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Original Article

Introduction and Registration of Food Barley Varieties for Fedis and Similar Districts of the Eastern Hararghe Zone, Eastern Ethiopia

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ABSTRACT

Trials from adaptation to registration of food barley varieties were conducted at Fedis district in Eastern Hararghe Zone of Eastern Ethiopia during 2010/11, 2011/12 and 2012/13 main seasons to evaluate the performance of introduced improved early maturing food barley varieties. The treatment of adaptation trial consisted of six Barley varieties laid out in randomized complete block design with three replications. The results indicated that three varieties Aquila, Golden eye and Walker exhibited superior characters in terms of grain yield, early maturity and resistance to diseases. Golden eye was observed to give the highest yield per hectare with a value of 29.86 followed Aquila with a value of 26.00 quintal per hectare. The seed of three varieties that perform better both in yield and in disease reaction were distributed to five kebeles of Fedis district to be planted in FTCs with a brochure on all the management practice and farmers' field day constituting 500 agricultural experts and more than 500 farmers were commented the good performance; as a result creating higher demand for the varieties. Then, Variety verification trial on the three candidate varieties with standard check was accomplished at four kebeles. The three varieties remained superior in yield and other parameters in these trials also regardless of the location. Unlike the adaptation trial the variety Walker gave highest yield of (25.97qt/ha) followed by Aquila (23.47qt/ha). The variety with the lowest amount of yield per hectare (13.83 qt/ha) was the standard check. Moreover, the candidate varieties were able to tolerate the leaf rust infestation that regularly occurred in the area. The trials were visited by National Variety Releasing Committee (NVRC); where by a fantastic news on three varieties registration in the name of Fedis Agricultural Research center for Fedis and similar agro ecologies with full mandate of the center to multiply and maintain the varieties with the intention of delivering to the beneficiaries keeping their identity was given to center. Recently, the varieties were able to successfully enter to the cropping system of the area benefiting farmers to solve significantly the food security problem that repeatedly occurs in the area.

Keywords: Food barley, grain yield, Disease resistance, registration, NVRC

INTRODUCTION

In developed countries, barley is primarily used for animal feed, malting and brewing with little designated for food. However, in Ethiopia and in many developing countries, barley is produced mainly as a food crop, and it is the fifth most important cereal crop in Ethiopia after tef, maize, sorghum and wheat (CSA, 2000). The country is recognized as the secondary centre of diversity for barley (Vavilov, 1951), and the Ethiopian barley germplasm has been important worldwide as a source of useful genes for traits such as disease resistance (Bonman *et al.*, 2005). The crop is produced by subsistence farmers mostly grown as landraces with little or no application of fertilizers, pesticides and herbicides (Lakew *et al.*, 1997). Landraces are defined as traditional varieties developed through natural and human selections, which are named and maintained by traditional farmers to meet their social, economic, cultural, and ecological needs (Teshome, 1997). Barley is cultivated from 1400 to over 4000 m above sea level, and its importance increases in drought-prone areas and at higher elevations (above 2800 m) where poor soil fertility, frost, water logging, and soil acidity and degradation are the major yield limiting factors (Asfaw, 2000). The major barley producing regions in Ethiopia are Oromiya, Amhara and Tigray Regional States, which account for about 87% of the national barley production (CSA, 2000). Therefore, barley holds an important position in the food security of Ethiopia.

The national barley improvement program in Ethiopia has been working on barley with more focus on highland areas and able to release many varieties to this agro ecology. However, only two varieties namely: *Mintu* and *Desta* were released for dry land areas with average annual rainfall of greater than 500mm (EIAR, 2007). On contrary, dry land areas in Eastern Hararghe were not used to receive this amount of rainfall in the main season; if they were able to receive the amount described and above, the distribution is uneven and erratic. It is known that, drought is one of the major production constraints that reduce crop yields in water-limited areas, where many of the world's poorest farmers live (Nguyen, Babu and Blum, 1997). This is a serious problem in arid and semi-arid regions, and in places where total precipitation is high but unevenly distributed through the growing season. About 70% of the land mass of Ethiopia is prone to low rainfall, and genetic improvement for grain yield of different crops under this constraint has been very slow (Mulatu and Grand, 2011). As a result, farmers in dry areas lead a precarious existence with few resources and the risk of drought discourages investment in inputs, particularly fertilizer. Rainfall is invariably low and often erratic and low yields are common. As the world population continues to grow and water resources for crop production decline, development of drought-tolerant cultivars and water use-efficient crops is a global concern.

