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Research article

EFFORTS TOWARDS SOLVING THE DISASTEROUS EFFECT OF EXTREME *STRIGA HERMONTICA* INFESTATION AND SHORTAGE OF RAIN ON SORGHUM PRODUCTION IN THE LOWLANDS OF EASTERN ETHIOPIA

Samuel Tegene*, Birhanu Atomsa*, Amsalu Ayana Asrat Zewidie*, Alemayehu Biri*, Gabisa Banti*, Solomon Ayele* and Fikadu Taddesse*.**

*Fedis Agricultural Research Center P.O. Box, 904 Harar, Ethiopia. ** Integrated Seed Sector Development Program (ISSDP) National coordinator

Author's E-mail address: sm2teg@yahoo.com

ABSTRACT

This paper tried to highlight the efforts made by the newly established Research Center, Fedis Agricultural Research Center, in Eastern Hararghe towards solving the chronic problems of sorghum production faced by the farmers in the lowland areas for a long periods of time by integrating different stakeholders working in the area. At the beginning, we tried to identify the priority problems that needed urgent answer with active participation of farmers. As a result, the farmers were able to list and rank the most important problems which severely affect the yield of sorghum. Accordingly, striga infestation and rain shortage were identified to be the most important. With these in mind, we arranged a forum to make farmers not only source of a problem but also part of the solution. Hence, the farmers were sited the solution to be striga resistant and early maturing varieties. Therefore, we had brought around five early maturing non-striga resistant and four striga resistant sorghum varieties from other Research centers working in the lowland area, checked for their adaptation. The result from the adaptation trial was observed to be promising as compared to the previous local varieties used by farmers. After that, the varieties were demonstrated on FTC and on farmers' fields for two years. Various field visit and field days were prepared and different stakeholders commented on the wider promotion of the varieties. Scaling up and scaling out of the varieties was also accomplished with socio-economic and Extension team of the center as a result of which a number of farmers in

wider areas were benefited from the technology. Even though, Research Centers in our country were not mandated to produce seed for such varieties, Fedis Agricultural Research Center had taken the responsibility of producing the seeds of these sorghum varieties for four consecutive years and able to deliver a total of 967.56 kuntal of nine varieties of sorghum to the lowlands of Eastern Ethiopia whereby 1935 farmers of 10 lowland woredas of the Eastern Hararghe zone, Harari region, Somali and Dire Dawa had got access to seeds to cover at least half a hectare of their land. However, seed production for sorghum and also for other crops was a very laborious and intensive activity which could not be accomplished by research centers sustainably; the center has decided to share the responsibility to other stakeholders such as Minister of Agriculture and Integrated Seed Sector Development Program (ISSDP) to organize seed producing farmers and capacitate them in terms of skill and money by training and buying some input like seed and fertilizer as a starting material, in close association with Fedis Agricultural Research Center.

Keywords. Sorghum, Striga hermonthica, resistance.

INTRODUCTION

Sorghum (*Sorghum bicolor*) is an essential to diets of poor people in the semi-arid tropics where droughts cause frequent failures of other crops. Sorghum contributes to the food security of many of the world's poorest, most food-insecure agro-ecological zones (FAO and ICRISAT, 1996). Poverty alleviation has been a principal objective of technology development strategies in sub-Saharan Africa for crops with drought resistance, specifically sorghum, millet, peanuts, and cowpeas. Poverty is concentrated in rural areas and a high proportion of the population (25%) of sub-Saharan Africa lives in semiarid regions (Sanders et al., 1996). Sorghum is one of the leading food crops of Ethiopia. It ranks third in the country following maize and tef in total production and second to tef in injera making. The crop is utilized in different forms, where the grain is used for human food and home made beverages, the leaves and stalks are commonly used as animal feed. The hefty stalked sorghum is used for construction of houses and as fuel wood. The juicy stalks are commonly chewed like sugarcane (Birhane, 1982; Habtu, 1995). Sorghum suffers from a lot of pests among which striga is the most important. The genus Striga belongs to the family Scrophulariaceae and currently thought to include 35 species (Parker and Riches, 1993). Of these species of Striga currently recognized as present in Africa, *Striga hermonthica, S. asiatica, S. aspera, S. forbesii* and *S. gesnerioides* are of particular economic importance as crop pests (Mohammed et al., 2001). These species attack all the important tropical cereals with the exception of S. gesnerioides which parasitizes only dicotylidons.

