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Participatory variety selection of hybrid maize (*Zea mays L.*) varieties under irrigation for dryland areas of Wag-Lasta, Eastern Amhara

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ABSTRACT

Aim: The aim of this study was to select well-adapted, yield and high-green cob maize varieties with the preference of farmers and extension experts for wag-lasta maize producing areas under irrigation season.
Materials and Methods: The experiment was conducted in areas of wag-lasta for one irrigation season in two representative environments of the mandate areas. Five improved maize varieties were laid out in a randomized complete block design with three replications by using surface furrow irrigation.
Results: Highly significant differences ($p < 0.01$) among varieties in most traits of days to tasseling, cob length, fresh biomass, total cob weight and weight of cob were observed. In each location farmers select their best varieties in line with the criteria, number of cob per plant, cob length, earliness, and Vegetative performances. Based on farmer preference, BH549 and BH546 were selected as top varieties in both locations. Based on the result of the combined analysis varieties BH549 and BH546 scored the top in terms of both green cob and grain yield.
Conclusion: It was concluded that varieties BH549 (6024.7kg/ha) and BH546 (5761.1kg/ha) are best performing and profitable for green cob production and selling which are superior over the overall mean across location and other tested varieties.

Keywords: Dry land irrigation, improved yield, maize, participatory varieties.

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Introduction

Ethiopian economy is dominated by the agricultural sector, which also generates jobs, foreign exchange profits, and the country's GDP. Ethiopia heavily depends on agriculture to drive economic growth, and it continues to be considered to be a sector that plays a critical role in promoting the nation's overall financial development (CSA, 2016). Ethiopia is one of the top suppliers of maize in Africa (FAO, 2013). The most widely grown cereal crop in the nation is maize, which stands first both in terms of total national production and productivity and second in terms of coverage, adhering to teff (CSA 2015). Ethiopians use maize mostly for enjera, kitta, anebabro, bread, porridge, and regional alcoholic beverages such katikala and tella (Asrat, 2012). In addition to being used for human food, maize is also extensively used in industry.

Over 50,000 metric tons of maize grains are processed annually by firms that produce food products made from corn, and the amount of corn used as a raw material is steadily rising (Mulugeta, 2012)

Maize grows in various agro-ecological conditions and areas. Four general agro-ecologies can be identified in the growth environments: low altitude sub-humid, high altitude sub-humid, mid altitude moisture stress area, and mid altitude sub-humid. Moisture stress and low altitude agro-ecologies, however, are favorable for maize growth (EARO, 2000).

In Ethiopia, maize production patterns vary by location. The crop is suitable for various crop orders and crop alternations depending on soil fertility and environmental conditions in different places. It is grown mostly during the primary growing season known as meher, but also during the lesser rainy season known locally as Belg. During the meher season, it is cultivated under rainfed conditions, however in the off-season, it is frequently grown under residual moisture with additional irrigation (Mosisa et al.

2012). Although the rate of application of these fertilizers for maize varies by location and soil fertility, the blanket recommendation is 100 kg/ha of Urea and 100 kg/ha of DAP (EIAR 2007). Results, Its average production under rainfed conditions is 33.87Qt/ha in Ethiopia, 35.08Qt/ha in the Amhara Region, and 13.37Qt/ha in the Waghimra Zone (CSA, 2016). During the irrigation season, maize, particularly green cob, is economically wealthy and profitable in both rural and urban populationsLast year, in the Wag-last zone, the total potential area covered by irrigation was 3424.76ha, and the productivity of maize under irrigation was 20 Qt/ha of the green cob sold and consumed by the producer (personal communication, Agriculture Bureau). During the irrigation season, maize is primarily produced for green cob consumption, which is economically lucrative in both rural and urban populations. It is the primary source of income for women who reside in cities and do not have other employment opportunities.

Despite its importance, maize productivity continues to be very low, and there is no equal satisfaction of demand and supply, especially within urban areas as a green cob roasted, due to erratic rainfall and a lack of improved varieties with high productive and early maturing traits to adapt to the target areas under irrigation. On the other hand, being able to generate maize throughout the irrigation season is less prone to disease and insect pest infestation than other vegetable crops, and its perishability is relatively low, allowing it to live for an extended period of time. Participatory variety selection (PVS) has been shown to identify more candidate varieties through farmers in less time than the conventional approach; PVS has been reported as an effective strategy for diversifying better varieties (Joshi and Wit come, 1996). It is imperative to test their adaptability with the participation of the farmer. Therefore; the main aim of the study was evaluate and select improved maize varieties under irrigation system with farmer's participation in variety selection process.

