilus oryzae*) were major constraints (Table-9). The combination of storage pests, poor threshing facilities and high moisture content was ranked second in importance in infecting sorghum grain. A few farmers (4.7%) responded that they did not face post harvest problems. The main argument given by these few farmers were that 'post harvest problems were considered as an indicator of carelessness of the farmer themselves'. If one could have avoided the main factors that lead to post harvest loss of sorghum then the loss wouldn't have occurred. According to the elder farmers the causes of post harvest deterioration could be prevented in advance by keeping optimum moisture content at maturity, care at the time of harvesting not to include immature plants, leaving the panicles at threshing floor for some days to dry well before threshing, ensuring the storage environment is clean and if problem of post harvest encountered then timely care should be taken such drying and winnowing.

**Table-9.** Major post harvest constraints affecting sorghum.

| Factors of post harvest problem | | | | | | |
|---|---|---|---|---|---|---|
| **Sub zoba** | **Storage pests** | **Poor threshing** | **High MC** | **Grain mold** | **Storage pests, poor threshing and high MC** | **No post harvest problem faced** |
| Goluj | 25 | 0 | 0 | 0 | 24 | 3 |
| Hamelmalo | 26 | 0 | 1 | 0 | 16 | 4 |
| Segeneyti | 35 | 0 | 0 | 0 | 3 | 2 |
| Tesseney | 35 | 2 | 4 | 0 | 10 | 0 |
| Post harvest problem % | 63.7 | 1.1 | 2.6 | 0.0 | 27.9 | 4.7 |
| Rank | 1 | 5 | 4 | 6 | 2 | 3 |

The post harvest management practices used by farmers could be categorized into traditional, mechanical and physical controls. Farmers have traditionally used plants and tree leaves inside and around their store as sources of insecticides. However, there is very little direct evidence which demonstrates these botanical plants used by the farmers are effective grain protectants. Majority of the farmers do mechanical techniques such sieving, winnowing combined with sun drying, water traps and baits that considered as an insect control in storage. Addition of dusts such as ash is practiced physically by few farmers that provide a barrier to insect movement and damage the insect cuticle causing death by dehydration.

**Variation of sorghum landraces identified and seed systems in the surveyed sub regions**

Subsistence farmers in the survey area generally gave high value on their landraces because of the specific and distinct roles these landraces played in relation to adaption and yield insurances. The choice of landrace to be grown depends on several factors. In field conditions some of the factors that were observed to affect the diversity of landraces include precipitation, temperature, growing season, crop types, farmers' selection criteria and intensity of cropping activities. These factors are directly or indirectly associated with altitude. Sorghum grows slower in higher altitudes. Much of the Eritrean sorghum diversity therefore occurs in the mid and lower altitude areas such as in Gash Barka and Anseba regions. During the survey, it was noted that there were landraces that grew both in the mid and lower altitudes but not in the cool highlands above 1700 m. Sorghum landraces such as Zengeda and Amal are examples of those that adapted to cooler environments. While many of the recorded lowland landraces did not grow in the highlands because they were adapted to the lowland environmental conditions (Table-10).

During the group discussion farmers indicated that they did not rely on one landrace only for production and consumption preferences rather they have more than one cultivar of choice. This is in agreement with Bellon, (1996) and Smale *et al*., (2001), who pointed out that there is no one single variety that is able to satisfy farmers both in production and consumption needs at the same time. Hence, farmers demand multiple varieties to meet a range of objectives. Though farmers have multiple varieties of sorghum in their hand, some of the landraces however are steadily being neglected due to climatic variability such as moisture stress and growing season variabilities. The late maturing varieties are those that are most vulnerable to extinction. Erratic rainfall conditions made the cultivation of long duration varieties very risky. Under such circumstances, only early maturing crop varieties can be grown. Such a situation could gradually lead to a loss of biodiversity. Majority of the Eritrean local sorghum landraces are common among several ethnic groups.

