Performance of Improved Maize Varieties under Irrigation for Grain Production at Koga Irrigation Scheme, West Gojam, Amhara Region.

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Abstract

Maize is one of the most important food crops in Amhara region. It provides high grain yield under irrigation compared to rain-fed. The trial was conducted with the objective of identifying and recommending adaptable and high yielding improved maize varieties that suit to the irrigation environments. Twelve hybrids and six open pollinated maize varieties were studied as a two sets of experiment in randomized complete block design with three replications. The plots were irrigated using furrow irrigation every 14 days. Urea and DAP were used as nitrogen and phosphorus sources respectively. All agronomic managements were applied uniformly to all plots. Data were collected and analyzed using SAS statistical software and different treatment means were separated using least significant difference at 5%. The result revealed that varieties showed high genetic variation among themselves for most traits. Shone variety gave the highest grain yield (13458 kg ha^{-1}) followed by PHB3253 (Jabi) (13320 kg ha^{-1}) in 2013/14 with no significant difference between them. While in 2014/15, the highest grain yield was obtained from BH-660 (10747 kg ha^{-1}) and AMH-760Q (10567 kg ha^{-1}). Averaged over years, Shone gave the highest grain yield (11486 kg ha^{-1}) followed by AMH-760Q (11277 kg ha^{-1}). Similarly, Gibe-1 (OPV) gave the highest grain yield 11673.8 kg ha^{-1} in 2013/14, 10093.1 kg ha^{-1} in 2014/15 and 10883.4 kg ha^{-1} averaged over years. The grain yield performance of most tested varieties under irrigation was higher than their grain yield performance under rain-fed condition. Under irrigation, Shone variety gave 35.1 % and Gibe-1 variety 39.5% yield advantage over the rain-fed. Therefore, Shone and Gibe-1 are recommended as potential improved varieties under irrigation for grain yield whereas AMH-760Q as potential quality protein for Koga irrigation scheme and similar environments.

Key words: grain production, hybrid, irrigation, open pollinated, maize,

Introduction

Maize (*Zea mays* L.) is one of the most important strategic cereal crops in Ethiopia in-terms of food security. It ranks second in area coverage next to teff and first both in total production and productivity (CSA, 2014). Out of 79.38 % crop area covered by cereals, maize took up 16.08 % of land. Maize contributed 17.57 % to the total Cereal production of 85.51% of the grain production (CSA, 2014). Maize is used for food, feed, fuel and fibers and a good source of carbohydrate when it used as food and feed.

Both hybrid and open pollinated maize varieties are cultivated in the region. Hybrid maize varieties are high yielder and more uniform for mechanization compared to open pollinated. Only seed of hybrids is produced and distributed to maize producers in Amhara region and no seed of improved open pollinated maize varieties is produced and disseminated. But improved high yielding open pollinated maize varieties have considerable importance in areas where seed industry is not well developed and they are also better options in the context of resource poor farmers who cannot afford the hybrid seeds and are inclined towards use of recycled seeds. In addition to these facts open pollinated maize varieties provided comparable yield to hybrids in low potential environments and under stress conditions.

More over farmers in the region use the seed of local open pollinated maize varieties and second generation of hybrid seed for production. Amhara Region Bureau of Agriculture maize production and marketing plan (2017) stated that from the total land covered by maize in the region only 38% planted by certified hybrid seed. The remaining more than 60% of the land was cultivated by local open pollinated and the second generation of hybrid seed. The main reason for the coverage of large portion of maize land by the local open pollinated and second generation hybrid varieties are the cost of certified seed and fertilizers mostly relatively higher than the price of the grain. Open pollinated maize varieties are economical options for resource poor farmers when the price of the hybrid seed and fertilizer are relatively higher than the price of the grain (Kevin and Baenziger, 2001).

Maize production under irrigation provide better yield as compared to rain fed production for controlled amount of water supplied by irrigation at the required growth stages of the crop. Boshev et al., (2014) and Jacob et al., (2014) have proved that maize varieties produced high grain yield under irrigation but might not be good yielder in rain fed production. The authors concluded that maize varieties with high and stable yields could be expected only with irrigation.