Materials and Methods

The experiment was conducted in the area of wag-lasta (Woleh and Lalibela for one year during irrigation production season. The scaling up program was also conducted in 2023 irrigation season in three districts where the participatory variety selection trial was confirmed, namely Sekota, Lasta and Gidan representing maize Producing area and accessible to irrigation. Sekota Dryland Agricultural Research Center (SDARC) trail sites of Woleh, Shumsheha and Gidan, partitioned under Sekota woreda Kebeles in waghimra zone which is far from the capital city Addis Ababa via 724km and partitioned under lasta and Gidan woreda Keble's in north wollo zone respectively. Geographically, Woleh trail site is located at 12° 37' 43.56'' North latitude and 39° 2' 13.95'' East longitude via 2247.29m.a.s.l. And also lasta trial site is located at 12° 1' 51.24'' North latitude and 39° 2' 51.47'' East longitude via 2444.44m.a.s.l. The minimum and maximum temperature of Sekota (Woleh)and lasta is 12.9°C and 31°C and 13.4°Cand 24.9°C respectively.The district of Gidan also located at 12° 15' 0" North latitude and 39° 10' 0" East longitude and its altitude is reach 2400 m.a.s.l (Kombolcha meteorological substation, 2020).

Experimental Materials and Design

The experiment was laid out in randomized complete block design with three replications. The experimental plots size were 5m*3m (15m^2), inter and intra row spacing of 0.75m and 0.25m with the spacing between plots and replications were 0.5m and 1m respectively. Each plot contains four rows and 80 plant populations, fewer than four rows two of which were used as green cob and the remaining for grain yield data collections. Five improved maize (namely; MHQ138, BH546, BH547, Mh140, and BH549) varieties that collected from national research center were evaluated in biological data and social preference both for grain yield and green cob to the target areas.

Experimental Procedures and Field Activities

Th experiment was conducted as mother and babies trial in line with the Amhara Regional Agricultural Research Institute participatory variety selection protocol for released varieties. A mother trial is characterized as a study overseen by a researcher and can be carried out at various locations such as a research site, farmer training center, or directly at farmers' fields, with a meticulously designed and replicated trial setup. Conversely, a baby trial refers to a collaborative trial involving farmers, extension workers, and researchers, exclusively farmers actively participating in variety selection. In baby trials, field observations and data on farmer preferences are assembled, organizing on a single replication

of the mother trial. To maintain consistency, three baby trials were conducted at farmer field, positioned at specified distances from their respective mother trials, with identical plant spacing and row arrangements as those in the mother trial (A. Assefa et al., 2021). Except its replication on the mother trial, all agronomic management practice on the mother and babies' trial was applied equally and properly as per recommendations. The experimental sites were prepared via oxen plough and the plots in the replication and the row in the plots were made by hand hoes. The sowing of two seed was applied per hills with seed rate of 30kg/ and thinned down after 10 days of emergence. The experiment was received 100kg NPS and 50kg of UREA rate Fertilizer, UREA in split form at sowing and knee stage of the plant height was applied. Irrigation was applied via making of tie ridgeand furrowing irrigation system within each row per plot.

Farmers/Farm Selection and Responsibility Sharing among Actors in the Scaling-up Program

In combination, 77 (17-female) farmers were selected for the pre-scaling up program in one production years, of which 1, 29 and 47 farmers were from Sekota, Lasta and Gidan districts respectively. The selection process was done purposely to compriseover 20% female under the program. Farmers having 6 ha clustered land and had got training on basic agronomic practices to create awareness about the improved variety in particular and the technology packages in general. And also, the socioeconomics and agricultural extension research directorate (SEAERD) organized MOU with stakeholders to create awareness as well as share responsibilities among actor's .The main stakeholders from zonal to kebele level agricultural development offices and Sekota Dry-land Agricultural Research Center working for agricultural development in both districts.

Data Collection

Yield and Yield Related Traits: The biological (agronomic and yield) data were taken per plot overall and per plant base of the experiment at fresh (green cob) and harvesting stage were collected and recorded for analysis.

