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Evaluation of Maize (*Zea mays* L.) Genotypes for Forage Biomass Yield and Nutritional Quality

Mulisa Faji[1], Gezahagn Kebede[1], Aschelew Tsegahun[1], Kedir Mohammed[1], Muluneh Minta[1], Fekede Feyissa[2] and Solomon Mengistu[1]
[1]*Holetta Agricultural Research Centre, P. O. Box 31 Holetta, Ethiopia*
[2]*Ethiopian Institute of Agricultural Research, P. O. Box 2003 Addis Ababa, Ethiopia;*
Corresponding author e-mail address: mulisa.faji2016@gmail.com

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ይህ ጥናት በሆለታ ግብርና ምርምር ማዕከል በሆለታና አዳበርጋ የመኖ ምርምር ጣቢያዎች የበቆሎ ዝርያዎች ያላቸውን የደረቅ መኖ ምርት እና የመኖ ንጥረ-ነገር ይዘታቸዉን ለመገምገም የተካሄደ ነበር፡፡ ጥናቱም በሁለት የማጨጃ ጊዜ የተካሄደ ሲሆን የመጀመሪያው በሳይሌጅ (ገፈራ) ደረጃ ሲሆን ሁለተኛው በአረንጓዴ ቆረቆንዳ (ኮብ) ደረጃ ነበር፡፡ የደረቅ መኖ ምርት፣ የዕፅዋት ቁመት እና በአንድ ተክል ላይ የሚገኙ ቆረቆንዳዎች (ኮብ) ብዛት እና የመኖ ጥራት መረጃዎች ተሰብስበዋል፡፡ በሁለቱም የማጨጃ ጊዜ በዕፅዋት ቁመት፣ በደረቅ መኖ ምርት፣ በሚፈጭ (Digestible) የደረቅ መኖ ምርት እና በፕሮቲን የደረቅ መኖ ምርት ላይ ከፍተኛ (P<0.001) የሆነ ልዩነት ጥናቱ በተካሄደባቸው ሁለት ቦታዎች ላይ ታይቷል፡፡ የተቀናጀ የትንታኔ ውጤት እንደሚያመለክተው በገፈራ የማጨጃ ጊዜ ኩሌኒ ከፍተኛ የዕፅዋት ቁመት የነበረው ሲሆን ተከትሎም AMH-854 እና ጅባት ከፍተኛ (P<0.05) ቁመት ነበራቸው፡፡ በሁለቱም የማጨጃ ደረጃዎች በዝርያዎች መካከል ከፍተኛ የሆነ ልዩነት በድራይ ማተር (DM) ላይ እንደነበር የተቀናጀ የትንተና ውጤት አመልክቷል፡፡ ከADF ዉጭ ለሁሉም ንጥረ ይዘቶች በጂኖታይፖች መከከል (P<0.05) ልዩነት አልነበረም፡፡ በአረንጓዴ ቆረቆንዳ (ኮብ) የማጨጃ ጊዜ ጂኖታይፖች መካከል ከፍተኛ (P<0.01) የሆነ ልዩነት በድራይ ማተር (DM)፣ አመድ (Ash)፣ ADF እና ADL ላይ እንደነበር ያሳያል፡፡ በሁለቱም የማጨጃ ጊዜ በተወሰደው በደረቅ መኖ ምርት እና በዕፅዋት ቁመት መረጃ ላይ በመመርኮዝ ኩለኒ፣ AMH-853 እና ጅባት የበቆሎ ዝርያዎች ለጥናቱ አካባቢዎች እና ለተመሳሳይ የግብርና ስነ-ምህዳሮች እንደ አረንጓዴ መኖነት እንዲጠቀሙበት ጥናቱ ይመከራል፡፡ ነገር ግን ጠቅለል ያለ ድምዳሜ ላይ ለመድረስ በተሞከሩት ዝርያዎች ላይ የገፈራ ጥራት እና የእንስሳት ምርታማነት ላይ ተጨማሪ ሥራዎች መሰራት አለባቸው፡፡

Abstract

A study was conducted to evaluate maize (Zea mays L.) genotypes for their forage dry matter yield and nutritive value at Holetta and Adaberga forage research stations of Holetta Agricultural Research Centre. Genotypes were tested in a randomized complete block design with three replications. The study was conducted in two sets; the first set consisted of genotypes harvested at the silage harvesting stage and the second set included genotypes harvested at the green cob stage. The data collected consisted of dry matter yield, plant height and number of cobs per plant and nutritional quality of the maize genotypes. All data were subjected to analysis of variance, with significance tested at $P<0.05$. The location had a significant ($P<0.001$) effect on plant height, dry matter yield, digestible dry matter and crude protein yield at both stages of harvest. In both stages of harvest, plant height was significantly ($P<0.05$) affected by genotype. The result of the combined analysis showed that Kuleni had the highest plant height followed by AMH-854 and Jibat at the silage harvesting stage ($P < 0.05$). The result of a combined analysis indicated that DM was significantly different among genotypes at both harvesting *stages. Non-significant ($P<0.05$) differences were found among the genotypes in all the nutrient contents, excluding ADF. For genotypes harvested at the green cob stage, dry matter, ash, acid detergent fiber, and acid detergent lignin were significantly ($P<0.01$) influenced by genotype. In conclusion based on dry matter yield and plant height data taken at both harvesting stages, Kuleni, AMH-853 and Jibat maize genotypes were recommended as a green feed for the study areas and similar agro-ecologies. But, to reach exhaustive conclusions further works shall be done on the silage quality of the recommended genotypes and their effect on animal performance.*

