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Research Article

Participatory Variety Selection of Improved Highland Sorghum on the Basis of Farmers Preference Traits in Eastern Part of Ethiopia

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ABSTRACT

Participatory variety selection is the most important breeding program which enhanced adoption of suitable improved varieties in order to address the needs of a broader range of users and to enhance farmer skills in variety selection and seed production efforts. It plays significant role in collaboration between breeders, farmers, marketers, processors, consumers, and policy makers. It also allows farmers to take part in the development of new varieties more suitable to marginal environments and to organic farming agronomic practices. Several different improved sorghum varieties are released at different international and national research institutions in different times, however the technologies were not properly addressed the farmers based on participatory, client oriented and demand driven. Therefore, the experiment was conducted in Eastern part of Ethiopia of Oromia regional state to evaluate the performance of improved sorghum varieties and to identify farmers' preference traits through continuous performance evaluation at different stages of the crop. Five sorghum varieties along with local check collected from study area were evaluated in randomized complete block design in 2019 main cropping season. Farmers' evaluation was made at two different stages of the crop, namely at flowering and maturity using both direct-matrix and pair-wise ranking methods of selection scheme. Farmers' set; grain yield, disease resistance, grain color and seed size as selection criteria to evaluate and identify their preferred varieties. The results of analysis of variance indicated the existence of highly significant differences among varieties for all traits measured except plant height at 5% probability level. The highest mean grain yield was obtained from the variety Dibaba (11325 $Kgha^{-1}$) and Jiru (10200 $Kgha^{-1}$) respectively. Grain yield had positive and highly significantly correlated with thousand seed weight (0.95**) and also positively and significantly correlated with days to 50% flowering (0.85*). Likewise, based on the overall farmer's preference (from both pair-wise and direct matrix ranking evaluations), Dibaba and Jiru were ranked first and second and followed by Adelle, ETS2752 and Chiro respectively. Thus, the varieties Dibaba and Jiru were chosen for their performance in the field and from farmers' evaluation perspective. Moreover, this study indicated participatory varietal selection is a viable method to gain greater insight into farmers' perceptions, preferences, merits and shortcomings of sorghum varieties. Therefore, based on the results of this study, Dibaba and Jiru are recommended for multiplication and distribution to farmers through both formal and informal seed systems. Generally, the integration of plant breeders and farmer's perception used to increase the adoption rate and design a good breeding program for future improvement.

Key words: Participatory; Farmers preference; Selection; Farmers breeding; Integrated breeding; Improved varieties

INTRODUCTION

Sorghum (*Sorghum bicolor (L.) Moench*] is predominantly a self-pollinating C_4 crop belonging to the family *Poaceae*. Sorghum is the fifth most important cereal crop in both total production and acreage in the world and occupies the second position among the staple food grains in semi-arid tropics (FAOSTAT, 2018). The origin and the early domestication of sorghum took place in northeaster Africa approximately 5000 years ago (Doggett and Prasada Rao, 1995). Ethiopia is the center of origin and diversity for sorghum where large genetic diversity in wild and cultivated is substantially available (Doggett, 1988). Sorghum stands third in Ethiopia in terms of area coverage after teff and maize and second next to maize in terms of productivity (CSA, 2018). The adaptation of grain sorghum to a wide range of environmental conditions has led to the evolution and existence of extensive genetic variation for

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different agronomic traits. Accordingly, sorghum is expected to play an increasingly remarkable role in agriculture and meeting world food demand in the face of climate change, land degradation and increasing water scarcity. Sorghum is grown globally for food and feed purposes in dry land agriculture because of its wider adaptability to drought prone areas (Reddy *et al*., 2004). As food-grade, special attention is given to sorghum because it is gluten-free and contains high levels of health-promoting phytochemicals (Asif *et al*., 2010).