Plot Basis Dat

Days to tasseling (days): the anthesis data was taken when the plant reaches to 50% tasseling.

Days to maturity (days): The date by which 90% of the plot is ready for harvest.

Fresh weight biomass (kg/ha): Taking above ground biomass at green stage and measure it.

Dry weight biomass (kg/ha): Taking above ground biomass at harvesting stage and measure it.

Total cob weight (kg/ha): The weights of the cob were measure all the net plot cob in the experimental plot at harvesting stage for green cob and grain yield at dough and harvesting stage respectively.

Gross income (Birr): The total cobs in the hectares were calculated on the basis of the present market price per cob size which gives the gross income per hectare.

Grain yield: Grain yield measurements must be corrected to a standardized moisture level (standard moisture content) to ensure consistency and comparability of results.

Plant Basis Data:

Plant height (cm): Average height a minimum of 5 plants randomly taken from each plot at physiological maturity.

Length of cob (cm): The mean result of five randomly selected cobs per plot

Row per cob (cm): The row data of maize are the average of the five randomly selected cob row results which express in number.

Weight per cob (g): It is the mean product of five cob weights which were selected randomly from each plot for both green cob and grain yield at dough and harvesting stage respectively.

Social Data

In line with participatory variety selection approach or mother baby approach, Field visits to the baby trial plots were arranged at both sites during the crop's maturity stage(A. Assefa et al., 2021). A total of 15(five women and ten male) former farmers from both research sites, chosen by their kebele development agents, took part in the field evaluation and variety selection process. Farmers were organized into groups, where they collectively determined the evaluation criteria for the varieties based on their preferences. Within each group, discussions took place, leading to the prioritization and mutual agreement on set their selection criteria for cob number per plant, cob size, earliness and vegetative performance. The farmers employed a pairwise ranking method to rank each evaluation criterion, and these ranks were utilized to assign weights to the criteria. After establishing their selection criteria, the farmers received direction on evaluating the varieties and were encouraged to meticulously assess all varieties based on each selection

criterion were ranked from 1 to 5 (5 = very good, 4 = good, 3 = average, 2 = poor and 1 = very poor) for each variety. The sums and means of the scores for the evaluation criterion of each variety were then calculated. The overall value of each variety was determined by multiplying the weight assigned to each evaluation criterion by the mean score of that criterion across all criteria. Finally, the varieties were ranked based on their overall value for the final selection, with the lowest sum ranking highest.

Scale up Data

In scale up program, agricultural experts and researchers continuously followed up the activity and structured questionnaire which were used to collect farmers' opinion about the technology. In nature the collected data were both quantitative and qualitativein which quantitative data on grain and biomass yieldand the qualitative data like perception and attitude of farmers towards the technology specifically; germination and vegetative performance, pest and disease resistant, water allotment *(wuhamansat)*, earliness and other criteria of farmers were gathered. Farmer's days were organized with the participation of farmers and stakeholders aiming to evaluate the performance as well as to promote the varieties to the broader community.

Biological, Farmers Preference, and Scale upData Analysis: Data from each locations underwent variance analysis using the statistical software SAS. The homogeneity of error variances between the two locations was tested using the F test following the methodology outlined by Gomez and Gomez (1984). Combined data analysis was conducted for the parameters demonstrating homogeneous error variances, while separate analysis of variance was performed for parameters with differing error variances in individual locations. Mean comparisons were carried out using the least significant difference (LSD) method. The collected data, in which farmers participated, were evaluated using pair-wise ranking and direct matrix techniques.

Table 1. Characteristics of the varieties used at woleh and Shumsheha in irrigation cropping season.

Varieties	Year of release	Altitude	Yield at research field	Released center
MHQ138	2012	1000-1800	75-80	MARC
BH546	2013	1000-1750	60-70	BARC
BH547	2013	1000-1800	55-80	BARC
BH549	2017	1500-1800	90-120	BARC
Mh140	2013	1000-1800	85-95	MARC

Table 2. Duties and responsibilities of major stakeholders in the pre-scaling up program