Improved maize varieties developed or adapted to the irrigation environment are also other detrimental factors to increase the production and productivity of maize. Selecting improved maize varieties that have a high yield potential, good disease and insect tolerance, good resistance to lodging and a maturity length that suit the irrigation environmental conditions are very crucial to improve maize production. So far, no maize varieties have been developed for irrigation system in Ethiopia in general and in Amhara Region in particular. Improved maize varieties cultivated in the region as well as in the country were also not evaluated for green cobs. As maize is one of the strategic crops for assuring food security, its production under irrigation and development of irrigated maize varieties are fundamental to increase maize production. Therefore, the study was carried out to identify and recommend adaptable, high yielding improved maize varieties that suit to the irrigation environment.

Materials and Methods

The experiment was conducted at Koga irrigation scheme for two years (2013/14 and 2014/15). Koga irrigation command area is located in Mecha District; 41 kilometres away from Bahir Dar on the way to Addis Ababa via Debre Markos. Geographically, the site was located at 37°7'29.721" E and 11°20'57.859" N at an altitude of 1953 m a.s.l. The average annual rainfall of the area was about 1118 mm and the mean maximum and minimum temperatures were 26.8 ^{0}C and 9.7 ^{0}C respectively. Twelve hybrid and six open pollinated maize varieties from diverse backgrounds and maturity groups (Table 1) were planted in two sets in a randomized complete block design with three replications. The plot size was 5.1m by 3.75m (19.125m^2) and contained five rows. The distance between rows was 0.75 m with the hills spaced at 0.3 m. The plots were planted to two seeds per hill and thinned to obtain 44444 plants per hectare. The recommended seed rate (25 kg ha^{-1}) and fertilizer rates (200 kg urea ha^{-1} and 200 kg DAP ha^{-1}) were used in the experiment. The whole amount of DAP was applied at planting while urea was spilited into half at planting and the remaining half at knee height. The trial was irrigated using furrow irrigation every 14 days. Weeding and hoeing were carried out according to the standard cultural practices. Data were collected for different traits including plant height, ear height, grain yield, days to 50% silking, days to 50% tasseling, ear diameter, ear length, ear aspects and number of cobs.

The central three rows from each plot were harvested at maturity and the fresh ear weight was measured in each plot. Grain yield data was calculated from the fresh ear weight of three central rows of each plot by adjusting to 13 percent moisture content and subjected to analysis of variance (ANOVA) using SAS version 9.0. To satisfy assumptions of analysis of variance, all variables were subjected to the Levene test of homogeneity of variance and to the Shapiro-Wilk W test of normality and the least significant differences among means were calculated to identify differences among treatments.

Table 1. Description of hybrid maize varieties tested and their adaptation

No	Hybrids	Maize type	Source	Adaptation (meter asl)
1	BHQPY543	Non-QPM	Bako ARC	1000-1800
2	BHQPY545	QPM	Bako ARC	1000-2000
3	BH660	Non-QPM	Bako ARC	1600-2200
4	BH661	Non-QPM	Bako ARC	1600-2200
5	AMH-760Q	QPM	Ambo ARC	1800-2600
6	PHB3253	Non-QPM	Pioneer seed	1000-2000
7	AMH850	Non-QPM	Ambo ARC	1800-2400
8	AMH851	Non-QPM	Ambo ARC	1800-2600
9	AMH800	Non-QPM	Ambo ARC	1800-2600
10	SHONE	Non-QPM	Pioneer seed	1000-2000
11	BH-140	Non-QPM	Bako ARC	1000-1800
12	BH-540	Non-QPM	Bako ARC	1000-1800
	Open pollinated			
13	Gibe-1	Non-QPM	Bako ARC	1000-1800
14	Gibe-2	Non-QPM	Bako ARC	1000-2000
15	Kuleni	Non-QPM	Bako ARC	1600-2200
16	Guto	Non-QPM	Bako ARC	1600-2200
17	Hora	Non-QPM	Ambo ARC	1800-2600
16	Alemeya composite	Non-QPM	Haromya university	1000-2000

Note: QPM= Quality Protein Maize.