In developing countries, sorghum is primarily used as a food crop (Bawazir, 2009) and has been improved to a great extent for grain yield (Adebo *et al*., 2018). More than 500 million people consume sorghum as their principal food source in developing countries (Burke *et al*., 2013). Participatory variety selection is the research process by which farmers are routinely involved in selecting varieties that they prefer the most appropriate traits for their own uses among stable varieties that are being field tested. In participatory variety selection, farmers are involved with the opportunities to make decision in selecting the best performed varieties based the key criteria of their desirable traits. Farmers' involvement in participatory variety selection can take many advantages, which includes defining breeding goals and priorities, selecting the best varieties, hosting trials on their land, selecting varieties for further crossing; discussing results with the scientists, planning for the following year's activities, suggesting methodological changes, and multiplying the seed of the selected varieties. Participatory variety selection generally involves a higher and more complex degree of involvement of farmers, as they are engaged in decision-making in earlier and more fundamental stages of the variety development chain (Witcombe, 2005).

Participatory variety selection is based on the idea that farmers as well as professional plant breeders have important knowledge and skills that could complement one another (Bhargava *et al*., 2014). Participatory variety selection involves a mix of actors including scientists, breeders, farmers and other stakeholders in plant breeding stages (Probst, 2016). Participatory variety selection is a strategy for plant breeding with its own set of methodologies that applies in situations where the demand for specific varietal traits among producers, traders, industries and consumers is poorly understood and difficult to diagnose with conventional market research methods (Malandrin and Dvortsin, 2013). In conventional plant breeding (CPB) new varieties are released before knowing whether the farmers like them or not and the process is typically supply-driven. However, participatory variety selection is turned upside down because the process is driven by the initial adoption by farmers at the end of a full cycle of selection and is therefore demand-driven (Nelson *et al*., 2015).

Therefore, participatory research is now seen by many as a way to address the problems of most agricultural research programs, as participatory variety selection is expected to produce varieties that are targeted, relevant and appropriate (Bellon, 2006). Participatory variety selection is enhanced adoption of suitable improved varieties in order to address the needs of a broader range of users and to enhance farmer skills in variety selection and seed production efforts (Bhargava *et al*., 2014). Participatory varietal selection can be used effectively to identify farmer-acceptable varieties and thereby overcome the constraints that cause farmers to grow old or obsolete varieties (Rahman *et al*., 2015). Participatory variety selection also provides an opportunity to the farmers to evaluate many kinds of varieties on their own fields; cultivars can be searched according to the needs of the farmers of study areas with some other characters, such as earliness, high yielder, biomass, disease and insect resistance and others good quality traits. It also enhances farmer's access to crop varieties and increase in diversity; increase production and ensure food security; help to disseminate the adoption of pre and released varieties in larger areas; allow varietal selection in targeted areas at cost-effectiveness and as a consequence help seed production and scaling-up at community level (J.B. Ogliari *et al*., 2013).

The national and regional sorghum improvement programs routinely develop improved sorghum varieties for different agro-ecologies of the country without the involvement of end-users; in many cases their new varieties have not been adopted by farmers. The reason is that farmer's preferences and perceptions are rarely taken into consideration during the breeding process (Mekbib, 2007). Despite the economic importance and contribution of sorghum to attain food security and food-self-sufficiency in the region in general and in the study area in particular, farmers were not aware of the availability of improved sorghum varieties for their agro-ecologies. Hence, farmers in the Eastern Ethiopia are still cultivating disease-susceptible, long-maturing and low yielding local landraces. Thus, the utilization of improved sorghum varieties (lack of farmers preferred high yielding sorghum varieties, early maturing, better quality, diseases and pests) is very low in the study areas. The adoption of improved sorghum variety is very low due to poor participation of farmers' in varietal selection process, inadequate knowledge of the farmers about the varieties, lack of improved variety that adapt the specific environments and inadequate supply of seed of the varieties to satisfy farmers' needs, inadequate research interventions, lack of improved varieties that give reasonable yield under farmers' cultural management, and poor research-extension-farmer linkage (Adugna, 2007).

For successful breeding and increased adoption of new varieties, integrated plant breeding should be adopted in order to develop better varieties, and thereby to increase sorghum productivity in the country. For the rapid improvement of sorghum production, and to enhance the adoption of new sorghum cultivars in eastern Ethiopia, there is an urgent need to better understand the impact of farmer's preferences and key traits that would be preferred in new sorghum cultivars in the target areas. The ultimate goal of plant breeding is to increase yield through targeting farmers preferred traits. In addition to farmers trait preference understanding of the crops breeding behavior is prerequisite to design a good breeding program. Therefore, the objectives of this study was to evaluate the best performing improved sorghum variety/es and to advance the best performed and adapted improved sorghum variety/ies to large scale demostration by identifying farmers' selection criteria and to strengthen the partnership and networking with sorghum growers in order to generate information for future breeding program.

