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PART ONE: Agricultural Economics

Expansion of *Acacia decurrens* plantation on the acidic highlands of Awi zone, Ethiopia and its socio-economic benefit for the society.

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Abstract

Expansion of Acacia decurrens plantation on the acidic highlands of Awi zone, Ethiopia and its economical benefit for the society was undertaken in Fagita-Lekoma district in 2014/15. Land use change from cropland to Eucalyptus in mid altitude and Acacia decurrens in the high altitude areas of north western Amhara, Ethiopia has been increasing in alarming rates. Hence, the main objectives of the study were to assess major motives of farmers behind the expansion of Acacia decurrens plantation at the expense of annual crop production and to evaluate the economic benefit of Acacia decurrens versus annual food crops production. A multi-stage purposive and random sampling technique was employed to collect cross-sectional survey data from farmers, traders and experts at four kebeles of Fagita-Lekoma district of Awi zone, Ethiopia. The study employed descriptive statistics as well as Cost-Benefit Analysis (CBA). Benefit-Cost ratio (B/C), Net Present Value (NPV) and Internal Rate of Return (IRR) to compare annual crops and Acacia decurrens plantation. The results of the study indicated that tef (35%), potato (22%), barley (15%) and wheat (13%) were the most dominant crops grown by sample households. Acacia decurrens plantation was introduced as a public forest plantation by Derg regime and expanded as private plantation for charcoal making since 2009 and reached 4,083 hectares in 2014. Experts and traders were eye-openers for Acacia decurrens plantation innovation for charcoal making purpose. High economic benefit, source of firewood and fencing, improving soil fertility and decreasing run-off, tolerance to natural hazards compared to annual crops and sources of employment were found to be the major motives behind the expansion of Acacia decurrens plantation while sharing of grazing land, requirement of high initial capital and competition of fertile land with annual crops were major problems. The result of the Cost-Benefit Analysis indicated that farmers gain net profit of 6,594 and 4,882 Eth. Birr from the production of one hectare of tef and bread wheat crops per annum, respectively. On the other hand, farmers could gain a non-discounted net profit of 62,854.5 Eth. Birr from the production of one hectare of Acacia decurrens plantation after waiting 4 or 5 years. Crop production generates a net present value of 5,430.54 Birr/ha with Cost-Benefit ratio of 1.09 while Acacia decurrens plantation generates a net present value of 26,682.68 with Cost-Benefit ratio of 1.53 and IRR of 58%. Therefore, farmers are fetching attractive economic benefit and conserving their soils from Acacia decurrens

plantation. Hence, acacia plantation is a more attractive business than annual crop production like tef and wheat. Further study on the human health, soil properties and environmental aspects of Acacia decurrens plantation as well as marketing and value chain aspects is recommended.

Key words: Acacia decurrens, Cost-Benefit-Analysis, Fagita-Lekoma, plantation, farmers.

Introduction

The *Acacia decurrens* tree belongs to the species Acacia section Botryocephalae, a group of 44 mostly arborescent species, characterized by having bi-pinnate adult foliage and flower heads normally arranged in elongated racemes that predominate in temperate areas of eastern and southeastern Australia (Orchard and Wilson, 2001). It is endemic in New South Wales where it occurs chiefly on the coast and tablelands from the Hunter Valley south to the Australia Capital Territory (Orchard and Wilson 2001; Maslin *et al.*, 1988). *Acacia decurrens* are shapely erect trees with 5-10 meter tall but sometimes attaining 20–22 meter tallness under favourable conditions, commonly with single, straight to almost straight main stems, strong, shallow lateral roots (Boland 1987, Pryor and Banks 1991). It is a relatively short-lived species which declines in vigour after 10–15 years (Pryor and Banks 1991).

Forests play important provisioning and supporting roles in the livelihoods of rural households and many of those who live in extreme poverty are to some degree reliant on forests for their livelihood (Byron and Arnold, 1999; Sunderlin *et al.*, 2005). Recent comparative evidence suggests that forest and environmental income contributes 28 percent of the total income to households in or near forests (Angelsen *et al.*, 2014). Trees have multiple purposes in rural Ethiopia, providing significant economic and ecological benefits. Planting trees supplies rural households with wood products for their own consumption as well for sale, and decreases soil degradation. *Acacia decurrens* is an excellent source of fuel-wood used for building poles, pulpwood, tanning of hides, mine props, fence posts, hardboard production, valuable timber species, etc (Gamble 1902; Allen and Ethel, 1981; Maiden, 1889). *Acacia decurrens* is also a moderately deep rooted, drought-tolerant, nitrogen-fixing tree widely planted as windbreak, controls wind erosion, stabilizes ash spoil, ornamental plantings (Vivekanandan, 1979; Streets 1962).

Acacia decurrens (J.C. Wendl.) Willd was introduced into the central highlands of Ethiopia in the early 1990s as short-rotation forestry (Sawyer, 1993) to counter urban firewood shortages arising from deforestation (Pohjonen and Pukkala, 1990). Moreover, *Acacia decurrens* was introduced into state-owned plantations of the north-western highlands around the same year (Achamyeleh, 2015). Recently, the tree species has also been recommended for large-scale watershed rehabilitation in the country (GIZ, 2015).

Acacia decurrens plantation in the highlands of Awi zone of Fagita-Lekoma district, Ethiopia has been practiced since the last few years, but the practice is expanding in an alarming rate competing for annual cropping and grazing land. All acacia trees have been used for charcoal production except the foliage and some thin twigs left on the ground that are used for fencing and firewood. Charcoal making (charring) has been practiced on the same land on which plantation was done or nearby farms on a series of heaps. There is no coppice after harvest unlike to eucalyptus and it is easy to plow the land for farmers due to its bare root. After harvest, the land would be plowed and used for crop

production so that, in the second year, farmers intercrop *Acacia decurrens* with annual crops for future (next) wood lot plantation, so that the cycle of plantation goes like this.

Land use transformation from crop lands to *Acacia decurrens* and charring on the farmlands in the highlands of Awi zone of Amhara National Regional State of Ethiopia could have the potential to ameliorate the degraded soil, can mitigate climate change by sequestering carbon and can have economical benefit from the two systems of annual crop and *Acacia decurrens* charcoal productions. Therefore, this study was initiated to evaluate the motives and status of *Acacia decurrens* expansion and its economic benefit for the society in the study area with the following objectives:

Objectives:

- To assesses major motives of farmers that make them to shift from annual food crops to *Acacia decurrens*;
- To evaluate the economic benefit of *Acacia decurrens* versus annual food crops produced by small holder farmers;

Research Methodology

Study Area Description:

The study was conducted in Awi zone, Fagita-Lekoma district, Amhara National Regional State, Ethiopia in 4 kebeles namely *Endewuha*, *Gaffera*, *Gulla-Giorgis* and *Gezehara*. Awi zone is one of the 10 Zones and Fagita-Lekoma is one of the 105 districts in the Amhara Regional State, Ethiopia. Fagita-Lekoma district has an area of 653.39 square kilometers and it is bordered to the south by Banja-Shikudad; to the west by Guangua; to the north by Dangla; and to the east by West Gojjam zone. The district has a total population of 146, 848 people from which about 90 % live in rural areas with population density of 224.7 people per km^2 (CSA, 2015). The topography of the district is rugged and undulating and land use in the district is dominated by a mixed crop-livestock system (Achamyeleh 2015). Main crops grown in the district are barley (*Hordium vulgare*), teff (Eragrostis tef Zucc.), wheat (*Triticum vulgare*) and potato (*Solanum tuberosum*). The major sources of cash for the community of the area are crop production and tree (*Eucalyptus* and *Acacia decurrens*) products. These days, *Acacia decurrens* plantations are abundant in the study area and established mostly by replacing crop and grazing lands.

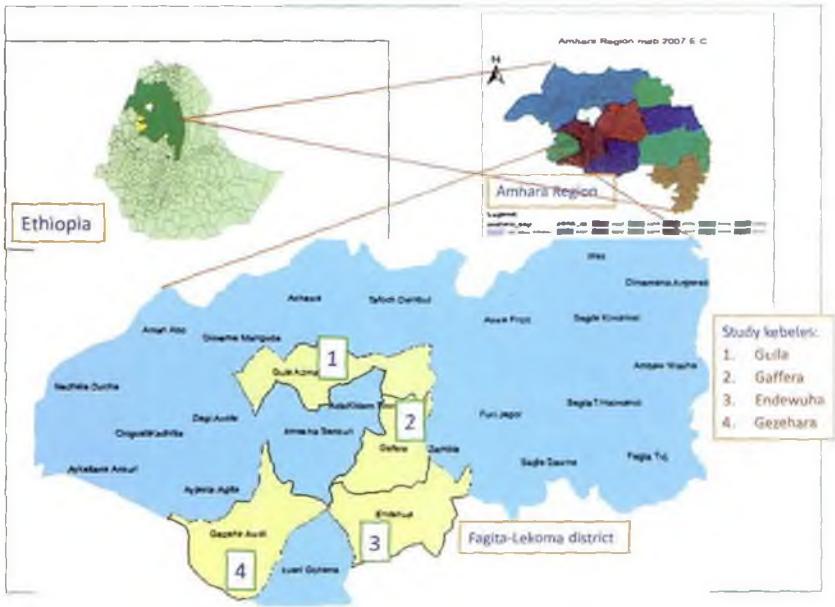


Fig 1. Map of Fagita-Lekoma district, Awi zone, 2014/15.

Data Sources, Types, Sampling and Method of Data Collection:

Data sources were both primary and secondary. The primary data was collected from interview of farmers and key informants (elders, traders, brokers and office of agriculture experts) while secondary data was collected from the office of agriculture, Central Statistical Authority (CSA) of Ethiopia and published and unpublished documents. A multi-stage sampling procedure was used so that, Awi zone and then Fagita-Lekoma district were selected purposively based on volume of *Acacia decurrens* production and representativeness in the first and second stages, respectively. Then in the third stage, four kebeles namely Endewuha, Gaffera, Gulla-Giorgis and Gezehara and in the fourth sampling stage, 25 to 30 respondent farmers per kebele that sum up to 108 were selected randomly for interview (Table 1). Respondent farmers were randomly selected and interviewed based on structured questionnaire. Two to three key informant interviews were conducted per kebele as well as field observations were made in the study district to compliment the data by qualitative analysis and triangulation.

Table 1: Sample kebeles and number of farmers selected in each kebele for interview

Kebeles	Endewuha	Gaffera	Gulla Giorgis	Gezehara	Total
Number	26	30	27	25	108
Percent (%)	24.07	27.78	25	23.15	100

Source: Survey data, Ethiopia, 2015.

The price of output (crop and *Acacia decurrens* yield) and inputs (seeds, fertilizer and chemicals) were collected from farmers, local market, input dealers and district/zonal office of finance and economic development during the survey. The primary data collected includes socioeconomic profile of farm households, livestock holding (cattle, small ruminants, equines, chickens and beehives), area planted (allocated) for *Acacia decurrens (ha)* and yield of each annual crops grown during the survey year, rotation cycle of *Acacia decurrens*, crops grown before and after *Acacia decurrens* and their productivity per ha with their price per ton per ha, volume (sacks) of char per area or ha and its price per char or sack or ha, cost of production per ha for crops and *Acacia decurrens* (on that specific land), trends of land use change from cropland to *Acacia decurrens* and motives of farmers behind expansion of *Acacia decurrens* (economic, soil conservation, drought resistance, or any other motives).

Method of Data Analysis

Cross-section data that was collected from sample farmers and other organizations/individuals was analyzed by descriptive statistics followed by economic analysis. In order to describe the overall agricultural production system with respect to the desired characteristics, descriptive statistics such as mean, standard deviation, percentages, graphs and charts were used. Economic analysis like Cost-Benefit Analysis (CBA), Benefit-Cost ratio (B/C), and Internal Rate of Return (IRR) was used to compare annual crops production and *Acacia decurrens* plantation. The two land use systems considered in the study (annual crops production and *Acacia decurrens* plantation) areas have different production cycles, i.e. the production cycle for annual crops is one year while it is 5 years for *Acacia decurrens* plantation. To compare the costs and benefits of land-use systems, a five-year time horizon (maturity of *Acacia decurrens* for charcoal making) was considered in the analysis based on inputs, outputs, and farm-gate prices of each produce. To facilitate the comparison, all costs and benefits were brought to present value by using a discounting method (Rasul, 2009). This is done due to the time value of money, so that future cost and benefit values were discounted to enable comparison with present values. The opportunity cost of labor in the study area varies by gender and season. Following the prevailing wage-labor rates, ETB 50 (USD 2.5) was considered to be the daily per capita opportunity costs of adult workers. Given the scarcity of land in the study area, both private

and social objectives aim to maximize returns from a unit of land. Returns to land are expressed by net present value (NPV) which discounts the streams of benefits and costs back to a base year (Macharia *et al.* 2006; Gittinger, 1982). The NPV of both annual crops production and *Acacia decurrens* plantation over a period of five years was calculated using the following equation:

Where,

B_t = land-use specific benefits accrued over the five years,

C_t = land-use specific costs incurred over the five years,

r = the discount rate, 12% according to current Ethiopian condition, and

t = time period, five years in this case.

The discount rate or interest rate should be equal to the opportunity cost of capitali.e. the rate of interest which could be obtained in the best alternative investment or the rate of interest on borrowed

$$NPV = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+r)^t} \quad \text{.....1}$$

capital. It was assumed as 12 percent for the analysis of the present study depending on the Ethiopian condition.

Benefit to Cost Ratio (B/C) was determined by dividing discounted benefits by discounted costs:

$$B/C \text{ Ratio} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}} \quad \text{.....2}$$

If B/R > 1, then the total revenue is greater than the total cost; if B/R = 1 then the total revenue is equal to the total cost and if B/R < 1 then the revenue is less than the total cost.

The Internal Rate of Return (IRR) is the discount rate where the net present worth of costs is equal to net present worth of benefits, i.e., the NPV equals zero. IRR is r where:

$$IRR = \sum_{t=1}^{n} \frac{INB_t}{(1+r)^t} = 0 \quad \text{.....3}$$

Statistical Package for Social Science (SPSS) and STATA computer softwares were applied to analyze the data.

Results and Discussion

Descriptive results of the socio-demographic characteristics of respondents

All sample households were male-headed and average age of sample respondents was found to be 48.6 years with minimum and maximum age of 30 and 74 years, respectively. Education level of

sample households was 2.61 grades and mean family size was 6.76 numbers of persons per family. Moreover, the active labor force proportion (15-64 years of age) of the sampled households was about 57.42% (Table 2). Farm households having large family size of active labor force, have more chance to cultivate (plowing, land preparation, weeding, harvesting, storage and transportation) their farming activities. Education helps farm households to acquire and interpret information on agricultural technologies and rationally allocate existing farm resource to achieve their household farming objectives and goals.

Table 2: *Household characteristics of respondents*

Description	Minimum	Maximum	Range	Mean	St.Dv	%
Age	30	74	44	48.6	10.43	-
Sex (male %)	-	-	-	-	-	100
Education level (years) (illiterate %)	0	10	10	2.61	3.01	23.70
Total Family members	2	10	8	6.76	1.65	100
Male	1	6	5	3.16	1.26	46.67
Female	1	9	8	3.61	1.50	53.33
Children under 15 years old	0	5	5	2.74	1.45	40.65
Adult 15-64 years of age	2	8	8	3.87	1.36	57.42
Dependent above 64 years of age	0	2	2	0.13	0.41	1.93

Source: Survey data, 2015.

Livestock production is an integral part of the farming system in the study area that contributes a lot for crop production like source of draught power, food (meat and milk), cash, animal dung as organic fertilizer (manure) and fuel and means of transport. For standardization and understanding purpose, livestock number was converted to tropical livestock unit (TLU) (Storck *et al.*, 1991). The overall average TLU of the households was 6.74. Moreover, sampled households own mean of 1.64 oxen and 2 horses (Table 3). Horses and/or mules are common animals than oxen for plowing purposes since the area is high land. Although *Acacia decurrens* plantation is sharing most of the grazing lands of livestock, farmers are still trying to feed their animals by buying straw with the income they generate from charcoal of *Acacia decurrens*.

Moreover, farmers can grow and harvest animal feed (grass) under the *Acacia decurrens* trees plantation for the first two to three years until the trees become big and prevent grasses to grow due to shading effect.

Table 3: Livestock ownership

Description	Minimum	Maximum	Mean	St.Dv
Livestock ownership (number)				
Cattle: Oxen	0	2	1.64	0.49
Cows	0	5	2.33	2.33
Heifers	0	5	1.92	1.15
Calves	0	4	1.62	0.75
Small Ruminants: Sheep	0	7	3.46	1.64
Nu-ruminants: Horse	0	4	2.00	0.82
Chickens	0	12	4.35	2.77
Beehives	0	7	3.6	2.07
TLU	0	15.06	6.74	3.07

Source: Survey data, 2015.

Land is a very scarce resource and an important asset which is an indicator of wealth and perhaps a proxy for social status and influence within a community for farmers in Ethiopia. The total owned land size of sample respondents varied from 0.00 to 2.00 hectares with an average holding of 1.01 hectares with a standard deviation of 0.49. The average total cultivated land (including lease in) was found to be 1.40 hectares with a standard deviation of 0.48 (Table 4). Farmers also rented in or out land in the study area for annual crop cultivation and/or *Acacia decurrens* tree plantation based on cash payment or share cropping. Moreover, some innovative and progressive farmers, experts and urban dwellers rent in land for *Acacia decurrens* tree plantation mostly based on cash payment.

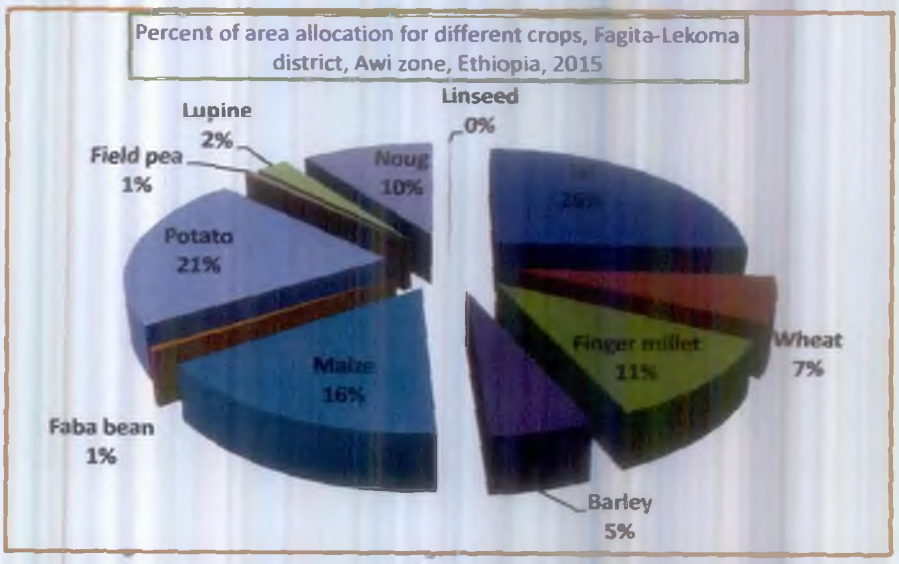
Table 4: Land ownership of sampled households

Description	Minimum	Maximum	Mean	St.Dv
Land ownership (in ha): Own	0	2	1.01	0.49
Rented in	0.13	1.25	0.56	0.30
Total cultivated	0.50	2.38	1.40	0.48

Source: Survey data, 2015.

Cropping pattern of farm households

Crop-livestock mixed farming system is the basic feature of Fagita-Lekoma district farmers.Crop production is the most important farm activity in this area. However, *Acacia decurrens* tree plantation for charcoal making is becoming the major farming activity these days. The most dominant crops grown by farm households in the district were found to be tef, potato, maize, finger millet, noug, wheat and barley with 26%, 21%, 16%, 11%, 10%, 7% and 5% of area allocation, respectively (Fig.2). Lupine, field pea, faba bean and linseed are crops grown in small proportion.



Overview of Acacia decurrens tree plantation in Fagita-Lekoma district

Acacia decurrens plantation was introduced as a public forest plantation on mountainous areas by the then Derg Regime in the 1980's in Fagita-Lekoma district of Awi zone, Ethiopia (*personal communication* and key informant interview). Furthermore, the tree was also introduced for roadside planting as fence and decoration. Then, farmers were exercising planting *Acacia decurrens* tree around their farm land and used it as live fence and firewood too. *Acacia decurrens* plantation for charcoal making was started lately after farmers saw its charcoal making quality from border trees that were used as live fences (*key informant interview*). In addition, the emergence of attractive regional charcoal markets and the need for soil fertility improvement have led to its wider expansion into woodlot plantations on cultivated land.

Agricultural experts and traders in town were eye-openers for the innovation of *Acacia decurrens* tree plantation for charcoal making purpose that become the main source of livelihood for the households. And now, it has become one of the "best innovations of farmers" in the country since the practice is

totally new in Ethiopia that needs further research and development effort. According to Fagita-Lekoma district office of agriculture annual report, the area under *Acacia decurrens* tree was 720 hectares in 2009 and reached about 4083 hectares in 2014 (Fig. 3). According to the office report, currently the area under *Acacia decurrens* tree plantation reached more than 14,000 ha of land which is more than 50% of the total land in the district. Moreover, Google earth image of Fagita-Lekoma district in 2005 and 2014 shows the expansion of *Acacia decurrens* tree plantation in the district (Fig. 4).

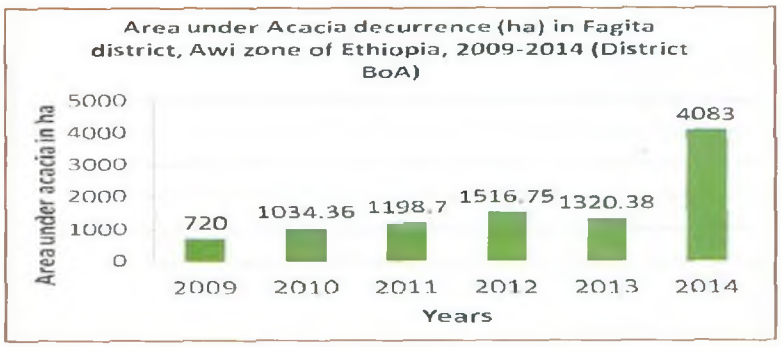


Fig. 3 Area allocated for *Acacia decurrens* plantation at Fagita-Lekoma district in 2009 to 2014.

Source: Fagita-Lekoma district office of agriculture, 2015.

Fig. 4. Google Earth image of Fagita-Lekoma district in 2005 and 2014

Acacia decurrens plantation system of farm households in Fagita-Lekoma district

Experience of farmers in Acacia decurrens plantation

Farm households in Fagita-Lekoma district usually plant and cultivate *Acacia decurrens* trees for charcoal making as usual; they do the same as annual crops production. Farmers' experience of *Acacia decurrens* plantation for charcoal making varies from 4 to 15 years with mean value of 7 years in the study district (Table 5). About 10.53%, 23.68%, 18.42%, 23.68%, 5.26%, 5.26%, 7.89% and 5.26% of farmers have an experience of 4, 5, 6, 7, 8, 10, 12 and 15 years of *Acacia decurrens* plantation for charcoal making (Fig. 5). Respectively. Moreover, farm households have an experience

of one to five number of plantation rounds with mean number of 1.82 times since the start of the *Acacia decurrens* plantation for charcoal making process in the area. About half (52.6 %) of farmers have plantation rounds of one time while 23.7% have two times of plantation rounds. Only 2.6% of farmers have experience of 5 times plantation rounds of *Acacia decurrens* (Fig. 5). Farmers usually harvest *Acacia decurrens* tree for charcoal making from 4 to 5 years time after planting (Table 5). Land renting-in and sharing-in are common phenomena in the study district for *Acacia decurrens* plantation for charcoal making. On average, farmers allocated about 0.58 ha (minimum of 0.125 ha and maximum of 1.25 ha) for *Acacia decurrens* plantation per year or per plantation round and the process goes like that after harvesting and planting.

Table 5: Experience of farmers and harvesting time of *Acacia decurrens*

Description	Min	Max	Mean	St.Dv
Experience of farmers in acacia plantation	4	15	7.05	2.86
Harvesting time of acacia for charcoal making (years)	4	5	4.5	0.51
Number of plantation rounds of farmers	1	5	1.82	1.06
Area allocated for acacia plantation (ha)	0.125	1.25	0.58	0.243

Source: Survey data, 2015.

Fig. 5. Farmers' plantation rounds and experiences of *Acacia decurrens*

Source: Survey data, 2015.

Cultivation and management of Acacia decurrens plantation

Seed sources of farm households for *Acacia decurrens* plantation are public and/or church forests as well as age-old plants around their farms. Farmers usually prepare seedlings of *Acacia decurrens* in February near rivers or their backyards. It is customary that youths prepare seedlings by renting small plots of land near rivers from farmers and sell to growers by 0.25 to 0.35 Ethiopian Birr per seedling

when planting time comes. The spacing of *Acacia decurrens* plantation varies from farmer to farmer being 1meter x 0.75meter to 0.75 meter x 0.75 meter with a total population of 16,000 to 18,000 per hectare. Moreover, there are some farmers who plant it with a spacing of 0.50 meter x 0.75 meter and 0.50 meter x 0.50 meter and the population would reach about 26,700 to 40,000 in this case. This needs research and development intervention so that the economic spacing or plant population/density should be studied according to the farmers' current production objectives.

Planting time for *Acacia decurrens* is June, July and July-August if plantation takes place on fallow land, intercropped with tef land and intercropped with wheat land, respectively. Crops sawn before *Acacia decurrens* plantation are tef, wheat, lupine and barley in order of their importance. Most of the time, farmers plant their unproductive fallow land with *Acacia decurrens* and change it to productive crop land after *Acacia decurrens* 1st harvest. On the other hand, crops sown after *Acacia decurrens* plantation include tef, wheat and finger millet in order of their importance (Fig. 6).

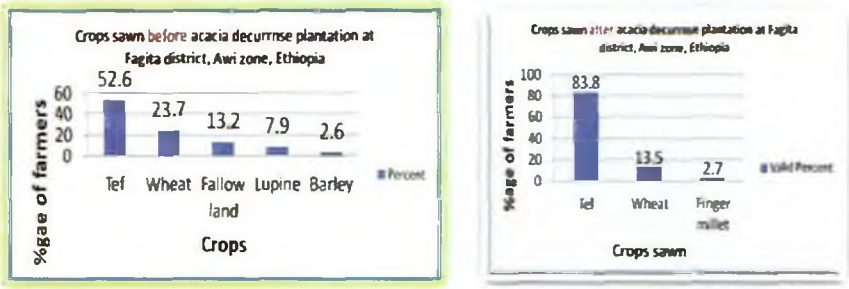


Fig. 6. Crops sawn before and after *Acacia decurrens* plantation, 2015

Some of the farmers prepare their charcoal from *Acacia decurrens* plantation on the same land that was used for plantation while some of them charred out of the production site. Charring in the crop lands has beneficial effect for the soil chemical and physical properties, because many charcoal residues (leftover) can be left there and incorporated to the farm land during plowing. This charcoal leftover will serve as a soil amendment for the degraded soils of the area (Fig. 7). After charcoal preparation, farmers collect the charcoal into sacks and transported to the nearby roadside from where it is taken to distant markets and to some extent retail markets. If the plantation site is accessible for transport, cars/lorries went to the site and just load it for distant market.

Fig. 7. *Acacia decurrens* plantation system (seedling preparation (A), young plantation site (B), matured plantations (C), charcoaling (D) and pilling for market (E), Fagita district, Ethiopia, 2015: Photo by Yazie Chanie.

Motives of farmers in expanding Acacia decurrens plantation: from farmers' perspectives

Acacia decurrens plantation has many advantages in Fagita-Lekoma district. As the multiple response analysis result (Fig. 8) shows, the main objective of farm households planting *Acacia decurrens* is to derive economic benefit from it by making and selling charcoal and its byproducts from the tree. Other benefits of planting *Acacia decurrens* tree are sources of firewood, fencing, source of employment for the society, soil fertility improvement, minimizing run-offs, windbreaks, etc. Farmers are expanding *Acacia decurrens* plantation from year to year, shifting from annual crops production to *Acacia decurrens* due to the following main reasons (Fig. 8):

High economic benefit: Sell of charcoal from *Acacia decurrens* plantation is the main source of income for farmers and thus they call it "The black sesame…*Tikuru Selit*" since they knew that sesame is the main cash crop in the low land parts of Awi zone and they have experience of the crop when they go for seeking seasonal employment. Moreover, farmers stated that…"planting *Acacia decurrens* means putting money in the bank" that you will find your money being increased through attractive interest. This can be testified as indicated in Table 7 to 11 that farmers are fetching good income from the charcoal of *Acacia decurrens* plantation (gross income of 104,192 and net return of 62,854 Birr per ha) and it was by far better than the income from annual crops, although it is long term investment. Similarly, based on the financial analysis, Achamyeleh, 2015 reported a net present value of 127, 128.75 ETB ha^{-1} (5968 USD ha^{-1}). Those who lacked sufficient financing and labor for making charcoal sold their wood to charcoal makers so that charcoal makers would sell the produce and pay back the money to them. Moreover, planters got the tree fitted for their production system so that, the system allowed them to produce food crops (tef, wheat, barley and finger millet) and animal feed (grass) to support their livestock during the tree establishment phases (mostly for 2 to three years after planting). More importantly, the local government is collecting high revenue from *Acacia decurrens* charcoal production and marketing by imposing tax of 8-10 Ethipoian Birr per bag.

Source of fuel wood and fencing: Biomass energy at the national level provides more than 96.9 percent of the total domestic energy consumption: 78 percent from woody biomass, 8 percent from crop residues, and 11 percent from animal dung (IBC, 2012). Rural farm households living in developing countries like Ethiopia use forest and forest products as the main source of fuel wood for cooking (baking "*inejra*", roasting and boiling grains and making stew), lighting, used as source of heat during cold seasons/times, etc where other energy sources like electricity are not available and/or affordable. Branches of *Acacia decurrens* trees that remain after poles are prepared for charcoal making and remains of charcoal (small sized) are the main sources of fuel wood for farmers and source of income if sold. Moreover, branches of *Acacia decurrens* are used for fencing residential areas and farm boundaries to keep safe from human and animal interference (Fig. 8).

Fig.8. ***Acacia decurrens*** **branches transportation (a), women collecting remains of charcoal (b) and fences of branches, Fagita district, Ethiopia, 2015**

Soil fertility improvement: Farmers perceived that, and it is also a real fact according to the researcher's field observation, whatever process or reaction is going on the farmers' *Acacia decurrens* plantation fields, the soil becomes more fertile than ever after the immediate harvest of *Acacia decurrens* plantation. In addition to the improvement of soil physical properties, like soil depth, soil structure, texture and colour; farmers witnessed and proved the soil fertility improvement by calculating the yield difference of annual crops before and after *Acacia decurrens* plantation. Farmers reported a double yield increment of annual crops due to the soil fertility improvement on *Acacia decurrens* plantation field (Table 6). Therefore, the growers used *Acacia decurrens* plantation for soil reclamation or amendment in addition to other multiple advantages of its plantation and this strategy seems feasible for farmers who own marginal lands owing to continuous cultivation, soil acidity (Achamyeleh, 2015) and lack of money to buy fertilizer. Farmers also reported that, due to soil fertility improvement, we minimized the amount (dose) of chemical fertilizer application by half and we could have extra chemical fertilizer to be applied for other non-fertile fields that are not planted by *Acacia decurrens* trees (Table 6). Moreover, farmers stated that, *Acacia decurrens* plantation decreases weed infestation favouring annual crops production since it suppresses weed emergence.

Table 6: Productivity of annual crops (quintal/ha) on farm sites (on the same plot of land) and fertilizer application before and after *Acacia decurrens* plantation

Descriptions	Before acacia decurrens plantation				After acacia decurrens plantation			
	Min	Max	Mean	St.Dv	Min	Max	Mean	St.Dv
Crop productivity (Qt/ha): Tef	2	16	9.20	4.14	4	18	11.5	3.26
Wheat	4	20	18	2.35	11	42	22.34	3.15
Potato	10	120	65	3.64	70	185	124.5	3.84
Mean DAP fertilizer rate	12	50	30.67	12.74	5	25	18.88	7.17

Descriptions	Before acacia decurrens plantation				After acacia decurrens plantation			
	Min	Max	Mean	St.Dv	Min	Max	Mean	St.Dv
for crops (kg/0.25ha)								
Mean UREA fertilizer rate for crops(kg/0.25ha)	12	25	21.79	5.09	10	25	13.44	5.82

Note: Min=Minimum; Max= Maximum and St.Dv= Standard Deviation

Source: Survey data, 2015.

Minimization of run-off and improvement of climate variability: Farmers suggested that, *Acacia decurrens* plantation can minimize soil erosion since there is no soil disturbance after plantation and due to its branched tap roots that keep the soil from being eroded. Farmers recognized and replied that, due to *Acacia decurrens* plantation in the area, rain comes early these days which was not common previously.

Tolerance to natural hazards: Most smallholder farmers in Ethiopia are subsistant and risk averters and decide their farming depending on nature. Farmers reported that, *Acacia decurrens* tree tolerates natural hazards like storms and disease/pest unlike annual crops which are susceptible. This may be significantly noticed by farmers since the area is highland and natural hazards like storm which usually occur damage annual crops grown by farmers. *Acacia decurrens* plantation is also used as shelter belt or wind breaks for farmers around their annual cropping fields.

Employment opportunities: *Acacia decurrens* plantation minimized migration of people for work to other areas, usually to productive low land areas which are potential for sesame production that need huge seasonal labor but not suitable for permanent dwelling. Farmers explained that, these days youths, men and women are busy on all the value chains of acacia i.e. seedling preparation, plantation, charcoaling, brokerage, etc activities (Fig. 9). For instance, among the growers, about 30% of them purchased seedlings usually from youths who raised it for sale and this indicate that youths are users on the value chain. In Fagita district , it is common to see youths (boys and girls) raising seedlings in the nearby rivers renting land from farmers and establishing nursery sites and sell for *Acacia decurrens* growers by 0.25 to 0.35 Ethiopian Birr per seedling when planting time comes. This is really good opportunity for rural youth job creation if it would be properly planned in the future. *Acacia decurrens* growers employee many labors and/or engage their families during plantation, harvesting, charcoal making, transporting and storing. For example, growers pay about 8 to 10 Ethiopian Birr per bag for making charcoal and about 1 to 7 Ethiopian Birr per bag for transporting (usually done by women and youths) from charcoaling site to road side or market place. Moreover, there are a lot of brokers on *Acacia decurrens* plantation and marketing systems including selling of

whole plantation to charcoal marketing. Generally, the value chain of *Acacia decurrens* plantation and consumption absorbs a lot of labour force that is good opportunity for the district.

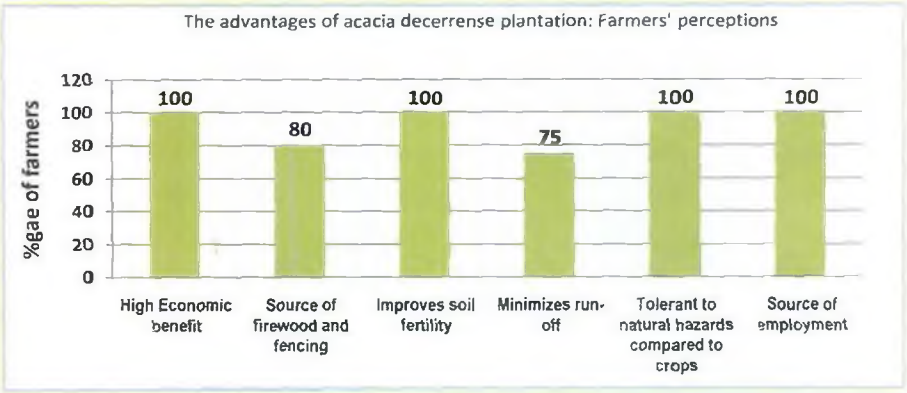


Fig. 9. Farmers' perception about advantages of *Acacia decurrens* plantation (multiple response percentages)

Source: Survey data, 2015.

Farmers' perceptions about problems of Acacia decurrens plantation

About 65% of respondents agreed that, *Acacia decurrens* plantation shares livestock grazing land and it needs guarding (40%) for atleast 2 years from livestock attacks after plantation (Fig. 10). Farmers perceived that smoke of *Acacia decurrens* charcoal is hazardiuous for health especially for those who make charcoal under traditional ways. Moreover, farmers are planting fertile and irrigable lands with *Acacia decurrens* attracted by the higher income obtained from the plantation instead of allocating the land for annual crops production. Farmers added that, *Acacia decurrens* plantation is a long time investment that needs capital till it matures (4 to 5 years) for harvesting. This makes difficult for the poor smallholder farmers to apply it and thus forced them to rent out their land for the rich and/or urban people. About 95% respondents replied that marketing problem is another obstacle so that farmers are not that much benefiting instead it is the traders and brokers who benefit much from the plantation (Fig. 10).

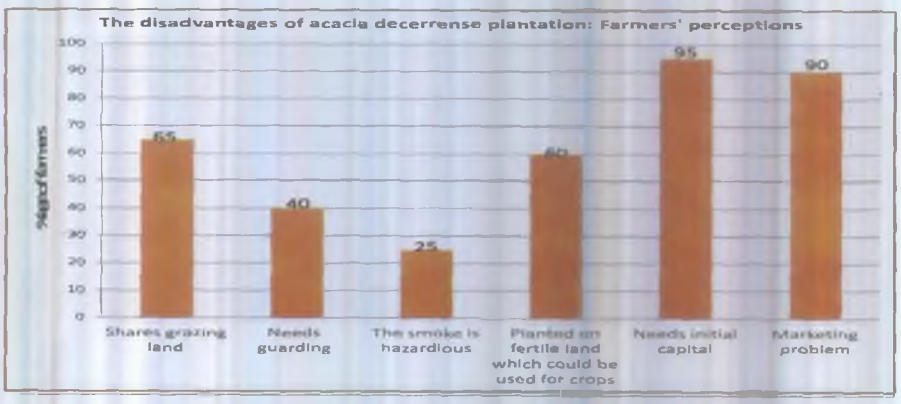


Fig. 10. Farmers' perception about disadvantages of *Acacia decurrens*, using multiple response technique.

Source: Survey data, 2015.

Cost-Benefit analysis of annual crops production and Acacia decurrens plantation

Farmers have their own judgment on their production activities according to their limited physical capability, social and natural resources. Crop production arrangement is also following several principles within their limited land, labor, capital, technologies, and information. Cost-Benefit analysis of major annual crops grown in the district and *Acacia decurrens* plantation was considered for c their competition and comparative advantage on the limited resources available for growers. Financial profitability from the farmers' point of view was assumed to affect farmers' crop production choice including *Acacia decurrens* plantation given their limited resources. The smallholder farmers may not list and calculate costs and returns of each crop enterprise, but may go for farm enterprise crops that deserve lower cash outlay and fetch better prices.

The cost benefit analysis was mainly done using the average prices, inputs, and outputs. The analysis was done according to the yield and input data obtained from farmers during the survey. The cost and benefit analysis is presented in Table 7 and 8. The benefit of each enterprise was calculated by multiplying yield by price. And since, straw has market value, the benefits from crop residue were also considered in this analysis. Labor costs were considered mainly for the preparation of land, planting, weeding, harvesting, and threshing activities. The cost of oxen was for land preparation and threshing.

The result of the analysis indicated that total gross return from tef and bread wheat production was 20,640 and 17,400 Ethiopian Birr/ha, respectively while the average total cost per hectare were 14,046 and 12,518 Ethiopian Birr in that order. Therefore, farmers gain the net profit of 6,594 and 4,882 Ethiopian Birr from the production of one hectare of tef and bread wheat crops, respectively.

On the other hand, the total cost for *Acacia decurrens* plantation per 4 or 5 years per ha was found to be 41,337.5 Ethiopian Birr while the gross return was 104,192. Therefore, farmers/producers could gain a non-discounted net profit of 62,854.5 Ethiopian Birr from the production of one hectare of *Acacia decurrens* plantation after waiting 4 or 5 years. This means producers could get a non-discounted net benefit of 12, 570.9 Ethiopian Birr per ha per annum from *Acacia decurrens* plantation. The Non-discounted net return of *Acacia decurrens* per annum when compared with the net return of wheat and tef was greater by 90.64% and 157.49%, respectively.

In general, even though the farmer/producer has to wait up to 4 to 5 years to get the benefit, he/she is currently fetching good profit/benefit from *Acacia decurrens* plantation. The result indicated that *Acacia decurrens plantation* is financially more profitable than other competent annual crops production.

Table 7: Cost-Benefit analysis of major crops

Description		Tef			Wheat		
RETURN		Yield (qt)	Price /qt	Total value	Yield (qt)	Price /qt	Total value
Average Yield (qt/ha)		9.20	1200	11,040	18	800	14,400
Straw yield (carts/ha)		33	300	9,600	30	100	3,000
Gross return				**20,640**			**17,400**
COST		Man-day/ha	Price/man-day/day in birr	Total cost/ha in birr	Man-day/ha	Price/man-day/day in birr	Total cost/ha in birr
Labor cost	Plowing + ox	6.70x4	120	3,216	4.5x4	120	2,160
	Level +plant	14.68	50	734	5.44	50	272
	Weeding	45.4	50	2,270	40.28	50	2,014
	Harvesting	22.84	50	1,142	21.44	50	1,072
	Threshing and cleaning	23.04	50	1,152	24.56	50	1,228
	Total labor cost			8,514			12518
Animal Threshing		24.24	50	1,172	23.44	50	1,172
input cost	Seed (kg/ha)	100	12	1,200	160	8	1,280
	Fertilizer (DAP+UREA)	240	13	3,120	240	13	3,120
	Total material cost			4,320			4,400
Total cost				14,046			12,518
NET RETURN				*6,594*			*4,882*

Source: Survey data, 2015.

Table 8: Cost-Benefit analysis of *Acacia decurrens*

RETURN		Acacia decurrens		
		Yield (qt)	Price /qt/cart in Birr	Total value in Birr
Average Charcoal Yield (qt/ha)		1136.2	90	102,258
Av. branches/remains yield (carts/ha)		38.68	50	1934
Gross return				104,192
COST		Man-day/ha	Price/man-day/day in birr	Total cost/ha in birr
Labor cost	Level and planting	35.28	50	1764
	Guarding for two years (100 Birr/month)	48	50	2400
	Harvesting	215.64	50	10782
	Charcoal making cost (Birr/sack)	1136.2	8	9089.60
	Transport cost from farm to road	1136.2 qt/ha	2.25	2556.45
	Guarding for a week before sale	7x2=14	50	700
	Total labor cost			27,292.05
Input cost	Seeding cost (Birr/ha)	16115.6	0.378	6091.70
	Sack cost (Birr/ha)	1136.2 (sacks)	7	7953.4
	Total material cost			14,045.1
Total cost				41,337.15
NET RETURN after 5 years				*62,854.85*

Source: Survey data, 2015.

Table 9: Summary of Cost-Benefit analysis of major crops and *Acacia decurrens*

Description	*Tef*	Wheat	*Acacia decerruns*	*Acacia decerruns per annum*
Gross benefit (Birr/ha)	20,640	17,400	104,192	20,838.4
Total Costs (Birr/ha)	14,046	12,518	41,337.5	8,267.5
Net return (Birr/ha)	6,594	4,882	62,854.5	12,570.9

Note: Non-discounted net return of *Acacia decurrens* per annum over wheat and tef (in %) was greater by 90.64 and 157.49, respectively.

Source: Survey data, 2015.

Financial Viability of Acacia decurrens plantation and annual crop production

Costs and returns do not serve as true yardsticks for making a decision to go for investing *Acacia decurrens* plantation due to the fact that costs incurred in and returns obtained from plantation are not comparable without discounting such costs and returns. The present worth of costs and benefits was estimated by using 12 percent interest rate or discounting rate considering the present investment opportunities (financial condition) of Ethiopia. Present worth of benefits for the period of one to four years of *Acacia decurrens* were obtained from crop, grass and branches (from pruning) that growers obtained before the tree reaches for harvest.

Net present worth was estimated to be Ethiopian Birr of 26,682.68 for *Acacia decurrens* and it was 5,430.54 for annual crops production after five years of investment (Table 10). The benefit cost ratio (B/C) was 1.09 and 1.53 for *Acacia decurrens* plantation and annual crops production investment, respectively. Although B/C is more than unity and total revenue is greater than the total cost for both *Acacia decurrens* plantation and annual crops production, *Acacia decurrens* plantation is more justifiable investment than crops production. More importantly, the Internal Rate of Return (IRR) was 26% for annual crops and 58% for *Acacia decurrens* plantation which are by far better than the 12% interest rate or discounting rate considered (Table 10 and 11). This also indicates that, *Acacia decurrens* plantation is more attractive investment for growers than annual crop production. All the financial viability indicators show that, *Acacia decurrens* plantation investment is highly profitable from financial point of view that gave higher returns.

Table 10: Discounted costs and benefits, Cost-Benefit Analysis (CBA), NPV and IRR:

Years	CROP (mean of Tef+wheat)		ACACIA	
	Cost	Benefit	Cost	Benefit
0	0	0	0	0
1	11,806.22	16,906.67	11,806.22	16,906.67 (from crop)
2	10,494.42	15,028.15	4,533.73	1,580.25 (from grass)
3	9,328.373	13,358.35	4,029.98	351.17 (from branches*)
4	8,291.887	11,874.09	3,582.21	624.30 (from branches*)
5	7,370.566	10,554.75	19,558.72	57,819.16 (from charcoal)
	NPV	5,430.54		26,682.68
	B/C ratio	1.09		1.53
	IRR	26%		58%

Note: Initial investment was 15,000 and 7,088 EtB for crops and *Acacia decurrens* respectively. Moreover, annual costs and benefits for crops were 13,282 and 19,020 EtB respectively while it varies for *Acacia decurrens*.*= Branches obtained after pruning the tree to initiate erect growth. Source: Survey data, 2015.

Table 11: Annualized present values of benefits and costs (Birr/ha) of enterprises

Description	Average of Tef and Wheat	Acacia decerruns
Gross benefit (Birr/ha)	13,544.40	15,456.31
Total Costs (Birr/ha)	9,458.29	8,702.17
Net return (Birr/ha)	4,086.11	6,754.14

Source: Survey data, 2015.

Marketing of Acacia decurrens charcoal: Overview

Farmers usually sell their charcoal on-farm just after harvest. They use nylon sacks/bags of 100 kg size to put charcoal. Price varies from 80 to 120 Birr per bag. Charcoal is transported by human load paying 1 to 7 Birr/bag depending on distance of the plantation site to the main road/pilling place for whole sell. Charcoal buyers are mostly wholesalers coming from distant area through brokers. Ofcourse, there are retail traders who sell charcoal on the main asphalt road sides whom they are either producers themselves or roadside retailers. The charcoal has only one main trade route and is taken to Addis Ababa by truck with capacity of 200 to 460 bags per car depending on the capacity of the car or lorry. It is customary to see lots of trucks either being loading charcoal or stopped in line for paying tax on the district revenue authority offices, usually the district office of agriculture.

Conclusions and recommendations

Conclusions:

Although *Acacia decurrens* plantation was introduced as a public forest plantation on mountainous areas in the 1980's in Fagita-Lekoma district of Awi zone, Ethiopian farmers are fully implementing as plantation agriculture in rotation with annual crops for charcoal production that become the main source of livelihood for the households and it is new practice in the country which could be considered as "best innovation of farmers". High economic benefit, source of firewood and fencing, improving soil fertility and decreasing run-off, tolerance to natural hazards compared to annual crops and sources of employment were found to be the major motives behind the expansion of Acacia decurrens plantation. Farmers are fetching attractive economic benefit and conserving their soils from *Acacia decurrens* plantation. All the financial viability indicators show that, *Acacia decurrens* plantation investment is highly profitable from financial point of view that gave higher returns.

Recommendations:

- ✓ Introduction of better *Acacia decurrens* species (if any) that are short maturing, give more wood yield, less hazardous on the environment and human health during charcoaling;

- ✓ Nursery management (seedling preparation) is an area of intervention for employment creation for landless youths and women so that arranging nursery land, seedling raising materials, credit and marketing issues, etc would help to implement it;
- ✓ Modernize the traditional charcoal making technique: introduce and test improved charcoal making tools/techniques;
- ✓ Improve marketing of *Acacia decurrens charcoal:* forming farmers' marketing cooperatives to make growers more beneficiary from the plantation;
- ✓ Introduce the "Best innovation practice of farmers" experience to other similar areas of Amhara Region which are degraded and unable to grow annual crops like Adawa mountain areas of Yilmana-Densa district; South Gonder zone of Lai-Gaint district;
- ✓ Further study on the human health, soil properties and environmental aspects of *Acacia decurrens* plantation and charcoaling as well as marketing and value chain aspects is recommended.

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Value Chain and Marketing Analysis of High Land Bamboo Production: Evidence from Awi zone, Amhara Region, Ethiopia

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Abstract

Bamboo is a multipurpose tree of high economic and environmental value with broad range of applications. Bamboo has become an important raw material and a substitute for wood and metal. Amhara region has two indigenous bamboo species (Yushania alpine and Oxytenantheria abyssinica). Awi zone has a high potential for highland bamboo that is suitable for several purposes and uses due to its easy workability, strength, straightness, lightness, hardness and short period of maturity. Bamboo value chain development is very important to producers; bamboo supplied to the market passed through different marketing agents from producers to consumers. The major actors involved in marketing of bamboo were producers, traders, processors and consumers. Starting from production to marketing, every producer produces and sells on individual basis. They simply sell bamboo culms for consumers, traders and processors. Theconsumers either directly use the culms they bought from producers or traders otherwise purchase the processed bamboo culm products from processors. Thus, bamboo has a tremendous potential for economic development but there is little link between nature and pattern of demand, location of markets, location of products and their characteristics to guide bamboo sector in Amhara region in general and Awi zone.