Keywords: Genotype; green cob; location; maize; silage

Introduction

The critical limitation to profitable livestock production in developing countries is the shortage of quality forage (Sarwar *et al*., 2002). The use of locally available and introduced forage crops which are adaptable to the local agro-ecological conditions is highly recommended to combat feed shortage. Maize is a warm season cereal, which is commonly cultivated in large areas for grain production in Ethiopia. Maize ranks third, following wheat and rice, in the world production of cereal crops and it is the most important nutrient for local populations in middle and South America, Africa and China. It is mostly cultivated in many countries for silage production in last thirty years. Maize is the most important silage crop in the world, because it is the most proper crop for ensiling. It produces abundant amount of green herbage and maize silage has high nutritive value and palatability (Akdeniz, *et al*., 2004; Erdal *et al*., 2009). Maize fodder is good for all types of animals. Green maize forage is rich in vitamin-A (Chaudhry, 1982). Use of maize as animal feed is important because of the fact that pastures do not stability available throughout the year, causing seasonality in dry matter production. Seasonality of feed availability escalates the production cost as feed cost is 70% of the total cost of production (Paulino and Carvalho, 2004), making animal supplementation compulsory from alternative sources.

Maize is thought to be an excellent crop plant for silage due mainly to its high dry matter and sugar contents as well as its ease of fermentation when harvested at the right stage (Duran and Ahmet, 2014). Maize (*Zea mays L.*) has the ability of adaptation to different climatic and soil conditions (Ruiz *et al.*, 2005; Bellon *et al.*, 2011; Zhou *et al.*, 2016). In industrialized countries its uses are mainly for forage production, raw material for the production of processed foods, and recently, for ethanol production (Cox and Cherney, 2005; Dhugga, 2007; Persson *et al.*, 2009). Green feed maize can yield large quantities of green fodder per hectare relative to most other alternative summer fodder crops, and summer pasture (Buxton, 1974). Iptas (1993) reported that plant height of maize genotypes varied from 177.4 to

292.4 cm and herbage yield 38.67 to 82.20 tha^{-1} and dry matter yield 6.93 to 26.44 tha^{-1} and crude protein (%) 6.46 to 8.62.

In developed regions different fodder crops like maize, sorghum, millet and Guar are cultivated to fulfil the dietary requirements of the animals. Among these fodders, maize is of great importance and quite famous among dairy farmers because of some superior characters like quick growth nature, wider adaptability, high biomass, free from anti-nutritional components, high palatability and digestibility. It also holds sufficient nutritional quality as compared to other non-leguminous fodders (Mahdi *et al.,* 2011). Researchers have strongly expressed the need for food-feed maize cultivars that provide good stove fodder quantity and quality in addition to grain yield (Singh *et al.,* 2004). If dual-purpose maize varieties are developed, as a result of the increased supply of feed to farmers to feed their livestock, it is believed to be of great contribution to the integration of maize and livestock. In Ethiopia, however, the maize cultivars have been evaluated for grain yield for past decades, excluding feed concern. While several maize varieties are released for grain yield by the Ethiopian institute of agricultural research, in collaboration with the regional research institute. As a result, evaluating these released and disseminated maize varieties for feed can contribute to alleviate the feed shortage. Thus the prime aim of this study is to evaluate the released maize varieties for livestock feed.

Maize growth parameters, forage yield, dry matter and crude protein influenced by cultivars whereas crude fibre was not influenced significantly (Ayub *et al.*, 2001). The most important component providing high yield is that to use the best adapted genotypes in any region. Genotypes may show highly different biomass yield performances depending on soil and climatic conditions from one region to another, so the best adaptable genotypes should be determined for any region. Additionally, one should remember that genotypes of different origin may provide different yield (Saruhan *et al.* 2007). Therefore, the objective of this study was to evaluate the herbage yield potential, some yield components and nutritive value of different maize (*Zea mays* L.) genotypes under rain fed conditions in the central highland of Ethiopia.

Materials and Methods

Description of the study area

The experiment was conducted at Holetta and Adaberga forage research station of Holetta Agricultural Research Center during the main cropping season of 2017/18 to 2018/19 (for two years) under rain fed conditions. HARC is located at 9°00'N latitude, 38°30'E longitude at an altitude of 2400 masl. It is 34 km west of Addis Ababa on the road to Ambo and is characterized with the long term (30 years) average annual rainfall of 1055.0 mm, average relative humidity of 60.6%, and average maximum and minimum air temperature of 22.2°c and 6.1°c, respectively. The rainfall is bimodal and about 70% of the precipitation fall in the period from June to September while the remaining 30% falls in the period from March to May (EIAR, 2005). The soil type of the area is predominantly red nitosol, which is characterized by an average organic matter content of 1.8%, total nitrogen 0.17%, pH 5.24, and available phosphorus 4.55ppm (Gemechu, 2007). Adaberga is located at 90 16'N latitude and 38^0 23'E longitude. In this district, the rainfall pattern is bimodal, with a short rainy period from March to May and a long rainy season from June to September and the rest of the months are dry. The annual temperature and rainfall ranges from 18°C to 24°C and 1000 to 1225 mm, respectively.