Results and discussions

Genetic variability among genotypes is vital to develop and identify adapted, high yielding and biotic and abiotic factors resistant or tolerant varieties. The analysis of variance mean squares revealed significant differences among hybrid maize varieties for most of the traits measured in both seasons (Table 2 and 3). This variation could be attributed to genetic, environmental effects and the interaction of the two. The phenotypic performance of the genotypes is the result of variation due to genetic, environment and the interaction of the two (Melkamu and Molla, 2016 and Farshadfar *et al*, 2013). Moreover, the results of the analysis showed highly significant differences among the mean values for most traits. Different researchers have reported significant variability in different maize varieties including hybrids, top-crosses and open pollinated varieties (Idris and Mohammed, 2012; Melkamu *et al*, 2014).

1. *Performance of hybrid maize varieties under Irrigation*

Hybrid maize varieties have shown plenty of potentials to different traits due to hybrid vigor (hetrosis) in 2013/14 off season (Table 2). Heterosis is the main genetic contributor for variation among genotypes and for their traits that provides better performance for hybrids (Bidhendi *et al*, 2012 and Rajendran *et al, 2014*). The highest number of cobs (83370 cobs ha^{-1}) was obtained from BHQPY-545 indicating multi-ear (prolific) genetic potential of the variety. A variety producing more number of cobs per plant and per hectare had high prolific (producing more cobs) genetic potential (Martin *et al*, 2006). The longest cob (with the average cob length of 19.9 cm) was produced by BH-661 revealing its genetic quality for giving long cobs but not significantly different from AMH-851, AMH-850, PHB-3253, AMH-800, BH-660 and Shone. Cob girth is one of the main yield component traits. PHB-3253 (Jabi) gave higher average cob diameter of 5.8 cm followed by Shone, BH-140 and AMH-850 (Table, 2). Shone gave the highest grain yield (13458 kg ha^{-1}) followed but at par by PHB-3253 (Jabi) (13320kg ha^{-1}).

Table 2. Mean performance of twelve hybrid maize varieties for yield and yield related traits under irrigation in 2013/14 off season.

Ent no.	Variety	PH (cm)	EH (cm)	DT	DS	CL (cm)	CD (cm)	CN ha^{-1}	GY kg ha^{-1}
1	BHQPY-545	238.0^{CDE}	138.2^{FG}	114.3^{A}	117^{AB}	14.3^{E}	4.8^{C}	83370^{A}	8504^{D}
2	BH-140	253.7^{CD}	167.5^{BCD}	113.0^{A}	117.7^{A}	15.6^{ED}	5.2^{BC}	52288^{BCD}	12140^{ABC}
3	BH-543	253.0^{CDE}	153.5^{CDEF}	112.0^{A}	117.7^{A}	18.3^{AB}	4.9^{BC}	56064^{BC}	11975^{ABC}
4	BH-540	257.3^{BCD}	154.3^{CDEF}	112.3^{A}	116.7^{AB}	15.9^{EDC}	5.1^{BC}	46768^{BCD}	9991^{CD}
5	SHONE	256.3^{BCD}	139.5^{FG}	105.7^{CD}	112.0^{CDE}	18.3^{AB}	5.2^{BC}	41830^{D}	13458^{AB}
6	BH-660	288.0^{A}	186.4^{AB}	112.3^{A}	118.0^{A}	18.7^{AB}	5.1^{BC}	47059^{BCD}	10033^{BCD}
7	AMH-760Q	260.7^{BC}	168.9^{ABC}	106.3^{BCD}	113.7^{ABCD}	17.6^{BDC}	5.0^{BC}	46768^{BCD}	11988^{ABC}
8	BH-661	281.3^{AB}	189.0^{A}	111.3^{AB}	116.7^{AB}	19.9^{A}	5.1^{BC}	54321^{BCD}	11406^{BCD}
9	AMH- 850	226.3^{E}	135.5^{FG}	101.3^{DE}	109.3^{CDE}	18.9^{AB}	5.2^{BC}	45606^{CD}	11621^{ABCD}
10	AMH- 800	259.7^{BCD}	161.4^{CDE}	100.3^{E}	108.7^{DE}	19.0^{AB}	5.1^{BC}	55483^{BC}	12197^{ABC}
11	AMH- 851	254.7^{BCD}	146.8^{EFG}	102.0^{DE}	107.3^{E}	18.5^{AB}	4.8^{C}	51416^{BCD}	10824^{BCD}
12	PHB-3253	233.3^{DE}	126.5^{G}	101.3^{DE}	107.3^{E}	18^{ABC}	5.8^{A}	48221^{BCD}	13320^{ABC}
CV (%)		**6.3**	**7.8**	**2.87**	**2.63**	**7.4**	**5.6**	**14.2**	**17.2**
LSD (0.05)		**26.99**	**20.51**	**5.23**	**5.05**	**2.2**	**0.48**	**9510.6**	**3430.9**

