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Performance Evaluation and Participatory Variety Selection of Improved Highland Sorghum Varieties at West Hararghe Zone

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Abstract: Developing high yielding cultivars with acceptable and farmers preference traits are the ultimate goal of crop improvement program. However, farmers in marginal areas continue to cultivate low yielding, susceptible to pests and disease sorghum land-races. Therefore, the experiment was conducted at the Hirna and Chiro with the objective to evaluate the adaptability and identify farmers' preferred traits to address the issues of farmers' selection criteria. A total of six sorghum varieties were evaluated using randomized complete block design during 2019 main cropping season. Farmers' evaluation was done through direct-matrix and pair-wise ranking methods at flowering and maturity developmental stages. Farmers prioritized grain yield, biomass, seed color, disease resistance and seed size traits during evaluation and identification of their preferred varieties. The results of combined analysis of variance showed the presence of highly significant genetic variation among varieties for all the studied characteristics at 1% probability level. Dibaba (11.375tha^{-1}) and Jiru (10.175tha^{-1}) varieties recorded the highest grain yield and identified as the superior improved sorghum varieties by both field experiment and farmers visual observation. Grain yield had positive and highly significantly correlation with days to50% flowering (0.91**), days to maturity (0.73**) and thousand seed weight (0.91**). Likewise, based on the overall farmer's preference, Dibaba and Jiru were ranked first and second and followed by Adelle, Chiro and ETS2752 respectively. Hence, the varieties Dibaba and Jiru were selected due to their superior performance as compared to the rest varieties by farmers' evaluation and field experiment results. Therefore, the result of the experiment manifested as Dibaba and Jiru improved sorghum varieties were 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: Farmer's Preference · Selection Criteria · Farmers' Perception · Sorghum · Participatory Variety Selection

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench; 2n=2x=20] is the fifth most important cereal crop plants after maize, rice, wheat and barley in the world [1] and grouped under C_4 tropical crop which belongs to the family *Poaceae* [2]. It is naturally self-pollinated plant with the degree of spontaneous cross pollination, in some conditions, reaching up to 20%, relying on panicle types [3]. Ethiopia is the country of origin for sorghum and has large sorghum genetic diversity for future genetic improvement for desirable traits [4]. The crophas a broader adaptation andtolerance to different abiotic and biotic constraints like drought, extreme temperature, poor soil fertility and resistant diseases, insects and weeds [5].

Sorghum is one of the most important cereal crops supporting the lives of millions of people across the globe and particularly in the developing world [6]. The world production of sorghum was 63.5 million tons in 2015 cropping season and cultivated on 44 million hectares of land from 2006-2008 [7]. Sorghum is the second most important cereal crop after maize in Sub Saharan Africa [8],

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the foundational staple food for many rural communities, especially in drought prone areas. 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 [9]. It is the dominant crop in the dry lowlands areas of Ethiopia, which accounts for 66% of the total cultivated area of the country [10].

Sorghum grain is processed and consumed in different forms like flat bread and porridge [11]. Sorghum is a source of different micro and macronutrients, particularly iron, phosphorus and zinc [12]. Sorghum is playing a pivotal role in contributing and ensuring food security in Ethiopia. Sorghum is a gluten-free cereal crops and providing essential nutrients including carbohydrates, protein, vitamins, minerals and nutraceuticals such as antioxidants, phenolics and cholesterol-lowering waxes [13].Sorghum is source of feed and food particularly in semi-arid region there the yield is reduced due to drought problem [14].

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. Witcombe and Joshi [15] defined participatory plant breeding as involving farmers in selecting genotypes from genetically variable, segregating materials whereas participatory variety selection as involving the selection by farmers ofnon-segregating materials, characterized as products from plant-breeding programs. The participatory variety selection approach has been used to improve local landraces and evaluate the finished breeding materials, obtained from research institutions on farmers' field. Participatory variety selection is broadly defined as an approach that involve a mix of actors including scientists, breeders, farmers and other stakeholdersin plant breeding stages [16]. According to Halewood *et al*. [17] involvement of farmers in participatory variety selection can take many forms: defining breeding goals and priorities; selecting or providing sources of germ-plasm; hosting trials on their land; selecting lines for further crossing; discussing results with the scientists; planning for the following year’s activities; suggesting methodological changes; multiplying and commercializing the seed of the selected lines.