MATERIALS AND METHODS

Location of the Experiment

The experiment was conducted at West Hararghe zone, particularly at Chiro District during 2019 main cropping season. Chiro is located at $09^0$05'N latitude and $40^0$88'E longitude at an altitude of 1856 m.a.s.l. It is 328 kilometers far away from Addis Abeba in the eastern part of the country in the Oromia Regional State and where the highland sorghum is intensively and extensively produced by farmers. The area has the average minimum and maximum temperature of 12^0c and 23^0c respectively and receives 950 mm annual rainfall. The soil type of the experimental station is classified as black Vertisols (Gosa, 2016).

Plant Materials

A total of six sorghum genetic materials were included in the experiment. Five of them were improved sorghum varieties while the other one was the most widely used local sorghum landrace collected from the study area. The improved sorghum genotypes used in the experiment were released for the highland agro-ecologies by the National Sorghum Improvement Program in different times. These materials were evaluated and released for the advantages of well adaptive and stability of yield, earliness in terms of maturity, resistance to diseases, seed size and color, biomass and other quality characteristics.

Experimental Design and Trial Management

The experiment was arranged in a completely randomized block design with two replications during 2019 main cropping seasons to evaluate the genotypes. The experimental units were composed of four 5m-long rows, spaced by 0.75m. During planting, the seeds were manually drilled at the seed rate of 12kgha^{-1}. At approximately twenty-one days after planting, the seedlings were thinned to 0.20 m distance between plants. All the standard agronomic packages and fertilizer rates of 100 kgha^{-1} DAP was applied to the basal at the time of planting whereas 50 kgha^{-1} Urea was applied in the form of split application, half of which was applied together with DAP during planting and the remaining top dressed before heading at knee stage. Hand weeding was practiced as frequently as needed and karate insecticide was sprayed to control pests on the basis of it's recommended of frequency and doses.

Data Collection

Data were collected on plant and plot basis for different agronomic traits (IBPGR/ICRISAT, 1993).

Data collected on the basis of individual plants

Plant height (PH in cm): The height of the plant from the bottom to the tip of the panicle during flowering on 5 randomly tagged plants.

Panicle yield (PY in g): The weight of individual panicle measured using one randomly selected representative plant.

Data collected on the basis of plots

Days to flowering (DTF): Number of days from emergence till 50% of the plants in a plot showed flowering halfway down the panicle.

Days to maturity (DTM): The number of days from emergence to the date when 95% of the plants matured physiologically.

Disease reaction (score): Disease severity (1-5) was recorded from each plot during at different growth stages of plants.

Grain yield (GY): Grain yield obtained from total harvest of the plot and then converted to ton/ha after adjusting to optimum seed moisture content.

Thousands seed weight (TSW in g): The weight of 1000 grains sampled from a plot at 12.5% moisture content recorded in gram.

Over all plant aspect (PAS): Over all agronomic performance of the observation based on the recorded traits using 1-5 scale, where 1= excellent, 2= very good, 3= good, 4= poor and 5= very poor.

Qualitative data collected

Seed color: 1 = White, 2 = Light white, 3 = Red, 4 = Gray, 5 = Medium brown, 6 = Dark brown,
Seed size: 1= Big, 2= Medium, 3= Small

Farmers' Participatory Varietal Selection (PVS)