Where, PH = Plant height, EH = Ear height, DT = Days to 50% tasseling, DS = Days to 50% silking, CN = Cob number, EAS = Ear aspect, CL = Cob length, CD = Cob diameter and GY = Grain Yield

There was also significant difference in yield and yield parameters among the hybrid maize varieties in 2014/15 (Table 3). This difference depicts the existence of genetic variation for improvement. Large number of cobs was produced by AMH-760Q (49383 cobs ha^{-1}) followed by AMH-800 (41830 cobs ha^{-1}) at par with AMH-850 and AMHQPY-545. Shone and BH-660 also provided longest cobs but not significantly different from PHB-3253, AMH-851, BH-140, AMH-850, BH-661 and BH-540. Shone gave the higher cob diameter (5.7 cm) followed by PHB-3253 (Table 3). Similarly, Shone had excellent ear aspect with ear aspect value of one. In year two (2014/15) the highest grain yield was obtained from BH-660 (10747 kg ha^{-1}) followed by AMH-760Q (10567 kg ha^{-1}) which had grain yield at par with BH-543, Shone, BH-661, AMH-850, AMH-800 and PHB-3253(Table 3). The result is in agreement with the findings of Bidhendi *et al*, 2012 and Rajendran *et al, 2014* who reported that hybrids varieties are preferred for their high yield potential due to heterosis, a manifestation of the superiority of hybrid performance. The grain yield produced by the improved varieties under irrigation was higher than the yield under the rain-fed system (Jacob et al., 2014 and Melkamu et al., 2014).

Crop performance is the result of the genetic potential of the crop, the environment and the interaction of the two. Large number of cobs was produced by BHQPY-545 (49274) across years followed by AMH-760Q. BH-661 (18.1 cm), BH-660 (17.9 cm) and Shone (17.9) provided longest cobs over the two years showing their genetic potential. Hybrid maize Shone, AMH800, AMH851, AMH850 and PHB3253 were also produced long cobs over years and showed similar performance with BH-661. Similarly, BH-660, Shone and PHB-3253 gave large cob diameter. Maize grain yield is a complex trait which is affected by genetic, environment and their interaction. The result indicated that Shone and AMH-760Q produced the highest grain yield per hectare providing 11486 kg and 11277 kg grain yield respectively. The grain yield performance of these two maize hybrids under irrigation was much higher than their performance in the rainfed system. The evaluation of eight hybrid maize varieties in rain-fed condition for two years in Jabitehinan and South Achefer districts indicated that grain yield potential of Shone was 8500 kg ha^{-1} (Melkamu et al, 2014). According to this result, Shone had 2986 kg (35.1%) yield advantage under irrigation. Jacob et al. (2014) indicated that maize production under irrigation was much higher than rain fed by average yield of 4500 kg ha^{-1}.