Key word: Bamboo; Value chain; production; marketing; Structure-Conduct-Performance; Awi Zone

I. Introduction

Bamboo is non-timber forest product, which can be found in the tropical and sub-tropical zones. Ethiopia has a bamboo forest about 1 million ha (LUSO Consult, 1997 and 1996). The total Ethiopian natural bamboo forest is estimated to be about 1 million ha, which is about 7% of the world's total and 67% of the African bamboo forest area (Kassahun, 2003). Two bamboo indigenous species are found in Ethiopia. Those are lowland bamboo (*Oxytenanthera abyssinica (A. Rich.) Munro,* which is located in the western part along major river valleys and in the lowlands bordering Sudan. Thehighland or African alpine bamboo (*Arundinaria alpina K. Schumach.),* is located in the south, south-west, central and north-west highlands. In Ethiopia, besides, the vast area of natural highland bamboo stands, there are many places where highland bamboos are found in small plots on farmland next to natural stands.

Table 1: Major highland bamboo areas in Ethiopia

	Bambo Area	Region	Natural stand (Ha)	Plantation (Ha)	Total area (Ha)
1	Awi	Amhara		2350	
2	Agaro	Oromiya	-	1500	1500
3	Bale mountin	Oromiya	56,851	-	56851
4	Shenen	Oromiya	1774	2561	4335
5	Gera	Oromiya	36000	1250	37250
6	Bore	Oromiya	-	2450	2460
7	chencha	south	2460	3250	5710
8	Jembero	south	-	1850	1850
9	Jima	Oromiya	-	900	900
10	Mizan	south	-	1850	1850
11	Debresina	Amhara	35	-	35
12	Wushwush	South	-	1120	1120
13	Bonga	South	7997	-	7997
14	Masha	south	18652	-	18652
15	shashemene	Oromiya	4183	-	4183
	Total				

Despite the availability of bamboo, the use of bamboo resources in the country is sub-optimal (Ensermu et al, 2000).Tthis is because the bamboo industry is not well developed and most of the products seen are at a very rudimentary level, limited to construction, material for housing, fences, and beehives in the villages. Many of the landless men buy bamboo culm from farmers and engage in producing mats, and furniture e.g. chairs, sofas, and baskets and sell along the roadside. Besides,

using bamboo for the development of tourist lodges and some cultural coffee houses were common. However, lack of a regular raw bamboo supply poses a serious bottleneck to manufacturers operating in towns and there only exists a very limited local market for bamboo handicrafts, which is not further developed or organized. It is essential to understand how to manage bamboo production, marketing and utilization systems is functioning (Kassahun, 2003, EFAP. 1993 and Melaku, 2006) and to realize the existing full range of activities that are required to bring a product from its conception, through different phases of production, to its final customer as a means of alternative livelihoods through a well-developed marketing strategy. Better understanding of the interventions required to develop the bamboo sub-sector while benefiting rural people. The objectives of this study are to assess the roles and functions of the actors and their linkages, the current situation of the bamboo value chain, major opportunities and constraints of bamboo value chain, asses main policy issues in need to be addressed and the services to be developed (Andargatchew., 2008.).

2. Materials and Methods

2.1. Description of the Study Area

The study is conducted in Awi zone, Amhara region. According to CSA 2007, the Zone has a population of 982,942, in an area of 9,148.43 square kilometers with a population density of 107 persons/sq. kilometer. The site was selected based on the availability of bamboo resources and its potentials and significance to the surrounding community specifically and the country in general. The zone has three main agroecologies: Dega (17%), Weynadega (72%) and Kola (11%). Natural and artificial forests account 29.3% of the total area of the zone. High land and low land bamboo contributes 2.4% (Table 1).

Table 2: Bamboo production in Awi zone

No	Woreda	Bamboo coverage in hectare
1	Banja	732
2	Injibara	38.5
3	Guguisa	134.85
4	Ankesha	1112.85
5	Fagita	118.32
	Total	2136.42

2.2. Sampling Method

Primary data were collected through structured questionnaire from randomly selected main actor's farmers, traders (wholesalers and retailers), processors, consumers and support providers (MFIs, SKEs, and Bureaus of Agriculture). A total of 160 respondents constituting 90 bamboo producers, 9 retailers, 12 wholesalers and 29 processors were interviewed.

2.3. Data Analysis

The data was analyzed using both descriptive statistics and econometrics analysis. Descriptive statistics includes mean, percentage, frequency, standard deviation and econometrics analysis includes Structure – Conduct – Performance Analysis.

3. Result and Discussion

3.1. Bamboo Production

Bamboo production in the study area is characterized by rain fed production system owned by smallholder farmers. The sources of seedling in the two model nursery sites were one cooperative nursery and farmers own seedling production. 76.7 % of the respondents replied that their source of seedling was not readily available and mostly they have used their own seedling sources, only 23.3 % of the respondents were getting input such as seedling readily available (Table 3). This shows that the extent of extension support is not satisfactory and should be improved.

Table 3: Input availability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	69	76.7	76.7	76.7
	yes	21	23.3	23.3	100.0
	Total	90	100.0	100.0	

Respondents provided multiple responses in relation to bamboo propagation methods and we have grouped them into two bamboo propagation methods, the major ones are offsite propagation method (826.7 %) and seedling propagation method (13.3%). Respondents reasoned out that the offsite propagation method was adopted from their elders and take short time to adopt after transplanting, takes short time during maturity and it has more biomass than seedling propagation method (table 4).

Table 4: Method of propagation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	offsite	78	86.7	86.7	86.7
	seedling	12	13.3	13.3	100.0
	Total	90	100.0	100.0	

According to the data from district office of agriculture, the average harvest of bamboo per farmer in the last five years has increased and the number of farmers involved in bamboo cultivation and area coverage were very significantly increased by 50%. The survey respondents replied that the maximum average and minimum harvest per day was 289, 52, 12 number of bamboo, respectively.

The respondents also told us that the frequency of bamboo harvest differs among farmers and the maximum average and minimum frequency of bamboo harvest per month was 8, 4, 0.5 times, respectively (table 3).

Table 5: Harvesting of bamboo

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Harvest per month?	90	12.00	289.00	4764.00	52.9333	63.53479
Frequency of harvest/month?	90	.50	8.00	361.50	4.0167	1.87750
Valid N (listwise)	90					

3.2. Bamboo Processing

There are a number of people leading their livelihood. Value is added to the bamboo and turned into basket, chair, mate, table and other crafts. Time for making, number of culm needed and price for each value added product have been seen. Consumers demand has increased because other materials such as wood, cement, etc are becoming expensive and bamboo has a higher aesthetic value and can last for long years.

Table 6: Time, price and amount of Bamboo

	N	Minimum	Maximum	Mean	Std. Deviation
time to make basket for injera?	29	5.00	7.00	5.8966	.81700
time to make table?	29	1.00	3.00	2.4483	.57235
time to make double chair?	29	4.00	6.00	4.9655	.82301
time to make smal chair?	29	1.00	2.00	1.4655	.46925
time to make mat?	29	.30	1.30	.9207	.23961
time to make basket for cloth?	29	5.00	7.00	5.9655	.82301
time to make modern sofa?	29	36.00	72.00	53.3793	13.82851
price of basket for injera?	29	9.00	15.50	12.0345	2.03071
price of table?	29	30.00	70.00	47.2414	12.99630
price of basket double chair?	29	17.00	26.00	21.3448	2.84449
price of smal chair?	29	5.00	9.00	7.0690	1.41247
price of mat?	29	4.00	13.00	8.3448	2.84449
price of basket for cloth?	29	15.00	23.00	19.1724	2.61956
price of modern sofa?	29	2150.00	2850.00	2385.5172	168.55881
no. of culm used for basket for injera?	29	2.00	3.50	2.3793	.54536
no. of culm used for table?	29	3.00	5.00	3.9310	.84223
no. of culm used for double chair?	29	4.00	6.00	5.0000	.75593
no. of culm used for smal chair?	29	.50	1.00	.7586	.25427
no. of culm used for mat?	29	.50	2.00	.8621	.39858
no. of culm used for basket for cloth?	29	2.00	2.50	2.0690	.17547
no. of culm used for modern sofa?	29	7.00	11.00	8.0690	.98106
Valid N (listwise)	29				

3.2 Marketing and Value Addition

3.2.1. Mapping Bamboo Value Chain

The results from surveys along the value chain revealed that the bamboo commodity chain starts at culm production areas where the bamboo lots, roadside and river bank plantings are well managed,. The bamboo value chain is known for three major channels in the bamboo production-to-consumption chain in the Amhara region. Market observations show that the chain is characterized by raw bamboo transformation followed by marketing and the product reaching end consumers. In the level element, producer farmers sell their bamboo culms to local traders where the local traders in turn sell it to town or city processors from where the products reach end consumers (Fig. 1).

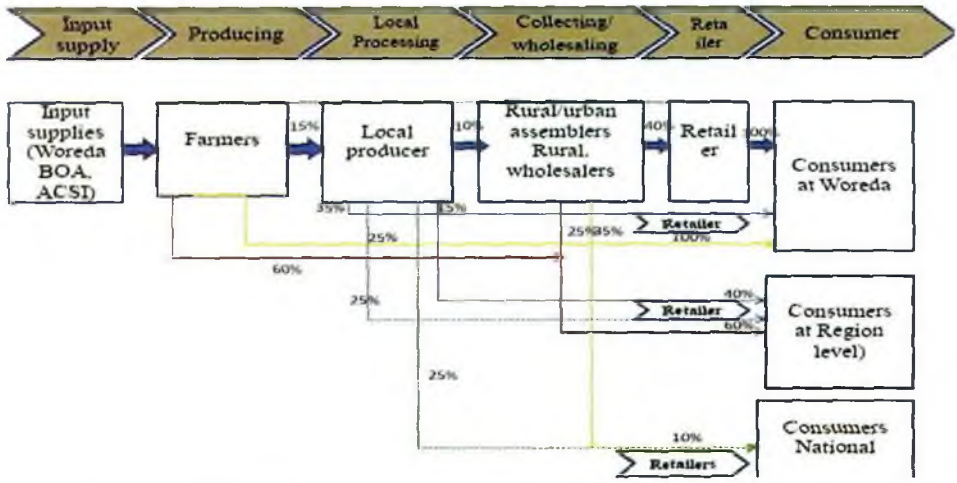

Fig. 2. Bamboo value Chain Map

3.2.2. Market Conduct

The pricing of bamboo has different forms from other tree pricing types in which the pricing was dependent on the production seasons and size of the bamboo culm. The survey respondents replied that the price for culm increases during farming and raining season, from April to June (48.9%) and November to December (45.6%). One of the reasons for the increase in price was mainly due to an increase in demand for the bamboo culms and products. The survey results also pointed out that starting from production up to marketing; every farmer produces and sells on individual basis. The survey results indicated that the transaction made on bamboo marketing takes place with direct contact between sellers and buyers. There were no observed operational brokers in bamboo marketing channels during the survey period. All sample bamboo traders pointed out that the purchase price was settled by negotiating with that of the producers.

Table 7: Bamboo supply time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	January – March	2	2.2	2.2	2.2
	April – June	44	48.9	49.4	51.7
	July – October	2	2.2	2.2	53.9
	Nov- Dec	41	45.6	46.1	100.0
	Total	89	98.9	100.0	
Missing	System	1	1.1		
Total		90	100.0		

The respondents also replied that the price of bamboo is fixed based on the size and on average, the price ranges from 1.5 to 9 Birr per culm. The minimum and maximum price for the small, medium and large size culms was 0.5 and 3.5 ETB, 1 and 5 ETB, and 3 and 13 ETB, respectively. For different handicrafts different bamboo species and sizes are required.

Table 8: Price for size of culms

	N	Minimum	Maximum	Mean	Std. Deviation
Small size culm price?	90	.50	3.50	1.5667	.95164
Medium size culm price?	90	1.00	5.00	3.0000	1.42214
Large size culm price?	90	3.00	13.50	8.9611	3.22318
Valid N (listwise)	90				

3.2.3. Market Performance

The analysis of bamboo marketing performance included marketing margins by taking into account associated marketing costs for key marketing channel actors and taking consideration of costs and purchase prices of the channel actors, profit was calculated. The bamboo collection takes place from the farmers' village as well as from the markets. The survey respondents replied that the average minimum and maximum culm collection per month reached 400, 848 and 2870. The net profit reported from bamboo collection ranged from 670 to 3300 Birr per month.

Table 9: Bamboo profit

	N	Minimum	Maximum	Mean	Std. Deviation
number of culm bought per month?	12	400.00	2870.00	848.5000	705.62319
Net profit per month?	12	670.00	3300.00	1795.7500	1049.27985
Valid N (listwise)	12				

The survey from the marketing margin shows that out of the total gross marketing margin 38.67% was gross margin of bamboo traders, while 47.73% was that of processors. This indicates that the producers have much lower marketing margin as compared to any other marketing participants.

Table 10: Marketing Margin

No.	Chain actors	ETB/culm	Cost	Gross profit	Gross Margin
1	Producers	2.55	-	2.55	13.6
2	Traders	11.5	5.89	5.61	47.73
3	Processors	18.75	12.90	5.85	38.67

4. Conclusion and Recommendation

The area has the largest bamboo resources. However, the development of bamboo value chain is at its infant stage and is practiced in traditional way in which the farmer got the least marketing margin (Kelbessaet al, 2000). Traditionally, the most value is added on handcrafts. But, there is high demand for bamboo materials and furniture. Lack of skill both among harvesters and producers contributes to the minimum quality and low value addition. This is the major problem observed in the study area. Thus, an improvement of technical, functional and aesthetic aspects of bamboo products and diversification of new markets is needed. The bamboo sector should follow the good examples of the cereal, coffee and other agricultural products marketing systems.Farmers are still using bamboo for different purposes in their surroundings. In order to give use right and security over the use of the resource, a strong policy direction is essential. Despite the inefficient value chains, respondents indicated an increasing trend of demand for bamboo products. Development of a comprehensive strategy that will encompass sustainable bamboo resource management and utilization and organization of farmer-based cooperatives is crucial. Bamboo entreprenernial activity that will use the resources in innovative manners, improving the infrastructure that will add value to bamboo products and that can help to upgrade the value chain is very important. Technologies that diversify bamboo products based on consumer needs and behavior are crucial. Specific bamboo propagation and stand management techniques should be developed and communicated to the farmers. Further socio-economic research and mapping of the resources that comprehends the full value of bamboo resources to local, regional, and national economies is also central.

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Determinants of Prices of Sheep in the Rural Market of Western Amhara, Ethiopia

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Abstract

This study aims to assess the nature of sheep price variability and examine implicit factors affecting prices of sheep. A quantile regression approach was employed to analyze hedonic prices of sheep attributes. The results of this analysis indicated that prices of sheep are found to have significant seasonal patterns, which can be explained by seasonal variations in supply and demand. While cash needs and availability of feeds are the main drivers of sheep supply, buyers' taste and preference, market occasion (major festive seasons of Ethiopian New Year and Easter), and availability of closer substitutes are the main determinants of the demand for sheep. Otherwise, weight of sheep is a significant determinant of prices, indicating that consumers are rather interested in weight than other phenotypic characteristics. Smallholder farmers need to recognize which animal attributes in a specific season are preferred and 'for whom they produce'. In addition, the producers have several untapped opportunities to optimize their production following the needs of buyers and thereby reap better benefits from sale of their products. This however calls for establishment of a reliable and sustainable livestock information system as a key tool for market development.

Key words: Hedonic price model; Quantile regressions; Price formulation; Washera Sheep

Introduction

In Ethiopia, people are highly concerned with the phenotypic characteristics of live animals (Terfa et al. 2013; Terefe et al. 2012; Andargachew and Brokken 1993). These concerns underscore the need for understanding consumers' preferences for animal attributes. To produce animals whose characteristics correspond with consumer preferences, producers and fattening processors need to understand the implicit values of animal attributes. However, not only do producers currently lack these concepts (Andargachew and Brokken 1993), but most biological researchers ignore the implicit values of animal attributes in their attempts to improve the poor potential of indigenous breeds (Kosgey and Okeyo 2007). As a result, sheep producers' did not attain optimum benefits from sheep production due to absence of productive and sustainable breeding program although this breed has potential for commercial mutton production for both local and export markets (Taye et al. 2011; Gizaw et al. 2010).

The hedonic pricing method provides an important means of estimating consumers' implicit values of animal attributes. It permits monetizing non-market goods by observing the consumption behavior of households in the market. The approach to consumer behavior developed by (Lancaster 1966) argued that utility is derived from the characteristics of the goods, not from the goods themselves. In general, Rosen (1974) stated that in a competitive market products are valued for their utility-bearing attributes or characteristics, and utility anticipated by the buyers is ranked indirectly through the characteristics that products possess. In relation to this, empirical results from livestock marketing studies in Africa note that animal attributes result in price discrepancies and they are milestones in animals' price formulation. Sheep are differentiated products and distinguished by breed with an element of geographical specificity. However, sheep marketing studies have been scanty and so far rather concentrated on the eastern and central highlands of Ethiopia (see Terfa *et al.* 2013; Terefe *et al.* 2012; Kassa *et al.* 2011; Teklewold *et al.* 2009; Ayele *et al.* 2006; Andargachew and Brokken 1993). Ayele *et al.* (2006) employing hedonic price modeling in his study that aimed at investigating determinants of inter-annual price variation of small ruminants' price in the eastern highlands of Ethiopia, reported significant differences in prices between seasons and markets, controlling for attributes of animals. Similarly, Kassa *et al.* (2011) applied general linear model to examine factors that influence sheep prices in the highlands of north eastern Ethiopia. The results of this study showed that animal characteristics such as weight, sex, age, condition, season, and color are very important determinants of sheep price. These scholars suggest that understanding of the implicit price of animal attributes allows for insight into price formulation.

Intuitively, valuations of traits of sheep and identification of seasons in which they can have high value are important to attain successful market clearing price and to optimize producers and fattening processors benefit from sheep production. Understanding how buyers value specific attributes is

important for making effective production decision. In addition, identifying specific attributes demanded is curial for making efficient marketing strategies. Therefore, the objective of this study was to examine the sheep attributes implicitly determining prices and how and to what extent consumers' preferences are reflected by the prices and sheep characteristics.

Materials and Methods

The Study Areas

The study was conducted in Yilmana Densa and Quarit districts in the Northwestern highlands of Amhara region, Ethiopia. Yilmana Densa is found at about 42 km Southeast of Bahir Dar, capital city of Amhara region and geographically located at 11°10′–11°15′ N and 37°30′–37°40′ E. It has an altitude of 2,300 m. a.s.l. with a uni-modal type of rainfall receiving a mean annual rainfall of about 1,291 mm. **Quarit** is located about 280 km distance from Bahir Dar at the South. Geographically it is located at 11°00′ N and 37°20′–37°30′ E. It has an altitude of 1,500–3,200 m a.s.l. and receives an average annual rainfall of 900–1,400 mm.

Data Collection

The data used in this study were collected as part of the initiative "*Community and Conservation-based Improvement Scheme for Washera Sheep*" in an attempt to improve the productivity of Washera sheep and thereby increase the benefit of smallholder farmers from sheep production. Yilmana Densa and Quarit districts were selected purposively as target areas of the study considering their potential for Washera sheep production. Washera sheep is an indigenous sheep breed in Ethiopia which mainly inhabits the wet and warmer mid-highlands of Amhara Region, Ethiopia (Gizaw et al., 2010). It is kept in the traditional smallholder production system as an adjunct to other agricultural activities along with other livestock species, providing cash income (from sale of live sheep, meat and skin), manure, and social and cultural functions for the smallholder farmers (Mengistie et al., 2010). Several studies (Chipman, 2003; Gizaw et al., 2010 and Taye et al., 2010) indicated that Washera sheep is among the potential sheep breeds of the country for commercial mutton production for the local as well as export market with relatively high reproductive and productive performances.

Samples of 158 farmers were chosen from a population of sheep producers/sellers in these districts who have an experience in sheep production over six years (October 2004 to April 2010). Hence, the data collection activity for a particular animal transaction was started ahead of the transaction if the owner has a plan to sell this particular animal in the immediate coming market days and completed if the owner sold it as of his/her plan.

Data collection format was designed to capture information on sex of the animal, birth date (or dentition), transaction date, selling live weight, body conditions when sold, color of the animal, and selling price. The format also included a question of for whom they sold their animals to assess the

purpose of the buyer's/the type of buyer's/ information. This format was filled by a trained enumerator in weekly basis at each study area. Data on animal attributes such as live weight (recorded using Salter balance with 50 kg capacity), sex, age, color and body conditions were taken a week before animals were sold while data on price, date of transaction and for whom the sellers sold their animals were recorded after the transactions. During the study period, a total of 1137 transactions were recorded. Among which, 405 transactions (35.6%) were conducted in Yilmana Densa district at Mentadeber market and the remaining 732 (64.4%) were in Quarit at Gebeze-Mariam market.

Table 1: Definition of variables that used in the analysis of Washera sheep price determinants

Variables	Type of variables and measurement
Price per head in Eth Birr	Continuous
Live weight of goat in Kg	Continuous
Age group	Categorical, where 1= < 0.5 year, 2= 0.5 < A ≤ 1 year, 3= 1 < A ≤ 2 years, 4= 2 < A ≤ 3 years, 5= 3 < A ≤ 4 years, 6= >4 years
Animal sex	Dummy, where 0= Female, 1= Male
Body condition	Dummy, where 0= Good, 1= Very good
Color	Categorical, where 1= Black, 2= Red, 3=White, 4= Red and white, 5= other
Buyer's purpose/type of buyers/	Categorical; 1= Resale (traders), 2=Production (producers) 3= Consumption (consumers), 4= Growing, 5= others (sacrifice and fattening)
Month	Categorical; 1= September 2= October,---,12= August

Categorical variables denoted as number "1" is STATA default bench mark; "A" represents the word age

Model Specification

The study employed both graphical and econometric analysis. Graphical analysis was used to analyze the interdependent phenomena of price variation with the two markets, and sex categories across months. Hedonic price model was employed to identify factors that affect market price of sheep. This study adopted log-linear functional form of hedonic model corresponding with Bin (2000) and Haab and McConnel (2002). The model is specified as follows

$$ln(price) = X_i\beta_i + \varepsilon_i$$

Where x_i is the vector of independent variables including attributes of sheep and socioeconomics characteristics of market actors, βi is a vector of parameters to be estimated and ε_i is identical and independent distributed error term.

Most analyses that used the hedonic pricing model have employed conventional least squares regression methods. The reliability of the estimates based on the classical assumptions is hardly in estimating parametric model using Ordinary Least Squares. If the classical assumptions do not hold true, inaccurate standard errors and inefficient estimators are expected from the result. The alternative methodology is a quantile regression which is a robust regression estimation technique in a situation where the typical Guassian assumption particularly normality of the error term might not be strictly satisfied (Koenker and Bassett, 1978). Moreover, quantile regressions have been used simply to get information about points in the distribution of the dependent variable other than the conditional mean (Buchinsky, 1994, 1995; Eide and Showalter, 1997). To this effect, the study employed quantile regression using STATA version 11, econometric software. The standard error for quantile regression coefficient estimates has employed using bootstrapping methods, which is more practical and provides robust results (Koenecker and Hallock 2001; Hao and Naiman, 2007).

Result and discussion

Sheep characteristics

Table 2 shows the descriptive statistics of the variables used in the econometric model. The average live weight and selling price of sheep during the study period was 17 kg and around ETB 150, respectively. The amount of marketed male sheep was low as compared to female sheep in both markets. This is against to Terfa *et al.* (2013) findings. Since households are both producers and consumers of goods, they consume not only marketed goods but also home grown products through giving priority attention for their needs/preferences. In the study areas, rural households mostly prefer male sheep for home consumption. The interesting result here is the selling age of sheep, for more than half of the recorded transactions, was below six months implying lamb selling is a dominant sheep supplying practice to the market, which can even attract the export markets. Sheep traded in those markets was observed to have different type and pattern of color. The type of sheep coat colors that have patchy pattern, red dominant with white, was predominant followed by red color. The

purpose of most actors at Menetadeber market (85%) was for resale while at Gebeze-mariam was for reproduction (39%). These different market actors' target is expected related with access to large markets. Transactions made across months have some fluctuations and higher transactions were recorded on festive seasons specifically during New Year of Ethiopia and Easter.

Table 2: Descriptive statistics of sheep in local primary markets

Description	Mean (SD)/Percentage	
	Mentadeber	Gebeze-Mariam
Price per head of sheep (ETB)	145.56 (65.63)	159.42 (74.96)
Live weight of sheep (kg)	17.13(7.03)	17.96 (8.49)
Sex groups (%)		
Male	47.01	44.58
Female	52.99	55.42
Age groups (year) (%)		
≤ ½	65.7	54.06
1/2 < A ≤ 1	18.22	20.30
1 < A ≤ 2	6.78	11.17
2 < A ≤ 3	4.46	5.08
3 < A ≤ 4	2.91	6.35
> 4	1.94	3.05
Body condition (%)		
Good	88.93	54.34
Very good	11.07	45.66
Sheep coat color (%)		
Black	1.53	2.30
Red	39.89	24.04
White	8.59	16.50
Red and white	43.13	54.60
Others	6.87	2.50
Buyers' purpose (%)		

Resale	85.19	23.05
Reproduction	8.85	38.92
Consumption	2.47	25.48
Others	3.50	12.55
Months (%)		
September	8.17	11.31
October	9.34	4.40
November	4.09	4.52
December	5.64	6.66
January	9.73	5.28
February	4.67	3.52
March	8.37	14.32
April	12.45	19.72
May	8.75	10.18
June	8.75	5.15
July	8.17	5.90
August	11.87	9.05

Source: Own computation of the survey data (2004-2010)

Price variation

As the graphical description of monthly nominal sheep prices presented in Fig. 1 indicated, there were peaks and troughs observed with different amplitude in price oscillations during the study periods. The highest price of sheep per head was observed in April followed by June due to high meat and cash demand, respectively. April is the month in which Ethiopian Easter market is appearing and most people celebrate Easter holiday by slaughtering selected and larger fattened sheep. June is the month in which farmers brought their sheep to the market to get cash for purchasing of agricultural inputs. During this month, farmers tend to supply animals that can attract buyers to liquidate more easily and fetch more money. In contrast, the lowest price was observed in October followed by January the fact that these months come immediately after the celebration of the Finding of the True Cross and Christmas holiday, respectively during which most of the people slaughter beef together with their relatives and friends, instead of slaughtering sheep individually.

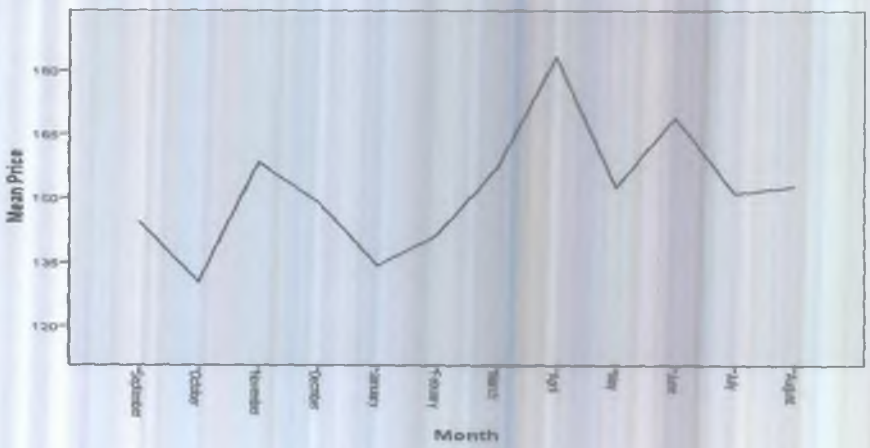

Fig. 1: Monthly average live weight price of sheep.

Source: Own survey data (2004-2010)

Fig.s 2 and 3 indicate monthly nominal sheep price variation which is disaggregated in terms of market place and animal sex categories. The peaks and troughs of price oscillation that observed in Fig.s 2 and 1 are for Gebeze-Mariam market. Sheep commands the highest price in December and April at Menetadeber market and Gebeze-Mariam market, respectively. During December, since farmers have gained surplus cash and enough feed is available for animals, they have high demand for sheep. While in September and January sheep commands the lowest price at Menetadeber market and Gebeze-Mariam market, respectively. This is most likely due to shortage of feed and disease outbreak. Yitayew et al. (2013) reported that sheep mortality is high during September at Yilmana Densa and January at Quarit district. This indicates that the lowest price during those months is due to high supply of sheep as a coping up strategy of the risk of loss.

On which market place producers suffer more from the price fluctuation is also vital. From the magnitude of the price difference (i.e., highest price minus lowest price) we can observe price fluctuation is serious problem at Gebeze-Mariam market as compared to Menetadeber market.

Fig. 2: Monthly average sheep price at Mentadeber and Gebeze-Mariam markets.

Source: Own survey data (2004-2010)

The average price of female sheep was higher than male sheep across months except during January where female and male sheep commands equal price. This is related with the animals' selling age; most of the male sheep were sold at younger age while female animals' were sold at maturity and old age. In the study areas, 75% of male sheep were sold at the age of below 6 months (Yitayew et al., 2013). The highest average price of male and female sheep was observed in April and June, respectively. Producers most often grow ram lambs and add value on it to obtain advantage from Ethiopian Easter market which mostly appears in the month of April In contrast, farmers compel to sell breeding animals (female sheep) mainly during June to satisfy their high cash need for purchasing of agricultural inputs. During Ethiopian Easter, most of the farmers sell sheep particularly not used for breeding purpose due to high demand for meat. As a result during June, the flocks that are kept are of relatively best performing and hence they command a higher price.

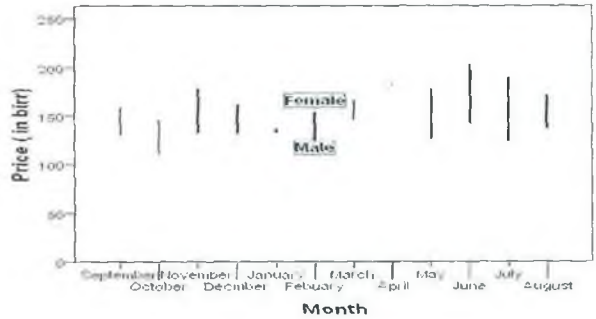

Fig. 3: Monthly average price of male and female sheep

Source: Own survey data (2004-2010)

Determinants of price of sheep

Estimating a hedonic price model using quantile regression (QR) analysis provides dual advantages in respect to relaxing the Gaussian assumptions of classical OLS and inferences about the conditional quantile function. The Shapiro-Wilk test for normal data provides evidence on the failure of the assumption of normality. The assumption of QRs is flexible; therefore, it is an appropriate method for robust analysis of non-normally distributed data (Koenker and Bassett, 1978). QRs estimate the implicit values of sheep attributes in quantiles of the distribution, instead of estimating only at the conditional mean. This enables to estimate factors that affect prices of sheep with higher-priced characteristics and sheep with lower-priced characteristics. The left and right panels of Fig. 4 show how inferences from the QR estimation method can be derived from the points in the distribution of the dependent variable. The shaded grey area in this Fig. represents the QR estimate range of covariates effect disparities and is reliable in respect to consumers' willingness to pay for their heterogeneous preferences. Again, in this Fig. the dash line shows the OLS estimate of the conditional mean effect with 95% confidence interval represented by the two dotted lines. This shows that the covariates effect has no disparities against to willingness to pay for different sheep attributes. Thus, the conventional least square estimate does a poor job of representing the range of covariates effect.

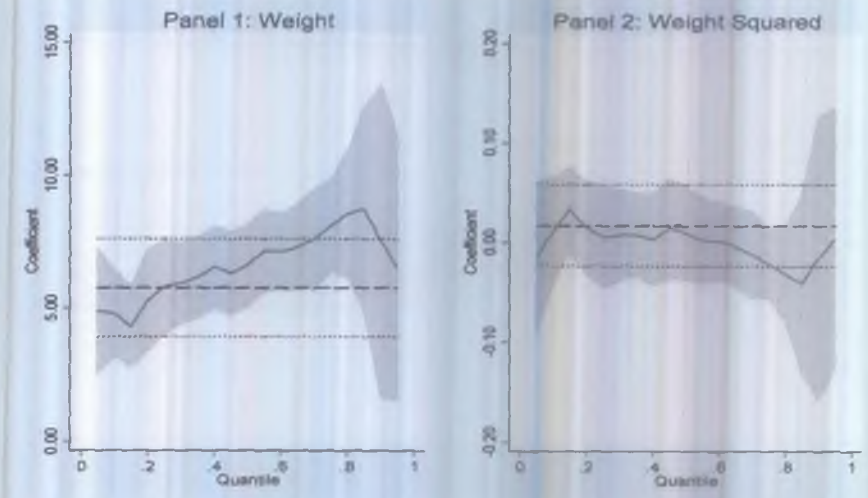

Fig. 4: Graph of coefficient of ordinary least squares and quantile regressions

Source: Own survey data (2004-2010)

Tables 3 and 4 indicate estimated parameters of factors that affect price of Washera sheep at Mentadeber and Gebeze-mariam markerts, respectively. The value of intercept for dummy variable represents the mean value of the bench mark. The coefficient that is attached to the dummy variable is the differential of intercept coefficient. This coefficient tells us by how much the value of the intercept differs from the value of the category of the bench mark. Thus, the positive sign of the coefficient within set of dummy variables signifies premiums while the negative sign indicates discounts relative to the intercept value.

The body weight of sheep had positive influence on price of sheep on all quantile regression employed in this study. This is in line with Kassa et al. (2011) and Andargachew and Brokken (1993). The quadratic effect of weight on price was larger and negative on the upper quantiles of price. This corresponds with the finding of Kassa et al. (2011) at similar market level. This indicates that price increases with an increasing in body weight of sheep, however, beyond a certain level of animals weight, price starts to decline.

Sex of the animal was found to be an important determinant of price of sheep at Mentadeber market. The quantile regression indicates a male animal has a price premium over female animals on the lower and median quantiles of price. At 5^{th} and 50^{th} quantile of price of sheep, male animals command higher price than female animals. During peak crop production season, farmers can have not only surplus cash but also enough feed for animals, leading them to purchase ram lambs as storage of asset and to fetch a return targeting Ethiopian Easter market particularly at Yilmana Densa district, which has high crop production potential. During such season, demand for ram lambs is higher than ewe lambs, which creates a significant price difference between them given lambs have generally lower price.

Animals' age was an important price determinant attribute at Mentadeber market, which is near and convenient to the tertiary market. In all quantile regression, sheep that are sold at a very young age (i.e., below six months) have a price discount over the ones sold at one up to four years of age. Similarly, a very young sheep have a price discount over those that are sold at the age of less than one year but it is on the upper quantile of price of sheep. As expected, the result reveals both very young and very old animals command lower price as compared to the matured animals. The taste and preference of consumers particularly at the tertiary market for leanness and tenderness at the two extreme age regimes of animals are low. Moreover, very young animals are not matured for immediate purpose; likewise, very old animals have little future economic purpose.

Animals' body condition has different effect on price formulation at different market places. At all quantile regression, animals with very good body condition have a price premium over animals with good body condition at Mentadeber market. In contrast, animals with very good body condition have

a price discount over good body condition at Gebeze-Mariam market on the lower quantiles of price. This possibility is due to the extent of market destination and buyers' purchasing power. The former is near and convenient to the secondary and tertiary markets while the latter is not The second and third market ladders of Mentadeber and Gebeze-Mariam markets are Adet and Bahir Dar markets, respectively. In Quarit district, producers have narrow market destination and the purchasing power of consumers are low because urbanization is limited and agriculture is for subsistence. On the other hand, animals transportation facilitates are poor and trekking of fattened animals into the higher market levels is risky.

It is not only animal's attributes that influence sheep price formation, but also buyer's purpose of purchasing the sheep. The effect of the latter is mainly related with two issues. First, individual buyer has different bargaining capacity in the price setting process. This is the result of local market transaction process. Sheep transactions are usually made on a per head basis by a long bargaining process between a seller and a buyer. Moreover, sellers and buyers hardly have equal market information, resulting in an inefficient sheep market due to market imperfection.

Secondly, the difference of animal attributes preferred by each type of buyers for instance trader's preference might be different from producer's preference. At Gebeze-Mariam market, traders bought sheep for profit making purpose at a price discount over producers and consumers. The possible reason is that traders might have better market information as compared to other market actors. In contrast, at Mentadeber market, traders bought sheep at a price premium over producers and consumers since traders buy animals with better quality to supply for secondary and tertiary markets. The price of sheep is similar for all types of buyers included in the study areas on the upper quantile of price at Mentadeber market and the lower quantile of price at Gebeze-Mariam market.

Given animal attributes and bargaining power of individual buyers, the season in which transactions are made was found to be an important determinant of price formation. This is in line with the economic principles of demand and supply. The demand for sheep varies across seasons. The possible reason for high demand for sheep is high demand for meat (festive periods), surplus income and enough feed availability (peak crop production). Likewise, there are seasons in which supply of sheep becomes high. The main driving force of high supply of sheep is high cash needs.

At Mentadeber market, sheep sold in September have a price premium at the upper quantile of price while at the lower quantile of price have a price discount, which indicates during festive periods animals that fulfill consumers' preference commands high prices, otherwise fetches lower prices. During Ethiopian neew year, consumers incur high cost to purchase young sheep with a good appearance and attractive color for good wish of the New Year. While during Ethiopian Easter, consumers' preferences highly differ and they rather highly worried about the quantity of meat they

will get from slaughtered animals because people (Orthodox Christian) barred from meat consumption for the two months of fastening.

At Gebeze-Mariam market, in contrast to Mentadeber market, on the lower quantile of price, sheep sold in September have a price discount, which indicates how the market situation differs even within the same market level. On the upper quantile of price, sheep sold in September have a price premium over December and January, and a price discount over April. Gebeze-Mariam market is nearly locked. Thus, the market situation is highly influenced by cash need and emphasis given for particular festive of the buyers is of people living in the district. For instance, cash need is high and income source is narrow for famers during September in which Ethiopian New Year is appeared.

Table 3: Quantile regression estimates of Mentadeber market.

Lnprice	OLS	0.05	0.25	0.50	0.75	0.95
Constant	3.9227***	3.3922***	3.5224***	3.7744***	4.125384***	4.284223***
	(.0558)	(.2392)	(.2676)	(.2693)	(.2813276)	(.2836502)
Weight	.0664***	.0557***	.0738***	.0635***	.066522***	.0695252***
	(.0664)	(.0163)	(.0191)	(.0164)	(.013211)	(.0167063)
Weight square	-.0007***	-.0005	-.0008*	-.0005	-.0006167*	-.00084*
	(.0002)	(.0003)	(.0004)	(.0004)	(.0003225)	(.0004237)
Male	.0591***	.1151***	.0491	.0653***	.0327094	.0575296
	(.0251)	(.0406)	(.0380)	(.0416)	(.0301463)	(.0589566)
.5 < A ≤ 1 year	.0645**	.0586	-.0211	.0135	.0908489***	.1393531***
	(.0324)	(.0605)	(.0426)	(.0416)	(.0430127)	(.0472778)
1 < A ≤ 2 years	.3104***	.3469***	.2090***	.1945***	.2141135***	.4862648***
	(.0525)	(.062)	(.0534)	(.0782)	(.0938041)	(.1981014)
2 < A ≤ 3 years	.4079***	.3173***	.2796***	.2793***	.3428117***	.3607619***
	(.0675)	(.1054)	(.1035)	(.1242)	(.0905957)	(.1003054)
3 < A ≤ 4 years	.3394***	.3697***	.3715***	.3532***	.4017467***	.456218***
	(.0791)	(.1566)	(.1511)	(.1259)	(.0927461)	(.1084887)
> 4 years	.0469	.0315	-.0056	.1244	.0597104	.1494847
	(.0943)	(.1395)	(.1534)	(.1686)	(.1546161)	(.1447164)
Very good BC	.2478***	.2391***	.2716***	.24381***	.2726146***	.2424652***
	(.0425)	(.0903)	(.0577)	(.0465)	(.0518651)	(.0562875)
Red	-.1597*	-.0299	.0428	-.0286	-.1311597	-.0491627
	(.0952)	(.1567)	(.1835)	(.2262)	(.2293365)	(.2010174)

Lnprice	OLS	0.05	0.25	0.50	0.75	0.95
White	-.0950	-.0196	.1513	.0659	-.0623871	.0351654
	(.1025)	(.1995)	(.1961)	(.2264)	(.2243833)	(.2049964)
Red and white	-.1125	-.0120	.0969	.0357	-.0987075	.0318721
	(.0953)	(.1728)	(.1820)	(.2252)	(.2313935)	(.207857)
Others	-.2285	-.0842	.0174	-.0198	-..1960493	-.0022169
	(.1022)	(.1862)	(.1896)	(.2362)	(.2362203)	(.2187522)
Production	-.0200***	-.0777	-.1294***	-.1455	-.0766036	-.111758
	(.0419)	(.0887)	(.0617)	(.0599)	(.0773735)	(.0896967)
Consumption	-.0975	-.3284	.0242	-.0425	-.0959533	-.0076748
	(.0769)	(.1965)	(.1699)	(.0816)	(.0847349)	(.0877772)
Others	.0683	.1576	.0180	.0591	.0121813	.0891983
	(.0706)	(.1477)	(.1204)	(.1071)	(.0811557)	(.0968805)
October	.1005*	.2678***	.1474	.1390*	-.0184641	-.1504463
	(.0538)	(.0954)	(.1103)	(.0741)	(.0797936)	(.1068316)
November	.0788	.2362	-.1940	.0599	-.0822972	-.1160105
	(..0759)	(.1511)	(.1678)	(.1357)	(.1245896)	(.13514)
December	.1713***	.4642***	.1091	.1038	.0411864	-.0544873
	(.0607)	(.0987)	(.1050)	(.0896)	(.0984466)	(.1058378)
January	.0970*	.2752***	.0993	.1523***	-.053659	-.2587093***
	(.0581)	(.1138)	(.1081)	(.0747)	(.082257)	(.0959392)
February	.1260*	.2732***	.1176	.1140	-.0693735	-.2195393*
	(.0675)	(.1170)	(.1086)	(.0813)	(.0942281)	(.110452)
March	.1183***	.3707***	.0990	.1363	.01285	-.0676434
	(.0583)	(.1046)	(.1027)	(.0804)	(.1034604)	(.1032982)
April	.0969*	.2888***	.0884	.0707	-.0386418	-.2202257***
	(.0507)	(.0912)	(.1024)	(.0735)	(.0792322)	(.103665)
May	.0494	.3021***	.0677	.0512	-.1304136	-.1968403*
	(.0546)	(.0855)	(.0991)	(.0761)	(.0838881)	(.0987753)
June	.1132***	.2921***	.1661	.1742***	.050923	-.0789027
	(.0547)	(.0891)	(.1271)	(.0800)	(.0801535)	(.1374858)
July	.0699	.2183***	.0642	.0295	-.0253102	-.245089***
	(..0619)	(.0870)	(.1198)	(.1105)	(.0962173)	(.0993344)
August	.1127**	.1841	.1257	.1437*	-.0324522	-.1722803

Lnprice	OLS	0.05	0.25	0.50	0.75	0.95
	(.1127)	(.1145)	(.2676)	(.0769)	(.0821477)	(.1114161)
Adjusted R^2	0.7381	-	-	-	-	-
Pseudo R^2	-	0.5386	0.4637	0.4953	0.5629	0.6211

***p < 0.1, **p < 0.05, *** p < 0.01, statistically significant; Fig.s in parenthesis are bootstrap standard error**

Source: Own survey data (2004 - 2010)

Table 4: Quantile regression estimates for Gebeze-Mariam market.

Lnprice	OLS	0.05	0.25	0.50	0.75	0.95
Constant	3.9607***	3.9681***	3.8329***	3.8187***	3.9056***	4.2451***
	(.1043)	(.1187)	(.1028)	(.1003)	(.1337)	(.2021)
Weight	.0735***	.0494***	.0725***	.0834***	.0915***	.0755***
	(.0061)	(.0108)	(.0074)	(.0066)	(.0093)	(.0171)
Weight square	-.0008***	-.0002	-.0007***	-.0011***	-.0012***	-.0010***
	(.0001)	(.0002)	(.0002)	(.0001)	(.0020)	(.0003)
Male	.0088	-.0013	.0241	.0107	.0160	.0111
	(.0221)	(.0414)	(.0244)	(.0220)	(.0438)	(.0554)
.5 < A ≤ 1 year	-.0332	-.1099***	-.0601	-.0081	-.0355	-.0841***
	(.0240)	(.0416)	(.0396)	(.0316)	(.0423)	(.0422)
1 < A ≤ 2 years	.0433	.0059	.0020	.0328	-.0194	.0287
	(.0341)	(.0592)	(.0422)	(.0373)	(.0594)	(.0880)
2 < A ≤ 3 years	.0900*	-.0147	.0238	.0191	.0785	.1053
	(.0472)	(.0795)	(.0507)	(.0553)	(.1117)	(.1159)
3 < A ≤ 4 years	.0692	.0351	.0255	.0578	.0305	.0200
	(.0475)	(.0959)	(.0588)	(.0553)	(.0896)	(.1085)
>4 years	.0788	.0231	.0877	.1085	.0669	.0583
	(.0602)	(.1265)	(.0745)	(.0840)	(.0963)	(.1054)
Very good BC	-.0343**	-.0554*	-.0649***	-.0341***	-.0201	-.0586
	(.0168)	(.0294)	(.0189)	(.0168)	(.0262)	(.0396)
Red	.0061	-.0230	-.0107	-.0051	-.0235	.0780
	(.0568)	(.0703)	(.0781)	(.0768)	(.0808)	(.1018)
White	.0339	.0535	.0323	.0049	-.0058	.1092
	(.0568)	(.0757)	(.0783)	(.0778)	(.0778)	(.1117)
Red and white	.0277	.0196	.0353	.0178	-.0172	.0346
	(.0555)	(.0709)	(.0754)	(.0770)	(.0815)	(.0943)
Others	-.0209	-.0202	-.0652	-.0180	-.0147	.0987

Lnprice	OLS	0.05	0.25	0.50	0.75	0.95
	(.0743)	(.1017)	(.0938)	(.0965)	(.1249)	(.1163)
Production	.0425	-.0234	.0510**	.0418*	.0530	.0111
	(.0260)	(.0513)	(.0256)	(.0235)	(.0440)	(.0540)
Consumption	.1035***	.0050	.0137	.0983***	.15302***	.2708***
	(.0275)	(.0553)	(.0300)	(.0255)	(.0507)	(.0780)
Others	.0406	-.0497	-.0025	.0438	.0164	.1934*
	(.0295)	(.0354)	(.0246)	(.0272)	(.0498)	(.0991)
October	-.0392	.0012	-.0258	-.0473	-.0796	.0223
	(.0489)	(.0988)	(.0386)	(.0396)	(.0727)	(.0961)
November	-.0289	-.0504	-.0688**	-.0414	-.0790	.1570
	(.0456)	(.1212)	(.0351)	(.0414)	(.0889)	(.1204)
December	-.1533***	-.0971	-.1342***	-.1181***	-.1618***	-.2426***
	(.0405)	(.1238)	(.0409)	(.0419)	(.0521)	(.0847)
January	-.1802***	-.1500***	-.1859***	-.2156***	-.2034***	-.2426
	(.0434)	(.0474)	(.0409)	(.0446)	(.0619)	(.1517)
February	-.0817	-.1704***	-.0916	-.1025**	-.0595	-.0659
	(.0506)	(.0666)	(.0629)	(.0520)	(.0787)	(.1978)
March	-.0220	-.1406**	-.0165	-.0356	-.0333	.0834
	(.0327)	(.0708)	(.0355)	(.0273)	(.0603)	(.0704)
April	.0133	-.0315	-.0001	-.0120	-.0047	.1458***
	(.0323)	(.0480)	(.0390)	(.0280)	(.0719)	(.0721)
May	-.0100	.0512	.0098	-.0146	-.0720	-.0003
	(.0352)	(.0412)	(.0258)	(.0288)	(.0527)	(.0822)
June	-.0486	-.1551***	-.0355	-.0503	-.0942	-.0045
	(.0431)	(.0739)	(.0425)	(.0410)	(.0589)	(.0796)
July	-.0056	.0084	-.0011	-.0202	-.0600	.0527
	(.0427)	(.0448)	(.0395)	(.0354)	(.0602)	(.0877)
August	.0331	.0006	.0659**	.0215	-.0100	.0243
	(.0375)	(.0668)	(.0330)	(.0325)	(.0597)	(.0781)
Adjusted R^2	0.7240	-	-	-	-	-
Pseudo R^2	-	0.4475	0.5092	0.5473	0.5183	0.4830

*p < 0.1, **p < 0.05, *** p < 0.01, statistically significant; Fig.s in parenthesis are bootstrap standard error

Source: Own survey data (2004 - 2010)

Conclusion and recommendation

The prices of sheep are volatile in response to a change in demand and supply. The main determinants of demand for Washera sheep are tastes and preferences for animal attributes, occasions (festive and non-festive), surplus cash and input (feed) availabilities. While supply of Washera sheep are mainly influenced by cash need of farmers. The results of QRs indicate that the effect of animal attributes at each level of price is not consistent. In order to recognize in which season particular animal attributes are preferred and by whom they are chosen, there is a need to establish reliable and sustainable livestock information system. If that is so, farmers can make the selling schedule accordingly. The study also identified that a blanket recommendation of sheep fattening is misleading. The production function of sheep fattening indicates that sheep fattening should be practiced in areas where infrastructure (road) is well developed. Otherwise, it is advisable to sell without fleshing. In areas where infrastructure is poor, in addition to sheep fattening production function, the effect of animal attributes such as age and body condition support selling of sheep at early age is recommended.