**Table-10.** List of sorghum landraces recorded during group discussion with their localities and status.

| S. No. | Landraces name | Place of production | | | Status | Remarks |
|---|---|---|---|---|---|---|
| | | Zoba | Sub zoba | Village/Town | | |
| 1 | Baryay red | Anseba | Hamelmalo | Gizgiza | Exist | |
| 2 | Baryay white | Anseba | Hamelmalo | Gizgiza | Exist | |
| 3 | Embulbul | Anseba | Hamelmalo | Gizgiza | Exist | |
| 4 | Kibra | Anseba | Hamelmalo | Fledareb | Exists in limited area | |
| 5 | Hariray | Anseba/ gash barka | Hamelmalo, goluj and tesseney | Hamelmalo fledareb, tesseney, goluj and gergef | Widely cultivated | |
| 6 | Red hillo | Anseba and south | Hamelmalo and segeneyti | Fledareb, hadida and adi hadid | Exist | |
| 7 | White hillo | Anseba and South | Hamelmalo and segeneyti | Fledareb, hadida and adi hadid | Exist | |
| 8 | Gimbilu | South | Segeneyti | Hadida, adi hadid, engela and akrur | Exist | |
| 9 | Zengeda | South | Segeneyti | Hadida, adi hadid, engela and akrur | Widely cultivated | |
| 10 | Kinibiba | Gash barka | Tesseney | Thalata Ashir and aligidir | Extincting | Farmers have lost seed |
| 11 | Amal | South zone | Segeneyti | Hadida and engela | Exist | |
| 12 | Anseba | South zone | Segeneyti | Akrur and hadida | Cultivated in limited area | Farmers have lost seed |
| 13 | Wediaker short | Gash barka | Tesseney | Thalata ashir and omhajer | Exist | |
| 14 | Wediaker tall | Gash barka | Tesseney | Thalata ashir and omhajer | Exist | |
| 15 | Feterit | Gash barka | Tesseney | Tesseney and goluj | Cultivated in limited area | |
| 16 | Arfae gedam | Gash barka | Tesseney | Tesseney gergef and omhager | Cultivated in limited area | |
| 17 | Wedifereg | Gash barka | Tesseney/ goluj | Tesseney, gergef, goluj and omhager | Exist | |
| 18 | Ugana/bazenay | Gash barka | Tesseney | Aligidir | Exist | |
| 19 | Koden short | South/gash barka | Tesseney and | Hadida and tesseney | Exist | |
| 20 | Koden tall | South /gash barka | Tesseney and | Hadida and tesseney | Exist | |
| 21 | Wedi arbaa | Gash barka | Tesseney | Aligidir | Exist | |
| 22 | Aklamoya | Gash barka | Tesseney | Aligidir | Extinct | Due to drought |
| 23 | Brown chimro | Gash barka | Tesseney | Aligidir | Cultivated in limited area | |
| 24 | White chimro/ (habarat) | Gash barka | Tesseney | Thalata ashir | Cultivated in limited area | |
| 25 | Ajebsidu | Gash barka | Goluj | Omhajer | Extinct | Due to drought |
| 26 | Hugurtay | Gash barka | Goluj | Goluj, gergef, omhajer and tesseney | Widely cultivated | |
| 27 | Korokora | Gash barka | Goluj | Goluj and gergef | In limited area | |
| 28 | Gunseber | Gash barka | Tesseney | Aligidir | Extinct | Due to drought |

The naming of local landraces was mainly based on their maturity period, grain colour or their use. It became evident that similar cultivars had different names due to differences in ethnicity and locality, thus, there were duplications within the landraces named and listed by the farmers during group discussion. As an example, Hariray grown in Gash Barka seems similar to Red Hillo and Embulbul in South and Anseba regions respectively (Table-10).

The study revealed that 63% of the interviewed farmers were aware of the existence of improved varieties. However, their adoption rates were very low. Nearly 90% of the households (170 households) cultivated mainly landraces, and only 10% of the households adopted improved varieties. The main reasons for not adopting the improved varieties were: risks associated with late maturity, poor tolerance to adverse climatic condition and poor availability. Besides, farmers were also very reluctant to use improved varieties even when available. Few farmers around Hamelmalo area indicated that they used an improved variety called Hamelmalo that was released by Hamelmalo Agricultural College in 2010. Improved varieties Shamuko, Bushka and ICSV 111 IN are also used by some farmers in sub regions Goluj and Tesseney. However, the general tendency of the farmers who participated in the group discussion in these sub regions indicated that the improved varieties are late in maturing and susceptible to striga and birds. The source of seed of improved varieties was the national research systems.

A key issue affecting the demand for improved and traditional landrace varieties is their ability to grow and give yield in marginal conditions. The risk management characteristics, such as good adaptability, early maturity, and drought resistance were considered as the most desirable attributes for farmers to use as a selection for good variety. Early maturing variety, (47%) reported to consider as good variety by the household farmers while 32% express giving reasonable yield during unfavorable condition and 21% adaptability consideration as desirable traits (Table-11).

**Table-11.** Farmers' consideration of most desirable attributes in local sorghum varieties.

| Sub regions | Desirable sorghum characteristics | | | Total |
|---|---|---|---|---|
| | Reasonable yield in bad years | Good adaptability | Early maturing | |
| Hamelmalo | 9 | 16 | 22 | 47 |
| Segeneyti | 26 | 10 | 4 | 40 |
| Tesseney | 18 | 10 | 23 | 51 |
| Goluj | 8 | 4 | 40 | 52 |
| Good attribute % | 32 | 21 | 47 | 100 |

**Sorghum production constraints**

Sorghum production in Eritrea is affected by many factors. This study collected extensive information on this issue to identify the farmer's main sorghum production limiting factors and their prioritization. The current study indicated that the two major sorghum production constraints in the surveyed sites were drought and the parasitic weed, striga. Across all the four sub regions moisture stress, (71%) ranked first followed by striga and diseases (17%) (Table-12). Drought occurs when rainfall is generally low and its distribution is erratic and sometimes leads to complete yield lose. The damage of drought on sorghum depends on the onset of drought and crop varieties used.

