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Participatory Varietal Selection Sorghum (*Sorghum bicolor L. Meonch*) for Mid-Land Areas of East Hararghe Zone, Ethiopia

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Abstract: Participatory varietal selection (PVS), which was used on sorghum in the East Hararghe, Ethiopia, has demonstrated success in identifying a greater number of farmer-preferred varieties in less time. The study's goals were to assess and choose improved sorghum varieties based on agronomic, yield, and yield parameter performance as well as farmer preferences. Eleven (11) Sorghum varieties including one local check were evaluated in RCBD with three replications at Meta and Kurfa Chale districts of East Hararghe zone in 2018, 2019 and 2020 main cropping season. According to their preferences and selection criteria, such as early maturity, bird damage, plant biomass, grain color and size, disease resistance, head size, and predicted yield, farmers were asked to rank the first five improved varieties out of 10 and one local varieties. Farmers thus favored the sorghum cultivars Adele, Dibaba, Gemedi, Chiro, Dano, and local check respectively. Days to flowering, Days to maturity, plant height, grain yield, and disease score were all recorded. The combined analysis' findings showed that the examined types differed significantly in all of the attributes. Therefore, Adele (42.74 Qt ha^{-1}) produced the maximum yield, followed by Dibaba (40.45 Qt ha^{-1}), Gemedi (40.09 Qt ha^{-1}), and Dano (35.62 Qt ha^{-1}), whereas Muyra-2 (30.36 Qt ha^{-1}), and Jiru (31.55 Qt ha^{-1}), respectively, produced the lowest yields. The results also revealed that farmers' preferences in most cases coincide with the researchers' selection. Based on the result of analyzed data and the farmers' preference, the first three sorghum varieties namely; Adele, Dibaba and Gemedi were recommended for the farmers of the study area and similar agro-ecologies of East Hararghe mid altitude and similar agro-ecologies. Therefore, the selected varieties would be multiplied and distributed to the farmers in order to improve adoption and varietal diversity.

Keywords: Sorghum, Selection Criteria, Varieties, Farmers'

1. Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is the third-largest cereal crop in Ethiopia behind tef and maize in terms of area farmed and overall production. It is the fifth-most significant cereal crop in the world [1]. It gives the nation food, animal feed, and alcoholic drinks. Sorghum is primarily used in Ethiopia to make Injera, a type of leavened bread that makes up 10% of the country's daily caloric intake [2]. Because of its many uses and resilience to harsh growing circumstances, sorghum will continue to feed the world's burgeoning populations, supporting the livelihoods of millions of subsistence farmers [3]. Ethiopian farmers may use every part of this plant, which has several applications. The grains used to make human foods including injera, syrup, nefiro, baby food, and the regional drinks "Tella" and "Arekie." The leaf and stalks are used to make fuel, animal feed, building materials, fences, and dwellings [4].

In Eastern part of Ethiopia, including East Hararghe, out of

the total grain cropped area of 253,816.82 ha, cereals accounted for about 84% (214,061.59 ha) of which sorghum accounted for the lion's share of about 56% (119,262.36 ha) of the totally annually cropped land in 2014/15 cropping season [5]. Over the years, a number of late, medium and early-maturing sorghum varieties have been evaluated and released by federal and regional research centers for different agro-ecologies of the country. However, those varieties are not being adopted by the farmers in a satisfactory rate, probably due to poor farmers' participation during selection process (on-station), inadequate knowledge of the farmers about the varieties lack of improved varieties that adapted to the specific environments and inadequate supply of seed of these varieties to satisfy farmers' needs.

Farmers in the east Hararghe zone of Oromia region are still growing local sorghum because they are unaware of the new kinds of sorghum that have been released for their agro-ecologies, despite the fact that many have been released by various research centers for promising sorghum locations. This is primarily due to the following constraints: poor farmer participation in the varietal selection process, insufficient research interventions, a lack of improved varieties that produce a respectable yield when managed culturally by farmers, an inadequate system for supplying improved seeds, and a weak link between research, extension, and farmers [6]. The majority of farmers in the studied areas produce landraces of sorghum that mature in 7-8 months and engage in sorghum monoculture.

Participatory Variety Selection (PVS) is an efficient method for identifying varieties that farmers will adopt, thereby removing the barriers that force farmers to use late-maturing varieties that are vulnerable to disease, pests, and drought [7]. Additionally, participatory research improves farmers' knowledge retention from year to year and the scientists' job efficiency [8, 9]. Farmers' participation in variety testing and selection can lower research costs and boost adoption rates [10, 8]. Participatory plant breeding/selection also takes advantage of the benefits of selective breeding by decentralizing selection in the target environment [11]. In East Hararghe, where farmers have been cultivating highland sorghum using their own landraces, no trials have been carried out. Therefore, the goals of this study were to assess and choose the best-performing mid-land sorghum variety or varieties, as well as to determine farmers' preferences and selection criteria to the study locations of the East Hararghe highlands with farmers' participation.

