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Performance of Improved Maize Varieties for Yield and Yield Components under Irrigation at Koga, West Gojjam, Amhara region, Ethiopia

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ABSTRACT

Development and identification of adapted high yielding maize varieties for irrigation environment is fundamental for assuring food security. The trial was investigated to identify and recommend adaptable, high yielding maize varieties for irrigation environments. Twelve hybrids and six open pollinated maize varieties (OPV) were studied as a two sets of experiment in randomized complete block design with three replications. Experimental plots were irrigated using furrow irrigation every 14 days. Urea and DAP were used as nitrogen and phosphorus sources, respectively. Agronomic management practices were applied uniformly to all plots. Data were analyzed using SAS statistical software and treatment means were separated using least significant difference at 5%. Both hybrids and OPV indicated high genetic variation among themselves for most traits. Hybrid shone provided highest grain yield (13458 kg/ha) followed by PHB3253 (13320 kg/ha) in 2013/14 without 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). Yield performance over years indicated that Shone gave the highest grain yield (11486 kgha-1) followed by AMH-760Q (11277kg ha-1). Mean grain yield potential of OPV signposted that Gibe-1 was out yielding in each year (11673.8 $kgha^{-1}$ in 2013/14 and 10093.1 $kgha^{-1}$ in 2014/15) and over years (10883.4$kgha^{-1}$). Shone and Gibe-1 illustrated 35.1 % and 39.5% yield advantage respectively compared to their rain-fed performance. 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.

Keywords: Furrow irrigation, Hybrid, Food security, Open pollinated, Quality protein maize.

INTRODUCTION

Maize is one of the major cereals that play the core role of Ethiopia's agriculture and food economy. It has largest small holder farmers' coverage and greatest production compared to other cereals (Central Statistical Agency, 2018). According to Central Statistical Agency 2018, maize exceeds tef, sorghum and wheat by 58.9, 62.4 and 80.7 percent respectively with total production of 8.4 million tons produced over 2.1 million hectares. About 11 million formers contributed for maize production and productivity (3.9 ton ha^{-1}). Amhara region shares 24.7 percent in total production cultivated over 0.52 million hectares of land with productivity of 3.98 ton ha^{-1}. Maize is a strategic crop for the food security and is the lowest cost caloric and protein source among all major cereals (Abate et al., 2015).

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 (Shah et al., 2000; Kukta, 2011; Omondi et al., 2014). Only seed of hybrids is produced and distributed to maize producers in Amhara region and almost no seed of improved open pollinated maize varieties is produced and disseminated. Amhara region Agricultural office 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 local open pollinated and the second generation of hybrid seed used to cover the remaining more than 60 % of land. The main reason for coverage of large portion of maize land by local open pollinated and the second generation of hybrid varieties are maize varieties need of strong awareness creation and well developed seed system, the cost of certified seed and fertilizers mostly relatively higher than the price of the grain. Open pollinated improved maize varieties have considerable importance in areas where seed industry is not well developed and they are also better options in the context of

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resource poor farmers who cannot afford the hybrid seeds and are inclined towards use of recycled seeds (Omondi et al., 2014). In addition to these facts open pollinated maize varieties provided reasonable yield in low potential environments and under stress conditions (Chimonyo et al., 2019).

Maize varieties produced higher and stable yield under irrigation as compared to rain fed production as irrigation supplies controlled amount of water at the required growth stages of the crop (Boshev et al., 2014). Bushong et al. (2014) added that maize varieties in irrigated plots yielded more than rain-fed by average yield of 4500kgha^{-1}. Selecting improved maize varieties that have a high yield potential under irrigation environmental conditions are very crucial to improve maize production. No maize varieties developed for irrigation environments which is one of the drawbacks for food security and lower production of maize in the country including Amhara region. As maize is one of the strategic crop for assuring the food security, its production under irrigation and development of irrigated maize varieties are fundamental to increase maize production. 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 carried out at Koga irrigation command area during winter for two years (2013/14 and 2014/15). Koga irrigation command area is located in Mecha District; 41 kilometres from Bahir Dar on the way to Addis Ababa via Debre Markos road (37°7'29.721"Easting and 11°20'57.859"Northing and at an altitude of 1953m a.s.l). The average annual rainfall of the area is about 1118 mm. The mean maximum and minimum temperatures are 26.8 ^{0}C and 9.7 ^{0}C respectively.Twelve hybrids and six open pollinated maize varieties from diverse backgrounds and maturity groups (Table1) were sown as two sets trial in randomized complete block design with three replications. Distance between rows was 0.75 m with hills spaced 0.3m and plots were planted two seed per hill and thinned to obtain 44444 plants per hectare. The plot size was 5.1m by 3.75m (19.125m^2) which contained five rows. Recommended seed rate (25 kg/ha) and fertilizer rates (200kg/ha urea and 200kg/ha DAP) were used in the experiment. The whole amount of DAP was applied at planting while Urea was split into one-third at planting and the remaining two third at knee high stage. The trial was irrigated using furrow irrigation method. 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 9.1. To satisfy assumptions of analysis of variance, all variables were subjected to the Levene test of homogenous 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.