Table 3. Mean performance of twelve hybrid maize varieties for yield and yield related traits under irrigation in 2014/15 off season.

Ent no	Variety	GY (Kg ha^{-1})	PH (cm)	EH (cm)	DT	DS	EL	ED	CN ha^{-1}	EAS
1	BHQPY-									

Table 4. Combined mean performance of twelve hybrid maize varieties for yield and yield related traits for 2013/14 and 2014/15

Entry no	Variety	GY (Kg ha^{-1})	PH (cm)	EH (cm)	DT	DS	EL	ED	CN ha^{-1}	EAS
1	BHQPY-545	7841^{D}	204^{F}	116.1^{G}	106^{AB}	109^{B}	13.1^{C}	4.79^{C}	49274^{A}	2.08^{ABC}
2	BH-140	9336^{ABCD}	231.7^{CD}	143.1^{CDE}	108^{A}	113^{A}	15.0^{BC}	5.1^{B}	34568^{BCD}	2.17^{ABC}
3	BH-543	9601 ^{ABCD}	238.2^{CD}	140.2^{DE}	107.5^{AB}	113^{A}	15.1^{BC}	4.9^{BC}	37572^{BCD}	1.92^{BC}
4	BH-540	8182^{CD}	237.5^{CD}	139.5^{DEF}	105^{BC}	108.5^{B}	15.4^{B}	5.1^{B}	33224^{D}	2.50^{A}
5	SHONE	11486^{A}	247.3^{BC}	135.6^{DEF}	101.8^{D}	106.3^{BCD}	17.9^{A}	5.5^{A}	32534^{D}	1.08^{E}
6	BH-660	10390 ^{ABC}	274.2^{A}	160.2^{AB}	101.7^{D}	108^{BC}	17.9^{A}	5.6^{A}	34595^{BCD}	1.67^{CD}
7	AMH-760Q	11277^{A}	240.3^{BCD}	157.6^{ABC}	101^{D}	107.3^{BC}	15.5^{B}	4.9^{BC}	42229^{AB}	2.00^{ABC}
8	BH-661	10060 ^{ABCD}	257.8^{AB}	166.5^{A}	101.2^{D}	107.7^{BC}	18.1^{A}	4.9^{BC}	37509^{BCD}	1.25^{DE}
9	AMH850	10375 ^{ABC}	206.3^{EF}	123.9^{G}	96.2^{E}	104DE	17.0^{AB}	4.9^{BC}	37146^{BCD}	2.33^{AB}
10	AMH-800	10380 ^{ABC}	240.5^{BCD}	145.4^{BCD}	95.7^{E}	103.5^{E}	16.1^{AB}	4.79^{C}	41721^{ABC}	2.08^{ABC}
11	AMH-851	8959 ^{BCD}	222.8^{ED}	128.6^{EFG}	102.5^{CD}	108^{BC}	17.7^{A}	4.84^{BC}	34096^{CD}	2.42^{AB}
12	PHB-3253	10784 ^{AB}	212.3^{EF}	114.7^{G}	100.5^{D}	105.3^{DE}	16.8^{AB}	5.6^{A}	32607^{D}	2.25^{AB}
CV (%)		20.1	6.87	9.73	2.33	2.22	11.37	5.29	18.74	23.2
LSD (0.05)		2311	18.7	15.7	2.76	2.77	2.15	0.31	8116	0.53

Where, PH = Plant height, EH = Ear height, DT = Days to 50% tasseling, DS = Days to 50% silking, CN = Cob number, EL = Ear Length, ED = Ear Diameter, EAS = Ear aspect

2. *Performance of Open Pollinated Maize Varieties under Irrigation*

Genetic variation is the base for the development of new improved varieties and identification of adapted varieties. Significant variations were observed among open pollinated maize varieties for number of cobs, grain yield, ear aspect, days to 50% silking and days to 50% tasseling in 2013/14 irrigation season (Table 5). However, there was no significant difference observed among open pollinated maize varieties for plant height, ear height, cob length and cob diameter.