2. Material and Method

2.1. Treatments and Experimental Material

The experiment was conducted on two locations of Kurfa chele and Meta districts of Oromia region on FTC and farmers' field for three consecutive years during 2018, 2019/20 and 2020/21 main cropping seasons. A total of eleven (11); ten (10) recently released and previously untested sorghum varieties and one local check had been evaluated in the study areas. The materials used for the experiment were; Adele, Jiru, Dibaba, Gemedi, Chemeda, Dano, Lalo, Muyra-1, Muyra-2 and Chiro with one local check.

A field experiment had been laid out in Randomized Complete Block Design (RCBD) with three replications and with the spacing of 1 m and 0.5 m between blocks and plots respectively and plot size of in 3.75 m x 5 m had been used. During planting, the seeds were manually drilled into five meters long and six row plot spaced 0.75 m apart at seed rate of 10 kg ha^{-1}. At approximately 21 days after planting, the seedlings were thinned to 0.20- 0.25 m distance between plants giving a total population of 66666 plants ha^{-1}. Nitrogen and phosphorus fertilizers were applied in the form of UREA and NPS at the recommended rate of 100 kg ha^{-1} each. NPS was applied at sowing time and Urea was top dressed before heading when the crop was reach at knee height. All other agronomic management was applied as recommended for the sorghum production.

2.2. Data Collection

Data were collected on plant and plot high basis for different agronomic traits. Plant height (cm) and panicle length were recorded from plant basis whereas; days to 50% flowering, days to physiological maturity and grain yield (kg ha^{-1}) were collected from plot basis.

2.3. Farmers' Participatory Varietal Selection (PVS)

Participatory methods were used to undertake participatory varietal selections (direct matrix ranking). Farmers were chosen primarily based on their experience cultivating sorghum, gender ratio, and willingness to take part in the study. 22 farmers in total, 17 men and 5 women, participated in the study. Farmers had used their own standards to evaluate the variety' physiological maturity and harvest stage. At these stages, feedback from farmers had been gathered in order to choose the kinds that performed the best. Scores were assigned for each of Farmer's evaluation criteria on a scale from 1 (very good) to 5 (extremely poor).

Farmers chose the top five sorghum types from a total of eleven, according to their willingness, and assigned rankings to these varieties. For the evaluated genotypes listed in the row and the farmer-preferred attributes listed in the column, a direct matrix table was created. According to the selection criteria, each variety was given a score (1 = very good, 2 = good, 3 = average, 4 = poor, and 5 = extremely poor). Farmers rated the relative weight of each selection criterion in a direct matrix ranking from 1 to 3 (1 being very important, 2 important, and 3 less important), and ratings of a variety's performance for each selection criterion were based on its level of importance. Each variety's score was multiplied by the relative weight of each character to reach the final score, which was then added to the scores of the other characters to produce the variety's overall score. According to [12], scoring and ranking were done by consensus, and disagreements were settled by conversation.

2.4. Statistical Data Analysis

The data collected from the experiment had been subjected to statistical analysis using GENSTAT 15th edition software. Mean separation was carried out using Duncan's Multiple Range Test (DMRT) at 0.05 probability level.

3. Result and Discussion

Performance Evaluation of Mid-land Sorghum Varieties

Analysis of variance (ANOVA) revealed that significance defenses (P< 0.05) were observed among the sorghum varieties evaluated. Significance differences were recorded on the traits (days to 50% flowering, days to physiological maturity, Plant height and grain yield) (Table 1). The study supported the findings of earlier research [13-15], finding that cultivar (genotypic) differences in grain sorghum significantly affect growth and phenological parameters as well as yield and traits related to yield. This could be because of the genetic potential of the genotypes used.

The analysis of variance (ANOVA) revealed that there was significant difference among sorghum varieties for yield (Table 2). The grain yield ranged from 2986 kg /ha to 4274 kg /ha and grand mean of 3733 kg/ha. The highest yield (4274 kg/ha) was recorded from Variety Adele followed by the varieties Gemedi (4109 kg/ha), and Dibaba (4045 kg/ ha) which was no significance difference from the highest yielded variety, while the lowest yield (2986 kg/ha) was obtained from Chiro which was statistically not significant from local check (3533 kg/ha). The variation in grain yield of the tested varieties showed the difference in adaptability of these varieties to the agro-ecology of the study area. The highly performed varieties revealed that the most adaptability to this environment.

