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Participatory Varietal Selection of Released Hybrid Maize (Zea mays L.) Varieties for Yield at Homosha District Western Ethiopia

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Abstract: In order to assess farmers' selection criteria for maize varieties for future maize improvement, participatory variety selection (PVS) trial was carried out in the Homosha district of Western Ethiopia in 2020. The trial was designed to select well performed of improved maize (Zea mayz L.) varieties. The activity was conducted at kubur 50 Homosha District with plot size of 10m*10m, which included three improved varieties with check. The outcomes showed that in certain instances, farmers' choices and the researchers' choice were similar. Farmers have, nonetheless, generally demonstrated their unique method of choosing a variety for their locales. These characteristics include Grain Yield, Maturity, Stalk and Root Lodging Tolerant, Ear aspect, Striaga Weed Tolerant, Number of ears per plant, bare tip problem, Disease Tolerant or Resistance, Plant and ear height. Therefore, it is crucial to consider farmers' preferences while choosing varieties. Therefore, the BH-549 and BH-546 are suggested for the study region based on scientifically determined features, farmers' preferences, and the site's agroecologies. The responsible body should pay close attention to the variety BH-549 since it has a high yielder for the study region. Preferences identified in the participatory activities could inform further development of maize breeding strategies for Western regions of Ethiopia.

Keywords: Maize, Variety, Pairwise Comparison Yield, Participatory Selection

1. Introduction

In Ethiopia, maize is a significant food crop [1]. A total of roughly 105 million quintals of maize were produced across 2.5 million hectares of land during the main agricultural season of 2020–21. [2]; 10.5 million tons are the equivalent. In 2020/21, cereals made up 81 percent of all grains produced in Ethiopia. Maize accounted for 35% of cereal production, followed by wheat, teff, and sorghum with 19, 18, and 15% of the total, respectively [3] Production of maize (Zea mays L.) in Western Ethiopia is hampered mostly by a lack of recently released varieties with high yielding potential [4]. In addition, the production of maize was significantly influenced by the education level of the produce, fertilizer application, and maize seed variety. 93 percent of farmers in Ethiopia's lowlands are maize growers, according to numerous reports of diagnostic surveys carried out in the country mid and low land rainfall zones, such as in the Benshangul gumuz region [5]. The interests of farmers have mostly been disregarded in Ethiopian selection of maize varieties up until now [6]. Contrarily, farmers are free to select the crop varieties that are most suited to their environment. While maize grain is used for domestic fuel, stouter is used for construction, animal feed, and food, sale, and marketing of a local brewery [7]. In Ethiopia, choosing maize varieties has often been primarily driven by grain output [8]. Only a few variants have been identified thus far despite numerous breeding lines having been generated at various research stations and tested in multiple locations over many years [6].

Varietal evaluation and decisions were made only by researchers but, this did not speed up the variety releasing process as expected, or their dissemination afterwards [9]. Participatory plant breeding and selection may provide new opportunities for boosting maize output and consumption by combining it with other pertinent local crop management strategies [10]. Many scholar [2, 9, 11, 12] have highlighted approaches that can be used to identify cultivars that are acceptable to resource-limited farmers [7]. The most notable of them is participatory varietal selection, which involves testing genotypes along with farmers in order to utilize diversity found in released varieties or in genotypes that are in advanced stages of testing [5]. This method assists farmers in overcoming obstacles that force them to cultivate landrace or out-of-date cultivars [9, 13] has been successfully applied in many nations to find crop cultivars suitable for farmers with limited resources. [1, 3, 6]. [11] have emphasized four steps that help farmers adopt cultivars: I identifying the needs of farmers in a cultivar; (ii) selecting suitable genotypes to test with farmers; (iii) testing the acceptability of the identified variety in farmers' fields; and (iv) spreading the farmer-preferred cultivar (s). It is entirely feasible to employ this strategy in conjunction with a community-based seed production system to promote recently released high yielding maize cultivars [14].

