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Full Length Research Paper

Participatory varietal selection of upland rice (*Oryza sativa*) varieties in the groundnut basin, Senegal

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In Senegal, rice plays a critical role for smallholder farmers by providing food security. However, rice production is very low compared to the high needs of the population. This might be explained to some extent by the use of not adapted and low yielding varieties. This study aimed at identifying the best upland rice varieties that meet farmers' criteria using participatory varietal selection method in order to speed up their early adoption and therefore increase upland rice diversity in the Southern and South-Eastern part of the groundnut basin agro-ecological zone. In total, 30 varieties including NERICA 6 as standard check were evaluated at ISRA Nioro research station. At flowering time, 29 farmers including both men and women were invited to participate in the selection process. Farmers classified upland rice varieties' selection criteria according to the order of importance: Earliness, moderate plant height, high yield and termite tolerance respectively. The most chosen varieties by farmers were NERICA 8 and ART16-13-13-2-2-B-1-B-1-B. For all the agronomic traits, the genotypes showed a highly significant variation. The high yielding varieties were CNAX 3031-78-2-1-7 and JOPYEONG which yielded respectively 48 and 44% more than the check. In general, the ranking according to farmers' choice was not in agreement with the method using grain yield. Based on agronomic performances, farmers and breeders selections, few varieties were selected and should be evaluated under multi-location trials in farmer' fields for two seasons, before undergoing for a release process.

Key words: Rice, participatory varietal selection, groundnut basin, Senegal.

INTRODUCTION

Rice is among the major food crops in Africa where it plays a critical role in smallholder farmers' food security. In 2013, the overall paddy rice production was estimated at around 741 million tons, representing more than 26%

of the overall cereals production (FAO, 2014). In sub Saharan Africa countries, rice demand has increased from 1.9 to 5.8 million tons during the past two decades (Ogunbayo et al., 2007, 2005). This high rice demand has resulted in a food crisis observed in 2008. In response to this world crisis, several West African countries have adopted strategies such as the use of improved seeds and better technical assistance to rice farmers (Seck et al., 2012).

In West Africa, Senegal is the seventh most important rice producer and one of the largest rice consumers, with more than 50% of total cereals consumed (FAO, 2014; Gergely and Baris, 2009). In 2011, rice consumption exceeded 1.14 million tons with an average per capita consumption of 92 kg (Demont and Rizzotto, 2012). Despite the importance of this cereal, the level of self-sufficiency is low compared to the overall leading to a huge proportion of the population which cannot meet its food needs. Consequently, a production gap was notices and needed to be supplemented annually by rice importation. This explains why Senegal is the third largest rice importer in Africa, after Nigeria and Ivory Coast (FAO, 2014). In 2013, the imported milled rice was estimated at around 918 897 tons which worth around US$ 250 million (ANSD, 2014). This high dependence is a source of food insecurity and has attracted the attention of governments as well as their partners. To close such a widening gap between supply and demand, the Senegalese government has developed a nationwide rice program for self-sufficiency by 2017. This program has established a contribution for each of the Senegalese agro-ecological zone. The Southern, South-eastern and South central (groundnut basin) parts of the country where rainfed rice is mainly produced should contribute for 40% of the total paddy rice production. In the groundnut basin, this has the largest agricultural land (60%) and total cereal production (40%), agricultural production dependents on climatic and soil conditions. Lands allocated for rice production are in a small portion and grain yield is very low with around 1000 kg ha^{-1} (DAPS, 2014). This low yield might be due to the use of no adapted and low yielding varieties, inappropriate technologies, and environmental constraints (low soil fertility, rainfall variation, etc.). In fact, the national rice breeding program with their different partners has released up to eight upland rice varieties having a mean yield potential of around 4 t ha^{-1} (MAER, 2012). However, these varieties have not been aggressively and widely popularized by farmers in the groundnut agro-ecological zone. This situation might be explained by the fact that these varieties are not well suitable for farmers' needs, preferences and conditions. This has been pointed out as one of the reasons for the low adoption of improved varieties in subsistence and small scale farming systems (Nkongolo et al., 2009; Röling et al., 2004). Thus, farmers' needs and preferences have to be identified and incorporated in the breeding process of any given crop so that they can test the right varieties. This can be done by using participatory varietal selection (PVS) process.

This technique has shown success in identifying farmers' preferred varieties, their wide dissemination and may help breeders to identify farmers' constraints and preferred traits in short time (Ceccarelli et al., 2007; Gyawali et al., 2007; Mulatu and Belete, 2001). It has been also demonstrated that this technique is more effective in terms of cost and transferring the right varieties to farmers. Mangione et al. (2006) have demonstrated that there is no significant difference in overall costs between participatory plant breeding and non-participatory plant breeding of barley. They found also that this technique provided more information compared to non-participatory plant breeding at the same cost.

The Senegalese Agricultural Research Institute (ISRA) was engaged to identify and/or develop farmers' preferred and adapted upland rice varieties which are high yielding and tolerant to biotic and abiotic stresses in the groundnut basin of Senegal and thus contribute to rice self-sufficiency by 2017. To identify these preferred varieties and have a better understand on rice farmers' preferences traits, a participatory varietal selection technique coupled with an agronomical evaluation was conducted.

MATERIALS AND METHODS

The study was conducted at ISRA Nioro Research station (13°45'27" N; 15°47'18" W) in 2015 rainy cropping season using 30 upland rice varieties from different origins including NERICA 6 as a standard check (Table 1). The trial was laid out in a randomized complete block design with three replications. Sowing was done with spacing of 25 cm between rows and 20 cm between plants within a row in plots of six lines of five meters for each evaluated variety. A 15N-15P-15K fertilizer at a rate of 200 kg ha^{-1} was applied before sowing. During the crop development a top dressing using urea (150 kg ha^{-1}) was done twice (100 kg ha^{-1} at 20 days after sowing (DAS) and 50 kg ha^{-1} at 45 DAS). All the recommended cultural practices were applied.