The gradual introduction trial and development of new technologies have allowed considerable progress to be made in some dry land farming communities (Chapman *et al.*, 1996). The adaptation of new techniques is entirely dependent upon the skill and environmental awareness of dry land farmers (Twomlow *et al.*, 1999). Integration of new technologies with tested management approaches is a measure that can improve human well-being at various levels. Breeding new and improved crop varieties enhances the resistance of plants to a variety of stresses that could result from climate change (Allard, 1960). These potential stresses include water, heat, salinity and the emergence of new pests. Varieties that are developed to resist these conditions will help to ensure that agricultural production can continue and even improve despite uncertainties about future impacts of climate change.

The cropping system in the lowlands of Eastern Hararghe is characterized by mono cropping of local variety sorghum which take seven to eight months year after year without rotation and diversification. The aim of crop diversification with regard to climate change is to increase crop portfolio so that farmers are not dependent on a single crop to generate their income (Ojasti, 2001). When farmers only cultivate one crop type like local sorghum in the lowlands of Eastern Hararghe, they are exposed to high risks in the event of unforeseen

climate events that could severely impact agricultural production, such as emergence of pests and the sudden onset of frost or drought. Introducing a greater range of varieties also leads to diversification of agricultural production which can increase natural biodiversity, strengthening the ability of the agro-ecosystem to respond to these stresses, reducing the risk of total crop failure and also providing producers with alternative means of generating income (Smale *et al.,* 2003). With a diversified plot, the farmer increases his/her chances of dealing with the uncertainty and/or the changes created by climate change. This is because crops will respond to climate scenarios in different ways. Whereas the cold may affect one crop negatively, production in an alternative crop may increase.

According to Allard (1960) plant introduction is the acquisition of superior varieties by importing them from other areas. Or plant introduction is the process of taking/ introducing plants/ genotype or group of genotype into new environment where they were not being grown before. Introduction may involve new varieties of a crop already grown in the area wild relatives of the crop species or totally new crop species for that area. Plant introduction may within the country between the countries or confirmed between the states or within the state. The plant may be introduced from the country or another continent.

In the case of Fedis, it was uncommon to grow barley in the area. So, people in the area used to grow local sorghum which took around eight months to mature without rotating year after year. It is known that sorghum canopy coverage is not sufficient enough to protect the upper fertile soil from erratic and unevenly distributed rainfall. Moreover, there was no opportunity for farmers to sow other crops of small cereals such as barley which could help to cope with climatic disasters. Hence, this leads to the deterioration of soil fertility, redundant pest incidence and crop failure. Diversifying from the monoculture of traditional staples can have important nutritional benefits for farmers in developing countries and can support a country to become more self-reliant in terms of food production (Smale *et al.,* 2003). Diversification can also manage price risk, on the assumption that not all products will suffer low market prices at the same time (Ojasti, 2001). Compared to producing monocultures, management techniques for diversified crops generally consist of more sustainable natural resource practices. Therefore, this activity was proposed with objective of curbing the above aforementioned problems.

MATERIAL AND METHODS

Site Description

Fedis district has latitude between 8°22’ and 9°14’ north and longitude between 42°02’ and 42°19’ east, in middle and low land areas: altitude range is from 1200 – 1600m.a.s.l metres, with a prevalence of low lands. 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. The population’s livelihood mainly consists of agriculture, husbandry and small-scale trade. The farm units are small family holdings with an average agricultural land area of less than one hectare. Agriculture is mainly rain-fed. The cropping system is classified as intensive with cereal mono-cropping mainly sorghum and maize. Similar to areas in the Horn of Africa, two rainy seasons characterise the Fedis district’s climate: the first, named *Belg*, is the shortest one and takes place between March and May, while the second and most important, named *Meher*, is between July and October. The rainfall distribution during the year is then bi-modal, with a dry spell period during the months of June and July, depending on its duration, may affect crop growth. The *Meher (Main)* season is the most important one; when the intensity of farm practices and production increase. This season ends with the main harvest of sorghum. The production cycle of the local sorghum varieties takes about 8 months: this crop is the only contributor to food security for farmers’ households.