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Profitability and Risk of Small Scale Beef Fattening in Western Amhara Region, Ethiopia

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Abstract

Cattle fattening enterprise is characterized as an important component of agribusiness sector of the economy with great implication on income generation, poverty reduction, and employment creation. This study aims to examine determinants of profit, marketing chain and channels, and risk of small scale beef fattening. Descriptive statistics, econometries analysis as well partial budget analysis were used to analyze the cost-benefit, determinants of profit, and risk of beef fattening enterprise using the data collected from 100 beef producers. Large number of smallholder farmers involved in beef fattening targeting their supply for Ethiopian Christmasand Easter markets to fetch better profit. The results of cost-benefit analysis indicated that the small scale fattening enterprise is a profitable business. A net enterprise income of 1,182 ETH Birr per beef was realized by a typical operator in the study districts, although profit discrepancy was observed among technically inefficient and efficient beef producers. This suggests there is still a scope for the less technically efficient producers to maximize the profit of their business if they could adopt the practices that the efficient producers actually followed without investing any other additional costs. It also suggests the need for technological and institutional interventions, for instance, the priority attention has to be given 'access to credit' for beef producers not only to gain benefit from production scale, but also enhance competitiveness of the beef industry for better quality, via encouraging new firms to enter into the business.

Key words: Beef fattening, Profitability, Market channels, Price Volatility, Ethiopia

Introduction

The Ethiopian economy is highly dependent on agriculture, where the annual contribution of agriculture to GDP of the country accounts on average 45%, followed by the service sector (43%) and the industry sector (12%) over 2011-2014, the first four years of Growth and Transformation Plan (World Bank, 2015). The agriculture sector also contributes to the livelihoods of more than 80% of the population (Edmond, 2007). The livestock subsector plays a vital role as source of food, income, and foreign exchange to the Ethiopian economy, which contributes to 12 and 33% of the total and agricultural GDP, respectively and 12–15% of the total export earnings of the country. (Ayele et al, 2003).

In Amhara National Regional State (ANRS), agriculture remains to be the dominant economic sector. Structurally, on average from 1999-2005 it accounted for 58% of the region's GDP and 89% of the population derives its livelihoods from agriculture and allied activities. The regional livestock population accounts for 29% of the country's livestock population. Livestock contributes to 22 and 12.5% of agriculture and total GDP of the region respectively (BoFED, 2005). According to BoFED (2006), the livestock resources have great contribution in improving the nutritional status of the people. Despite huge potential in the region, livestock productivity is low.

Ethiopia currently manages the largest livestock population in Africa, estimated at 56.7 million cattle, 29.3 million sheep, 29.1 million goats, and 56.9 million poultry (CSA, 2015). The country holds 2.4% of the world, 3.4% of developing countries, and 15.9% of Africa's cattle population (ILRI, 2000). When considering the economic dependency of the rural population, it was estimated that 7.8% are purely on livestock, 14.6% predominantly on livestock and 74.5% on crop production (Winrock, 1992).The pastoralist livestock production system which supports an estimated 10% of the human population covers 50-60% of the total land area of the country.

However, the benefit that the country still derives from this sector is much below what its potential allows. This is mainly due to low adoption rate of technology and marketing problems. Even though fattening was not a new activity in the study areas, commercialization of the beef farm is a recent phenomenon mainly related with the emergence of Sudan markets. Nowadays, the smallholder farmers in Amhara region started to consider beef fattening as one of the best options to reap optimal benefit from the huge livestock population. They have been practicing beef fattening at small scale targeting local market and Sudan market. Smallholder farmers (operators of beef business) have attempted to fatten beef following different fattening techniques with asymmetric bargaining ability of purchasing inputs and output selling. The profit that can be obtained from this business is, therefore, subject to technical and allocative efficiency of beef fattening in which operators are practicing. This study was, therefore, conducted aiming to address the following research questions: (1) Is small scale

beef fattening enterprise a profitable business? (2) What are the factors that determine beef fattening profitability? And (3) Is the business risky?

Materials and Methods

Description of Animal Fattening in Amhara Region

Small-scale fattening is an important avenue for income generation mainly for subsistence farmers in the highlands of Ethiopia, where scarcity of farm land is a major challenge. As fattened animals are a traditional urban consumable item, the increasing trend of urban expansion and agro-processing industrialization, and the growth of per capita income over recent years indicated that there is a continuously growing demand for beef domestically. Beef and mutton consumptions are expected to grow in the region of 3.8 to 4% annually between 1993 and 2020 (Delgado et al, 1999). Moreover, growth in meat demand in sub-Saharan Africa (SSA) is projected to increase over the next 20 years due to expected population and income growth (Delgado et al, 1999). This will also be a good opportunity for the beef farms even to reap maximum benefit by expanding their supply to export markets to which the country is expected to have comparative advantages over other SSA countries. This may, however, need commercialization of beef production mainly through strengthening the operators to adopt Good Agricultural Practices (GAP) and providing technical support services by R & D actors. As reported by FAO (2003), improving animal conditions through stall-feeding for example has the potential in much of rural SSA to generate additional income and employment and thereby improve the welfare of rural populations.

In line with this, the regional government, in its recent comprehensive plan for agriculture (BoARD, 2004), has given due attention to the promotion of fattening development. The comprehensive development plan for crop and livestock sectors, which has been implemented since 2004, aims at transforming the subsistence mode of agricultural production system into market oriented production system. The plan views improved livestock and livestock products marketing as an important regional development strategy to increase both rural incomes and foreign exchange earnings. Fattened animal production and marketing has, therefore, been included as one of the key intervention areas in the current commodity-based specialization and commercialization plan. According to the Fourth Livestock Development Project (MOA, 1996a), there are three types of cattle fattening systems in Ethiopia. These are traditional, by-product-based fattening and the Hararghe type of fattening. In the traditional system, oxen are usually sold after the ploughing season while they are in poor body condition. The by-product-based fattening system is a type in which agro-industrial by-products such as, molasses, cereal milling by-product and oilseed meals are the main sources of feed. In the Hararghe fattening system, farmers buy young oxen from the adjacent lowland pastoral areas, use them for ploughing for several years, and then fatten and sell them before they become old and emaciated.

Fattening activity in the Amhara Region, however, differs substantially from the aforementioned types of enterprises. Smallholder farmers in the region commonly fatten matured animals, which are much older (5 to 7 years), for short durations (usually three months). Ordinarily, farmers fatten their draught oxen while they become retired from draughting so that they could fetch better price when brought to market than doing so without fattening. On the other hand, some farmers purchase oxen purposively to carry out fattening as a business with the expectation to get a higher return or price per weight margins on each fattened animal. In such cases, animals are purchased based on their large skeletal frames and body conformation. In any case, whether purchased or own animals are used for fattening purpose, smallholder farmers use ox that already reach full skeletal size (BoARD, 2004).

Sampling and data collection

The study was conducted in Dera, Bahir Dar Zuria, Mecha, and Yilman districts, located in 4o km radius of Bahir Dar, the capital city of Amhara region. Those districts are potential sources of beef for Bahir Dar market, defined as terminal market to them. Since beef fattening is newly emerged business, both study areas and beef fattener smallholder farmers were selected purposively. Questionnaires were pre-tested and made improvement accordingly then data were collected from 100 small scale beef fattener farmers.

Data analysis

The data were analyzed using descriptive, partial budget, and econometric analysis. The profit of beef cattle fattening was analyzed using farm partial budget analysis. Net farm income is a good indicator of profit of any business including beef cattle fattening. In mixed livestock production system, however, profit of beef cattle fattening computed using net farm income might be overestimated or underestimated. As a result, this study employed gross farm income. Gross farm income is calculated by subtracting the variable production costs from the gross production value. Mathematically, the gross farm income of an enterprise is expressed as:

$$GFI = \sum P_i Y_i - \sum P_i X_j$$

Where GFI is gross farm income in Birr, p_i is price of i^{th} output (beef), Y_i is quantity of i^{th} output (beef), p_j is price of j^{th} input, and X_j is quantity of j^{th} input for beef fattening.

The relationship between profit and explanatory variables is defined as a profit function as:

$$\Pi_{ij} = f(X_{ij})$$

Using log-linear transformation, the profit function is re-defined as:

$$\ln y_{ij} = \beta_0 + \beta_{ij} X_{ij} + \varepsilon_{ij}; i=,...100; j=1,...$$

where $\ln y_{ij}$ is natural logarithm of gross profit per beef cattle (lnGPROFIT), X_{ij} is independent variables (*lnFCOST* - cost of feed, *lnBPRICE*- live beef cattle purchasing price for fattening, *ln SPRICE* - live beef cattle selling price, *HSIZE* - household member, *DUR* - duration of beef cattle fattening, *FAEXP* - fattening experience, *FEXPSQ* - the square of fattening experience and *DISMKT* - distance to market) and ε *is iid* error term.

Testing of OLS estimation against Gaussian assumptions is important to find reliable and stable estimation result from multiple linear models. Therefore, prior to the estimation of the parameters, it is crucial to look normal distribution of disturbance terms, degree of multicollinearity, and constant of variance. Before we use the *F* and *t* tests to test adequacy of the model and significance of each parameter estimates respectively, it is indispensable to check whether the error term follow the normal distribution. Histogram of residuals and normal probability plot (NPP) were used to test normality. Accordingly, the logarithmic transformation was used to adjust abnormal distribution of error terms.

In addition, the variance inflation factor (VIF) was used to test the degree of multicollinearity among the continuous variables. To avoid serious problem of multicollinearity, it is quite essential to omit the variables with VIF value greater than or equal to 10 from the multiple linear regression (MLR) analysis (Leahly, 2001). Since the VIF test for all six continuous independent variables were below 10, no need to drop any of the variables under consideration.

Assumption of constant variance (homoscedasticity) was violated, which is not surprising, rather expected from cross-sectional data. As a result, Structural heteroscedastic model-in-mean (SHM-in-m) is adopted to estimate multiple linear regressions with inconsistent variance and is useful to analyze the relationship between gross profit and volatility. The SHM regression model is a multivariate regression that regress gross profit and its standard deviation simultaneously to check the presence of profit variability and the model can be specified as:

$$\ln(profit) = X\beta + \sigma\alpha + \varepsilon$$

$$\sigma = Z\lambda + \upsilon$$

Where σ is the conditional standard deviation of the natural logarithm of gross profit (*SdlnGPROFIT*) - allowing for the existence of a direct correlation between profit levels and variability and α is its coefficient. Z is a vector of selected exogenous variables in X. λ is a vector of parameters, and υ is *iid* error term where the two equations are estimated simultaneously. The econometric software used for analyzing the data was STATA version 11.

Results and discussion

Beef fattening inputs and its profiles

Table 1 shows about 89% operator purchased cattle for fattening from the nearby markets. While the remaining used their own animal kept for breeding and for draft power at the time when it becomes old and less productive, targeting festive periods to fetch better prices. The investment on beef fattening for 70% operators generated from its own. Given this, in the study areas beef fattening is a slack period activity, 76% of operators use family labor, which is consistent with the finding of Sarma and Ahmed (2011).

In general, beef fattening being an emerging economic sector, smallholder farmers operate beef fattening at small scale. The annual supply of beef 58%t operators was less than five beef per annum. On the other hand, the average annual supply of fattened beef was 10.9 per year per operator with large standard deviation implying presence of some farmers who specialized in beef fattening. Beef fattening, on average, took 88 days. The results of this study indicated that the duration of beef fattening for the majority of the operators (62%) in Ethiopia specially in Amhara region was 3-4 months, whereas when we see a comparator country,say, Tanzania, 93% of the operators kept only for 2-3 months (Mlote et al., 2013. This has an important implication on cost of beef fattening. Hence, one can conclude that doing the beef business in Ethiopia is more costly than Tanzania, signifying the competitiveness of our beef industry in the global arena is negatively affected and becomes very questionable unless we could shorten significantly the fattening duration besides attempting to transform the subsistence beef farming into commercialized one.

Table 1: Beef fattening inputs and its profiles

Variables	Mean (±SD)/Percentage
Financial capital	
Own saving	70.48
Loan	12.15
Own saving and loan	17.36
Physical capital (cattle)	
Purchased	89.00
Reared	11.00
Labor	
Family labor	75.78
Hired labor	24.23
Fattening experience (in years)	4.59 (2.63)
Scale of beef fattening	
< 5 beefs per year	58.0
5-10 beefs per year	38.0
> 10 beefs per year	4.0
Number of beefs fattened per year	10.19 (13.04)
Fattening length	
< 2 months	9.28
2 ≤ months < 3	25.77
3 ≤ months < 4	61.86
> 4 months	3.10
Fattening duration (in days)	87.85 (27.84)

Cost-benefit analysis of beef fattening

In mixed crop-livestock production system, most operators keep livestock for draft and breeding purposes. In this context, including fixed costs such as shelter and feeding trough construction costs

and some benefit like animal manure in partial budget analysis is misleading. Therefore, the costs and benefits considered in the cost-benefit analysis are variable costs and benefits obtained from selling of beef. Variable costs include costs incurred to purchase cattle, feed, health service and labor hiring. Among the total variable costs, 81.37% accounts for purchasing of cattle, followed by the cost of feed (16.83%). A total variable cost incurred to fatten one beef was ETB 4,147.89. On average, after 88 days of the fattening period through semi-intensive fattening technology, the operator obtained a gross margin of ETB 1,182 per beef (See Table 2). The benefit-cost ratio of beef fattening was 1.29:1. The marginal rate of return of beef fattening was 29%, therefore, if you invest one Birr for beef fattening you will get a gross return of ETB 1.29 after three months.

Table 2: Gross profit margin per beef

Variables	ETB
Benefit obtained from beef selling	5,330
Variable cost	4,148
Cattle purchasing	3,375
Animal feed	704
Veterinary and medicament	21
Labour	36
Transaction cost	12
Gross profit	1,182

Determinants of beef fattening profit and its variability

Human, input and output related factors determine beef fattening profit. Given the production function of beef fattening, inputs cost primarily cattle and feed cost and output (beef) prices had negative and positive effect on profit of beef fattening, respectively. Interesting finding in this study related with input labour cost is that the numbers of household members on profit have positive and significant effect on profit of beef fattening. Smallholder farmers reduce labour cost by using family labour and hence farmers with large household members could optimize profit that could obtain from beef fattening. Beef fattening experience has negative and significant influence on profit of beef fattening. The possible explanation for this unexpected result is operators previously employ traditional fattening technology, for instance long period of fattening period. Standard deviation of profit (*SdlnGPROFIT*) is found to be positively significant, implying that there exists profit variability among operators. Moreover, coefficient of variation shows that prices of input and output are variable. The coefficient of variation of selling price of beef, purchasing price of cattle and cost of feed is 90.16, 105.57, and 119.03, respectively. This implies feed cost is more variable than cattle prices, in

turn; cattle prices are more variable than beef prices. Given seasonal factors, this variability could be derived from difference in quality of feed used for fattening and its source. Moreover, it is due to spatial difference of market places, operators may buy cattle at village market, rural market or a respective or adjacent district market.

Table 3: The estimate of SHM-in-mean model

Variables	SHM-in-mean	
	lnGROFIT	SdlnGROFIT
Constant	-1.457*	-0.697
	(0.807)	(0.744)
lnBPRICE	-2.870***	
	(0.278)	
lnSPRICE	4.142***	
	(0.321)	
lnFCOST	-0.514***	0.127
	(0.093)	(0.09)
HHSZ	0.002**	-0.001
	(0.006)	(0.007)
FAEXP	-0.162	0.014
	(0.076)*	(0.107)
FAEXPSQ	0.112	0.001
	(0.006)	(008)
DUR	0.001	0.003
	(0.001)	(0.003)
DISMKT	-0.016	0.095
	(0.041)	(0.058)
SdlnGPROFIT	-0.344***	
	(0.104)	
F-value	26.60	1.15
Prob > F	0.000	0.3418
R-squared	0.8388	0.1231

Standard errors in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Beef marketing chain and channels

Livestock markets are open place where cattle are bought and sold. Livestock markets in the study areas have no marketing facilities like water trough, feed trough, load unload, information center, and shelter. Livestock marketing are often undertaken in one-to-one bargaining and hand-to-hand payment. As indicated in Table 4, seven percent of the operators employ contractual beef fattening without legal background (informal contract). The marketing process follows a three-step system with primary, intermediate, and terminal markets through which marketable animals pass from producers to directly to consumers or to small traders and on to large traders and/or butchers. Most operators conduct transaction in cash at the respective district town, local livestock markets at the spot.

Table 4: Beef marketing strategies and transaction approaches

Variables	Response (%)	
	Yes	No
Market places	91.8	8.2
Contractual fattening	7.1	92.9
Relationship base beef marketing	3.1	96.9
Through broker beef marketing	5.1	94.9
Beef transaction in cash	99.0	1.0
Beef transaction in advance	8.1	91.9
Beef transaction in credit	1.0	99.0

Market actors are local consumers, local traders, and Sudanese. Sudan market is highly seasonal related with Muslim festive and frequent ban of animal trading route. As a result, producers mainly supply beef for local market during Ethiopian festive periods to satisfy the high demand for meat. These festivals are Ethiopian True Cross, Christmas, Easter, Lent, and Fast of the Apostles. Fig. 1 reveals about 80 % of the farmers produced beef targeting Christmasand Easter market. This is related with the demand for beef meat and availability of factors of production (feed and labor).

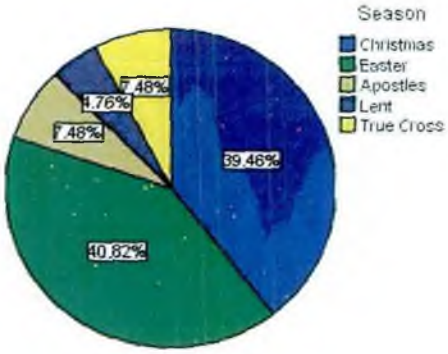

Fig.1. Beef production seasons

Producers sell beef at village, at respective district town, and at Bahir Dar livestock market. Most frequently they sell at their respective district town livestock market.. Market actors involved in beef marketing were producers, consumers, butchers/hotels, assemblers, and exporters. Farmers carried out transaction with those market actors through either of the following five marketing channels considering better price, good relationship, the capacity of market actors, and means of transaction (specially on cash).

1. Producer - - -> Consumer
2. Producer - - -> Exporter
3. Producer - - -> Butcher - - -> Consumer
4. Producer - - -> Assembler/finisher - - -> Exporter
5. Producer - - -> Assembler/finisher - - -> Butcher - - -> Consumer

Except at market channel 1, the prices in which consumers paid and producers received are different - called as marketing margin. As the market channel is long, the market margin increases and becomes inefficient. There were remarkable quality differences between beef supplied for local and export markets, given the same market level. The quality of beef supplied to Sudan market is superior to local one. This might be due to the difference in purchasing power as well as comparative disadvantage of beef farm in Sudan where the cost of production is relatively higher so that Sudanese may offer higher price for our beef product. Fig. 2 illustrates the beef marketing chain that the operators in Amhara region participated in.

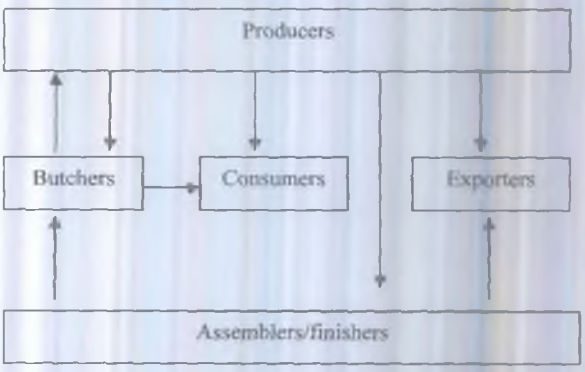

Fig. 2. Market chain of beef marketing

Producers: The main beef producers are rural farmers. Producers mainly sell their product at their respective district livestock market.

Consumers: Consumers are rural farmers and urban dwellers who buy beef animals in groups especially during holidays.

Butchers: These are service providers who buy beef animals directly from producers to resell consumers by adding value.

Assemblers: They are cattle traders come to market from their respective district to collectively buy beef directly from producers at village and local market and resell them to exporters and/or butchers.

Exporters: Cattle traders come to markets from Bahir Dar and Gondar to purchase beef from assemblers and export to Sudan.

Risk of beef fattening and market information

Beef fattening risks are sequentially market (28%), production (27%), financial (24%) and human capital (22%) risk (See Table 5). Land and water shortage and animal death are pointed out as the main sources of production risk. Lack of labor, fattening experience and business management skills result in human capital risk. Market risk is directly related to financial risk (business risk- volatility of beef prices and inflation risk- persistent rises of input prices) and market power risk. Most operators' risk was associated with business risk- the chance to loss from fattening decision. Operators who relatively fatten beef cattle under large scale have the power of leading the market as they want- market power risk. Since they have good relationship with beef exporters, they have practiced buying of beef from relatively small scale operators for reselling to exporters. The other risk is related with the general increase in the price level- inflation risk, which causes a general rise of money demand and make the business difficult to continue with due to limited access to credit for this business.

Over 47 and 27% of the operators access information from their friends and Radio, respectively. Under high price volatility situations, the reliability of the information plays vital role for making appropriate marketing decision. No matter what is/are the source(s) of information but from whom/where disaggregated information can generate is important, in this regard, the reliability of the information obtained from friends is under question. Operators decide to sell their beef if the last immediate week price (lag price) is sound for them. Despite this market information, prices of beef may be against what was in the previous week for different marketing reasons. In such case, the possible price volatility coping mechanisms are trucking the beef back to home (76%) and keep until price starts to rise, truck to other market (5%) in other market day and the last solution is selling at recurrent market price (20%) (See Table 5).

Table 5: Risk of beef fattening, source of market information and price variability copping mechanism

Variables	Percentage
Market risk to beef fattening	27.59
Production risk to beef fattening	26.72
Financial risk to beef fattening	23.85
Human capital risk to beef fattening	21.84
Source of market information is friends	47.46
Source of market information is radio	27.12
Source of market information is traders	11.86
Source of market information is extension agents	11.02
Source of market information is rural farmer cooperatives	2.54
Coping mechanisms to price volatility is animal truck back to home	75.61
Coping mechanisms to price volatility is truck to other market	4.88
No coping mechanisms to price volatility rather they sell in the existing market price	19.51

Conclusion and implication of beef fattening on livelihood of rural people

Small scale beef fattening is a profitable business. Beef fattening increases labor productivity of rural household members and generate incomes that supplement income of agricultural production. Thus, beef fattening can be used as a means of poverty reduction and creation of self employment

opportunities in rural areas. Despite this profit of beef fattening vary among operators and is determined by beef prices, cattle prices, feed cost, household members and fattening experience. Therefore, operators have to consider the time in which the price of an output (beef) becomes high and the price of input for beef fattening (cattle and feed) becomes low. The effect of fattening experience seems contradicting but the current fattening practice shows vibrant change from the previous practices. Long fattening duration, locally available feed utilization and fattening of old cattle are the features of previous fattening practice. In contrast, the current fattening practice has been changing in terms of fattening duration, age of cattle and feed type. The fattening duration is short, age of cattle is young, and feed type is commercial.

Prices of beef are variable across the fattening rotation. Fattening rotations are four and they are targeting New Ethiopian Year (at the beginning of September), Christmas (at the end of December), Easter (at April) and Apostle (at June). This is due to demand and supply of output (beef) and input (feed). Among the four fattening rotations, the profit significantly falls during Christmasmarket because of input availability (feed and cattle). Many farmers buy ox for draft power during crop production season, immediately after they finish farming, they start fattening the ox. In contrast, profit significantly rises during Easter market due to high demand and decrease in supply relative to the Christmasmarket. Profit variability among operators shows variation in technical efficacy among them. Regarding beef fattening the agriculture extension lags behind operators' practices and their fattening techniques vary among them. From this we understand that some farmers are technically efficient and some of them are not. Without introducing new fattening technology one can boost the income generated from beef fattening by simply adopting the existing practices of an efficient operator, although further study is important to investigate technical efficiency of beef fattening.

To this end, government should give due attention for fattening technologies to reduce fattening duration and development of least cost feed formulation, designing appropriate policy for livestock marketing information system and access to credit targeting beef fattening. To achieve long-run equilibrium, expansion of market destination is important to create sustainable export market.

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Baseline survey on Finger Millet (*Eleusine coracana* L.) production system in North western Ethiopia

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Abstract

The study was carried out to assess the current finger millet (Eleusine coracana L.) production system and identify major production constrains in Metekel zone (Dibatie district), Awi zone (Guangua district), West Gojjam zone (Jabitehinan, South Achefer and Mecha districts) and South Gonder zone (Dera district), Ethiopia. Data sources were both primary and secondary sources and primary data were collected from 107 farm households using a structured questionnaire. Moreover, key informants, agricultural experts and development agents were interviewed as well field observation was used to collect data. Descriptive statistics was applied to analyze the data. Finger millet, Maize and Tef were the most important crops being produced by farmers taking 32, 30 and 13 % of the area share out of the total land available for farming. Finger millet was found to be the main staple food crop in the study areas. Smallholder farmers in the study areas mostly use black seeded local finger millet variety and only 12% of them grow improved variety. Out of the total sample households, 60%, 8%, 12% and 20% of respondent farmers grew black seeded, white seeded, red seeded and mixed seeded finger millet types, respectively. Lack of improved variety and low soil fertility were the major problems of finger millet production. Farmers do not apply the recommended agronomic practices (row planting, optimum seed and fertilizer rates and post harvest technologies). Therefore, introduction and demonstration of improved finger millet technologies (improved varieties, agronomic practices and weeding and threshing machines) and arranging training on improved production packages of finger millet for farmers and agricultural experts to facilitate acceptance and adoption of improved finger millet technologies are some of the activities recommended to improve finger millet production.

Key words: Finger millet, baseline survey, farmers, Ethiopia.

Introduction

Finger millet (*Eleucine coracana* (L.) Gaertn.) is a staple cereal food crop for millions of people in the semi arid region of the world, particularly in Africa and India, and especially those who live by subsistence farming (Shinggu *et al.*, 2009). Finger millet is originally native to the Ethiopian highlands and was introduced into India approximately 4000 years ago (ICRISAT, 2017) and the crop is commonly known as Ragi (India), Bulo (Uganda), Wimbi (Swahili), Tellebun (Sudan) and Dagussa (Ethiopia) (Bheema *et al.*, 2011). In eastern Africa, it is produced in Ethiopia, Uganda, Kenya, Tanzania, Rwanda, Burundi, Democratic Republic of Congo, Sudan and Somalia (Oduori, 2005). Finger millet is important minor millet in the tropics grown in more than 25 countries of Africa and Asia and accounts for 12% of the global millet area (ICRISAT, 2017) in which major finger millet producers are Uganda, India, Nepal, China, Kenya, and Ethiopia (Dramadri, 2015).

In Ethiopia, finger millet is grown usually as sole crop in rotation with other annual crop preferably legumes by subsistence farmers and serves as a food security crop because of its high nutritional value and excellent storage qualities (Dida *et al.*, 2007). According to the same author, despite its importance as a low input crop, its productivity in the region is limited to between 400 and 2,000 kg/ha. The major attributes of finger millet are, its adaptability to adverse agro-ecological conditions with minimal inputs, tolerant to moisture stress, can be produced on marginal land where other crops cannot perform, and tolerant to acidic soil (Upadhyaya *et al.*, 2007). Moreover, it has high nutritional value and excellent storage qualities (Dida *et al.*, 2007).

Finger millet is the 6th important crops after tef, wheat, maize, sorghum and barley in Ethiopia comprising 3.62 percent of the total land devoted to cereals in which smallholder farmers allocated about 453,909.17 ha of land with production volume of 915, 315 ton of finger millet produce (CSA, 2015). Finger millet is produced in Amhara, Oromiya, Tigray, Benishangule-Gumz, Southern Nations and Nationalities and Peoples (SNNPs), and Gambella Regional State of Ethiopia. It is mainly grown in North Gondar, West Gojjam, some parts of Tigray and West Wollega (Molla, 2012). Finger millet is widely grown in the Amhara Region covering an area of 242,894.75 ha with total production volume of 490,201 ton of grain, which is almost 54% of the total national production and area coverage (CSA, 2015).

Finger millet grain is used for the preparation of traditional foods mainly "*injera*", spongy fermented flat bread that serves as the staple food for most Ethiopians that can be prepared by using sole finger millet products as an ingredient or by mixing its flour with teff, maize and/or sorghum), porridge and local beverages (local beer and local "*Areki*"). Moreover, its straw is valuable for animal feed and mud house wall construction purposes. It can also withstand various environmental challenges better than other crops such as maize and being preferable and produced year after year by smallholder

farmers. Generally, finger millets represent one of the critical plant genetic resources for the agriculture and food security of poor farmers that inhabit arid, infertile and marginal lands and its utilization is deep-rooted in the culture of the Ethiopian people (Dagnachew *et al.*, 2012).

Finger millet productivity is very low mainly due to lack of improved varieties, management technologies and other biotic and abiotic factors (Kebere *et al.*, 2006). Moreover, despite its advantages, finger millet has received little attention in terms of research and development efforts in Ethiopia in general and in Amhara Region in particular. Related to this fact, there is no current and updated information on the production status, problems and opportunities of the crop. Hence, this baseline survey research activity was initiated to generate recent information on finger millet production in representative areas of Amhara region, Ethiopia for research and development intervention.

Objectives of the study were:

- To assess the current finger millet production system of farmers', and
- To identify farmers' major finger millet production opportunities and constraints.

Research Methodology

Area description:

The study was conducted in Metekel zone (Dibatie district), Awi zone (Guangua district), West Gojjam zone (Jabitehinan, South Achefer and Mecha districts) and South Gonder zone (Dera district) of the Amhara National Regional State of Ethiopia (Fig. 1).

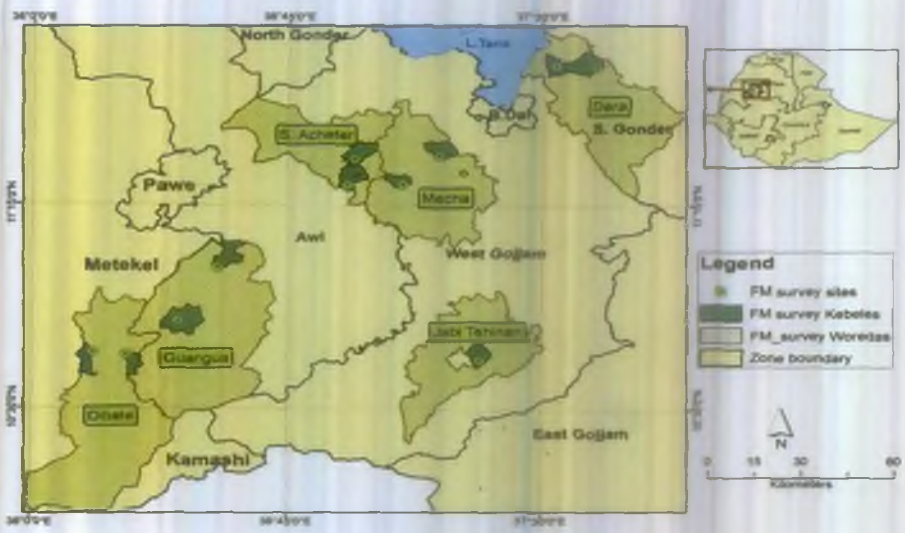


Fig. 1. Map of the study districts, Amhara Region, Ethiopia, 2015.

The study districts are described briefly as follows (source: office of agriculture of each district, Wikipedia, the free encyclopedia and working documents):

Debatie district is one of the 20 districts in Metekel Administrative Zone of Benishangul-Gumuz Region of Ethiopia, with an estimated area of 2,425.32 square kilometers. According to the 2007 national census, the total population of the district was reported to be 66,654 of which 33,452 were men and 33,202 were females, out of which only 11.1% were urban dwellers. Haricot bean, soybean, finger millet, sorghum and groundnut are the major crops grown by farmers.

Guangua district is one of the districts in Awi Administrative Zone of Amhara Region, Ethiopia with total area of 106,964 hectares. Based on the 2007 national census of Ethiopia, this district has a total population of 223,066 of which 111,172 are men and 111,894 are women with 14.12% urban inhabitants. Finger millet, maize, tef, nigger seed, groundnut, soybean, wheat and barley are major crops grown in the district. The altitude of the district ranges from 1,600 to 2,060 meter above sea level while rainfall ranges from 1,300mm to 1,800mm. The temperature ranges from 22 to 27°C. The soil type of Guangua district is characterized as 80% red and 20% brown in colour.

Jabitehinan district is one of the nine districts of West Gojjam Administrative Zone, located 180 km south of the regional capital, Bahir Dar and 350 km north of the national capital, Addis Ababa. The total area of the district is estimated to be 1,170 km^2 or 116,954 ha and is divided into 37 rural *kebeles*. Moreover, the district is known by its potential in maize and hot pepper production with total population (2007 census) of 277,590 of which 139,616 were women and 137,974 were women of which only 6% were urban inhabitants. The altitude of the district ranges from 1,500-2,300 meter above sea level-m.a.s.l (the majority of the area lies in the higher altitude range, closer to 2,300 masl). Agro-ecologically, 88% of the district is classified as midland (*Woyina Dega)* and the remaining 12% as lowland (*kola)*. The major crops grown include maize, finger millet, pepper, tef, wheat, faba bean, potato, barley and Niger seed (Asresie *et al*, 2014).

South Achefer is located in west Gojjam Administrative Zone of Amhara Region,Ethiopia with total population (2007 census) of 136,508, of which 69,239 are men and 67,269 are women and 8.63% are urban inhabitants. The total area of the district is 118,282 ha of which 39,195 ha, 23,661ha, 6,862ha, 8,282ha and 1,776 ha are cultivated, grazing, forest, bush and bare lands respectively while the rest 38,506 ha is used for different purposes. The altitude of the district ranges from 1,500 to 2,600 m.a.s.l while rainfall ranges from 1,365 to 1,630mm. The temperature ranges 18 to 27°C. Agro-ecologically, the district is 87% midland and 13% lowland while the topography of the district is 72% plain, 10% mountainous, 12% undulating and 6% valley. The soil is 50% red, 40% brown and 10% black in colour. Maize and finger millet are the dominant crops being grown and tef, barley and Niger seed are also cultivated.

Mecha is one of the thirteen districts in west Gojjam Administrative Zone of Amhara Region, Ethiopia located 30 *kms south-west* of the regional capital, Bahir Dar with total population (2007 census) of 292,080 (147,611 men and 144,469 women) and 7.76 are urban dwellers. The district has total area of 1,481.64 square kilometers with population density of 197.13, which is greater than the Zone average of 158.25 persons per square kilometer. The district is known for its flat topography, which accounts for about 75 percent of the total area and the rest 13 percent, 8 percent and 4 percent are characterized as undulating, mountainous and valley topographies, respectively. The altitude of the district ranges from 1,800 to 2,500 *m.a.s.l* while *annual rainfall ranges* from *1,000mm* to 2,000mm. The total area of the district is about 156,027 hectares of which half (72,178 hectares) are used for cultivation. Forest land and the grazing land cover 18,547 hectares and 15,591 hectares, respectively. The land covered by water bodies accounts for about 1,386 hectares. The soil type of Mecha district is characterized as 93%, 3% and 4% red, black and gray soil, respectively. The main crops grown include maize, teff, finger millet, wheat, chickpea, beans, Niger seed and cabbage (Molla *et al* 2014b).

Dera district is located in south Gonder Zone of Amhara Region,Ethiopia with 46% arable or cultivable land, 6% pasture, 1% forest or shrub land, 25% water bodies and the rest 25.9 used as different purposes. According to the 2007 national census, the total population of the districts was reported to be 248,464 of which 126,961 were men and 121,503 were females, out of which only 6.75% were urban inhabitants with population density of 162.90. The district is estimated to have a total area of 158,948 ha of which 35% is plain, 20% is mountainous, 18% is gorges and 27% is undulating and the latitude ranges from 1,500 to 2,600 m.a.s.l while the average annual rainfall is 1,250mm. Tef, maize, finger millet, sorghum and cotton are important crops grown in the district (Molla *et al*, 2014a).

Sampling procedures:

Three stage sampling procedure was used to select representative sites and respondent farm households in the study areas. In the first stage, four potential finger millet growing zones and six districts were selected using purposive sampling while 11 *kebeles* (smallest administrative units in Ethiopia) were selected purposively and randomly in the second stage. In the third stage, 13 to 21 respondent farmers were selected randomly in each *kebele* that sum up 107 respondents (Table 1).

Table 1: Description of the study locations and sampling, Ethiopia, 2015

Districts	Kebeles	Altitude (masl)	Number of samples taken	% age
Dibatie	Zigh	1308	13	12.10
	Sasmandan	1567		
Guangua	Ymali	1607	19	17.80
	Trubrhan	1736		
Jabitehinan	Hodansh	1863	17	15.90
South Achefer	Abchikli	-	21	19.60
	Ahuri	1985		
Mecha	Mekeni	2038	19	17.80
	Bachima	-		
Dera	Wonchet	1934	18	16.80
	Gedamgeregera	1978		
Total			**107**	**100**

Source: Survey data, Ethiopia, 2015.

Data sources and methods of data collection:

Data sources for the baseline survey were both primary and secondary sources. Structured questionnaire was developed and used to collect primary data from the sampled households about the basic household characteristics and finger millet and overall farming related issues. The interview was conducted by experienced researchers and enumerators who got training on methods of surveying approaches and all the contents included in the questionnaire. The questionnaire was pre-tested before the normal field survey was conducted. Moreover, primary data was collected from key informants, agricultural experts and development agents coupled with field observation. Secondary data from district offices of agriculture and published and unpublished sources was collected and used.

Fig. 2. Face to face farmers' interview and discussion with Development Agents (DAs), Ethiopia, 2015.

Source: Survey data, Ethiopia, 2015.

Methods of data analysis:

Descriptive statistics such as mean, standard deviation, frequency, percentage and graphs were employed for analyzing the quantitative data. Data were analyzed and reported using a software program called Statistical Package for Social Scientists (SPSS).

Results and Discussion

Socio-Economic characteristics of sample respondents:

The average age of the respondent farmers was 42.41 years with minimum and maximum value of 22 and 68 years, respectively. About 30.8% of respondents were illiterate with total family members of 6.46 people per household. Moreover, more than 50% of the household members were active labor force that has an indication for availability of labor for the labor demanding finger millet production (weeding and threshing). The detail is indicated in Table 2.

Table 2: Household characteristics of the study districts, 2015

Description	Minimum	Maximum	Range	Mean	St.Dv	%
Age	22	68	46	42.41	10.68	-
Sex (male%)	-	-	-	-	-	95
Education level (years) (illiterate %)	0	12	12	2.50	3.00	30.80
Total Family members	2	12	10	6.46	2.25	100
Male	1	9	8	3.29	1.64	50.90
Female	1	7	6	3.17	1.55	49.10
Children under 15 years old	1	7	6	2.90	1.32	44.90
Adult 15-64 years of age	1	10	9	3.42	1.79	52.94
Dependent above 64 years of age	0	4	4	0.14	1.08	2.17

Source: Survey data, Ethiopia, 2015.

Livestock holding of households: livestock production that include cattle, small ruminants (sheep and goats), monogastric animals (donkey, mule and horses), chickens and beehives is an integral part of the farming system in the study areas contributing a lot for finger millet production during plowing, threshing and transpiration activities. They also serve as a measure of wealth in rural area. For standardization and understanding purpose, livestock number was converted to tropical livestock unit (TLU) and the overall average TLU of the households was 6.74 TLU units with a standard deviation of 3.24 (Table 15).

Table 3. Livestock ownership of the respondents

Description	Minimum	Maximum	Mean	St.Dv
Livestock ownership (number)				
Cattle: Oxen	1	7	2.53	1.16
Cows	1	10	2.34	2.25
Heifers	1	8	1.98	1.43
Calves	1	8	2.00	1.47
Small Ruminants: Sheep	1	11	3.91	2.62
Goat	1	25	7.44	6.99
Nu-ruminants: Horse	1	2	1.08	0.29
Chickens	1	30	6.81	5.83
Beehives	1	30	8.87	9.55
TLU			6.74	3.24

Source: Survey data, Ethiopia, 2015.

The total owned cultivated land size of sample respondents varied from 0.18 to 7.00 hectares with an average holding of 1.43 hectares with a standard deviation of 0.99. The average total cultivated land (including lease in) was found to be 1.82 hectares for all respondents with a standard deviation of 1.18 (Table 4).

Description	Minimum	Maximum	Mean	St.Dv
Land ownership (in ha): Own	0.188	7.00	1.43	0.99
Rented in	0.12	15.00	1.16	1.88
Rented out	0.25	3.00	1.39	1.17
Total cultivated (own + rented in)	0.25	7.50	1.82	1.18

Source: Survey data, Ethiopia, 2015.

Access to agricultural services and information: Access to agricultural services like extension and credit shows that farmers got an extension advice of 22 times per year and about 56.2 percent of farmers received formal training mainly from office of agriculture. On the other hand, about 65.4 percent of the sampled households have access to credit and 44.6 percent took credit in 2014/15.

Table 5. Access to Agricultural services and information:

Description	For all locations	
	Number	%
Number of times extension advice received (number/year)	22	-
Farmers received formal training on agricultural production	-	56.2
Number of times training received per 3years (number/year)	2.5	-
Trainer on agricultural production:		
Extension/MoA	-	76
Research Centers	-	2
NGOs and Universities	-	1
Both Extension/MoA and Research Centers	-	1
Access to credit:		
Farmers have access to credit (Yes)	-	65.4
Took credit in 2014/15	-	44.6
Took credit in 2015/16	-	26.0

Source: Survey data, Ethiopia, 2015.

Crop production of respondent farmers:

A crop-livestock integrated farming system was the main farming system in the study districts and crop production was found to be the most important farming activity in these areas. The major crops grown in the study areas are indicated in Fig. 3. Finger millet, Maize and Tef were the most important crops being produced by farmers taking 32, 30 and 13 % of the area share out of the total land available for farming while hot pepper, sesame, sorghum, soybean, haricot bean, ground nut and noug were the minor ones.

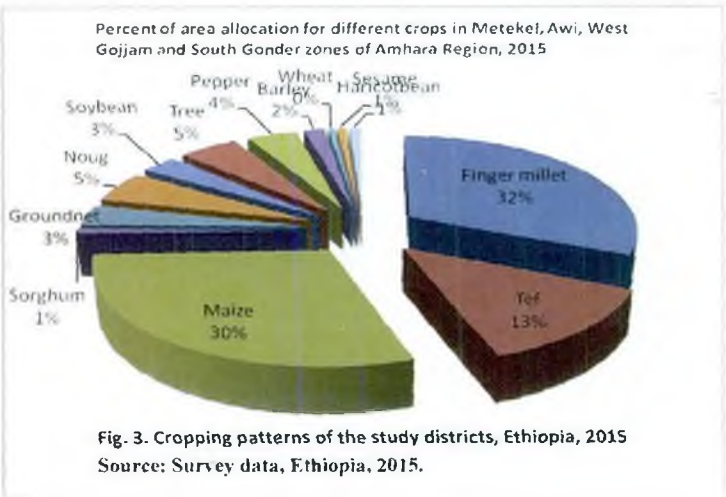


Fig. 3. Cropping patterns of the study districts, Ethiopia, 2015
Source: Survey data, Ethiopia, 2015.

Finger millet production system:

Finger millet is the major crop in the study districts and farmers allocated on average, 0.70 ha of land for this crop in 2014/15 cropping season (out of their mean area of 1.43 ha of total land available). Moreover, farmers allocate 1.76 plots of land out of their mean plots of 3.63. Farmers usually prepare their finger millet field from March to June and sow it in the middle of June to July 1st and harvest from November to December. Farmers do not practice intercropping finger millet with legumes to improve nutrition, soil fertility and yield; they rotate it mainly with maize and tef crops. However, farmers in Dibatie and Guangua districts rotate finger millet with legumes. Farmers usually prepare their finger millet land in March to June and sow it in June half to July 1st and harvest in November to December. Proper applications of improved agricultural technologies boost agricultural production and productivity. However, input utilization of finger millet producing farmers in the study districts is not uniform as well as in accordance with the recommended rate (Table 6 and 7).

Table 6. Area allocated for finger millet and agronomic practices, 2015

Description	Min	Max	Mean	SE ±
Land allocated for finger millet in 2014/15 (ha)	0.12	2.50	0.70	0.04
Total Plots of land owned by farmers in 2014/15	0.75	10.00	3.63	0.22
Plots of land allocated for finger millet in 2014/15	0.75	7.00	1.76	0.10
Frequency of plowing for finger millet	2.00	10.00	5.07	0.15
Weeding frequency of finger millet	1.00	3.50	1.39	0.05
Seed rate for finger millet (kg/ha)	3.00	120.00	43.32	2.25
%age of farmers who apply fertilizer (%)	89.60	-	-	-
DAP amount kg per ha	12.00	200.00	82.09	4.12
UREA amount kg per ha	2.00	200.00	48.21	3.66

Source: Survey data, Ethiopia, 2015.

Table 7. Crop rotation and cropping calendar of finger millet, Ethiopia

Description	Locations			
	Metekel	Awi	West Gojjam	South Gondar
Crop rotation: crops	Maize, Groundnut, Soybean, Noug	Noug, Maize, Soybean, ground nut,	Maize, Tef, pepper, finger millet	Maize, Tef, pepper, barley
Time of land preparation	May to June	March to April	March to June	March to June
Time of sowing	June last to July 1st	June 20 to July 10	June 10 to July 10	June 8 to July 01

Finger millet farmers in the study areas mostly use black seeded local finger millet variety locally nicknamed as "*Tikur-Dekie dagussa*" and only 12 percent of them grow improved variety. Out of the total sample households, 60%, 8%, 12% and 20% of the respondent farmers grew black seeded, white seeded, red seeded and mixed seeded types of finger millet types, respectively (Table 8).

Table 8. Types and varieties of finger millet produced by respondent farmers

Description	% of farmers producing it	Major characteristics
Finger millet varieties: Local	88	Low yield, good straw quality
Improved	12	High yield
Type of finger millet produced by farmers:		
Black seeded (*"Tikur Dekie*)	60	It can grow on soils with low fertility status; shatters easily; easy to thresh; gives good yield than others;
White seeded (*"Nech Dekie*)	8	It needs good (fertile) soil; good for consumption (injera making);
Red seeded (*"Angedie dagussa"*)	12	It needs good (fertile) soil; can resist unexpected rain damage; late maturing; needs more threshing hour,
Mixed (*"Dabo dagussa"*)	20	Non-uniform maturity, good yield

Source: Survey data, Ethiopia, 2015.

Fig. 4. Finger millet field (matired), harvesting and pilling of the crop in Ethiopia, 2015.

Source: Survey data, Ethiopia, 2015.

Major production opportunities of finger millet:

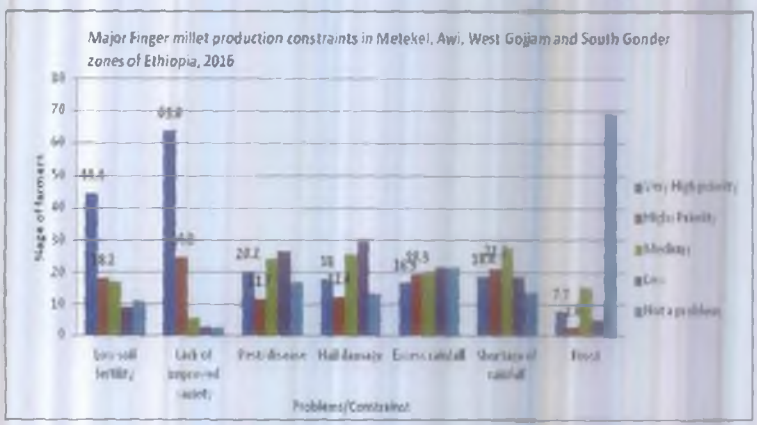
The following major finger millet production opportunities were identified by the base line survey from farmers, experts and different documents.

- Availability of improved finger millet varieties and agronomic packages (seed rate, row planting, transplanting, etc) from the research institutes;

- The crop adapts to adverse agro-ecological conditions with minimal inputs, is tolerant to moisture stress, and is produced on marginal land where other crops do not perform well, and is tolerant to acidic soil and termite attack (Barbeau and Hilu, 1993);
- Storability of seed for a longer time without damage;
- Less vulnerability to attack by storage insect pests;
- Finger millet generally suffers less from diseases compared to common cereals grown in Ethiopia;
- Tolerant to heavy hail damage which is common in high potential areas of the region, etc.

Major production constraints of finger millet production system:

The following major finger millet production constraint and/or problems were identified by the base line survey from farmers and experts based on qualitative data collected from farmers and key informants interviews as well as group discussions with farmers (Fig. 5). Major finger millet production problems were forwarded for farmers each at a time to be ranked 1 to 5 scales (1 being "very high priority", 2 "high priority", 3 "medium priority", 4 "low priority" and 5 "not a problem") using multiple response technique. The overall result showed that lack of improved variety and low soil fertility were the major problems of finger millet production (Fig. 5). Lack of improved variety was ranked as very high priority, high priority and medium priority problem by 63.8%, 24.8% and 5.7% of farmers, respectively while low soil fertility was ranked as very high priority, high priority and medium priority problem by 44.4%, 18.2% and 17.2% of farmers in the same order.



Fig, 5. Major production constraints of finger millet (multiple response), Ethiopia, 2015.

In addition to the above problems, finger millet is one of the neglected and underutilized crops of Ethiopia i.e. finger millet is not a strategic crop. It was not included in the annual crop production package manuals of the country that resulted little research and development attention by the

government. Finger millet is also normally grown with the application of small amount of inorganic fertilizers due to unaffordable price. Poor extension service, high lodging percentage (local varieties), diseases (neck and Head Blast), labor intensiveness (weeding, harvesting, threshing) and poor agronomic practices (broadcasting, crop rotation, fertilization, weeding) are also some of the bottlenecks of the finger millet production system.