Grain yield is the final product of many multiplexes morphological and physiological processes takes place during the growth and development of crop. Grain yield ranged from 11673.8 kg ha^{-1} for Gibe-1 to 8041 kg ha^{-1} for Kuleni. Gibe-1 was the highest yielding open pollinated maize variety followed by Alemaya composite giving a grain yield of 11673 kg ha^{-1} and 10718 kg ha^{-1}

respectively. Melkamu and Molla (2016) investigated that grain yield mean performances indicated significant differences among open pollinated maize varieties. They added that the evaluation of open pollinated maize varieties in rain fed condition indicated that Gibe-1 provided 8800 kg ha^{-1} at South Achefer and 7800 kg ha^{-1} average yield across testing environments.

Table 5. Mean performance of six open pollinated maize varieties for yield and yield related traits in 2013/14 off season

Variety	PH (cm)	EH (cm)	DT	DS	EL (cm)	ED (cm)	CN ha^{-1}	GY (kg ha^{-1})	EAS
Gibe-1	256.7	157.4	105^{AB}	112^{B}	18.5	5.8	46478^{B}	11673.8^{A}	1.8^{AB}
Gibe-2	234.0	135.6	103.7^{AB}	111^{B}	18.5	5.5	67974^{A}	9697.6^{ABC}	1.2^{B}
Hora	231.0	143.9	98.7^{B}	107^{B}	19.1	5	50835^{B}	8783.5^{BC}	2.7^{A}
Guto	233.3	139.2	109.3^{A}	117.7^{A}	16.9	5.3	70007^{A}	8333.8^{C}	1.8^{AB}
Alemaya composit	254.3	156.4	104^{AB}	111^{B}	19.1	5.5	41540^{B}	10718.0^{AB}	1.3^{AB}
Kuleni	250.3	157.6	98^{B}	107^{B}	18	5	50254^{B}	8041.0^{C}	2.0^{AB}
Cv (%)	5.7	7.9	3.7	2.6	4.5	6.3	16.82	12.1	25.6
LSD (0.05)	NS	NS	6.98	5.17	NS	NS	16682	2099.3	0.84

Where, PH = Plant height, EH = Ear height, DT = Days to 50% tasseling, DS = Days to 50% silking, CN = Cob number, EAS = Ear aspect, ED = Ear Diameter, GY = Grain yield, EL = Ear Length

Open pollinated maize varieties produced high grain yield and even statistically comparable with most commercial maize hybrids (Malik et al, 2010). SARE (2004) evaluated open pollinated maize, synthetic population and varietal hybrids and indicated no significant difference for grain yield between open pollinated and varietal hybrids. This shows that open pollinated maize can produce comparable yield to hybrid maize varieties especially in low potential environment.

The highest cob number was produced by Guto (70007 cobs ha^{-1}) followed by Cibe-2 (67974 cobs ha^{-1}). Cob number per plant and cob number per plot as well as cob number per hectare are not always positively correlated with weight of grains which directly indicates the yielding ability of the variety.

Significant mean difference was observed among open pollinated maize varieties for all traits including grain yield in 2014/15 irrigation season (Table 6). Melkamu and Molla, 2016 reported that open pollinated maize varieties displayed disparities for grain yield and yield components; Hence, Gibe-1 produced the highest grain yield with desirable stability. Ear length varied from 15.7 cm for Alemaya composite and Kuleni to 11.1 cm for Guto. The highest cob length obtained from Alemaya composite and Kuleni indicating their genetic yield potential. Ear diameter for open pollinated maize varieties ranged from 5.4 cm for Gibe-2 to 4.5 cm for Hora. Higher ear diameter was produced by Gibe-1 and Gibe-2. Gibe -1 produced cobs with good ear aspect (Table 6).

The grain yield performance of open pollinated maize varieties was highly significantly different in 2014/15 (Table 6). The highest grain yield was produced by Gibe-1 (10093.1 kg ha^{-1}) followed by Gibe-2 (7913.8 kg ha^{-1}). The result in high yielding potential of open pollinated maize varieties is in line with the study reports made by many authors (Omandi *et al*, 2014; Melkamu and Molla, 2016 and Kutka, 2011).