Understanding farmers’ preferences across different agro-ecologies and growing seasons is an important first step for breeding programs who seek to develop acceptable varieties by farmers [18]. There areseveral factors may account for the limited adoption of new varieties. First, breeders’ selection criteria may not match the needs and preferences of growers. Small farmers consider multiple traits to satisfy their diverse needs [19]. Lack of awareness and absence of farmers’ perception on the development of superior varieties caused difficult challenges on the acceptability and adoption of improved sorghum varieties. Several and different improved sorghum varieties were released from international and national research institutions with little or no involvement of farmers participation for demand driven technology development. Breeders were developing varieties primarily for yield potential without considering other farmer’s preferences and perceptions [20]. However farmers’ selection traits are multivariate in nature. Small farmers consider multiple traits to satisfy their diverse needs and the farmers’ selection criteria for improved varieties were not adequately assessed and well documented especially in Ethiopia.

Hence, the top-down approach to variety selection has resulted in the release of varieties mostly not suited to farmers’ climatic conditions and socio-economic circumstances [21]. This top-down approach has not been able to convince the farmers to grow improved varieties particularly in marginal areas. Therefore, the complex nature of agricultural research demands coordinated effort among biological scientists, extension agents and farmers in order to develop the appropriate technology with desired qualities [22]. Farmer-developed local varieties are an important resource and logical starting point for plant breeding programs that seek to strengthen these diverse systems. Close cooperation between scientists and farmers in evaluating plant material and in establishing plant-breeding goals is also a key feature of these strategies known as the method of participatory research [23].

Sorghum production and productivity is mainly limited due to biotic and abiotic constraints. Particularly in Ethiopia, optimal production and productivity of the sorghum crop has not yet been achieved due to various socio-economic constraints such aslack of farmer preferred variety, lack of awareness toward the improved varieties, lack of improved seed system, poor market linkage, lack of value addition, poor extension service support, poor financial support and lack of storage facility [24]. Despite the economic importance and contribution of improved sorghum varieties to ensure food security in the region in general and in the study area in particular, farmers in the Eastern Ethiopia are still cultivating disease susceptible, long-maturing and low yielding local landraces.

The reason is that the main variety selection criteria of breeders in Ethiopia are limited to few traits that do not represents farmer's selection traits.Hence, there is a need for selecting varieties adapted to different agro-ecologies and growing seasons with farmers' preference criteria. Hence, participatory variety selection is important in understanding farmers' selection criteria, raising awareness and facilitating adoption of improved varieties. It also allows farmers to take part in the development of new varieties more suitable to marginal environments and to organic farming agronomic practices.Therefore, the objectives of the study were to evaluate the performance improved sorghum varieties and identify farmers' variety selection criteria for designing good breeding program in the future and to accelerate the adoption rates of farmers chosen varieties through farmer-to-farmer seed exchange mechanisms.

MATERIALS AND METHODS

Description of the Study Area: The study was conducted in Oromia Regional State of West Hararghe zone particularly at Hirna and Chiro districts during 2019 main cropping season. Hirna is located with an altitude of 1, 763 meters above sea level at 9° 12' N latitude, 41° 4' E longitudes. It is 388 kilometers far away from Addis Ababa; the capital city of Ethiopia in the eastern part of the country. The area receives mean annual rainfall of 990 mm to 1010 mm with an average temperature of 14°C to 24°C. The dominant soil type of the experimental station is classified as black Vertisols. Chiro is located at 09°05'N latitude and 40°88'E longitude at an altitude of 1856 m.a.s.l. It is 328 kilometers far away from Addis Ababa, the capital city of Ethiopia in the eastern part of the country. The area has the average minimum and maximum temperature of 12°C and 23°C respectively and receives 950 mm annual rainfall. The soil type of the experimental station is classified as black Vertisols [25].