Conclusion and Recommendations

Conclusion:

Although there are many factors contributing for low productivity of finger millet such as weed, low level of improved technology use by farmers, low soil fertility, little attention to the crop by the government, etc., it is still the main staple food for farmers in the study areas. Farmers do not use or apply the recommended agronomic practices such as row planting, optimum seed and fertilizer rates, transplanting, threshing machines. Farmers do not intercrop finger millet with legumes to optimize yield and improve nutrition as well as soil fertility but usually sow finger millet as a sole crop. Finger millet, Maize and Tef were the most important crops being produced by farmers in the study areas.

Recommendations:

- Research and development attention should be given for finger millet since it is the major staple field crop still being produced by smallholder farmers allocating significant portion of their valuable land.
- Introduction and demonstration of improved finger millet technologies to farmers such as:
- Improved finger millet varieties;
- Improved agronomic practices such as row planting, application of recommended fertilizer rate and critical time of weeding, etc;
- Improved machinaries such as weeders and threshers;
- Intensify finger millet production system by introducing legume intercropping and appropriate crop rotation techniques in order to improve the soil property, nutritional status as well as income of smallholder finger millet farmers,
- Arrange training on improved production packages of finger millet for farmers and agricultural experts to facilitate acceptance and adoption of improved finger millet technologies.

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PART Two: Agricultural Research and Extension Activities

Participatory Evaluation and Demonstration of Improved Groundnut Technologies in the Low Lands of North Shoa, Ethiopia

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Abstract

Groundnut (Arachis hypogaea L.) is an important annual legume industrial crop used for oil industry and other purposes of food and animal feed all over the world. The lowland areas of Ethiopia in general and some parts of the Amhara region in particular have considerable potential for increased groundnut oil crop production. The demonstration activity was done to attain the objectives of creating awareness about the technology to farmers and extension workers and to assess farmers and extension workers responses about the technology. This study was done in one of the low land areas of north shewa zone, Kewet district at a separate farmer's field in three replications using the improved varieties of Lote-01, Werer-961 and Sedi. The research was done in participatory approuch in which farmers and extension workers were participated in the events of variety selection and field day evaluation. Participant farmers set their selection criteria and evaluated the varieties against the criteria using direct matrix ranking. Yield and other field level data were obtained from each plot and the data were analyzed using simple descriptive statistics. Based on the selection criteria and yield data results, variety Sedi was selected. Further technology disseminations and large scale production of groundnut varieties are required clustering approach to produce quality

Key words: Groundnut; varieties; technology; farmerences' preferences, achievement; challenges products.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important monoecious annual legume used for oilseed, food and animal feed all over the world (Pande *et al*., 2003; Upadhyaya *et al*., 2006). It is used mainly as a source of food in various forms as well as a component of crop rotation in many countries (Gbèhounou and Adengo, 2003). Groundnut covers 26.4 million ha worldwide with a total volume of production 38.2 million metric tons (FAOSTAT, 2010). Among which developing countries account for 97 and 94% of the world's groundnut area coverage and volume of production, respectively. Although the national average yield of groundnut (13.8 q/ha) (CSA, 2013) is larger than the average of Africa (9.8 q/ha) (FAOSTAT, 2010), it is still much lower than the average of the world's groundnut productivity of 14.9 q/ha. Researchers associated this lower productivity of groundnut to abiotic, biotic and socio-economic factors (Pande *et al*., 2003; Upadhyaya *et al*., 2006 and Caliskan *et al*., 2008).

However, the lowland areas of Ethiopia have considerable potential for increased oil crop production including groundnut. In 2012/13 main cropping season, the estimated area coverage and yield of groundnut in Amhara regional state, where the study area is located, was about 90,155.57 hectares (4.23% of legumes) with a total volume of 1,244,187.53 quintals of grains (3.57% of legumes) production (CSA, 2013). Groundnut is a warm-season crop and is produced in areas with 40 mm or more annual rainfall and there should be at least 20 mm rainfall in the growing season. Dry weather is required for ripening and harvesting. The most suitable soils are well–drained, loose, friable, sandy loams, and well supplied with calcium and with moderate amounts of organic matter. It can be grown on heavier soils, but this makes harvesting more difficult as the soil adheres to the nuts and it may also stain them. Soils which crust or cake are unsuitable because of the difficulty of peg penetration. Well -aerated soil with good drainage is essential as the crop cannot tolerate water logging. The study areas are characterized by production of cereals mainly sorghum and tef year after year as a result the soil nutrients become depleted due to cereal based cultivation system.

It needs intervention to break the system and bring options for sustainable agricultural production system. Based on the observation data collected from the area, it is suitable for the production of groundnut and it is very important to evaluate and select the most appropriate varieties that suit farmers need. This area is also near and suit for product market. Thus, this study generally aims to demonstrate how to practice improved groundnut technologies under on-farm conditions as well as to evaluate their performances with the participation of key stakeholders mainly farmers and extension workers.

Objectives

General objective:

- To increase farmers' awareness, and accelerate the rate of technology expansion;
- **Specific objectives:**
- To create wider demand on groundnut production technologies;
- To strengthen linkage among the possible actors on groundnut technology transfer;
- To enhance groundnut production and dissemination system and improve its productivity;

Materials and Methods

The experiment was conducted in North Shewazone Kewot district in 2014/15 production year in the main season using rain fed system. This district was selected as a research location purposively, for its potential to grow groundnut and it will be one of the place where a significant portion of the regional production of groundnut coming from. First the appropriate research site was selected in collaboration with development agents (DAs) and district office of agriculture. Three farmers were then chosen as replications, each hosting all the trials of the three improved technologies/varieties, namely Sedi, Werer 961 and Lote 01.

These improved varieties were planted on a ridge basis with a spacing of 60 and 10 cm respectively between rows and between plants in a plot size of 10 m*10 m. Farmers allocated their land for the trials voluntarily free of any charge and fully participated from the inception to the final evaluation of the experiment.

Data on quantitative and qualitative variables (such as, yield, farmers' preference and others) were collected from a total of 9 observations (i.e., three observations for each treatment). Each technology hosting farmer has provided a total plot size of 310 m^2 farm lands for planting the three varieties, hence groundnut is new for the intervention area so no local or traditional varieties included in the study. The data on farmers' preferences were set and analyzed using direct matrix rankings methods and the yield data were evaluated by using simple descriptive statistics of mean for each variety. At the end of stakeholders evaluation feedbacks were also collected for future production intervention.

Results and Discussions

Farmer's preferences

Farmers played a pivotal role in process of evaluating and selecting the best performing improved varieties while the researchers played only a facilitative role. In a participatory manner through brain storming, farmers first listed a number of attributes/factors as selection criteria. They identified early maturity, moisture conservation; disease resistance, adaptability, pod/plant, and seed size are the major criteria for technology choice. Finally, they evaluated each of the three improved varieties

Introduction

Groundnut (*Arachis hypogaea* L.) is an important monoecious annual legume used for oilseed, food and animal feed all over the world (Pande *et al*., 2003; Upadhyaya *et al*., 2006). It is used mainly as a source of food in various forms as well as a component of crop rotation in many countries (Gbèhounou and Adengo, 2003). Groundnut covers 26.4 million ha worldwide with a total volume of production 38.2 million metric tons (FAOSTAT, 2010). Among which developing countries account for 97 and 94% of the world's groundnut area coverage and volume of production, respectively. Although the national average yield of groundnut (13.8 q/ha) (CSA, 2013) is larger than the average of Africa (9.8 q/ha) (FAOSTAT, 2010), it is still much lower than the average of the world's groundnut productivity of 14.9 q/ha. Researchers associated this lower productivity of groundnut to abiotic, biotic and socio-economic factors (Pande *et al*., 2003; Upadhyaya *et al*., 2006 and Caliskan *et al*., 2008).

However, the lowland areas of Ethiopia have considerable potential for increased oil crop production including groundnut. In 2012/13 main cropping season, the estimated area coverage and yield of groundnut in Amhara regional state, where the study area is located, was about 90,155.57 hectares (4.23% of legumes) with a total volume of 1,244,187.53 quintals of grains (3.57% of legumes) production (CSA, 2013). Groundnut is a warm-season crop and is produced in areas with 40 mm or more annual rainfall and there should be at least 20 mm rainfall in the growing season. Dry weather is required for ripening and harvesting. The most suitable soils are well–drained, loose, friable, sandy loams, and well supplied with calcium and with moderate amounts of organic matter. It can be grown on heavier soils, but this makes harvesting more difficult as the soil adheres to the nuts and it may also stain them. Soils which crust or cake are unsuitable because of the difficulty of peg penetration. Well -aerated soil with good drainage is essential as the crop cannot tolerate water logging. The study areas are characterized by production of cereals mainly sorghum and tef year after year as a result the soil nutrients become depleted due to cereal based cultivation system.

It needs intervention to break the system and bring options for sustainable agricultural production system. Based on the observation data collected from the area, it is suitable for the production of groundnut and it is very important to evaluate and select the most appropriate varieties that suit farmers need. This area is also near and suit for product market. Thus, this study generally aims to demonstrate how to practice improved groundnut technologies under on-farm conditions as well as to evaluate their performances with the participation of key stakeholders mainly farmers and extension workers.

Objectives

General objective:

- To increase farmers' awareness, and accelerate the rate of technology expansion;
- **Specific objectives:**
- To create wider demand on groundnut production technologies;
- To strengthen linkage among the possible actors on groundnut technology transfer;
- To enhance groundnut production and dissemination system and improve its productivity;

Materials and Methods

The experiment was conducted in North Shewazone Kewot district in 2014/15 production year in the main season using rain fed system. This district was selected as a research location purposively, for its potential to grow groundnut and it will be one of the place where a significant portion of the regional production of groundnut coming from. First the appropriate research site was selected in collaboration with development agents (DAs) and district office of agriculture. Three farmers were then chosen as replications, each hosting all the trials of the three improved technologies/varieties, namely Sedi, Werer 961 and Lote 01.

These improved varieties were planted on a ridge basis with a spacing of 60 and 10 cm respectively between rows and between plants in a plot size of 10 m*10 m. Farmers allocated their land for the trials voluntarily free of any charge and fully participated from the inception to the final evaluation of the experiment.

Data on quantitative and qualitative variables (such as. yield, farmers' preference and others) were collected from a total of 9 observations (i.e., three observations for each treatment). Each technology hosting farmer has provided a total plot size of 310 m^2 farm lands for planting the three varieties, hence groundnut is new for the intervention area so no local or traditional varieties included in the study. The data on farmers' preferences were set and analyzed using direct matrix rankings methods and the yield data were evaluated by using simple descriptive statistics of mean for each variety. At the end of stakeholders evaluation feedbacks were also collected for future production intervention.

Results and Discussions

Farmer's preferences

Farmers played a pivotal role in process of evaluating and selecting the best performing improved varieties while the researchers played only a facilitative role. In a participatory manner through brain storming, farmers first listed a number of attributes/factors as selection criteria. They identified early maturity, moisture conservation; disease resistance, adaptability, pod plant, and seed size are the major criteria for technology choice. Finally, they evaluated each of the three improved varieties

against these criteria. Table 1 depicts the main selection criteria that the farmers set and their evaluation results as follows. The selection criteria were set by the host and follower farmers invited to participate in the field evaluation. As shown in Table 1, farmers ranked first Sedi variety in all attributes. Even they also have given first priority for the same variety in terms of vegetative growth as an additional parameter. The other important attribute the farmers have seen separately to evaluate these technologies was the yield parameter. The candidate varieties were evaluated against the set criteria using direct matrix method using general voting methods.

Table 1. Farmers' technology selection criteria and evaluation results

Major criteria	Improved varieties		
	Lote 01	Sedi	Werer 961
Early maturity	3	1	2
Moisture conservation	3	1	2
Disease resistance	3	1	2
Adaptability	3	1	2
Pod/plant	2	1	3
Seed size	2	1	3
Overall rank	**3rd**	**1st**	**2nd**

Where, 1= best, 2= medium and 3= poor.

As shown in Table 2, the highest yield was recorded in the case of Sedi variety whereas the variety Lote-01 result the lowest yield due to disease and pest infestation on the variety compared to other candidates. Both in farmers' selection criteria and yield parameters Sedi was selected for further large scale production.

Table 2. Average yield of the three varieties

Varieties	Average yield Kg/Plot	Average yield Kg/ha
Lote 01	4.2	1167
Sedi	8.6	2389
Werer 961	6.9	1917

Achievements

The field-day was organized to evaluate the technologies demonstrated with the participation of the respective zonal and woreda administrators, officials and experts. A total of 82 (12 female) farmers and experts have attended this field-day program. All the participants were interested with the introduced varieties. They reported that producing such cash crops will not only help to diversify the income source of the local farmers and reduce the risk of producing cereal based crops, but also reduce food insecurity and self-insufficiency problems. Moreover, it would stimulate production of other crops through playing a proper crop rotation role like other legume crops. High demand was created during the field day and hence almost all farmers who participated in the field day were interested to plant the selected variety (Sedi) in the next cropping season.

Challenges

Seed shortage is a major problem facing farmers at the initial stage of participatory evaluation and demonstration of the technologies that has to be addressed for further dissemination of the research results depending on the farmers' interest and demands raised during the intervention.. No abundant seeds available for the interested farmers. As it is a newly introduced crop, there is no market linkage for it. Market access will also be the main challenge that discourages the producers.

Conclusion and Recommendation

Conclusion

Famers have limited access to produce alternative cash crops and other leguminous plants for home consumption. Introduction of such alternative technologies is helpful in those areas having limited options. The area is suitable and has high potential for the production of groundnut besides the high demand of farmers to grow the newly introduced crop variety. The introduced crops will also be an important intervention option to create employment opportunities for unemployed youths on the agro-processing activities.

Recommendations

Setting up the up-scaling mechanisms of selected technology to reach the wider community will be the future concern. Once such interest was created, creating market linkage among producers and other interested partners will be the future task for extension workers and other development practitioners. As an entry point for up-scaling of the technology at wider level, it is suggested to carry out pre-scaling up activity on cluster basis to reduce field damages.

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Participatory on farm Evaluation of Improved Bread Wheat Varieties in western Amhara Region

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Abstract

Six released varieties of bread wheat (Triticum aestivum L.) were evaluated on 9 framers fields in Yilmanadensa, Debre-Elias and Basoliben districts of western Amhara Region in 2014/2015. The objectives were to test the adaptability and acceptance of bread wheat technologies and create awareness to the farmers. The result of farmers' variety preference and the actual mean grain yield showed that Alidoro, Tay and Gassay are the 1st, 2nd and 3rd preferred varieties with the overall evaluation criteria in Yilmanadensa district. In Basoliben district, Hogana, Tay and Alidoro were the 1st, 2nd and 3rd preferred varieties by farmers, respectively. According to actual grain yield, Kekeba, Hogana and Tay were the 1st, 2nd and 3rd, respectively. In Debre-Elias district, the result of farmers' variety preference showed that, Hogana, Tay and Kekeba were the 1st, 2nd and 3rd preferred varieties by farmers, respectively. The combined analysis also showed the same result between farmers' rank and actual rank for Hogana and Tay Varieties. The statistical analysis showed that there were highly significant difference among varieties in plant height, spike length, number of seeds/spike, number of days to maturity; and grain yield. Therefore, in Yilmanadensa district, pre-scaling up of Alidoro and Tay varieties should be conducted while in Basoliben and Debre-Elias districts, pre-scaling up of Hogana and Tay varieties should be conducted in the coming production season.

Keywords: Bread wheat, released varieties, evaluation, farmers

1. Introduction

Ethiopia has the potential to easily feed itself looking at the immense diversity in climate, physiological and genetic resources; that transcend national boundaries to global agriculture. With this potential, Ethiopian agriculture has been unable to feed its population and thus forced the nation to look for food aid. Currently, the need to increase agricultural production and productivity and ensuring food security is no where more pressing than Ethiopia. In order to feed the rapidly growing population, the current level of cereal production must be doubled by 2025 (Seleshi, 2005).

Wheat is an important crop commodity in Ethiopia, which could contribute a major part in achieving the millennium goal of the country, food grain self sufficiency. In sub-Saharan Africa, Ethiopia ranks second next to South Africa in terms of total production and area coverage of bread wheat. In Ethiopia, wheat is the second major cereal crop accounting for about 19.2% (1.8 million hectares) of the total yearly acreage (10.7 million hectares) and 24.9% (4.96 million tons) of the gross annual grain production (19.9 million tons) of all the seven major cereals grown in the country (FAO, 2008). It also stands second in productivity (2.41t/ha) next to maize (2.44 t/ha). Bread wheat and durum wheat are the two species predominantly grown in the highlands and mid-altitudes areas of Ethiopia. Wheat is used as sources of food and income, and as row materials for agro-industries. The bulk of the country's wheat production comprises resource-poor small-scale farmers, while emerging farmers and large scale state commercial farms occupy only about 2% of the total wheat area and contribute 3% to the total wheat grain production (FAO, 2008).

Wheat is mainly grown in Oromiya, Amhara, Southern Nations and Nationalities People and Tigray regions, of which Amhara region is the second largest producer of wheat. According to CSA (2009), the region shares 30% (434,386 ha) of the area and 26% (6,545,021 qt) of the total wheat production of the country.

In spite of the enormous economic significance of the crop in the country and the existence of huge potentials of favorable environmental conditions, however, the productivity of wheat in Ethiopia has remained relatively low. The major constraints limiting the productivity and production of wheat, amongst others, include low inherent yield potential of the wheat types under widespread cultivation, prevalence of diseases, poor agronomic and cultural practices, poor soil fertility, moisture stresses, frost and other biotic and abiotic stresses (Hailu et al., 1991).

In order to solve those problems, continuous identification of the best and suitable bread wheat production technologies appeared to be essential. Participatory on farm evaluation of available bread wheat technologies with farmers is a good approach to identify the most adaptive and suitable technologies in different agro ecologies of the region. Dissemination of preferred technologies should also be under taken as it has a tremendous impact on the total bread wheat production and

productivity, and this also fosters supply alternative seed sources to the farmers. Therefore, this participatory bread wheat evaluation was designed to create awareness to farmers' about bread wheat production technologies and evaluate the yield performance of the varieties for further scaling up program.

Objectives:

- To create opportunity for farmers to evaluate available improved bread wheat varieties and select the best ones with their own criteria for enhancing adoption;
- To provide farmers with a menu of technologies;
- To demonstrate the technology to farmers so as to assess farmers technology preference and enhance demand driven technology dissemination;

2. Materials and Methods

Up on discussion with farmers, woreda office of agriculture (WOA) experts and extension workers on the purpose and implementation of evaluation activity, in each woreda, three farmers were selected to host the trial. Six bread wheat varieties namely Tay, Gassay, Alidoro, Kekaba, Hogana, Kubsa were planted on nine host farmers fields.

A plot size of 10mx10m for each variety was used. All the varieties were treated equally with recommended management practices, i.e. seed rate of 150 kg/ha for all districts and fertilizer rate of 100 kg/ha DAP and 161 kg/ha UREA at Yilmanadensa and 100 kg DAP/ha and 261 kg/ha UREA was applied at Bassoliben and Debre-Elias districts (UREA in equal split application of 3 times at plating, tillering and butting stages). The planting method used was drill row planting on 20 cm while the trials were weeded 3 times. Host farmers were guided on the proper application of recommended agronomic practices throughout the cropping season.

Field days were conducted at maturity stage where by farmers' evaluation criteria for wheat varieties were identified and prioritized in order of their importance (Weighted = 1 the best criterion). With these criteria farmers evaluated each variety by direct scoring. Scores given to each variety with each criterion by different farmers were added together.

2.1. Field evaluation

Kekeba bread wheat variety was found to be well adopted in all districts. Thus, there was no need to include extra local cultivars as a check in all districts. In all other pre and post stand establishment, cultural practices in the experimental plots were managed by the farmers themselves under close supervision of researchers and respective development agents from agricultural offices of each district. Assessments were made on all agronomic and phonological characters recorded immediately after germination that included plant population and development (vegetative and flowering),

uniformity, plant height (cm), spike length (cm), number of seeds/spike, yield kg/ha and number of days to maturity at optimum plant harvesting stage and insect and disease incidence one-five scale considered as a whole.

2.2. Farmers' assessment

In this study, individual and group discussions, field visits and questionnaire was used for data collection. Through recurrent discussions, we reiterated our engagement to ground the research on farmers' knowledge and preferences. Our relationship with the farmers and key informants developed into a sort of contract based on mutual benefit. Such contracts with farmers appeared as pre-requisites for joint learning and platform establishment and form the frames on which the research trial and activities are developed. Through focus group and individual discussions with farmers and key informants in three districts; a total of 15 different criteria were identified by farmers as selection and preference. These criteria were submitted to the group of farmers for further evaluation in each district.

Selection of individual farmer was made with key informants familiar about the crops to determine the adaptability and the growth performance of all bread wheat technologies through the entire growing period. The interviews are later extended to group participatory discussions with selected farmers in two clusters from each district. Group discussions were conducted to carefully build on and critically examine derived information from individual farmers of different households. It was also intended to clear conflicting ideas on issues like adaptability, the yield potential and growth performance of those of improved bread wheat varieties.

The group discussions critically focused on: i) Preference and selection of the varieties ii) Yield potential iii) Growth performance and adaptability of the varieties iv) Resistance to frost, disease and insect pests and v) Seed size as a whole. Focus group interviews and key informants were used to understand the underlying factors influencing farmers' decisions to conserve and sustainably utilize improved technologies on farmers' field. Information obtained from the interviews (individual households and group discussion) and from the key informants was used to obtain a broad understanding on sustainable utilization of those technologies in the areas. After harvesting the crop, tested farmers from each district was evaluated and gave its ranking of selected varieties based on their evaluation criteria.

The pair-wise ranking (Russell, 1997) method was used to analyze the position of each of the variety in tested areas by farmers evaluation criteria. A matrix table of varieties in each district was constructed. Farmers were asked to compare each variety with other varaities pertaining to the values (yield, plant height, spike length, number of seeds/ spike, and size, etc.) and the priority each farmer gives to the variety. Each variety was compared in turn with each of the other varieties. The process

was repeated for all varieties until all possible comparisons were made. The number of times each variety was found to be more important was counted for each individual farmer. This value represents the individual score for each variety. An aggregation was then realized on the scores for each variety over the farmers participating in the exercise. This aggregated score represents the district score. The ranking of these scores provides the position of the varieties in the local economy. The same process was applied to the criteria farmers considered for the choice of varaities in the three districts.

2.3 Types and Methods of Data collection

Farmers' wheat selection criteria, farmers' assessment about the overall improved wheat management practices, selected varieties by farmers with rank and grain yield and bio-mass per plot and per hectare were collected.

2.4 Data Analysis Procedure

The processing of the data was as follows: List farmers' evaluation criteria exhaustively; rank each criteria by farmers using pair-wise ranking (weight); evaluate the varieties with each criteria and give score (1,2,3...the number of varieties; 1=the best) by individual or small groups of farmers; add the score given to each variety with each criteria (least sum is ranked 1^{st}); multiply the rank with respective weight for each variety; add the products for each variety with all criteria for final selection (least sum is ranked1^{st}); let farmers all together give rank to the varieties with the overall criteria for cross checking; check the actual grain and biomass yield after harvesting and compare with farmers' rank to each variety; then, make farmers know the result and reach agreement on which variety/ies to be promoted in the future.

3. Results and Discussion

During field evaluation, 86 farmers (7 females) evaluated the varieties and selected the best varieties with their own wheat selection criteria. Bread wheat varieties evaluation criteria of farmers in order of their importance in Yilmanadensa, Basoliben and Debre-Elias districts were:

- Disease resistance (1^{st}) Weight=1
- Grain yield (2^{nd}) Weight=2
- Spike length (3^{rd}) Weight=3
- Tillering capacity (4^{th}) Weight=4

With these criteria farmers evaluated each variety by direct scoring. Sum of the score given to each variety (1 to 4; 1= the best) with each criterion by 32 farmers in Adet Hana (12), Abika (10) and D/mawi (10) Kebeles is presented in Table 1.

Table 1. Farmer's selection criteria in Yilmanadensa district, 2015/16

Variety	Criteria and scores give by of farmers at Yilmana Densa district											
	Adet Hana				Abika				D/mawi			
	Dis. Tol	Yield	sp/length	Tillering	Dis. Tol	Yield	sp/length	tillering	Dis. Tol	Yield	sp/length	Tillering
Alidoro	(1) 12	(1)12	(1) 12	(2) 24	(2) 20	(1) 10	(1) 10	(1) 15	(1) 10	(1) 10	(1) 10	(2) 20
Tay	(2) 14	(3)24	(2) 24	(1) 12	(1) 10	(2) 20	(2) 20	(2) 16	(2) 20	(2) 20	(2) 20	(1) 10
Hogana	(3) 36	(5) 69	(6) 72	(6) 72	(3) 30	(5) 58	(6) 58	(4) 33	(3) 30	(6) 60	(6) 60	(5) 50
Kubsa	(5) 62	(6) 74	(5) 64	(5) 60	(5) 44	(4) 50	(4) 49	(6) 50	(6) 60	(5) 50	(5) 50	(6) 60
gassay	(4) 48	(2) 15	(3) 36	(3) 36	(4) 40	(3) 30	(3) 30	(3) 20	(4) 40	(3) 30	(3) 30	(3) 30
Kekeba	(6) 70	(4) 49	(4) 39	(4) 48	(6) 60	(6) 60	(5) 50	(5) 38	(5) 50	(4) 40	(4) 40	(4) 40

Note: Dis.Tol=Disease tolerance; sp=Spike

Pair wise ranking and final preference values analysis result showed that farmers gave higher emphasis/weight for disease resistance followed by high grain yield potential of varieties. Spike length and tillering capacity were the second important criteria in selecting bread wheat varieties. In over all evaluation criteria, Alidoro,Tay, Gassay, Hogana, Kekeba and Kubsa bread wheat varieties were selected 1st, 2nd, 3rd, 4th, 5th and 6th respectively by farmers own selection criteria in three kebeles at Yilmanadensa district (Table2). Alidoro, Gassay and Tay were selected mainly by their high yielding potential and tillering capacity. Alidoro is red seeded bread wheat variety which is vigours and high yielding both in grain and biomass (straw) yield and mostly preferred by farmers for home consumption and local market.

Table 2. Preference value and final acceptability rank of varieties in Yilmanadensa district, 2015/16

Adet Hana						Abika					D/mawi					Total	Rank
Variety	Dis. Tol =1	Yield=2	sp/len=3	tillering 4	sub total	Dis. Tol =1	Yield=2	sp/len=3	tillering 4	Sub total	Dis. Tols=1	Yield =2	sp/len =3	tillering 4	sub total		
Alidoro	1	2	3	8	14	2	2	3	4	11	2	2	3	12	19	44	1st
Tay	2	6	6	4	18	1	4	6	8	19	1	4	6	4	15	52	2nd
Hogana	3	10	18	24	55	3	10	18	16	47	3	5	18	16	42	144	4th
Kubsa	5	12	15	20	52	5	8	12	24	49	5	8	12	24	49	150	6th
Gassay	4	4	9	12	29	4	6	9	12	31	4	6	9	8	27	87	3rd
Kekaba	6	8	12	16	42	6	12	15	20	53	6	12	15	20	53	148	5th

Note: Dis.Tol=Disease tolerance; sp=Spike

Sum of the score given to each variety (1 to 4; 1= the best) with each criterion farmers in three kebeles of Basoliben district is presented in Table 3.

Table 3. Farmer's selection criteria in Basoliben district, 2015/16

Variety	Criteria and scores give by of farmers at Basoliben district											
	Farmer 1				Farmer 1				Farmer 1			
	Diseas res.	yield	sp/length	Tillering	Disease res.	yield	sp/length	Tillering	Disease res.	Yield	sp/length	Tillering
Alidoro	(2) 14	(5) 43	(1) 9	(5) 36	(3) 28	(4) 32	(1) 8	(6) 48	(3) 24	(5) 32	(1) 8	(4) 32
Tay	(3) 18	(3) 27	(2) 18	(2) 15	(2) 12	(2) 16	(2) 12	(2) 12	(2) 16	(2) 11	(2) 16	(2) 16
Hogana	(1) 9	(1) 9	(3) 27	(1) 13	(1) 8	(1) 8	(5) 36	(1) 8	(1) 8	(1) 8	(5) 27	(1) 8
Kubsa	(6) 54	(9) 46	(6) 54	(6) 54	(4) 29	(6) 48	(6) 43	(5) 40	(6) 42	(6) 48	(6) 32	(6) 44
gassay	(4) 36	(4) 33	(5) 36	(4) 27	(5) 32	(5) 40	(4) 28	(4) 32	(4) 28	(4) 28	(3) 20	(5) 36
Kekeba	(5) 45	(2) 18	(4) 31	(3) 18	(6) 34	(3) 24	(3) 16	(3) 24	(5) 35	(3) 24	(4) 24	(3) 24

In over all evaluation criteria, Hogana, Tay, Kekaba, Alidoro, Gassay and Kubsa bread wheat varieties were selected 1st, 2nd, 3rd, 4th, 5th and 6th respectively by farmers own selection criteria in three kebeles at Basoliben district (Table 4). Hogana, Kekaba and Tay were selected mainly by their high yielding potential and tillering capacity.

Table 4. Preference value and final acceptability rank of varieties in Basoliben district, 2015/16

	Baso-1					Baso-2					Ba-3						
Variety	Dis. Tol =1	Yield= 2	sp/len =3	tillering 4	sub total	Dis. Tol =1	Yield= 2	sp/len =3	tillering 4	Su total	Dis. Tol =1	Yield=2	sp/len =3	tillering 4	sub total	Total	Rank
Alidoro	2	10	3	20	35	3	8	3	24	38	3	10	3	16	32	105	4th
Tay	3	6	6	8	23	2	4	6	8	20	2	4	6	8	20	63	2nd
Hogana	1	2	9	4	16	1	2	15	4	22	1	2	15	4	22	60	1st
Kubsa	6	18	18	24	66	4	12	18	20	54	6	12	18	24	60	180	6th
Gassay	4	8	15	16	43	5	10	12	16	43	4	8	9	20	41	127	5th
Kekaba	5	4	12	12	33	6	6	9	12	33	5	6	12	12	35	101	3rd

Note: Dis.Tol=Disease tolerance; sp=Spike

Sum of the score given to each variety (1 to 4; 1= the best) with each criterion farmers in three kebeles of Debre-Elias district is presented in Table 5.

Table 5. Farmer's selection criteria in Debre-Elias district

variety	Debre-Elias											
	1				2				3			
	Dis.Tol	yield	sp/length	tillering	Dis.Tol	yield	sp/length	tillering	Dis.Tol	yield	sp/length	tillering
Alidoro	(3) 17	(5) 47	(1) 10	(5) 40	(3) 27	(4) 36	(1) 9	(6) 54	(3) 30	(5) 40	(1) 10	(5) 40
Tay	(2) 13	(4) 30	(2) 20	(2) 18	(2) 16	(2) 18	(2) 13	(2) 18	(2) 18	(2) 13	(2) 20	(2) 20
Hogana	(1) 10	(1) 10	(3) 30	(1) 10	(1) 9	(1) 9	(5) 40	(1) 9	(1) 10	(1) 10	(5) 45	(1) 10
Kubsa	(6) 60	(6) 52	(6) 60	(6) 60	(4) 33	(6) 54	(6) 49	(5) 45	(6) 54	(6) 60	(6) 40	(4) 32
gassay	(4) 40	(3) 24	(5) 40	(4) 30	(5) 36	(5) 45	(4) 27	(4) 36	(4) 34	(4) 34	(3) 24	(6) 43
Kekeba	(5) 50	(2) 20	(4) 35	(3) 20	(6) 39	(3) 27	(3) 18	(3) 27	(5) 43	(3) 30	(4) 30	(3) 30

Note: Dis.Tol=Disease tolerance; sp=Spike

In over all evaluation criteria, Hogana, Tay, Kekaba, Alidoro, Gassay and Kubsa bread wheat varieties were selected 1st, 2nd, 3rd, 4th, 5th and 6th respectively by farmers own selection criteria in three kebeles at Debre-Elias which is the same to Basoliben district (Table 6). Hogana, Kekaba and Tay were selected mainly by their high yielding potential and tillering capacity.

Table 6. Preference value and final acceptability rank of varieties in Debre-Elias district

Variety	Baso-1					Baso-2					Ba-3						
	Dis.Tol =1	Yield=2	sp/len=3	tillering 4	sub total	Dis.Tol =1	Yield=2	sp/len=3	tillering 4	sub total	Dis.Tol =1	Yield=2	sp/len=3	tillering 4	sub total	Total	Rank
Alidoro	3	10	3	20	36	3	8	3	24	38	3	10	3	20	36	110	4th
Tay	2	8	6	8	24	2	4	6	8	20	2	4	6	8	20	64	2nd
Hogana	1	2	9	2	14	1	2	15	4	22	1	2	15	4	22	58	1st
Kubsa	6	12	18	24	60	4	12	18	20	54	6	12	18	16	52	166	6th
Gassay	4	6	9	16	35	5	10	12	16	43	4	8	9	24	45	123	5th
Kekaba	5	4	12	12	33	6	6	3	12	27	5	6	12	12	35	95	3rd

Note: Dis.Tol=Disease tolerance; sp=Spike

Analysis of Variance (ANOVA) result of yield in quintal per hectare (Qt/ha) and other agronomic parameter performance of improved bread wheat varieties under evaluation and demonstration is given in Table 7 to 9 in each district. There was significant difference among varieties in plant height, spike length and yield. Tay was the longest variety with more seeds per spike at Yilmanadensa district (Table 7) and Hogana took more number of days to mature than other varieties. Alidoro, Tay and Gassay gave the highest yield (35, 34.17 and 33.08 Qt/ha respectively) followed by Kekeba, Kubsa and Hogana with mean yield of 30.46, 28 and 24.16 Qt/ha respectively at Yilmanadensa district (Table 7).

Table 7. Mean grain yield and some other agronomic parameters of 6 improved bread wheat varieties at Yilmanadensa district, 2015/16

Treatment	Plant height (cm)	Spike length(cm)	Seeds/spike	Days to mature	Yield/ha (quintal)
Alidoro	97.67ab	10.33a	63.00a	128.7c	35.00a
Tay	102.67a	9.33ab	57.67a	130.0c	34.17a
Hogana	86.00cd	7.33b	40.67c	137.7d	24.16b
Kubsa	83.33d	7.33b	48.00b	115.0ab	28.00ab
Gassay	93.00b	8.67ab	46.00bc	119.7b	33.08a
Kekeba	92.00bc	7.67b	57.00a	111.7a	30.46ab
G/ mean	92.44	8.44	52.06	123.78	30.81
LSD	6.429	1.272	3.967	2.812	7.326
CV	3.8	8.3	4.2	1.2	13.1
P.Value	***	***	ns	ns	*

Analysis of Variance (ANOVA) table of improved bread wheat varieties is given in Table 8 for Basoliben district. There was significant difference among varieties in plant height, spike length and days to maturity. Although there is no significant difference in yield, Kekeba, Hogana and Tay were the top yielders giving mean grain yield of 37.7, 36.2 and 34.3 Qt/ha, respectively.

Table 8. Mean grain yield and some other agronomic parameters of improved bread wheat varieties at Basoliben district, 2015/16

Treatment	Plant height (cm)	Spike length(cm)	Seeds/spike	Days to mature	Yield/ha (quintal)
Alidoro	99.00ab	11a	57.33a	125.67b	32.3
Tay	105.33a	9.67ab	56.33a	126.00b	34.3
Hogana	93.67bc	7.67c	46.33bc	132.00c	36.2
Kubsa	81.33d	7.33c	41.33c	117.67a	25.9
Gassay	94.33bc	8.67bc	54.00ab	125.67b	34.1
Kekeba	88.67cd	7.67bc	43.67c	119.33a	37.7
Grand mean	93.7	8.67	49.8	124.39	33.4
LSD	*8.31*	*1.448*	*8.51*	4.157	*13.6*
CV	4.9	9.2	9.4	1.8	22.4
P.Value	***	***	ns	***	ns

Analysis of Variance (ANOVA) table of improved bread wheat varieties is given in Table 9 for Debre-Elias district. There was significant difference among varieties in plant height, spike length and yield. Hogana was the highest mean grain yielder (40.18 Qt/ha) followed by Tay (36.40 Qt/ha), Gassay (32.45 qt/ha) and Alidoro (31.45 Qt/ha) at Debre-Elias district (Table 9). Kubsa and Kekeba varieties were the lower yielders with mean grain yield of 29.76 and 26.94 Qt/ha, respectively at Debre-Elias.

Table 9. Mean grain yield and some other agronomic parameters of 6 improved bread wheat varieties Location- Debre-Elias

Treatment	Plant ht(cm)	*Spike length(cm)*	Seeds/spike	Days to mature	Yield/ha (quintal)
Alidoro	93.67a	*10.33a*	46.3	125.33	31.45abc
Tay	96.33a	*9.33b*	53.3	126.33	36.40ab
Hogana	88.00b	*8.00c*	45.7	129.33	40.18a
Kubsa	82.00cd	*7.33c*	49.3	119.33	29.76bc
Gassay	86.33bc	*8.33c*	47.3	125.33	32.45abc
Kekeba	79.67d	*7.67c*	43.3	123.33	26.94c
Grand mean	87.67	*8.5*	47.6	124.83	32.9
LSD	5.092	*0.996*	9.46		8.23
CV	3.2	*6.4*	10.9		13.8
P.Value	***	***	ns	ns	*

Actual grain yield performance and farmers preference rank summary in each district is given in Table 10. Actual yield rank and farmers' preference ranks were the same for Alidoro, Tay and Gassay bread wheat varieties at Yilmanadensa district while there is mismatch in Kekeba and Kubsa varieties.

On the other hand, in Basoliben district, the result of farmers' variety preference analysis showed that Hogana, Tay and Gassay are the 1st, 2nd and 3rd preferred varieties respectively by farmers while Kekeba, Hogana and Tay ranked 1st, 2nd and 3rd respectively in actual grain yield. This means Hogana was 1st in farmers' selection but ranked 2nd in actual yield, Tay was selected 2nd by farmers but was 3rd in actual yield rank and Kekeba was 3rd in farmers' selection but 1st in actual yield rank (Table 10). Gassay, Kubsa and Kekeba varieties were not preferred by farmers since they were infested by disease at Basoliben district.

In Debre-Elias district, Hogana and Tay bread wheat varieties ranked same (1st and 2nd respectively) by farmers' selection criteria and actual grain yield. Moreover, farmers' preference rank was 3rd, 4th, 5th and 6th for Kekaba, Alidoro, Gassay and Kubsa varieties respectively while actual yield rank was 6th, 4th, 3rd and 5th in that same order (Table 10).

Table 10. Farmers' preference value rank and actual yield rank comparison of varieties, 2015/16

No	*Districts and rank of varieties*									
	Varieties	Yilmanadensa			Basoliben			Debre-Elias		
		Farmers rank	Actual yield (qt/ha)	Actual yield rank	Farmers rank	Actual yield (qt/ha)	Actual yield rank	Farmers rank	Actual yield (qt/ha)	Actual yield rank
1	Alidoro	1st	35.00	1st	4rd	32.26	5th	4th	31.45	4th
2	Tay	2nd	34.17	2nd	2nd	34.30	3rd	2nd	36.40	2nd
3	Hogana	4th	24.16	6th	1st	36.25	2nd	1st	**40.18**	1st
4	Kubsa	6th	28.00	5th	6th	25.92	6th	6th	29.76	5th
5	Gassay	3rd	33.08	3rd	5th	34.11	4th	5th	32.45	3rd
6	Kekaba	5th	30.46	4th	3th	**37.73**	1st	3rd	26.94	6th

Conclusion and recommendations

Alidero, Tay and Gassay were the highest grain yielders with 35 qt/ha, 34.17 qt/ha and 33.08 qt/ha actual grain yield respectively while these varieties were preferred by farmers as 1st, 2nd and 3rd in that order. Kekeba, Hogana and Tay bread wheat varieties gave actual grain yield of 37.73, 36.25, and 34.3 qt/ha respectively in Basoliben district while farmers ranked Hogana, Tay and Gassay as 1st, 2nd and 3rd preferred varieties. In Debre-Elias district, Hogana, Tay and Alidero gave actual grain yield of 40.18, 36.4, and 31.45 qt/ha respectively while Hogana is selected 1st and Tay 2nd by farmers while Alidoro was selected 4th by farmers.

The results of farmers' preference analysis and actual yield result showed that, Alidoro and Tay are the best varieties selected among the six bread wheat varieties evaluated in Yilmanadensa district. On the other hand, Hogana and Tay are the best varieties among the six bread wheat varieties evaluated at Basoliben and Debre-Elias.

Therefore, wider promotion or pre-scaling up of Alidoro (for home consumption and local market purposes) and Tay varieties in Yilmanadesa district and Hogana and Tay varieties in Basoliben and Derbe-Elias districts should be conducted in the next production season.

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Transfer of Garlic (Allium sativum L.) Production Technologies in Anditid Learning Watershed, North Shoa, Ethiopia

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Abstract

This study aims to pre scale up the promising garlic technology to enhance the productivity and production practices of the small holder farmers in learning watershed, of North ShewaAmhara Region. The results of yield analysis indicated that improved variety of MM98 has a yield advantage of 57% compared to the local cultivar and encourages farmers to grow the variety in large scale instead of producing in small plots of land at the homesteads. Pre-scaling up of improved technologies created a wider demand for the technology, besides improving farmers' productivity and source of cash income.

Key words: Garlic, Technology; yield; cropping systems; income

Introduction

Garlic (Allium sativum L,) belongs to the family alliaceae and is the second most widely used Allium next to onion (Rubatzky and Yamaguchi, 1997). Garlic is a basic flavoring bulb crop for a multitude of dishes ranging from vegetable soup, meat, salad, tomato combination, spaghetti, sausages, pickles, etc. (Brewster, 1994). In Ethiopia, it is one of the most important bulb crops produced by smallholder farmers and commercial growers for both domestic and export markets and home consumptions (Metasebia and Shimelis, 1998). Garlic is spread throughout the country being cultivated under irrigation as well as rain-fed condition (Lemma and Hearth, 1994). Garlic is produced mainly in the mid and high lands of Ethiopia. The crop is also produced as a cash crop to earn foreign currency by exporting to Europe, the Middle East and USA. It had been under commercial production by Horticultural Development Corporation at Debre Zeit, Guder and Tseday State Farms (Getachew and Asfaw, 2000). Diverse crop management problem and the nature of propagation limited the supply of production in Ethiopia.

In Ethiopia the major production constraints of garlic include lack of improved varieties, diseases like garlic rust, downy mildew, basal rot, white rot, purple blotch and insects of onion trips (Getachew and Asfaw, 2000). In addition, garlic was produced on small plots in the homestead areas, low or absence of inputs use for production and lack of farmers' awareness on proper production skills on garlic are the other constraints in garlic production.

To take advantages of its diverse economic and dietary importance, improving garlic production and productivity need to be a top priority activity. Being a cash crop in many parts of the country, increasing its productivity per unit area and production will enable farmers to get encouraging returns and contribute its role in achieving the food security goals. In many countries, garlic is established crop and cultivars that are well adapted to the local conditions and the local markets have been selected (Rabinowitch and Currah, 2002). Great efforts have been made in the selection and breeding of locally adapted cultivars and the development of cultural techniques for production improvement of garlic (Rabinowitch and Brewster, 1990).

Farmers in Andit Tid watershed have not been experienced to produce garlic. Introduction of improved garlic production technologies including the improved variety of MM-98 is an alternative commodity mainly to diversify source of income for the growers who have limited access. The introduction of improved garlic varieties with their production practices helps to address the issue of lack of awareness of garlic production and less diversified vegetable production system in the community. This study, therefore, generally aims to increase garlic productivity and income of farmers through enhancing farmers' awareness, easy access to improved technologies with management practices and accelerated rate of seed dissemination among farmers to the wider communities at large.

Materials and Methods

In the pre-scaling up of improved garlic technologies, first farmers who are interested to participate and host technologies were selected and organized into Farmers Research and Extension Groups (FREGs) based on their farm history and suitability for the production of garlic. Training was the other important activity in pre-scaling up given for those selected farmers and interested agricultural experts about the production requirements of garlic and its market and production potentials together with production techniques. The training mainly focused on improved production systems of garlic based on characters of technologies and their agronomic practices, seed production, post-harvest handling of garlic, and concepts and importance of FREG. Once FREG was organized and training was given to its members, the research center distributed the improved variety of MM98 to all FREG members to grow and evaluate its performance relative to the local cultivars. These farmers then demonstrated the technology to other follower or non-group member farmers within and outside watershed areas in the one hand and to evaluate by themselves how it performed well as compared to the existing local cultivars on-farm conditions and to create wider demand for improved variety in the first year on the other hand. Finally, the improved variety (MM98) introduced in large scale for interested farmers to disseminate it to the communities at large.

Farmers hosting improved variety planted garlic with a spacing of 30 cm between ridges and 10 cm between plants. They applied fertilizers at the recommended rate of 200 kg/ha of DAP at planting and 150 kg/ha of Urea at a split base: half at the time of planting and the remaining half 45 days after planting. The multidisciplinary team of researchers, agricultural experts and group of farmers were continuously monitoring and following up the pre-scaling up activities. Field days were organized with various stakeholders comprising of farmers, agricultural experts and researchers. Farmers' reflections and feedbacks were collected for future production improvement. Finally, seed producer and marketing cooperative was established to sustain seed supply and production system. The activity was done by organizing interested farmers to produce and cultivate the improved variety of garlic in their homesteads. Primarily they agreed to produce seed and volunteered to exchange with other farmers either in kind or cash. A total of 18 (5 female) farmers with different farm sizes participated in the production of MM-98 variety.

Results and discussions

Training participants

At the initial stage of the pre-scaling up activities, training was given for 51(11 female) participant farmers and 3(1 female) agricultural experts in order to aware them how to produce garlic with the recommended agronomic practices in the identified areas. The interested farmers made to participate in

the training to be involved actively in the future production periods and the extension workers participated to support the future sustainable production of garlic in the area.

A team of researchers, farmers and extension groups participated during follow ups and support the proper application of garlic production on host and follower farmers. The farmers were very interested to correct the management of garlic production depending on the comments provided during follow up and support.

Field day was organized and farmers and extension workers were invited to evaluate the performance of improved variety compared with the local one in the implementing area. Host farmers and their neighbors were highly appreciating the field performance and disease resistance capacity of the variety compared with the local one.

Samples of yield data were taken from the improved and the local garlic varieties to campare the performance and yield advantages of the improved variety against the local check. Stand count after emergency and at maturity stage were taken in addition to yield and plant height. In all the parameters and yield component variables improved garlic variety was higher than the local check in comparison. MM-98 resulted high tuber yield which enabled the producer farmers benefited from the production of garlic. MM-98 variety has a high yield advantage as compared to the local cultivar (Table 2).

Table 1 Garlic production results

Variety	MM-98	Local
Plot size	$65m^2$	$65m^2$
Stand count	984	871
Plant height (cm)	86	65
Yield (t/ha)	5.24	3.33

Thefield performance of improved garlic variety (MM-98) when compared with that of the local cultivar indicated that the improved variety resulted in high performance in plant height, disease resistance and bulb size during observation and farmers evaluation.

System related changes

The farming systems changed from fallowing every other year of the farm lands into proper crop production and rotation systems. This is the fact that farmers easily accessed to different improved technologies including garlic together with potato and barley. Since garlic is now one of the alternative crops, farmers mainly produce it in the study areas; seed producer and marketing cooperatives are involved in the supplying of improved seeds to farmers. The productivity of garlic farms become increased and source of farmer's cash income enhanced. Farmers' awareness towards

the use of improved technologies progressed from time to time. Farmers' reflections encourage the researchers and interested donors to bring about livelihood improvements in the area.

Institutional arrangement

The system is included to integrate with SLM (Sustainable Land Management) plans in the district to sustain the multiple benefits resulted from the intervention. The task force established at zonal level after the workshop reflected the improvements made in the area.The farmers witnessed that the changes have resulted from the intervention implemented in the area and thus farmers are encouraged to sustain the achievements. Wereda Office of Agriculture agreed to take the initiative or responsibility for future support and following up of the activity so as to sustain and maintain the system.

Conclusions and Recommendations

Once the technology is introduced to the farmers in the proper way and provides benefits to them, farmers would have high demand for the technologies and would be encouraged to sustain the production system through the use of the improved technologies. Training is very important to create awareness about improved technologies. Organizing the interested farmers into FREGs helps to get organized feedbacks and reflection from the farming community, instead of individual interests. The organized farmers' group also assists in the transfer of indigenous knowledge and sharing of farming experiences among farmers through farmer-to-farmer exchange system.

Targeting small-holder farmers so as to make them beneficiaries of technology transfer through the use of different extension approaches such as training, field day participation, monitoring and evaluation, awareness creation and workshops with agricultural office experts and representative farmers will help individual farmers and the farming community at large to get high benefits through diffusion of the technologies and smoothening of the technology transfer system. Establishment of institutions provides sustainable technology supply system and creates easy access to improved technologies in the nearby locality. Seed producer and marketing cooperatives help the members to get market access to sell their improved bulb products.

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Participatory Evaluation of Hybrid Sorghum Technologies: in Mid and Low Land Areas of Waghimra Zone, Eastern Amhara, Ethiopia

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Abstract

The study aims to evaluate the performance of two improved sorghum varieties relative to the local variety with a participatory approach. Six farmers in sorghum growing areas of Sekota and Abergele districts of Waghimra cultivated ESH-1 and ESH-2 sorghum varieties including the local cultivar on randomly assigned plots treated with improved and farmers' management practices. The technologies were evaluated through participation of farmers organized into two Farmers' Research and Extension Groups (FREGs), one in each district comprised of 18 and 12 farmers (30% women) representing the different social segments in Sekota and Abergele, respectively. The results of participatory evaluation and partial budget analysis indicated that the performance of improved varieties is significantly larger than the local by most parameters in both districts. Therefore, ESH-1 variety had a yield advantage of 17.5% and 41.1% respectively from the local check with improved management and farmers practice in Aybra. Also, ESH-2 had 47.2% and 151.3% yield advantage over the local check with improved management and farmers practice in Marnet, respectively. In addition, farmers' evaluation based on the overall weighted ranking of their selection criteria revealed that ESH-1 and ESH-2 varieties took the first and the second place in Sekota and vice-versa in Abergele. This suggests that it's safe for scaling up these sorghum technologies in their respective trial districts while it's important to rethink about the establishment of farmers' seed producing and marketing cooperatives and/or providing pre-basic seeds for seed multiplying enterprises, as a means to build a sustainable seed source as an exit strategy.