A field day was organized at flowering stage where farmers were invited to evaluate the new rice varieties. Farmers from Fatick, Kaolack and Kaffrine regions, located in the southern and south-eastern part of the groundnut basin agro-ecological zone (Figure 1) were randomly selected and in overall, 29 rice farmers were involved. No ethical issues, as defined in the EU 7th Framework Program guide to applicants were identified for this study. During the participatory varietal selection process, farmers were assisted

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Table 1. List of upland rice entries evaluated at Nioro Research Station.

Entry	Variety name	Origin
1	ART15-21-23-1-3-1-1-B-1-B	AfricaRice
2	ART15-21-32-4-1-1-4-B-1-B	AfricaRice
3	ART15-21-56-2-1-1-1-B-1-B	AfricaRice
4	ART16-9-4-18-3-2-1-B-1-B	AfricaRice
5	ART16-4-13-1-2-1-1-B-1-B	AfricaRice
6	ART16-9-29-12-1-1-2-B-1-B	AfricaRice
7	ART16-12-22-1-3-1-1-B-1-B	AfricaRice
8	ART16-13-13-2-2-B-1-B-1-B	AfricaRice
9	ART16-17-7-18-1-B-1-B-1-B	AfricaRice
10	ART3-7-L3P3-B-B-2	AfricaRice
11	ART3-7-L9P8-1-B-B-1	AfricaRice
12	ART3-11-L1-P1-B-B-2	AfricaRice
13	BRS SORTANEJA	Brasilia
14	BRS PEPITA	Brasilia
15	BRS CARAJAS	Brasilia
16	BRS CONAÏ	Brasilia
17	BRS PRIMAVERA	Brasilia
18	NERICA 4	AfricaRice
19	NERICA 8	AfricaRice
20	NERICA 14	AfricaRice
21	NERICA 11	AfricaRice
22	WAB 609-43-1-1-HB	AfricaRice
23	WAB 775-21-5-2-HB	AfricaRice
24	WAB 804-23-11-2-HB	AfricaRice
25	ART3-9-L6P2-B-B	AfricaRice
26	ART3-7-46-B-B-3	AfricaRice
27	CNAX 3031-78-2-1-7	Unknown
28	JOPYEONG	Korea
29	K1	Korea
30 (Check)	NERICA 6	AfricaRice

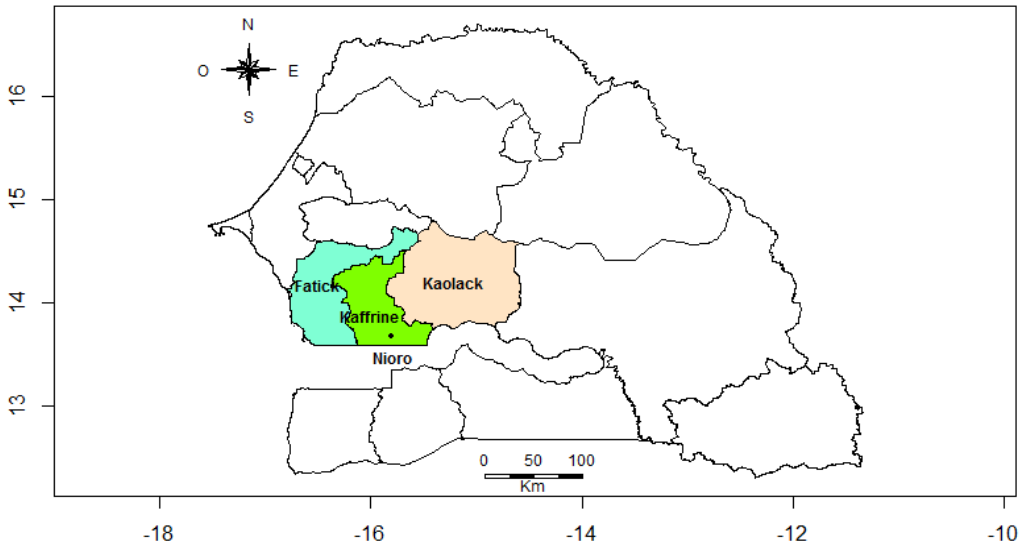

Figure 1. Localization of the regions and experimental site in the south and south-eastern groundnut basin of Senegal.

Table 2. Description of sampled farmers from 3 regions in the south and south-eastern groundnut basin of Senegal (n = 29).

Variable	Region			Total	Percentage
	Fatick	Kaolack	Kaffrine		
Gender					
male	2	5	9	16	55
Female	6	7	0	13	45
Level of education					
illiterate	7	10	6	23	79
Primary	0	2	2	4	14
Secondary	1	0	1	2	7
Age					
<35	3	3	4	10	35
35-50	3	4	3	10	34
>50	2	5	2	9	31

Table 3. Chosen upland rice varieties (n = 29).

Entry	Region			Total	Percentage
	Fatick	Kaolack	Kaffrine		
NERICA 8	7	12	5	24	83
ART16-13-13-2-2-B-1-B-1-B	5	9	8	22	76
JOPYEONG	4	8	4	16	55
ART3-7-L3P3-B-B-2	5	5	6	16	55
NERICA 4	1	0	1	2	7
NERICA 6	0	0	1	1	3
ART3-7-L9P8-1-B-B-1	0	1	1	2	7

by researchers from ISRA and experts from the NGO Symbiose. Before starting the field evaluation, farmers were grouped in order and set principal criteria which they would like to see into a newly bred cultivar. These criteria were termite resistance, plant height, earliness and grain yield. Farmers discussed and all these criteria were ranked in the order from 1 to 4 according to their importance by each farmer for selecting a new variety Characteristic with smallest rank is considered to be the most important while the one with higher rank is perceived to be less important in choosing a new variety. Farmers were also asked to give an overall assessment of tested varieties and select two to three varieties that they would like to grown in their rice field. In addition to farmers' evaluation, an agronomical evaluation was conducted and all agronomic data were collected and subjected for analysis of variance using SAS software, version 9.2.