The performance of open pollinated maize varieties combined over years (2013/14 and 2014/15) revealed that there was genetic differences among the varieties for all traits (Table 7). Years also showed significant differences for all traits except days to 50% silking indicating the performance of the open pollinated maize varieties was not consistent from year to year. The genotype by year interaction was statistically significant for grain yield, ear length, days to 50% silking, cob number and ear aspect disclosing the open pollinated maize varieties performed differently in different years. The result is in accordance with Melkamu and Molla (2016) who reported that the performance of open pollinated maize varieties influenced by the variation among them, environment variation and genotype by environment interaction.

Green cobs of maize can be consumed in a variety of forms, either fresh in roasted (boiled) or as an ingredient in cakes, ice-creams and a number of other foods (Silva, 2010 and Almeida *et al,* 2005). Production of green cobs is more profitable than grain production and harvested in short period compared to the grain harvesting time (Silva et al., 2010; Almeida *et al*, 2005). Cob length, cob diameter, cob number and ear aspect are some of the traits used to identify good grain cobs. Hence, Gibe-1 followed by Gibe -2 produced cobs with higher ear diameter 5.5 cm and 5.4 cm respectively. Higher cob number ha^{-1} (61226) was obtained from Gibe-2 followed by

Guto (55817). Cobs with better ear aspect were also obtained from Gibe-1 (1.83) followed by Gibe-2 (1.75) (Table 7).

Table 6. Mean performance of six open pollinated maize varieties for yield and yield related traits in 2014/15 off season

Variety	GY (Kg /ha)	PH (cm)	EH (cm)	DT	DS	EL	ED	CN ha^{-1}	EAS
Gibe-1	10093.1^{A}	249.7^{A}	159.7^{A}	106.3^{AB}	110.0^{AB}	13.2^{AB}	5.1^{AB}	49092^{AB}	1.8^{C}
Gibe-2	7913.8^{B}	187.0^{C}	117.3^{D}	105.7^{AB}	109.0^{B}	10.6^{B}	5.4^{A}	54321^{A}	2.3^{AB}
Hora	5078.1^{C}	197.7^{C}	120.7^{CD}	104.3^{B}	108.0^{B}	15.7^{A}	4.5^{D}	42411^{ABC}	2.7^{A}
Guto	4987.6^{C}	196.3^{C}	115.7^{D}	109.7^{A}	112.7^{A}	11.1^{B}	4.7^{CD}	41540^{ABC}	2.7^{A}
Alemaya composite	6427.9^{BC}	236.0^{AB}	156.0^{AB}	104.3^{B}	109.0^{B}	15.7^{A}	5.0^{ABC}	36311^{BC}	2.7^{A}
Kuleni	5073.6^{C}	219.7^{B}	137.0^{BC}	107.7^{AB}	113.0^{A}	15.7^{A}	4.8^{BDC}	27306^{C}	2.0^{BC}
CV (%)	17.3	4.6	7.8	2.1	1.5	11	4.9	21.1	10.7
LSD (0.05)	2084.6	18.1	19.2	4.1	3.1	2.7	0.44	16129	0.45

Where, PH = Plant height, EH = Ear height, DT = Days to 50% tasseling, DS = Days to 50% silking, CN = Cob number, EAS = Ear aspect, ED = Ear Diameter, GY = Grain yield, EL = Ear Length

Combined over years, the highest grain yield was obtained from Gibe-1 (10883.4 kg ha^{-1}) followed by Gibe-2 (8805.7 kg ha^{-1}) while the lowest was obtained from Kuleni (6557.3 kg ha^{-1}). The result illustrates that Gibe-1 had better yield performance under irrigation system. Melkamu and Molla (2016) also reported that Gibe-1 gave higher grain yield (7800 kg ha^{-1}) under the rain-fed system. However, the grain yield produced under irrigation was higher than that produced under rainfed. i.e the yield obtained under irrigation was by 39.5% greater than yield obtained under rainfed.