Key words: Participatory evaluation, farmer preferences, hybrid sorghum, partial budget analysis

Introduction

Ethiopia is the second largest sorghum producer in eastern and southern Africa next to Sudan in both total area and volume of production (Abera *et al.*, 1996). Nationally sorghum ranks third in terms of total area and volume of production among cereal crops (CSA, 2015). Sorghum is utilized in different forms; such as the grain is used for human consumption such as food and homemade beverages while the leaves and stalks are used as animals feed. The stalks are also used for construction and as a fuel wood as well as the juicy stalks are commonly chewed like sugar cane. As sorghum is growing under a wide range of environmental conditions, the range of both biotic and abiotic production constraints are diverse, resulting in very poor performance of sorghum under farmers' circumstances. The average national yield of 23.69 q/ha is by far very low compared to 3-6 t/ha achieved from use of improved varieties and production technologies (CSA, 2015).

Similarly, in Waghimra zone where sorghum is the major food crop, the average productivity of sorghum ranges from 10 q/ha up to zero in sever moisture deficit seasons.This is by far less than the national average. The area coverage of sorghum in Waghimra zone is estimated to be 38,909.19 hectare with total producer farmers of 80,533 and productivity of 13.42 q/ha in the study year (CSA, 2015). Moisture deficit and lack of improved varieties fitting to the different growing conditions are some of the major yield limiting factors in the study areas. With the aim of addressing these problems, several hybrid varieties were developed and released nationally. Some of the hybrid sorghum varieties like ESH-1, ESH-2, and ESH-3 have a special merit of high yielding over the other improved and local sorghum varieties. To identify the most promising ones among the number of hybrid sorghum varieties, adaptation trials were first done by Sekota Dry Land Agricultural Research Center with the aim of evaluating their performance on station solely with the management of researchers, without involving farmers over the entire stages of the trials. It is only at the final stage of the growing period various participants from different institutions evaluated the varieties during field days. Meanwhile, this approach limited farmers' involvement in managing the trials and their views on variety selection criteria starting from the onset; hence it is argued that it limits the acceptance and adoption of improved varieties.

Therefore, adopting a participatory approach to evaluate the performance of improved hybrid varieties is an important opportunity for farmers to identify their favorite varieties enhancing demand driven technology adoption rate, which ultimately increases their production and productivity. This study is, therefore, mainly designed with the aim of evaluating the hybrid sorghum varieties by providing farmers with a menu of technology options that in turn helps to select economically feasible and socially acceptable technology basing their best selection criteria. It specifically aimed to assess farmers' technology preferences and/or selection parameters that help to enhance demand driven technology dissemination system in sorghum producing dry-land areas of Waghimra zone.

Materials and Methods

Discription of the study (implementation) areas

This study was conducted at Sekota and Abergele districts of Waghimra zone, Eastern Amhara located inside Tekezie basin growth corridor of the Amhara region in 2013/14 production year. Representative Kebele in each district was purposively picked to host the trial, thus Aybra and Marnet kebeles were selected from Sekota and Abergele districts, respectively. Geographically, Aybra is located at 12.68°N' latitude and 39.015°E' longitude with an altitude of 1976 m.a.s.l. It receives a mean annual rainfall of 750 mm with respective maximum and minimum temperatures of 31.6°C and 26.2°C. The major soil type is enteric carnbisols, usually termed as black soil. On the other hand, Marnet is located at 13°20' N' latitude and 38"58' E' longitude with an altitude of 1150-2100 m.a.s.l, and 90% of its arable land is suitable for sorghum production. The area's annual rainfall ranges from 250-750 mm; and the soil type is mainly of three types, 55% brown and porous, 30% red and silt and 15% sandy (WAO, 2013).

Farmers' research and extension group (FREG) establishment

For enhancing participatory evaluation and transfer of sorghum technologies, farmers' research and extension group (FREG, hereafter) was organized in each district having a member of 18 and 12 farmers in Sekota and Abergele respectively based on settlement conditions. The group members representing different social segments (having diverse spectrum of age, sex and wealth status) were selected in consultation with the local agricultural office experts and key informants that are conversant about the areas. Each group has chairman and secretary in order to facilitate FREG tasks in collaboration with researchers and extension workers at the trial kebeles. Then, from each group six farmers were randomly selected to host the trial by providing farmland (free of charge) while other experimental costs were covered by the research center. Before the trials, all group members were trained on basic agronomic practices in particular and the technology packages in general for two days consisting both theoretical and practical components. The group members had an action plan and meeting schedule to evaluate the varieties following main physiological growth stage of the crop.

Land preparation and plantation

In this study, both hybrid sorghums varieties (ESH-1 and ESH-2) and the local check were tested for their germination performance using petri dish, thus they had 98% and 97% germination rate, respectively. The trial was laid out on 10mx10m area for each variety with a gross area of 100 m^2. Planting was done in row with the seed rate of 10 kg/ha. Fertilizer was applied at the rate of 50/100 kg/ha UREA and DAP, correspondingly and UREA was applied in split at knee height stage of the crop. The local varieties were treated both with improved management as well as farmers practice in order to show clear variations of the varieties. Thus, local with improved management (LIM) was

adjusted to the above recommended seed and fertilizer rates whereas local with farmers' practice (LFP) was sown in broadcast without fertilizer at 20 kg/ha seed rate. Distance between plants and rows were 15cm and 75cm, respectively for improved management treatments. Plowing, weeding and other management practices were done as required. The plantation of all treatments was considered as un-replicated simple block, farmers as replications.

Participatory evaluation, data collection, partial budget and statistical analysis

Individual and group discussion with FREG members, field visit, questionnaire and field days were used to evaluate the technologies as well as data collection. Over frequent discussions, researchers were playing the role of facilitation instead of being engaged in grasping tangible ground level farmers' knowledge and preferences. Our relationship with farmers and key informants developed into a sort of contract based on mutual benefit. Such contract with farmers appears as pre-requisite for joint learning and platform generation and forms the frames on which the research trials and activities are developed.

Through discussions with FREG members in the two districts, 10 major parameters were identified and weighted based on importance and sensitivity for selection and preferences before and after harvesting. Germination, vegetative and seed setting performance as well as earliness, disease resistance, color, grain yield, stalk yield, marketability and water allotment (*Wuhamansat*) were the identified parameters. The weight and necessity of each parameter varied across locations due to the slight difference in livelihood and cultural make up of communities in the two districts.

Post-harvest data was collected only from host farmers and their spouses; these include grain yield, stalk yield, marketability and water allotment of the varieties. The host farmers and group members gave value/score for each parameter based on their social realities. Once farmers gave value for each parameter from 10 points, the researcher summed up values of each parameter and converted it to percent (100%) to weight each parameter's share from the total.

The pair-wise ranking method was used to analyze the position of each variety in each district and weighted ranking matrix table was constructed. Members were asked to compare and contrast each variety with the other to assign values based on identified parameters and the same procedure was repeated for all varieties. By counting the number of times each variety was chosen by each individual farmer and group, the aggregation was made to put scores for each variety. These aggregated scores multiplied by weight and the result obtained from multiplication summed up to represent the rank and position of the varieties in each district (Russell, 1997).

Grain and stalk yield was expressed in ton[1]/ha simply by converting the local units of measurement used to collect data which were *quintals* and *shekim*. The partial budget analysis was calculated to show the effect of changes in farm operations (costs and benefits) of various treatments. Hence, economic advantage of varieties across treatments was evaluated. The MRR of one treatment to the other was calculated using MRR ratio formula:

$$MRR = \frac{\Delta NB}{\Delta TVC} \times 100$$

Where:

MRR = marginal rate of return,

ΔNB = change in net benefits, and

ΔTVC = change in total variable input costs.

The minimum return which farmers expect to earn from a technology called acceptable minimum rate of return (AMRR) was set to be between 50 and 100% because the technology packages are new to the farmers and requires that they learn some new skills; hence 100% AMRR was taken as a reasonable estimate (CIMMYT, 1998). All costs and benefits were valued in monetary terms calculated at the farm get prices. Finally, yield and yield components as well as other preference parameters were analyzed in descriptive and inferential statistics like mean, percentage and ANOVA tables using SPSS (version-16) software.

Results and Discussions

Yield and yield component performance

Yield was the major variable that determines the adoption /non-adoption status of new technologies. As shown in Table 1, the total grain yield of sorghum was varied among varieties. The highest mean yield in Sekota (Aybra) was observed on ESH-1 hybrid sorghum variety (3.23 t/ha). In contrast, in Abergele (Marnet), the highest mean yield was from ESH-2 variety (2.84 t/ha) (see table in Annex). However, a significant yield variation among similar verities across districts was observed due to agro ecological differences of the two districts; where Sekota has relatively deep and fertile soil than Abergele which is characterized as degraded, shallow, low fertile and warmer. On the other hand, the productivity of both hybrid sorghum varieties was better than the local variety within similar agro ecology in both districts. Therefore, ESH-1 variety had a yield advantage of 17.5% and 41.1%, respectively from LIM and LFP in Aybra. Similarly, ESH-2 had 47.2% and 151.3% yield advantage over LIM and LFP in Marnet, respectively. Besides, ESH-1 had highest mean stalk yield of 5.43 t/ha and 6.1 t/ha for Ayibra and Marnet trial kebeles, respectively. Moreover, the ANOVA (Tukey-HSD)

[1] 1 ton = 10 quintal (1 quintal = 100kg) of grain yield; 1 ton = 40 tie *(Shekim)* = 25 kg of stalk yield

test result shows that there is statistically significant difference in mean grain and stalk yields between treatments in both districts at 10% or lower significant level (Table 1 and 2).

Days to maturity

With respect to days to maturity, the analysis shows that both hybrid varieties in both districts had shorter days than the local varieties but the difference is insignificant between hybrid varieties. At the same time, local varieties had similar maturity date in Aybra. But the difference was significant between different treatments of local variety in Marinet. Farmers justified that the variation was due to the improved management; particularly the effect of tie-ridgingtook the lion share, as if it conserves better moisture than the locally treated plot. The ANOVA (Tukey-HSD) test also indicated that there is statistically significant difference at less than 5% significant level in maturity days between treatments in both districts (Table 1and 2).

Table 1. ANOVA test on differences in grain yield, stalk yield and maturity days across sites

Parameters	Source of variation	Aybra					Marnet				
		Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.
Grain yield (t/ha)	Treatments	15.135	3	5.045	48.24	.000	10.504	3	3.501	93.32	.000
	Errors	2.092	20	.105			.750	20	.038		
	Total	17.226	23				11.255	23			
Stalk yield (t/ha)	Treatments	10.818	3	3.606	2.82	.065	28.471	3	9.490	4.732	.012
	Errors	25.591	20	1.280			40.115	20	2.006		
	Total	36.409	23				68.586	23			
Days of maturity	Treatments	12195.125	3	4065.04	1.991E3	.000	11445.50	3	3815.167	1.117E3	.000
	Errors	40.833	20	2.042			68.333	20	3.417		
	Total	12235.958	23				11513.83	23			

Table 2. Tukey-HSD test to identify best performing varieties in grain yield; stalk yield and maturity days across sites

Parameters	Pair of varieties	Aybra			Marnet		
		Mean Difference	Std. Error	Tukey-HSD Sig.	Mean Difference	Std. Error	Tukey-HSD Sig.
Grain yield (t/ha)	ESH1 – ESH2	.4167	.1867	.149	-.2333	.1118	.192
	ESH1 – LIM	.4833*	.1867	.076	.6750***	.1118	.000
	ESH1 – LFP	2.0833***	.1867	.000	1.4667***	.1118	.000
	ESH2 – LIM	.0667	.1867	.984	.9083***	.1118	.000
	ESH2 – LFP	1.6667***	.1867	.000	1.7000***	.1118	.000
	LIM – LFP	1.6000***	.1867	.000	.7917***	.1118	.000
Stalk yield (t/ha)	ESH1 – ESH2	.633	.653	.768	-2.300**	.818	.049
	ESH1 – LIM	.322	.653	.960	-.400	.818	.961
	ESH1 – LFP	1.780*	.653	.058	.617	.818	.874
	ESH2 – LIM	-.312	.653	.963	1.900	.818	.126
	ESH2 – LFP	1.147	.653	.323	2.917***	.818	.010
	LIM – LFP	1.458	.653	.148	1.017	.818	.608
Days of maturity	ESH1 – ESH2	-.167	.825	.997	.500	1.067	.965
	ESH1 – LIM	-45.167***	.825	.000	-44.000***	1.067	.000
	ESH1 – LFP	-45.167***	.825	.000	-42.833***	1.067	.000
	ESH2 – LIM	-45.000***	.825	.000	-44.500***	1.067	.000
	ESH2 – LFP	-45.000***	.825	.000	-43.333***	1.067	.000
	LIM – LFP	.000	.825	1.000	1.167	1.067	.698

Note that *, ** and *** imply significance levels at 10, 5 and 1% respectively

Farmers' variety preference criteria

In Sekota (Aybra) district, farmers identified eight main parameters to select their best variety from others; these parameters were valued and weighted based on their importance and sensitivity. The value of each parameter was converted into 100% to obtain the single parameter's share from the total. The conversion of each value was as follows: Seed setting performance (value = 8, weight = 16% = 0.16), Disease resistance (value = 8, weight = 16% =0.16), Earliness (value = 7, weight = 14% = 0.14), Grain yield (value = 10, weight = 20% = 0.20), water allotment *(wuhamansat)* (value = 5, weight = 10% = 0.10), marketability (value = 4, weight = 8% = 0.08), color (value = 4, weight = 8% = 0.08) and stalk yield (value = 4, weight = 8% = 0.08). The result of weighted matrix ranking analysis shows that a variety which has greater percentage share from the total weight was picked as their first choice. Therefore, in Aybra, farmers preferred ESH-1 primarily in all parameters with the percentage of 40.7% from the total weight. However, they did not compare disease resistance capacity of varieties as there was no disease score in the production year and the matrix shows equal score*weight product. ESH-1 as compact head and the remaining are lose headed varieties.

Moreover, marketability of ESH-1 was extremely higher than the local and ESH-2 varieties, because of its quality and white color. Among the hybrid varieties, ESH-2 has more ear sheath (covers) which reduces the price. Mostly farmers consider white seed color as best quality for food and price. But, the local variety had the least value according to most criteria set by farmers. From overall results of farmers' assessment, ESH-2 took the second place after variety ESH-1 (Table 2).

Meanwhile, in Abergele (Mamet) district farmers indicated that there were dissimilarities in selection parameters both in type and values assigned to evaluate the treatments. This is due to variance in livelihood and cultural make up of communities in the two districts. Vegetative performance was also equally evaluated with earliness, disease resistance and seed setting performance since they gave high credit for sorghum stalk and leafs in order to have a lot of stalk concentration for their livestock. Thus, the conversion of each value was as follows: Seed setting performance (value = 6 weight = 12% = 0.12), Disease resistance (value = 6 weight = 12% = 0.12), Earliness (value = 6 weight = 12% = 0.12), Grain yield (value= 8 weight = 16% = 0.16), *wuhamansat* (value = 5 weight = 10% = 0.10), vegetative performance (value = 6 weight = 12% = 0.12) , germination performance (value = 5 weight = 10% = 0.10) and stalk yield (value = 8 weight = 16% = 0.16).

In this study district, most of the members had the same interest on improved variety ESH-2 based on higher grain and straw yield than other varieties (Table 3). The general indication is that farmers preferred ESH-2 improved hybrid technology mainly to solve their livestock's feed shortage problem. Therefore, this variety has played significant role to fill the feed shortage and concentration gaps. Moreover, in both districts, varieties (ESH-1) and (ESH-2) were selected as the first and the second

ranks due to the following merits; both varieties have good seed setting performance, high grain and stalk yield, relatively better *wuhamansat* and very short maturity date. On the other hand, local variety had hardly been selected by farmers in both experimental districts due to its poor seed setting performance, long maturity date and low grain and stalk yield. The performance of LFP was poor in all areas this is probably resulting from poor input and package usage as the land is cultivated for many years without rehabilitating and zero treatment.

Table 3: Summary of farmers' evaluation criteria and preference ranking among hybrid sorghum varieties in Aybra and Marnet

Weighted parameters		Sekota (Aybra)				Abergele (Marinet)			
		ESH-1	ESH-2	LIM	LFP	ESH-1	ESH-2	LIM	LFP
Seed setting performance	Score	3.00	2.00	1.00	0.00	2.00	3.00	1.00	0.00
	Weight	0.16	0.16	0.16	0.16	0.12	0.12	0.12	0.12
	Score *weight	0.48	0.32	0.16	0.00	0.24	0.36	0.12	0.00
Earliness	Score	3.00	2.00	1.00	0.00	2.00	3.00	1.00	0.00
	Weight	0.14	0.14	0.14	0.14	0.12	0.12	0.12	0.12
	Score *weight	0.42	0.28	0.14	0.00	0.24	0.36	0.12	0.00
Grain yield	Score	3.00	2.00	1.00	0.00	2.00	3.00	1.00	0.00
	Weight	0.20	0.20	0.20	0.20	0.16	0.16	0.16	0.16
	Score *weight	0.60	0.40	0.20	0.00	0.32	0.48	0.16	0.00
Water allotment *(Wuhamansat)*	Score	2.00	2.00	1.00	1.00	2.00	2.00	1.00	1.00
	Weight	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	Score*weigh	0.20	0.20	0.10	0.10	0.20	0.20	0.10	0.10
Resistance to diseases	Score	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	Weight	0.16	0.16	0.16	0.16	0.12	0.12	0.12	0.12
	Score *weight	0.48	0.48	0.48	0.48	0.36	0.36	0.36	0.36
Color	Score	3.00	2.00	1.00	1.00				
	Weight	0.08	0.08	0.08	0.08				
	Score*weight	0.24	0.16	0.08	0.08				
Stalk yield	Score	3.00	1.00	2.00	0.00	1.00	3.00	2.00	0.00
	Weight	0.08	0.08	0.08	0.08	0.16	0.16	0.16	0.16

	Score*weight	0.24	0.08	0.16	0.00	0.16	0.48	0.32	0.00
Germination performance	Score					2.00	3.00	1.00	0.00
	Weight					0.10	0.10	0.10	0.10
	Score*weight					0.20	0.30	0.10	0.00
Vegetative performance	Score					1.00	3.00	2.00	0.00
	Weight					0.12	0.12	0.12	0.12
	Score*weight					0.12	0.36	0.24	0.00
Marketability	Score	3.00	2.00	1.00	1.00				
	Weight	0.08	0.08	0.08	0.08				
	Score*weight	0.24	0.16	0.08	0.08				
Sum $\sum_i (s * w)$		2.90	2.08	1.40	0.74	1.52	2.42	1.18	0.46
Percentages (%)		40.7	29.2	19.7	10.4	27.2	43.4	21.1	8.30
Rank		**1.00**	**2.00**	**3.00**	**4.00**	**2.00**	**1.00**	**3.00**	**4.00**

Ranks: 1= Best; 2= fair; 3= worst 4= not selected. The score represents farmer's comparison results. The score multiplied by the weight to provide degree of preference for each variety considering varied parameters.

Partial budget analysis

The term "partial budget" is a reminder that not all production costs are included in the budget, rather costs that vary between alternative treatments. Expenditures which are similar to treatments (costs that are not varied) will not be taken and analyzed. This is termed as "citrus paribus" other things remain unchanged. Hence, for this study all costs that vary across treatments and the benefits obtained were taken and considered. While, the process of rejecting dominated treatments[2] from further analysis is called dominance analysis. Hence for this experiment, treatment LIM and ESH-2 were rejected due to lower net benefit than ESH-1 at higher and similar total variable input cost, respectively in Aybra. Similarly, treatments LIM and ESH-1 were excluded due to lower net benefit than ESH-2 at higher and similar total variable input cost, respectively in Marinet.

Accordingly, the experiment indicated that marginal rate of return shows that for every ETB 1.00 invested in improved hybrid variety (the marginal rate of return for changing the variety from local to ESH-1 at same improved management), farmers can expect to recover the ETB 1.00 and obtain an additional ETB 4.29 in Sekota district. On the other hand, at Abergele district, for every ETB 1.00

[2] A dominated treatment which has the lowest net benefit than other treatments within the same or higher total variable input cost.

invested in improved hybrid variety (the marginal rate of return for changing the variety from local to ESH-2 at same improved management), farmers can expect to recover the ETB 1.00 and obtain an additional ETB 5.38 (Table 5).

Field day and promotion

At the end of the trial, field days were organized by Sekota Dry Land Agricultural Research Center in collaboration with district offices of Agriculture and NGO (HELVETAS). The participants were model farmers, development agents (DAs), farmers from the trial kebeles, experts and administrative officials from the seven districts of Waghimra zone. A total of 399 (118 female) participants visited the trial in Aybra and favored ESH-1 variety for its seed yield and earliness than the other varieties. Likewise, 75 (25 female) participants visited the trials in Marnet and preferred ESH-2 variety mainly for its stalk yield.

Table 4. Partial Budget Analysis

Cost/Benefit items	Sekota (Aybra)				Abergele (Marnet)			
	ESH-1	ESH-2	LIM	LFP	ESH-1	ESH-2	LIM	LFP
Average grain yield (t/ha)	3.230	2.82	2.75	1.15	2.6	2.84	1.93	1.13
Adjusted grain yield by 10 % (t/ha)	2.880	2.54	2.48	1.04	2.34	2.56	1.76	1.02
Average grain farm gate price (ETB/ton)	7080	7080	7080	7080	5200	5200	5200	5200
Average stalk yield (t/ha)	5.430	4.80	5.10	3.70	3.8	6.1	4.2	3.20
Adjusted stalk yield by 10 % (ton/ha)	4.890	4.32	4.59	3.33	3.42	5.49	3.78	2.88
Average farm gate price of stalk (ETB/t)	806.8	806.8	806.8	806.8	773.2	773.2	773.2	773.2
Gross benefits from grain yield (ETB/ha)	20390.4	17983.2	17558.4	7363.2	12168	13312	9152	5304
Gross benefits from stalk yield (ETB/ ha)	3945.3	3485.4	3703.2	2686. 6	2644.4	4244.9	2922.7	2226.8
A = Total Gross benefits (ETB/ha)	24335.7	21468.6	21261.6	7363.2	14812.4	17556.9	12074.7	7530.
Cost of improved /local seed (ETB b/ha)	150.0	150.0	80.0	160.0	200.0	200.0	100	200
Labor cost for row / broadcast (ETB /ha)	272	272	272	12.9	337.5	337.5	337.5	155
Cost of DAP/ N fertilizer (ETB/ha)	1787.8	1787.8	1787.8	0.00	1787.8	1787.8	1787.8	0.00
Labor cost for fertilizer application, tie ridging and *shilshalo* (ETB/ha)	1622	1622	1622	783	2421	2421	2421	975
B = Total costs that vary (ETB/ha)	3831.8	3831.8	3761.8	955.9	4746.3	4746.3	4646.3	1330
A-B= Net benefits (ETB/ha)	20503.9	17636.8	17499.8	6407.3	10066.1	12810.6	7428.4	6200.8

ETB, Ethiopian birr

Table 5. Dominance analysis of treatments

Treatments (sowing, fertilizer, moisture)		Sekota (Aybra)			Abergele (Marnet)		
		TC (ETB/ha)	NB (ETB /ha)	MRR	TC (ETB/ha)	NB (ETB/ha)	MRR
ESH-1	Improved (in row, fertilized, tie ridged)	3831.8	20503.9	42.92	4746.3	10066.1	**D**
ESH-2	Improved (in row, fertilized, tie ridged)	3831.8	17636.8	**D**	4746.3	12810.6	53.82
LIM	Local (in row, fertilized, tie ridged)	3761.8	17499.8	3.95	4646.3	7428.40	0.37
LFP	Local (in broadcast, zero fertilizer, shilshalo	955.9	6407.3	R	1330	6200.8	R

Note: "*Shilshalo*" means local moisture conservation technique, "D" means dominated and "R" means Rejected. TC, NB and MRR stand for total variable costs, net benefit and marginal rate of return, respectively.

Conclusion and Recommendations

To this end, the study basically focused on participatory evaluation of preferences to create demand driven promotion of improved hybrid sorghum technologies in Sekota (Aybra) and Abergele (Marnet) districts in Eastern Amhara. Hence, two improved hybrid sorghum varieties with their technology packages as well as the local sorghum variety with improved management and farmers practice were used for evaluation. The result indicated that the performance of improved technologies have shown significant variability among treatments. Thus, both hybrid sorghum varieties were found to be by far advantageous than the local check in most farmers' preference parameters: plus the partial budget analysis result showed that the hybrids are economically feasible over the local variety. Moreover, the overall weighted ranking matrix comparison of farmers' preference indicated that varieties ESH-1 and ESH-2 took first and the second places, respectively in Sekota and vice versa in Abergele districts. Therefore, further promotion of the hybrid sorghum technologies in respective districts is strongly recommended and viable seed source should be identified via establishment of seed multiplication cooperatives and/or through provision of pre basic seeds to seed multiplying enterprises.

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Appendix table 1: Analyzed results of grain yield, stalk yield and maturity date across verities in f Aybra and Marnet sites

Plot No.	Sekota (Aybra)												Abergele (Marnet)											
	Grain yield (t/ha)				Stalk yield (t/ha)				Days to maturity				Grain yield (t/ha)				Stalk yield (t/ha)				Days to maturity			
	ESH-1	ESH-2	LIM	LFP	ESH-1	ESH-2	LIM	FP	ESH-1	ESH-2	LIM	LFP	ESH-1	ESH-2	LIM	LFP	ESH-1	ESH-2	LIM	LFP	ESH-1	ESH-2	LIM	LFP
1	3.1	2.8	2.9	1.6	5.0	4.38	3.8	2.5	91	92	137	138	2.7	2.9	2.0	1.2	2.5	6.3	2.5	5.0	93	95	138	132
2	3.2	2.8	2.6	1.5	6.3	5.63	7.5	5.0	92	90	138	137	2.8	3.0	2.2	1.0	5.0	5.0	2.5	3.8	92	90	137	135
3	3.0	3.0	3.0	1.0	3.8	5.0	4.38	5.0	91	91	136	136	2.7	2.85	2.0	1.1	3.8	5.0	2.5	1.3	96	91	136	136
4	3.4	2.2	2.0	1.0	7.5	5.0	5.0	3.8	91	92	133	133	2.6	2.7	1.85	1.2	5.0	7.5	7.5	2.5	91	92	133	135
5	3.4	3.3	3.0	1.0	5.63	3.8	5.0	3.13	90	92	138	136	2.6	2.75	1.4	1.0	3.8	6.3	5.0	2.5	90	92	136	137
6	3.3	2.8	3.0	0.8	4.38	5.0	5.0	2.5	92	91	136	138	2.2	2.8	2.1	1.3	2.5	6.3	5.0	3.8	92	91	138	136
Mean	**3.23**	**2.82**	**2.75**	**1.15**	**5.43**	**4.8**	**5.1**	**3.7**	**91.2**	**91.3**	**136**	**136**	**2.6**	**2.84**	**1.93**	**1.13**	**3.8**	**6.1**	**4.2**	**3.2**	**92.3**	**91.8**	**136.3**	**135.2**

Participatory Evaluation of Improved Linseed Varieties with their Production Packages in North ShewaZone, Ethiopia

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Abstract

This study aims to select the best performing variety of linseed among the alternatives in terms of farmers' selection criteria, yield and other agronomic parameters following an approach of participatory variety selection (PVS). The yield and farmers preferences were studied including farmers selection crieteria set by the farmers' research group and other agronomic data were collected. Two improved and promising varieties of linseed together with one local cultivar were evaluated at Andit Tid watershed in Northshoa highlands, Bassonawerana district. Limited access for improved varieties of linseed and low productivity of the local variety were the main production constraints in the area. The experiment was designed in simple random plot design in five locations farmers as replication with a plot size of 25m² per location per plot consisting of three linseed varieties in 2014 during main cropping season using rain fed production system. Based on farmers selection criteria genotypes were scored using direct ranking method. Yield and other agronomic traits were estimated and the variety was selected based on the data collected and analysed. The highest yield was observed from Kulumsa variety, while the lowest yield was recorded from the local genotype. In general, results indicated that there is good scope for crop improvement through participatory varietal selection. Based on farmers' selection criteria Kulumsa variety scored the highest and the local variety scored the lowest preference value. Participatory variety selection (PVS) is the powerful way to involve farmers for selecting and testing elite varieties that are adapted to their specific environment and suit to their needs and systems. Farmers need based technology evaluation will be done based on participatory approach. The selected varieties will be scaled up for further technology dissemination and production improvement of linseed. Delivery of seed of the selected variety will enhance research and farmers linkage for similar technology interventions.

Key words: Linseed, farmers' selection criteria, participatory varietal selection and yield.

Introduction

Linseed (*Linum usitatissimum* L.) is a traditional crop in Ethiopia and the second most important oil crop in production after noug (*Guizotia abyssinica* CASS) in the higher altitudes of the country (Adugna and Adefris, 1995). In Ethiopia, small-scale farmers have been producing linseed without applying any chemicals (fertilizers, herbicides, pesticides) and with a minimum level of other inputs (Adugna, 2000). Linseed is a member of the Linaceae family which has 14 genera and about 150 species. *Linum usitatissimum* L. is the only economically important cultivated species. In our country, this crop is usually cultivated in higher elevation areas where frost is a threat for other oil seeds such as noug seed and Ethiopian mustard (*Gomenzer*). Linseed is one of the major oilseeds and a rotation crop for barley in high elevation areas of Arsi, Bale, Gojjam, Gondar, Wollo, Shoa and Wellega (Getinet and Nigussie, 1997).

Ethiopia is the fifth world producer of linseed, where linseed accounts for 13% of its total oilseed production but is negligible as exporter in the world market (Wijnands *et al.*, 2009). In the year 2014, linseed production in Ethiopia covers 95,582.79 ha of land with a total volume of production 879,459.08 quintals. In the same year, among the oil seeds produced in North Shewa where the study area is located, linseed stands first covering 4,383.13 ha of land with an average productivity of about 0.9 tones/ha followed by sesame (CSA, 2014).

Linseed is produced primarily for the purpose of food as well as generating cash income to farmers from selling either in local or export markets (Adefris *et al.*, 1992). This may be the fact that linseed has the following benefits. Linseed oil has 45-65% of unique alfa-linolenic fatty acid (an essential omega 3 fatty acid), which has beneficial effects on health and the auto immune system (Moris, 2005). Studies indicated that Alpha-linolenic has anti-hypercholesterolemia and anti-carcinogenic effects and is important for the normal development of brain and retinal tissues of infants (Cunnane *et al.*, 1995). Linseed is particularly consumed during fasting days, when animal products (milk, butter, cheese, egg and meat) are not eaten by Orthodox Christians in Ethiopia. The seeds are usually roasted, grounded and mixed with spices and some water to be served along with different local breads. It is also consumed in various forms such as, soups, soft drinks and with porridges, cooked potatoes, etc. Hence, linseed has been cultivated in Ethiopia for its seed and oil, but its use as a fiber crop is very limited (Adugna *et al.*, 2004).

It has also a lot of unsaturated fats as well as mucilage. The presence of these compounds in the plant turns the linseed into a highly valued remedy especially for treating many of the intestinal and chest conditions. Hence, linseed is currently becoming popular worldwide for its functional food products. Indeed, people in some countries like Ethiopia, India and China have traditionally consumed linseed and appreciated it for various medicinal values since ancient times (Seegler, 1998).

It is noted for the high quality dying oil produced in its seed. The high content of α-linolenic acid in linseed oil makes it industrially attractive for manufacturing paints, stains, inks, lacquers, varnishes, linoleum, etc. However, this character of linolenic acid that readily oxidizes and produces off-flavor (rancidity) limited use of linseed oil for edible purposes, particularly for cooking oil. In order to overcome this problem, "Linola" and "Solin" edible oil cultivars were developed in Australia and Canada, respectively (Adugna *et al.*, 2004). It is reported that the content of linolenic acid reduced to about 2%, while the level of other fatty acids remained constant. They argued that such achievements will help to expand market opportunities and uses of linseed globally.

Plant breeders, however, invariably encounter genetic and environment interactions when testing crop varieties across a number of environments. Depending upon the magnitude of interactions or the differential genotypic responses to environments, the varietal rankings can differ greatly across environments. In Ethiopia, although research on linseed crop was commenced in early 1960s at the then Debrezeit Research Station, a systematic research was initiated during 1970s leading to release high yielding and disease resistant improved varieties in the 1980's (Adefris *et al.*, 1992). Since there exists genetic variability across various agronomic traits, breeders have exerted much efforts to develop promising linseed varieties and hence released many varieties for production so far. These varieties would have wide adaptability and higher yield potential compared to the local cultivars.

Since 2007/08, Deber Birhan Agricultural Research Center have conducted adaptation trials in the high land areas of North Shewaand recommended improved linseed varieties for these agro-ecologies. The purpose of this study is, therefore, to select the most promising varieties among those recommended linseed technologies following the PVS approach, a powerful way to involve farmers in selecting and testing elite varieties that are adapted to their needs, systems and environments (Yetsedaw *et al.*, 2013). It specifically aims to evaluate disease resistant and high yielding varieties and thereby demonstrate selected early maturing, disease resistant and high yielding linseed varieties in major growing areas.

Objectives

General objective:

- To increase farmers' awareness, and accelerate the rate of technology expansion;

Specific objectives:

- To create wider demand on linseed production technologies;
- To strengthen linkage among the possible actors on linseed technology transfer;
- To enhance linseed production and dissemination system and improve its productivity;

Materials and Methods

Prior to conducting the experiment multidisciplinary team of researchers was established to evaluate the production constraints and farmers need on production of linseed. Constraints of linseed production and its potential in the area were identified. The activity was planned to catchup the production constraints and to satisfy farmers needs. The experiment was conducted in the high lands of North-Shoa areas of Bassonawerana district in Anditid watershed during main cropping season of 2014/15 under rain fed condition.

These sites are known to be suitable for linseed production and selected purposively based on its potential and farmers limited access to have limited alternative crop that suits their farm lands. The experiment was done using two improved varieties namely; Belay-96, Kulumsa and local checks. The experiment was conducted in five locations on different farmers' fields in simple random plot design. Farmers were set as replications for all varieties with a 5m*5m plot size for each variety at each farmers plot. Seed rate and fertilizer rate was applied based on agronomic recommendations. Both theoretical and practical trainings were given for both host and follower farmers and development agents about linseed production and agronomic practices applied to be implemented for linseed production and participatory evaluation of linseed technologies. The experiment was conducted based on cost sharing approaches of delivery for production resources. Land and labour were supplied by the host farmers whereas seed and technical support were delivered by the researchers and development agents.

Both yield and farmers' preference data were collected at different growing stages. Host farmers and followers were organized as a farmer's research group to provide organized feedback about the technologies and to enable group learning among the farmers. Those organized farmers of both hosted and followers were participated during the implementation periods and evaluation of the varieties. Farmers' preference data were analyzed using direct matrix methods. Hosted farmers were agreed to deliver their lands for demonstration purposes freely. Yield data was collected from each location for all varieties and farmers' selection criteria was set and varieties were evaluated based on the farmers selection criteria set to evaluate and select the most productive variety that suits to their needs.

Results and Discussions

The local variety produced in the study area has a character of long maturity, low yielding and many branches lacking uniform maturity. As a result, farmers become disappointed to produce linseed. These technologies were evaluated by the participatory research approaches of farmers and researchers team. Following the participatory variety selection approach, the farmers group together with development agents was invited to evaluate the performance of improved varieties verses the

local check based on the identified selection criteria set by the farmers group with the help of researchers and extension agents during evaluation.

First, the five locations were evaluated by the group of farmers and researchers to select three most appropriate locations for further evaluation. After site selection farmers variety selection criteria, comprising of tillering, branch number, pod number, earliness, plant height and seed size, were set to compare the performance of the improved varieties of (Kulumsa and Beley 96) with local against each selection criteria. The farmers also attempted to evaluate these varieties based on yield parameter independently, considering it is the most important factor for technology choice. As depicted in (Table 1), farmers preferred Kulumsa variety as the most promising one compared to Belay 96 and local varieties based on the first six factors of the farmers' selection criteria. The selection criteria were set to evaluate the candidate varieties as value level of 1=best, 2= medium and 3= poor

Table 1. Farmers' selection criteria and evaluation results

Selection criteria	Varieties and their selection rank		
	Local	Kulumsa	Belay-96
Number of tillers	1	3	2
Branch	3	1	2
Pod number	3	1	2
Earliness	3	1	2
Height	3	1	2
Seed size	3	1	2
Over all rank	**3rd**	**1st**	**2nd**

The farmers' selection was conceded on the same variety of Kulumsa with the yield data obtained after harvesting (Table 2). Farmers reported that their farm lands are much degraded and the soil nutrients are depleted due to soil erosion and cultivation without nutrient replacement using improved soil management practices. The land has been cultivated for so many years and become degraded thereby reducing the productivity of their land. They usually practiced fallowing production system in every other year. They found that linseed is the best alternative crop next to potato to fit on every other year production and crop rotation purposes instead of fallowing their lands. This will enhance the overall productivity of farmers. *Kulumsa* was the selected variety both in farmers' preferences and yield data that will be further designed for up-scaling activities to reach the wider community.

Table 2. Yield of the Linseed varieties

Varieties	Average yield Kg/ Plot	Average yield Kg/ hat
Belay 96	2.9	1160
Kulumsa	3.3	1320
Local	2.5	1000
Mean	2.9	1160

Conclusion and Recommendations

Conclusion

Linseed is the most appropriate crop produced in the highland areas and other similar agro ecologies. Smallholder farmers' household income and food security can be increased and ensured when improved varieties are used. Limited access for improved varieties of linseed and low productivity of the local variety are the main limiting factors hindering small holder farmers livelihood improvement. Access to trainings for proper production of linseed and organized feedback about the production constraints for the researchers provides the room to access and strengthen farmers and researchers learning room. The varieties were evaluated against the local checks with productivity, disease resistance and early maturity in the highland areas. Based on these farmers' selection criteria and the actual yield data, Kulumsa variety was selected for large scale production in the intervention area.

Recommendations

Further expansion of the selected variety is essential to improve production and productivity of linseed for similar agro ecologies. Kulumsa is the most appropriate variety that suits to farmers need; it is selected by the farmers because of its high yielding, short maturing and disease resistance traits. Delivery of seed of such variety to farmers is essential for large scale production in the intervention area.

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Demonstration of faba bean response to fertilizer and inoculants application in western Amhara Region, Ethiopia

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Abstract

The trial was conducted in Yilmana Densa and Farta districts of Amhara Region, Ethiopia in 2014/15 cropping season with the objectives of evaluating the performance of improved faba bean (Vicia faba L.) varieties with Phosphorus fertilizer and bio- inoculants under on-farm conditions so as to improve food security of the farming community. The treatments were faba bean intercropped with field pea (Pisum sativum L.) without any input; faba bean intercropped with field pea with phosphorus fertilizer and bio-inoculants; faba bean without input; and faba bean with phosphorus fertilizer and bio-inoculants at Farta district; while the treatments were faba bean without input and faba bean with phosphorus fertilizer and bio-inoculants at Yilmanadensa district. The trial was conducted on sixteen host farmers' fields on 10 meter by 10 meter plot size per treatment. DAP Phosphorus fertilizer at the rate of 100 kg/ha and bio-inoculants strain called FB-EAL-110 at the rate of 500 gram per hectare were applied at planting for the treatments with inputs. Host farmers were participated in the whole process of the trial from land preparation to harvesting and were able to evaluate the treatments based on their own selection criteria. Field days were organized to create wider demand by farmers, experts and officials for further promotion in the next season. Maximum mean grain yield of faba bean was obtained from faba bean alone with phosphorus fertilizer and bio-inoculants treatment at Farta and Yilmanadensa districts (26.59 qt/ha and 13.36 qt/ha), respectively. Moreover, this treatment was preferred by farmers in both locations. For the intercropped treatments, the land equivalent ratio (LER) value for faba bean with inputs and faba bean without inputs was 1.18 and 1.12 respectively that shows intercropping faba bean with field pea is feasible since LER is more than unity. The partial budget analysis indicated that, faba bean with treatment has a Marginal Rate of Return (MRR) of 0.2103, i.e. a farmer could generate 0.21 Ethiopian Birr (ETB) more by investing 1 ETB per unit. It can be concluded that, faba bean with inputs (application of phosphorus fertilizer and bio-inoculants) gave the highest yield and thus it was preferred by farming communities. Therefore, faba bean with inputs should be promoted to wider scale production among the farming community to ensure food security.

Key words: Intercropping, Land Equivalent Ratio, Marginal Rate of Return, Nitrogen fixation, Yield, Faba bean

1. Introduction

Faba bean (*Vicia faba* L.) is one of the most important cool season grain legumes in Ethiopia in terms of area overage, total production, foreign exchange earnings and soil amelioration (Amare, 1990). Faba bean contributes to smallholder livelihoods in multiple ways: it can play a significant role in improving smallholders' food security, as an affordable source of protein and other essential nutrients. Faba bean can have an income benefit for smallholders as it yields a higher gross margin than cereals (IFPRI, 2010). Its crop residue is also widely used as animal feed for equines. In addition to improving food and nutritional well-being, Faba bean can improve soil fertility through its ability of fixing atmospheric nitrogen to the soil.

Faba bean is a legume capable of fixing nitrogen in an endosymbiotic association with root nodule bacteria: *Rhizobium leguminosarum* var. *viceae* and it is the most efficient nitrogen fixer of the pulse crops grown (McVicar *et al.*, 2005) so that the amounts of N2-fixed (kg/ha) by faba bean have been 240 to 325 kg ha^{-1} yr^{-1} (Somasegaran and Hoben, 1994). The dual contribution of faba bean as a source of protein for the majority of population, and its capability to fix nitrogen and improve soil fertility has been used in crop rotation and traditional mixed low-in put agricultural systems. Although the most common mineral N-fertilizer source employed in Ethiopia is urea, its prices has tremendously increased and reached to the level that most smallholder farmers often face difficulty to purchase and utilize;consequently the productivity of faba bean and cereal crops are generally far below the potential. On the other hand, Biological N-fixation, the major means of recycling of N in the biosphere, is an economically justifiable and ecologically safe N source to agriculture (Amanuel *et al.*, 2000). These days, there is one private company called Menagesha Biotech Private limited company (PLC) that produces Bio-inoculants usually called inoculants in sachets of 125gm each and distributed for legume producers of smallholder farmers in Ethiopia. Moreover, inoculants are being produced and used at Holetta agricultural research center.

Research on cropping systems in Ethiopia indicated that the improvements in soil fertility from planting wheat after faba bean in rotation can improve grain yield of wheat by more than one ton per hectare and can reduce fertilizer usage for cereals in the next season by up to 60% (Amanuel and Daba, 2006). Different research works made in recent years revealed that inoculation of Faba bean with R. leguminosarum can increase yield by 10 to 50% (Abere *et al.*, 2009). However, as most of the research works on faba bean with bio-inoculants were conducted in the controlled conditions in green houses, farmers have no awareness about the existence of such technology to utilize. Therefore, this study was conducted with the objectives of evaluating the performance of improved faba bean alone and intercropped with field pea (*Pisum sativum* L.) and applying Phosphorus (P) fertilizer and bio-fertilizer under on-farm conditions while introducing such a technology package to farmers thereby paving the way for wider adoption.

Objectives

- To demonstrate faba bean varieties and their response to Phosphorus fertilizer and bio- inoculants, and
- To assess farmers technology preference and enhance demand driven technology dissemination in order to improved food security of the farming community;

2. Materials and Methods

2.1 Area description

The trial was conducted at Yilmana Densa district in west Gojjam Zone and Farta district in South Gonder zone of the Amhara National Regional State, Ethiopia in the 2014/15 main cropping season on 16 host farmers' field.

Yilmana Densa district: It is one of the districts in the Amhara region of Ethiopia and part of the west Gojjam zone located between 11^0 16' 0 North latitude and 37^0 22' 0 East longitudes. The mean maximum temperatures in the district ranges from 22.3 ^{0}c in August to 29 ^{0}c in March while the mean minimum temperatures range from 5.7 ^{0}c in January to 11.6 ^{0}c in June. June to September are the major rainy months while February to May are the hottest months of the year and October to January are the coldest months of the year.

Farta district: The district is located in south Gondar Administrative Zone of the Amhara National Regional State, Ethiopia with total area of 109,925 hectares. Altitudes of the district ranges between 1,500 and 4,135 m.a.s.l. with mean annual rainfall of 1,651 mm. The mean temperature ranges from 4.9 ^{0}c to 18.4 ^{0}c May to October are the major rainy months of the year while February to April are the hottest months of the year and October to January are the coldest months of the year.

2.2 Treatments and agronomic practices

The trial was conducted on sixteen host farmers' fields on 10 meter by 10 meter plot size per treatment. DAP Phosphorus fertilizer at the rate of 100 kg/ha and bio-inoculants strain called FB-EAL-110 at the rate of 500 gram per hectare were applied at planting for the treatments with inputs. The bio-inoculants *Rhizobium sp.* strains used for seed inoculation was obtained from the private company called Menagesha Biotech Private Limited Company (PLC) which is currently the only private company that produces and distributes inoculants in Ethiopia. Fertilizer was applied as banded, 10 cm away from the planting line, in a 2cm deep trench and a spacing of 40 cm by 10 cm between rows and plants respectively was used. *Walki* improved faba bean variety and local field pea were used for the trial. *Walki* improved faba bean variety was released for production by Holetta agricultural research center in 2008 in Ethiopia with productivity of 24-52 qt/ha and 20-42 qt/ha on research and farmers' fields respectively at the time of release (MoARD, 2008).

The treatments were faba bean intercropped with field pea (*Pisum sativum* L.) without any input; faba bean intercropped with field pea with phosphorus fertilizer and bio-inoculants; faba bean without input; and faba bean with phosphorus fertilizer and bio-inoculants at Farta district while they were faba bean without input and faba bean with phosphorus fertilizer and bio-inoculants at Yilmanadensa district (Table 1). Faba bean was intercropped with field pea at Farta district since intercropping is the most common practice of farmers in the district. Intercropping of 75% Faba bean with 25% field pea was used for intercropping treatments since it has been agronomically recommended in Ethiopia (Tolera and Daba, 2008; Amare, 1996).

Table1: Treatment description of the experiment

Treatments at Farta district			**Treatments at Yilmana Densa district**		
Treatments	**DAP**	**Bio-inoculants**	**Treatments**	**DAP**	**Bio-inoculants**
1. Faba bean intercropped with field pea	-	-	1. Faba bean	-	-
2. Faba bean + Field pea	+	+	Faba bean	+	+
3. Faba bean	-	-			
4. Faba bean	+	+			

Note: + means with fertilizer and/or bio-inoculants; and – means without fertilizer and/or bio-inoculants

Before sowing, faba bean seeds of experimental plants were soaked in rhizobia suspension using humble hot water being on tree shade on farmers' field for treatments with bio-inoculants. All crop management and agronomic activities were managed by farmers themselves with close support and supervision from researchers and agricultural experts. Experimental fields were plowed three times. Weeding was done twice at different stages of the plant. Harvesting, threshing and weighing were accomplished for grain yield comparison purposes.

3. Capacity building, monitoring and evaluation and field days

Trainings (to improve knowledge, skill and attitude) and field days (to create wider demand) were organized and feed backs were collected. Moreover, continuous monitoring and evaluation (M and E) of the trials on field was conducted by a team of researchers from different disciplines and agricultural experts. During M and E, application of agronomic practices like proper weeding and crop management issues by farmers and any challenges and constraints were assessed and solutions were suggested immediately on the spot.

4. Results and discussions

4.1. Trainings for capacity building

Training is one of the capacity building methods in extension research to create awareness and improve skill and knowledge of farmers and experts. Computer power point presentations in Amharic language, leaflets and posters in Amharic language, audio visuals, etc were used as a training materials and teaching aids during training sessions. Two trainings were organized at Adet and Bahir Dar towns for 51 persons (19 farmers and 32 agricultural experts) on data management and bio-inoculants application techniques (Table 2). More importantly, practical on-job (on-field) training was given for farmers and experts on bio-inoculants preparation and application techniques by researchers. Couple training approach was used so that both husband and wife were participants of the training.

Table 2: Trainings arranged and number of participants, 2014/15

Location	Contents of the training	Number of trainees			
		Farmers		Experts	
		Male	Female	Male	Female
Adet	Inoculation technique	17	2	4	1
Bahir Dar	Data management	0	0	24	3
	Total	17	2	28	4
		19		**32**	
Total		**51**			

4.2. Field days organized and feedbacks collected

Field day is one of the extension approaches mostly used to create wider demand on the technology under evaluation and demonstration. Therefore, two field days have been organized, one at Farta and one at Yilmana-Densa districts of Amhara Region, Ethiopia. Farmers, district and zonal agricultural experts and development agents (DAs) were field day participants and a total of 133 persons (60 male and 5 female farmers and 59 male and 9 female experts) participated in the field day (Table 3). Moreover, continuous monitoring and evaluation (M and E) was carried out in both districts for smooth functioning of the activity.