Research Center	• Preparing manuals and provide training for farmers and DAs • Confirm cluster farms, provide seed and fertilizer on time • Monitor the technology implementation process • Provide technical support to farmers and experts • Organizing field days with district Agriculture Offices • Taking necessary data and writing scientific report
Agriculture Offices	• Participate in workshops and trainings • provide technical support in site and farmers selection • Monitor the activities and participate in field days • Convince farmers and select clustered farmlands • Select farmers and measure their farms using GPS. • Provide technical support on major agronomic practices • Provide information to researchers on disease(pest) outbreak • Participate in field days and collect seed from farmers
Farmer's	• Prepare the farmland to the optimum level • Planting on time, managing weed, harvest and trash on time • Keeping the seed quality, give back the seed in kind • Teach neighbour farmers about the technology and • Exchange the seed to interested farmers in any arrangement

The collected quantitative data in the scale up program were analysed using descriptive statistics in SPSS (v-20) software. Farmers' preference and perception was analysed using 5-point likert scale rating method.

Results and Discussion

Biological Data Evaluation

The combined analysis of variance revealed that the main effect of environments on varieties were not significant difference for grain yield and other yield related parameters, denotes that the varieties were tested across different location is not affected by environment and express its genotype effect meritoriously or the varieties on different location have stability in yield and yield related traits which leads to combined different environmental data, Abdalla et al. (2014), stated that the difference locations data showed no significant difference indicated that the environments have similar agro ecologies.

Grain (Dry) Yield Data Evaluation

In line with the ANOVA result, the varieties showed significant difference in most traits (days to tasseling, cob length, fresh biomass, total cob weight and weight of cob) except traits of plant height and row in a cob. This result agreed withGelaye & Kassie,(2019)stated that most trait of hybrid varieties showed significant difference due to its hybrid vigour or heterosis characteristics. Stress genetic variability is essential to the development and identification of new genotypes for yield, biotic and abiotic (Gelaye & Kassie, 2019). The result of the combined analysis revealed that MH138 variety took short period of time for tasseling (76 days) while BH549 took long period of time for tasseling (82.0days), the same trend as tasseling, MH138 took less time for maturing(111.5days) as compared to the other varieties and the late variety MH546 (117.7days). Physiological maturity is determined by accomplishing of grain filling processes, black colouration of kernel edge, and 28-34% of moisture content (Martin et al., 2015). Cob length is one of the determinant factors for maize production and productivity which implies that shortcob length variety yielded lower unless its cob recorded widest diameter. The longest cob length was recorded by BH549 (32.567 cm) whereas the shortest was recorded by MH138 (22.900 cm) and the average cob length was 28.03cm. Highly significance difference (0.01) was observed among varieties for biomass, the highest biomass and cob weight was recorded by the variety BH549 (8611.1 kg/ha and 0.17kg respectively) that relates positively to grain yield. Those above parametrical traits are compassionate to grain yield and Grain yield among varieties was highly significance. The superior grain yield was recorded in the variety BH549 (6024.7kg/ha) while the lowest grain yield was observed by MH140 (4756.2kg/ha) similar results were recorded in the previous findings (Hassen et al., 2003) (Table 3). Beyond these, the tested variety BH549 (6024.7kg/ha) and BH546 (5761.1/ha) had superior yield as compared to the regional (3508 kg/ha) and zonal (1337kg/ha) mean grain yield (CSA, 2020).

Green Cob Data Evaluation

Days to tasseling, cob length, row per cob in green cob analysis were shared the same result from the analysis of variance for the purpose of grain yield as the agronomic trait of those the above listed traits were taken on the net plot before dissecting for the purpose of green cob and grain yield. The only difference for green cob analysiswas fresh weight biomass, weight of cob, total weight of the cob and gross income. Results, the combined analysis revealed that highly significance difference (<0.01) was observed among varieties on total weight of the cob, gross income, fresh weight biomass and weight of a cob. Based on these, BH549 showed the highest fresh biomass yield (15.741t/ha). On the contrary the lowest fresh biomass yield was recorded by MH140 (9.691t/ha). Likewise, BH549 (0.268kg) also recorded highest weight of a cob that directlyrelated to the total weight of the cob (112.35 qt/ha) while the lowest total weight of the cob wasobtained from MH138 (0.18200kg) variety and the average weight of the cob was8103.7qt/ha (Table 4).

The mean gross income which was at the farmers field what have not mentioned via partial budget analysis as the expense of all the varieties tested under the experiment were the same and range across locations were from190123birr to 324074 birr. Variety BH549 had provided highest in terms of biomass, total cob weight, gross income, grain yield and other parametrical trait both for the purpose of green cob and grain yield purpose flowed by BH546. BH549 is highest in terms of green con yield and other parametrical trait among the tested varieties followed by BH546, indicated that there were similar results with yield expressed on basis of grain (Table 4).