Farmers' evaluation was made at two different stages of the crop, namely at flowering and at maturity using both direct-matrix and pair-wise ranking methods of selection scheme. Many farmers were participated on varietal selection trial using participatory tools. Farmers' selection was done based primarily on their sorghum growing experience, gender ratio and willingness to participate in the research. A total of 450 farmers of both sexes (male = 354, female = 96) participated in the study. Farmers were allowed to set their own selection criteria and then both male and female participants prioritized and jointly agreed on two characters (earliness and stalk borer resistance) and four characters (grain yield, disease resistance, grain size and seed color) during flowering and physiological maturity stage of the crop respectively. All of them were tabulated in a matrix scoring table and each selection criterion was compared with each other in a pairwise fashion. The rank assignments were determined from the number of times each selection criterion was preferred by the group. After identifying and weighing their best selection criteria, farmers were invited to observe carefully all the experimental units and select the best variety (ies) based on its/their fitness to the specific criteria according to the existing constraints and opportunities in their micro environments. A direct matrix table was prepared for the evaluated genotypes listed in the row and traits preferred by farmers listed in the column. Scores were given to each variety based on the selection criteria (5 = very good, 4 = good, 3 = average, 2 = poor and 1 = very poor).

Statistical Data Analysis

The data were analyzed using PROC ANOVA in SAS software version 9.4 (SAS, 2016) and means were separated using LSD (Least Significant Difference) at the 5 % level of significance. Farmers' preference data were analyzed using pairwise matrix preference ranking method. Pairwise comparison matrix is a good way of weighing up the relative importance of different courses of action. It is a tool that provides a framework for comparing each course of action against all others and helps to show the difference in importance between factors.

Genotypic Correlation Analysis of Yield and Yield Related Traits

Correlation analysis was done by using the following formula (Trumbo, 2002).

$$r = \frac{Sxy}{\sqrt{sxxsyy}}$$

$$\text{Genotypic correlation (rg)} = \frac{\delta^2 gXY}{\sqrt{(\delta^2 gX)(\delta^2 gY)}}$$

Where, $\delta^2 gXY$ = genotypic covariance between two traits X and Y

$\delta^2 gX$= genetic variance of trait X

$\delta^2 gY$ = genetic variance of trait Y

RESULTS AND DISCUSSION

Analyses of Variance (ANOVA)

The analyses of variance (ANOVA) for all quantitative traits indicated the presence of highly significant difference ($P < 0.01$) among the highland sorghum varieties for yield and yield related components; however, plant height trait appeared insignificant (Table 2). The presence of significant difference among sorghum varieties for the studied traits ensured the presence of large genetic variation to be improved through selection. Similar results of large genetic effects were reported by Abiy and Firew (2016); Kinde *et al*. (2016). Genotypes exhibited significantly high ($P < 0.01$) for days to 50% flowering, days to 95% maturity, grain yield (kg), and thousand seed weight (g). This indicated the presence of considerable variation in the genetic materials for these traits and improvement of the parental lines with these traits is possible with simple selection. Plant breeding is primarily depends on presence of substantial genetic variation to address the maximum genetic yield potential of the crops and exploitation of this variation through effective selection for further improvement. Hence, the obtained results encourage the availabilities of substantial genetic variation among genotypes for the major studied traits.

Mean performance of Highland Sorghum Genotypes

Yield improvement is the primary concern of plant breeders to mitigate the effect of food security problems. This day, the development of the superior genotypes in terms of yield, maturity, resistance to diseases and insets and other many different traits very critical to address the required challenges of human population growth and climate change. Overcoming these difficult challenges will be harder in the absence plant genetic improvement to increase agricultural productivity through addressing the problem of yield reduction and its links with pest management and climate change. Based on the mean performance, the superior sorghum genotypes were identified for different traits as indicated in (Table 3). The mean grain yield for genotypes ranged from 4.275 tha^{-1} to 11.325 tha^{-1}. The grain yields obtained from Dibaba (11.325 tha^{-1}), followed by Jiru (10.200 tha^{-1}) was significantly (P 0.01) higher than that from the other tested varieties and had yield advantage of 265% and 239% over local check (4.275 tha^{-1}), respectively. The highest yield was obtained from Dibaba variety (11.325 tha^{-1}), followed by Jiru (10.200 tha^{-1}), Adelle (8.175 tha^{-1}), ETS2752 (6.075 tha^{-1}), Chiro (5.775 tha^{-1}), Shafare (4.275 tha^{-1}). This implied that, the performance of the Dibaba variety was highest as compared to the rest varieties whereas the local variety (Shafare) was the lowest for yield trait.