Barley Varieties Introduction

Before contemplating any introduction, a rigorous security assessment should be conducted. This involves compiling an inventory of varieties by crop, including varieties currently used by farmers, as well as new varieties not yet available to farmers for testing (Hall, 2003). It is important to get an overview of the strengths and weaknesses of current agricultural and seed systems and an in-depth understanding of the root causes of any current and potential stresses. Fundamentally, a decision to introduce new varieties needs to be founded on sufficient evidence that new varieties offer promising opportunities, and, equally, that their introduction will not expose farmers further to increased risk (Hall, 2003). In this regard, the varieties were introduced to the country following the right procedure with all the necessary tests made by the national quarantine office for pests. Moreover, the materials performance in relation to locally available materials with regard to drought tolerance and early ness was studied ahead of introduction.

Adaptation Trial of Introduced Barley Varieties

The experiment on introduced drought tolerant barley varieties was carried out at Fedis Agricultural Research Center (FARC) on station at Boko which was known by its moisture stress in East Hararghe Zone in 2010. Six early maturing and drought tolerant barley varieties namely: *Golden eye*, *Aquila*, *Walker*, *Millinium*, *Xena* and *Streptoe* were introduced from America and were planted with the objective of testing their adaptability to that specific district in the main cropping season. The land was ploughed three times using oxen plough. The varieties were planted in randomized complete block design (RCBD) with three replications with spacing of 30cm between rows. Seed rate of 85 kg/ha was used by drilling in the prepared rows. Plot size of 5m x 5m was used. Shallow planting of 2-4cm depth was used in the presence of ample soil moisture. Fertilizer rate of DAP 85kg/ha and Urea 85 kg/ha was applied with DAP at sowing and Urea half at sowing and half at stem elongation stage respectively. Two effective weeding was accomplished; one at one month after sowing and the other after two months after sowing respectively.

Data collection and Analysis

All agronomic data such as days to heading, days to maturity, plant height, spike length, number of seeds per spike, thousand seed weight and grain yield per plot were collected. For plant height, spike length, number of seeds per spike; a random sample of ten plants were taken from the center of the plot and value for each was recorded and the average was taken for the plot or for the variety. Data on disease incidence specifically leaf rust was recorded by counting the number of diseased plants out of hundred and expressed in percentage. Leaf rust severity was recorded using modified Cobb scale (Peterson *et al.,* 1948). All quantitative data were analyzed using statistical software known as IRRISTAT to reveal the variability among the varieties.

Demonstration and Participatory Evaluation of the Varieties

In 2011 main cropping season, the selected varieties from adaptation trial were planted in a plot size of 10m×10m both at research stations, at Farmers' Training Centers (FTCs) demonstration fields and on farmers' field so as to enable the local farmers observe the varieties performance on day to day basis. At the stage near to maturity, Farmers Field Day was prepared with the objective of creating opportunity for the actors to comment on the performance of the varieties and to create door for wider promotion. Moreover, various national and regional media like Ethiopia TV and Radio, Oromiya TV and Radio, Walta Information Center were invited to visit and take the perception of farmers, researchers, Development Agents about the introduced varieties so as to document and forecast the event.

Invitation of National Variety Release Committee (NVRC) for Registration

By 2012, the three highly performing varieties were planted at four different *kebeles* of Fedis district with a plot size of 10mX10m in non- replicated plots considering the sites at each *kebeles* to be a replica. Then, a letter requesting the varieties registration in the name of the center was sent to the national variety releasing committee with two years data of the varieties. Moreover, the committee was also invited to see the varieties in the field for all their attributes.

Seed Production and Maintenance

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 (Ajeigbe *et al.,* 2009). Also the seed of released/registered varieties must be maintained in such a way that stocks of pure propagating seed is constantly moving into commercial channels. Seed production is carried out under standardized and well organized conditions. During seed production strict attention is given to maintain the genetic purity and other qualities of the seeds. As a result, all the necessary management practice from land preparation through weeding and fertilizer application was accomplished following standard procedure.