Genetic Materials: The experiment consisted of five released sorghum varieties with one local sorghum landrace which is the most widely used and collected from the study area. The improved highland sorghum varieties were released for highland agro-ecologies by the national sorghum improvement program in different times. These materials were further evaluated through both field experiment andfarmers' visual observationto ensure the merits of adaptation and stabilityin multitude quantitative and qualitative characteristics.

Experimental Design and Trial Management: The field experiment was done in a randomized complete block design with two replications. The individual plot size was 4 rows wide, 0.75m between rows, 0.20 m between plants and 5 m long. During planting, the seeds were manually drilledat the seed rate of 12kgha^{-1} and thinning was done after 20 days emergence. Fertilizer was applied at the rates 100kgha^{-1} Urea and 100kgha^{-1}NPS. NPS was applied during planting and split application was used for Urea, half of it at planting time and the remaining half at knee stage period. All other field management practices were carried out as per the recommendations.

Data Collection: Data were collected on plant and plot basis for different agronomic traits [27]. Data collected on the basis of individual plants.

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

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.

Days to Maturity (DTM): Defined as 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.

Table 1: Sorghum varieties included in farmers group variety evaluation experiment at Hirna

S.N	Variety	Agro-ecology	Releasing year	Yield (tha^{-1})	Color
1	ETS2752	Highland	1978	3.0-5.5	White
2	Chiro	Highland	1998	4.2-5.8	Red
3	Dibaba	Highland	2015	3.7-5.0	Brown
4	Jiru	Highland	2016	3.3-8.6	Brown
5	Adelle	Highland	2016	3.7-7.2	White
6	Shafare	Highland	Local (check)	low	Red

Source: Melkassa miscellaneous year's variety release documents [26]

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 Collection:

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

Statistical Data Analysis: Analysis of variance (ANOVA) for alpha lattice design was performed using statistical package version 9.4 [28] for both the specific and combined analysis over location. Prior to combining the data from the different environments, Bartlett's test for homogeneity of variance was done and checked by using F-test (ratio of the largest mean square error to the smallest mean square error is less than three or four) according to Gomez and Gomez [29] and the test indicated that the error means were homogeneous for all traits and the data were combined for further analyses. Mean comparisons among genotypes were done by the least significant difference (LSD) test at 1% and 5% levels of significance. The model for randomized complete block design for combined yijk = μ+lij+rlj+brlj+gj+gElj+ϵijk, Where, Yijk= denotes the value of the observed trait for i^{th} treatment received in the kth block within j^{th} replicate, μ = over all mean, gi= effect of the ith genotype (i = 1, 2, …, t), rj=effect of the jth replicate (j = 1, 2, …, r); bjk = effect of the k^{th} incomplete block within the jth replicate (k = 1, 2, …s) and ϵijk= an experimental error associated with the observation of the i^{th} treatment in the k^{th} incomplete block within the jth complete replicate.

Genotypic Correlation Analysis of Yield and Yield Related Traits: Correlation analysis was done by using the following formula [30].

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

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

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

Farmers' Participatory Varietal Selection (PVS): Participatory variety selection was done at two different stages of the crop, namely at flowering and at maturity using participatory tools like pair wise ranking methods. A total of one hundred farmers (male=76 and female=24) participated to evaluate and select improved sorghum varieties using participatory tools during 2018 and 2019 cropping seasons respectively. Both male and female key informant farmers were randomly selected and participated regardless of their religion and wealth to determine the adaptability performance of sorghum improved technologies. Male and female were set and prioritized their own selection criteria and jointly agreed on three characters (biomass, grain yield and seed color)during flowering and five characters (grain yield, biomass, disease resistance, grain size and seed color) during physiological maturity stage of the crop.

Farmers identified their best selection criteria and carefully observed the entire experimental plots to choose their fitness to the specific criteria according to the existing constraints and opportunities in their micro environments. The assignments of ranks to each varieties and traits were determined from the number of times each selection criterion was preferred by the group [31]. The ranking procedure was explained for farmer participants and then each selection criterion was ranked and scored on a scale of 1-5 (5=excellent, 4=very good, 3=good, 2=poor and 1=very poor). During the evaluation, all farmers were selected varieties with their trait of interest. All the selected characters were tabulated in a matrix scoring method and pair wise fashion was used to compare each selection criteria. The farmers' own selection criteria were analyzed using pair-wise ranking matrix (Table 5). The promising sorghum varieties were identified based on simple ranking score method (Table 6-7). Simple ranking is a participatory tool which used to identify promising varieties based on farmers' preferences [32].