Farmers actively participated during field days and raised important questions about improved faba bean variety and bio-inoculants where as respective researchers replied and clarified questions and comments raised. Based on this, farmers characterized the faba bean alone with inputs (DAP fertilizer and bio-inoculants) plot as long plant height, long pod length, full pod setting, and less disease

occurrence while they characterized the faba bean alone without inputs plot as medium plant height, less pod setting potential and high disease occurrence. On the other hand, farmers characterized the faba bean intercropped with field pea and with inputs plot as long plant height and vigours but has less pod numbers due to competition and lack of sunlight (due to dens population of faba bean and field pea). The comment given for the faba bean intercropped with field pea and without inputs is the same as that of intercropped with field pea and with inputs plot.

Agricultural experts suggested that, there should be a kind of survey work on faba bean disease (faba bean gall disease or *Kormed/Kortim* in local language, *Amharic*) occurrence because the disease incidence varies according to soil fertility, precursor crop history and slope conditions of the area. According to Endale *et al.*, 2014, faba bean is threatening by new gall forming disease with typical symptoms of green and sunken on the upper side of the leaf and bulged to the back side of the leaf, and finally develops light brownish color lesion, chlorotic galls, and progressively broaden to become circular or elliptical uneven spots. Moreover, village based faba bean seed grower groups should be established to make the seed system sustainable and make seed locally available for farmers since there is no improved seed supplier of faba bean.

Table 3: Field days organized and number *of participants for faba bean demonstration, 2014/15*

Location	Participants			
	Farmers		Experts	
	Male	Female	Male	Female
Yilmana Densa	35	0	18	5
Farta	25	5	41	4
M and E at both districts	Team of researches			
	60	5	59	9
Total	**65**		**68**	
		133		

Fig.1. Faba bean crop at early crop stage (A), farmers evaluating faba bean demonstration plots (B), faba bean root nodules due to inoculation (C) and practical on-farm training about inoculation for farmers and experts (D), Yilmana- Densa and Farta districts, 2014/15

Fig. 2. Field day events at faba bean demonstration sites (Mass media event and general discussion on future directions and feed back), Farta district, Ethiopia, 2014/15.

4.3. Grain yield at Farta district

Yield of four treatments of faba bean demonstration plots in quintal (one quintal is equivalent to 100kilograms) per hectare (qt/ha) of improved Walki faba bean variety at Tsegur, Atta, Awuzet and Minet kebeles of Farta district is given in Fig. 3. Higher yield was recorded at Atta and Awuzet kebeles (33.6 qt/ha and 33qt/ha, respectively) from faba bean with inputs (fertilizer and bio-inoculants) plot. Generally, a mean faba bean grain yield of 14.97, 15.57, 24.72 and 26.59 qt/ha of faba bean was recorded from faba bean intercropped with field pea and without inputs, faba bean intercropped with field pea with inputs, faba bean alone without inputs and faba bean alone with inputs treatments, respectively (Fig. 3).

From intercropping, a mean grain yield of 5.69 and 7.22 qt/ha of field pea was obtained from faba bean intercropped with field pea with inputs and faba bean intercropped with field pea without inputs treatments, respectively. Faba bean yields from faba bean intercropped with field pea plots are lower than the faba bean alone due to competition and lack of sufficient sunlight among high plant population of intercropping. This was also explained by farmers as 'intercropped plots seem vigours but have less pod numbers due to competition and lack of sunlight" during field evaluation and stated in the field day event.

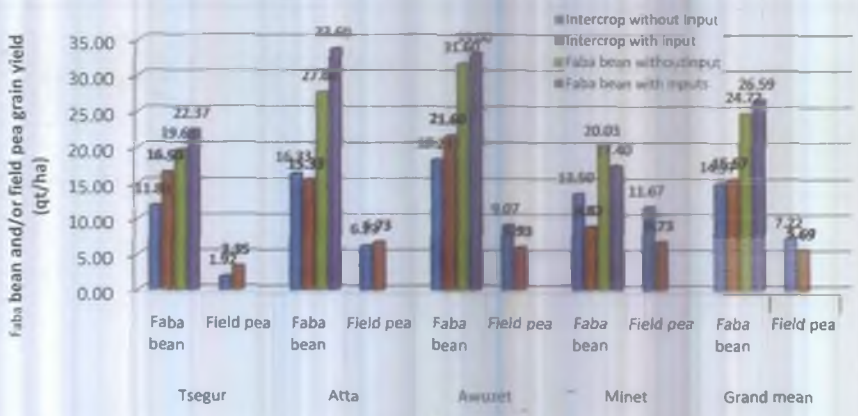

Fig. 3. Faba bean yield (qt/ha) of 4 treatments at Tsegur, Atta, Awuzet and Minet kebeles of Farta district, Ethiopia, 2014/15.

4.4. Land Equivalent ratio (LER)

The productivity of land with intercropping was determined by land equivalent ratio (LER). According to Willey, 1979, the most generally useful single index for expressing the yield advantage is probably the Land Equivalent Ratio (LER), defined as the relative land area required as sole crops to produce the same yields as inter-cropping. It denotes the relative land area under sole crop required to give the same yield as obtained under mixed or an intercropping system at the same level of management. Algebraically LER can be expressed as:

$$LER = (Y_{FI}/Y_{FS}) + (Y_{FpI}/Y_{FpS})$$

Where: Y_{FI} = Yield of faba bean intercropped with field pea (either with inputs or without inputs)

Y_{FS} = Yield faba bean alone (either with inputs or without inputs)

Y_{FpI} = Yield of field pea intercropped with field pea (either with inputs or without inputs)

Y_{FpS} = Yield of field pea sole (CSA, 2015 data of South Gondar zone, Ethiopia)

The land equivalent ratio (LER) value for faba bean with inputs and faba bean without inputs was 1.18 and 1.12 respectively which are more than unity which means that intercropping faba bean with field pea is feasible for both with inputs (fertilizer and inoculants) and without inputs treatments, but higher for faba bean with inputs treatment (Table 5).

Table 5: Mean yield grain of faba bean and field pea and land equivalent ration (LER), Farta district , Ethiopia, 2014/15

Grain yield of (qt/ha)						LER of:		
Faba bean intercrop with inputs	Faba bean intercrop without input	Sole faba bean with inputs	Sole faba bean without inputs	Field pea intercrop with inputs	Field pea intercrop without inputs	Sole Field pea*	Faba bean with inputs	Faba bean without inputs
14.95	15.55	26.6	24.7	7.175	5.675	11.56	**1.18**	**1.12**

***= CSA, 2015, (Field pea yield in qt/ha of South Gonder zone, Ethiopia).**

4.5. Grain yield at Yilmana-Densa District

Faba bean was sown as faba bean alone with inputs (Phosphorus fertilizer and bio-inoculants) and without inputs at Yilmana-Densa district on farmers' fields. On average, a grain yield of 13.36 quintal/ha and 11 quintal/ha was obtained from demonstration plots of inoculated with bio-fertilizer and with non-inoculated, respectively (Fig. 4). The highest faba bean grain yield was obtained at Debremawi kebele from which 15.20 quintal/ha and 17.68 quintal/ha was obtained from faba bean without inputs and faba bean with inputs demonstration plots respectively while the lowest yield of 8.27 qt/ha was obtained among all kebeles at Geregera kebele from faba bean without inputs plot (Fig.4). On the other hand, the lowest faba bean grain yield of 11.02 quintal/ha among with inputs plots was obtained at Adet-Hana kebele.

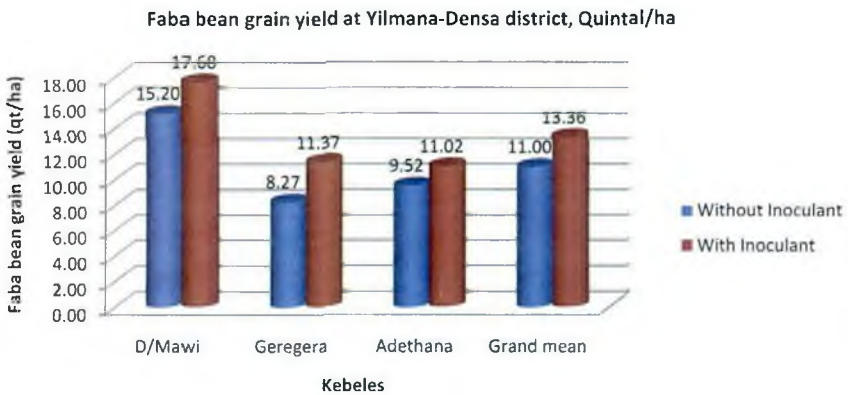

Fig.4. Faba bean grain yield (qt/ha) from 2 treatments at Yilmana-Densa district, 2014/15.

4.6. Partial budget analysis

Partial budget analysis based on CIMMYT 1988 manual was carried out for faba bean with inputs and faba bean without inputs plots by assuming variable costs of 100 kg/ha fertilizer (DAP only) and 500 gm/ha bio-inoculants. The unit cost for fertilizer was taken as 14 Ethiopian Birr (ETB)/kg (1400 ETB/ha) and cost of inoculants/ha was taken as 160 ETB/ha (40 ETB/0.25 ha). The farm gate selling price for faba bean produce was taken as 8 ETB per kg for both treatments.

The result of partial budget analysis indicated that faba bean with inputs (fertilizer and bio-inoculants) treatment has a Marginal Rate of Return (MRR) of 0.2103, i.e. a farmer could generate 0.21 ETB more by investing 1 ETB per unit (a farmer investing 1 ETB would get an additional 0.21 ETB (21 cents) benefit after covering his 1 ETB investment). Faba bean with inputs treatment (plot) had also a yield advantage of 21.45% over the faba bean without inputs treatment (plot) (Table 6).

Table 6: Partial budget analysis for Faba bean with and without inputs production in Yilmana-Densa district, Ethiopia, 2014/15

Treatments	Yield (qt/ha)	Gross benefit (ETB/ha)	Total variable cost (ETB/ha)	Net benefit	Marginal benefit	Marginal cost	MRR	Yield advantage of Faba bean with inputs over without inputs
Sole Faba bean without inputs	11.00	8800	0	88000				2.36 qt
Sole faba bean with inputs	13.36	10688	1560	9128	328	1560	0.2103	21.45%

4.7. Women famers empowerment

One of the main intentions of the demonstration activity in the study area was to empower women farmers in the farming community. Based on this, women farmers were able to participate almost in all parts of the implementation processes of the demonstration activity starting from capacity building to execution as well as post harvest handling. Women farmers were treated equally on capacity building, implementation and decision on product handling. They were active participants especially on bio-inoculants preparation and application, weeding, harvesting, weighing and selling activities. They said that we were unable to produce faba bean for our home consumption which can be consumed as sauce considering it as meat. Faba bean is a cash crop mostly used for sell and now, we learnt through the demonstration process that it can be produced and used for home consumptrion and

for market as well. Therefore, we are ready to produce faba bean in the coming production season (Fig. 5).

Fig.5. Women farmers participation on faba bean demonstration plots during early stages (A); field days (B) and during discussions. 2014/15. Ethiopia

4.8. Main Challenges encountered

Occurrence of sever disease on Faba bean (new disease called faba bean gall or *Kormid/Kortim* in local language, *Amharic*) was one of the main challenges faced (Fig. 5). Low awareness of farmers about Bio-inoculants since it needs care in transporting, storing and using. There was a difficulty in fertilizer application for intercropped plots (which recommended fertilizer to apply, for main crop, faba bean or supplemental crop, field pea, was one of the challenges). Moreover, chemical application for faba bean disease control options (chocolate spot (*Botrytis fabae* Sard.) and faba bean gall disease) versus inoculating faba bean seed need further research since there may be negative interaction as bio-inoculants are living organisms whose efficiency may be affected by chemicals.

Fig. 5. Main challenges (Disease occurrence) on faba bean demonstration plots at Yilmana-Densa and Farta districts, 2014/15.

5. Conclusions and recommendations: The way forward

Walki improved faba bean variety with bio-inoculants gave better yield on farmers' fields and has been accepted by farmers. The demonstration conducted increased the knowledge level of farmers about the technologies of bio-inoculants (bio-inoculants application technique and its uses). It was observed that, Bio-inoculants could increase the productivity of faba bean with lower cost since farmers are reluctant to apply chemical fertilizers especially for legume crops like faba bean.

Therefore, Walki improved faba bean variety with bio- inoculants should be promoted to wider production scale to farmers in the next production season so as to increase production and productivity of faba bean so that food security and income of the farming community will be enhanced.

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Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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A Move from Grain to Seed Business: Enhancing Chickpea Technologies Pre-Scaling Up through Local Producer Cooperatives and Individual Farmers in West and East Belesa Woredas, North Gondar Zone, Amhara Region, Ethiopia

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Abstract

Chickpea is widely grown across the country and serves as a multi-purpose crop. It is the sources of protein, energy, minerals and cash income. Improved seed unavailability at the right place and time coupled with poor promotion system and limited uses of improved seeds are contributing for low agricultural productivity. The objectives of the study were to enhance chickpea production and productivity, to develop functioning chickpea local seed system and to provide need-based agricultural extension support services. Methodologies were followed participatory varieties selection, preparation of inception workshop, area clustering, delivering of training, and organization of farmers' field days. Workshop was held with 26 participants at Arbaya town. After the delivery of training, the seed was sown by 338 (22 women) participant farmers who are direct beneficiaries on 173.89 ha of land with eight clusters. During the field days, a total of 753 farmers and other stakeholders participated. Mass Media from the Ethiopian national television and radio service, Amhara mass media, and Fana broadcasting corporate broadcasted the event. The results obtained include technology package development, increment of chickpea productivity by 100%, about 161 tons of seed was produced, creation of demand on the technology, strengthening of partnership and establishment of two chick pea seed producer cooperatives. Systematic pathway combining starting from participatory chickpea variety selection to demand stimulation and seed production has been established. Therefore, this success story in technology scale up and organized seed production does not end here. Generally, this chickpea technology package scaling out through seed producer cooperatives has shown a promising area for quality seed production. The Research center, the office of agriculture, and the office of cooperatives promotion should support technically and materially to scale out the technologies.

Key words: Chickpea, Technologies, Pre-scale up, Stakeholders, Training, Field day

Introduction

Ethiopia ranks sixth in chickpea production in the world market (Ronner and Giller, 2013). Seed is the basic agricultural input. More importantly, quality seeds of any preferred varieties are the basis of improved agricultural productivity since they respond to farmers needs for both their increasing productivity and crop uses. However, small scale farmers increasingly face many challenges including both biotic and abiotic factors and must respond to market demands. Unavailability of quality seeds at the right place and time coupled with poor promotion system are the key factors accounting for limited use of improved seeds, which further contribute for low agricultural productivity. Local landraces alone do not constitute solution to all these multiple constraints. Therefore, improved and formally bred varieties can contribute to meeting some of those challenges (Pelmer, 2005, and Dawit, 2011).

In Ethiopia, the majority of farmers mainly get their seeds from informal channels which include farm saved seeds, seed exchanges among farmers or/and local grain/seed market. These channels contribute about 90-100 % of seed supply depending of the crop. Despite the importance of this system, unlike the formal seed systems, the informal is rarely supported. Subsequently, its improvement has been very limited or non-existent. Therefore, this has negative effect on agricultural productivity and income of farmers and more particularly to poor and marginalized farmers. Nevertheless, it has been proved that once well supported and linked to sources of improved varieties, the informal seed sector can be a reliable and efficient way of accessing improved varieties of crops whose seeds attract a very limited interest of commercial seed sector (Abebe and Lijalem, 2011 and Dawit, 2011).

According to the study of Alemneh *et al.*, (2017), the productivity of chickpea is very low due to local variety, disease and pest problem and poor management practices. The yield was about 1.83 ton per hectare which is less than the potential of improved varieties (CSA, 2016).

Considering this fact, Gondar agricultural research centre with Tropical Legumes II (TL-II) project has carried out participatory chickpea variety selection on five farmers' fields in the 2012 cropping season at West Belesa woreda. Accordingly, *Habru* and *Ejere* improved chick pea varieties have been selected by farmers for their higher yield advantage and especially variety *Habru* was chosen for its disease tolerance ability. Therefore, the research center in collaboration with other stakeholders scaled up the selected technologies with the following objectives.

Objectives

1) To create wider demand on chickpea technology package in the woreda;
2) To create and strengthen linkage among the possible actors;
3) To enhance technology multiplication and dissemination;

Materials and Methods

Engaging farmers in chickpea participatory variety selection

Gondar Agricultural Research Centre has been testing new crop varieties on research stations as well as on farmers' fields. Sometimes, farmers get difficulty in adopting the technologies because they are not familiar with the technologies. Now, farmers themselves decide what works best for them on their farms under normal farming practices. Involving farmers in selecting and testing improved varieties of chickpea with an approach known as 'participatory varietal selection has proven to be successful in Mirab Belesa Woreda.

Gondar and Debre-Zeit agricultural research centers with the budget support from Tropical Legumes phase two (TL-II) project conducted participatory chickpea variety selection in 2012. The varieties included were five improved and one local for comparison namely Habru, Shasho, Ejeri, Arerti and Mastewal. Decentralizing variety selection to target zones (different agro-ecologies), selecting genotypes with the participation of farmers and bringing farmers (from different social categories) early in the selection process, and giving them the opportunity to choose and use the technology based on their agro-ecologies is critical. Farmers who tested and adopted the new chickpea varieties already harvested more seed. Involving farmers in the selection of varieties has tremondus advantage. so efforts need to be focused on making this approach more widely accepted in the research system. Improved chick pea variety, Habru was sown by participating 230 (14 women) direct beneficiary farmers on111.28 hectares of land with eight farmers' field clusters.

Identifying potential stakeholders and developing partnership

A one day workshop was held on 12th of March 2012 in West Belesa woreda. Its primary objective was to sensitize senior management bodies of North Gondar Zone Department of Agriculture, West and East Belesa office of Administration, West and East Belesa woredas office of agriculture, and farmers on the proposed scaling up of chickpea technologies and create partnership. About 26 participants attended this workshop. The workshop was facilitated by researchers from Gondar Agricultural Research Centre (GARC). The workshop covered genesis of the participatory chickpea variety selection process; farmers' participation and interest; development of pre-scaling up plan; the monitoring and evaluation mechanism after implementation; and the responsibility of each party. The last part of the workshop was dedicated in discussing the way forward for the planed scaling up of the chickpea technology and a number of related issues. They included the merits of organizing seed grower cooperatives, backstopping of farmer-led seed multiplication, monitoring and evaluation process, sustainability of the seed producers cooperatives, enhancement of local technical knowledge, and strengthening research and extension linkages. Following discussions between Gondar agricultural research centre and Belesa office of agriculture, agreement was reached and signed. The signed agreement clearly stated the role and responsibilities of each stakeholder. Focal persons were selected and assigned from each stakeholder and prepared their own action plan.

Participant selection and area clustering

Participant farmers' selection and area (farmers' field) clustering was carried out mainly by East and West Belesa district office of agriculture experts and development agents. Two hundred thirty farmers (14 women) who are willing and have farm lands adjacent to each other were selected. Researchers from Gondar agricultural research centre, experts and office heads from North Gondar administrative zone department of agriculture helped them in identifying suitable fields for chickpea production.

Farmers' skills and knowledge enhancement

Building community members' trust in the research process which is so crucial in pre-scaling up activities takes a lot of time and patience. To do so, sensitization workshop was carried out to let farmers know what has been planned and how it is going to be implemented. Detailed plan of activities with farmers' role was jointly prepared. After acquiring farmers trust, training on production and management of chickpea was provided to farmers and development agents. Topics covered during the training include introduction to chickpea production, disease and pest management, quality seed production, and main concepts related to organization of seed producers cooperatives, agronomy and marketing of chickpea.

Putting the technology on the ground

A chickpea variety named 'Habru' was planted on 111.28 hectares of land which is owned by 230 farmers (14 women) clustered in eight groups in belesa woreda. The detail is indicated in the table below.

Table 1. Habru variety land coverage and participant farmers in West and East Belesa Woredas

Location		Quantity of seed used (ton)	Area of land covered (ha)	Number of participants			Number of Cluster
District	*Kebele*			M	F	Total	
West Belesa	Shura	4.40	36.68	66	4	70	3
	Arbaya	3.07	25.6	41	3	44	2
East Belesa	Dengora	2.40	20	36	3	39	1
	GuhalaZuria	1.38	11.50	42	4	46	1
	Achikan	2.10	17.50	31	0	31	1
Total		13.35	111.28	216	14	230	8

Source: Sampled data, 2015

A chickpea variety named 'Habru' was planted on 62.63 hectares of land which is owned by 108 farmers (8 women) clustered in four groups. About 57.12 hectare of the area was row planted with local producer cooperatives while 5.50 hectare was broadcasted. The detail is indicated in the table below.

Table 2. Land coverage of Habru variety through local producer cooperatives in West Belesa

Cooperatives name	Cluster name	Participant farmers		Quantity seed used (ton)	Area of land covered (ha)	Planting method
		M	F			
Kalay	Kalay walika	35	3	2.76	21.38	Row
	Saniki	15	3	1.36	10.50	Row
Dikana	Gudhaula	21	0	1.65	12.75	Row
	Mariza	22	2	1.63	12.50	Row
Sub-total		**93**	**8**	**7.40**	**57.13**	**Row**
	Gundabharg			0.20		
	Menti	12	0	0.20	5.50	Broadcasting
	Wareb			0.20		
Aggregate total		**105**	**8**	**8**	**62.63**	

Seed Quality Control

Seed quality is an important factor for economic benefit for seed producers to act sustainably. During the seed production process, North Gondar Zone Agricultural Department, Amhara Seed Enterprise-Gondar Seed Laboratory, seed grower farmers in the districts and researchers from Gondar agricultural research center jointly inspected the seed production fields. Farmers were assisted with appropriate technical guidance in different steps of seed production such as identification of varieties, removing of off-types, management of disease and pest, harvesting and threshing and finally in seed treatment and storage. About 161 ton of chickpea seed was produced in the woredas. Farmers sold for Tsehay union and for their multipurpose cooperative in the woredas. Farmers can use and recycle chickpea seeds for 3-5 years. However, private sector lacks the incentive to farmers in the enhanced delivery of seeds (Rao *et al.*, 2012).

Technology popularization and demand creation

Field days were organized to popularize the technology more for non-participant farmers, adjacent kebels and stakeholders in the woreda. Field day participants appreciated the performance of the technologies in the woreda. They also promised to scale out the technology to adjacent kebeles and woredas to fetch the potential of the technology. Field day participant farmers who are not

practicallyparticipants in the pre-scaling up activity were also highly convinced to demand and make use of the Habru chickpea variety.

Table 3. Field day Participants in west and east belesa woreda on chickpea

Participant	West belesa			East Belesa		
	Male	Female	Total	Male	Female	Total
Participant farmers	65	16	81	109	7	116
Non participant farmers	-	-	-	106	12	118
District experts and others	22	4	26	25	5	30
GARC staffs	4	0	4	14	1	15
Zonal experts and others	16	0	16	18	0	18
Regional experts and others	-	-	-	10	1	11
National experts and others	1	0	1	1	0	1
Communication experts	2	0	2	4	0	4
Grand Total	**110**	**20**	**130**	**287**	**26**	**313**

To aware farmers and other stakeholders, a series of field days have also been organized since 2012. A minimum of six field days have been organized by Gondar agricultural research center, and West and East Belesa woredas offices of agriculture. The objective was to create awareness about the advantage of available chickpea varieties under farmers' contextual environments and to popularize these varieties through farmer training, field visits and experience sharing. During participant selection, emphasis has also been given to make 70% and 30% participants male and female respectively that belongs to poor, medium and well-off farmers. Field days were organized and attended by a total of 316 farmers, agricultural experts, management bodies, and other stakeholders from regional offices, zonal offices, neighboring district and from East and West Belesa woredas. Leaflets were prepared and distributed and mass Medias from Ethiopian national television and radio service, Amhara mass media agency, and Fana broadcasting corporate broadcasted the event.

Farmers were pleased to have an opportunity to see on-farm experiments and new technologies undertaken by their fellow or neighboring villagers. At the end of the field days, the discussion with participants provided feedback i.e. high productivity, disease tolerance and attractive seed color on the technologies and experiments that they observed.

Generally, after the delivery of the training, improved Habru chick pea variety was sown by participating 338 (22 women) direct beneficiary farmers on 173.89 ha of land with eight clusters.

During field days, a total of 753 farmers, agricultural experts, management bodies, and other stakeholders from regional and zonal offices, and neighboring districts participated on the event.

Results and Discussion

The principal output expected was to develop and implement a functioning and sustainable chickpea seed system in the area to enhance the availability and accessibility of improved crop varieties by promoting the growing of high yielding chickpea varieties and local seed business. The following outputs were observed after implementing the scaling out of chickpea technology package:

- **A chickpea technology package developed:** New high yielding varieties (Habru) reliably and sustainably was developed and validated by farmers through participatory variety selection and shown to more than double yield and generate increased income.
- **Increased chickpea productivity:** In total, 343 (24 women) farmers have been trained in improved seed multiplication, including improved production techniques for higher quality and yield. This work has strengthened ties with stakeholders, a 100% yield improvement on participant farmers' field. The average productivity of the local variety is 1.2 ton per hectare, but the improved variety gave on average 2.46 ton per hectare on farmers' field with farmers' management. Ethiopian average chickpea yield was 1.2 tons per hectare, yet farm tests on experimental plots in the country have achieved yields from 2.9 to 3.5 tons per hectare (Shahidur, *et al.et al.*, 2010)
- **Seed producer cooperatives established:** Two seed producer cooperatives were established, namely, '*Kalay*' and '*Dikana*' primary seed producer cooperatives having 93 (8 women) farmer members. These cooperative members produced 161.40 ton of chickpea seed variety '*Habru*', which could be used as seed for next cropping season.
- **Seed production as an income generating option:** Farmers is now generating additional income from their production of the improved chickpea seed, which is not only more accessible to local community members now but also commands a premium, swiftly selling at higher prices than other seeds on local market in the woredas.
- **Demand for the technology created:** Two major factors hindering the use of the improved chickpea varieties were the lack of awareness about the right varieties and the inaccessibility of seeds of these varieties to farmers especially the poor and those living in remote areas. This activity addressed the two aspects by facilitating the participatory promotion/demand stimulation followed both by local seed production.
- **Chickpea seed produced:** Participant farmers' managed seed multiplication at the community level to ensure efficient supply of improved seeds for further scaling out of the technology in the woredas. The quality of the seed has been inspected by the respective organ i.e. office of seed inspection and quality control.
- **Partnership developed and strengthened:** The awareness created via the workshops, agreement signed, various trainings, field visits and a range of stakeholders' involvement in these events brought them a common understanding about improved technology and its management in the woredas.

Participant stakeholders efficiently recharged their responsibility in the process and agreed to support the informal seed multiplication and strengthen chickpea marketing processes.

Conclusions

Through this approach to increase seed multiplication at community level and establish functioning seed system, best experiences were gained. First, changing farmers' attitude about quality seed production was a constant challenge. Second, there was lack of awareness on the availability of improved varieties in the area. Third, without proper participation of key actors, there had been some failed experiences in the past with seed multiplication. Therefore, several lessons were learned behind the success of this activity:

- The field days and exchange visits conducted revealed that farmers and each stakeholder should be made aware of the availability of improved seed in their area and economic advantage of seed production.
- It was realized that farmers lacked the relevant skills and knowledge to conduct seed production as a business. Through the collaborative effort exerted, two seed producer cooperatives have been established.

Recommendations

In order to ensure the accessibility of quality seeds of chickpea varieties to small scale farmers through systematic pathway, combining a set of activities starting from participatory chickpea variety selection to variety demand stimulation and grass root level quality seed production and accessibility creation have been done. In order to accelerate further scaling out, the technologies and the use of improved varieties, some major steps are important to be considered. Firstly, the economic benefit for seed producers is one of the important elements for the sustainability of such kinds of seed systems. Quality of seed is always a key issue in the seed business which needs continuous support from relevant organizations. Marketing skills of members and access to market network are another case in point for sustainability of farmer managed seed production system. These are focus areas which require more investment and technical backstopping for the sake of sustainability.

Amhara seed enterprise has confirmed that it is ready to buy the certified seed which is above the districts capacity with 15% margin of the market price. Therefore, this success story in technology scale up and organized seed production does not end here; it is the beginning to solve the problem of continued use of the unproductive and low quality variety in the area. In general, this chickpea technology package scaled out through seed producer cooperatives has shown promoting group action among small-scale farmers as a promising area for quality seed production and supply. Office of agriculture, cooperatives promotion and other stakeholders should give their strong support for the sustainability of the system in the woredas.

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Pre- scale up of Potato Seed Production Technologies in Watershed Areas, North ShewaZone, Ethiopia

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Abstract

Potato is a cool season crop grown in many parts of the country with its ability to escape harsh weathers like frost and low moisture. In the highlands of North Shoa, farmers usually grow potato at the backyard due to lack of access to improved varieties in addition to less attention of the farmers to grow the crop. Since the agro-ecology of this highland area is suitable for growing potato together with the use of improved varieties, it was demonstrated that it is a high yielder and disease resistant crop. During the demonstration the potentials of the introduced varieties attracted the farmers to produce in large scales. This caused farmers to become highly interested to grow potato in their farm lands as a field crop nowadays, and hence the demand for potato tubers increases continuously and farmers have got higher returns from potato seed produces. The farmers started to empower their market bargaining capacity by organizing themselves into Seed Producer and Marketing Cooperative. The cooperative constructed two modern diffused light storages (DLS) with the support of International Water and Land Resource Center. It has played a pivotal role in potato tubers' supply chain; through purchasing tubers from growers. It would be selling back the sprouted tuber seeds to other farmers who didn't otherwise get access to grow potato within and outside the watershed areas. The pre-scaling up of improved tubers mainly through the involvement of cooperatives in the system helped farmers to boost the productivity of their farm lands and source of cash income. Add to this, introduction of potato in this particular area generally improves production and productivity of the farm land through enhancing proper crop rotation and farming system changes. Continuous seed replacement and technical backstopping help the farmers to sustain the production system improvement and farmers field benefits.

Key words: potato, pre-scaling and learning watershed

Introduction

Potato is essentially a cool season crop, with temperature being the main limiting factor. In tropical areas, potato should be grown where the climate is moderated by altitude (1500 – 4200 m.a.s.l) or at lower altitudes provided that the crop is grown during the cool season (Aramayo, Antonio, 1998; Oscar et al., 2009 and FAO, 2009). It holds a huge promise in improving the livelihoods of smallholder farmers in the risk-prone highlands of Ethiopia. The crop has early maturing varieties to escape the harsh weather condition (frost) and support the household food shortage where other crops remain green in these areas (Gebremedhin et al., 2006). Due to this fact farmers were motivated to grow potato and posed huge amount of seed tuber demand. The researchers mobilized a lot of resources to create potato seed tuber producer farmers and cooperatives. As the demand for potato tuber seeds continuously increasing, farmers preferred to organize themselves into Seed Production and Marketing Association. Thus, apart from resolving the increasing trend of seed demand in the localities, farmers benefited from the sale of potato tubers and changed their livelihoods (Yalembrhan, 2008 and Zerihun *et al.*, 2013).

Potato is a high potential crop produced by smallholders in various areas of the country valued for its nutritive purposes and market participation among horticultural crops. Traditionally, potato tubers are used to make "*wot*" for home consumptions and market purposes in hotels and restaurants. Nowadays, it passes through different value adding processes and prepared into different types of food to be eaten as chips, boiled potato, soup, porridge, *shiro*, etc.

In Ethiopia potato is one of the main horticultural crops grown for alleviating food security problems. Currently, this crop is produced in various areas of the country but its productivity is low due to lack of improved high yielding and disease resistant varieties. Although highlands of North Shewaare suitable for potato production, till the two improved potato varieties released by Sheno the then Debrebirhan Agricultural Research Center (DBARC), farmers in this area had produced very small amount of potato in their backyards with local varieties, (DBARC, 2002/3). Farmers' awareness about the production and productivity of the crop were very limited. They used to plant blemish full and very small tubers keeping in dark rooms and sometimes just immediately after harvesting or by leaving unwanted tubers in their fields.

Because of their non-productive experience, farmers refused to grow potato out of their backyard in their crop fields. Although this was the challenge that the DBARC researchers had been facing, it changed such condition in short period of time through training and on-farm demonstration of the released varieties with associated agronomic practices recommended for the area (Abdulwahab and Semagn, 2008). In this particular area, potato becomes the primary crop for smallholder farmers. It has many opportunities and potential production improvement options which have got great attention

by the research center to work upon it in order to bring impacts on the livelihood improvement of individual farmers. Improved potato technology transfer activity was one of the production improvement options for those smallholders who had no experiences to produce potato though have potential growing agro-ecologies.

Pre-scaling up activity aims to improve the productivity of potato through introduction of high yielding and early maturing varieties to escape the problem of frost. Intensifying efforts through scaling up of promising agricultural technologies to small scale farmers helps to improve the livelihood of the communities at large by enhancing production and productivity. This in turn contributes to individuals for food security improvement through realizing the full potential of agricultural technologies. Add to this, pre-scaling up activity plays an important role in bringing research outputs to farmers and then to the markets.

Debre Birhan Agricultural Research Center has recommended different potato varieties for the specific highland areas of North Shewathrough technology development and adaptation. Gera and Gorebella varieties are among the recommended varieties resulted from the center. Pre-scaling up of these varieties with the recommended packages in this specific area helped the farmers to have a greater chance to grow the varieties and improve the productivity of potato. The importance of this specific activity was to strengthen and sustain the informal seed supply system through the establishment of seed production and marketing cooperative.

Lack of improved seed availability, low level of farmers' awareness on potato production, high rate of seed requirement and absence of improved seed supplier institutions in the required amount are the major causes for low production and productivity. Establishment of seed production and marketing business institutions is the new opportunity for farmers to bring market alternatives for selling of their produce and input purchase and help to strengthen and sustain the technology diffusion system. The demand for seed potato tuber has been increasing in the area from time to time as the highlands of North Shewais ideal for healthy potato seed production and the released varieties (Gera and Gorebella) are adaptive in other areas. DBARC has continued supporting the existing cooperatives and organizing new ones to sustain potato production in North Shewain particular and in the region at large. This activity was implemented to create wider demand for the technologies, strengthening linkage with actors' and enhance seed dissemination systems.

Materials and Methods

During the implementation of the activity, we practiced different approaches in order to facilitate technology transfer and smooth information flow among the farmers, researchers and extension workers. Depending on our technology transfer experiences this approach helps to solve the problems in sustainable way. We used multi-disciplinary team approach comprising researchers, extension workers and farmer groups to improve farmers' production skill and transfer of indigenous knowledge from farmers to farmers and extension workers. The area which was suitable for seed tuber production was selected. The center provided the released varieties to selected farmers. Small DLSs were constructed using local materials in the backyards of each farmer to store the seeds until it reaches the amount to satisfy the existing demand. This was not only useful for farmers and extension workers, but also for the researchers to get organized feedbacks about the technology from end users. In this particular activity different stakeholders such as farmers, extension workers, administrative bodies, researchers and project donors of WLRC and Integrated Seed Sector Development (ISSD) were involved in pre-scaling up activities with different responsibilities.

To enhance proper implementation of the pre-scaling up activities, the researchers from different disciplines have given training for interested participant farmers and extension workers. The research center supplied improved potato seeds for farmers based on their technology needs through Farmers Research and Extension Groups (FREG) and Seed Production and Marketing Cooperative (SPMCS) with agreements to sustain and strengthen the technology transfer system and institutionalize the approaches of effective technology dissemination. Initially WLRC project provided fertilizer inputs to support application of the recommended technology packages. Farmers have been participating in every operational activity of agronomic practices, and monitoring and evaluation. Extension workers mobilized the community to participate in technology transfer through seed exchange system.

Monitoring and following up of the activities were done with participatory and collaborative approach with farmers, researchers and districts and kebele agricultural experts. There were also consecutive site visits made by these stakeholders to follow up the field works. Farmers were organized in groups to learn from each other and following up each stage of crop performances through practical observations and feedbacks at various stages.

Key implementation approaches and procedures.

In order to make the technology transfer system sustainably effective, it is indispensable to apply certain useful approaches that mainly consider the circumstances of smallholder farmers. Establishment of multidisciplinary team of researchers, and organizing farmers who are interested in potato production into FREG and then SPMCs is very important. Provision of theoretical and practical trainings for farmers and extension workers; continuous monitoring and evaluation; field day

evaluation with a team of different stakeholders were the main duties performed during implementation of the activity for sustainable technology transfer. Trainings were given mainly focusing on improved production systems of potato based on technologies characters and their agronomic practices and about the concepts and importance of FRG and SPMCs.

Site selection was carried out by involving multi-disciplinary team of researchers, extension workers and farmers. Awareness creation and practical training on potato seed production techniques and its agronomic practices was delivered to all participant farmers. Field days were conducted for the last two years with the participation of farmers, researchers, project donors and other stakeholders. Finally, at the end of the activity plan, two workshops were organized in 2014 at woreda and zonal levels to evaluate the watershed development status and transfer the approaches to responsible organizations. Kebele administrators and development agents from 32 kebeles, different political leaders and experts, university representatives and instructors participated in the woreda level workshop. Zonal office of Agriculture representative, Zone administrative head, district office of agriculture head, woreda administrative head, and kebele office of agriculture, kebele chairman, cooperative members and representative farmers also participated in Zonal workshop.

Results and Discussions

Eighty six quintals of improved potato tuber seeds were disseminated to cover over 4 hectare of land in order to participate 124 (about 18% female) farmers. For successful technology transfer, training and field day participation of farmers and other stakeholders play a pivotal role especially in creating awareness about the technology with its recommended packages and demand for the technology. Based on these approach 106 and 208 persons participated in the training and field days, respectively.

Due to potato technology transfer efforts made during the last two years, farmers were convinced to produce and sell potato seed tuber to their institution (SPMAS) (Fig. 1).

Fig. 1. Potato production and marketing in the learning watershed

Potato production

After introduction of new improved varieties of potato technologies the productivity was increased to a maximum of more than 45 tons per hectare. In this watershed area host farmers produced an average of 30 tons per hectare. Yields and total production of potato is relatively improved from persistent to large scale production. The average, the maximum and minimum yield of potatao varieties is 301.5, 451.1 and 160.7 quintal/ha, respectively.

Productivity and marketing

The respective marketable yield of Gera and Gorebela varieties in the second year was 34.4 and 32.2 tons per hectare. There was also non-marketable yield of 2.3 tons/ha for Gera and 3.9 tons/ha for Gorebela used for home consumptions. Annual total potato seed tuber production has an increasing tendency of 55 and 68% in 2013 and 2014, respectively compared to the initial year of 2012. The total potato seed sold by the cooperative was 5.34 and 9.4 tons with the value of 35,238 and 97,800 Birr in 2012 and 2013 production year, respectively.

Seed supply system improvement and linkages

Produced seeds were disseminated to member farmers via the cooperative on credit basis to those who are unable to purchase. Farmers as well as the cooperative have been selling potato seeds both within and outside the kebele for the last three years. A total of 42 tons of improved seeds were collected and

sold to generate 546,000 Birr over the last three years. This helps farmers to have easy access to the seed business. The cooperative has, therefore, an impact on potato seed dissemination or supply chain improvement through bridging producers with other farmers who otherwise have limited access to improved seeds.

Partial budget analysis

The partial budget analysis was employed to evaluate the profitability of introduced varieties against the local check. The production of Gera variety has a net benefit advantage of 72%, 7% and 26% local and Gorebela varieties table (Table 3).

Table 1 Partial budget analysis

Items	Local	Gera	Gorebela
Labour cost (Birr/ha)	2,040	2,040	2,040
Seed cost (Birr/ha)	24,000	30,000	30,000
Fertilizer cost (Birr/ha)	3,690	3,690	3,690
Total variable cost (Birr/ha)	29,730	35,730	35,730
Yield (t/ha)	20	34.4	32.2
Adjusted yield (t/ha)	18	31	29
GB (Birr/ha)	90,000	155,000	145, 000
NB (Birr/ha)	60,270	119,270	109,270
MRR	2.03	3.34	3.06

Achievements

There is an increase in the awareness level of farmers in using improved potato varieties and post-harvest handlings. They also benefited from the services provided by the potato seed producer cooperative. FREG was transforming to SPMCs and cooperative member farmers are increased from 51 at initial time to 113 (about 17 % female). Farmers who are members of the cooperative accessed to the nearby market opportunity and benefited from sell of potato seeds to the cooperative, and store seeds in the DLS.

Farmers' reflections

Farmers used potato to produce barley as the major crop and other pulses at low proportion. They are interested to use improved technologies for production and productivity enhancement from the exposures of prescaling up activity. The community is impressed by the change of production and

productivity of their plots because of the introduced improved potato production practices. Particularly participant farmers witnessed the practices change in benefits obtained from potato seed production. During the field days, farmers expressed their views and impressions about their livelihood changes in a short period intervention. The farmers said that "we have never produced potato and not benefited before from productivity improvement, but at this moment we learned how to produce potato seed tubers and post-harvest handling. Now, we are capable of producing quality potato seed and gain income from the sale of seed as a business."

Over all achievements and key lessons

Because of the intervention, farmers are aware of improved technologies and productivity of farm lands enhanced by utilization of improved technologies. Different stakeholders including office of agriculture, cooperative promotion and organizational office and administrative bodies become responsible for the future support and following up of the system and acknowledged the approach. Sustainable technology transfer system through seed production and marketing cooperative in local communities established not only for potato but also for all other introduced improved technologies. Participatory, integrated, multi-disciplinary and stakeholder linkages strategy is the best approach and helpful for continuous and sustainable technology transfer and seed dissemination tasks with less efforts and great outcomes. Capacity development of farmers, extension workers and other stakeholders through need based continuous training and support are essential for adapting improved management practices and help change the attitudes of different stakeholders.

Community participation and institutionalization of the system for sustainable technology transfer through participation of different community groups in problem identification, planning and implementation improve the sustainability of seed exchange and technology transfer options. Enhance productivity of farm lands for smallholder farmers through the use of improved technologies instead of fallowing their farms due to decline of productivity resulting from poor production practices and use of less productive varieties year after year. The achievement is the result of interactive learning outcomes from different actors of political leaders, farmers, researchers, extension workers and project donors.

Opportunities and Challenges for up- scaling

Opportunities

Farmers in the implementation areas as aresult of consecutive years of intervention shown sustainable and increasing demand for the improved varieties introduced for uninterrupted production improvement and try to implement the recommended packages for similar local cultivars. They improved their production system practices. Farmers have good experiences of potato production for many years and barley is the major crop grown in the area. The agro- ecology and climate is highly

suitable for potato production. Potato was grown by farmers for home consumption purposes and also sold to consumers with low price.Now improved potato is used as cash source sold with attractive price as seed for potato grower farmers.

Challenges

There are, however, certain challenges that the farmers have been facing during the interventions. It was difficult to follow up each farmer's field due to topography. The cooperative has limited finance to purchase all the seeds produced by seed growers. There were certain ups and downs to sustain the cooperative. There is an increasing demand for improved seed in one side and limited capacity of the cooperative to purchase all the seed produced in the area for wide scaling and sustainable production improvement.

Conclusion and Recommendations

The introduction of improved potato seed production technologies through farmers based support institutions bring changes in the income sources and production systems of small holder farmers. In the future new technologies will be introduced easily through cooperatives with little efforts through simple orientations for the cooperative members and other participant farmers about the technology. Seed money is very essential for the cooperative to purchase and transact seeds through credit system. Technical backstopping is very essential for farmers and cooperative members through training and market linkages.

Capacity building for cooperative leaders and potato grower farmers is critical both in financial, material and technical management's skill. Continuous follow up, advisory services, market linkage from extension and research is central to enhance the expansion of the technology. Technical support and developing a potato value chain are critical for the sustainability of potato production and marketing. Replace the existing seed class by new in a certain time interval. Strengthening the seed inspection and quality assurance system through linkage with seed quarantine clinic and reinforcing community organization for sustainability of benefits are important.

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Pre-scaling up of Potato Technology Package in the High Land of Debark Woreda, North Gondar Zone, Amhara Region, Ethiopia

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Abstract

Potato plays a great role for the achievement of food security due to its high yielding capacity and availability of suitable land for the crop in the country. However, its productivity is far less than its potential due to lack of improved technologies and poor agronomic practices. The objectives of this activity were to promote potato technology packages in the area and to develop functioning potato local seed system in the area. Methodologies were selection of farmers in cluster approach, delivery of training, organizing field day and leaflet distribution for all participant stakeholders. Training was delivered to woreda agricultural experts, kebele development agents and selected farmers in Debark town mainly focusing on potato agronomic practices, plant protection and prevention from disease and insects and post-harvest handling condition for the production of potato crop. Gera potato variety was popularized on 30 potato producer farmers delivering of 4 ton of potato seed tuber. Based on training, farmers applied the technologies package on the ground for the production of potato crop in the intervention area. A total of 82 farmers, agricultural experts, management bodies, other stakeholders from regional and zonal offices, and farmers from neighbouring districts participated on the field day event organized. Leaflets were prepared and distributed and mass Medias from Ethiopian national television and radio service, Amhara mass media agency, and fana broadcasting corporate broadcasted the event. Potato productivity improvement, potato as seed business for income generation, creation of wider demand on potato technologies and development and strengthening of partnerships were some of the major achievements of the pre-scaling up activity. This approach encourages farmers to increase seed multiplication at community level and functioning farmer to farmer seed tuber exchange system. Generally, this potato technology package scaling up through participant farmers has shown promoting group action among small-scale farmers as a promising area for quality seed tuber production and supply in the Woreda. This technology should be scaled out by office of agriculture and other partners to neighbouring kebeles to benefit potato tuber producer farmers in the woreda. Therefore, this success story in technology scale up and organized seed production does not end here: it is the beginning to solve the problem of continued use of the unproductive and low quality variety in the area.

Key words: Potato, Technologies, Promotion, Field day and Training.

Introduction

Potato production is an important economic activity in Ethiopia. The production system ranges from home gardening, smallholder farming to commercial farms owned both by public and private enterprises (ATA, 2014). Indeed, Ethiopia is endowed with diverse agro-ecologies suitable for the production of different categories of vegetables. Tropical, sub-tropical and temperate vegetables are produced in the low lands (<1500 meters above sea level), midlands (1500 meters above sea level), and highlands (> 2200 meters above sea level), respectively (EHDA, 2011).

Potato is one of the stable foods in North Gondar mid and highland areas and produced under rain fed and irrigation condition. It is among the most important crops to ensure food security and generate income for small scale farmers in North Gondar (Tesfaye and Yigzaw, 2008). North Gondar has one of the major high potential agro-ecologies for potato production and productivity in Amhara region. Debark, Dabat, Wogera, Chilga, Janamora, and Beyeda districts are the main potato growing areas in North Gondar. 16 % of potato production in Amhara region was obtained from North Gondar Zone in 2014 (CSA, 2014). The potato average yield of North Gondar (14.3 ton/ha) is higher than the national average (11.7 ton q/ha) but below than the Amhara region average (15.3ton/ha) (CSA, 2014). However, compared to the achievable yield potential using improved high yielding varieties released in the country, it is too low by far and yet to be enhanced.

Main constraints in potato production in the region are lack of disease resistant varieties, lack of quality seed tuber, inaccessibility to improved varieties, diseases e.g bacterial wilt and blight, traditional way of production and post-harvest handling (Tesfaye and Yigzaw, 2008). Farmers use local potato variety which is 7.26 ton per hectare in productivity in the main season for long period of time, and only 21.5% of farmers used improved potato varieties (Yazie *et al.*, 2017). Potato production constrained by a number of factors among which disease, storage problems, low market prices of tubers at harvest, and insufficient quality seed tubers for planting were the major challenges of potato production (Hailu *et al.*, 2017: Melkamu *et al* 2017 and Yassin Ismael, 2017). One of the major high potential agro-ecologies for potato production in North Western Ethiopia is found in North Gondar. However, potato tuber yield is too low, due to lack of disease resistant varieties and use of old and low yielder local varieties by resource poor-small scale farmers.

Good quality planting material is one of the foremost prerequisites of healthy and successful crop production venture, because, planting materials are important vehicles for innovative technologies and may eventually disseminate serious pests and disease causing pathogens. A known solution for this kind of problem is the production and distribution of high quality disease free planting materials. Thus, production and distribution of affordable, quality, high yielding potato varieties needs serious

attention and a well-designed system. In order to improve this situation, the operation of each seed system needs to be strengthened, realizing that each system has its values and limitations in terms of availability, price and quality.

Considering this fact, Gondar agricultural research centre with woreda office of agriculture and farmers has carried out participatory potato variety pre-scaling up in Debark woreda. Accordingly, *Belete* and *Gera* improved potato varieties have been selected for their higher yield advantage and disease tolerance ability with farmers' participation. Therefore, the research centre in collaboration with other stakeholders scaled up the selected technologies with the following objectives.

Objectives

- To create wider demand on potato technologies in the woreda;
- To create and strengthen linkage among the possible actors;
- To enhance technology multiplication and dissemination;

Materials and Methods

Experimental area description

Chilga is located at 37.06' N longitude and 12.55' E latitude and the midland agro-ecology has an altitude of 2146 m.a.s.l. The minimum and maximum temperature of the area is 19 °C and 27 °C and its average annual rainfall is 1050 mm. The dominant soil type of the study area is red brown cambisols and vertisol (CDOA, 2012).

Plant materials and description of the study area

Nine improved potato varieties released in the country and local check were tested for their adaptability by Gondar Agricultural Research Centre under rain fed condition. The testing varieties were Shonkolla, Jalene, Belete, Marachere, Bulle, Gabisa, Gudenie, Hunde, Gera and local check. The varieties were tested on station and on farm at Debark woreda in North Gondar administrative zone, Ethiopia. Debark is positioned at 37.92' N longitude and 13.19' E latitude. It is located at an altitude of 2885 m.a.s.l. and has tepid to cool moist highland agro-ecology. The minimum and maximum temperature of the study area is 3.7 °C and 23.1°C and it receives 1231 mm mean annual rainfall annually. The dominant soil type of Debark woreda is acrisols (Fentahun M. and Hager H., 2012).