Table1. 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

Irrigation performance of hybrid maize varieties:

The analysis of variance mean squares revealed significant differences among hybrid maize varieties for most of the traits measured in 2013/14 irrigation season (Table 2). Evaluated hybrid maize varieties showed plenty potential for different traits due to hybrid vigor or heterosis. The highest numbers of cobs were produced by BHQPY-545 which was 83370 cobs ha^{-1} indicating multi-ear (prolific) genetic potential of the variety. The longest cobs were produced by BH-661with the average cob length of 19.9cm 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) provided cobs with better cob girth which had average cob diameter of 5.8cm and followed by shone, BH-140 and AMH-850 with cob diameter of 5.2cm. Shone had the highest grain yield (13458 kg/ha) performance followed by PHB-3253 (Jabi)

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

Variety	PH(cm)	EH(cm)	DT	DS	CL(cm)	CD(cm)	CN/ha	GY kg/ha
BHQPY-545	238.0^{CDE}	138.2^{FG}	114.3^{A}	117^{AB}	14.3^{E}	4.8^{C}	83370^{A}	8504^{D}
BH-140	253.7^{CD}	167.5^{BCD}	113.0^{A}	117.7^{A}	15.6^{ED}	5.2^{BC}	52288^{BCD}	12140^{ABC}
BH-543	253.0^{CDE}	153.5^{CDEF}	112.0^{A}	117.7^{A}	18.3^{AB}	4.9^{BC}	56064^{BC}	11975^{ABC}
BH-540	257.3^{BCD}	154.3^{CDEF}	112.3^{A}	116.7^{AB}	15.9^{EDC}	5.1^{BC}	46768^{BCD}	9991^{CD}
SHONE	256.3^{BCD}	139.5^{FG}	105.7^{CD}	112.0^{CDE}	18.3^{AB}	5.2^{BC}	41830^{D}	13458^{AB}
BH-660	288.0^{A}	186.4^{AB}	112.3^{A}	118.0^{A}	18.7^{AB}	5.1^{BC}	47059^{BCD}	10033^{BCD}
AMH-760Q	260.7^{BC}	168.9^{ABC}	106.3^{BCD}	113.7^{ABCD}	17.6^{BDC}	5.0^{BC}	46768^{BCD}	11988^{ABC}
BH-661	281.3^{AB}	189.0^{A}	111.3^{AB}	116.7^{AB}	19.9^{A}	5.1^{BC}	54321^{BCD}	11406^{BCD}
AMH- 850	226.3^{E}	135.5^{FG}	101.3^{DE}	109.3^{CDE}	18.9^{AB}	5.2^{BC}	45606^{CD}	11621^{ABCD}
AMH- 800	259.7^{BCD}	161.4^{CDE}	100.3^{E}	108.7^{DE}	19.0^{AB}	5.1^{BC}	55483^{BC}	12197^{ABC}
AMH- 851	254.7^{BCD}	146.8^{EFG}	102.0^{DE}	107.3^{E}	18.5^{AB}	4.8^{C}	51416^{BCD}	10824^{BCD}
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
R^2	**0.66**	**0.79**	**0.81**	**0.74**	**0.69**	**0.66**	**0.76**	**0.60**

Where, PH= Plant height, EH= Ear height, DT= Days to 50% tasseling, DS= Days to 50% silking, NC/ha= number of cobs per hectare, EAS= Ear aspect