RESULTS AND DISCUSSION

The description of sampled farmers chosen for the participatory varietal selection (PVS) in the three regions is given in Table 2. The sampled rice producers who assisted to the PVS included 55.5% male farmers. However, the male proportion is relatively lower in Fatick (25%) and in Kaffrine no female has participated to the PVS. In fact, farming activities are perceived to be very tedious in this part of the country and this may explain why crop production is dominated by males. The greater majority of the rice farmers (79%) did not have any form of formal education. Only a small fraction (21%) of them had some form of formal education with 14% educated up to primary level and 7% up to secondary level. Rice production in the study area involves mainly farmers in their middle ages. The majority of them (69%) were less than 50 years. This result is interesting and might boost efforts to improve rice production in this part of the country In fact, these are farmers who are targeted by various projects, NGOs and with their enthusiasm they are more likely to invest in new technologies.

At flowering time, farmers were invited at Nioro research station to evaluate and chose varieties based on their own established criteria. As indicated in Table 3, among the total of 30 tested upland rice entries, seven including the check were chosen by the farmers who participated in the PVS. Out of the seven rice varieties selected, NERICA 8 and ART16-13-13-2-2-B-1-B-1-B originated from AfricaRice were the most preferred by farmers across the project locations, followed by ART3-7-

Table 4. Mean rank of the most important preferred traits of upland rice cultivars.

Characteristics*	Region			Mean	Rank
	Fatick	Kaolack	Kaffrine		
Short duration	1.6	2.3	1.6	1.8	1
Plant height	2.0	1.7	2.5	2.1	2
High yield potential	2.6	2.2	2.8	2.5	3
Termite Resistance	3.8	3.8	3.0	3.5	4

*Characteristic with smallest mean rank within a column is perceived to be the most important.

L3P3-B-B-2 and JOPYEONG. NERICA 8 and ART16-13-13-2-2-B-1-B-1-B were chosen respectively by 83 and 76% of the farmers. The reasons behind farmers' preferences of these varieties are attributed to their high grain yield, early maturity and moderate plant height.

Farmers have shown strong interest in the use of early upland varieties because of the short rainfall season which characterize this part of the country (Table 4). Then, such varieties can escape easily drought. Besides earliness, the semi-tall stature and high yield potential could be found as the putative favorable attributes for preference into a new bred upland rice cultivar. In the study areas, farmers were less concerned about termite resistance and ranked fourth criterion in selected a cultivar. Farmers of this agro-ecological zone wanted intermediate plant height after early maturity and explained that short statured cultivars were more difficult to harvest than an intermediate cultivar. When harvesting an intermediate plant height they reduce the problem of bending down to cut the panicles, activity mainly done by women with a knife. Tallness was not desirable because of the associated problem of lodging. These results on preferred traits of upland rice varieties are in accordance with those of Efisue et al. (2008) and Virk et al. (2003). They reported that farmers in the upland ecology in the eastern part of India and in Sikasso region of Mali adopted rice cultivars that are early maturing, intermediate to tall plant height and high yield potential. It is imperative, therefore, for upland rice breeders to create and select upland rice varieties with early flowering, moderate plant height and having a high yield potential to meet food demand and contribute to rice self-sufficient goal by 2017.

Analysis of the data revealed highly significant variations among the tested upland rice varieties for all the agronomic traits observed and measured (Table 5). The tallest variety was ART15-21-32-4-1-1-4-B-1-Bwith 127 cm whereas the shortest were BRS PEPITA (74 cm) and JOPYEONG (75 cm). NERICA 8 (93 cm) and ART16-13-13-2-2-B-1-B-1-B (108 cm), the two most preferred by farmers, had moderate plant height. These results are in agreement with the rank of most important traits of upland rice cultivars done by farmers in this area where they indicated that the plant height is an important traits and ranked after earliness. The flowering time ranged from 55 to 74 days after sowing (DAS). Indeed, earliness is an important criterion in selecting an upland rice variety and might explain why JOPYEONG which flowered 55 DAS was selected. So, its selection was certainly driven by its early flowering time rather than the plant height. This variety can be improved for plant height in order to meet farmers' needs. All the other selected varieties flowered between 64 and 70 DAS. According to the mean values of grain yield, CNAX 3031-78-2-1-7 and JOPYEONG had the highest yield with 5821 kg ha^{-1} and 5662 kg ha^{-1}, respectively. They were significantly more productive than all the other varieties. This is in agreement with Kim et al. (2014) who reported that JOPYEONG, a multiple resistance variety to stripe virus, bacterial blight and blast, is a highly yielding variety. The grain yield of farmers' selected varieties during the PVS process ranged from 3362 kg ha^{-1} to 5662 kg ha^{-1} with a mean value of 4062 kg ha^{-1}. This average grain yield of 4 t ha^{-1}a is higher than the grain yield potential of some national released upland varieties (MAER, 2012). Only ART16-13-13-2-2-B-1-B-1-B, one of the farmers' selected varieties, was among the top ten high yielding varieties. Hence, the result clearly indicated why high yielding criterion was ranked third in selecting a new upland variety. The consistency of earliness and plant height as the most important criteria for selecting varieties indicated that these criteria should be considered as the major selection criteria in upland rice improvement programme targeting the groundnut basin in order to ensure varietal acceptance and adoption.

Conclusion

This study conducted in the groundnut basin agro-ecological zone in Senegal characterized upland rice varieties from diverse origins and examined farmers' preferences traits into newly bred cultivars. The results show that a number of new genotypes are better than the check NERICA 6 for yield and other characteristics that farmers considered to be important in selecting a cultivar to grow. Farmers prefer to have early maturing varieties with moderate plant height, high yielding and tolerant to termite. Farmers were not very concerned about termite tolerance as it was ranked fourth. Some of these farmers'

Table 5. Mean values and analysis of variance for agronomic traits.