Table 3. The combined analysis of variance for grain yield and other yield related trait at Lalibela and Sekota.

Variety	DT	DM	LC (cm)	RC	PH (cm)	DBM (kg/ha)	WE (kg)	GY (kg/ha)
MH140	76.00b	111.50c	27.00b	13.50a	168.6a	4814.8c	0.12b	4756.2b
MH138	79.17ab	113.67bc	22.90b	14.17a	172.9a	5370.4c	0.12b	5024.7b
BH546	81.17a	117.67a	26.18b	14.33a	171.9a	8506.2 a	0.17ab	5761.1a
BH547	81.17a	115.00abc	31.50a	14.50a	170.3a	6913.6b	0.15ab	5077.2b
BH549	82.00a	115.67ab	32.57a	15.17a	163.1a	8611.1a	0.17a	6024.7a
Mean	79.90	114.70	28.03	14.33	169.4	6843.216	0.15	5328.8
LSD(5%)	*	*	**	Ns	Ns	**	*	**
Cv(%)	3.44	2.61	12.061	12.86	5.32	17.80	20.35	4.77
En	**	**	**	Ns	Ns	Ns	Ns	**
En*Trt	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Table 4. The combined analysis of variance green cob and other yield related trait at Lalibela and Sekota.

varieties	DT	FBM	LC	WC	PH	RC	TCW	Birr
MH140	76.0b	9691b	27.0b	0.21bC	168.633a	13.5a	5815c	190123b
MH138	79.7ab	10185b	22.9b	0.18c	172.9a	14.2a	6123c	217284b
BH146	81.7a	12562b	26.2b	0.23ab	171.9a	14.3a	8611b	298765a
BH147	81.7a	11790b	31.5a	0.25ab	170.3a	14.5a	8735b	296296a
BH149	82.0a	15741a	32.6a	0.270a	163.1a	15.2a	11235a	324074a
Mean	79.9	11993.8	28.03	0.23	169.4	14.33	8103.70	265308.6
LSD(5%)	*	*	**	*	Ns	Ns	**	**
Cv(%)	3.4	19.2	12.06	15.1	5.3	12.8	22.6	14.4
En	**	**	**	**	Ns	Ns	**	Ns
En*Trt	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