RESULTS AND DISCUSSIONS

Analyses of Variance (ANOVA): Analyses of variance due to different source of variations were computed as per standard the procedure of randomized complete block design for combined over the two locations. The analyses of variance (ANOVA) for all quantitative traits showed the presence of highly significant difference ($p < 0.01$) among the sorghum varieties for yield and yield related characteristics (Table 2). The presence of substantial genetic variation among sorghum varieties for yield and yield related traits revealed the possibly of improvement through intensified selection. Genotypes exhibited significantly high ($p < 0.01$) for days to 50% flowering, days to 95% physiological maturity, plant height (cm), grain yield (kg) and thousand seed weight (g). To address the problems of yield gap, breeders are relied on the presence of genetic variation to advance the genetic materials for further improvement. The presence of considerable variation in the genetic materials for the studied traits confirmed to achieve maximum genetic improvement through effective selection. Therefore, the obtained results ensured the possibility of improvement of sorghum genetic materials through simple selection for the significantly different traits.

Mean Performance of Highland Sorghum Varieties: The superior sorghum varieties were identified based on the mean performance for different characteristics as indicated in (Table 3). The high grain yield was obtained from Dibaba (11.375 tha^{-1}) followed by Jiru (10.175 tha^{-}),[l] Adelle (8.375 tha^{-1}), Chiro (5.825 tha^{-1}), ETS2752 (5.315 tha^{-1}) and Shafare (4.250 tha^{-1})with the average value of 7.552 tha^{-1} which had higher mean value as compared the local check (Shafare).Especially, the yield performance of the Dibaba variety was highest as compared to the rest varieties whereas the local variety (Shafare) was the lowest of the tested varieties. This revealed the improved highland sorghum varieties had better adaptation and yield performance over local landrace that farmers are growing right now. 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 variety flowed (123 days) and matured (172.5 days) earlier whereas the Shafare (landrace) flowed (141.5 days) and matured (216.5 days)late. Days to maturity and flowering are the most important traits that need to be considered in selecting varieties when and where the shortage of rainfall is limited factor for further improvement of crop plants.

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 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 variety (Dibaba) required 121.5 days to flower and 181 days to mature which was close to the average for genotypes, 129.08days for flowering and 187.17 days for maturity. This indicated the yielding potential is not necessarily associated with crop phenology provided that genes for high yield potential are incorporated in the variety. Plant height is directly related biomass and is determinant factor in yield improvement. From the obtained result Chiro variety (353cm) was the tallest as compared to all other varieties whereas Shafare variety (333cm) was the shortest in plant height. Nowadays breeding is forwarded to improve grain yield in the same way with biomass contents.Breeding for shorter plant height was one of the major goals of the sorghum breeding program for dry lowland areas where drought adversely affects the plants which had prolonged vegetative growth but drought is not major and determinant factor for highland areas. Therefore, breeding for taller in plant height has advantage since biomass is equally demanded with grain yield for forage and construction purpose. The Dibaba variety showed superior mean performance in thousand seed weight (42g), which had direct proportional with yield and as well as very important in vigorisity and germination.

Genotypic Correlation Analysis of Yield and Yield Related Traits: Correlation determines the direction of improvement of one trait with other traits to apply the right breeding procedures. Correlation is used to find degree and direction of relationship between two or more variable, so it is also correlate mutual relationship between two or more variables [33]. The values of estimated genotypic correlation coefficient between pair of characters in all possible combination are presented in (Table 4). Correlation coefficient also used to quantify the association between two continuous variables.