RESULTS AND DISCUSSION

Varietal introduction

The cropping system in Fedis area was known to be intensive with cereal mono-cropping mainly sorghum and maize. Hence, farmers were not accustomed to grow barley in the area. Moreover, no suitable food barley varieties were released for this district and other similar agro ecologies. In this regard, assessment for the availability of food barley varieties suitable for Fedis district in the country was done rigorously ending in none. This called our attention to assess outside the country. Thanks for Morell Agro Industry PLC for introducing the varieties targeting to solve the problems of dry land areas in Ethiopia.

Morell Agro Industry PLC was one of American investors which came to Ethiopia with a vision of enabling farmers in dryland areas to produce ample crop yield for food with the amount of rain available in the area by introducing dryland adapted crop varieties. In line with this, high yielding food barley varieties were among the introduced crop varieties to Ethiopia with the necessary test for quarantine pests. After that, the varieties were sent to different agricultural research centers operating in drought affected areas of Oromiya. However, the varieties were failed to perform well in none of the areas except Fedis. Eventually, the varieties were tested for three years in different locations in our areas with the intention of confirming their consistent with regard to yield in time and space.

Adaptation Trial of introduced Food barley varieties at Fedis district of Eastern Hararghe

The experiment on introduced drought tolerant and early maturing food barley varieties was carried out at Fedis Agricultural Research Center (FARC) on station which was known by its moisture stress in East Hararghe Zone in 2010. 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. Six food barley varieties namely *Golden eye*, *Aquila*, *Walker*, *Millinium*, *Xena* and *Streptoe* were introduced from America and were planted with the objective of testing their adaptability to that specific district in the main cropping season. The varieties showed very good agronomic performance and gave a promising yield at Fedis (Figure 1). The result revealed that there was significant variation among the varieties in all the agronomic and yield parameters. Three of the varieties

namely *Golden eye, Aquila* and *Walker* were selected based on their yield and disease resistance. *Golden eye* was observed to give the highest yield per hectare with a value of 29.86 followed *Aquila* with a value of 26.00 kuntal per hectare. The lowest yield of 7.06 kuntal per hectare was obtained from a variety called *Millinium* (Table 1).

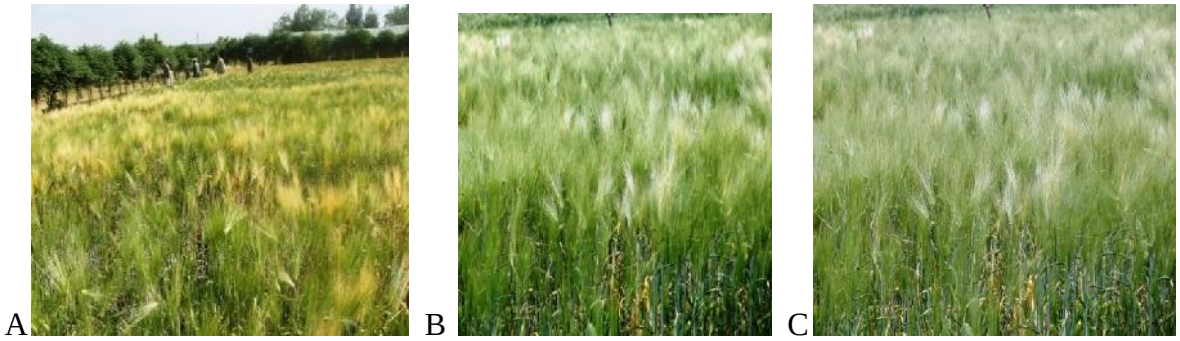

Figure 1: Agronomic performance of the candidate varieties *Aquila (A), Golden eye (B)* and *Walker(C)* at Fedis district

All the selected varieties bear six-rowed head which have a direct implication for good yield. Their head size and number of effective tiller per plant also showed highly significant variation with a value that vary between 61 and 78.33cm for head size; and 3.67 and 7.67 for number of effective tiller per plant respectively (Table 1). Furthermore, the varieties revealed resistant reaction with trace severity for foliar disease specifically for leaf rust except for *Xena, Millinium* and *Streptoe* which were highly susceptible for leaf rust. Three varieties (*Golden eye, Aquila* and *Walker)* among the six were selected for further testing.