The superiority of the improved sorghum varieties over the check variety in grain yield indicates the potential positive economic advantage of improved sorghum varieties in the diverse sorghum-growing environments. Adelle (175 days), Jiru (176 days) and Dibaba (180 days) varieties were stood first in maturing trait whereas Shafare (local) (213.50 days) variety was the longest maturing genotypes. Days to flowering and maturity are among the most important attributes that need to be considered in selecting varieties when and where the shortage of rainfall is limiting factor for further improvement of yield and yield related traits. However, the shortage of rainfall is not common and critical factor for highland areas. Both early and late maturing genotypes had the same grain fill duration, However, variation was detected for grain yield and related yield components among these genotypes, indicating that, the variation in the other attributes might be associated with factors other than duration of grain fill. The top yielder genotypes (Dibaba) required 119.5 days to flower and 180 days to mature which was close to the average for genotypes, 125.17 days for flowering and 186.33 days for maturity. This indicates that, the yielding potential is not necessarily associated with crop phenology provided that genes for high yield potential are incorporated in the genotypes. The Dibaba variety showed superior mean performance in thousand seed weight (41.50g), which had direct proportional with yield and very important in vigorisity and germination.

Genotypic Correlation Analysis of Yield and Yield Related Traits

Correlation analysis is very critical in determining the direction of selection and number of traits to be considered in improving grain yield. Correlation coefficient also used to quantify the association between two continuous variables. Correlation analysis quantifies the direction and strength of the linear association between the two characters studied for further improvement. The result of correlation analysis of agronomic traits for the highland sorghum genotypes indicated the presence of important associations among yield and yield related characters (Table 4). Days to 50% flowering had positive and highly significant correlation with days to physiological maturity (r = 0.97**), thousand seed weight (r = 0.94**) and significant grain yield (r = 0.85*). This revealed the strong association of the days to 50% flowering with days to 95% physiological maturity and possibilities of improving the traits simultaneously at the same time. Grain yield had positive and highly significantly correlated with thousand seed weight (0.95**) and also positively and significantly correlated with days to 50% flowering (0.85*). This showed that the maximum flowering difference observed in the whole set of varieties did not bring about variation in grain yield and strongly associated with the major yield components. These indicates that those traits are important for improvement of grain yield in sorghum and this result was in agreement with those obtained by Firew *et al*. 2016 and Guade *et al*. 2017.

Participatory Variety Selection

Participatory variety selection study was conducted to identify and select improved sorghum varieties based on farmer's preferred yield and yield related traits. This day,

Table 1: Sorghum varieties included in farmers group variety evaluation experiment at Chiro district during 2019

S. N	Variety	Agro-ecology	Releasing year	Flowering Date	Height (cm)	Yield t/ha	Color
1	ETS2752	Highland	1978	130 – 140	243-285	3.0- 5.5	White
2	Chiro	Highland	1998	130 – 140	234-315	4.2- 5.8	Red
3	Dibaba	Highland	2015	120- 140	290-320	3.7- 5.0	Brown
4	Jiru	Highland	2016	117 – 144	239-389	3.3- 8.6	Brown
5	Adelle	Highland	206	123 – 149	255-356	3.7- 7.2	White
6	Shafare	Highland	Local (check)	Late flowering	Medium	low	Red

Source: Melkassa miscellaneous years variety release documents (2018)

Table 2: Mean squares from analysis of variance (ANOVA) of measured phenological and agronomic traits

Source of Variation	DF	DTF	DTM	PHT	GY	TSW
Replication	1	0.33^{ns}	33.33^{ns}	0.33^{ns}	991875.00^{ns}	0.08^{ns}
Treatment	5	81.93**	416.73**	137.93^{ns}	15067875.00**	24.88**
Error	5	1.13**	11.13**	187.53^{ns}	217875.00**	0.88**
Mean		125.17	186.33	344.17	7637.50	36.58
CV%		0.85	1.79	3.97	6.11	2.57

**Highly significant at 1% probability level, ns = non-significant at 5% probability level where, DTF=days to 50% flowering, DTM=days to physiological maturity, PHT=plant height, TSW=thousand seed weight, GY=grain yield.

