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ORIGINAL ARTICLE

Morphological characters, dry matter production, and feed quality of three maize (*Zea mays* L.) varieties as influenced by milk and dough harvest stages

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Varietal differences and stages of crop harvest have great contributions to biomass quantity and quality of maize stovers, however, little/no studies have been done in these regards. We evaluated three maize varieties: Jibat, Kuleni, and Kolba for their morphological characteristics, dry matter production, and feed quality harvested at milk and dough stages for two years in a randomized complete block design with four replications. Variety had no significant ($P>0.05$) effect on the measured morphological traits except for cob length (CL). Plant height (PH) and dry matter yield (DMY) were significantly ($P<0.001$) influenced by year at both harvest stages. The DMY achieved at the milk and dough stages significantly increased by 22.6 and 36.3% in 2020 compared to 2019. At both stages, Kolba and Jibat recorded significantly higher number of cobs per plant, and these varieties also achieved longer leaf lengths at the milk stage than kuleni. We found insignificant ($P>0.05$) differences among varieties for DMY at milk and dough stages. The fiber contents (NDF, ADF, and ADL) were influenced by varieties only at the milk stage. Thus, Jibat and Kuleni could be appropriate for feed with better quality when harvested at the milk stage. After removing the green cobs for human consumption, the three varieties are also used as animal feed at the dough stage.

Keywords: Dry matter production, Feed quality, Maize varieties, Milk stage, Dough stage, Holetta.

Introduction

Maize (*Zea may* L.) is the most versatile and important crop and can be grown worldwide in varied agro-climatic environments. In Ethiopia, second to teff (*Eragrostis tef*), the crop covered over 2.5 million hectares of land but stands in the first position in grain production, with around 10.6 million tons produced (CSA, 2020/21). Although it has remarkable productive potential, the average national yield of maize in the country is 3.38 tons ha^{-1} showing an increasing trend, but still far below as compared to the world average of 5.5 tons ha^{-1} (Mosisa, 2011; Cochrane and Bekele, 2018). The crop is grown commonly in crop-livestock mixed farming systems and, there is a great deal of interdependence between the production of crops and livestock (Tegegne, et al., 2013; Ertiro, et al., 2013). For instance; the crop residues provide a source of feed dominantly during the dry season; on the other hand, Livestock contributes organic manure for crop production as a source of cash for the purchase inputs (Tolera and Said, 1992; Thornton, 2010; Dejene et al., 2022). Maize can be directly used for human consumption (food), and (feed) the stovers as animal fodder has great potential to support higher animal performance in crop-livestock production (FAOSTAT, 2008; Saiyad and Kumar, 2018). It contributes a significant amount of fodder either green or as dry stover for livestock feeding more importantly in the major maize growing areas (Geleti, et al., 2011; Gebre and Mohammed, 2015).

Knowing the factors that affect forage quality is very important for producing suitable quality feed by following up on the management practices for a given situation. Several factors for instance; biotic (pest and disease) or abiotic stress (drought, salinity, and nutrition), genotypes, stage of crop harvest, and environmental effects during growth have great contributions to the influence biomass quantity and quality (Somegowda, et al., 2021). The maize genotypes and/or improved varieties have a substantial contribution to the influence of both biomass yield and quality of stovers. Many studies investigated that the quantity and quality attributes (crude protein (CP), neutral detergent fiber (NDF), Acid detergent fiber (ADF), dry matter digestibility (DMD), and *in-vitro* organic matter digestibility (IVOMD) were affected by genotypic or varietal differences (Tolera, et al., 1999; Geleti, et al., 2011; Ertiro, et al., 2013; Anandan, et al., 2013).

In addition, agronomic practices, and stage of crop harvest, provide good stover yield and quality feed contribution. The maize stovers are used as animal feed either in green or dry stover form. when the green cobs are harvested for human consumption, thereby the green stovers containing the stalk, leaves, husks, and tassels are utilized as animal feed due to their high carbohydrate content, good biomass yield, highly palatable, and useful for feeding all kinds of livestock (Zom, et al., 2012; Tuturoong, et al., 2020). If the maize stover is harvested at the proper harvesting stage, it is the best-suited crop for silage and exhibits high dry matter yield, good intake characteristics and digestibility potentials, and high starch contents that enhance fermentation and storage in the silo (Kennington, et al., 2005; Wang, et al., 2020). Thus, the stover contains 10.5% Crude protein, 91.9% dry matter, and 59.5 to 88.7% dry matter and organic matter digestibility (Tuturoong, Malalantang, and Moningkey 2020). On the other hand, the dry stovers, when harvested at grain maturity, are characterized by a high concentration of fiber and low concentration of nitrogen, with low voluntary intake and poor animal performance (Tolera and Sundstol, 1999; Ertiro, et al., 2013).