Experimental treatments and design

The experiment was conducted with two sets of trials, the first set was genotypes harvested at silage and second set was genotypes harvested at green cob stage. The genotypes were evaluated under free pollination. A randomized complete block design with 7 treatments (maize genotypes) and three replicates was used, totalling 21 experimental plots per each set of trial. Plot size was 3 m x 4 m for each genotype. The spacing between plots and blocks was 1 m and 1.5 m respectively.

Maize sowing and management

The four released maize varieties (Jibat, Horra, Kuleni and Argene) for grain yield and three unreleased maize varieties (AMH-760Q, AMH-853 and AMH-854) were sown to ploughed fields at the beginning of the main rainy season (early July) for the two consecutive years (2017/18 and 2018/19). The seed was planted with the help of hand drill keeping 75 cm and 25 cm between row and seed respectively. A blanket basal phosphorus fertilize was uniformly applied to all plots in the form of diammonium phosphate (DAP) at the rate of 200 kg/ha and 120 kg/ha of urea was applied in split application. The genotypes were harvested at two harvesting stage which was considered as a set 1 and set 2 of the experiment. The genotypes in the set one harvested at silage stage (when the grains presented a flouring aspect or Kernels are white, filled with clear fluid, with moisture content of about 85%, silks have completed their function and become dark and dry). The genotypes in a set two trial were harvested when kernel contain fluids with a doughy consistency and have a moisture content of about 70%.

Field level data collection

Data were collected on the number of cobs per plant and hectare, plant height at harvesting and forage dry matter yield. Plant height was measured from the ground to the highest leaf. Plant height and number of cobs per plant was recorded from 6 randomly selected plants within sampling area. The number of plant per plot was also counted to calculate the number of cobs per hectare obtained.

Weight of the total fresh biomass yield was recorded from each plot in the field and 500 g sample was taken from each plot to the laboratory to determine dry matter yield. The dry matter content was determined by oven drying at 65 ^{0}C for 72 hours. The oven dried samples were ground to pass through a 1 mm sieve size for laboratory analysis. Before scanning, the samples were dried at 60 ^{0}C overnight in an oven to standardize the moisture and then 3 g of each sample was scanned by, the Near Infra-Red Spectroscopy (NIRS). Dried samples were subjected to analysis of dry matter (DM), Ash, crude protein (CP), Neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and *in vitro* dry matter digestibility (IVDMD) using a calibrated NIRS (Foss 5000 apparatus and Win ISI II software)and reported on DM basis. Crude protein yield was calculated with the following formula:

$$\text{CPY} = \frac{Drymatteryield * Crudeprotein\ percentage}{100}$$

Relative feed value is a forage quality index that is used to rank feeds according to their overall nutritive value. This ranking is made relative to the typical nutritive value of full bloom alfalfa hay, containing 41% ADF and 53%NDF on a DM basis and having an RFV of 100 and is considered to provide the average score. Though RFV has no units, it compares the potential of two or more like forages on the basis of energy intake. Thus, it serves as an index of forage quality for comparing forage lots. Forages with RFV greater than 100 are of higher quality than full bloom alfalfa hay and forage with a value lower than 100 are of lower value than full bloom alfalfa. Relative feed value (RFV), will be calculated from the estimates of dry matter digestibility (DMD) and dry matter intake (DMI) (Rohweder *et al*., 1978)

DDM % = 88.9 - (0.779 × %ADF),
DMI as % of BW = 120 / %NDF,
RFV = (%DDM × %DMI) /1.29,
Where ADF: acid detergent fiber (% of DM), DMI: Dry matter intake (% of Body Weight).

Statistical analysis

Analysis of variance (ANOVA) procedures of SAS general linear model (GLM) was used to analyze the quantitative data (SAS, 2002). LSD test at 5% significance was used for comparison of means. The data were analyzed using the following model:

$Yijk = \mu + Gi + Lj + Bk + GL_{ij} + eijk$
Where, Yijk = dependent variables (mention at least few one of these variables),
μ = grand mean,
Gi = effect of genotype i,

L_j =Location j
B_k = effect of block k, and
GL_{ij} = Interaction of genotype and location
e ijk = random error effect of genotype i, Location j and block k.