The parasitic weed *Striga*, which attaches itself to the roots of plants and "sucks out" the nourishment, has caused extensive loss of cropland productivity in the drought-affected, food deficit areas of Eastern Ethiopia. Estimated losses in infested fields of sorghum and finger millet range from 40-100% (Robert, 1996). Farmers choose terms that appropriately characterise their problems. In Amharic, *Striga* is called *`Kitgyn'* which literally means syphilis. The insinuation is that the land becomes unproductive and the condition becomes difficult to cure. In Oromifa, *Striga* is

called `*Desso'* which means `that which stunts another' (Robert, 1996). Striga is almost certainly responsible for more crop loss in Africa than any other individual weed species. Over 5 million ha of crops - mainly sorghum, millets and maize - are affected in six countries of West Africa alone (Sauerborn, 1991), possibly 10 million ha in Africa as a whole. One plant of Striga per host plant is estimated to cause approximately 5% loss of yield (Parker and Riches, 1993) and high infestations can cause total crop failure. Overall yield losses are estimated at 21% of all sorghum in northern Ghana, 10% of all cereals in Nigeria, 8% in Gambia and 6% in Benin (Sauerborn, 1991). Other countries seriously affected include Cameroon, Cote d'Ivoire, Burkina Faso, Niger, Mali, Senegal, Togo, Sudan, Ethiopia, Kenya, Uganda and Tanzania.

The damaging effect of Striga on the host plant derived not only from the direct loss of water, minerals, nitrogen and carbohydrate to the parasite, but from a disturbance of the host photosynthetic efficiency (Press and Graves, 1991) and a profound change in the root/shoot balance of the host, leading to stimulation of the root system and stunting of the shoot.

Many factors contribute for the infestation of striga in the Eastern Hararghe to be sever and wider in area coverage. Low and unreliable rainfall (400-600 mm) prevalent in many of the poor lowland areas of the Eastern Hararghe means a high incidence of drought and crop failure, further contributing to food insecurity and poverty. However, *Striga* thrives on low rainfall or drought situations can use up to 4 times more water than sorghum and its metabolic system stunts sorghum top growth which would shade and compete with the *Striga*. Small land holdings and shortage of assets of the poor people in the area further limit the choice of crops and practices for controlling or rehabilitating land from *Striga* infestations. The small farmer must plant the majority of his land in sorghum to have any chance of providing enough food for the family. So, mono-cropping of sorghum is their usual practice which aggravates the infestation. Besides, inputs of chemical fertilizer and herbicides, which can help control or eliminate *Striga* infestations as well as raise yield levels, normally have low marginal returns in drought prone, *Striga* infested areas, making these farmers poor credit risks for input loans. Lastly, poor soil fertility, especially soils low in nitrogen and organic matter, not only give poor crop yields but also contribute to increased *Striga* germination, increased flowering and seed production and prolonged *Striga* seed viability in the soil.

No completely immune cereal varieties have yet been developed, but many sorghum varieties show high levels of resistance, at least under local conditions. Selection and breeding programmes in India and Africa have led to the development and release of many lines with at least reduced susceptibility, and these may be valuable as components of an integrated control approach (Carsky et al., 1996). However, improved varieties released from different research centers in Ethiopia often show relatively high tolerance, and these may yield well in spite of heavy infestation.

Basically, the farming system in Fedis and Babile *woreda*s should be revised in the cropping areas, since Eight-month-cycle and susceptible to striga sorghum, being rain-fed, is simply too vulnerable and dependent on rainfall

patterns. A re-orientation towards shorter cycle crops like early maturing sorghum, wheat, haricot beans, pulses and vegetables would help farmers cope better with the climatic hazards of the *woreda*. However, the reason why farmers have stayed with the traditional cultivation of long-cycle sorghum was the fact that people use the plant not only as a food source but use the stems as animal feed, construction material for house roofs and as cooking fuel. Therefore, before changing crop patterns, meaningful substitutes need to be developed to compensate for the multi-purpose use of sorghum. However, the local sorghum varieties sown under higher striga infestation were unable to deliver the multiple functions it gave under non-infested condition because of the stunting effect of the striga due to competition for nutrient and water. More over, the integration of different research teams in availing the multiple benefit farmers get from long cycle sorghum is also important. In this regard, Animal feed and natural resource team of our center had availed a lot of solutions to the farmers.