**Table-12.** Sorghum production constraints across the four surveyed sub regions.

| Sorghum production factors | Sub zoba | | | | Total | Constraints (%) | Rank |
|---|---|---|---|---|---|---|---|
| | Hamelmalo | Segeneyti | Tesseney | Goluj | | | |
| Drought (moisture stress) | 29 | 27 | 40 | 39 | 135 | 71.1 | 1 |
| Striga and diseases | 8 | 11 | 7 | 8 | 34 | 17.9 | 2 |
| Access to seed | 0 | 2 | 0 | 1 | 3 | 1.6 | 5 |
| Access to labour | 3 | 0 | 0 | 3 | 6 | 3.2 | 3 |
| Access to credit | 2 | 0 | 2 | 1 | 5 | 2.6 | 4 |
| Access to land | 1 | 0 | 2 | 0 | 3 | 1.6 | 5 |
| Access to fertilizer | 3 | 0 | 0 | 0 | 3 | 1.6 | 5 |
| Access to market | 1 | 0 | 0 | 0 | 1 | 0.5 | 6 |


Drought affects sorghum at different developmental stages such as seedling, vegetative, flowering and post-flowering. The knowledge of the growth stage of sorghum is important feature to alleviate when such condition occurred. The results indicated that drought happened at post flowering stage of growth was the most important in influencing farmer's production. Farmers in sub zoba Tesseney and Goluj, however, expressed that the occurrence of moisture stress at post flowering stage was the most common phenomenon. Seed loss due to total sorghum crop failures by drought has been observed once in every three years. This problem was more serious in sub zoba Tesseney where the amount of rainfall is much lower than the other sub regions.

The management methods practiced by the farmers to alleviate moisture stress differ from one sub region to another. In areas like sub region Hamelmalo and Segeneyti where the landscape is hilly and undulated, farmers have established terraces and bundings to harvest the available rainfall inside their fields. Basically to establish such structures is very expensive for resource poor farmers and they are assisted by the Ministry of Agriculture and local administration. The land and crop fields of Goluj and Tesseney sub regions are flat and farmer's drought control practices were mainly focused on establishing soil bunds and flood water diversions. Few farmers who have the capacity to make such activities in their field shared experiences and the yield advantage they got during the group discussion.

The other most commonly used approach to overcome drought was selection of crop variety that fits into the short growing period. Majority of the interviewed household farmers know using drought escaper and early maturing sorghum is at the expense of yield. However, early maturing sorghum landraces assured them of some yields during bad years.

## CONCLUSIONS AND RECOMMENDATION

The sorghum landraces that are documented in this study are from four sub regions which cover part of the existing sorghum diversity in the country. This study brings a future research opportunity to explore in depth and document the entire diversity of sorghum that is available in Eritrea. It becomes clear that farmers play an important role in the dynamics of the creation, perpetuation and extinction of this crop plants. Farmers also provide opportunities for hybridization by bringing together geographically and ecologically isolated landraces. Farmers' selections for desirable agronomic traits are major forces in shaping of this crop plant population on a farmland. The existences of diverse and important morphological traits are the result of farmer's indigenous knowledge of selection and adaption to their areas in the four sub regions. Those landraces we see them today may not exist after some years as happened for the neglected cultivars. It should therefore be emphasized that recollection exercises are necessary for farmers' landraces in Eritrea where genetic erosion is common, primarily due to natural disasters.

Most local landraces are selected by farmers on the basis of good food quality, stable grain yields, brewing quality, and earliness in maturity and drought tolerance. The preparation of traditional home made drinks from Red and Brown grain sorghum for instance can be changed into industry based brewing factory. Sorghum can be thought as a new potential substitute for barley, which can not only resolve the ingredient problem, but also raise economic status of the small scale farmers in particular and the country at large.

This study revealed that farmers faced many challenges in producing sorghum. Terminal drought that prevailed during post flowering stage of the crop was a major constraint that needs attention. Framers recognized that drought escaping and early maturing varieties were the most common desirable traits to overcome this problem. However, in using drought escape as a solution, some of the potential yield was sacrificed in return for improved stability under stress. This is serious; especially when the moisture environment is un-predictable and may vary to a large extent between years. Sorghum improvement program of the country needs to push towards developing promising sorghum varieties with good yield and resistant to drought.

Good seed is the basis for better crop establishment. Seed should be available at right time, produced with great care and stored in suitable environment. Majority of the farmers who participated in this study indicated that they saved their own seed. Seed selection while the crop was in the field was practiced by most farmers who deliberately selected them on the basis of panicle and seed size, seed color and well matured plants. Farmers selected landraces on the basis of phenotypic appearance. However, due to the existence of wild and semi cultivated sorghum progenitors, high rate of out crossing and contamination is expected in the surveyed region. In this regard the national breeding program have to intervene in disseminating improved sorghum varieties with enough seed supply and create awareness on their advantage without endangering the local landraces.

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