Results and Discussion

Environment, genotypes and their interaction effect

The effects of genotype, location and their interaction on plant height, dry matter yield, number of cobs per plant and per hectare, crude protein and digestible dry matter yield of maize genotypes evaluated for forage purpose at two harvesting stage is indicated in Table 1. At the silage harvesting stage, plant height ($P<0.001$), number of cobs per plant ($P<0.01$), dry matter yield and digestible dry matter yield ($P<0.05$) were significantly affected, however crude protein yield and number of cobs per hectare did not significantly ($P>0.05$) influenced. Location had significant effect on number of cobs per hectare ($P<0.001$), plant height, dry matter, digestible dry matter and crude protein yield ($P<0.001$) at silage harvesting stage. This might be due to differences among the locations in altitude, soil types, temperature and differences in both amount and distribution of annual rainfall and other agro-climatic factors.

Interaction of genotype and location was not significant at 5% level of significance for all measured parameters at the silage harvesting stage. This result suggests that the performance of maize genotypes was stable across the environment and this might be due to the similar response of the genotypes to the environments and/or similarities of the two testing environments. When genotypes perform consistently across locations, breeders can effectively evaluate germplasm with a minimum cost in a few locations for the ultimate use of the resulting varieties across wider geographic areas (Gemechu, 2012). Conversely, when genotype by location interaction effects is significant, genotypes selected for superior performance under one set of environmental conditions may perform poorly under different environmental conditions.

Plant height was significantly ($P<0.05$) affected by genotype at green cob harvesting stage. However, number of cobs per plant and hectare, dry matter, digestible dry matter and crop protein yield were non-significantly affected by genotype ($P>0.05$). All measured parameters were significantly ($P<0.001$) influenced by location at green cob harvesting stage. Likewise, at the silage harvesting stage, all measured parameters did not significantly ($P>0.05$) influenced by the interaction of genotype and location at the green cob harvesting stage. Therefore, evaluations of yield performance and adaptation patterns of maize genotypes for green forage in multiple environments are not important for proper management and utilization in terms of cost and time expense. Because the adaptation and yield performance of genotypes were stable across the locations and the recommendation made for one location can be applicable for another location according to the result of this study. For silage stage harvest, the higher forage dry matter yield was observed than green cob harvesting stage, and this might be due to the forage dry matter yield was calculated including the cobs for silage stage harvest, but the cobs were separated for green cob harvesting stage and biomass yield data was taken.

In summary, the overall performance of maize genotypes for green feed at both stage of harvest was better in Holetta than Adaberga. This suggests that Holetta has better soil and climatic conditions for maize genotypes growing for forage purposes.

Table 1. Effects of genotype, location and their interaction on plant height, dry matter yield, number of cobs per plant and hectare, crude protein yield and digestible dry matter yield of Maize genotypes evaluated for green feed at two harvesting stage

Parameters	Silage stage				
	G	L	G x L	Mean	CV
Plant height (cm)	***	***	ns	166.45	12.58
Dry matter yield (ton ha^{-1})	*	***	ns	8.32	36.27
Number of cobs per plant	*	ns	ns	1.31	18.55
Number of cobs per hectare	ns	***	ns	29855.04	19.60
Crude protein yield (ton ha^{-1})	ns	***	ns	0.51	38.70
Digestible dry matter yield (ton ha^{-1})	*	***	ns	7.34	36.19
green cob stage					
Plant height (cm)	*	***	ns	176.75	20.77
Dry matter yield (ton ha^{-1})	ns	***	ns	6.51	52.22
Number of cobs per plant	ns	**	ns	1.82	21.12
Number of cobs per hectare	ns	*	ns	87539.68	29.10
Crude protein yield (ton ha^{-1})	ns	***	ns	0.29	54.67
Digestible dry matter yield (ton ha^{-1})	ns	***	ns	5.78	52.23

G= genotype; L= location; G x L =interaction of genotype and location; CV= Coefficient variation; ns= non-significant ($P > 0.05$);
* = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

Number of cobs

The mean number of cobs per plant and per hectare of maize genotypes evaluated for forage purpose is indicated in Table 2. Genotypes showed a significant ($P < 0.05$) difference in mean number of cobs per plant and hectare at silage stage of harvest in Adaberga. However, genotypes did not significantly ($P > 0.05$) different in a number of cobs per plant and hectare in Holetta. AMH-760Q maize genotype had lower ($P < 0.05$) number of cobs per plant and hectare than other genotypes in Adaberga.

At green cob harvesting stage, the number of cobs per hectare was significantly ($P < 0.05$) different in Adaberga location and AMH-853 and Jibat genotypes exhibited higher ($P < 0.05$) number of cobs per hectare compared to Argene, Kulani and Horra. Genotypes had higher number of cobs per plant ($P < 0.01$) and hectare ($P < 0.05$) at Holetta than Adaberga. This result suggests that hereditary properties of cobs formation/yield are very low and are significantly affected by environmental conditions. Concurrent to these study Bilal *et al.* (2017) reported that the hereditary properties of quantitative characters are very low and are significantly affected by environmental conditions.

The result of combined analysis revealed that number of cobs per plant was significantly different among genotypes ($P<0.05$), but number of cobs per hectare was not affected ($P>0.05$) by genotypes at silage stage. The AMH-760Q genotype was gave small number of cobs per hectare than other genotypes. At green cob harvesting stage, the result of combined analysis showed that both the number of cobs per plant and hectare were not significantly ($P>0.05$) affected by genotype.