Table 2: Analysis of variance of sorghum genotypes for yield and yield related traits

Source of variation	DTF	DTM	PHT	GY	TSW
Replication	2.08^{ns}	1.33^{ns}	2.08^{ns}	233802.08^{ns}	3.00^{*}
Genotypes	122.08^{**}	517.13^{**}	96.08^{**}	16429552.08^{**}	30.53^{**}
Error	1.28	4.93	7.68	45302.08	0.40
Mean	129.08	187.17	346.42	7552.08	36.83
CV (%)	0.88	1.19	0.80	2.82	1.72

**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				
Genotypes	DTF	DTM	PHT	GY	TSW
Adelle	123.00^{c}	172.50^{d}	347.00^{a}	8375.00^{c}	38.00^{c}
Chiro	133.50^{b}	192.50^{b}	353.00^{a}	5825.00^{d}	36.50^{d}
Dibaba	121.50^{c}	181.00^{c}	348.00^{a}	11375.00^{a}	42.00^{a}
ETS2752	131.50^{b}	185.50^{c}	350.00^{a}	5315.00^{d}	35.00^{d}
Jiru	123.50^{c}	175.00^{d}	347.50^{a}	10175.00^{b}	39.00^{b}
Shafare	141.50^{a}	216.50^{a}	333.00^{b}	4250.00^{e}	30.50^{e}
Mean	129.08	187.17	346.42	7552.08	36.83
LSD	2.91	5.71	7.13	547.13	1.63
CV (%)	0.88	1.19	0.80	2.82	1.72

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

Table 4: Genotypic correlation of sorghum varieties for major traits

Traits	DTF	DTM	PHT	GY	TSW
DTF	1	0.92^{**}	0.53^{ns}	0.91^{**}	0.91^{**}
DTM		1	0.67^{*}	0.73^{**}	0.81^{**}
PHT			1	0.34^{ns}	0.61^{*}
GY				1	0.91^{**}
TSW					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

Correlation analysis showed the direction and strength of the linear association between the two characters studied for further improvement. Days to 50% flowering had positive and highly significant correlation with days to physiological maturity (r = 0.92**), thousand seed weight (r = 0.91**) and grain yield (r = 0.91**). Days to 95% maturity showed positive and highly significant genotypic association with grain yield (0.73**), thousand seed weight (0.81**) and significant association with plant height (0.67*). Thousand seed weight revealed positive and highly significant correlation with yield (0.91**) and positive significant association with plant height (0.61*). These showed that improvement of these traits would result in a substantial increment and possibilities of improving the traits simultaneously at the same time. This positive and significance associations among traits were due to the effect of genes can be the result of strong coupling linkage between their genes or the result of pleiotropic genes that could control the traits within the same direction [34].

Participatory Variety Selection: Several farmers participated and selected different improved sorghum varieties based on their preference characteristics and agronomic performance. Farmers preferred traits were selected according to the identified and prioritized sorghum traits. These traits were high yielding, high biomass, bold grain size, white color and better resistance to anthracnose and other common sorghum diseases. The sorghum varieties were selected based on major criteria like high yield potential, early maturity and wide adaptation. Farmers provided the highest weight to grain yield followed by biomass (plant height) and disease resistance.

Similarly, FentieMolla [34] reported that farmers identified seed color and disease reaction as important criteria and disease resistance and plant height were also selected by farmers' as moderate significance. Dibaba and Jiru varieties were selected by farmers for future utilization based on yield performance, biomass, bold or large grain size and resistance to different fungal

Table 5: Pair-wise ranking of farmers selection criteria for traits at maturity stages

S/N	Selection criteria	GY	PHT	GC	DR	GS	Score	Rank
1	GY	x					5	1
2	PHT	GY	x				4	2
3	GC	GY	PHT	x			2	4
4	DR	GY	DR	GC	x		3	3
5	GS	GY	PHT	GS	DR	x	2	4

GY=Grain Yield, PHT=plant height, GC= Grain color, DR= Disease resistance, GS= Grain size

Table 6: Direct matrix ranking evaluation of sorghum varieties by of group of farmers

Selection criteria	Grain yield	Plant height	Grain size	Disease resistance	Total score	Rank
Relative weight	5	4	3	3		
ETS2752	15(3)	12(3)	6(2)	9(3)	42	5
Chiro	15(3)	12(3)	6(2)	12(4)	45	4
Jiru	25(5)	16(4)	12(4)	12(4)	65	2
Adelle	20(4)	16(4)	9(3)	12(4)	57	3
Dibaba	25(5)	20(5)	12(4)	15(5)	72	1
Shafare (local)	10(2)	12(3)	6(2)	6(2)	34	6