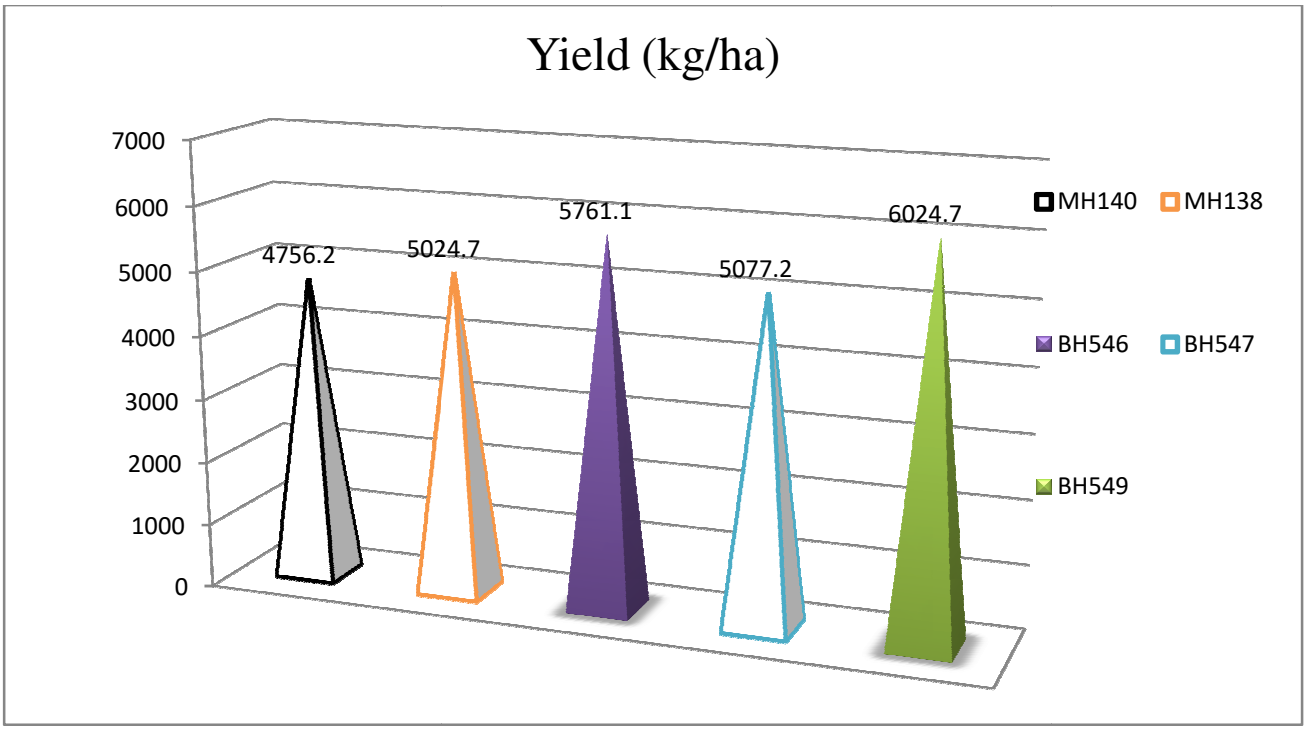

Fig 1. Yield data for five hybrid maize varieties in different location

This result varied with the result reported by Almeida et al., (2005), indicated that Grain filling is clearly not finished when green cob are harvested, and varieties may differ in how quickly and how long the grain filling stage lasts. In the target environment, green cob yield is more profitable than yield harvested with regards to grain yield which was stated via other findings (Almeida et al., 2005 and Gelaye & Kassie, 2019).

Farmer's Participatory Preference Data Evaluation

During main irrigation season, 12 male and 7 female (19 farmers) and 14 male and 6 female (20 farmers) were participated on the selection of varieties at Sekota and Lalibela location respectively. The farmers who participated in both locations were well experienced and long wisdom about maize traits which have limiting factor for production and productivity. Farmers freely discussed with each other and set their criteria. On the basis of their criteria, number of cob per plant, cob length, earliness, and Vegetative performances were scored first, second third and fourth respectively (Table 5).

Table 5. Farmers preference traits of maize technology in Sekota and Lalibela location.

Trait	Rank	
	Sekota	Lasta
Number of cob per plant	2	2
Cob size	3	3
Earliness	1	1
Vegetative performances	4	4

The present studysharedmost common evaluation methodswith the previous findings, that were cob length, number of cob per plant, earliness, biomass and overall performance of the plant identified as farmers' selection criteria (Assefa et al., 2014; Amare & Kassahun, 2021; Chakle et al., 2022; Gelaye & Kassie, 2019; Hassen et al., 2003). On the other hand, other traits, husk cover, ear aspect, stalk strength and diameter, husk tip coverage were set by farmers selection criteria in different findings at different areas. These criteria indicate that there are different view and traits that limit the production and productivity of crops in different areas with different agro ecologies.Results; merely having stable genotypes across various environments based on biological data is not adequate; it is essential to integrate farmers' observations with the biological data in the variety development program (A. Assefa et al., 2021; Amare & Kassahun, 2021).

BH549 (6024.7kg/ha) and BH546 (5761.1kg/ha) varieties gave greater yield and other parametrical yield traits like cob length, weight per cob and biomass yield both in green cob and grain yield purpose. As a result, these varieties were selected as the top and preferred by the farmers in different criterion that the farmer observed in different way of purpose include the straw yield for the purpose of fodder and other important traits beyond the researcher. Consequently, Spearman's Rank correlation coefficients analysis showed that a positive correlation of 98% and 97% at woleh and lalibela respectively (Table 6).

On the basis of the formula Spearman's Rank correlation:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

The result of the Pearson correlation analysis revealed that grain yieldpositively correlated with length of cob, row per cob and weight per cob,this indicatedthat the increment of those the above agronomic traits have added the value to grain yield (Table 7).

The result of the Pearson correlation analysis revealed that the weight of green cob had positively and significantly correlated with length of cob, row per cob and weight per cob which indicates the increment of those the above agronomic traits add a value to green cob (Table 8).