Furthermore, maize has different growing stages; the milk stage is one of the reproductive growth processes that begins about three weeks after flowering, when the corn kernels begin grain filling, in which it turned to yellow with a milky fluid on the inside. At this stage it is suitable for consumption, and for forage. The dough stage occurs about 26 days after the silking and the milky inner fluid of the kernels will have accumulated 50% of their dry weight or the maize can be used as an edible product (Jia, et al., 2020). Detecting the variations exhibited in stover quantity and quality due to varietal differences and stage of harvest is crucial to optimize the use of the feeding value of the stovers. Thus, the purposes of this study were to evaluate the morphological characteristics, biomass production, and nutritional quality of three selected maize varieties harvested at milk and dough stages under rainfed conditions in Holetta, the central highland of Ethiopia.

Materials and Methods

Experimental site, soil characteristics and weather condition

The experiment was carried out in the research field of Holetta Agricultural Research under rainfed conditions in the years 2019-2020. Geographically, the center is located at 9°3' N latitude and 38°30' E longitude with an altitude of 2400 meters above sea levels. The farming system of the study area is characterized by a mixed crop-livestock production system.

The physical and chemical properties of soil in the area are mainly red nitosol soil type and texturally clay dominated over sand and silt with moderately acidic pH (4.9). The soil had low organic carbon content (1.8%), available total nitrogen (0.18%), and available phosphorus 5.6 ppm, 5.03 mg kg^{-1} potassium, 29.5 mg kg^{-1} calcium, 13.7 mg kg^{-1} magnesium and 0.16 mg kg^{-1} Sodium.

The long-term (thirty years) average annual rainfall of the area is 1055 mm. The area has a bimodal rainfall distribution with 70% falling from June to September, and the remaining 30% occurring from March to May. The temperature ranged from 6.1°C to 22.2°C.

The area also had an average relative humidity of 60.6%. During the experimental periods, the area received a mean annual rainfall of 112.0 and 105.5 mm in 2019 and 2020 years, respectively (Table 1). The mean monthly temperature ranged from 13.2 to 17.8°C with an average of 15.8°C in the first year, and 12.5 to 17.1°C with an average of 15.3°C in the second year.

Table 1. Monthly total rainfall (mm) and mean monthly temperature (°C) at Holetta, during 2019 and 2020 cropping years.

Months	Monthly total rainfall (mm)		Monthly mean temperature (°C)	
	2019	**2020**	**2019**	**2020**
January	80.1	0.0	17.6	14.9
February	2.6	0.0	16.3	15.4
March	53.4	73.2	16.8	16.9
April	80.1	92.4	17.8	17.1
May	109.2	100.6	17.2	16.9
June	187.4	126.1	16.2	16.1
July	249.0	280.3	16.9	15.6
August	356.1	334.2	15.1	15.2
September	187.0	216.2	14.3	14.9
October	7.8	31.6	13.2	14.3
November	28.2	8.0	14.3	13.2
December	3.6	3.2	13.9	12.5
Mean	112.0	105.5	15.8	15.3

Source: Holetta Agricultural Research Center meteorological data during 2019 and 2020 years.

Experimental treatments, design, and management

Three highland maize varieties including Jibat, Kuleni, and Kolba were selected and evaluated in their response to the milk and dough harvesting stage. The experiment was performed with two sets of trials (set one; harvested at the milk stage, and set two; harvested at the dough stage). Each set of experiment was laid out in randomized complete block design (RCBD) with four replications and each set consisting of a total of twelve plots. Planting was made on a gross plot size of 15 m^2 (3 m x 5 m) with a recommended space of 0.75 m between rows, followed by 0.25 m between plants. The space between plots and blocks was 1m and 1.5 m, respectively.

Before sowing the experimental land was plowed. Planting was done in good soil moisture contents in a fine seedbed, two seeds per hole were dropped and then covered by light soil. Diammonium phosphate (DAP) fertilizer at the rate of 200 kg ha^{-1} as a basal application at sowing time. To maintain the optimal plant population, thinning of unwanted plants was done 15 days after planting. Urea was applied at the rate of 120 kg ha^{-1} in split applications twice during the growing season and the remaining top-dressed at the knee-high stage. Weeding and earthing-up using hoe were done two times manually.

Data collection and sampling

Data on morphological characters collected in this study were plant height at harvest, leaf length, cob length, number of leaves per plant, number of cobs per plant, and forage dry matter yield. Plant height (PH) is the measurement taken from the base of the plant just above the ground level to the tip of the uppermost of extended leaf and measured from 6 randomly taken sample plants in the central rows, and the mean values of each plot were calculated and recorded for data analysis. Leaf length (LL), is the length taken from the flag leaf and measured from the point of the leaf ligule to the tip of the leaf blade of 6 sample plants. Cob length (CL) is the length measured from 6 randomly taken cobs when reached at the dough stage. The number of cobs per plant (NCPP) number of cobs arising from the stem of 6 randomly taken sample plants in central rows was counted and the average of these cobs was calculated and recorded for data analysis. Dry matter yields (DMY) of the maize varieties were determined from two separate sets of experiments in different harvesting stages when the kernel was at milk and dough stages. The total fresh biomass yield was recorded from each plot in the field and a sub-sample of 500 g was taken from each plot to the laboratory to determine dry matter yield. The dry matter content was determined by oven drying at 65°C for 72 hours.