Host-plant resistances are the inherited ability of a plant species toward off or resist attack by pests or to be able to tolerate damage caused by pests. Resistant varieties are one of the important components of pest management and can easily be combined with other control methods. In line with this and the above aforementioned problems, the cereal and farm management teams of the center had proposed these activities with the following objectives:

Objectives

- To see the adaptability of improved, early maturing, high yielding and striga resistance sorghum varieties for striga infested and non-infested moisture stress areas of Eastern Haraghe
- To jointly evaluate, demonstrate, promote and avail adapted varieties of sorghum to the farmers in the vicinity with different stake holders

MATERIALS AND METHODS

Site description

East Hararghe, located in the North Eastern part of Oromyia Region and bordering Somali Region as well as the urban administrative regions of Dire Dawa and Harari, comprises three agro-climatic zones: *kolla* (lowlands, about 36.5 per cent of the sub-region's surface), *weyna dega* (midlands, 44 per cent) and *dega* (highlands, 19.5 per cent). While at lower altitudes crop cultivation is usually rather limited leading to a more livestock-based economy, the economy at higher altitudes is characterised by both food crops and cash crops. Chat, a mildly narcotic plant used as a stimulant, is among the major cash crop which also include onions, Irish potatoes and vegetables. An exception to the general cultivation constraints of the lowlands represents the eastern weredas of Babile and Gursum, where groundnuts (peanuts) are produced as a cash crop (Ralph, 1998).

Traditionally the lowland areas suffer from chronic food insecurity. To a certain extent, some locations at mid-altitudes also have a history of vulnerability, since by and large the agriculture system remains rain-fed, exposing mainly long cycle crops such as sorghum and maize to the mercy of rainfall patterns. While all the 20 *woredas* of

East Hararghe Zone have at least some pocket areas with needy populations, those regularly requiring major relief food intervention in the recent past are *Fedis, Babile, Girawa, Gursum, Gola Odana and Goro Gutu*. Among these, the *weredas* located in the eastern and southern part of the zone have significant lowland areas.

Recently established Fedis Agricultural Research Center (FARC) is located in the Eastern part of the country and carried out a lot of research activities (from the field to the dish) which helped and based mainly on the lowland areas which were known by their moisture stress in East Hararghe. These areas usually receive average annual rain fall of 400 - 600 mm. The minimum and maximum temperature of the areas is 20 – 25^{o}C and 30 – 35^{o}C, respectively and their altitude ranges from 1200 – 2118 meter above sea level (masl).

Problem Identification

Before conducting crop research, it was important to identify the problems and determine the extent of the problems of crop production, using Participatory Rural Appraisal, direct observation, farmer surveys, or expert opinion. Since PRA exercises provide the community members with the opportunity to share their ideas, identify and prioritize their problems, co-plan, co-implement and co-evaluate activities. PRAs were accomplished in some of the Lowland Districts of the zone with a multidisciplinary team of Researchers in the center. Group discussions with farmers of different category were held separately like with men and women, with young and old, with rich and poor to get comprehensive information about the area. Participants were asked to list and rank the constraints of crop production including the pest problems. As a result, a number of crop production problems were identified. A direct observation was also made to crosscheck the reality of the existing situation.

Adaptation trials of striga resistant and non-striga resistant, high yielding and early maturing Sorghum Varieties in the lowlands of Eastern Hararghe

The experiment on striga resistant sorghum varieties was carried out at Fedis Agricultural Research Center (FARC) on station which was known by its moisture stress in East Hararghe Zone in 2009. The area receives average annual rain fall of 400 - 804 mm the minimum and maximum temperature of the area is 20 – 25^{o}C and 30 – 35^{o}C, respectively and its altitude ranges from 1200 – 1600m.a.s.l. Seven early maturing sorghum varieties namely *Abuare*, *Girana*, *Meko*, *Misikir*, *Yeju*, *Teshele* and *Raya* were collected from Melkassa Agricultural Research Center. More over, four early maturing and striga resistant varieties namely *Abshir*, *Gubiye*, *Gedo* and *Hormat* brought from the same center and other centers working in similar agroecology in the country; planted separately with striga seeds sown uniformly on each plots intentionally to see the plants performance under striga infestation.