Entry	Flowering (DAS)	Plant Height (cm)	Tiller	Harvest Index	Yield (kg ha^{-1})
ART15-21-23-1-3-1-1-B-1-B	71	110	7	0.2	2631
ART15-21-32-4-1-1-4-B-1-B	74	127	11	0.2	3952
ART15-21-56-2-1-1-1-B-1-B	72	105	8	0.3	3411
ART16-9-4-18-3-2-1-B-1-B	70	100	9	0.3	3784
ART16-4-13-1-2-1-1-B-1-B	66	95	11	0.3	3675
ART16-9-29-12-1-1-2-B-1-B	65	99	13	0.3	4095
ART16-12-22-1-3-1-1-B-1-B	69	119	12	0.3	4463
ART16-13-13-2-2-B-1-B-1-B	65	108	10	0.3	4609
ART16-17-7-18-1-B-1-B-1-B	68	110	12	0.3	4783
ART3-7-L3P3-B-B-2	65	111	9	0.3	3837
ART3-7-L9P8-1-B-B-1	64	94	10	0.3	3927
ART3-11-L1-P1-B-B-2	66	97	9	0.3	3706
BRS SORTANEJA	73	98	12	0.3	4306
BRS PEPITA	74	74	21	0.2	3670
BRS CARAJAS	69	117	14	0.2	3122
BRS CONAÏ	65	90	14	0.3	4401
BRS PRIMAVERA	69	116	9	0.2	1947
NERICA 4	70	103	11	0.3	3362
NERICA 8	67	93	12	0.3	3838
NERICA 14	64	102	14	0.3	4816
NERICA 11	68	106	9	0.3	4118
WAB 609-43-1-1-HB	74	97	13	0.2	3928
WAB 775-21-5-2-HB	71	120	9	0.2	3158
WAB 804-23-11-2-HB	74	78	22	0.1	3094
ART3-9-L6P2-B-B	71	103	10	0.3	4310
ART3-7-46-B-B-3	71	103	8	0.2	3532
CNAX 3031-78-2-1-7	73	116	11	0.4	5821
JOPYEONG	55	75	21	0.3	5662
K1	74	76	18	0.1	2716
NERICA 6	71	116	9	0.3	3926
CV (%)	2.437	10.0	15.0	18.1	22.2
Mean	69	102	12	0.3	3887
Standard error of mean	0.46	1.71	0.43	0.006	113.1
LSD (5%)	2.2	16.6	2.9	0.08	1409.3
Mean square variety	52.4***	567.2***	44.4***	0.009***	2002725***
Mean square error	2.2	103.5	3.23	0.002331	743550

*** = significant difference at the 0.001 probability level.

selected and high yielding varieties will be evaluated under multi-location trials in order to identify which one will be proposed for release.

Conflict of Interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

Participatory evaluation of hybrid sorghum technologies: In mid and low land areas of Wag Himra zone, Eastern Amhara, Ethiopia

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Participatory evaluation of two improved hybrid sorghum varieties and one respective local sorghum variety with improved and farmers' management was carried out on six farmers plot in sorghum growing areas of Sekota and Abergele districts of Wag Himra zone in Eastern Amhara. This evaluation was undertaken through farmers' participation approach by organizing two farmers' research and Extension Groups (FREG); one per district. FREG members were selected purposively to have 18 and 12 farmers in Sekota and Abergele, respectively; each group consists of households from different social segments with 30% women involvement. The objectives of the study were to provide farmers with a menu of technology options and to assess farmers' technology preference criteria; thereby, contribute to increase demand driven technology dissemination in sorghum growing areas of Wag Himra. The performance of improved and local varieties have shown significant amount of variability among treatments in both districts. For instance, mean grain yield and maturity date varied from 3.23 to 1.15 t/ha and 91.2 to 136.3 days in Sekota and 2.84 to 1.13 t/ha and 91.8 to 136.3 days in Abergele. Similarly, partial budget analysis result showed that, total net benefit of treatments varied from 20503.9 to 6407.3 birr in Sekota and 12810.6 to 6200.8 birr in Abergele with 4.90 and 1.94 birr marginal rate of return, respectively. Hence, based on the overall weighted ranking matrix comparisons of farmers', varieties ESH-1 and ESH-2 took first and second places in Sekota and vice-versa in Abergele. Thus, it is safely recommended for promotion and scale-up of these technologies in respective trial districts; while sustainable seed source should be identified through establishing farmers' seed multiplying cooperatives and/or providing pre basic seeds to seed multiplying enterprises.

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

INTRODUCTION

Ethiopia is the second largest sorghum producer in Eastern and Southern Africa preceded only by Sudan in both total area and production (Abera et al., 1996). Nationally, sorghum ranks third both in terms of area and

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total production (CSA, 2015). Sorghum is utilized in different forms. The grain is used for human consumption and homemade beverages, while the leaves and the stalks are commonly used as feed to animals. The stalks are also used in construction and as a fuel wood. The juicy stalks are commonly chewed like sugar cane.

As sorghum is grown under a wide range of environmental condition, the range of both biotic and a biotic sorghum production constraints are also diverse, resulting in very poor performance of sorghum under farmers' circumstances. The average national yield is 23.69 qt/ha which is by far very low compared to 3 to 6 t/ha that can be achieved by using improved varieties and production technologies (CSA, 2015).

Similarly, in Wag-Himra zone where sorghum is the major food crop and its productivity is low with average yields of 10 qt/ha up to zero in sever moisture deficit seasons which are by far less than the national average. Though, many factors can be cited, moisture deficit and lack of improved varieties which fit to the different growing conditions are among the major yield limiting factors.