The number of cobs per plant and hectare were observed to have positively influenced forage dry matter yield and digestible dry matter yield. Moreover, crude protein yield and crude protein contents were also positively affected by number of cobs per plant and hectare and this might had something to do with the cob which is the nutritious part of maize sampled with mixture sampled for laboratory analysis. This implies that number of cobs per plant and hectare can be used as very good indicators for the above parameters to be obtained.

Plant height

The mean plant height of seven evaluated maize genotypes that were harvested at two stages indicated in Table 3. At the silage harvesting stage, plant height was significantly ($P < 0.01$ for Holetta; $P < 0.05$ for Adaberga and combined analysis) different among genotypes for both locations and combined analysis and this could be linked to differences in genotype. In agreement to this study, Ullah *et al.* (2009) reported variations in plant height to be linked to genotypic differences and explained this trait to be influenced by differential response of genotypes to prevailing site and crop management conditions. Horra was the shortest genotype, followed by Argene as the analysis results of each location and combined. From the combined analysis, Kuleni had taller ($P<0.05$) plant height than Horra and Argene. The maize genotypes had taller ($P<0.00$) plant height in Holetta than Adaberga at a silage stage of harvest and this might be associated to the influence of climate and soil characteristics. Plant height significantly ($P<0.05$) influenced by genotype in Holetta, at the green cob harvesting stage. But there was no significant ($P>0.05$) difference between genotypes for plant height at Adaberga and the combined analysis at the green cob harvesting stage. Kuleni had the highest plant height followed by AMH-853 and AMH-854 in Holetta at green cob harvesting stage. At green cob harvesting stage, genotypes had taller ($P<0.001$) plant height in Holetta than Adaberga.

Table 2. Mean number of cobs per plant and hectare of Maize genotypes evaluated for green feed at two harvesting stage

S. No	**Genotypes**	**Silage stage**					
		Number of cobs per plant			**Number of cobs per hectare**		
		Holetta	**Adeaberga**	**Mean**	**Holetta**	**Adeaberga**	**Mean**
1	AMH-760Q	1.22	0.64^{b}	0.93^{c}	55185.00	1061.20^{b}	28123.00
2	Horra	1.22	1.40^{a}	1.31^{ab}	57778.00	2332.30^{a}	30055.00
3	AMH-853	1.33	1.50^{a}	1.42^{ab}	57593.00	2493.90^{a}	30043.00
4	AMH-854	1.22	1.28^{a}	1.25^{bc}	55741.00	2138.80^{a}	28940.00
5	Jibat	1.56	1.60^{a}	1.58^{a}	61667.00	2671.80^{a}	32169.00
6	Kuleni	1.33	1.36^{a}	1.35^{ab}	62037.00	2265.30^{a}	32151.00
7	Argene	1.22	1.45^{a}	1.34^{ab}	52593.00	2414.70^{a}	27504.00
	Mean	1.30	1.32	1.31	57513.23^{a}	2196.85^{b}	29855.04
	CV	18.57	23.33	21.12	21.25	23.36	29.10
	Significance level	ns	*	*	ns	*	ns
		Green cob stage					
1	AMH-760Q	1.89	1.66	1.78	85185.00	83333.00^{ab}	84259.00
2	Horra	1.89	1.57	1.73	92222.00	75556.00^{bc}	83889.00
3	AMH-853	1.67	1.75	1.71	75370.00	88333.00^{a}	81852.00
4	AMH-854	2.00	1.83	1.91	93148.00	82778.00^{abc}	87963.00
5	Jibat	2.22	1.83	2.03	110185.00	91667.00^{a}	100926.00
6	Kuleni	1.89	1.41	1.65	90370.00	71111.00^{c}	80741.00
7	Argene	2.22	1.58	1.90	110185.00	76111.00^{bc}	93148.00
	mean	1.97^{a}	1.66^{b}	1.82	93809.52^{a}	81269.84^{b}	87539.68
	cv	22.72	9.79	18.55	24.81	8.43	19.60
	significance level	ns	ns	ns	ns	*	ns

CV= Coefficient variation; ns= non-significant ($P > 0.05$); * = $P < 0.05$.

Table 3. Mean plant height (cm) of Maize genotypes evaluated for green feed at two harvesting stage.

S. No	**Genotype**	**Silage stage**			**Green cob stage**		
		Holetta	**Adaberga**	**Combined**	**Holetta**	**Adaberga**	**Combined**
1	AMH-760Q	182.77^{ab}	145.57^{abc}	164.17^{abc}	198.63^{abc}	147.37	173.00
2	Horra	159.98^{c}	123.57^{c}	141.78^{c}	182.38^{c}	139.67	161.02
3	AMH-853	183.05^{ab}	151.93^{ab}	167.49^{ab}	202.73^{ab}	159.43	181.08
4	AMH-854	204.45^{a}	147.80^{abc}	176.12^{ab}	202.58^{ab}	169.40	185.99
5	Jibat	187.78^{ab}	157.58^{a}	172.68^{ab}	200.22^{ab}	147.17	173.69
6	Kuleni	201.38^{ab}	164.12^{a}	182.75^{a}	215.02^{a}	166.27	190.64
7	Argene	180.57^{bc}	129.11^{bc}	154.84^{bc}	191.11^{bc}	152.47	171.79
	Mean	185.71^{a}	145.67^{b}	165.69	198.95^{a}	154.54^{b}	176.75
	CV	10.32	15.68	17.75	7.34	16.49	17.37
	SL	**	*	*	*	ns	ns

CV= Coefficient variation; SL= significance level ns= non-significant ($P > 0.05$); * = $P < 0.05$; ** = $P < 0.01$.