Characteristics of Pre-scaling up Participant Farmers

The average age of pre scaling up participant farmers were 52.29 with mean farming experience of 36.57 years. Among partakers, the most were engaged from marriage profiles while 16.8% were female headed. The average family size was 5.27 which indicate that most farmers had sufficient labour for technology application particularly for row preparation, sowing and weeding. The educational status of participants also determines extension internalization and technology application. Hence, 57.1% of the farmers were illiterate and the rest were literate only for reading and writing in the primary education level. All pre-scaling up participant farmers got training and agreed with the training that provided adequate to apply the technology packages. Since tillage frequency of farmland determines productivity and the agronomic

Table 6: Actual grain yield obtained and farmers' visual rank of grain yield for each variety and d^2 Sekota and Lasta.

Sekota						Lalibela				
Varieties	Grain Yield (qt/ha)	Actual grain yield Rank	Farmers rank	d^2	r_s	Grain Yield (qt/ha)	Actual grain yield Rank	Farmers rank	d^2	r_s
MH 138	53.58	4th	5rd	$(4-5)^2$	0.99 (99%)	46.91	4th	5rd	$(4-5)^2$	0.99 (99%)
BH 546	58.88	2nd	3rd	$(2-3)^2$	0.99 (99%)	56.33	1st	4th	$(1-4)^2$	0.94 (94%)
BH 547	54.13	3rd	1st	$(3-1)^2$	0.97 (97%)	47.40	3rd	1st	$(3-1)^2$	0.97 (97%)
BH 549	64.56	1st	2nd	$(1-2)^2$	0.99 (99%)	55.92	2nd	2nd	$(2-2)^2$	1 (100%)
MH 140	51.29	5th	4th	$(5-4)^2$	0.99 (99%)	43.82	5th	3rd	$(5-3)^2$	0.97 (97%)

findings suggested that 'four times ploughings are optimum level' for maize production. Thus, 14.3% farmers were tilling more than sufficient level (5 times) while the remaining 85 were tilling and adequate level (4times). Performing agronomic activities on basis of crop calendar has directlyaffects the productivity of a given variety. Hence, the pre-scaling up result indicated that 100% (all) farmers were planting on the exact time.

Farmers' Perception to Maize Technology

In order to simplify farmers' perception, calculating sum and average scores of the likert scale is enviable. Therefore, sum score = frequency of strongly agree + frequency of agree + frequency of not decide + Frequency of disagree + frequency of strongly disagree and average Score = sum score ÷ total sample size (Table 9). If average score is greater than 3.51, farmers have good perception on the technology. If the average score is 2.51 – 3.50, farmers have not confidence on the technology. If the average score is below 2.50, farmers have not good perception on that technology (Tim willet, 2013). Most farmers had positive view and good perception on the technology in most parameters, like germination, vegetative as well as its cob length (Table 10). However, large number of farmers had no confidence on pest resistance capacity in which they suggested that the variety needs chemical application during the early vegetative stage of the crop. At the same time, except few farmers (35.7%) most farmers were not take the variety to market rather prefers to keep for home consumption. In general, the responses of the farmers Likert scale average result was 4.63 which imply that farmers perceived and accepted the technology with full confidence (Tim Willet, 2013).

Table 7. Correlation coefficients of grain yield and other agronomic traits of five hybrid maize varieties in two locations.

	DBM	LC	Rc	WE	GY
DBM	1	0.23645	0.11664	0.56116	0.58932
LC		1	0.42697	0.14479	0.39267
RC			1	0.15146	0.40420
WE				1	0.44297
GY					1

Table 8: Correlation coefficients of green cob weight and other agronomic traits for five hybrid maize varieties in two locations.

	FBM	LC	WC	TWC	GI
FBM	1	0.56418	0.05191	0.81453	0.40995
LC		1	0.17948	0.70688	0.46599
WC			1	0.29079	0.44175
TWC				1	0.70527
Birr					1

Farmers' Reaction and Technology Demand

All Farmers confidentially interested to apply the technology by next year and most of them recommended neighbour farmers to exercise the technology. From suggested farmers, most were positive to use the technology by the upcoming years. Thus, their viewpoints summarized into positive and negative reactions. At the end of pre scaling up, field days were organized by the Center and the extension experts, 85 (8 females) participants attended; including farmers, agricultural experts, mass media and experts. During the days, participants' opinion to the