In this study, a comparative analysis of farmers' activities was performed taking into account the PVS programs undertaken in major maize producing areas of Western regions in Ethiopia [1]. The objectives of this study were to identify the key traits/preferences and for farther dissemination of the technology of farmers' for maize among farmers and according to sex. The objective of this study is to select well performed maize variety for specific area [15].

2. Materials and Methods

The activity was conducted at Kubur 50 kebele in Homosha District which is located at 700 kilometers from northwest of Addis Ababa at an altitude of 1380 meters above sea level. The average annual temperature ranges from 17°C to 32°C, and the mean annual of rainfall 1200mm. The soil characteristic is dominantly Nitosol type. The demonstration was carried out during the main cropping season of 2020 with the help of farmers and the District Bureau of Agriculture, utilizing the varieties BH546, BH547, and BH549 as the demonstration plots and BH545 as the standard check.

The activity was planted using a 10*10m plot area for each variety with spacing of 30 cm between two consecutive plants and 75 cm between rows, which is comparable to a planting density of roughly 44,444 plants ha^{-1}. With a 25kg ha^{-1} seed rate, inorganic fertilizers NPS and urea were applied in quantities of (125 and 182, respectively). NPS fertilizer was applied during planting, whereas urea was split two times for applications: one at planting and the other at knee height or 35–40 days later after sowing. To maintain the recommended planting density per unit area, each maize variety was first planted with two seeds per hill and thereafter thinned at the 21^{st} day after planting to one seedling per station. The researchers, Kebele developmental agents, and district specialists with the agronomic advice assisted the farmers with all agronomic techniques.

2.1. Data Collection

Grain yield and some yield-related parameters were collected from the demonstration fields. Data were collected from each demonstration site's 10m by 10m sample plot areas. The number of ears harvested per plot, ear weight (kg plot-1) at harvest, and moisture content (%) were all recorded. Finally, the harvested field weight per plot in kg ha^{-1} was converted to tha^{-1} in CIMMYT using the Galinat method [10].

$$Grain\ yield\left(\frac{ton}{ha}\right) = \frac{field\ weight\left(\frac{ton}{ha}\right)*(100-MC)*0.8*10000}{1000(100-15)*100}$$

Where: MC = grain moisture content at harvest in %, 0.8 = shelling co-efficient, 100 = harvested plot area in m^2), 1 hectare = 10,000m^2, 1ton= 1000kg and 85% = Standard Value of Grain Moisture at 15%.

The qualitative data were completed using the frequency distribution of matrix ranking using a tool for decision-making and prioritization procedure stated by Harder [16], while the quantitative data were summarized using the actual grain yield based on the formula stated by Galinat in CIMMYT [3] The following two processes were used to summarize the rate distribution and relative weight for pair wise ranking and direct matrix values:

Step 1: Count the number of times an option was chosen as being preferred over another potential and enter that number in the score column for the relevant row. For example: First count the number of frequencies each trait voted throughout the matrix, then sum up each trait value to detect the score.

1) List each trait's score values on the right side of the column.
2) Add a column next to the score column with the rank values that allow comparing the score of each characteristic obtained.
3) Enter a zero in the ranking column if the trait and/or variety received no scores during the field days.

Step 2. In accordance with the qualitative grading and ranking provided in the first phase, relative weights were calculated with the possibility that the sum of all weights may equal 100%. A linear proportion between all of the weights is assumed, and the formula is solved to arrive at that initial set of values [17].

Where: x represents the percentage (%) value of the relative weight (%) for each trait multiplied by (a1, a2, a3,..., an) indicated the number of frequencies each trait voted throughout the matrix. a summary of the selection criteria used by farmers for the variety evaluation at field days in both locations in 2021.