Dry matter, digestible dry matter and crude protein yield

The dry matter, digestible dry matter and crude protein yield of evaluated maize genotypes are indicated in Table 4. Dry matter yield was significantly different among genotypes at Holetta ($P<0.001$) at silage harvesting stage. At Holetta, Jibat and AMH-854 genotypes were significantly ($P<0.001$) more dry matter yielder than Horra genotype; however Jibat and AMH-854 genotypes were non-significant ($P>0.05$) with the other genotypes in dry matter yield. Moreover, the result of the combined analysis also showed that Jibat was more ($P<0.01$) dry matter yield producer than Horra, Argene, Kuleni and AMH-760Q genotypes at silage harvesting stage. Taller plant height genotypes in both locations and combined analysis resulted in better biomass yield. This is because longer plants possess relatively more leaves and branches that may result in an increase in biomass yield. Genotypes had high ($P<0.001$) dry matter yield at Holetta than Adaberga at a silage harvesting stage.

Digestible dry matter and crude protein yield did not show ($P>0.05$) variations among the different genotypes considered across each location and for the result obtained from the combined analysis at silage stage of harvest. The numerical increment of digestible dry matter and crude protein increment was consistent with the increment of dry matter yield. In consistent to dry matter yield, genotypes were observed to have yielded more ($P<0.001$) crude protein and digestible dry matter yielder at Holetta than Adaberga location at a silage harvesting stage and this might be associated with the difference in an environmental condition such as rainfall, soil fertility, temperature. This suggests that hereditary properties of dry matter, digestible dry matter and crude protein yield were significantly influenced by environment.

At green cob harvesting stage, dry matter yield was significantly different among genotypes in Adaberga ($P<0.01$) and in combined analysis ($P<0.05$), however no differences were detected ($P>0.05$) among genotypes at Holetta. The Kuleni genotype was more dry matter yielder than AMH-760Q and Horra genotypes at Adaberga and in combined analysis. Moreover, the Kuleni genotype produced more ($P<0.01$) dry matter yield than AMH-854 and Jibat genotypes at Adaberga. Dry matter yield of genotypes was higher ($P<0.001$) at Holetta than Adaberga which was consistent with the significant difference of plant height and number of cobs per hectare between locations.

Genotypes did not significantly affected ($P>0.05$) digestible dry matter yield and crude protein yield at green cob harvesting stage. At a green cob harvesting stage, the numerical difference of digestible dry matter and crude protein yield among the genotypes in both location and combined analysis were consistent with dry matter yield and plant height. Moreover, crude protein yields difference between the genotypes is a more reflection of the difference in crude protein content existing among the genotypes. This could be due to the crude protein yield of the genotypes mathematically derived from dry matter yield and crude protein content of genotypes.

Digestible dry matter yield and crude protein yield were significantly ($P<0.001$) different among locations at green cob harvesting stage and this might be attributed to biotic, edaphic, climatic and geophysical differences between the locations. Genotypes were seen to be producing more ($P<0.001$) digestible dry matter and crude protein yield at Holetta than Adaberga can be justified to the plant height, dry matter yield and number of cobs per hectare of the different genotypes. This result suggests that plant height can positively influence dry matter yield and this can further be attributed to the fact that longer plants possess relatively more leaves and branches that may result in increase in biomass yield. This implies that plant height could be a good indicator of the dry matter yield to be obtained.

Generally, digestible dry matter yield and crude protein yield did not significantly ($P>0.05$) affected by genotypes at both harvesting stages in each location and for the result of combined analysis. However, dry matter, digestible dry matter and crude protein yield were significantly ($P>0.001$) affected by location. This implies environmental factors can significantly influence the yield performance and adaptation patterns of maize genotypes.

Table 4. Mean dry matter, digestible dry matter and crude protein yield (t ha^{-1}) of Maize genotypes evaluated for green feed at two harvesting stage