But, better yielding improved hybrid varieties are developed and released nationally. Hybrid sorghum varieties like ESH-1, ESH-2 ESH-3, etc., have a special merit which is that those varieties give high yielder varieties over other improved and local sorghum varieties. Adaptation trials were done by Sekota Dry Land Agricultural Research Center; however, those adapted improved hybrid varieties were evaluated at research center solely by researchers without the involvement of farmers in the whole stages of the trial. It is only at the final stage of the growing period that these varieties were evaluated by the field day participants. Hence, it is believed that the limited farmer's involvement and lack of incorporation of farmers' view and variety selection criteria starting from onset limits the acceptance and adoption of improved varieties.

Therefore, a participatory approach to evaluate the new improved hybrid varieties is vital to give farmers an option to select their favorite varieties and enhance demand driven adoption rate and consequently increase production and productivity. Thus, this participatory hybrid sorghum evaluation study approach has been designed to provide farmers with a menu of technology options, thereby to select economically feasible and socially acceptable technology; in addition, to assess farmers' technology preference parameters and enhance demand driven technology dissemination system in sorghum producing areas of Wag Himra zone.

MATERIALS AND METHODS

Description of the study area

This study was conducted at Sekota (Aybra) and Abergele (Marnet) districts of Wag-Himra zone, Eastern Amhara located inside Tekezie basin growth corridor of Amhara region in 2013 and 2014 production years, respectively. The sorghum area coverage of Wag-Himra zone is estimated at 38,909.19 ha. Also, the number of farmers with growth sorghum and productivity of 80,533 and 13.42 Quintal/ha, respectively (CSA, 2015). Aybra is located at 12.68°N' latitude and 39.015^{o}E' longitude with an altitude of 1976 meter above sea level (m.a.s.l). The site receives mean annual rainfall of 750 mm with respective maximum and minimum temperatures of 31.6 and 26.2°C. The major soil type of the area is Enteric Carnbisols. Marnet is located at 13°20' N' latitude and 38°58' E' longitude with 1150 m up to 2100 m.a.s.l altitude, has around 16,363.375 ha arable land from this area 90% is suitable for the production of sorghum. The area's annual rain fall ranges from 250 to 750 mm; and it is only limited to the cultivation of some drought resistant crop varieties. The soil type of the area is mainly of three types; which are 55% brown and porous, 30% red and silt and 15% is sandy soil (WAO, 2013).

Farmers' Research and Extension Group (FREG) formation/organization

Farmers Research Group (FRG) members were organized in the two districts which have 18 members in Aybra and 12 members in Abergele based on settlement conditions of the community. The group consists of households from different social segments (young, men, women and wealth status) and they were selected based on consultation with experts of district agricultural offices and key informants that are knowledgeable about the community.

The group was organized purposively to include 30% female headed households and to have the chairman and secretary who facilitate all the FRG activities with researchers and extension workers in each trial Kebelle Administration (KA). From each group, six individual farmers were hosting the trial by permitting their land for free, while other experimental expenditures were covered by the center.

Before starting the work all group members were trained on basic agronomic practices in particular and the technology packages in general. The training comprised both theoretical and practical components and had given for two consecutive days. These group members had action plan prepared prior to the activity and based on the plan they were meeting in each physiological growth stage to evaluate the crop and took data. Here, the researchers and extension workers had participated only for facilitation rather than guiding and leading.

Land preparation and plantation

In this study, the hybrid sorghum seeds had 98.0% germination percentage and the seeding rate was adjusted to recommended rate of 10 kg/ha for the three improved varieties (ESH-1 ESH-2 and LIM) and 20 kg/ha for local variety (LFM) which was sown in broadcast. The experimental plots were fertilized 100 kg DAP/ha and 25 kg Urea/ha at sowing, and the remaining 25 kg of Urea was applied after the crop reached knee height for three improved varieties with 50% Urea split application recommendation and the remaining one treatment was without fertilizer.

The plot size was 10 × 10 m for each variety and the distance between plants and rows was 15 and 75 cm, respectively. The plantation of all materials was considered as un-replicated simple block, farmers as replications.

Participatory evaluation, data collection, partial budget and statistical analysis

In this study, individual and group discussion with members, field visit, field days and questionnaire were used for evaluation of the

technologies and data collection. During frequent discussions, researchers were playing the role of facilitation instead of engagement in order to grasp 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 contacts with farmers appear as pre-requisites for joint learning and platform generation and form the frames on which the research trial and activities are developed.

Through discussions in group and individual with members in two districts, a total of 10 major parameters were identified and weighed based on importance and sensitivity for selection and preferences before and after harvesting. These major parameters were germination performance, vegetative performance, seed setting performance, earliness, disease resistance, color, grain yield, stalk yield, marketability and water holding capacity (Wuha Mansat). The weight and necessity of each parameter varied across location due to the slight difference in livelihood and cultural make up of communities in the two districts.

Parameters which were collected after harvesting time were only from host farmers and their spouses since it was difficult to get the data from non-participating group members. These include grain yield, stalk yield, marketability and water holding capacity (Wuha Mansat) of varieties. Information gathered from individual households and group discussion was used to obtain a broad understanding on technology preference mechanisms of each particular area. Finally, the host farmers and group members from each district were assigned value for each parameter based on their real social conditions. They gave value for each parameter from 10 point, then the researcher sum up each value and converted to percent (100%) to weight each parameter's share from 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 to the other with regard to the values based on identified parameters and the procedure was repeated for all varieties. The number of times each variety was counted for each individual farmer and group, and then 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 as tone/ha simply using mathematical conversion methods for data which were collected in local measurements. Such that for this study, 10_quintal (1 quintal is equivalent to 100 kg) of grain yield = 1 t and 40 tie (Shekm) of stalk yield = 1 t; in case of stalk yield, standard measurement and 1 tie (Shekm) was equal to 25 kg.