2.2. Field Day

At kuburu 50 kebele Homosha districts, farmers' field day was organized at the crop's physiological maturity stage with both male and female farmers were participated. There were 20 participants in total, with 12 men and 8 women. The variety evaluation and selection technique was carried out on the field days through group discussion. Utilizing Roger's [17] matrix of direct ranking methods and pair-wise ranking techniques, variety selection was done [16]. For each variation and significant qualities, the rating performance was graded from 5 to 1 (5 being exceptional, 4 being very good, 3 being decent, 2 being poor, and 1 being extremely poor). The frequency of selection scores for each variety and attribute through the matrix, along with the active participation of farmers, were used to determine the relative weight, which was then ranked. The trait of anticipated grain yield was then compared to the actual grain yield following harvest. Following these steps we used to do pairwise comparisons: Farmers' selection criteria were first determined through discussion in a group and arranged to be ranked in a square matrix, after which pairs of criteria were compared across rows, and lastly the outcomes of each evaluated criteria were ranked and given relative weights. The farmers ultimately decided on the best type and suggested it for further scaling up.

3. Results and Discussion

Farmers were actively participated in the field days and observed how each variety fared. Based on their preference at Kubur 50 kebele in Homosha District, striga weed tolerance was selected as the first critically important trait, and predicted grain yield were also selected as the second significant trait. Regarding the current experiment, prior studies on Maize [3, 10, 13, 16], [18] reported the existence of genotypic variation for grain yield and yield components. This implies the likelihood of selection to increase grain yield in the investigated materials.

This might be due to serious striga infestation at low soil fertility and wide infestation of this parasitic weed. Consequently, the proportional weight of anticipated grain yield and striga weed tolerance was 23.31% (Table 1, 2, 3 and 4). Scientific studies confirmed the importance of traits such grain weight, ear aspect, bare tipness, husk cover, and disease tolerance for maize productivity, which were validated by farmers' trait preferences [19].

Table 1. *Here, the coefficients are the number of appearance of each criterion in the matrix. Therefore.*

1	GY = 6x =23.31%	2nd
2	MD = x = 3.33%	8th
3	S &RLT = 3x = 9.99%5th	4th
4	EA = 2x = 6.66%	6th
5	SWT = 7x = 23.31%	1st
6	BTP = x= 3.33%	7th
7	DT/R = 6x =19.98%	3nd
8	P&EH =3 x = 9.99%	5rd

Farmers' selection criteria

Farmers were selected well performed maize variety in terms of grain yield. The majority of features were deemed to be extremely promising and rated as exceptional (five) and very good (four) (Table 3). Both the BH549 and BH546 varieties were favored and selected by farmers for its yield and tolerance for striga weed.

Table 2. *Pair wise ranking of farmers' maize trait preference criteria at maturity stage at Homosha and (Kubur-50) in 2020 cropping season.*

Selection Criteria		GY	MD	S & RLT	EA	SWT	BTP	DT/R	P & EH	Total score	Rank
		1	2	3	4	5	6	7	8		
1.	GY		1 (9)	1 (4) 3 (8)	1 (9)	1 (4) 5 (7)	1 (3) 6 (16)	1 (16)	1 (19)	7 (55F)	2nd
2.	MD			3 (19)	4 (12)	5 (15)	6 (9)	7 (16)	8 (11) 2 (5)	1 (5F)	8th
3.	S & RLT				3 (17)	5 (15) 3 (5)	6 (18)	7 (19)	2 (16) 8 (3)	3 (44F)	4th
4.	EA					5 (18)	6 (15)	7 (18)	4 (11) 8 (6)	2 (23F)	6th
5.	SWT						5 (17)	5 (15) 7 (5)	5 (16)	7 (103F)	1st
6.	BTP							7 (15)	6 (16)	1 (3F)	7th
7.	DT/R								7 (19)	6 (92F)	3nd
8.	P&EH									3 (20F)	5rd

Note: GY = Grain Yield, MD = Maturity, S & RLT = Stalk and Root Lodging Tolerant, EA = Ear Aspect SWT = Striaga Weed Tolerant, NEP = Number of ears per plant, BTP = Bare tip problem, DT/R = Disease Tolerant or Resistance, P&EH = Plant and ear height