N.B. total number of farmers=100 (M=76 and F=24); 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

Table 7: Farmer's pair-wise ranking of evaluated highland sorghum varieties

Varieties	ETS2752	Chiro	Jiru	Adelle	Dibaba	Shafare (local)	Score	Rank
ETS2752	x						1	5
Chiro	Chiro	x					2	4
Jiru	Jiru	Jiru	x				4	2
Adelle	Adelle	Adelle	Jiru	x			3	3
Dibaba	Dibaba	Dibaba	Dibaba	Dibaba	x		5	1
Shafare (local)	ETS2752	Chiro	Jiru	Adelle	Dibaba	x	0	6

and bacterial diseases. With regard to grain color, most of the farmers preferred ETS2752 and Adelle because of their white attractive color and Dibaba and Jiru had brown color which was acceptable from farmers' perspective. Even though, color alone cannot be preferred selection criteria in sorghum. Hence, based on the summarized results of farmers' evaluation and field experiment, the varieties Dibaba and Jiru were the most preferred ones.

Genotypes were evaluated using direct matrix table, in which genotypes in the column wise and traits listed in the row wise. Based on the total score (relative weight of the criteria x relative weight of the importance), the evaluation of farmers ranged from 34 to 72. According to direct matrix ranking evaluation, the highest value was provided to Dibaba (72) followed by Jiru (65) and the least value were provided to Shafare (34) because of blast diseases and low yield. According to pair-wise ranking method, variety Dibaba selected five times and ranked first followed by Jiru which ranked second. Therefore, based on the obtained results of direct matrix and pair wise ranking evaluation, Dibaba and Jiru were the most preferred ones due to their superior performance.

A total of one hundred farmers 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 form. Based on the overall farmer's preference, Dibaba and Jiru were ranked first and second respectively and followed by Adelle, Chiro and ETS2752. 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. The joint evaluation of farmers' and researchers' preference of individual trait played a crucial role in selection of best performing varieties. The superior performing varieties identified based on farmer's trait preference and rank sum method to design a good breeding program for further improvement.

CONCLUSION

The study identified the superior performing sorghum genotypes by farmers' evaluation and field experiment results jointly. The presence of substantial genetic variation among sorghum varieties for yield and yield related traits revealed the possibly of improvement through selection. The results also revealed that farmers' preferences in some cases coincide with the researchers' selection. Therefore, based on researchers' experimentation and farmers' evaluation, Dibaba variety was the highest yielder and was rated highly by almost the entire host participants' farmers. Based on the analyses of variance, mean performance and correlation analyses, the study consistently identified varieties that produced more grain yield than the already existing old varieties that used as a check. Pairwise and direct matrix analyses explained that farmers prioritized grain yield, biomass, grain color, diseases resistance and grain size.

Small-holder farmers participated on varietal selection trial at flowering and maturity using both pair-wise ranking and direct-matrix methods of selection procedure. Based on farmer's preference criteria, the most adapted improved sorghum varieties were effectively identified to address the challenges of both local adaptation and farmers' end use requirements issues. Moreover, this experiment ensured participatory varietal selection is very critical breeding procedure to get farmers' perceptions, preferences, merits and shortcomings of sorghum varieties for further improvement.

Therefore, based on the results of field experiment and farmers' evaluation, Dibaba and Jiru improved sorghum varieties preferred by farmers because of their satisfaction in multiple traits demand. It also proved that high yielding and earliness 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. High yielding, earliness, resistance to anthracnose, long smut and stock borers would be welcomed by farmers. Generally, farmer's participation played very important in variety evaluation and selection to design breeding methodology for further improvement of sorghum varieties with farmers' end use requirements. Finally, Dibaba and Jiru were selected for continued cultivation and needs to be multiplied and distributed to the farmer's for very large-scale production. These promising varieties were recommended to the farmers of Hirna area and other districts having similar agro-ecologies for further production and adoption.

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