A partial budget shows the effect of change(s) in farm operations. Partial budgeting is a method of organizing experimental data and information about the costs and benefits of various alternative treatments. Hence, economic advantage of varieties across treatment was evaluated. The net benefit was computed by subtracting the total variable production costs from the total gross benefit of each treatments yield per hectare. The MRR of one treatment to the other was calculated using MRR ratio formula:

$$MRR = \Delta NB/\Delta TVC \times 100$$

Where MRR is marginal rate of return, ΔNB is change in net benefits and ΔTVC is change in total variable input costs.

The minimum return which farmers expect to earn from a technology Acceptable Minimum Rate Return (AMRR) is set to between 50 and 100%, because the technology packages are new to the farmers and require that they learn some new skills; hence, 100% AMRR was taken as a reasonable estimate (CIMMYT, 1998).

All costs and benefits were taken in monetary value calculated at the farm get price. Finally, the analysis of yield and other parameters were performed using SPSS (Version - 16) software and the result was expressed in simple descriptive statistics like mean, percentage, graph and tables with figurative narration.

RESULTS AND DISCUSSION

Results of field (quantitative) data analysis

The quantitative data such as grain yield, stalk yield and maturity date analysis result showed that the performances of all improved hybrid varieties were by far better than the local variety even in improved management package and both ESH-1 and ESH-2 were best performed in all host farmers' field (Table 1).

Grain and stalk yield

Yield was the major variable which determines the adoption/non adoption status of new technologies. Farmers in both districts indicated that yield is their main criteria to adopt or not towards new technology supplied. As shown in Table 1, the total grain yield of sorghum varied among varieties.

The highest mean total yield in Sekota (Aybra) was observed on ESH-1 hybrid sorghum variety (3.23 t/ha). ESH-2 (2.82 t/ha), local with improved management (2.75 t/ha) and local with farmers management (1.15 t/ha) placed second, third and fourth, respectively.

However, in Abergele (Marnet), the highest mean yield was from ESH-2 hybrid sorghum variety (2.84 t/ha). ESH-1 (2.6 t/ha), local with improved management (1.93 t/ha) and local with farmers management (1. 13 t/ha) were placed second, third and fourth, respectively in mean yield.

There was significant difference between similar verities across districts in terms of yield. Due to differences in agro ecological situation of the two districts where Sekota (Aybra) has relatively deep and fertile soil than Abergele (Marnet) which is characterized as degraded, shallow, low fertile soil condition and hotter than its counterpart. This is literally to mean that agro ecological variation among districts lead similar technologies to perform differently with in uniform treatment.

On the other hand, both hybrid sorghum varieties productivity was better than local variety within similar agro ecology in both districts. Therefore, the highest mean yielder varieties of ESH-1 had yield advantage of 0.48 t/ha (17.5%) and 2.08 t/ha (41.1%), respectively from local variety with improved management (LIM) and local variety with farmers' management (LFM) in Aybra. Similarly, ESH-2 had yield advantage of 0.91 t/ha (47.2%) and 1.71 t/ha (151.3%) as compared to local variety with improved management (LIM) and with farmers' management (LFM) in Marnet, respectively.

Besides, the mean grain yield, ESH1 had the highest mean stalk yield (5.43 t/ha) and followed by LIM (5.1

Table 1. Analyzed results of grain yield, stalk yield and maturity date values of 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	LFM	ESH-1	ESH- 2	LIM	LFM	ESH-1	ESH- 2	LIM	LFM	ESH-1	ESH- 2	LIM	LFM	ESH-1	ESH- 2	LIM	LFM	ESH-1	ESH- 2	LIM	LFM
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
Sum	19.4	16.9	16.5	6.9	32.6	28.8	30.7	21.9	547	548	818	818	15.6	17.0	11.6	6.8	22.6	36.4	25	18.9	554	551	818	811
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
F		48.238				4.652								93.321				4.719						
Sign.		0.000				0.013								0.000				0.012						

t/ha), ESH2 (4.8 t/ha) and LFM (3.7 t/ha), respectively in Aybra. Apparently, in Abergele district ESH2 was the leading variety in mean stalk yield (6.1 t/ha) and LIM (4.2 t/ha), ESH1 (3.8 t/ha) and LFM (3.2 t/ha), respectively were second, third and fourth in that order. Additionally, as depicted in the table 1 the ANOVA test shown that there is statistically significant at less than 5% significant level in grain yield and stalk yield between each treatments in both districts.

Days to maturity

With respect to days to maturity, the analysis shows that both hybrid varieties in all districts had shorter days than the local varieties, but there was no significant difference between hybrid varieties. At the same time, local varieties had similar maturity date in Aybra. On the contrary, in Abergele, there was non-significant difference among hybrid varieties in maturity date, but the difference was significant between different treatments of local variety. Farmers justified that this variation was observed due to the application improved management; especially the impact from tie ridge took the lions share, as if it conserved better moisture than the locally treated plot. Additionally, as depicted in the table 1 the ANOVA test shown that there is statistically significant at less than 5% significant level in days to maturity between each treatments in both districts.

Survey (qualitative) data analysis results

Sekota (Aybra) district

Farmer Research and Extension Groups (FREG) identified 8 important parameters to select their best variety from the other; these parameters were valued and weighted based on their importance and sensitivity. The value of each parameter converted in to 100% to obtain the single parameters share from the total. The following are the conversion of each value.

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 holding capacity (wuha mansat) (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 weighted matrix ranking analysis result shows that variety which has greater percentage share from the total weight was peaked 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. ESH-2, LIM and LFM were preferred as second, third, and fourth with the percentage of 29.2, 19.7 and 10.4%, respectively.

FREG members 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 the seed color (white) and as best quality for food and price. However, 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).

Abergele (Marnet) district

The result of participatory approach conducted in Abergele district indicated that there were differences in selection parameters both in type and the value assigned to evaluate these treatments. This is due to difference in livelihood and cultural make up of communities in the two districts.