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

Variety	GY (Kg /ha)	PH (cm)	EH (cm)	DT	DS	EL	ED	NC/ha	EAS
BHQPY-545	7179^{BC}	170.0^{F}	94.0^{D}	98^{BC}	101^{BC}	11.8^{E}	4.8^{CD}	36020^{AB}	1.7^{BCD}
BH-140	6532^{C}	209.7^{CDE}	118.7^{BCD}	103^{A}	108.3^{A}	14.4^{ABCDE}	5.0^{BC}	29920^{B}	2.0^{ABC}
BH-543	7226^{ABC}	223.3^{BC}	127^{ABC}	103^{A}	108.3^{A}	11.9^{DE}	4.8^{CD}	33115^{B}	2.3^{AB}
BH-540	6372^{C}	217.7^{BCD}	124.7^{ABC}	98^{BC}	100.3^{CD}	14.9^{ABCDE}	5.1^{B}	31373^{B}	2.7^{A}
SHONE	9513^{ABC}	238.3^{AB}	131.7^{AB}	98^{BC}	100.7^{BCD}	17.6^{A}	5.7^{A}	33696^{B}	1.0^{D}
BH-660	10747^{A}	260.3^{A}	134.0^{AB}	91^{D}	98^{D}	17.1^{A}	4.9^{BCD}	33696^{B}	1.8^{ABCD}
AMH-760Q	10567^{AB}	220.0^{BC}	146.3^{A}	95^{C}	101 ^{BC}	13.3^{CDE}	4.9^{BCD}	49383^{A}	2.3^{AB}
BH-661	8714^{ABC}	234.3^{ABC}	144.0^{A}	91^{D}	98.7^{CD}	16.4^{ABC}	4.8^{CD}	34277^{B}	1.2^{CD}
WONCHI	9128^{ABC}	186.3^{EF}	109.3^{BCD}	91^{D}	98.7^{CD}	15.1^{ABCDE}	4.7^{DE}	40087^{AB}	1.8 ^{ABCD}
ARGENI	8563^{ABC}	221.3^{BC}	129.3^{AB}	91^{D}	98.3^{CD}	13.1^{CDE}	4.4^{E}	41830^{AB}	1.8 ^{ABCD}
JIBAT	7093^{BC}	191.0^{DEF}	110.3^{BCD}	103^{A}	108.7^{A}	16.9^{AB}	4.8^{CD}	29630^{B}	2.2^{AB}
PHB-3253	8247^{ABC}	191.3^{DEF}	103.0^{CD}	99.7^{B}	103.3^{B}	15.6^{ABCD}	5.4^{A}	29049^{B}	2.0^{ABC}
Cv %	**25.01**	**7.7**	**11.9**	**1.44**	**1.67**	**14.8**	**3.37**	**23.7**	**26.2**
LSD (0.05)	**0.65**	**0.79**	**0.67**	**0.95**	**0.90**	**0.62**	**0.87**	**0.58**	**0.57**
R^2	**35.3**	**27.8**	**24.7**	**2.37**	**2.88**	**3.7**	**0.28**	**14140**	**0.84**

Where, PH= Plant height, EH= Ear height, DT= Days to 50% tasseling, DS= Days to 50% silking, NC/ha= number of cobs per hectare, EAS= Ear aspect

(13320kg/ha) and no significant difference between them.

Hybrid maize varieties showed significant variation among themselves in 2014/15 (Table 3) off season confirming the existence of genetic variation for improvement. Large number of cobs produced by AMH-760Q (that provided 49383 excellent ear aspect with ear aspect value of one. BH-660 and AMH-760Q produced highest grain yield per hectare which were 10747kg/ha and 10567kg/ha respectively. These hybrids were not importantly different from most of the maize hybrids (BH-543, Shone, BH-661, AMH-850, AMH-800 and PHB-3253).

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

Variety	GY (Kg /ha)	PH (cm)	EH (cm)	DT	DS	EL	ED	NC/ha	EAS
BH-545	7841^{D}	204^{F}	116.1^{G}	106^{AB}	109^{B}	13.1^{C}	4.79^{C}	49274^{A}	2.08^{ABC}
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}
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}
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}
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}
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}
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}
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}
AMH-850	10375^{ABC}	206.3^{EF}	123.9^{G}	96.2^{E}	104^{DE}	17.0^{AB}	4.9^{BC}	37146^{BCD}	2.33^{AB}
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}
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}
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**
R^2	**0.68**	**0.84**	**0.83**	**0.94**	**0.93**	**0.72**	**0.68**	**0.64**	**0.66**
LSD (0.05)	**2311**	**18.7**	**15.7**	**2.76**	**2.77**	**2.15**	**0.31**	**8116**	**0.53**
Year(Y)	***	***	***	***	***	***	*	*	**NS**
GxY	**NS**	**NS**	**NS**	***	***	**NS**	**NS**	***	*

Where, PH= Plant height, EH= Ear height, DT= Days to 50% tasseling, DS= Days to 50% silking, NC/ha= number of cobs per hectare, EAS= Ear aspect