Table 9. Likert scale result on farmers' perception on improved pearl millet variety, n =14

Parameters	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	**Sum scores**	**Mean scores**
Germination performance is good	--	--	---	----	100	70	5
Vegetative performance is good	--	--	--	---	100	70	5
Cob length is good	--	--	--	--	100	70	5
The variety is disease resistant	--	--	--	--	100	70	5
The variety is pest resistant	--	100	--	--	--	28	2
The variety is early maturing	--	--	--	14.3	85.7	68	4.8
Trash ability of the variety is good	--	--	--	--	100	70	5
The variety's productivity is good	--	--	--	7.1	92.9	69	4.9
Food quality of the variety is good	--	--	--	--	100	70	5
		Average					4.63

technology was collected and farmers showed their full interest to the technology. The clustering approach appreciated as it creates competition among farmers on farm management, as well as having "eye catching" power to impress other individuals about the technology in the extension system.

The variety is very adaptive to our area and can give attractive yield. Likewise, during ear set a single plant can have up to 2-3 numbers of cobs and its cob length also got good-looking by the farmers and extension experts. The farmers interested to cover their farms more than by this technology in the next season but they mentioned as the problem of pest infestation and its hybrid characteristics that afford for chemical and seed in the production system. Woreda plant development officer and kebele development agent said "*maize well come from home garden to farms production field*" (Farmers day, April 21, 2023).

Table 10. Farmers' and stallholders' reaction to maize technology

Positive sides	**Negative sides**
· early maturing palatable for feeding(green feed) · high yielder and has good vegetative performance · The stalk is good for livestock(palatability) and household biofuel · It's attractive colour like *white*	· It's not pest resistance · Needs chemical for pest(cost)

Table 11**:** Grain and biomass yield of BH-546 variety in scaling up program

	N	Min.	Max.	Mean	Std. Dev
Grain yield (kg/ha)	15	40	50	4233	3.628
Biomass yield (Shekim/ha)	15	32	160	107.28	46.35

Grain yield and Straw Biomass

Yield is one of the main benchmarks for farmers' to adopt any crop technology. The mean yield of BH 546 was 42.33qt/ha, which is higher than the regional average reported in main season (CSA, 2016) but it is lower than the PVS result which is 60.2qt/ha which showed that mostly farmers' management practice lower than researchers' management. However, the pre scaling up result had a 58.4% yield advantage compared to the (CSA, 2016) yield report of 13.37qt/ha in similarenvironments that the scaling up program were conducted.Likewise, straw biomass productivity of the variety was higher and also it is palatable for animal feedingwhich is important for the Dryland areas of wag last zone (Table 11).

Establishment and Strengthening of Linkages

Shared responsibilities among main stakeholders aiming to make linkage among farmers-extension-research and secure technology promotion and sustainability. In doing so, all participant farmers took agreement to distribute the variety with its working packages through teaching non-accessed neighbour farmers. Again, agricultural experts at different levels have handling tasks to facilitate the technology dissemination via continuous follow up, technical support, and consultation. Thus, farmers in the scaling up area wants to share the variety for those interested in and outside the village using different exchange arrangements (in cash and kind) ,but it is hybrid and leads to yield penalty that needs to afford the seed for the next production season.

Conclusions

In line with farmers' preference, the analysis of the experiment grain yield and other related traits varieties BH549 (6024.7kg/ha) and BH546

(5761.1kg/ha) are best performing and profitable for green cob production and selling which are superior over the overall mean across location and other tested varieties. Therefore, BH549and BH546are recommended as an alternative for production area of woleh, Shumsheha and other similar environments under irrigation production season.

The pre scaling up result confirmed that improved maize varieties with its packages provided better grain and biomass yields. The mean yield was 4233kg/ha, which is higher than the regional average and the pre scaling up result had a 58.4% yield advantage over the yield report of 1337kg/ha obtained in the area. Likewise, straw biomass productivity of the variety was higher and has good palatability to livestock. Strong demand for the technology created to farmers and other stakeholders working on agricultural development in the areas still with researchers and experts' follow up all participant farmers on 6 ha applied the full package. From the conclusions, recommend that *BH-546* improved maize cultivars with their packages should further scaled out to similar agro-ecologies. Seed producing and marketing cooperatives should strengthen to make the technology multiplication and transfer sustainable system in the production program..

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