The varieties were planted in randomized complete block design with three replications with spacing of 50cm and 15cm between rows and plants respectively. Plot size of 5m x 10m was used. Seed rate of 8 kg/ha was used by drilling in the prepared rows then immediately 10 days after emergency thinning was accomplished with the

intention of having optimum plant population with the desired plant spacing. Shallow planting of 2-4cm depth was used. Fertilizer rate of DAP 75kg/ha and Urea 50 kg/ha was applied with Dap at sowing and urea at booting stage respectively. Weeding was accomplished two times one at one month after sowing and one and half months after sowing. Two earthening ups followed the two weedings; the first being for ease of moisture uptake by the plant and the second being to enable the plant easily utilize urea and avoid loss of urea from volatilization.

Demonstration and Participatory evaluation of Adapted sorghum varieties

Adapted and selected varieties of sorghum were planted both on-station and on three FTC fields in a plot of area of 10X10m in non-replicated plots with the recommended management practices. Farmers Field day encompassing different stakeholders was prepared. Stake holders involved in the field day were University professionals, NGOs, Researchers from different research centers, MOARD, Zone and Woreda Administrators and Farmers. Feedback and comments on the way forward and on the performance of the varieties was taken.

Large scale seed multiplication and promotion of the varieties

After demonstration the varieties were multiplied in large scale with the Center's Farm Management team since there was no organization which multiplies seeds of adapted sorghum varieties in the area. Different Media like TV and Radio were used to promote the multiplied varieties. To produce quality seed, all the management activities starting from land preparation up to storage and packing were strictly monitored by a team of researchers consisting of Agronomists, Breeders, plant protection expert, Pre-harvest researchers, post-harvest researchers and Agricultural mechanization researchers.

Scaling up and scaling out of adapted sorghum varieties

The purity, germination percentage and their emergency potential of the harvested seeds was done for each of the multiplied seeds following standard procedures. This information was packed with the seeds. More over, leaflets on the necessary agronomic practices from land preparation to harvesting and storage was prepared in three languages Amharic, English and in Oromifa and accordingly the leaflet was inserted into the sack depending on the destination of the seeds. In two of the woredas, Babile and Fedis farmers were trained on how to manage the varieties. Besides, a team of researchers consisting agronomists and extension agent was used to assist farmers from land preparation, through sowing, weeding up to harvesting. At the end, farmers' perception and feed back on the varieties was collected by socio economics researchers.

Data Analysis

All agronomic and yield data were collected and analyzed using IRRISTAT software program. Besides, all other relevant data were summarized and presented using descriptive statistics.

RESULTS AND DISCUSSION

Problems identified

Thorough discussions with farmers' and farmers' representatives through Participatory Rural Appraisal (PRA) and Focus Group Discussion (FGD) were held at Fedis and Babile *Woreda*s to identify and prioritize crop production problems in the area (Fig. 1.).

Figure 1: PRA and Focus group discussion held with Farmers to identify and prioritize crop production problems and possible solutions

As a result, problems such as crop diseases and insect, lack of improved varieties for major crops, moisture stress (shortage of rain), striga problem and low soil fertility were the identified through PRA. As it was observed, the identified problems were interrelated. Since it was difficult to address the whole identified problems at once, there was a need to prioritize the problems with pair-wise ranking as revealed on the table 1 by farmers themselves. Accordingly, farmers tried to prioritize the problems of crop production in the area. As a result, striga infestation was identified to be the most important problems which needed immediate solution (Table 1). The second problem which needed intervention was moisture stress or rain shortage. The last was low soil fertility. Having this in mind, the team has tried to assess the existing situation to cross

check the prevalence of the problems identified. Hence, the team redundantly observed severely striga infested farmers' field in different kebeles in the Woreda (Fig. 2.).