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	Yield (kg/ha)	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**
R^2	**0.60**	**0.54**	**0.71**	**0.76**	**0.65**	**0.58**	**0.72**	**0.70**	**0.67**

cobs per hectare) followed by AMH-800 (which had 41830 cobs ha^{-1}) but both of them are not significant different from hybrid maize AMH-850 and AMHQPY-545. Shone and BH-660 provided longest cobs which were not significantly different from PHB-3253, AMH-851, BH-140, AMH-850, BH-661 and BH-540. Diameter of cobs is one of the yield component traits that have direct effect on yield. Shone produced cobs that had good diameter (5.7cm) which were not better than cobs produced by PHB-3253. Ear aspect is a maize trait which used to evaluate maize varieties. Shone had

The performance of hybrid maize varieties revealed that large number of cobs produced by BHQPY-545(49274) across years followed by AMH-760Q. BH-661(18.1cm), BH-660 (17.9 cm) and shone (17.9) provided longest cobs over the two years showing their rain- fed genetic potential. BH-660, shone and PHB-3253 gave cobs that had large cob diameter. The combined result indicated that shone and AMH-760Q produced the highest yield per hectare providing 11486 $kgha^{-1}$ and 11277$kgha^{-1}$ grain yield respectively.

Irrigation performance of open pollinated maize varieties:

Significant variations were found 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). No statistical difference was observed among open pollinated maize varieties for plant height, ear height, cob length and cob diameter. Grain yield open pollinated varieties ranged from 11673.8 kg/ha for Gibe -1 to 8041 kg/ha for kuleni. Gibe-1 was the highest yielding open pollinated maize variety followed by Alemaya composite providing 11673.8 kg/ha and 10718kg respectively. The highest cob number produced by Guto (70007 cobs/ha) followed by Gibe-2 (67974 cobs/ha).

Mean differences among open pollinated maize varieties were observed for all traits including grain yield in 2014/15 irrigation season (Table 6). Ear length varied from 15.7cm for Alemaya composite and kuleni to 11.1cm for Guto. Alemaya composite and keuleni produced highest cobs in length indicating their genetic potential. Ear diameter for open pollinated maize varieties ranged from 5.4cm for Gibe-2 to 4.5cm for Hora. Gibe-1 and Gibe -2 produced cobs which had better ear diameter. Gibe -1 produced cob which had good ear aspect. Highest number of cobs was produced by Gibe-2 (54321cobs ha^{-1}) followed by Gibe-1(49092 cobs ha^{-1}). The grain yield performance of open pollinated maize varieties indicated that highest grain yield was produced by Gibe-1 (10093.1kg/ha) followed by Gibe-2 (7913.8 kg/ha) and highly statistical differences were observed among the varieties for grain yield.

Performance of open pollinated maize varieties revealed genetic differences among the varieties for all traits over both years (2013/14 and 2014/15) (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. Gibe-1 followed by Gibe -2 produced cobs with highest ear diameter with 5.5cm and 5.4 cm respectively.

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	NC/ha	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**
R^2	**0.83**	**0.91**	**0.84**	**0.62**	**0.71**	**0.82**	**0.74**	**0.63**	**0.84**
LSD (0.05)	**2084.6**	**18.1**	**19.2**	**4.1**	**3.1**	**2.7**	**0.44**	**16129**	**0.45**

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	NC/ha	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

Gibe-2 provided large number of cobs (61226 cobs/ha) and Guto was the second open pollinated maize in cob numbers (55817 cobs/ha). Cobs with better ear aspect were produced by Gibe-1 and Gibe-2 with ear aspect of 1.83 and 1.75 respectively.

The two years data indicated that mean grain yield of open pollinated maize varieties make known highly significant differences among the varieties. Gibe-1 produced the highest grain yield (10883.4kgha^{-1}) but the lowest grain yield was provided by kuleni (6557.3 kgha^{-1}). Gibe-2 was the second open pollinated variety in grain yield with 8805.7kg/ha.

DISCUSSION

Genetic variability among genotypes is vital to develop and identify adapted, high yielding and biotic and abiotic factors resistance or tolerance varieties. Analysis of variance displayed significant variation among hybrid and open pollinated maize varieties indicating the possibility of genetic improvement. Different researchers have reported significant amount of variability in different maize varieties including hybrids, top-crosses and open pollinated varieties (Idris & Mohammed, 2012; Melkamu & Molla, 2016). The performance of both hybrids and open pollinated maize varieties varied from year to year that could be attributed by effect of genetic, environment and the interaction of the two. Genotypes performance difference to different environments contributed due to genetic, environment and their interaction (Farshadfar et al., 2013; Melkamu & Molla, 2016).