Table 3: Mean values of different Sorghum varieties for grain yield and other agronomic characters

			Mean		
Varieties	DTF	DTM	PHT	TSW	GY
Adelle	121.00^{c}	175.00^{c}	346.00^{a}	37.50b^{c}	8175.00^{b}
Chiro	126.50^{b}	190.50^{b}	332.00^{a}	35.50^{c}	5775.00^{c}
Dibaba	119.50^{c}	180.00^{c}	345.00^{a}	41.50^{a}	11325.00^{a}
ETS2752	125.50^{b}	183.00b^{c}	356.00^{a}	35.50^{c}	6075.00^{c}
Jiru	121.50^{c}	176.00^{c}	348.00^{a}	38.50^{b}	10200.00^{a}
Shafare (local)	137.00^{a}	213.50^{a}	338.00^{a}	31.00^{d}	4275.00^{d}
Mean	125.17	186.33	344.17	36.58	7637.50
LSD	2.74	8.58	35.20	2.42	1199.90
CV%	0.85	1.79	3.97	2.57	6.11

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to least significant difference (LSD); DTF=days to 50% flowering, DTM=days to physiological maturity, PHT=plant height, TSW=thousand seed weight, GY=grain yield (Kg/ha).

Table 4: Genotypic correlation of sorghum varieties for major farmers preferred traits at Chiro District during 2019

	DTF	DTM	PHT	TSW	Yield
DTF	1	0.97**	0.42^{ns}	0.94**	0.85*
DTM		1	0.54^{ns}	0.84*	0.76^{ns}
PHT			1	0.33^{ns}	0.34^{ns}
TSW				1	0.95**
Yield					1

**Highly significant at 1% probability level, ns=non-significant at 5% probability level where, DTF=days to 50% flowering, DTM=days to physiological maturity, PHT=plant height, TSW=thousand seed weight, GY=grain yield.

Table 5: Pair-wise ranking of farmers selection criteria at maturity stages at Chiro District during 2019

No	Selection Criteria	GY	GS	GC	DR	PHT	score	Rank
1	GY	x					4	1
2	GS	GY	x				1	4
3	GC	GY	GS	x			2	2
4	DR	GY	DR	GC	x		2	2
5	PHT	GY	PHT	GC	DR	x	1	4

Where: GY=Grain Yield, GS= Grain size, GC= Grain color, DR= Disease resistance.

Table 6: Direct matrix ranking evaluation of genotypes by of group of farmers' at Chiro District during 2019

Selection criteria	Grain yield	Grain size	Grain color	Disease resistance	Total score	Rank
Relative weight	3	2	1	1		
ETS275	9(3)	4(2)	4(4)	4(4)	21	4
Chiro	9(3)	4(2)	3(3)	4(4)	20	5
Jiru	15(5)	8(4)	5(5)	4(4)	32	2
Adelle	12(4)	8(4)	4(4)	5(5)	29	3
Dibaba	15(5)	10(5)	5(5)	4(4)	34	1
Shafare(local)	6(2)	6(3)	3(3)	2(2)	17	6

N.B. Number of farmers in the evaluation=450 (M=354 and F=96); numbers in parenthesis indicated the performance rating value of each variety given from 1-5 (5=excellent, 4=very good, 3=good, 2=poor and 1=very poor) and numbers written in the bold indicate total score of a variety as per each selection criteria, which was obtained by multiplying the relative weight of each selection criteria with that of the performance rating number in the parenthesis.

Table 7: Farmers pair-wise ranking of evaluated highland sorghum genotypes at Chiro District during 2019

Varieties	ETS275	Chiro	Jiru	Adelle	Dibaba	Shafare(local)	Score	Rank
ETS275	x						2	4
Chiro	ETS275	x					1	5
Jiru	Jiru	Jiru	x				4	2
Adelle	Adelle	Adelle	Jiru	x			3	3
Dibaba	Dibaba	Dibaba	Dibaba	Dibaba	x		5	1
Shafare(local)	ETS275	Chiro	Jiru	Adelle	Dibaba	x	0	6