Table 1. *Mean squares from analysis of variance (ANOVA) of measured phenological and agronomic traits in 2018 and 2019/20 main cropping season at the study area.*

Source of Variation	Df	DF (days)	DM (days)	PH-cm	Gyld-Qt-ha
Replication	2	65.92	53.379	576.7	4.08
Treatment	10	440.07***	282.633***	4678.5***	83.63**
Error	42	20.64	8.379	704.6	24.47
Mean		142.62	206.17	255.3	25.9
CV (%)		3.2	1.4	10.4	19.1

Highly, * very highly significant at 1% probability level, where, df= degree of freedom, DF= days to 50% flowering, DM= days to physiological maturity, PH= plant height, Gyld- Qt-ha-= grain yield (Qt/ha)

Table 2. *Combined Mean values of DF, DM, PH and Grain yield of sorghum tested during 2018-2020/21 main cropping season at East Hararghe and Harari region.*

Varieties	DF	DM	PH (cm)	GYLD (kg/ha)
Adele	140.4 ab	205.7 b	226.8 de	4274 a
Chemeda	155.2 d	215 cd	246.8 cd	3474 cd
Chiro	138.8 a	207 b	217.9 e	2986 d
Dano	155.3 d	215.7 d	278.3 ab	3562 cd
Dibaba	136.1 a	203 a	214.9 e	4045 abc
Gemedi	153.8 d	218.7 e	225.9 de	4109 ab
Jiru	144.6 bc	205 ab	246.4 cd	3155 d
Lalo	154.6 d	218.3 e	301.5 a	3594 bcd
Local check	148 c	212.7 c	254.7 c	3533 cd
Muyra 1	147.2 c	207 b	269 bc	3203 d
Muyra 2	147.9 c	206.7 b	252.9 c	3036 d
Mean	147.44	210.42	248.60	3733.70
LSD (5%)	8.20	4.34	40.31	1196.74
CV%	3.40	1.30	9.90	19.70

Means in the same column followed by the same letters are not significantly different at 5% level of significance according to DMRT; DF= days to 50% flowering, DM= days to physiological maturity, PH= plant height, Gyld-Qt-ha^{-1}= grain yield (Qt/ha)

Analysis of variance revealed very highly significant difference (p<0.001) among varieties for plant height (Table 2). The plant height ranged between 214.9 cm to 301.5 cm. The highest height was given by variety Laaloo while the lowest was by variety Dibaba. As the data indicated; Laaloo, and Danno were taller standing with mean values of; 301.5 cm and 278.3 cm respectively, while Dibaba, Chiro, Adelle and Gemedi were shorter standing; 214.9 cm, 217.9 cm, 226.8 cm and 225.9 cm respectively. Even though, plant height has no direct relation with grain yield, the tallest plant is important for its highest biomass which is desirable for different purposes. Dibaba was the earliest maturing of all the varieties tested with 203 days, whereas Lalo and Gemedi with 218.3 and 218.7 days were the longest maturing varieties respectively.

Table 3. *Direct matrix ranking evaluation of sorghum varieties by of group of farmers'.*

Criteria										
Variety	**Earliness**	**Panicle weight**	**Seed size and color**	**Disease tolerance**	**Bird damage**	**Biomass yield**	**Grain Yield**	**Total score**	**Average score**	**Rank**
Adele	1	1	1	1	1	2	1	8	1.14	1
Chiro	3	3	4	3	2	3	3	21	3	4
Dano	4	3	3	3	2	3	3	21	3	5
Dibaba	1	1	2	1	2	1	1	9	1.3	2
Gemedi	3	3	3	2	2	3	2	18	2.6	3
Local check	5	4	4	5	3	3	5	29	4.14	6

In this participatory varietal selection, farmers were selected the first five (5) sorghum varieties depending on their own selection criteria's. Farmers were giving relative weight to the selection criteria the set [12]. Accordingly, the set grain yield and disease tolerance (very important), bird damage (important) and grain color and size and plant biomass (less important). This is consistent with the findings of [16], who discovered the same selection criteria as the most significant farmers' criteria for wheat varieties. Furthermore, [17] stated that farmers preferred the Tadesse variety of finger millet over the other varieties because of its early maturity and excellent grain output. Farmers also stated that the most crucial factors in choosing which maize varieties to adopt were grain yield, cob size, grain size, and early maturity [18]. Based on mean overall score the most preferred varieties were Adele and Gemedi (Table 3). Variety Adele ranked first because of higher productivity, bird damage and plant biomass whereas Dibaba and Gemedi ranked second and third respectively for their better in grain yield, bird damage, grain color and size.

4. Conclusion and Recommendation

Participatory varietal selection was done in the study were tested at district not only because farmers' cultivars were old, but also none of these evaluated varieties was previously grown by farmers except the local check. The key criteria used by farmers to evaluate and select the preferred varieties were grain yield, disease tolerance, grain size and color, plant biomass and bird damage. Farmers used different parameters and methods to evaluate the tested mid-land sorghum varieties. For fast adoption and dissemination, the new variety/ies considering the preferences of farmers and consumers are necessary, otherwise it is less likely to be widely adopted or accepted by the farming community. In this study farmers 'and breeders' evaluation and selection were confirmed that Adele, Dibaba and Gemedi, were found good for yield potential and other agronomic traits among the eleven tested varieties based on both farmer's and researchers' evaluation. According to the analysis of result and farmers' selection variety Adele, Dibaba and Gemedi, were best performing with grain yield and yield components and were selected for the study area.

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