Table 1: Pair-wise rank of crop production constraints by a sample of farmers from five *Kebeles* of Fedis and Babile Districts

Problems	**Crop disease & insect**	**Lack of improved variety**	**Moisture stress**	**Striga problem**	**Low soil fertility**	**Score**	**Rank**
Crop disease & insect (CDI)		CDI	MS	SP	SP	1	4
Lack of improved variety (LIV)			MS	LIV	LIV	2	3
Moisture stress (MS)				SP	MS	3	2
Striga problem (SP)					SP	4	1
Low soil fertility (LS)						0	5

It was common to observe fields that were highly infested with *striga hermonthica* even after harvest in the areas (Fig. 2). These clearly revealed farmers were observed and prioritized the problem which needed urgent solution. So, the team didn't need further investigation to realize the information. As a result, existing opportunities for giving urgent solution were browsed from anywhere in the country or outside the country. From identified solutions, improved, early maturing and striga resistant varieties released from different research centers in the country for similar agro ecologies with our area was sounded better and was able to answer multiple problems of the farmers.

Figure 1: Striga infestation in farmers' sorghum field even after harvest in the lowlands of Eastern Hararghe

Adaptation trials of non-striga resistant, high yielding and early maturing and striga resistant Sorghum Varieties in the lowlands of Eastern Hararghe

Seven early maturing and non-striga resistant varieties namely *Abuare*, *Girana*, *Meko*, *Misikir*, *Yeju*, *Teshele* and *Raya* were collected from Melkassa Agricultural Research Center and sown at Fedis On-station to see their adaptation in the area in non-striga infested fields with a problem of rain shortage. These varieties matured in 3-4 months in relation to farmers' varieties which took long time approximately up to eight months to mature. Moreover, the varieties were high yielding up to 40 kuntals per hectare in the case of *Teshale* provided that the necessary management practice was accomplished (Table 2). The varieties showed highly significant variation in terms of their grain yield per hectare. *Teshale* outsmarted all the varieties in its yield with 40 kuntale per hectare (Table 2.). *Meko* and *Miskir* both yielded second with 37 quntal per hectare. While, a variety *Abuare* was identified to give the lowest yield with 23 kuntal per hectare.

In general, the varieties were able to give reasonable yield under the existing moisture shortage prevailed in the area. However, it is important to adjust the sowing time of the varieties so as to synchronize the varieties' maturity with the local varieties or clustering the same varieties in the villages. This enabled the varieties to escape the high bird pressure and damage as a result of early maturing. So, it is advisable to sow these varieties starting at end of June up to the mid of July under Eastern Hararghe condition to enable the varieties to mature at the maturity period of the local varieties. Moreover, these varieties have susceptible reaction to striga and needs intensive management from land preparation, sowing, thinning through weeding, fertilizer application and earthening up. Hence, farmers with striga free fields were selected during seed distribution.

Table 2: Mean grain yield and some agronomic parameter of early maturing sorghum Varieties

Varieties	Days to Emergency	Days to Heading	Days to Flowering	Stand count at Emergency	Stand count at Harvest	Days to Maturity	Grain yield in kuntal per hectare	Thousand seed weight in gram
Abuare	9.67	61.67	65.67	206.33	184.00	110.00	23.00	27.00
Girana	10.67	52.00	60.67	291.67	280.00	105.00	35.00	32.17
Meko	9.33	63.00	67.67	306.67	288.33	110.00	37.00	33.00
Misikir	11.00	52.67	59.00	239.00	222.33	105.00	37.00	34.00
Yeju	10.33	52.00	55.00	173.67	164.00	105.00	32.50	30.00
Teshale	10.33	66.00	71.67	259.00	245.00	110.00	40.00	37.67
Raya	11.00	62.00	66.33	245.00	232.00	110.00	30.00	30.00
SE	±0.43	±1.85	±1.78	±8.36	±10.04	±0.56	±1.22	±0.14
P-value	ns	**	**	**	**	ns	**	*

**= P < 0.01 and ns=P >0.05

To give urgent answer for the prioritized problem, four striga resistant/tolerant varieties namely: *Abshir*, *Gubiye*, *Gedo* and *Hormat* were brought from Melkassa Agricultural Research Center in 2009 cropping season and sown at Fedis On-station to see their adaptation in the area of striga infested fields through creating sick plots for each

varieties. Accordingly, all varieties revealed non-significant variation in all parameters considered to measure their performance (Table 3). These varieties performed invariably well in terms of yield in relation to the local varieties on striga infested field. No significant variation was observed among the varieties in terms of yield. *Gubiye* with 34.78 kuntal/hectare ranked first in yield followed by *Gedo* with 32.67 kuntal/hectare. The lowest yield was achieved with *Abshir* yielding 29.00 kuntal/hectare.