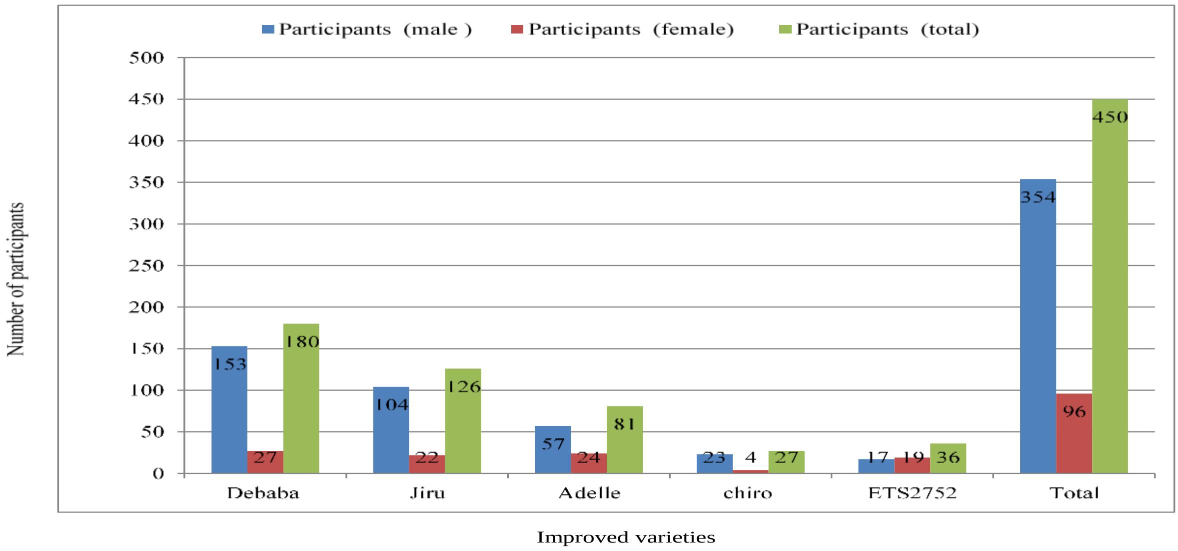

Fig. 1: Rank of improved highland sorghum varieties selected by participants based on selection criteria

the poor farmers in marginal areas continue to grow old sorghum crop varieties that are often low yielder, susceptible to pests and disease, and which are less suited to current constraints and opportunities experienced by farmers. Thus, the criteria farmers used in identifying the suitable varieties depend on the existing constraints and opportunities farmers faced in their micro and macro environments. The key criteria used by farmers to evaluate and select the preferred varieties were grain yield, disease resistance, grain size and color. These farmers have had little exposure to grow new sorghum varieties. Hence, participatory varietal selection is the basic means of addressing the problems that cause farmers to grow low yielding old or obsolete varieties, cultivating disease-susceptible and long-maturing local landraces. Participatory variety selection focuses on the facilitation and collaboration between plant breeders and farmers to gain the poorest farmers the opportunity to benefit from new varieties.

Pair-wise matrix ranking and direct matrix ranking were used to identify the prioritization order of the farmers' selection criteria (Table 5, 6 and 7). Several farmers were participated and selected different improved sorghum varieties based on their preference characteristics and agronomic performance. Accordingly, the preferred improved sorghum variety should have high grain yield, bold grain size, brown and white grain color and better resistance to common leaf and panicle diseases. Farmers gave the highest weight to grain yield followed by grain size and color. Similarly, Fentie Molla, (2012) reported that farmers identified seed color and blast disease reaction as important criteria. Moreover, disease resistance and plant height were also selected by farmers' as moderate significance. Based on average grain yield, grain size and disease reaction performance, farmers' selected Dibaba and Jiru as the best varieties for their highest yield, bold or large grain size and resistance to different fungal and bacterial diseases. With regard to grain color, most of the farmers preferred ETS2752 and Adelle were selected because of their white attractive color whereas Dibaba and Jiru had brown color which was acceptable from farmers' perspective. However, color alone could not be a good selection criterion in sorghum. Therefore, based on the results of field experiment and farmers' evaluation the varieties Dibaba and Jiru were the most preferred ones.