Table 3. *Direct matrix ranking evaluation of varieties by group of farmers at Homosha (Kubur-50) in 2020. Note: 5= excellent, 4 = very good, 3= good, 2= poor and 1= very poor.*

Selection Criteria		Relative weight	BH-546	BH-547	BH-545	BH-549
1	GY = 6x =23.31%	2nd	5 (19)	4 (15)	2 (19)	4 (19)
2	MD = x = 3.33%	8th	3 (19)	3 (19)	5 (19)	4 (19)
3	S &RLT = 3x = 9.99%5th	4th	4 (17)	5 (12)	2 (19)	5 (19)
4	EA = 2x = 6.66%	6th	5 (19)	4 (15)	3 (19)	5 (18)

Selection Criteria		Relative weight	BH-546	BH-547	BH-545	BH-549
5	SWT = 7x = 23.31%	1st	5 (19)	5 (10)	3 (16)	4 (19)
6	BTP = x= 3.33%	7th	5 (19)	5 (19)	3 (18)	5 (19)
7	DT/R = 6x =19.98%	3nd	5 (14)	5 (18)	2 (19)	5 (17)
8	P&EH =3 x = 9.99%	5rd	5 (19)	4 (15)	2 (17)	5 (16)

GY = Grain Yield, MD = Maturity, S & RLT = Stalk and Root Lodging Tolerant, EA = Ear Aspect SWT = Striaga Weed Tolerant, NEP = Number of ears per plant, BTP = Bare tip problem, DT/R = Disease Tolerant or Resistance, P&EH = Plant and ear height

Yield

The highest grain yield (7.23 t ha^{-1}) was recorded in BH549 whereas the lowest grain yield (4.64 t ha^{-1}) was observed in BH-545 maize variety. The total ranking showed that farmers selected BH549 maize variety followed by BH546 maize variety (table 4). BH-547 and BH-546 both were voted two times in the matrix, so the score is 2 for each. But the number of participant in the vote for BH547 is less than BH-546 by fourteen participants while BH-545 didn't have any vote through the matrix. Therefore the subsequent active participation, farmers selected and ranked the varieties (table 4).

Table 4. *Pair wise ranking and selection result of maize varieties at Homosha District (M-4) in 2020.*

Varieties		BH-549	BH-546	BH-547	BH-545	Total score	Rank	GY t/ha
		1	2	3	4			
1.	BH-549		1 (19)	1 (27)	1 (19)	3 (65F)	1	7.23
2.	BH-546			2 (14) 3 (6)	2 (19)	2 (33F)	2	7.15
3.	BH-547				3 (19)	2 (19)	3	5.25
4	BH-545					0	4	4.64

Where: GY= Grain Yield, t/ha –tones per hector

Figure 1. *Farmers participation during evaluation at Assoasa Zone Homosha district kubur 50 PA.*

4. Conclusion

Farmers may require multiple traits from one key crop such as maize. However, researchers may not know the traits that are important to farmers and vice versa. Participatory varietal selection has significant role in technology adaptation and dissemination in short time than conventional approach.

Through PVS, the farmers' situation, their preferences and their indigenous knowledge in setting criteria were well understood. It is also possible to consider farmers 'evaluations and feedback and incorporate their preferences in the research processes. It was also able to ascertain that it is desirable to participate farmers in the maize improvement program from the very beginning and exploit their indigenous knowledge and their criteria for maize variety selection so as to develop farmer preferred varieties that can be easily and quickly disseminated to farmers.

In this study farmers' selection criteria were Grain Yield, Maturity, Stalk and Root Lodging Tolerant, Ear Aspect, Striga Weed Tolerant, Number of ears per plant, Bare tip problem, Disease Tolerant or Resistance, Plant and ear height. Based on the criteria they set, their preferred varieties were BH-549 and BH-546. Researchers also recommend these two varieties for the study area based on the data analysis, agro ecologically suitability. Therefore, we conclude that BH-549 maize variety was selected by farmers followed by BH-546 maize variety.

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