BHQPY-545 produced 83370 cobs ha^{-1} and AMH-760Q provided 49383 cobs ha^{-1} in2013/14 and 2014/15 irrigation season respectively. Average cob number performance over years presented that BHQPY-545(49274 cobs ha^{-1}) gave the largest number of cobs followed by AMH-760Q. Producing more number of cobs per plant and per hectare indicated prolific (producing more cobs) genetic potential of the hybrid maize (Zamir et al., 2011). Number of cob performance of open pollinated maize varieties explained that largest cob numbers were provided by Guto (70007cobs ha^{-1}) and Gibe-2 (49092 cobs ha^{-1}) in 2013/14 and 2014/15 irrigation season correspondingly. Cob number performance over years for open pollinated maize varieties showed that 61226 cobs were produced by Gibe-2 and 55817 cobs by Guto.

Grain yield is the final target of any crop improvement resulted from the contribution of many yield related traits. Hybrids' grain yield result showed that the out yielding varieties were Shone (13458 kgha^{-1}) in 2013/14 and BH-660(10747kgha^{-1}) in 2014/15 but not significantly different from PHB-3253 (Jabi) (13320kgha^{-1}) and AMH-760Q (10567kgha^{-1}) in the same order. Shone (11486 kgha^{-1}) and AMH-760Q (11277kgha^{-1}) were the highest yielding hybrids over years. Heterosis is the main genetic contributor for their high yielding potential among hybrids and provides better performance for their traits (Bidhendi et al., 2012; Rajendran et al., 2014). Irrigation grain yield performance of hybrids was much higher compared to the rain-fed production. Bushong et al. (2014) certified that maize production under irrigation was higher than rain fed by average yield of 4500kgha^{-1}. Grain yield performance of eight hybrids in rain-fed condition at Jabitehinan and South Achefer districts indicated that grain yield potential of shone was 8500 kg /ha. According to this result, shone had 2986 kgha^{-1} (35.1%) yield advantage under irrigation.

The grain yield potential of open pollinated maize varieties revealed that Gibe-1 provided the highest yield for each year (11673.8 kgha-1 in 2013/14 and 10093.1 kgha^{-1} in 2014/15 irrigation season) and over two years (10883.4kgha^{-1}). High yielding Open pollinated maize varieties were selected in rain fed season (Omondi et al., 2014; Melkamu & Molla, 2016). Yielding ability of open pollinated maize varieties under irrigation is higher than their rain fed. Melkamu and Molla (2016) investigated grain yield performance of open pollinated maize varieties in rain fed at Jabitehinan and south achefer districts. They added that Gibe-1 was the highest yielding with grain yield of 8800 kgha^{-1} at south achefer and 7800kgha^{-1} average yield across testing environments. The average grain yield potential of open pollinated maize varieties indicated Gibe-1 had 39.5% yield advantage under irrigation compared with the rain fed.

Green cobs of maize can be consumed in a variety forms, either fresh in roasted (boiled) or as an ingredient in cakes, ice-creams and a number of other foods (Almeida et al., 2005; Silva, et al., 2010). Production of green cobs is more profitable than grain production and harvested in short period compared to the grain harvesting time (Almeida et al., 2005; Silva et al., 2010). Cob length, cob diameter and ear aspect are some of the traits used to identify good grain cobs. Shone and AMH-760Q had comparable cob length, cob diameter and ear aspect with the best hybrids. Gibe-1 was capable in providing long cobs with better diameter and ear aspects.

In conclusion, evaluation of improved maize varieties under irrigation to identify adapted varieties is an advantageous work as it helps to increase maize production to assure food security and 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 production. Hybrid

shone had the highest grain yield (13458 kgha^{-1}) performance followed by PHB3253 (Jabi) (13320kgha^{-1}) in 2013/14 with no significant difference between them. While hybrids BH-660 and AMH-760Q produced highest grain yield per hectare which were 10747kgha^{-1} and 10567kgha^{-1} respectively in 2014/15. Shone and AMH-760Q had good performance for grain yield across the two years with 11486 kgha^{-1} and 11277kgha^{-1} grain yield in the same order. The mean grain yield potential of open pollinated maize varieties pointed out Gibe-1 was out yielding in each year and over years. Gibe-1 produced 11673.8kgha^{-1} and 10093.1kgha^{-1} in 2013/14 and 2014/15 irrigation season respectively and the average grain yield performance was 10883.4kgha^{-1}. 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 illustrated 35.1 % and 39.5% yield increment respectively under irrigation compared to rain-fed. Therefore; shone and Gibe-1 are recommended as potential improved maize varieties for production under irrigation for grain yield and green cobs for koga irrigation command areas and similar environments. AMH-760Q is also recommended as potential quality protein hybrid for production under irrigation for grain yield and green cobs for koga irrigation command areas and similar environments

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