Table 3: Mean performance of grain yield of Striga resistant sorghum and some agronomic parameter

Varieties	Days to Emergency	Days to Heading	Days to Flowering	Stand count at Emergency	Stand count at Harvest	Days to Maturity	Grain yield in kuntal per hectare	Thousand seed weight in gram
Abshir	7.33	50.67	54.67	186.00	171.00	105.00	29.00	32.83
Gedo	8.67	54.67	59.00	319.67	295.00	110.00	32.67	32.00
Gubiye	8.22	54.54	58.70	315.76	269.80	111.00	34.78	32.60
Hormat	8.33	55.33	58.67	342.00	319.67	110.00	32.50	31.50
SE	±0.38	±1.47	±2.16	±8.96	±10.58	±0.49	±0.96	±1.15
P-value	ns	ns	ns	**	**	ns	ns	ns

**= $P < 0.01$ and ns=$P > 0.05$

The performance of the varieties in dry land areas with erratic rainfall and where there is chronic moisture shortage in addition to striga infestation is approved by different authors. According to Yitebitu, 2004 the varieties were able to grow in areas, which were too dry and too hot for other crops. Therefore, sorghum is called the 'camel' of the plant kingdom. Complete failures to moisture scarcity are much less frequent in sorghum than other crops like maize, wheat etc. The use of resistant crop cultivars is the most economically feasible and environmentally friendly means of *Striga* control. However, cultivars with immunity to *Striga* have not been found in any host crops (Vogler, et al., 1996). Vogler, et al., 1996 described further that multiple genes for *Striga* resistance, found so far only in sorghum, have been pyramided in cultivars that also possess desirable genes for agronomic and grain quality traits. In this regard, striga resistant improved varieties of sorghum yield better than the local varieties under the prevailing sever infestation of striga and moisture stress. It was redundantly observed that the local varieties in the area were harvested for animals with very small to zero yield because of shortage of rain and sever striga infestation in the area. Figure 2. below also confirmed the existence of variation in yield and striga infestation in two nearby fields planted with striga resistant *Gedo* and local varieties. Moreover, the use of resistant sorghum varieties could be a key component in combating *Striga* since the lower level of stimulant exuded from the roots greatly reduces *Striga* germination (http://www.worldscibooks.com/lifesci/6470.htm) which further contribute for lowering of striga seeds from soil seed bank which other wise produce seed for next season infestation.

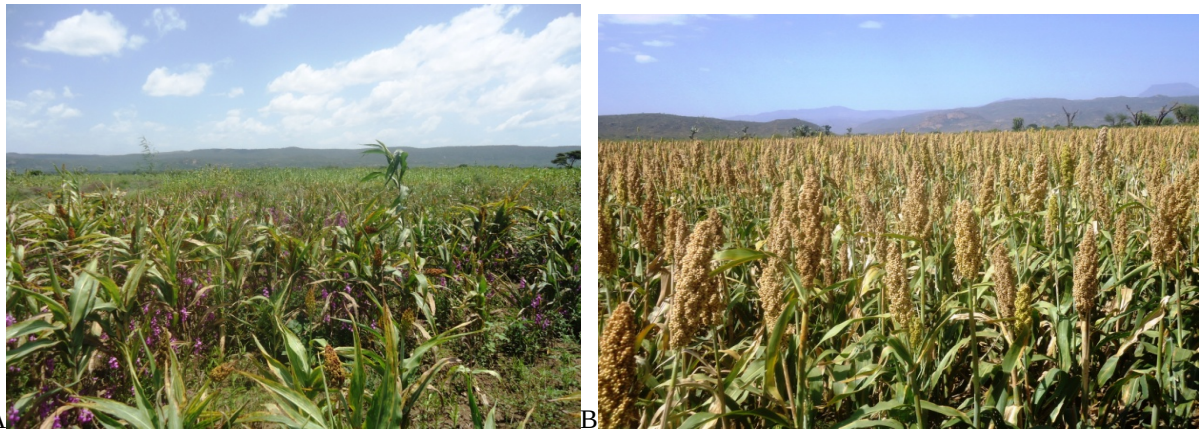


Figure 2: Variation observed in striga infestation and in yield of two nearby fields planted with local(A) and improved striga resistant variety *Gedo*(B) at Fedis