Table 1: Mean grain yield and some agronomic parameters food Barley Varieties at Fedis district

Varieties	Days to Heading	Days to flowering	Number of effective tillers/plant	Plant height in cm	Head size in cm	Thousand seed weight in gm	yield in quintal per ha	Days to maturity	Leaf rust Severity
G/eye	37.67^{x*}	44.67^{d}	6.33^{f}	73.33^{k}	7.67^{g}	44.77^{n}	29.86^{s}	79.33^{a}	10Mr
Walker	40.00^{v}	47.67^{a}	6.00^{f}	65.00^{nm}	5.67^{i}	36.17^{p}	18.06^{t}	86.33^{b}	tr
Aquila	39.67^{vx}	47.00^{a}	7.67^{g}	78.33^{l}	10.00^{h}	43.00^{q}	26.00^{s}	83.67^{c}	5Mr
Xena	51.00^{y}	58.67^{b}	3.67^{h}	61.00^{m}	9.00^{gh}	33.33^{r}	11.11^{u}	90.33^{d}	60s
Millinium	57.33^{z}	64.67^{c}	4.00^{h}	63.33^{nm}	4.00^{j}	28.83^{o}	7.06^{u}	98.33^{e}	70s
Sterptoe	75^{w}	80.67^{d}	6.00^{f}	70.33^{k}	7.67^{g}	48.33^{v}	9.60^{u}	132^{f}	80s
SE	**0.64**	**0.71**	**0.33**	**1.48**	**0.48**	**0.25**	**1.64**	**0.55**	

*****Means within a column followed by the same letter are not significantly different at $p \leq 0.05$ according to DMRT

Demonstration and Participatory Evaluation of the Selected Varieties

The seed of three varieties that perform better both in yield and in disease reaction were distributed to five kebeles of Fedis district to be planted in FTC with a brochure on all the management practice. Hence, the varieties were evaluated by farmers at different stages of the growth with the facilitation of DAs and researchers. Moreover, farmers' field day was prepared in coordination of Fedis Agricultural Research Center and Haramaya University where by 500 professionals from different parts of the country and more than 500 farmers in the vicinity were invited and the varieties were thoroughly evaluated (Figure 2). Most of the guests were surprised with the varieties performance at the district with the knowledge of shortage of rain in the district. Most the participants encouraged the farmers to sow the crop in their farm. The varieties were highly preferred by the farmers for they matured early, resist disease and tolerate rain shortage. Both national and regional media (TV, Radio and News

paper) broadcasted the varieties performance to rural communities in the country as a result of which great demand for the varieties was created.

Figure 2: Farmers' field day for Evaluation of the Barley varieties planted at different kebeles in Fedis district

Output from Evaluation of the Varieties by National Variety Release Committee (NVRC)

The NVRC appointed a sub-committee by invitation of Fedis Agricultural Research Center composed of a national variety releasing committee (NVRC) members and other specialists to report on variety performance after examining the data and field visits. The report covered performance data evaluation, field performance evaluation and recommendations for the NVRC. Accordingly, In 2012 NVRC consisting of three researchers; one breeder, one agronomist and one pathologist were come to Fedis and were able to observe the varieties planted at four locations at Fedis district (Figure 3). As a result, the committee has collected different data with their respective profession and appreciated the varieties performance with the prevailing hot weather in the area.

Figure 3: Candidate food Barley varieties visited by NVRC at different kebeles of Fedis district

The varieties performance in terms of yield and other attribute at the four kebeles were remained consistent except some variation because of time of planting. The analysed data on agronomic performance and yield of the varieties also revealed that there was significant variation among the varieties in all the variables except for number of effective tillers and plant height (Table 2). Unlike the adaptation trial the variety *Walker* gave highest yield of (25.97qt/ha) followed by *Aquila* (23.47qt/ha). The variety with the lowest amount of yield per hectare (13.83 qt/ha) was the standard check. Moreover, the candidate varieties were able to tolerate the leaf rust infestation that regularly occurred in the area.

All data with regard to the varieties were submitted to the NVRC both in hard and softcopies for the decision. Finally, fantastic news on three varieties registration in the name of Fedis Agricultural Research center for Fedis and similar agro ecologies with full mandate of the center to multiply and maintain the varieties with the intention of delivering to the beneficiaries keeping their identity was given to center.