Hence, farmers from this district used germination and vegetative performance instead of color and marketability and even they provide equal value for grain and stalk yield. Vegetative performance was also equally evaluated with earliness, disease resistance and seed setting performance at second place, this is because they gave high credit for sorghum stalk and leafs in order to have a lot of stalk (straw) concentration for their livestock. Similarly, they said that germination performance had equal value with Wuha Mansat, because if the germination is low and scarce, both stalk and grain yields would lose due to drying by existing high temperature and wind blow.

Thus, the conversion of each value is 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), wuha mansat (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 2). The general indication is that farmers preferred ESH-2 improved hybrid technology is mainly to solve their livestock's feed shortage problem. Therefore, this variety has played significant role to fill feed shortage and concentration gaps. The weighted matrix ranking comparison of varieties by FREG members in Aybra KA showed that variety (ESH-2) placed second next to variety (ESH-1) and the first in Marnet followed by variety ESH-1 (Table 2).

The farmer's logic behind this result was that even if the supply of improved varieties in different crops including sorghum enables farmers to have technology options; there was no continuity and even there will be improved seeds scarcity in the local markets. Moreover, in both districts, varieties (ESH-1) and (ESH-2) were selected at the first and second ranks due to the following merits; both varieties have good seed setting performance, high grain and stalk yield, relatively better Wuha Mansat and very short maturity date.

On the other hand, local variety had hardly selected by farmers in both experimental districts due its poor seed setting performance, long maturity date and low grain and stalk yield. Based on farmers' evaluation and field observation, it was concluded that ESH-1 and ESH-2 hybrid varieties are highly adapted varieties for Aybra, Abergele and other similar environments respectively; and thus can be safely recommended for specified similar agro ecologies. However, the performance of LFM was poor in all areas; this is probably resulting from poor input and technology usage as the land is cultivated for many years without rehabilitating and zero treatment.

Field day and promotion

At the end of the trial, field days were organized by Sekota Dry Land Agricultural Research Center and collaboration with agricultural development offices and Swish International (non-governmental organization (HELVETAS)). The participants of the field days were model farmers, development agents (DAs), experts and officials from the seven Woredas of Wag Himra, farmers of the pre scale up KA and administrative officials from other districts of Wag-Himra zone.

A total of 399 participants have visited the trial in Aybra. Farmers prefer the variety ESH-1 for seed yield as it set seed earlier and produces better seed than the other varieties. Similarly, 75 participants have visited the trial in Marnet and prefer the variety ESH-2 for seed yield and stalk yield as it set seed earlier, produces better seed and stalk yield than the other varieties (Table 3).

ESH-1 and ESH-2 have better net benefits than the other treatments and have net benefit of 20503.9 and 12810.6 Ethiopian Birr in Aybra and Marnet kebelle respectively (Table 4).

Partial budget analysis result

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 each treatment (costs that are not varied) was not taken and analyzed. This is termed as

Table 2. Summary of major farmers' evaluation criteria of hybrid sorghum varieties and their preference ranking; at Sekota (Aybra) and Abergele (Marnet) districts of Wag-himra zone.

Weighted parameter		Sekota (Aybra)				Abergele (Marinet)			
		ESH-1	ESH-2	LIM	LFM	ESH-1	ESH-2	LIM	LFM
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	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	0.6	0.4	0.2	0.00	0.32	0.48	0.16	0.00
Wuha Mansat	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
Disease resistance	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

Table 2. Contd.

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 of products	$\sum(s*w)$	2.90	2.08	1.40	0.74	1.52	2.42	1.18	0.46
Percentage from total	%	40.7	29.2	19.7	10.4	27.2	43.4	21.1	8.30
Preference rank	#	1.00	2.00	3.00	4.00	2.00	1.00	3.00	4.00

Rank: 1= Best; 2= fair; 3= worst; 4= not selected. The score represents farmer's comparison result. This scoring multiplied by the weight to provide degree of preference of each variety in considering each parameter. Only FREG members undertook the evolution, researchers as facilitator.

Table 3. Field day participants by location, sex and technology visited.

S/N	Participants	Number of participants in field days					
		Aybra KA			Marnet KA		
		Male	Female	Total	Male	Female	Total
1	Farmers	186	111	297	37	21	58
3	Expertise	72	5	77	11	3	14
4	Officials	23	2	25	2	1	3
Total		281	118	399	50	25	75

"citrus paribus", other things remain unchanged. Hence, for this study all costs which vary across treatments and the benefits obtained were taken and calculated.

Dominance analysis

The process of eliminating dominated treatments from further analysis is called dominance analysis. A dominated treatment has the lower net benefit than other treatments of the same/higher total variable input cost. Hence, from our experiment, treatment LIM and ESH-2 were eliminated due to lower net benefit than treatment ESH-1 at higher and similar total variable input cost, respectively in Aybra KA. Similarly, treatment LIM and ESH-1 were eliminated due to lower net benefit than treatment ESH-2 at higher and similar total variable input cost, respectively in Abergele (Table 5).

Marginal analysis

According to the experiment, the result of marginal rate of return shows that for every Ethiopian birr 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 birr 1.00 and obtain an additional Ethiopian birr 42.92 in Sekota district.

On the other hand, at Abergele district, the result of marginal rate of return shows that for every Ethiopian birr 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 birr 1.00 and obtain an additional Ethiopian birr 53.82. Therefore, adopting ESH-1 and ESH-2 together with improved packages implies a >100% rate of return and economically feasible in Sekota (Aybra) and Abergele (Marnet) districts.

Table 4. Partial budget analysis.