S. No	**Genotypes**	**Silage stage**								
		Dry matter yield			**Digestible dry matter Yield**			**Crude protein yield**		
		Holetta	**Adaberga**	**Combined**	**Holetta**	**Adaberga**	**Combined**	**Holetta**	**Adaberga**	**Combined**
1	AMH-760Q	9.54^{ab}	4.60	7.07^{cd}	8.46	4.08	6.27	0.62	0.30	0.46
2	Horra	8.65^{b}	4.01	6.33^{d}	7.67	3.55	5.61	0.55	0.26	0.41
3	AMH-853	9.94^{ab}	7.56	8.75^{abc}	8.82	6.70	7.76	0.54	0.41	0.48
4	AMH-854	13.56^{a}	5.91	9.74^{ab}	12.01	5.25	8.64	0.87	0.38	0.62
5	Jibat	12.91^{a}	7.43	10.17^{a}	11.45	6.59	9.02	0.80	0.46	0.63
6	Kuleni	9.86^{ab}	6.38	8.12^{bcd}	8.74	5.65	7.20	0.58	0.38	0.48
7	Argene	10.77^{ab}	4.78	7.77^{bcd}	9.55	4.24	6.89	0.69	0.30	0.49
	Mean	10.75^{a}	5.81^{b}	8.28	9.53^{a}	5.15^{b}	7.34	0.66^{a}	0.35^{b}	0.51
	CV	32.28	41.86	47.54	32.29	41.87	36.19	34.28	45.36	38.70
	SL	***	Ns	**	Ns	Ns	ns	ns	Ns	Ns
		Green cob stage								
1	AMH-760Q	9.13	2.77^{c}	5.95^{bc}	8.09	2.45	5.27	0.36	0.11	0.23
2	Horra	7.17	3.18^{c}	5.18^{c}	6.36	2.82	4.59	0.32	0.15	0.23
3	AMH-853	9.53	5.56^{ab}	7.54^{ab}	8.44	4.93	6.69	0.43	0.25	0.34
4	AMH-854	8.56	3.96^{bc}	6.23^{ab}	7.58	3.51	5.55	0.40	0.19	0.29
5	Jibat	9.34	4.29^{bc}	6.82^{ab}	8.28	3.81	6.04	0.38	0.18	0.28
6	Kuleni	8.81	6.36^{a}	7.59^{a}	7.81	5.64	6.72	0.43	0.30	0.37
7	Argene	7.23	5.23^{ab}	6.23^{ab}	6.41	4.63	5.52	0.35	0.26	0.31
	Mean	8.54^{a}	4.48^{b}	6.51	7.57^{a}	3.97^{b}	5.77	0.38^{a}	0.21^{b}	0.29
	CV	28.02	26.02	60.53	28.02	26.05	52.23	28.80	22.17	54.67
	SL	ns	**	*	Ns	Ns	ns	ns	Ns	Ns

CV= Coefficient variation; SL= significance level ns= non-significant ($P > 0.05$); * = $P < 0.05$

Nutritional content

The nutritive quality of maize genotypes evaluated for forage purposes are indicated in Table 5.Dry matter percentage did not significantly ($P>0.05$) influenced by genotype at silage harvesting stage. However, at green cob harvesting stage dry matter percentage was significantly ($P<0.05$) influenced by genotype and this might be attributed to differences in growth rate and growth habit, which are mediated through the genotypic and phenotypic differences. This is a common phenomenon in grasses (Mganga. 2009; Ogillo. 2010). At green cob harvesting stage AMH-854 had more ($P<0.05$) dry matter percentage than AMH-853 and AMH-760Q genotypes.

Ash content was not significantly varied ($P > 0.05$) among genotypes evaluated for forage purposes either at silage or the green cob harvesting stage. Linn and Martin (1999) reported that, most forage has ash content ranging from 3 to 12% and the Ash value observed in this study has laid in that range.

Acid detergent fiber (ADF) was significantly influenced by genotype at silage harvesting stage ($P < 0.01$) and green cob harvesting stage ($P < 0.05$). Hora genotype had lower ($P < 0.01$) ADF than AMH-760Q, Kuleni, Argene and AMH-853 genotypes at silage harvesting stage. High ($P < 0.05$) ADF value was recorded for AMH-760Q than other genotypes at green cob harvesting stage. Costa *et al.* (2005) reported that the digestibility of feeds is related to the fiber because the indigestible portion has a proportion of ADF, and the higher the value of ADF the lower the feed digestibility. According to the report of these Authors, Hora can be more digestible and thus had more intake thanAMH-760Q, Kuleni, Argene and AMH-853 genotypes at silage stage of harvest. On the other hand AMH-760Q genotype harvested at a green cob stage is expected to have lower intake owning to its lower digestible dry matter than other genotypes. NRC (2001) reported the minimum recommended value of ADF for forage should be 17-21% and according to this report all evaluated maize genotypes for forage purpose exceeded this ADF value recommended for forage.

Crude protein did not show significant ($P>0.05$) difference among genotypes. Lonsdale (1989) reported that the feeds that have <12%, 12-20% and >20% CP are classified as low, medium and high protein sources, respectively. Based on this classification, all maize genotypes evaluated for forage purpose and harvested at both stages (silage and green cob) are classified as low protein feed sources. However, Machogu (2013) reported that forages whose CP contents could range between 9–12% can be regarded as are highly palatable.