Table 7. Mean performance of six open pollinated maize varieties for yield and yield related traits in 2013/14 and 2014/15 off seasons

Variety	GY (Kg /ha)	PH (cm)	EH (cm)	DT	DS	EL	ED	CN ha^{-1}	EAS
Gibe-1	10883.4^{A}	253.2^{A}	158.5^{A}	105.7^{AB}	111.0^{B}	15.9^{BC}	5.5^{A}	47844^{BC}	1.83^{BC}
Gibe-2	8805.7^{B}	210.5^{C}	126.5^{B}	104.7^{B}	110.0^{BC}	14.6^{DC}	5.4^{A}	61226^{A}	1.75^{C}
Hora	6930.8^{C}	214.3^{C}	132.3^{B}	101.5^{B}	107.5^{C}	17.4^{A}	4.7^{C}	46550^{BC}	2.67^{A}
Guto	6660.7^{C}	214.8^{C}	127.4^{B}	109.5^{A}	115.2^{A}	14.0^{D}	4.9^{BC}	55817^{AB}	2.25^{AB}
Alemaya composite	8573.0^{B}	245.2^{AB}	156.2^{A}	104.2^{B}	110.0^{BC}	17.4^{A}	5.2^{AB}	38944^{C}	2.00^{BC}
Kuleni	6557.3^{C}	235.0^{B}	147.3^{A}	102.8^{B}	110.0^{BC}	16.9^{AB}	4.9^{BC}	38822^{C}	2.00^{BC}
CV (%)	14.2	5.3	7.9	3.5	2.2	7.9	5.5	17.85	19.1
R^2	0.86	0.86	0.77	0.61	0.71	0.89	0.75	0.75	0.74
LSD (0.05)	1369.1	14.4	13.3	4.3	2.9	1.5	0.33	10307	0.47
Year (Y)	*	***	***	*	NS	***	***	***	***
GxY	***	NS	NS	NS	*	*	NS	*	*

Where, G = Genotype, PH= Plant height, EH= Ear height, DT= Days to 50% tasseling, DS= Days to 50% silking, CN= Cob number, EAS= Ear aspect, ED = Ear Diameter, GY = Grain yield, EL = Ear Length

Conclusion and recommendation

Evaluation of the released improved maize varieties under irrigation to identify adapted varieties is an advantageous work as it helps to increase maize production to assure food security. Testing released improved maize varieties under irrigation is also a key indicator for the development of new maize varieties for irrigation production. Improved maize varieties showed high genetic variation for most traits revealing the importance of variety development for irrigation system. Hybrid variety, Shone had the highest grain yield (13458 kg ha^{-1}) performance followed by PHB3253 (Jabi) (13320 kg ha^{-1}) in 2013/14 with no significant difference. In 2014/15 irrigation season, hybrids BH-660 and AMH-760Q produced higher grain yield per hectare 10747 kg ha^{-1} and 10567 kg ha^{-1} respectively. Shone and AMH-760Q had good performance for grain yield combined over years 11486 kg and 11277 kg ha^{-1} in the same order. The mean grain yield potential of open pollinated maize varieties (OPVS) pointed out that Gibe-1 was out yielded in both years and combined over years. Gibe-1 gave 11673.8 kg ha^{-1} and 10093.1 kg ha^{-1} in 2013/14 and 2014/15 irrigation seasons respectively and the average grain yield performance was

10883.4 kg ha^{-1} combined over years. The result specified that the grain yield performance of most of the tested improved maize varieties was much higher than their rain-fed performance. Shone and Gibe-1 gave 35.1% and 39.5% yield increment respectively under irrigation compared to the rain-fed. Therefore, Shone and Gibe-1 are recommended as potential improved maize varieties for production under irrigation for grain yield for Koga irrigation scheme and areas with similar environments. AMH-760Q is also recommended as potential quality protein hybrid for production under irrigation for grain yield for Koga irrigation scheme and areas with similar environments.

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