Participatory variety selection

The local check was the earliest to flower (52 days) and mature (93 days) among tested varieties. The longest plant height was achieved from variety Shenkola (56.4cm) (Table 1). The best yielding varieties tends to have longer plant height than low yielder varieties. The local check gave the maximum number of stems per plant (7.1) and the highest yield providing varieties tend to have less

number of stems per plant (Table 1). Similar result was also reported by Yigzaw *et al.* (2008) that marketable tuber yield had positive statistically significant association with plant height and negative correlation with number of stems, rainfed potato production system.

The maximum weight of individual tuber was recorded from variety Shenkola (77.6gm) followed by Belete (76.0gm) and the local check (48.68gm) gave the smallest weight among tested varieties (Table 1). Tesfaye *et al.et al.*, (2013) likewise reported that Belete and Shenkola have given heaviest tuber weight among tested genotypes and the lowest weight tubers have been harvested from farmer's cultivar. The 1-9 disease score scale described by Heinfnings (1987) was used.

Over all, at both locations, the maximum marketable (24.6ton/ha) and total tuber yield (28.4ton/ha) was obtained from variety Belete followed by variety Maracher (Table 1). Belete variety has outyielded the local check by 70.5% in terms of marketable tuber yield (Table 1). In agreement with the present result, variety Belete was found to be one of the best yielding variety in marketable tuber yield (Tesfaye *et al.*, 2013). The local check was the lowest in tuber yield compared to all tested varieties. Variety Belete was found to be moderately resistant to late blight among tested varieties. Belete variety was also categorized as moderately resistant by Getachew *etal.* (2016).

Table 1 Mean tuber yield and agronomic characters of potato varieties at Debark and Chilga

Varieties	Days to flower	Days to maturity	Plant height	Number of stem per plant	Tuber weight (gm)	Marketable tuber yield (ton/ha)	Total tuber yield (ton/ha)	Late blight severity (1-9)
Belete	56.17c	97.28ab	49.67bc	5.03c	76.07ab	24.60a	28.41a	3.04c
Shenkola	54.39d	94.61cd	56.41a	4.63c	77.61a	21.39bc	22.58de	4.12b
Gabisa	55.83c	96.83b	44.58ef	4.92c	66.58cd	21.83bc	24.61bcd	3.92b
Jalenie	58.67b	97.06ab	51.79b	6.45ab	70.58bc	22.07abc	25.52bc	3.54bc
Gudenie	61.39a	93.39d	49.18bc	6.09	66.89cd	21.88bc	23.93cd	4.02b
Bulle	54.11d	99.06a	47.84cd	6.28b	58.66e	16.97d	20.11ef	3.95b
Maracher	49.5f	98.22ab	44.09ef	4.72c	63.28de	23.32ab	26.90ab	3.71b
Hunde	49.44f	96.61bc	42.42f	4.51c	62.9de	20.15c	23.261cd	3.91b
Gera	56.94c	97.50ab	49.78bc	4.84c	73.82ab	22.46abc	24.43bcd	3.79b
Local	52.67e	93.83d	45.95de	7.11a	48.68f	14.43d	17.52f	4.72a
Mean	54.91	96.44	48.17	5.46	66.50	20.9	23.73	3.87
CV%	3.48	3.18	8.5	21.56	14.65	18.77	16.71	23.09
LSD	1.263	2.031	2.706	0.778	6.44	2.5927	2.6202	0.59

Based on combined mean result and stability analysis of total tuber yield, Belete, Marachare, Gera, Jalenie and Gudenie were selected as high yielder and the most stable. Belete and Gera were preferred by farmers based on their yield, disease tolerance and taste. Belete and Gera were recommended for North Gondar zone potato producing areas and other similar agroecologies.

Farmers' selection and training

Host farmers (30 individuals) were selected in Debark woreda at Mekara and Miligebsa kebeles. Training was given on improved potato production practices and technologies, seed production techniques, disease identification and management options and post-harvest handling mechanism to improve the knowledge and skill of participant farmers, district experts and Kebele DAs in Debark town. The training methodology was both theoretical and practical for easy understanding by the trainees. Participant farmers and agricultural experts expressed their high level of satisfaction based on participants' feedback on the training condition.

Table 2: Training participants and its content

No.	Participant	Male	Female	Total	Training content
1.	*Woreda* experts	3	0	3	✓ Agronomic practice Plant protection Post-harvest handling
2.	*Kebele* development agents	3	0	3	
3.	Participant farmers	27	3	30	
4.	Research centre	5	0	5	
	Total	**38**	**3**	**41**	

Putting the technology on the ground

Gera potato variety was popularized on about 1.78 hectare of land by participating 30 potato producer farmers by delivering 4 ton potato seed tuber. It was planted on the farmers' field based on recommendation of 75cm between rows apart and spacing between plants was 30cm. Fertilizer was applied at the rate of 81 kg/ha N and 69 kg/ha P_2O_5 in the form of Urea and diammonium phosphate, respectively. Urea fertilizer was applied at planting and the remaining half during tuber initiation stage while P_2O_5 was applied at planting. Other recommended agronomic practices such as weeding, and hoeing were conducted uniformly for all farm fields. Based on the training given, farmers in the study area applied the technology package for increased potato production.

Table 3: Land coverage and delivery of Gera potato variety for participant farmers

Site		Seed tuber (ton)	Land coverage (ha)	Number of participant		
Woreda	*Kebele*			Male	Female	Total
Debark	Mekara	0.70	0.13	9	0	9
	Miligebsa	3.30	1.65	18	3	21
Total		4	1.78	27	3	30

Technology popularization and demand creation

Field day was arranged and attended by pertinent stakeholders, including zone and woreda administrators, office of agriculture, seed enterprises, cooperative promotion agencies, NGOs, neighbouring *woredas* and farmers. Leaflets were prepared and distributed to field day participants. Mass Medias from Ethiopian national television and radio service, Amhara mass media agency, and Fana broadcasting corporate broadcasted the event.

Farmers were pleased to have an opportunity to see on-farm experiments and new technologies carried out by their fellow or neighbouring villagers. From the discussions made with participants at the end of the field days feedbacks were obtained pertaining attractiveness of the stand performance, disease tolerance and management practices of improved potato variety.

Table 4: Field day participants on the pre-scaling up activity

No.	Participant	Male	Female	Total
1.	Farmers	67	15	82
3.	Development agents	3	0	3
4.	*Woreda* experts and others	7	4	11
5.	Research staffs	12	2	13
6.	Zonal agriculture, cooperative experts, and NGOs	6	0	6
7.	Research institution staffs	2	0	2
8.	Media and communication experts	3	1	4
	Total Participant	**100**	**22**	**122**

Achievements

The principal output expected was to develop and implement a functioning and sustainable potato seed tuber system in the area to enhance the availability and accessibility of improved crop varieties by promoting the growing of high yielding potato varieties and local seed business. The following achievements were observed after implementing this potato technology package scaling out.:

- **A Potato productivity enhancement:** The average productivity of the local variety is 13.7 ton per hectare, yet improved variety gave on average 24.4 ton per hectare on farmers' field under farmers' management (CSA, 2015). A 78% yield improvement on participant farmers' field was obtained. Potato tuber seed multiplication at the community level to ensure efficient supply of improved seeds for further scaling out of the technology in Debark and neighbouring *woredas*. The quality of the seed has been inspected by Gondar seed quality quarantine and control organization.
- **Potato seed tuber production as an income generating option:** Group of farmers who are acting as local potato seed tuber producers are generating additional income from improved potato variety produces selling their produce at high prices than other crop seeds on the market and becoming seed sources for community members.
- **Demand created on the technology:** This activity addressed the two aspects by facilitating the participatory promotion/demand stimulation followed both by local tuber production. Participant farmers were appreciating and preferred to allocate their land by this technology; they also promised to produce and keep this technology for the future. Stakeholders committed to assist farmers during production and marketing of potato tuber.
- **Partnership developed and strengthened:** Stakeholders awareness created about improved potato technologies, agronomic practices and their responsibilities via the workshops, agreement signed, various trainings, field visits and a range of stakeholders' involvement in these events brought them a common understanding. Participant stakeholders efficiently recharged their responsibility in the process and keep on supporting the informal tuber multiplication and potato market strengthening processes.

Table 5: Yield performance of Gera variety at Miligebisa *kebele* in Debark *Woreda*

Site	Marketable tuber		Non-marketable tuber weight			
	Yield (kg/5 m^2)	Yield (ton/ha)	Small tuber yield (ton/ha)	Disease yield (ton/ha)	Injured yield (ton/ha)	Total yield (ton/ha)
1	16.00	32.00	3.60	2.00	5.20	10.8
2	19.40	38.80	3.00	2.00	2.80	7.80
3	6.20	12.40	5.20	0.00	1.20	6.40
4	8.40	16.80	4.40	2.00	0.00	6.40
5	13.40	26.40	4.80	0.40	0.80	6.00
6	12.00	24.00	4.00	0.00	1.20	5.20
7	10.20	10.20	3.40	0.00	2.00	5.40
Average yield	**12.22**	**24.40**	**4.06**	**0.91**	**1.89**	**6.85**

Conclusion

Belete and Maracher varieties were found to be the best yielding. Stability parameters similarly selected varieties Belete, Maracher and Gera as the best yielding and more stable. Belete and Gera varieties were preferred by the participant farmers. Hence, Belete, Maracher and Gera varieties were recommended for wide production in high and mid altitude areas of North Gondar and other similar agro-ecologies. In the subsequent year, variety Gera was pre scaled up with the full technology package up at Debark district. Potato varieties are accessible to small scale farmers, through systematic pathway combining a set of activities starting from participatory potato variety selection to variety demand stimulation and grass root level quality seed production and accessibility has been established. Field days and exchange visits conducted revealed that farmers and each stakeholder made aware of the availability of improved seed in their area and economic advantage of seed production. Technology scale up does not end here; it is the beginning to solve the problem of continued use of the unproductive and low quality variety in the area. In sum, this potato technology package scaled up through participant farmers has shown promoting group action among small-scale farmers as a promising area for quality seed production.

Recommendations

First, changing farmers' attitude about quality seed production was a constant challenge i.e. quality seed production, tuber seed storage and uncertainity on improved variety and implementation of agronomic practices. Second, there should be an effort to increase the awareness of the neighbouring farmers on the availability of improved varieties in the area. Third, without proper participation of key actors, there had been some failed experiences in the past with seed multiplication. It was realized that farmers lacked the relevant skills and knowledge to carry out seed production as a business but it is also an area of focus which requires more investment and technical backstopping for sake of sustainability. This success story should be further scaled out by the districts offices of agriculture and cooperative promotion.

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Pre-scaling up of Improved Tef Technologies in Moisture Deficit Areas of Wag -Lasta, Eastern Amhara, Ethiopia

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Abstract

The study was carried out in Wag-lasta areas, aiming to transfer best performing tef technologies to the wider community. Two improved tef cultivars namely Kuncho and Zoble with their full packages had been promoted for two consecutive production years. A total of 254 participant farmers who had 0.25 ha on average and entirely 71.95 ha clustered farmland were selected. The result indicated that, the performance of both improved tef varieties had shown significant difference over the local varieties in all locations. Accordingly, Zoble and Kuncho tef varieties had a yield advantage of 19.9 and 31.7% over the local varieties in Wag and Lasta areas, respectively. On the other hand, out of partaker farmers 78.8% were highly interested to cultivate the varieties by next year and the remaining 21.2% refused to plant; because of labor shortage and technical skill gap for package application. The linear regression model result indicated that sex, age, farm size and perception are statistically significant variables affecting farmers' full package application. Farm size and perception as the technologies are labor intensive are factors adversely affecting package application while the remaining two variables enhance farmers' package application. Generally, 1888 farmers and stakeholders attended the field day and 90% in Wag and 100% in Lasta were rapt and promised to take the varieties in the future. Among partaker farmers 54.3% were diffused 429 kg of both varieties for 112 fellow intent farmers, amid 32% of them are in the village while the rest were strangers. Thus, it's safely suggested for further scaling up/out of the tef technologies through establishing sustainable seed multiplying cooperatives in the respective locations. Besides, mechanization research should take heavy duty of inventing simple row seeder apparatuses in order to ease farmers' labor burden.

Key words: Compatibility, clustering, field day, improved varieties, pre scaling up and perception

Introduction

Teff (*Eragrostis tef*) is the most important and traditional staple cereal crop in Ethiopia and is grown extensively under various climatic and soil conditions. It is a dominant cereal accounting about 32% of the total cereal production (MoARD, 2007) and provides over two-thirds of the human nutrition in Ethiopia (Lacey and Llewellyn, 2005; Stallknecht et al., 1993). It is the most preferred crop in utilization to other cereal crops not only for the higher milling efficiency and baking returns but also for the superior quality *injera*, pancake-like soft bread forming the major portion of the favorite staple dish in the country. Its straw also has got several utilities serving primarily as fodder for cattle, and sometimes as bedding material, mulch and local fuel source. Add to this, tef is an important source of cash income for the farmers because of the higher prices for both its grains and straw than those of the other cereals (Hailu *et al.*, 2003).

Despite the above facts, tef productivity is much less than any other cereals both at national and regional levels. The national productivity of major cereals during *meher* season in 2013/14 was tef 1.465, barely 1.872, wheat 2.445, sorghum 2.283 and maize 3.254 t/ha (CSA, 2014). Similarly, tef is the leading crop both in area coverage and volume of production in Amhara region and its productivity (1.495 t/ha) is greater than the national average. The same holds in Wag-Lasta areas, where tef is the second in Wag and the first in Lasta in area coverage with the productivity of 1.251 and 1.336 t/ha, respectively (CSA, 2014). Still tef remains the less productive enterprise as compared to other cereals not only in the region and study areas but also in the country. To alleviate this low productivity and production problem, Sekota Dry Land Agricultural Research Center has been pursuing variety selection and adaptation trials with their agronomic practices to recommend best technology packages.

For this purpose, the center has organized farmers into FREG to select the best performing technologies through participatory evaluation of the different varieties such as *Simada, Kuncho, Zoble,* Dz-01-1285 and local varieties planted on farmers' plots in three locations namely Lasta (Lalibela), Woleh (Sekota) and Dahna with three times replicated in each location. Farmers then selected the best technologies that are fitting to their interest in productivity, volume of straw, earliness, and marketability related to seed color. To this effect, Kuncho and Zoble were selected in Lasta and Dahna district, respectively. Over the previous years, technologies had been demonstrated on scattered farm lands of early adopters. With this approach of technology dissemination, early adopters are the key targets who can easily adopt the technologies and thereby influence other neighboring farmers to adopt such technologies.

However, nowadays a clustered approach has become a more successful approach than the previous one (Lilja, N. and J. Ashby, 1999). This is due to the fact that clustered approach creates a good

opportunity for farmers to compete each other for the production of high quantity and better quality yields by applying the recommended agronomic practices and properly managing their fields. Moreover, it helps to control pests, attract eye of the other farmers and thereby stimulates them to ask, observe, and finally adopt the technology. All these benefits besides to others necessitated the scaling up of *Kuncho and Zoble* technologies in Lasta and Wag areas, respectively. This study, therefore, generally aims to transfer the best performing *tef* technologies to reach wider communities at large specifically through creating higher demand for scaling up and establishing a sustainable technology multiplication and dissemination system via linkage creation among possible actors in the supply chain of tef technologies mainly by strengthening the seed producer and marketing cooperatives.

Materials and Methods

The pre-scaling up of t*ef* technologies had been done for two consecutive production years of 2014 and 2015 in potential areas of Wag-Lasta. Before implementation of the scaling up activities, socioeconomics and agricultural extension research directorate (SEAERD) organized familiarization workshop with stakeholders living around the pre-scaling up sites to create awareness and share responsibilities; and finally signed memorandum of understanding (MoU). Since, it's vital to promote the extension approach to different hierarchy of government and NGOs to enhance technologies[3] dissemination to the wider areas having similar agro-ecologies. The major stakeholders were different level (zonal, woreda and kebele) agricultural offices of Wag -Lasta, Sekota Dry-land Agricultural Research Center and NGOs working on agricultural development in the respective areas.

Totally, 265 (57 female) farmers were selected to partake in pre-scaling up during the two production years, among which 139 in the first and 126 in the second year of pre-scaling up. More specifically, 57 farmers from Lasta and 82 farmers from Wag areas in the first phase, while 69 farmers (Lasta) and 57 farmers (Wag) in the second phase who have clustered farms were picked to host the pre-scaling up. Two improved *tef* varieties of *Kuncho* and *Zoble* with their full packages in Lasta and Wag areas respectively were promoted on the basis of their agro ecological adaptation. Average farm size allotted for pre-scaling up was decided by DAs and researchers to be between 0.25 - 0.5 ha per farmer so as to reach large number of farmers with the technologies and create equity among communities in technology access and supply. Researchers and DAs together have chosen farmers while DAs also measured farmers' field using GPS, thus a sum of 71.95 ha clustered land was certain. All farmers got training on basic agronomic practices to create awareness about the technologies and the extension approaches. The researchers provided the training for both participant farmers and agricultural experts who are working in the pre scaling up areas to assist farmers during the application.

[3] In this paper 'technology' is used interchangeably with full package application (sowing improved *tef* varieties: in row, with recommended fertilizer and seed rate, optimum tillage-3 times, weed management-2 times and using chemical [karate] for shut fly as required)

Planting was done in row at 10 kg/ha seed rate. Fertilizer was applied as per the recommendation (at the rate of 50/100 kg/ha UREA and P_2O_5, respectively as well as UREA was split in two equal lots to apply at planting and tillering stages). Weeding and other management practices were done as required. Karate 5% E.C chemical at 0.4 liter/ha was used for shoot fly *(Delia armbourgi)* control. Moreover, agricultural experts and researchers continuously followed up the pre-scaling up activities of the farmers while at the same time provided technical assistance starting from land preparation to harvesting. Field days were organized in both locations with the participation of farmers and other stakeholders targeting to evaluate the performance of technologies in a participatory manner as well as to promote the technologies for wider community.

Semi-structured questionnaire was used to guide farmers' interview to collect their individual views onto the technology packages. Out of 265 participant farmers, data from 11 farmers (3 in the first and 8 in second production year) were not collected due to the outbreak of certain shocks (flood and shoot fly attack) damaging the yield . Hence, the study used data collected from 131 and 143 farmers in Wag and Lasta areas, respectively. Data on grain and biomass yield on farm basis were collected. Farmers' preferences were collected and analyzed using likert scale rating method. The collected data was analyzed using descriptive statistics and econometric model. The linear regression model was used to analyze factors that determine participant farmers' package application in the pre scaling up. Thus, both analysis methods were subjected to SPSS (version-20) and STATA-14 soft wares.

Results and Discussion

Characteristics of pre-scaling up participant farmers

As depicted in Table 1, the average age of pre scaling up participant farmers from Wag and Lasta areas were 42.1 and 40.7 years with mean farming experience of 22.2 and 28.8 years, respectively. As to the households' composition, 14.5% of the participants in Wag and 20.3% in lasta were female headed but in both areas most farmers were engaged to marriage. Their respective average family size was 5 and 4.3, indicating that most households had sufficient labor for technology package application. The educational status of participants also determines extension internalization and technology application. Hence, 49.6% of the participants in Wag were illiterate and the rest were literate from read and write to college level. While in Lasta, 23.6% were illiterate and 76.4% attended school from informal to formal college level. Though utmost farmers were literate, their community partaking was limited to religious duties and kebele level politics. This suggests that more than half of the pre-scaling up participants in both sites were educated and not much busy in other community activities so that they are pretty better for applying the technologies.

Besides, 96.1% of the pre-scaling up participants have got training; among which 26.8% agreed that the training was not sufficient enough especially in terms of practical aspects and even provided for very short time as a highlight. Hence, they strongly believed that the training could not help to improve their skill and knowledge of technology application. But, they agreed that the trainers had no skill gap to train, except shortage of time to cover all necessary lessons of the training. While insignificant number of farmers reported that the trainers have used technical terms and even had communication barrier as they frequently used English.

Table 1. Household characteristics of participant farmers across Wag-himra and Lasta, n=254

Variables	Wag-himra (n_1=131)	Lasta (n_2=123)
Age (years)	42.1	40.7
Farming experience (years)	22.2	28.8
Female headed households (%)	14.5	20.3
Marital status (%)		
Married	90.8	82.1
Single	2.3	6.5
Divorce	3.8	8.1
Widowed	3.1	3.3
Family size	5	4.3
Educational Level (%)		
Literate	49.6	23.6
Illiterate	50.4	76.4
Community participation (%)		
Religious positions	6.1	1.6
Political positions	30.5	30.9
No participation	63.4	67.5
Trained farmers (%)	97.7	94.3

Agronomic conditions of pre-scaling up farms

Effectiveness of the technology is directly linked with the agronomic status of the farm land; which means a well prepared farm will produce yield as expected potential of the variety sown. Since tilling frequency of cultivable land determines the technology's productivity, the agronomic findings of these two varieties recommended that 'three times tilling is an optimum level'. But, as the pre scaling

up data indicated, in Wag areas 61.1% of participant farmers were tilling at sufficient level (three times) while the remaining 32.0 and 6.9% were tilling above and below the optimum level (≥ 4 and ≤ 2 times), respectively. In Lasta areas, 67.5% participants were tilling at optimum level (three times) while the remaining 32.5 were tilling above optimum (≥ 4 times). The variation was due to household's accessibility to draft animals and labor; those poor households and women were the ones who ploughed at minimum level since they lacked draft animals and at the same time women could not plough by themselves due to cultural taboo.

As a result, most women participants were either recruiting laborers or requesting their relative men to assist in plowing their farmlands. Working main agronomic activities on periodic bases has a direct relation with the effectiveness and productivity of a given technology/variety. Hence, the two years' pre-scaling up data result indicated that 98.4% of the participant farmers were planting on the exact time while 1.6 % was planting early and late. This is due to inaccessibility of draft animals and labor mainly for female headed households. Similarly, 88.6% of them had good and very good weed management while the rest 11.4% farmers' field was invaded by weed. They justified that the use of fertilizer aggravated weed growth frequency, so that to have pure field free of weeds at minimum three times weeding was needed but due to shortage of labor and time they didn't do it on time. Moreover, due to weed problem and moisture deficiency 7.5% of the whole participants applied urea split lately but the majority (92.5%) was on time.

Compatibility of technologies

Among other factors ease of applicability of the new technology is playing significant role in technology adoption intensity. As indicated in Table 2, 96.8% of the total respondents reported that row sowing was very difficult because of labor intensiveness, lack of experience, and complexity of technology in order of importance. However, almost all respondents agreed that row sowing was very helpful for ease of management of pests, diseases and weeds. When we see technology applicability, with researchers and experts follow up 91.1% farmers (30.5 ha) in Lasta and 88.6% farmers (34.8 ha) in Wag-himra were sowing the varieties using full packages according to the recommendation. Literally, to mean that most participant farmers were responsive to the extension approach tracked to disseminate and promote *zoble* and *kuncho* tef improved varieties with their full packages. The package includes row sowing, fertilizing with DAP and N at a rate of 100/50 via splitting the latter, using minimum seed rate (10 kg/ha) and applying agronomic practices of optimum tillage and weed management.

Table 2. Farmers' limitation to apply improved tef with full package

Parameters	Frequency	Percent
Complexity of the packages	12	4.7
Lack of practical training	2	. 8.0
Lack of experience	80	31.5
Labor shortage	125	49.2
Both lack of practical training and labor shortage	11	4.3
Both complexity of the technology and lack of experience	18	7.1
Unspecified reasons	6	2.4
Total	254	100.0

Moreover, 84.6% of the pre scaling up participants believed that the technology is labor intensive especially at sowing and weeding stages, 67.7% of them were lacked labor due to small sized family and the remaining 32.3% were young households with no eligible family members. As a result, most pre-scale up farmers have got labor from their households, both from the household and hiring, hiring, both from the household and volunteers, experts and volunteers in descending order to carry out major agronomic activities (from sowing to threshing).

Grain yield and straw biomass of the varieties

Yield is their major criterion for adoption of crop technologies. As the results of yield analysis (Tables 3), indicated that the productivity of improved varieties (*Zoble* and *Kuncho*) was better than the local variety in respective location. In Wag areas, the mean yield of *Zoble* tef variety was 1.6 t/ha, while in Lasta areas it was 1.8 t/ha. The yield variation was observed due to management problems and other agronomic efforts of the farmers in each pre scaling up locations.

Table 3. Grain and straw yield performance of tef varieties across Wag-lasta areas

	Varieties	Min.	Max.	Mean	Std. Dev.
Grain yield (q/ha)	*Zoble*	13.00	20.32	16.24	1.532
	Kuncho	12.00	26.09	18. 34	2.909
Straw biomass (kg/ha)	*Zoble*	1560	5076	3103.2	11.34
	Kuncho	2610	5076	63.88	3832.8

Hence, the pre-scaling up result showed that the use of *zoble* and *kuncho* improved varieties under farmers' condition would ensure a yield increment of 0.27 and 0.44 t/ha compared to the yield report (CSA, 2015) 1.35 and 1.39 t/ha for Wag and Lasta areas respectively in the same production year.

Therefore, the use of *zoble* and *kuncho* improved varieties had 19.9% and 31.8% yield advantage over other locally available varieties in Wag and Lasta areas, respectively. Moreover, farmers in both areas applaud the greater potential of the respective improved varieties straw biomass productivity simply comparing with the local varieties' potential tracing back to past years.

Farmers' attitude and perception to the technologies

The results of Likert scale analysis (Table 4) showed that all of the respondents agreed and strongly agreed on good germination and vegetative performance of both *zoble* and *kuncho* tef varieties in Wag and Lasta areas. Here the farmers reported that almost all seeds dropped to the field germinated in good stand and had relatively longer spike and wider leaves. Similarly, almost all of the respondents in respective pre scaling up areas agreed and strongly agreed that the seed setting performance of the two varieties was good although 1.6% in Lasta and 1.5% in Wag-himra disagreed. Their justification was it had bigger head size relative to the varieties in the locality but few farmers criticized its seed setting performance was not good as compared to its big physical stand.

Moreover, 49.6 and 78.6% of the respondents from Lasta and Wag respectively had negative reflection to the pest resistance capacity of their respective varieties, as they were susceptible to shoot fly attack. However, most of them reported nothing about the variety's disease resistance capacity because fortunately tef is not susceptible to diseases and even no registered outbreak yet. In case of maturity, almost all of the respondents agreed and strongly agreed as it was early maturing, while 9.2% in Wag responded to the contrary as it was late maturing especially in black and moisture rich soil types; plus it maintains its greenness for longer period as long as rainfall is available. Almost all respondents in both areas agreed that the varieties were highly market sensitive due to their pure and white color; especially people who have restaurants were primary customers of the varieties as they need for white and high quality *injera*. As result, *zoble* and *kuncho* varieties had got better price than other tef varieties and 93.7% respondents were also interested with its water allotment (*wuhamansat)* potential in *injera* making. Concerning thresh ability conditions, almost all respondents agreed that there was no clear difference between the local and improved varieties because its directly linked to the dryness; which means that very dried one is easy to thresh and vice versa.

Table 4. Likert scale results on farmers' perceptions about performance of improved tef varieties across their selection parameters, n=254

Parameters	Varieties	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The technology (full package) is easy to apply	1		14.5	1.5	70.2	13.7
	2	2.4	21.2		63.4	13.0
The technology is labor intensive	1	20.6	3.8	0.8	26.7	48.1
	2		16.3	7.3	31.7	44.7
Germination performance of the variety is good	1				67.9	32.1
	2				49.6	50.4
Vegetative performance of the variety is good	1				66.4	33.6
	2		4.0		54.5	41.5
Seed setting performance of the variety is good	1	55.7	42.7	1.5		
	2			1.6	39.0	59.4
The variety is disease resistant	1			61.1	38.2	0.8
	2			56.0	41.5	1.5
The variety is pest resistant	1	36.6	42.0	3.1	17.6	0.8
	2		49.6	18.7	31.7	
The variety is early maturing	1		9.2	2.3	28.2	60.3
	2				25.2	74.8
Improved variety increased yield and productivity	1			2.3	59.5	38.2
	2		2.4	2.4	56.2	39.0
Straw biomass of the variety is good	1				55.7	44.3
	2			6.5	42.3	47.2
Marketability of the variety is good	1			0.8	39.7	59.5
	2				61.8	38.2
The food (*injera*) quality of the variety is good	1			12.2	30.5	57.3
	2			5.7	26	68.3

Note: 1= stands for ***zoble*** while 2= for ***kuncho***; numbers (values) are in percentage points

Farmers' interest and technology demand creation

Out of the pre scaling up participant farmers 78.8% were highly interested to cultivate these varieties with their full packages by next year but the remaining farmers refused to continue and/or not decided

yet. Those who refused to continue were due to labor shortage in the household and technical skill gap to apply. However, largest portion of the participants were proudly endorsed other eligible neighbor farmers to implement through amplifying the merits of the technologies via telling the success story, inviting physical visit and using both approaches. Hence, from endorsed farmers, the majority were optimistic to take by next year while the rest 5.5% and 7.7% were laggard to take and without response respectively; due to being pessimists and cynic in nature. Generally, most of pre scaling up participant farmers were very happy with the varieties productivity and experts follow up starting from farm preparation up to harvesting though the technologies seems complex initially. At the same time, the advantages of these technologies were not limited to better grain yield but stretched from high straw biomass up to quality grain with better market ultimatum and price.

Table 5. Farmers' interest and demand for the technologies

Variables		Frequency	Percent
Will you plant in row by next year?	Yes	200	78.8
	No	24	11.6
	Not decided	30	11.8
Will you recommend others to adopt?	Yes	239	94.1
	No	15	5.9
How do you told to farmers?	Showing Physically	195	83
	Telling story	10	4.3
	Both	30	12.7
What was their response?	Positive	204	86.8
	Negative	13	5.5
	No response	18	7.7

Determinants to full package application in tef pre scaling up

Variables hypothesized to influence farmers' full packages application in crop technologies were multifactorial, consisting demographic and socioeconomic features in which target farmers are expressed. Thus, based on the theory and researchers' understanding of the contextual setting, eleven variables were examined for their influence using simple econometric model. The dependent variable was considered as continuous since farmers were asked the number of proficient packages from entire packages. According to the model outputs, four variables (sex, age, farm size and perception as

technologies as labor intensive) are statistically significant variables affecting the package application of farmers (Table 6).

Farmland size in hectare and perception as technology is labor intensive are factors adversely affecting package application while the remaining two variables enhance farmers' package application. The marginal effect result depicts that being male headed household increases package application by 13.6% at 5% significance level; this may be because male farmers are closer to extension services and information than female. Older farmers also have the probability of applying the package though the marginal value is trifling (0.4%) at 10% significance level. However, farmers with large farm size have limited chance to apply the package; hence a hectare increase in farm size will cause a 23.6% decline in package application. This is possibly due to the fact that higher farm size will compete with household's labor and farming managerial times devoted for the package. Alike, farmers who perceived technologies as labor intensive had negative likelihood to apply the packages at 5% significance level. Thus, it will result in 1.3% decline in package application as far as they alleged the technologies are labor intensive. The predicted value of the dependent variable is about 0.89. The antilog of this predicted value is 4.64, suggesting that farmers were using this amount of packages from the entire 6 full package activities as predicted by all the variables.

Table 6. Estimation of factors influencing tef package application in Wag-lasta areas

Variables	Coef.	Std. Err.	dy/dx	P > t.
Sex of the farmer	0.136	0.055	0.1357*	0.014**
age of the farmer	0.004	0.002	0.0041	0.090*
Farmland size in hectare	-0.236	0.141	0.2362	0.095*
Marital status of the farmer	-0.004	0.049	-0.0037*	0.940
Family size of the farmer	-0.002	0.011	-0.0024	0.826
Education level of the farmer	0.005	0.008	0.0047	0.574
Community participation	-0.010	0.034	-0.0102*	0.766
Farming experience	-0.001	0.002	-0.0002	0.924
Training access of the farmer	0.002	0.105	0.0021*	0.984
Technology is labor intensive	-0.013	0.015	-0.0126*	0.026**

**, * labels significance level at 5 and 10%; (*) dy/dx is for discrete change of dummy variables from 0 to 1

Creation and strengthening of linkages

At the end of pre scaling up activities, field days were organized in each location. A total of 1481 (471 females) in Wag and 407(89 females) in Lasta areas were attending the event, including farmers, agricultural experts, mass media, NGOs and politicians. Different stakeholders visited the technologies and took lessons of working in collaboration for the benefit of poor small holder farmers who are struggling with food insecurity stemmed from stumpy agricultural productivity. During the field days, data were collected about participants' perceptions and reaction towards the technology through focus group discussion (FGD). Therefore, as a feedback 80% of the participant farmers in Wag and 100% in Lasta were interested in the technologies and promised to use the improved tef varieties with their full package by next year.

Improved varieties' seed diffusion

Among the methods used for wider dissemination of improved varieties, strong seed exchange system takes the lion share. Therefore, farmers in both scaling up sites shared the varieties for those interested in and outside the village via different exchange arrangements (in cash and in kind). Hence, from total participants 54.3% shared 429 kg seed of both varieties for 112 fellow interested farmers, among them 32% were from the village and the rest were strangers.

Table 7. Farmers seed exchange and dissemination in both pre scaling up locations

	Number of farmers who shared the seed	Number of receipt farmers within the village.	Number of receipt farmers outside the village.	Amount of seed exchanged in kg.
Frequency	138	36	72	
percentages	54.3%	32%	68%	429

Conclusion and Recommendation

The pre scaling up results clinched that improved tef varieties with their technology packages provided better advantage both in grain and biomass yield. Additionally, strong demand for the technologies was created to farmers and other stakeholders (agricultural offices from zonal to kebele levels and different NGOs working on agricultural development in the study areas). The econometric model result indicated that household features like sex, age, farm size and perception as technologies are labor intensive are statistically significant variables affecting the package application of farmers. Farmland size in hectare and perception as technology is labor intensive are factors adversely affecting package application while the remaining two variables enhance farmers' package application. From these conclusions, the authors recommend that *Kuncho* and *Zoble* tef improved

cultivars with their agronomic packages should be further scaled out in similar agro-ecologies via concerned stakeholders. Also, seed producer and marketing cooperatives should be established and play pivotal role to make technology multiplication and transfer system sustainable to satisfy the greater demand and publicize the technologies broadly. Furthermore, mechanization research should take heavy duty of inventing simple row seeder apparatuses in order to ease farmers' labor burden during planting.

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Success of Technology Transfer for improving Tef Production in Vertisols Areas of North ShewaZone, Ethiopia

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Abstract

Tef is the major cereal crop grown by most smallholder farmers in Ethiopia. It is primarily grown for the purpose of domestic consumption. Scaling up of the selected variety has been implemented in four districts of Moretinajiru, Ensaro, Siyadebirnawayu and Merhabete in North ShewaZone of Eastern Ethiopia for the last four years. During the study period 64.11 quintals of seed was distributed to 436 farmers (more than 14% were females) and covered 206.39 hectares of land. This would lead to a total yield of 45.3 tons of seed, and supported the seed supply system in those districts for more than 1000 smallholder farmers accessed from the technology hosting farmers. Nowadays as land becomes increasingly scarce, area expansion could not be an option for improving production; rather it is better to use improved technologies having high yield performance with other quality parameters to enhance productivity.

Key word: Tef; technology; pre-scaling up; seed, key words here

Introduction

Compared to other cereals, tef is considered a lower risk crop as it can withstand the adverse weathers (Fufa et al., 2011). Much of the increase in crop production has been due to increases in cultivated area. But, the area expansion is limited for such type of crops due to diversity of agro ecology and wide adaptation capacity of its nature. In Ethiopia five major cereals (Tef, wheat, maize, sorghum, and barley) occupy almost 78% (8.7 million ha) of the total cultivated area and 85% in total production volume. Tef accounts for 22.23% area coverage and 16.28% in production volume, respectively (CSA, 2013). Tef is Ethiopia's most important staple food crop by area and value (Bart M. *et al.*, 2013).

Among cereals, tef accounts for the largest share of cultivated area (28.5 percent in 2011), followed by maize (with 20.3 percent). Tef is second (to maize) in terms of quantity of production. Its market price is often two to three times higher than that of maize. Tef accounts for the largest share of the total value of cereal production. In terms of production beneficiaries, tef is grown by more than 6.2 million farmers (CSA, 2013). Since tef farm operations such as land preparation, weeding and harvesting are labor intensive compared to other cereals, with limited availability of suitable mechanical technologies, there are no large scale tef producer farmers in the country (FAO, 2013).

Tef takes the lion share in the total value of cereal production. Tef is grown by a total of 6.2 million farmers (Demeke and Marcantonio, 2013). Agriculture sector makes up 45% of GDP of the country; tef makes up 7.6% of agriculture sectors GDP (Gebremedhin Berhanu & Tegegne Azage, 2012). Increases in national production of tef leads to greater overall economic growth than similar increases for maize & wheat (IFPRI, 2012).

Tef is primarily grown in Ethiopia for domestic human consumption. Its grain flour is mainly used for preparing *injera*, which is the favorite national dish of most Ethiopians. Injera baked from tef flour has good odor, flavor, texture, and keeping quality. The grains give higher returns both in flour upon milling (i.e. 99 percent compared to 60-80 percent from that of wheat) and in *injera* upon baking. The flour is also used for the preparation of porridge and *kita* (non-fermented unleavened bread). Sometimes the grain is also brewed into a native beer, *tella* and a traditional alcoholic liquor, *Katikalla* or local *arakie*. Alternative tef dishes such as tef breakfast cereal, tef waffles, tef banana bread and the like are appearing in the western world particularly in the USA (citation…). Tef straw *(chid)* is the main source of feed for ruminants in various agro-ecologies of the country and also used for construction purposes.

Regarding the nutritional quality, tef straw ranks first among cereal crop residues produced locally and animal performance data especially growth or fattening responses indicated that tef straw is better than native grass hay (Tekilu Tesfay, unpublished). Farmers are aware of these merits and they

usually feed tef straw to the most productive animals. Furthermore, the straw also serves as a binder of mud used for plastering walls of local houses. Overall, the area devoted to tef cultivation has shown an increasing trend owing to the versatile merits of tef to the Ethiopian farmers. Firstly, both the grain and straw fetch a relatively higher price in the market as compared to other cereal crops. Secondly, tef is an excellently adapted crop to the changing environments in the country and, therefore, farmers face low risk. Tef is a better choice which has a potential to get some harvest in some environments where farmers face a complete crop failure due to moisture stress. Moreover, the extensive cultivation of tef by the Ethiopian farmers is often motivated by a high cash income from the grain and straw.

Both the grain and straw fetch the highest prices as compared to those of other cereals do. Tef will remain an important commodity in the country for its grain and straw in the future. The fact that Tef has become an export item will also increase farmers' cash income in the future. Improving the productivity of this important crop helps the smallholder farmers to improve their livelihoods. Due to these facts, transfer of improved high yielding and high quality tef production technology is very significant for both purposes of grain and straw. This study generally aims to scaling up the promising improved varieties of tef to reach the wider community at large; it specifically aims to create higher demand on the demonstrated tef production technologies in order to build and strengthen linkages among key actors on tef technology transfer, and to enhance tef technology multiplication and dissemination system.

Materials and Methods

The main approaches followed for this particular activity were establishment of multidisciplinary team of researchers and extension workers to support the host and follower farmers in all aspects of technical knowhow. Clustering of farm lands for the purpose of easy monitoring and support and production of quality seed during implementation is very important. Training was also given for participant farmers, extension workers and other stakeholders for four consecutive years focusing on improved production systems based on technologies characters and their agronomic practices, concepts and importance of seed production and marketing approaches and the role of farmers research and extension group (FREG). Field days were also organized in different weredas in different years to enhance farmers' awareness on sustainable seed production and diffusion of the technologies.

The varieties recommended for wider scaling up were selected from the variety adaptation trials implemented in three districts of Moretinajiru, Siyadebirnawayu and Merhabete in nine locations with three replications. A total of 12 varieties including two local varieties were evaluated in 2010 production season. From this experiment Degatef was selected and recommended for Moretinajiru and Siyadebirenawayu districts while Quncho was for Merhabete district.

Responsibility share of tasks

Workshops were organized for the purpose of division of labor and sharing of responsibilities for site and farmers selection with the collaboration of stakeholders (farmers, agricultural offices, cooperatives and research centers). For effective and sustainable technology transfer committed and responsive farmers had to be identified. Farmer to farmer technology exchange was the agreed strategy followed. Main responsible institutions included farmers, Office of Agriculture, Cooperative Promotion Agency, the established Farmers' Seed Producer and Marketing Cooperatives (SPMCs) and the Research Center, whose contributions and responsibilities were clearly identified for sustainable transfer of the technologies.

Accordingly, farmers were responsible for managing their farm lands based on the recommended practices, make ready the necessary inputs timely, produce quality seeds and supply seeds voluntarily at least to other five farmers in the short run and to the established seed production and marketing cooperatives in the long run. Office of Agricultures were responsible for smoothing farmer to farmer seed exchange systems between the participant and nonparticipant farmers, following up and securing availability of inputs both in the required time and amount, initiate the farmers to establish seed production and marketing cooperatives and encourage other farmers to use the improved varieties using field visits and experience sharing among the farmers. The research center was responsible to organize training for farmers, extension workers and other stakeholders; provide initial seeds based on repayment agreements; follow and support the farmers and extension workers and create the room for experience sharing among the farmers during field visits.

Based on the agreement different trainings were provided to farmers and concerned stakeholders. The scaling up activities was implemented by participation of farmers, agricultural experts (development agents and SMS), researchers, seed enterprise and cooperatives. Full package of technology dissemination was applied for successful implementation. Researchers, extension assisted farmers managed the fields based on share of responsibilities. Seed was delivered to the host farmers in revolving basis by the research center. Fertilizer and other required inputs including draft animal, farm implements and labour costs were covered by the host farmers. Technology hosting farmers shared their experiences to other farmers during field day and visiting events. Government officials at federal, regional, zonal and local level, agriculture offices (region, zone, wereda, kebele) heads and experts, government communication office, mass Medias (TV and radio) participated during the field days.

As an exit strategy, seed producer and marketing cooperatives were established in two districts and the seed produced by the host farmers sold to the seed enterprises and farmers are encouraged to

produce the seed. The activity was done for the last consecutive years to sustain the transfer of the technology.

Results and Discussions

For the last four years varieties of Dega tef were scaled up and 64.11 qt of basic seed was distributed for 436 (14.2% female) participant farmers as a result 206.39 ha of land was covered by this improved variety. Improved seed produced by the participant farmers was sold through cooperatives to Amhara Seed Enterprise for the last two years in addition more than 1000 farmers got access to the seed from the host farmers through farmer to farmer seed exchange system. Host farmers were benefited from seed production through selling of seed with 20% premium price and exchange with high value crops in addition to getting high productivity.

Different field days were organized and different stakeholders such as agricultural experts and administrative bodies from regional, zonal and district levels and farmers participated in the events. During the field visit almost the majority of the tef farms were covered by the variety in the highlands of Moretinjiru, Siyadebirnawayu and Ensaro districts. The demand for improved seeds continuously increased from year to year. This demand led to establish seed producer and marketing cooperatives and enabled linkage with the Amhara seed enterprise so as to have market access. The seed enterprise purchased the produced seed with premium price from the established Seed Producer and Marketing Cooperatives in the two districts of Moretinjiru and Siyadebirnawayu.

Fig. 2. Improved Dega Tef variety in large scale production.

Achievements and lessons learned

Two seed producer and marketing cooperatives are established and legalized in Siyadebire and Moretinajiru districts having a member of 135 and 110 participant farmers, respectively. One cooperative at Ensaro district is in the process of establishment. Farmers are very interested to transfer seeds to other farmers and transfer the lists to extension workers. More than 1000 individual farmers visited the technologies during the field days organized by districts offices of agriculture and the research center. Higher officials and political leaders from Federal, Regional, Zonal and district levels visited and evaluated the practice in 2012 and 2013. Now three districts have their own seed sources in a sustainable way. A market linkage was established among farmers, cooperatives and seed enterprise and the area is the main seed source of the improved tef variety for other areas.

Recommendations

Seed growers will provide seeds to the nearest seed production and marketing cooperatives. Technical backstopping about seed management will be provided through training and need assessments. Strengthening the market linkage among the producers with seed demanding farmers and seed enterprises is necessary. Capacity building and technical backstopping are essential for long time sustainability and support of new entrant farmers of seed growers and cooperatives pertaining both financial and managerial aspects through training and supervision.

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Pre-Scaling up of Improved Bread Wheat Technology in Moisture Stress Areas of Eastern Amhara, Ethiopia

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Abstract

The study was carried out to create wider demand on improved bread wheat variety through creating and strengthening linkage among possible actors, and then enhance technology multiplication and dissemination. Hawi improved bread wheat variety has been promoted for the last two consecutive production years in potential areas of Lasta. A total of 78 farmers who had 0.25ha on average and entirely 20.16ha clustered farmland were selected for the pre scaling up. The result indicated that, the performance of hawi technology had 34.8% yield advantage over the local varieties. On the other hand, out of partaker farmers 85.9% were highly interested to cultivate the variety by next year whereas 85.5% of farmers complacently advised other neighbor farmers to use the variety. In general, 407 farmers and stakeholders joined the field day and forwarded their feelings and then promised to use in the future. Therefore, it's recommended for further scale-up/out of the technology through establishing viable seed source and/or seed multiplying cooperatives in the area.

Key words: Bread wheat, compatibility, clustering, pre scaling up, seed dissemination

Introduction

Wheat (*Triticum spp.*) is one of the world's most important cereal crops along with maize and rice. It is reported to have been grown domestically as early as 9000 BC and is now grown in almost all parts of the world. Cereals, including wheat are largely produced by small holders, and consumed as food while residues and by-products fed to livestock (Maggo, 2011). The crop is grown at an altitude ranging from 1500 to 3000 m.a.s.l., between 6-160 N latitude and 35-420 E longitude. The most suitable agro ecological zones, however, fall between 1900 and 2700 m.a.s.l. The major wheat producing areas in Ethiopia are Arsi, Bale, Shewa, Illubabor, Western Hararge, Sidamo, North Gondar and Gojjam zones (Kate S. and Leigh A., 2010).

In Ethiopia, wheat grows in humid and sub-humid agro ecological zones of the highland temperate mixed farming system. The national wheat productivity is below East African and world's average. It ranges from 88 to 99% of the regional average, 77% of African average and 56% of world's average. Domestic wheat production accounts 79% of local supply while the rest is imported (Calvo, *et al.*, 2002). Eastern Amhara especially the North Wollo zone is one of the wheat producing areas of Ethiopia. The area has highland agro ecology suitable to wheat production. However, wheat productivity is below the national average due to low soil fertility, absence of improved wheat varieties, and other inputs such as less utilization of fertilizer and lack of decent management in general (CSA, 2015).

To relieve this problem, Sekota Dry land Agricultural Research Center in its Crop Research Directorate had been adapting different bread wheat varieties and recommend the best performing variety called *"hawi"* with its technology packages to Lasta area and other similar agro ecologies of eastern Amhara. This bread wheat variety has been demonstrated on farmers' fields, and then chances were given for farmers to evaluate the technology from socioeconomic and agro ecological perspectives. Farmers were highly interested with its performance and were motivated to cultivate the variety; hence this situation dictated extension researchers to promote in wider scale. Thus, this study aimed to create a wider demand on *"hawi"* bread wheat technology[4] through creating and strengthening linkage among possible actors thereby to enhance technology multiplication and dissemination as a system.

[4] In this study 'technology' stands for full package application of improved ***hawi*** bread wheat (sowing in row, using recommended fertilizer and seed rates, optimum tillage as well as weed management)

Materials and Methods

Pre-scaling up of *hawi* bread wheat technology has been done for the last two consecutive production years of 2014 and 2015 in the potential areas of Lasta in eastern Amhara. Before the implementation of the activity the socioeconomics and agricultural extension research directorate (SAERD) organized familiarization workshop with stakeholders living around the pre scaling up area to create awareness as well as sharing of responsibilities among actors then to sign memorandum of understanding (MoU). The major stakeholders were agricultural offices of Lasta area, Sekota Dry-land Agricultural Research Center and NGOs dealing with agricultural development in the area. A total of 81 farmers were then selected to participate in the pre-scaling up activity during the two production years, among which 43 were in the first and 38 in the second year of the activity. Average farm size allocated for pre-scaling up was decided by DAs and researchers to be between 0.125 - 0.5 ha per farmer so as to reach large number of farmers by the technology and create equity among communities in technology access and supply.

Researchers and DAs together have picked farmers while DAs also measured farmers' fields using GPS. A total of 81 (19 female) farmers having clustered land of 20.16 ha were selected and got training on basic agronomic practices to make them familiar with the technology in particular and the extension approach in general.

Planting was done in row at 110 kg/ha seed rate. Fertilizer was applied as per the recommendation (at the rate of 50/100 kg/ha N and P_2O_5, respectively as well as N was split in two equal lots to apply at planting and knee height stages). Weeding and other management practices were done as required. The researchers provided the training for both participant farmers and agricultural experts who are working in the pre scaling up areas to assist farmers during technology application. Moreover, agricultural experts and researchers continuously followed up the pre-scaling up activity while at the same time provided technical assistance starting from land preparation to harvesting. From the total 81 farmers, data of 3 farmers in thesecond production year were not collected since farmers were not in the village during data collection. Finally, field day was organized with the participation of farmers and stakeholders aiming to evaluate the performance of the technology and thereby promote the technology to the broader community.

Structured questionnaire was employed to collect farmers' views about the technology. The collected data were quantitative and qualitative in nature. The quantitative data on grain and biomass yield on farm basis were collected. The qualitative data are like perception and attitude of farmers towards bread wheat technology specifically; germination and vegetative performance, pest and disease resistant capacity, weed management, quality in food preparation, water allotment capacity *(wuhamansat)*, marketability, earliness and other criteria of farmers in comparison to the local variety.