Demonstration and participatory evaluation of adapted sorghum varieties

Farmers' field day encompassing around 500 agricultural professionals (Fig. 3) was prepared by the center to demonstrate and to give chance to different stake holders to share their view regarding the varieties and the way forward on the fate of the varieties. Farmers' field visit was prepared in the last two years. As a result, higher demand for these varieties was created. Moreover, the professionals participated in the field day were delivered their comment on the way the varieties were scaled up and out. The participants also stressed that the importance of the participation of development partners and even farmers and other seed producing agents in producing and availing the seeds of these varieties in good quality and quantity at the right time and place.

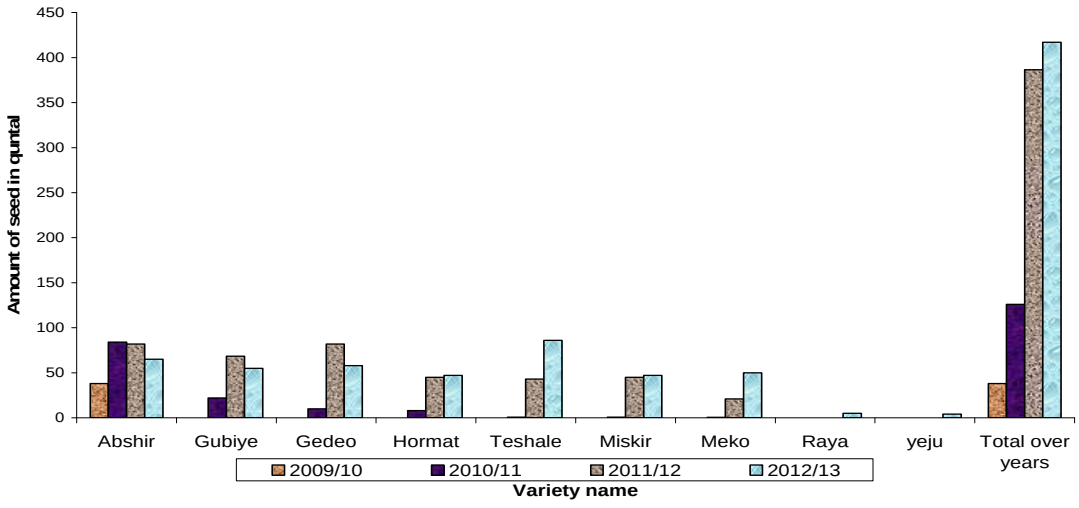
Figure 3: Field day and Field visits prepared in the last three years at Fedis and Babile

Output from Seed production and Promotion of the Varieties

Seed is a key input for improving crop production and productivity. Increasing the quality of seeds can increase the yield potential of the crop by significant folds and thus, is one of the most economical and efficient inputs to agricultural development (FAO, 2006). Generation and transfer of improved technologies are critical prerequisites for agricultural development particularly for an agrarian based economy such as of Ethiopian. Despite the release of several technologies, particularly of improved crop varieties, there has been limited use of improved seeds by the majority of farmers (CSA, 2010). Among others, unavailability of quality seeds at the right place and time coupled with poor promotion system, is one of the key factors accounting for limited use of improved seeds, which further contributing for low agricultural productivity. Poor availability and promotion of improved seeds is due to inefficiency of the seed systems of the country.

Farm management team of the center has been multiplying seed of striga resistant and non-striga resistant drought tolerant and early maturing varieties of sorghum for four consecutive years. As a result, the team had availed a total of 967.56 kuntal of nine varieties of sorghum to the lowlands of Eastern Ethiopia whereby 1935 farmers of 10 lowland woredas of the Eastern Hararghe zone, Harari region, Somali and Dire Dawa had got access to seeds to cover at least half a hectare of their land in collaboration with MOA, NGOs, Unions and other stakeholders (Fig. 4). It is known that sorghum as well as other crops seed production need special care and intensive management so as to maintain the purity and the quality to the desired standard. In this regard, the center has allocated a lot of budget and the required professionals in all steps to maintain the required standard. As a result, each variety was monitored closely from sowing to delivery to farmers to avoid any mistakes with regard maintaining purity and quality.