Genotype did not significantly ($P>0.05$) affect NDF at both harvesting stage. Van Saun, (2006) reported that forage grasses, which have < 50% NDF is considered high quality and > 60% as low-quality forage. According to this classification, all maize genotypes evaluated for forage purpose and harvested at both stage (silage and green cob) in this study can be categorized under low quality forages. Acid detergent lignin (ADL) did not significantly (P>0.05) differed among genotypes at a silage harvesting stage. Conversely, at green cob harvesting stage, ADL was observed to vary significantly (P<0.05) over genotypes with AMH-760Q having considerably higher ADL value than other genotypes excluding Argene. Van Soest (1982) reported that lignin content value above 6% to affect digestibility of forage negatively and in this study, forage materials from all genotypes had < 6% ADL implying digestibility of maize genotypes from the current study are not negatively affected by ADL content.

Table 5. Nutrient content of Maize genotypes evaluated for green feed at two harvesting stage.

A	Genotypes	Silage stage					
		DM	Ash	CP	NDF	ADF	ADL
1	AMH-760Q	92.55	7.61	6.46	69.00	31.61^{a}	3.31
2	Horra	92.58	8.16	6.33	70.76	26.78^{d}	3.21
3	AMH-853	92.70	7.79	5.39	68.90	30.23^{ab}	3.40
4	AMH-854	92.53	8.12	6.04	66.79	27.68^{cd}	3.08
5	Jibat	92.38	7.95	6.24	70.85	26.84^{cd}	2.92
6	Kuleni	92.36	8.03	5.90	64.89	28.74^{bc}	3.34
7	Argene	92.44	7.50	6.36	71,24	28.87^{bc}	3.38
	Mean	92.51	7.88	6.10	68.92	28.68	3.23
	CV	0.24	8.13	11.19	3.99	3.62	5.01
	SL	Ns	ns	Ns	Ns	**	ns
		Green cob stage					
1	AMH-760Q	92.20^{bc}	7.62^{b}	4.05	71.42	39.21^{a}	4.68^{a}
2	Horra	92.57^{ab}	10.30^{a}	4.58	70.51	31.59^{b}	3.58^{c}
3	AMH-853	91.93^{c}	9.80^{a}	4.52	65.82	33.19^{b}	3.68^{c}
4	AMH-854	92.60^{a}	10.81^{a}	4.73	65.22	32.18^{b}	3.66^{c}
5	Jibat	92.51^{ab}	9.90^{a}	4.16	65.82	32.58^{b}	3.77^{c}
6	Kuleni	92.53^{ab}	10.10^{a}	4.83	66.28	33.12^{b}	3.82^{bc}
7	Argene	92.28^{abc}	10.48^{a}	4.82	64.47	33.60^{b}	4.43^{ab}
	Mean	92.38	9.86	4.53	67.08	33.64	3.95
	CV	0.24	10.05	20.29	4.12	6.38	8.74
	SL	*	*	Ns	Ns	*	*

CV= Coefficient variation; SL= significance level ns= non-significant (P > 0.05); * = P < 0.05; ** = P < 0.01; DM = dry matter percentage; CP= crude protein yield; NDF = Neutral detergent fiber; ADF= Acid detergent fiber; ADL =Acid detergent lignin; IVDMD = *In-vitro* dry matter digestibility

Relative feed value

The mean relative feed value of Maize genotypes evaluated for green feed at two harvesting stage indicated in Table 6. The result of analysis revealed that relative feed value was not significantly (P > 0.05) influenced by genotype at both harvesting stages. The overall mean RFV index of around 120 for genotypes harvested at silage harvesting stage and 123 for genotypes harvested at green cob harvesting stage observed for the evaluated maize genotypes in this study falls within the range of 103-124 that leguminous hays of second grade quality are required to have (Owen and Jayasuriya, 1989; Seyum *et al.*, 1999). In fact the magnitude of the index is higher than a standard value of 100 implying the higher nutritional value of evaluated maize genotypes.

Table 6. Mean relative feed value (%) of Maize genotypes evaluated for green feed at two harvesting stages.

S. No	Genotype	Silage stage	Green cob stage
1	AMH-760Q	119.61	115.53
2	Horra	116.86	117.32
3	AMH-853	119.77	125.31
4	AMH-854	123.43	126.72
5	Jibat	116.90	125.29
6	Kuleni	127.19	124.46
7	Argene	115.84	127.92
	Mean	119.94	123.22
	CV	3.56	3.97
	SL	Ns	ns

CV= Coefficient variation; SL= significance level ns= non-significant (P > 0.05)

Conclusion and Recommendations

In summary, plant height, forage dry matter yield, number of cobs per plant and per hectare, crude protein yield and digestible dry matter yield were significantly influenced by location. The overall performance of all maize genotypes was better at Holetta than Adaberga both at silage and green cob harvesting stages. The interaction effect of location and genotype was non-significant for all measured parameters and this suggests that performance of the genotypes were stable across the locations. Genotypes significantly affected forage dry matter yield and plant height, however non-significant differences were detected among genotypes in nutrient contents except ADF for genotypes harvested at silage and green cob harvesting stages. In conclusion, based on dry matter yield and plant height data at silage and green cob harvesting stage, Kuleni, AMH-853 and Jibat maize genotypes are recommended for the study area and similar agro-ecologies. The final remark is that further works should be done on silage quality of the recommended genotypes and their effect on performance of animals to reach firm recommendations.

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