Based on the direct matrix rankings, the total score (the product of relative weight of each criterion by the relative importance) of the evaluation by farmers ranged from 17 to 34. The highest score was given to Dibaba (34) followed by Jiru (32); whereas the least score given to Shafare (17) due to its low yield and susceptibility to anthracnose disease. Moreover, pair-wise ranking evaluation provides opportunities to farmers to see in detail the merits and demerits of each variety by comparing and contrasting two varieties at a time. According to pair-wise ranking the variety Dibaba preferred five times and ranked first followed by Jiru preferred four and ranked second. Therefore, based on the results of direct matrix and pairwise ranking evaluation, Dibaba and Jiru were the most preferred ones.

A total of four hundred fifty farmers were participated to evaluate and select improved sorghum varieties based on their indigenous knowledge of sorghum cultivation. These farmers were preferred improved sorghum varieties using different selection criteria as indicated in table and figure form. Based on the overall farmer's preference, Dibaba and

Jiru were ranked first and second respectively and followed by Adelle, ETS2752 and Chiro. The integration of plant breeders and farmers used to increase the adoption rate and design a good breeding program for future improvement. As a result, the ultimate goal of plant breeding is to increase yield through targeting farmers preferred traits and awareness was created about the advantage of improved sorghum varieties as compared to the old varieties which they were growing for targeted communities. Ranking of varieties using individual traits could show clearly the relation between the farmers' preferences and the researcher's view across the varieties. Therefore, the best varieties could be identified using the rank sum method and in addition to farmer's trait preference, understanding of the crops breeding behavior is prerequisite to design a good breeding program.

CONCLUSIONS

Sorghum is the most important and dominant cereal crop in the world and sub-Saharan Africa in terms of largely a subsistence food crop, feed, fodder and fuel. In Ethiopia, sorghum is the third most important crop both in area coverage and tonnage after teff and maize and becoming fourth primary staple food crop after teff, maize, and wheat. The major sorghum producing regions of the Ethiopian country are Oromia (38.5%), Amhara (32.9%), Tigray (14.1%) and Southern Nations and Nationalities People (SNNP) region (7.6%). West Hararghe zone in the Oromia National Regional State is an area where sorghum is the first food crop and largely produced. However, shortage of widely adapted and high yielding improved sorghum variety is one of the major bottlenecks for production and productivity of the highland areas. The improved sorghum technologies are not properly and widely addressed Eastern part of Ethiopia in general, Western Hararghe Zone in particular on the basis of farmer's preference traits. Hence, farmers' participatory varietal selection was conducted to select improved sorghum varieties that possess farmers' preferred traits.

Participatory variety selection is a basic tool to in facilitating the adoption rate and enhancing the extension of the improved sorghum technologies. The development of successful improved sorghum varieties requires the incorporation of farmer's perceptions and desires into the end product. Failure to do this in the past probably explains the low rate of adoption of improved varieties. Based on the analyses of variance, the study consistently identified varieties that produced more grain yield than the already existing old varieties. Additionally, the pairwise and direct matrix analyses explained that farmers prioritized grain yield, grain size, grain color and reaction to diseases. The farmers selected varieties and grain yield were highly correlated. Therefore, farmer's participation was very important in variety evaluation and selection. Based on agronomic traits and farmers' visual observation at experimental site was highly and positively correlated. As a result, Dibaba and Jiru were selected for continued cultivation and needs to be multiplied and distributed to the farmer's for very large scale production.

Generally, the development of locally adapted and farmers preferred improved sorghum varieties to a particular environment is one solution to overcome the challenges of both local adaptation and local farmers' end use requirements. The current study focused on investigating the effectiveness of demonstrating the potential improved sorghum varieties that address the adaptation issue and multiple trait demands of farmers. Therefore, based on the results of field experiment and farmers' evaluation, the varieties Dibaba and Jiru were the most preferred ones. It also proved that earliness and high yield of improved varieties were the most important criteria for farmers to choose a new variety, but they indicated they would not totally reject their local varieties because of social considerations. Cultivar improvement should therefore target characteristics of local varieties in the creation of new ones. Early maturing varieties with high yield potential, resistance to sorghum midge, downy mildew and long smut would be welcomed by farmers. Interestingly, farmers were increasingly participated in agricultural research as scientists and development workers become more aware of the philosophy of 'farmer first' and its effectiveness. Participatory plant breeding or selection has shown success in identifying more number of preferred varieties by farmers in shorter time (than the conventional system), in accelerating their dissemination and increasing cultivar.

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