Table 2: Mean grain yield and some agronomic parameters of the candidate food Barley Varieties planted at four Kebeles of Fedis district

Variety names	Days to heading	Days to flowering	No of Effective tillers	Plant Height in cm	Spike length in cm	No of seed per spike	Thousand seed weight	Yield in qt /hectare	Days to maturity	Leaf rust Severity
Golden eye	56.25^{c*}	60.00^{f}	8.25^{a}	65.20^{h}	7.55^{mn}	58.33^{b}	41.25^{s}	20.97^{q}	92.50^{f}	10Mr
Aquila	50.50^{b}	55.50^{i}	5.50^{a}	71.65^{h}	9.20^{k}	64.00^{a}	42.00^{s}	23.47^{p}	93.00^{f}	5Mr
Walker	56.75^{c}	62.00^{gf}	5.75^{a}	64.15^{h}	6.70^{m}	63.33^{a}	41.75^{s}	25.97^{r}	87.75^{d}	10Mr
Standard Check	61.25^{c}	66.25^{g}	5.00^{a}	61.25^{h}	8.50^{kn}	44.00^{c}	38.25^{t}	13.83^{o}	108.50^{e}	25S
SE	**1.65**	**1.52**	**0.73**	**3.80**	**0.37**	**3.45**	**0.70**	**1.40**	**2.57**	

*****Means within a column followed by the same letter are not significantly different at $p \leq 0.05$ according to DMRT

Seed maintenance and Multiplication

The most important prerequisite for good crop production is the availability of good quality seeds of high yielding varieties, adapted to the growing area, and preferred by the farmers. The quality of seeds alone is known to account for an increase in productivity of at least 10–15%. To achieve this high quality, all the factors in production that will affect viability and genetic purity should be taken into account. The production techniques should be mastered and the environmental conditions (soil fertility and climate) known (Ajeigbe *et al.*, 2009).

From the end of the year 2012 onwards, the varieties had been multiplied at fields' of Farmers Training Centers (FTC) and on Research Stations; and delivered to a significant number of farmers in the area. The farmers were cultivating barley on small plot of land on their farm considering it as a food security crop because of its earliness in maturity. Most of the barley plots of farmers observed in the last two years were managed poorly as compared to FTCs and Research station (figure 4). In spite of poor management on farmers' fields, the crops performance in terms of yield was good. This was because of poor effort of the extension and Development agents in the area in training farmers. Taking this in to consideration, Fedis Agricultural Research Center has given training in 2013 for 1day for 50 DAs and Woreda Experts on management aspects of these varieties; from land preparation through sowing to harvesting and storing, giving brochures to all participants. This was done with the assumption that the DAs and experts would train the farmers in their vicinity.

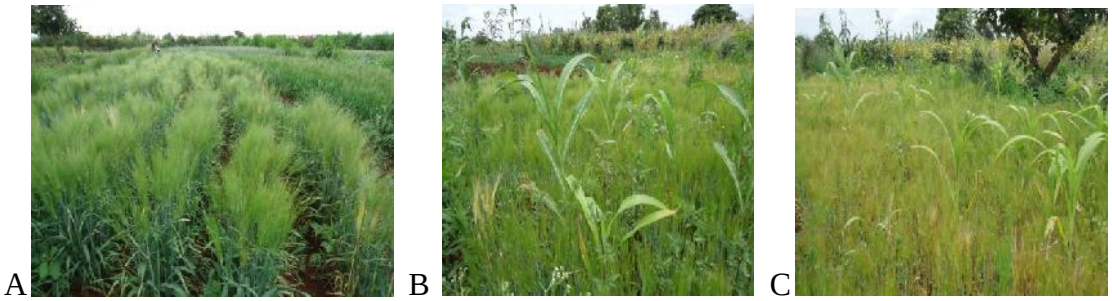

Figure 4: Plots of Barley varieties at FTC (A) and on Farmers' fields (B and C)

CONCLUSION AND RECOMMENDATION

Based on the current finding, the three varieties *Golden eye, Aquila* and *Walker* were able to cope with the rain shortage prevailed in the area and were selected by farmers. As a result, the NVRC has registered these varieties in the name Fedis Agricultural Research Center for Fedis and other districts with similar agro ecologies in Eastern Hararghe. The participatory evaluation and demonstration trials accomplished so far also created great demand for the varieties. To fill the gap on the demand of seeds for the varieties the integration of research

center, farmers, Office of Agriculture and Rural Development and other agricultural partners is important.

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