Cost/Benefit items	Treatments							
	Sekota (Aybra)				Abergele (Marnet)			
	ESH-1	ESH-2	LIM	LFM	ESH-1	ESH-2	LIM	LFM
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 get price (birr/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%(t/ha)	4.890	4.32	4.59	3.33	3.42	5.49	3.78	2.88
Average farm get price of stalk (birr/t)	806.8	806.8	806.8	806.8	773.2	773.2	773.2	773.2
Gross benefits from grain yield (birr/ha)	20390.4	17983.2	17558.4	7363.2	12168	13312	9152	5304
Gross benefits from stalk yield (birr/ha)	3945.3	3485.4	3703.2	2686. 6	2644.4	4244.9	2922.7	2226.8
Total Gross benefits (birr/ha)	24335.7	21468.6	21261.6	7363.2	14812.4	17556.9	12074.7	7530.8
Cost of improved/local seed (birr/ha)	150.0	150.0	80.0	160.0	200.0	200.0	100	200
labor cost for row*/ broadcast (birr/ha)	272*	272*	272*	12.9	337.5*	337.5*	337.5*	155
Cost of DAP/ Urea fertilizer (birr/ha)	1787.8	1787.8	1787.8	0.00	1787.8	1787.8	1787.8	0.00
Cost of labor for fertilizer** tie ridge** shilshalo* application (birr/ha)	1622**	1622**	1622**	783*	2421**	2421**	2421**	975*
Total costs that vary (birr/ha)	3831.8	3831.8	3761.8	955.9	4746.3	4746.3	4646.3	1330
Net benefits (birr/ha)	20503.9	17636.8	17499.8	6407.3	10066.1	12810.6	7428.4	6200.8

**,*Indicate similar costs across treatments. All numbers are in Ethiopian birr.

Table 5. Dominance analysis of treatments.

Seed	Treatments	Sowing	Moisture	Sekota (Aybra)			Abergele (Marnet)		
				Variable costs (birr/ha)	Net benefits (birr/ha)	MRR	Variable costs (birr/ha)	Net benefits (birr/ha)	MRR
ESH-1	Improved	Row	tie ridge	3831.8	20503.9	42.92	4746.3	10066.1	**D**
ESH-2	Improved	Row	tie ridge	3831.8	17636.8	**D**	4746.3	12810.6	53.82
LIM	Local	Row	tie ridge	3761.8	17499.8	3.95	4646.3	7428.40	0.37
LFM	Local	Broadcast	Shilshalo*	955.9	6407.3	R	1330	6200.8	R

*"Shilshalo" means local tool of in-suite moisture conservation. "D" means dominated and "R" means Rejected.

DISCUSSION

This study, basically focuses on participatory evaluation of preferences to create demand driven awareness and popularization of improved hybrid sorghum technologies in Sekota (Aybra) and Abergele (Marnet) districts of Eastern Amhara. Hence, two improved hybrid and one local sorghum variety with improved and farmers

management were used for assessment. Based on each production year result the performance of improved technologies have shown considerable amount of variability among treatments. For instance, mean total grain yields of varieties varied from 3.23 to 1.15 t/ha in Aybra and 2.84 to 1.13 t/ha in Abergele districts. Similarly, mean total stalk yields of varieties varied from 5.43 to 3.7 t/ha in Aybra and 6.1 to 3.2 t/ha in Abergele districts. Moreover, the maturity date of the technologies also varied from 136.3 to 91.2 days and 136.3 to 91.8 days for Aybra and Abergele districts, respectively. The result of farmers' evaluation criteria indicated that, farmers in both study districts acquire considerable knowledge about the hybrid sorghums and their attributed packages for each variety. Similarly, the partial budget analysis result also indicated that ESH-1 was more economically feasible in Aybra with 20503.9 total net benefits and birr 4.90 marginal rate of return; while ESH-2 was in Abergele with 12810.6 total net benefits and birr 1.94 marginal rate of return, respectively. Hence, based on the overall weighted pair-wise ranking matrix comparison of farmers, varieties ESH-1 and ESH-2 took the first and the second places orderly in Sekota district and vice versa in Abergele.

CONCLUSION AND RECOMMENDATIONS

The result of this experiment revealed that both hybrid sorghum varieties were found to be by far advantageous in most farmers' preference parameters and the cost benefit analysis result showed that they were economically feasible over the local variety. Therefore, there is a need to investigate further other evaluation for districts which have different socio-cultural set up to the current study areas for the effective promotion of this important crop to users. Based on this study (field observation, farmers preferences and partial budget analysis result), varieties ESH-1 and ESH-2 had good performance and preferences by farmers evaluation group in Sekota (Aybra) and Abergele (Marnet) districts, respectively. Thus, it can be safely recommended for promotion and scale-up these technologies in each respective district and sustainable seed source should be identified by forming farmer's seed multiplication cooperatives and/or through providing pre basic seeds to seed multiplying enterprises.

Conflict of Interests

The authors have not declared any conflict of interests.

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Abbreviations: FREG, Farmers Research and Extension Group; **FRG,** Farmers Research Group; **KA,** Kebelle Administration or Peasant Association; **Das,** Development Agents; **m.a.s.l.,** meter above sea level; **ESH-1,** Ethiopian Sorghum Hybrid one; **ESH-2,** Ethiopian Sorghum Hybrid two; **LIM,** Local Seed with Improved Management; **LFM,** Local Seed with Farmers' Management; **MRR,** Marginal Rate Return; **ΔNB,** Change in net benefits; **ΔTVC,** Change in total variable input costs; **AMRR,** Acceptable Minimum Rate of Return; **S,** score; **W,** weight; **%,** percentage; ∑, Summation; **ha,** hectares; **kg,** kilogram; m, meter; **E.C.,** Ethiopian Calendar; **Shekm,** local measurement of crop stalk yield; **Marnet,** local name of kebelle administration or peasant association; **Aybra,** local name of kebelle administration or peasant association; **SDARC,** Sekota Dry land Agriculture Research Center; **SPSS,** Statistical Package for Social Science; **WAO,** Woreda Agriculture Office; **Wuha Mansat,** a criteria for food preparation like injera preparation.

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