The collected data were analyzed using descriptive and inferential statistics using SPSS (v-20) software. Farmers' preference was analyzed using likert scale rating method. Cronbach's alpha was checked assessed the internal consistency of a questionnaire (or survey) that is made up of multiple Likert-type scales and items. Besides, thematic oriented narration was used to analyze the qualitative data obtained from FGDs.

Results and Discussion

Characteristics of pre-scaling up participant farmers

The average age of pre scaling up participant farmers was 42.1 with mean farming experience of 21.2 years. This is plainly to mean that most participant farmers were relatively in active age strata that may assist them to understand the extension advices and the new technology. Among partakers, the most were engaged to marriage while 23.1% were female headed. The average family size was 3.9, which indicates that utmost farmers had sufficient labor for technology application particularly for row sowing. The educational status of participants also determines extension internalization and technology application. Hence, 44.9% of the farmers were illiterate and the rest were literate from read and write to college levels. Although significant numbers of participants were literate, their role in the community was limited to religious and political participation. All pre-scaling up participant farmers have got training; among which 33.7% agreed that the training provided was not adequate enough practically to apply the technology packages. Accordingly, they described that the delivered training was not adequate to improve their skill and knowledge on the technology.

Table 1. Household characteristics of participant farmers in Lasta, n=78

Variables	Frequency	Percentage points
Age (years)	-	42.1
Farming experience (years)	-	21.2
Female headed households (%)		23.1
Marital status (%)		
Married	69	88.5
Divorce	3	3.8
Widowed	6	7.7

Variables	Frequency	Percentage points
Family size	-	3.9
Educational Level (%)		
Literate	35	44.9
Illiterate	43	55.1
Community participation (%)		
Religious positions	5	6.4
Political positions	24	30.5
No participation	49	63.4
Trained farmers (%)	78	100

Agronomic conditions of the pre-scaling up farmsteads

Since tilling frequency of cultivable land determines the technology's productivity, hence the agronomic findings of the *hawi* variety recommended that 'three times tilling is an optimum level'. But, as the pre scaling up data indicates, 65.4% of partaker farmers were tilling at sufficient level (3 times) while the remaining 34.6 were tilling exceeding optimum level (≥ 4 times), respectively. The variation was due to household's accessibility to draft animals and labor, as well as the soil type and slope of the farmland determines the tillage frequency. As a result, most women participants were either recruiting laborers or requesting their relative men to assist in plowing their farmlands. Performing main agronomic activities on periodic bases has direct effect on the productivity of a given variety. Hence, the pre-scaling up data result indicated that 97.4% of the participant farmers were planting on the exact time while 2.6% was planting lately due to lack of draft animals. Similarly, 89.8% of them had proper weed management while the rest 10.2% farmers' field was invaded by weed. They justified that traditionally weeding wheat is offensive for high straw biomass and even due to labor and time shortage they can't manage as required.

Compatibility of the Technology

Among other factors ease application of the technology is playing significant role in adoption intensity. As indicated in Table 2, 55.2% of the respondents reported that technology application in general and row sowing in particular was very difficult due to lack of practical training, complexity of the technology and its labor intensiveness in order of significance. However, almost all farmers agreed that row sowing was very helpful for ease management of pests, diseases and weeds. When we

see package application, with researchers' and experts' follow up 88.5% farmers' in17.9 ha were sowing the variety using the full package. Moreover, 62.8% of the pre scaling up partakers believed that the technology is labor intensive especially at sowing time, thus 70.5% of them were faced labor scarcity due to absence of eligible family members. Nonetheless, most pre-scaling up partaker farmers were getting labor both from their household as well as employed laborers to carry out the foremost agronomic activities (from sowing to threshing).

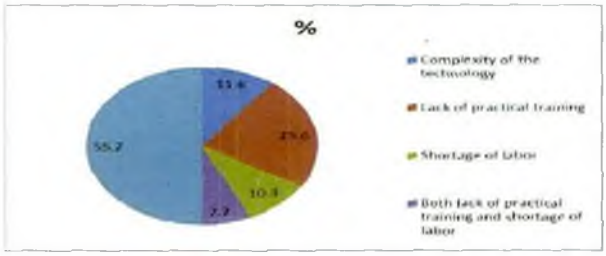

Fig. 1. Farmers' limitation to apply improved tef with its full package

Grain yield and straw biomass

Yield is farmers' main criterion in adopting any crop technology. The analysis result (Tables 2), indicated that the productivity of *hawi* improved variety was better than the local variety. The mean yield of *hawi* bread wheat was 2.5 t/ha, thus it had a yield increment of 0.658 t/ha as compared to CSA's yield report of 1. 9 t/ha released for the pre scaling up area in the same production year. Therefore, using *hawi* improved variety with its full packages had a yield advantage of 34.8% over locally available wheat varieties. Similarly, straw biomass productivity of the variety was better than the local varieties; hence farmers got averagely 3688.7 kg/ha straw biomass.

Table 2. Grain and biomass yield of hawi bread wheat variety in Lasta

	N	Min.	Max.	Mean	Std. Dev
Grain yield (t/ha)	78	2.3	3.6	2.5	2.698
Straw biomass (kg/ha)	78	2770	6250	3688.7	13.197

Farmers' attitude and perception to the technology

As described below (Table 3), most farmers agreed and strongly agreed on the complexity of the technology as well as its labor intensiveness. The respondents also had positive view on germination, vegetative as well as seed setting performance of the variety. Moreover, over half of the farmers have positive insight on the variety's earliness, straw biomass and marketability. As to maturity, they

conceitedly said that "it was sown lately since it has to be sown in good moisture but harvested as earlier as the local variety". Its high marketability was stemmed from bigger size and white seed color hence people wanted for bread baking and church due *(gibir)*. However, very few farmers had no notion on disease resistance capacity due to yellow rust observation especially in the seed setting time. Still few farmers had negative view on the variety's pest resistance capacity as it was susceptible to bird's attack. A reliability analysis was carried out on the perceived levels of the technology scale comprising 12 items. The statistics table gives coefficient and a score of over 0.7 showing high internal consistency. In this case, $\alpha = .83$, which shows the questionnaire is reliable. Cronbach's alpha showed the questionnaire to reach acceptable reliability, $\alpha = 0.83$. Most items appeared to be worthy of retention, resulting in a decrease in the alpha if deleted.

Table 3. Likert scale results on farmers' perceptions on improved wheat variety, n =78

Parameters	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Item means
The technology is easy to apply	--	16.4	8.3	50	25.3	3.74
The technology is labor intensive	17.9	--	2.6	29.5	50	3.93
Germination performance is good	---	--	--	59	41	4.41
Vegetative performance is good	--	--	--	53.8	46.2	4.47
Seed setting performance is good	--	--	--	34.6	65.4	4.33
The variety is disease resistant	--	--	7.6	46.2	46.2	3.44
The variety is pest resistant	--	59	--	41	--	2.63
The variety is early maturing	--	3.8	--	23.1	73.1	4.61
Improved variety increased productivity	--	--	--	50	50	4.51
Straw biomass of the variety is good	--	--	7.5	60	32.5	4.20
Marketability of the variety is good	--	5.1	11.5	46.2	37.2	3.90
The food quality of the variety is good	--		10.2	28.3	61.5	4.44
	Cronbach's alpha coefficient $\alpha = 0.83$					

Note: numbers (values) are in percentage points

Farmers' interest and technology demand creation

Among pre scaling up partaker farmers 85.9% were highly interested to cultivate the variety by next year but the rest were refused to plant, because of labor shortage. However, 85.5% of participants recommended other eligible neighbor farmers to use the variety by reporting the merits of the technology via storytelling, physical invitation to visit as well as using both approaches. Hence, from suggested farmers, 85.9% were positive to implement in near future while 6.4% will not accept due to labor shortage even if they were interested in the variety.

Table 4. Farmers' saying and demand for *hawi* bread wheat variety

Variables	Responses	Frequency	Percent
Will you apply the technology by next year?	yes	67	85.9
	no	11	14.1
Will you recommend others to adopt?	yes	69	85.5
	no	9	11.5
Have you told the merits?	yes	72	92.3
	no	6	7.7
What was their response?	positive	67	85.9
	negative	5	6.4
How do you told to farmers?	showing physically	35	44.9
	telling story	7	9.0
	both methods	30	38.5

Establishment and strengthening of linkages

At the end of pre scaling up activity, field day was organized hence a total of 1481 participants (471 females) attended the event; including farmers, agricultural experts, mass media, NGOs and politicians. During the day, data about participants' opinion and reaction to the technology was collected using focus group discussion (FGD). Thus, farmers show full interest to the technology. Again, farmers and other participants evaluated the cluster extension approach. Hence, clustering was appreciated as it creates competition among farmers on farm management; reduces the risk of pest damage as well as having "eye catching" power to impress other individuals about the technology.

Seed dissemination and exchange system

Among the methods used for wider dissemination of improved varieties, solid seed exchange system takes the front line. Thus, farmers in scaling up area shared the variety for those interested residing in and outside the village via different exchange arrangements (in cash and in kind). Hence, from the total participants 48.8% shared 1380 kg seed of *hawi* bread wheat variety for 68 fellow farmers, so that only 42% were within the village.

Table 5. Farmers seed exchange and dissemination in both pre scaling up locations

	Number of farmers who shared the seed	Number of receipt farmers within the village.	Number of receipt farmers outside the village.	Amount of seed exchanged in kg.
Frequency	38	29	39	
percentages	48.8%	42%	52%	1380

Conclusion and Recommendation

The pre scaling up results confirmed that improved wheat variety with its technology packages provided better benefit both in grain and biomass yields. Also, strong demand for the technology was created in the study area by farmers and other stakeholders working in agricultural development endeavors. From the conclusions, the authors strongly recommend that *hawi wheat* improved cultivar with its full packages should be further scaled out to other similar agro ecologies. Likewise, seed producer and marketing cooperatives should be established and play vibrant role to make the technology multiplication and exchange system viable to satisfy the emerging technology demands.

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Pre-scale up of Food Barley Technologies in Learning Watershed Areas, Eastern Ethiopia

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Abstract

Transfer of demand driven research outputs and best practices as development interventions to farmers ensures to feed the future generation. This helps to create higher demand for improved technologies and enhance technology multiplication for wider dissemination. Due to many reasons productivity of barley produced in various parts of the country is below the world's average and the potential. Lack of improved variety is one of the main reasons to low productivity. Amhara region has a share of 38% barley coverage from the country and its productivity is 1.75 t/ha next to maize, rice, sorghum and wheat. In order to facilitate technology transfer and smooth information flow among farmers, researchers and extension workers, different approaches were practiced. Improvement of farmers' production skill and transfer of indigenous knowledge from farmers to farmers and extension workers through theoretical and practical trainings, continuous monitoring and evaluation by different stakeholders and field day evaluation with a team of different stakeholders were the most common approaches practiced during the implementation periods. As a result of the intervention, more than 300 farmers were involved for the access of information about improved barley production technologies through training and field days during the implementation years. Compared to the local cultivar Agegnehu and Basso improved barley varieties resulted better yield advantages of 113 and 111%, respectively. Basing on these achievements, seed production and marketing cooperative (SPMC) is established and farmers' interest to join the cooperative increased from time to time. Provision of seed money, market linkage, and capacity building in management and finance and technical backstopping are very essential for the cooperative to transact seeds and improve technology transfer.

Key words: Food barly; learning watershed; yield advantage; seed effects.

Introduction

Barley is an important food crop in the highland parts of Ethiopia. It is an early maturing, emergency crop bridging the critical food shortage that occurs in September (Kemelew and Alemayehu, 2011). Barley is a versatile crop produced by smallholder farmers in various areas valued for its nutritive purposes as health crop among cereals. Traditionally, barley grains are used to make "*Injera*" and local beers for home consumptions and during festivals. Nowadays it passes through different value added processes and prepared in different forms of food to be eaten or drunk as bread, powder, soup, porridge, roasted grain.

In Ethiopia, barley is one of the main cereal crops grown next to tef, maize, wheat and sorghum. It has 10.6% share of cereal crops in area coverage and production, and its productivity is 1.71 t/ha. Currently, this crop is produced in various areas of the country below the world's average and the potential to be produced (FAO, 2009). It is the fifth cereal crop in area coverage next to tef, wheat, maize and sorghum in Amhara region. The region has a share of 38% barley coverage from the country and its productivity is 1.75 t/ha above the national average next to maize, rice, sorghum and wheat.

North Shewa is the largest barley growing zone from Amhara region (CSA, 2013). Barley is the most dominant crop grown and used as sources of food and income in the intervention watershed area and covers almost more than half of the farm lands during intervention. It is mainly produced for the purpose of home consumption in the form of *injera, kollo, bread, tella* and *besso*. In this particular area barley is the primary crop for the smallholder farmers. It has many opportunities and potential production improvement options which had great attention by the research center to work up on it to bring impacts on the livelihood improvement of individual farmers.

Scaling up of agricultural technologies, therefore, plays a pivotal role in bringing research outputs to farmers and then to the markets. These benefited the producer farmers to have a chance on access to scarce inputs of seed of improved varieties and knowledge. Transfer of the research outputs with best practices and integrate demand driven technologies with development interventions to farmers ensures to feed the future generation. Integrating technology transfer within a research arena *facilitates* technology transfer (Brenner and Buckhalt, undated).

Improved barley technology transfer activity is one of the production improvement options for resource poor farmers who have limited access to the required resources of inputs particularly improved seed in barley growing agro-ecologies. Prescaling up activity was designed aiming to improve the productivity of barley through introduction of high yielding and early maturing varieties to escape the problem of frost. Intensifying efforts through the scaling up of promising agricultural technologies to small scale farmers helps to improve the livelihood of the communities by enhancing

production and productivity. This can also improve food security and reduce poverty through realizing the full potential of agricultural technologies.

Debrebirhan Agricultural Research Center recommended Agegnehu and Basso varieties for the specific areas of North Shewa highlands through technology development and adaptation, respectively. Pre-scaling up of these varieties with their recommended packages in this specific area is indispensable for farmers to be well acquainted with these varieties to grow and improve the productivity of barley. The importance of this specific activity is to strengthen and sustain the informal seed supply system through establishment of seed production and marketing cooperatives. Due to many reasons, the formal seed supply system in Ethiopia has not yet developed well; its function concentrates only on very specific commodities such as maize, wheat and tef.

Since lack of improved seed availability and improved seed supplying institutions are the major causes for low productivity of barley, establishment of seed production and marketing business institutions encompassing this crop enterprise could also be the new opportunity for farmers who have limited access to other alternatives. If strengthened and promoted to involve in this business, seed production and marketing cooperatives would take part to fortify and sustain the technology diffusion system and make easy access of improved seeds for smallholder farmers. The activity was focused on wider demand creation, on the technologies and strengthened the seed system in the locality among the possible actors.

Materials and Methods

During the implementation of the activity, different approaches were practiced in order to facilitate technology transfer and smooth information flow among the farmers, researchers and extension workers. Multidisciplinary team approach composed of researchers, extension workers and farmer groups was used to improve farmers' production skill and transfer of indigenous knowledge from farmers to farmers and extension workers. This was not only useful for farmers and extension workers, but also for the researchers to get organized feedbacks about the technology from end users. Different stakeholders such as farmers, extension workers, administrative bodies, researchers and project donors of Water and Land Research Center (WLRC) and Integrated Seed System Development (ISSD) were involved in pre-scaling up activities with different responsibilities. Sites were arranged in cluster based for different varieties of barley for a total of 113 interested farmers. Site selection was carried out by involving multi-disciplinary team of researchers, extension workers and farmers.

Farmers have been participating in every operational activity of agronomic practices, and monitoring and evaluation while the extension workers played a role of mobilizing the community to participate in technology transfer efforts through seed exchange system. Monitoring and following up of the

activities were done with participatory and collaborative approaches with farmers, researchers and districts and kebele agriculture experts. There were also consecutive site visits made by these stakeholders to follow up the field works. Farmers were organized in groups to learn from each other and following up each stage of crop performances through practical observations and feedbacks at various growing stages.

Key implementation approaches and procedures

To enhance proper implementation of the pre-scaling up activities, the researchers organized trainings on production and management techniques applied during implementation for interested participant farmers and extension workers. The research center supplied improved seeds for farmers based on their technology needs through Farmers Research and Extension Groups (FREG) and Seed Production and Marketing Cooperative (SPMC) agreements to sustain and strengthen the technology transfer system and institutionalize the approaches of effective technology dissemination. Initially WLRC project provided fertilizer inputs to assist the application of the recommended technology packages.

In order to make the technology transfer system sustainably effective, it is necessary to apply certain useful approaches that mainly consider the circumstances of smallholder farmers. Establishment of multidisciplinary team of researchers, and organized farmers in FREG and SPMCs. Provisions of continuous theoretical and practical trainings for farmers and extension workers, continuous monitoring and evaluation and organized field days with a team of different stakeholders were the main duties performed during implementation period.

Trainings were given focusing on improved production systems of barley based on technologies characters and their agronomic practices and the concepts and importance of FRG and SPMC. Awareness creation and practical training on barley seed production techniques and its agronomic practices was delivered to all participant farmers. Field days were organized for the last two years consisting of farmers, researchers, project donors and other stakeholders.

At the end of the activity plan, two workshops at district and zonal levels were organized in 2014 to evaluate the watershed development status and transfer the approaches to responsible organizations. Kebele administrators and development agents from 32 kebeles, different political leaders and experts from their offices, university representatives and instructors participated in wereda level workshop. Zonal office of agriculture representative, zone administrative head, district office of agriculture head, administrative head, and kebele office of agriculture, kebele chairmans, cooperative members and representative farmers took part in zonal workshop.

Results and Discussion

For the successful transfer of technology, training and field day participation of farmers and other stakeholders play a pivotal role especially in creating awareness about the technology with its recommended packages and demand for the technology. Based on these facts, 106 (21% females) from various stakeholders and farmers participated on trainings and 208 (13% females) farmers participated in the training and field-days sessions, respectively in the last two implementation years.

A total of 36.84 hectare of farm land was cultivated by the two improved food barley varieties (Agegnehu and Basso) through in kind repayment bases of seed after production and 46.6 quintal of improved seed was delivered by the research center and distributed for 113 (27 female) host farmers (Table 1).

Table 1. Seed dissemination and number of participants

Area (ha)	Seed (qt)	Participants		
		M	F	T
36.84	46.6	86	27	113

As shown in Table 2, the results of yield analysis revealed that yields obtained from Agegnehu and Basso improved barley varieties, as compared to the local varieties of the control cultivars of the baseline data and the samples of the local were better in productivity with yield advantages of 113% and 111%, respectively. The high difference between the minimum and the maximum yield data implying that there was high variability of yields; this was due to the difference in soil fertility status among the farmers' fields.

Table 2 Average yield (t/ha) of three barley varieties

Varieties	Yield in tons/ha		
	Average	Max	Min
Agegnehu	2.13	3.43	1.2
Basso	2.11	3.3	1.11
Local	1.0	1.26	0.8

Achievements

Farmers' awareness towards improved technologies was increased. Crop varieties that fit to farmers' interest resulted in optimum level of yield depending on soil fertility and management practices. Seed production and marketing cooperative was established and farmers' participation increased from time to time. Farmers' demand for improved barley varieties increased not only in the watershed area but also outside of it. Due to suitability of these varieties to the specific area, farmers sold their produces at remunerative price 12 and 11 Birr per kilogram for Agegnehu and Basso as compared to the local sold with 7 Birr per kilogram to other farmers outside the watershed areas who otherwise have no access to the initial seeds.

Stakeholders' participation and preferences

Different stakeholders and local communities involved in monitoring and evaluation activities. Farmer's awareness and transfer of technologies to adjacent watersheds and kebeles increased tremendously compared to the local variety performance (Fig. 4). During evaluation farmers selected those varieties due to their higher yield, early maturity, disease resistance and tillering abilities. Farmers evaluated the technology during implementation and then technology's home use tests for different purposes after production. Accordingly, Agegnehu was selected due to its seed color, high market demand and early maturity and Basso was also selected due to its frost resistance nature, high productivity of grain and biomass yield and the growing ability on less fertile soils. The yield performance of the varieties on relatively low fertile soil and the wide scale of area coverage in the watershed in the two years period surprisingly impressed the communities.

Partial budget analysis

Production of the improved varieties benefited the host farmers with high net farm benefits of 18,325.00 and 15,525.00 Birr per ha of land for the varieties of Basso and Agegnehu, respectively. The market price was taken as the same market price of 7.00 Birr per kilogram for all grain produced from improved and local variety of barley. When the price is taken from the premium the net benefits of the improved variety was much higher than the local (Table 4).

Table 2. Partial budget analysis of barley production

Items	Local	Basso	Agegnehu
Labor cost (Birr/ha)	1,800	1,800	1,800
Seed cost (Birr/ha)	875	1,250	1,250
Fertilizer cost (Birr/ha)	1,725	1,725	1,725
TVC (Birr/ha)	4,400	4,775	4,775
Av.Yield (t/ha)	1.0	3.4	3.0
Adj. yield (t/ha)	0.9	3.3	2.9
GB (Birr/ha)	6,300	23,100	20,300
NB (Birr/ha)	1,900	18,325	15,525
MRR	0.43	3.84	3.25

Overall success

Because of the intervention, farmers are aware of improved technologies and productivity of their farm lands enhanced through the use of improved technologies. Different stakeholders including office of agriculture, cooperative promotion and organizational office and administrative bodies would become responsible for the future support and following up of the system and acknowledged the approach. Sustainable technology transfer system through seed production and marketing cooperative in local community needs to be established not only for barley but also for all introduced improved technologies.

Lessons drawn from the intervention

The major lessons learned from the intervention are useful for similar interventions in similar areas. Such lessons learned are participatory, integrated, multi-disciplinary, demand driven and stakeholder linkage strategies. These are the best approaches helpful for continuous and sustainable technology transfer and seed dissemination tasks with less efforts and great outcomes. Need based and gap filling capacity development of farmers, extension workers and other stakeholders through training and support are essential for adapting improved management practices and help change the attitudes of different stakeholders. Community participation and institutionalization of the system for sustainable technology transfer through participation of different community groups in problem identification, planning and implementation improved the sustainability of seed exchange and technology transfer options. Enhancing productivity of farm lands of small holder farmers through the use of improved technologies is important instead of fallowing farmlands.

This is important because the productivity of farmlands has declined as a consequence of poor production practices and use of less productive varieties year after year.

Challenges and opportunities for larger scaling up

Farmers in the implementation areas for the consecutive years of intervention shown sustainable and increasing demand for the improved varieties introduced for continuous production improvement and try to implement the recommended packages for similar local cultivars. They improve their production system practices. Farmers have good experiences of barley production for many years and barley is the major crop grown in the area. The agro- ecology and/or the climate is highly suitable for barley production. Farmers have grown barley mainly for home consumption purposes. Before the intervention, farmers used to sell their barley produces to consumers with lower prices but now they have started to sell improved barley seed for barley growers at higher prices. This was not only serving them as source of cash income, but also enhanced productivity and livelihoods of other farmers within and outside of the watershed areas.

However, there are certain challenges that the farmers faced during the intervention. Although the demand for improved varieties has shown an increasing trend, seed shortage was the critical constraint mainly due to limited capacity of the research center to distribute the technologies for further scaling up and financial incapacity of some farmers in the watershed to apply the recommended fertilizer rates at the initial stage.

Recommendations

In the future it is expected that new technologies will be introduced easily through cooperatives with little efforts through simple orientations for the cooperative members and other participant farmers about the technology. Seed money is very essential for the cooperative to purchase and transact seeds through credit system. Technical backstopping is also very essential for farmers and cooperative members through training and market linkages. Capacity building for cooperative leaders and barley growing farmers with respect to financial, material and technical management skill is critical.

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Women Farmers' Participation in Conservation Agriculture: The Case of West Gojam Zone, Ethiopia

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Abstract

This study was conducted at Jigayelmdar and Abchikli Kebeles of Jabithenan and South Achefer Woredas of West Gojam Zone, Ethiopia to identify determinants of women farmers' participation in research and extension with respect to conservation agriculture. Thematic data analysis technique was used for the qualitative data while binary logistic regression model and descriptive statistics were employed for the quantitative data analysis. The binary logistic regression result revealed that as distance from the main road increased, the probability of women participation in conservation agriculture declined. Moreover, the descriptive statistics results posited that women's participation in conservation agriculture is jeopardized by socio-cultural factors such as lack of self-worth of women; the society's belief that women are irrational, submissive, less assertive and are born for domestic chores; development agents and researchers insensitiveness to gender issues and their disinterest to work with women because of their doubt that success could be attained by working with them. The limited availability of credit, the delivery of advisory services by one development agent irrespective of his profession to all sub-kebeles, budgetary constraints of farmers training centers, the minimal commitment of organizations of "one-to-five" and "women's-development-groups" have been found out to be institutional impediments to participation. The focus on progressive farmers, the under representation of women in the kebele administration, lack of political dedication of women's league and civil societies in raising women' consciousness and working closely with them in agricultural activities have been identified as political obstacles to participation. Economic factors such as land and oxen shortage, financial incapacity and expensiveness of inputs have been identified as elements that hurdle women's participation. However, women have been beneficiaries of house-to-house advisory services, experience sharing visits, trainings, demonstrations, field days and tangible technologies to a limited extent. The policy attention given to women, the increased number of extension agents, the existence of agricultural research centers, farmers training centers and the launching of farmers research and extension groups(FREGs) where farmers are participants and "one-to-five" and "development groups" organizations of farmers have been recognized as opportunities of women farmers participation in conservation agriculture. .

Keywords: Participation, Women farmers, Conservation agriculture, Research and Extension

Introduction

Women make essential contributions to the agricultural and rural economies in all developing countries. Rural women often manage complex households and pursue multiple livelihood strategies. Their activities typically include producing agricultural crops, tending animals, processing and preparing food, working for wages in agricultural or other rural enterprises, collecting fuel and water, engaging in trade and marketing, caring for family members and maintaining their homes (FAO, 2011).

Women in Sub-Sahara African countries constitute 70% of the agricultural workers and provide 60-80% of the labor to produce food for household consumption and sale. Ethiopian women play a significant role in the country's agricultural economy and they are largely responsible for producing many of food crops and rearing livestock, particularly small ruminants and poultry (ATA, 2013).

Lemlem *et al.*, 2011 indicated that the overall length of the working day for women does not vary much between the wet and dry seasons. They work for between 10–12 hours per day, half of which is spent on household tasks such as fetching water and firewood, preparing food and caring for children. Thus, women work from dawn to dusk and, in contrast with men; women have little time for leisure or socializing. The majority of the work done by women tends to be economically "invisible." As a consequence, their important role is not translated into an equality of opportunities, especially when it comes to gaining access to productive resources, markets, and services (ATA, 2013).

Women in Ethiopia have not exploited the extension service as such because of different reasons that need to be looked into. This idea has been reinforced by ATA (2013) that some of the greater challenges women farmers face in comparison with their male counterparts include limited access to improved seed varieties, trainings, extension services and output markets.. Similarly, women have hardly been made participants of research activities of trainings, technology evaluation, demonstrations and field days. Agricultural policies have to address women not only because they are half of the total population and shoulder much of the work burden but also they account about 70% of the poor in world.

Taking in to consideration the aforementioned facts, it is imperative to explore the level and determinants of women farmers' participation in the research and extension activities of conservation agriculture (CA) in the intervention areas of West Gojam Zone.

Research Methods

Description of the Study Areas

The study was conducted at Jigayelmdar and Abchikli kebeles of Jabitehnan and South Achefer Woredas, respectively in Gojam Zone of the Amhara National Regional State. Jabitehnan woreda is located 180 km due south from the regional capital, Bahir Dar, and 350 km north from the country's capital Addis Ababa. The total area of the Woreda is estimated to be 1,169.54 km or 116,954 ha. (Source: woreda'office of agriculture). The district divided into 37 rural '*kebeles*'. The total population of the woreda in 2008 was estimated to be 277,590 of which 139,616 are male and 137, 974 female with the 2.8% average growth rate. (Source: woreda plan and economy). The altitude of the woreda ranges from 1500-2300 meter above sea level. The temperature of the woreda'ranges between 14 and 32 ^{O}c. The rain fall distribution of the woreda'is characterized by uni-modal one that lasts for three months from mid-May to mid-September. The average annual rainfall of the woreda is 1250 mm/annum.

South Achefer is the second study area which is located 60 km away from Bahir Dar town, the capital of Amhara Region, in the south western direction. The altitude of South Achefer woreda ranges from 1,500 to 2,500 meters above sea level. The woreda is known for its flat topography. Mountains, valleys and undulated features also exist. 87% of the woreda fall under temperate climate. The remaining 13% have cold climatic conditions. The mean annual rainfall ranges from 1450 to 1594 mm. According to the Amhara Regional State Bureau of Finance and Economic Development 2011, the total population of the woreda is about 148,974. The rural population is predicted to be 134,447, of which, the number of female population is 73,456.

Data Sources

Primary data were collected through focus group discussions (FGDs), key informant interviews and questionnaires where as secondary data were gathered from books, published and unpublished reports, bureau of agriculture, woreda agricultural offices and agricultural research organizations.

Sampling Techniques

Jabitehnan and South Achefer Woredas and their respective kebeles of Jigayelmdar and Abchikli were purposely selected as they are CA intervention areas of Sustainable Intensification of Maize-Legume Cropping Systems for Eastern and Southern Africa (SIMLESA), Conservation Agriculture for Smallholder Farmers in Eastern and Southern Africa (CASFESA) and Capacity Building for Scaling up of Evidence-Based Best Practices in Agricultural Production in Ethiopia (Cascape) projects. Based on Dawson (2007), eleven participants (both from MHHs and FHHs) were randomly selected for FGDs from each Kebele. Using Cochran's (1977) formula as indicated by Bartlett, Kotrlik and Higgins (2001), a total of 225 respondents (75 in MHHs and 42 in FHHs from Jigayelmdar kebele

while 72 in MHHs and 36 FHHs from Abchikli kebele) were randomly selected from the total population proportionally for individual interview. Moreover, 12 key informants from the extension and research organizations were selected for this study.

Data Analysis

Descriptive statistics such as percentage, frequency, mean and standard deviations were used to analyze the quantitative data. The qualitative data from key informant interview and FGDs were transcribed and thematic analysis technique was employed.

Results and Discussions

Women farmers' participation in extension services

The result of FGDs showed that women farmers both married and FHH do not take part in trainings, demonstrations, field days and experience sharing visits organized by the agricultural development offices as equally as that of their counterparts. This is because women are given less attention by DAs and hence women seldom attend such events. Nevertheless, FHHs are somehow treated better than married women. With respect to access to technologies and inputs, married women benefit along with their husbands, while FHHs have access to available technologies and inputs like that of MHHs.

Because of lack of confidence and self- worth of women and the biases of extension workers and researchers towards women farmers, women have been culturally barred from participation of trainings, experience sharing visits, demonstration and field days as it is male farmers who in most cases are invited for such events. However, according to the discussants, FHHs have equal access to agricultural inputs as that of MHHs. But in previous years discriminatory input distribution had been evident (less attention to FHH) in the study areas.

According to key informants, the reasons why the low participation of women in extension services are that married women's disinterest to attend trainings, undervaluation of their contribution and the perception that husbands' participation is enough and women have anything to do with the training, resistance of husbands to let their wives attend meetings and a sentiment that women are naturally men's inferior. Key informants have also posited that Development agents (DAs) usually offer their services to men farmers due to the stereotype perception of the society that women are born for domestic work has adversely affected women's participation in extension services.

The descriptive statistics result reveals that about 50% of the respondents have not taken part in trainings for a number of reasons; one of which is DAs biasness towards men farmers. This is in compliance with Chale (1991) and Birhanu and Kedir (2008) that most DAs are male and they target extension services mainly to men due to cultural barriers and not valuing women as farmers. Hence, fewer efforts are made to reach women in agricultural service provision. Only two of the seven

factors, i.e., attitude of DAs and the burden of household tasks of women, appear to have contributed substantially for the failure of women in participating trainings while age, health, husbands' participation, husbands' refusal, and misunderstanding did not contribute as much (Table 1).

Table 1. Reasons for failing to participate in trainings

No	Reasons	Response	
		Number of respondents (n=225)	
		Yes (%)	No (%)
1	Failure to participate usually because of old age	2.7 (6)	97.3 (219)
2	Failure to participate usually because of debilitated health	3.6 (8)	96.4 (217)
3	Busyness with domestic activities and/or marketing	20.1 (47)	79.1 (178)
4*	The participation of husband suffices	5.4 (8)	94.6 (139)
5*	Husbands refusal to allow wives to participate (lack of cooperation)	1.4 (2)	98.6 (145)
6	DAs failure to invite women as they undervalue them, pay them minimum attention and are doubtful that success will be attained by working with them	23.1 (52)	76.9 (173)
7	Misconception and understanding that participation in training will not make any difference	3.6 (8)	96.4 (217)

Note: questions in asterisk (*) were only forwarded to married women.

The descriptive statistics result reveals that about 71.2% the respondents who have been participated in demonstration field days have low participation when compared with their male counter parts. Only small numbers of women have equal attendance with that of male farmers.

From the seven factors attributed to participation in demonstration field days, lack of announcement, inattention of DAs, DAs partiality and biasness towards men; domestic work burden of women; DAs undervaluation women farmers and their doubt that success will be attained by working with women farmers appear to have contributed significantly for the failure of women in attending demonstration field days. Over a quarter of the respondents attributed these as good justifications for their failure to attend demonstration field days. The rest four factors did not contribute as much (Table 2). 64% of the respondents have said that extension agents are partial and do not render extension service equally to men and women and this corroborates reports of Catherine *et al.* (2012), Bisanda and Mwangi (1996),

Saito (1994) and Alemayehu *et al.* (2008) in such a way that MHHs receive more extension visits than FHHs. While 36.3% of the respondents have agreed that DAs and Subject matter specialists (SMS) provide extension service to all farmers regardless of their sex.

Table 2. Reasons for failing to participate in demonstration field days

No	Reasons	Response	
		Number of respondents (n=225)	
		Yes (%)	No (%)
1	Refusal to participate because of lack of awareness or old age or debilitated health	6.2 (14)	93.8 (211)
2	Lack of announcement and DAs inattention to married women or FHH; their partiality and biasness towards men	44 (99)	56 (126)
3	Busyness with domestic activities and/or marketing	30.7 (69)	69.3 (156)
4*	Husband's participation suffices	6.8 (10)	93.2 (137)
5*	Husband disinterest to permit wives to leave the house and attend FDs	5.4 (8)	94.6 (139)
6	Incorrect understanding that participation in demonstration FDs will not make any difference	3.6 (8)	96.4 (217)
7	Development agents undervalue women, pay them minimum attention and are doubtful that success will be attained by working with women	25.8 (58)	74.2 (167)
8	Other	3.6 (8)	96.4 (217)

Note: questions in asterisk (*) were only forwarded to married women

With respect to extension service, the result of the quantitative study shows that about 40% of the respondents agreed that men received more service than women because men had more power, speed and practice. Staying outdoors was the second most important factor (Table 3).

Table 3. Reasons for inequality of extension service

No	Reasons	Response	
		Number of respondents (n=225)	
		Yes (%)	No (%)
1	DAs prefer men because women do not satisfy them by performing tasks quickly	27.9 (62)	72.1 (160)
2	Women focus on domestic tasks and ignore other tasks coming from Das	10.8 (24)	89.2 (198)
3	Men are always outdoors and thus they attend any meeting and receive the advice of extension agents	34.2 (76)	65.8 (146)
4	DAs believe that men are powerful, fast, more practical in adopting technologies and are easy to work with and as a result they do not open wider room for women's participation	39.6 (88)	60.4 (134)
5	Other	2.3 (5)	97.7 (217)

Women farmers' participation in agricultural research on conservation agriculture

Adet and Andassa Research Centers in collaboration with SIMLESA, CASFESA and Cascape projects have been undertaking different research activities, demonstration and pre-scaling up of CA technologies by establishing farmers research and extension groups (FREGs) since 2012. FREG is a group of farmers involved in joint problem identification, experiment/trial designing/planning, execution and monitoring and evaluation in the process of technology generation, evaluation and transfer (MARC and ATARC, 2009). In this line, as indicated in Table 4, FREG women can get a number of advantages. Among the 41 FREG members 90.2% of the respondents have pointed out that women farmers can gain familiarity on crop and livestock technologies and best agricultural practices on CA through trainings. About 95% of the respondents asserted that they get technologies on CA. This goes in line with Lilja and Ashby (2001) that one of the advantages of farmers' participation in participatory research, where on farm trials are the usual practice, is to get early access to new agricultural technologies. Moreover, 63.4% and 78% of the respondents have stated that they get the chance for field days participation and advisory services on CA respectively.

Table 4. Benefits of women farmers from research on conservation agriculture

No	Variables/ Questions	Response. Number of respondents (n = 41)	
		Yes (%)	No (%)
1	Knowledge on crop, livestock technologies and best agricultural practices through training	90.2 (37)	9.8 (4)
2	Inputs (technologies) such as improved maize, haricot bean, forage crops, chemicals, tef, finger millet, potato and improved poultry	95.1 (39)	4.9 (2)
3	Field day participation	63.4 (26)	36.6 (15)
4	Advisory services in crop production, animal husbandry and natural resources conservation	78.0 (32)	22.0 (9)
5	Other	2.4 (1)	97.6 (40)

However, it can be imagined how women are poorly represented in FREG. The majority of the respondents have ensured that women's membership in FREG is low and 15.4% of the respondents made clear that they have been taking part in trainings organized by research centers. In this respect, only three of the eight reasons, i.e., failure of partaking because of none membership in FREG, inattention of researchers and DAs towards women farmers, the stereotype that women are inactive, irrational, less assertive and difficult to work with have contributed substantially for the failure of women in participating FREG trainings. Over one fourth of the respondents attributed these as good causes for their failure to attend FREG trainings while the rest five reasons did not contribute as much (Table 5).

Table 5. Reasons for non participation in FREG trainings

No	Reasons	Response: Number of respondents (n=225/147women)	
		Yes (%)	No (%)
1	Personally not chosen to be FREG member	73.4 (163)	26.6 (59)
2	Researchers do not give attention to women (women as a whole) like that of MHH and do not invite them often, if any it is negligible	63.1 (140)	36.9 (82)
3	Some of the researchers might have been influenced by the stereotype that women are inactive, irrational, less assertive and difficult to work with while the opposite holds true for men	32.4 (72)	67.6 (150)
4	Weak health	2.3 (5)	97.7 (217)
5	Failure to participate because of old age and misconception that training does not make any difference	6.3 (14)	93.7 (208)
6	Failure to participate because of domestic activities	5 (11)	95 (211)
7	My husband does not allow me to participate	-	100 (146)
8	Women's participation is affected by husbands who are at the forefront and usually takes part in trainings	6.8 (10)	93.2 (136)
9	Other	18.9 (42)	81.1 (180)

The study also indicates that about 75% of the respondents have not taken part in participatory technology evaluation (PTE), demonstration and pre-scaling up field days (FDs) for some reasons. Given the fact, respondents were also asked about the rate of their participation in such events; thus, 58% of the respondents have ensured that the level of their participation is low while 42% of the respondents confirmed that they had equal participation with that of their counter parts. Among the eight factors only three of them, i.e., failure to be chosen by DAs or researchers, researchers' lack of attention to women, researchers wrong perception that women are inactive, irrational, less assertive and difficult to work with and achieve success appear to have contributed significantly for the failure in taking part in PTE, demonstration and pre-scaling up field days. Over a quarter of respondents recognized these as good grounds for their failure to attend while the rest five factors did not affect as much (Table 6). Moreover, respondents were asked why women's participation in FREG, CA and FDs is low in the research domains. Therefore, 37.8% of the respondents have mentioned that lack of trust on the technologies where as 57.3% of the respondents have mentioned absence of compulsion of

husbands to appear to field days along with their wives for lower participation. Almost half of (48.4%) the respondents have stated that researchers and DAs do not want to work with women as they do not have confidence on them and are afraid of achieving success. A little bit higher than a quarter of (30.2%) the respondents revealed that women may not be interested to be embraced by FREG, involve in CA and attend FDs as they are busy with domestic activities. 40.8% of the respondents have pointed out that husbands may think their participation as head of the family is enough and do not allow their wives to participate in FREG for fear of failure to attend household chores. 34.7% of the respondents have stated that the maximum attention given to progressive (model) farmers who are mostly men has negatively affected women's participation in FREG, engagement in CA and FDs. Yeshi and Agajie (2008) have indicated that women's contribution in breeding program, technology evaluation and selection is immense if they are given the chance to participate in participatory research. In view of this, the result of the quantitative study underlines the same. Given the fact, only 8.9% of the respondents have said that women's role in technology evaluation such as CA is low while 33.8%, 36.9% and 20.4% of the respondents have affirmed that women have medium, high and very high roles respectively.

Table 6. Reasons for not taking part in PTE, demonstration and field days

No	Reasons	Response	
		Number of respondents (n=225/147women)	
		Yes (%)	No (%)
1	Personally not chosen (asked) to be FREG member	62.2 (140)	37.8 (85)
2	Failure to participate because of disinterest to be FREG member	0.4 (1)	99.6 (224)
3	Researchers do not give attention to women (women as a whole) and invite them like that of MHH; if any it is negligible	63.6 (143)	36.4 (82)
4	Researchers might have been influenced by the stereotype that women are inactive, irrational, less assertive, difficult to work with and achieve success	34.2 (77)	65.8 (148)
5	Failure to participate because of domestic work load	3.6 (8)	96.4 (217)
6	Husbands lack of understanding to allow wives to participate often	0.7 (1)	99.3 (146)
7	Wives participation is affected by husbands who are at the forefront and usually take part in the events/FDs	6.8 (10)	93.2 (137)
8	Other	14.7 (33)	85.3 (192)

According to the FGD discussants, the benefits obtained from participatory research is familiarity with improved technologies, improved agricultural practices (CA/minimum tillage), the acquisition of technologies and knowledge as a result of participation in training and demonstration FDs. The output of the discussion shows the same result as shown in Table 6.

CA is one of the benefits of research which attracts the attention of many farmers, agricultural officers and other stakeholders. In this regard, all respondents in the research domains have the knowledge on the importance of CA technology. With respect to its advantages, over three fourth of the respondents said that the technology does not require draft oxen or requires minimum tillage, improves soil fertility as a result of legume intercropping, controls soil erosion, maintains soil moisture, reduces labor cost, promotes efficient utilization of land as a result of legume intercropping and helps to improve family nutrition because of the introduction of QPM and haricot bean. Besides, 77.7% the respondents have stated that CA serves as source of livestock feed because of the forage legume intercropping (Table 7).

Table 7. Conservation agriculture

		Response	
		Number of respondents (n=225)	
No	Reasons	Yes (%)	No (%)
1	CA is beneficial to all farmers	99.5 (198)	0.5 (1)
2	Advantages of CA		
2.1	Does not require draft oxen or requires minimum tillage	87.5 (196)	12.5 (28)
2.2	Improves soil fertility as a result of legume intercropping and 30% of maize stover left in the plot	81.7 (183)	18.3 (41)
2.3	Controls soil erosion	82.6 (39)	17.4 (185)
2.4	Maintains soil moisture	76.8 (172)	23.2 (52)
2.5	Reduces labor cost	80.4 (180)	19.6 (44)
2.6	Promotes efficient utilization of land as a result of legume intercropping	76.3 (171)	23.7 (53)

No	Reasons	Response	
		Number of respondents (n=225)	
		Yes (%)	No (%)
2.7	Helps to improve family nutrition because of introduced QPM and haricot bean	77.2 (173)	22.8 (51)
2.8	Provides livestock feed	77.7 (174)	22.3 (50)
2.9	Other	-	100 (224)

As far as the application of CA is concerned, participants of the FGD asserted that the technology has been conducted mainly on male and on very few FHH farms. Despite the advantages of CA to female farmers, training and demonstration field days organized on CA have been attended by lower number of women than men. Similarly, the number of women farmers embraced by FREG on CA is low. This is because of inadequate effort made by the researchers and DAs to engage as many women as possible, denial of husbands to let their wives be FREG members with them, suspicion on the feasibility of the technology, inexistence of invitation of husbands with their marriage partners.

The unpublished report of Amhara Agricultural Research Institute (ARARI) shows that in 2012 out of the total number of 136 FDs attendants in the two kebeles only 16 of them were women. In 2013 only 29 of 237 were women attendants. Furthermore, the report reveals that among the 84 trainees on CA, only 7 of them were females. Based on the above, it is possible to conclude that women are underrepresented in CA. This is substantiated by Thomas *et al.* (2013) that Extension in Ethiopia has long focused on male farmers, in keeping with the cultural perception that "women do not farm," a perception that ignores the wide range of agricultural activities in which women engage. FGD participants have also pointed out the benefits CA provides to both MHHs and FHHs as a technology that does not require labor and draft oxen especially for those farmers facing acute labor shortages. They have also affirmed that CA contributes for improving soil fertility, reducing soil erosion and provides space for intercropping.

Apart from what has been confirmed by FGD discussants and key informants, economists emphasized on the importance of CA in suppressing the growth of weeds, and thus it minimizes labor and time for weeding and cultivation. The quality protein maize (BHQPM-545) and the haricot beans intercropped together with other crops help to improve family nutrition.

Conclusion and Recommendations

Conclusions

According to the findings of the study, research and extension systems have been facing challenges for under representation of women in kebele administration councils (leadership); the extreme focus on progressive farmers and the reduced chance of participation available to other non-innovative farmers; the less commitment of women's league, women's federation and women's association in organizing as many women as possible and raising the political consciousness of members have been taken as obstacles of women farmers participation in research and extension.

Economic incapacity of farmers has been discovered as one of the impediments to women farmers' participation in agricultural research and extension. Lack of land, shortage of draft oxen, low income and high cost of inputs has been cited by respondents as some of the elements that jeopardize farmers' productivity and participation in agricultural research and extension. This in turn has affected women's participationin CA. FHHs are the most affected HHs when compared with that of MHH. They suffer from lack of traction power, and as a result they enter into share cropping or hire out their land instead of cultivating what is under their possession. Those farmers who do not have land but draft oxen either enter into share cropping, engage in off-farm activities or go into brewery making. Farmers would not opt for the above if they possessed land which is the major means of production. A farmer who is financially handicapped cannot buy the necessary inputs such as improved crops and livestock breeds, fertilizers, herbicides, pesticides and farm implements, etc that are crucial to increased agricultural production. From the research result, it is possible to draw a conclusion that escalated cost of inputs is one of the major economic obstruction that affect participation in agricultural extension service and participatory research and thereby the overall agricultural production and productivity of small scale farmers. The extension system provides experience sharing visits and chances of participation in demonstration FDs whereby best practices of crop and livestock husbandry and natural resources conservation are visited and farmers take lessons.

The same holds true for participatory research, but farmers who are members of FREG are fully involved in the problem identification and execution of field experiments. They allocate the required size of land, prepare it, help in planting, weeding, harvesting, etc. Other than farmers' familiarity with technologies at various levels of participation, farmers will retain the harvested technologies after all the necessary data have been collected, if not they will be offered the same or their harvests will be bought by research centers.

To improve women farmers' participation in extension, the extension system has been focusing on women particularly on FHH in conformity with the policies of the government put in effect to alleviate their problems and increase their productivity. Thus, FHH and MHH women have been

made beneficiaries of inputs delivered on credit basis through agricultural offices. Despite some shortcomings, women farmers have been paid attention and been made beneficiaries of training, experience sharing visits and demonstration field days. Research which had not been demand driven and participatory some years back has shifted to be participatory with more focus on farmers' needs. Thus, those research centers which are involved in on farm research activities have established 8 FREGs in the two kebeles whereby 185 farmers are embraced and actively participate in undertaking different adaptation, demonstration and pre-scaling up trials on teff, potato, sweet lupin, CA and poultry. Whatever the inadequacy is there research has opened room for women's membership in FREG and their participation in events that membership provides. Besides, the political organizations and civil societies operating in study areas have to some extent contributed for the fight against the stereotype widespread in the society including women, husbands and agricultural experts.

Finally, from the findings of the research it can be deduced that the hypothesis women have still been marginalized and have not yet been made participants and beneficiaries of research and extension service is the reality prevalent in the research domains and other similar areas as well. Despite the number of measures taken over the years to improve women farmers' participation in research and extension service, quite a lot of women have not still been made active participants and beneficiaries of the endeavors such as CA made in the agricultural sector.

Recommendations

- Altering the stereotype against women deep rooted in the society by dealing with opinion and religious leaders first will help to reach all members of the community.
- Raise the researchers and DAs gender awareness to clear up their mind set and work towards proportional representation of women farmers in FREG and extension.
- Adopt couples training approach where both husbands and wives are trained together, envolve in CA and attend FDs.
- Subsequent trainings have to be offered on CA as it is helpful in many respects especially to FHHs who suffer from shortages of draft oxen, labor and money.
- Opening up rooms for wider participation of women as their contribution in evaluation of the quality/importance of technologies like CA is by far better than their counter parts.
- Rules and regulations have to be put in place that govern the extension service to be more gender-sensitive so that women farmers have full access to extension meetings, trainings, experience sharing visits, demonstration FDs and other activities including CA which is presumed to be feasible and useful to women especially of FHH.
- Gender mainstreaming has to be given due emphasis in the extension and research systems.

- Intervention of superiors need to be limited; extension agents ought to have the power to decide what is fit for farmers as they are conversant with the realities of the kebeles.
- Researchers should select farmers in collaboration with DAs for membership in FREG and on farm trials; they should not leave the task to DAs.
- The focus on few farmers who are presumed to be progressive (model) has to be balanced as it is a cause for discontent of many others.
- Organize separate FDs to women when they are not too busy.
- Strengthening the use of social networks, churches and mosques during worship or religious holidays or other occasional social gatherings and provide exte education.
- Encourage women farmers to form economic groups like saving and credit associations where they can borrow money without lots of ups and downs and with lower interest rates.
- Increase the number of female researchers and extension agents to ensure gender equality, bring as many females in the fields as possible to make use of their different insights and perspectives to in order to fully address the unique and pressing challenges of both female and male farmers in the region.

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