Figure.4 Amount of sorghum varieties multiplied by farm management team from 2009-2013



Seed production or maintenance of a genetic constitution of the seed is a quite specialized and scientific procedure and is not similar to general food crop production. It is important that seed of a new and superior variety should be multiplied and made available in quantities as soon as possible so as to benefit the farmers. Seed production is carried out under standardized and well organized conditions (Trivedi, et. al., 1998). During seed production strict attention is given to maintain the genetic purity and other qualities of the seeds. All cares with regard to starting with pure seeds, maintaining isolation distance from other fields or using physical barriers, following recommended agronomic practices, rogueing off-type plants, harvesting and threshing carefully, removing any off-type seeds, cleaning and drying the seeds well and storing the seeds were all accomplished properly.

Scaling up and scaling out of the technologies

Around three proposals were developed by socio-economics and extension team of the center so as to promote wider area production and dissemination of these varieties in collaboration with other partners. As a result, the varieties were reached the remote lowlands of Eastern Hararghe and even the neighbouring non-mandate regions of Somali, Harari and Dire Dawa were benefited from the varieties. The proposals encompassed activities like: promotion of the varieties with different media, giving training to farmers, facilitating the way for timely delivery of the seeds to the farmers in collaboration with other stake holders, delivering the seed with the necessary agronomic packages, monitoring and evaluation of the varieties if the varieties were managed properly on farmers field, assessing of successes and failures after production and recommend the way forward.

Feedback from the farmers was collected from two sample woredas Fedis and Babile. The farmers in the woredas gave their witness about the importance of using these varieties in alleviating the existing problems in the area. One of woman farmer in the area had tried to compare some of the varieties for instance *Abshir* in terms of '*Injera*' making quality with the local sorghum. Hence, she had grounded one kg of *Abshir* and one kg of local sorghum and made *injera* out of it. Comparing the two varieties in the number and quality of *injera*, *Abshir* had given more number of and quality *injera* than the local one. On the other hand, the farmers had faced sever bird problem as a result of maturing early due to early or untimely planting. Moreover, the varieties have short plant height and low biomass as compared to the local varieties. Since, farmers in the area planted sorghum not only for their grain but also for stalks which they used as animal feed, fuel and construction material.

It was known that synchronization of the varieties maturity with all crops' maturity through adjusting sowing date was important to decrease birds' pressure. Furthermore, striga resistant varieties are early maturing with short stalk, however under higher striga infestation the local varieties are highly stunted resulting in shorter stalk which by default low biomass than the striga resistant varieties. Moreover, farmers can plant the striga resistant varieties denser than the local which result in more biomass. On the other hand, the striga resistant varieties were observed to have more ratoon than the local one which further harvested for their animals later.

DISCUSSSION

Sever striga infestation and shortage of rain (moisture stress) were identified to be the most important problems constraining sorghum production. All improved varieties brought to solve the identified problems were observed to give good yield as compared to the local varieties except for stalk. The varieties were demonstrated to different stakeholders as a result the demand for the varieties rose. To satisfy the demand, Fedis Agricultural Research Center had taken the responsibility of producing the seeds of sorghum varieties for four consecutive years and able to deliver a total of 967.56 kuntal of nine varieties to the lowlands of Eastern Ethiopia whereby 1935 farmers of 10 lowland woredas of the zone, Harari region, Somali and Dire Dawa had got access to seeds to cover half a hectare of their land. However, seed production for sorghum and also for other crops was a very laborious and intensive activity which could not be accomplished by research centers sustainably; hence the center has started to give the responsibility to other stakeholders such as Minister of Agriculture and Integrated Seed Sector Development Program (ISSDP) to organize seed producing farmers and capacitate them in terms of skill and money by training and buying some input like seed and fertilizer as a starting material, in close association with Fedis Agricultural Research Center.

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