Chemical analysis and *in-vitro* dry matter digestibility

Chemical analysis and *in-vitro* dry matter digestibility of the three maize varieties harvested at milk and dough stages were determined at Holetta Agricultural Research animal nutrition laboratory. 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°C overnight in an oven at a constant weight 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), and lignin using a calibrated NIRS (Foss 5000 apparatus and Win ISI II software) and reported on DM basis. The oven-dried samples were ground to pass through 1 mm sieve in a Wiley mill and stored in polyethylene bags pending the chemical analysis. *In-vitro* dry matter digestibility (IVDMD) was determined using two-stage *in-vitro* digestibility technique of (Tilley and Terry, 1963).

Statistical analysis

Data were subjected to analysis of variance of the SAS general linear model statistical software (SAS, 2011). The means were compared using the least significant difference (LSD) at 5% level of significance. The general linear model used for the analysis of the data was;

$Y_{ijk}=\mu+V_i+Y_j+B_k+(VY)_{ij}+e_{ijk,}$;

Where Y_{ijk}=Response variables; μ=the overall mean; V_i=effect due to variety (i=1-3); Y_j=effect due to year (j=2019 and 2020); B_k=effect due to block k; $(VY)_{ij}$=effect due to interaction between i^{th} variety and j^{th} year; e_{ijk}=the random error.

Results and Discussion

Variety, year, and their interactions

The analysis of variance (ANOVA) for variety, cropping year, and the interactions of three maize varieties are shown in (Table 2). The mean square of variance of variety revealed no significant (P>0.05) effect on the measured morphological traits both at milk and dough stages except for cob length (CL). Whereas CL is significantly (P<0.01) influenced by varietal differences at the milk stage. The combined analysis of variance over the year showed highly significant (P<0.001) for plant height (PH) and dry matter yield (DMY) both at the milk and dough harvesting stages. The maize varieties exhibited significant differences for PH and DMY across the year might the variation due to non-genetic factors such as, growing seasons, amount of rainfall distributions and temperature. However, CL and number of cops per plant (NCPP) were not significantly (P>0.05) affected by the year. The result indicates that the response of the maize varieties for cob length and cob number were stable over the cropping year. No significant interaction was found between variety and year for all measured traits both at the milk and dough stages. Conversely to the current study variety and year interaction had a significant effect on plant height and dry matter yield (Saiyad and Kumar, 2018).

Table 2. Mean squares of combining analysis of variety, cropping year, and their interactions of three maize varieties for morphological traits evaluated at milk and dough stages.

Harvest stages	Parameters	Mean squares			Mean	CV (%)
		Variety	Year	Variety*Year		
Milk stage	PH (cm)	213.3ns	2081.3**	304.1ns	141.7	10.4
	CL (cm)	16.6**	0.4ns	10.1ns	14.5	14.1
	NCPP	0.8ns	0.02ns	0.04ns	1.1	23.1
	DMY (t ha^{-1})	2.8ns	17.2**	0.4ns	6.7	17.4
Dough stage	PH (cm)	334.5ns	18073.1**	292.4ns	173.6	9.8
	CL (cm)	5.5ns	2.8ns	1.2ns	13.2	10.9
	NCPP	0.1ns	0.1ns	0.1ns	1.2	19.1
	DMY (t ha^{-1})	1.2ns	52.2**	0.2ns	6.6	17.8

PH=plant Height; CL=cob length; NCPP=number of cobs per plant; DMY=Dry matter yield; CV=coefficient of variation); ns=non-significant (P>0.05); **=significant (p<0.001);

Year effect on morphological characteristics and dry matter yield

The effect of year on the plant height, cob length, number of cobs per plant, and dry matter yield of three highland maize varieties evaluated at milk and dough harvesting stages are indicated in (Table 3). The PH and DMY significantly (P<0.001) differed across the year. The results indicate that the highest plant was recorded in 2019 compared to 2020 at the milk stage and this was also consistent at the dough stage. The growing seasons, amount of rainfall distributions and temperature in 2019 might have positive impacts on the plant height of maize varieties at both stages. In 2020, at both harvesting stages, the highest DMY was achieved and increased by 22.6% and 36.3% at the milk and dough stages respectively, compared to the 2019 year. The higher DMY achieved in 2020 is probably due to variation in temperature and the amount of rainfall distributions might have positively or negatively influenced for the dry matter accumulation between years. In agreement with the present study, Szulc, et al., (2021) obtained a different dry matter yield results concerning variable in weather condition over the years.

Table 3. Combined means of cob length, number of cobs per plant, plant height, and dry matter yield maize varieties harvested at milk and dough stages during the 2019 and 2020 years.

Harvest Stages	Years	CL (cm)	NCPP	PH (cm)	DMY (t ha^{-1})
	2019	14.6	1.1	151.0^{a}	5.8^{b}
	2020	14.4	1.1	132.4^{b}	7.5^{a}
Milk stage	Mean	14.5	1.1	141.7	6.7
	CV (%)`	14.1	23.1	10.4	17.4
	P-value	0.76	0.63	0.007	0.003
	2019	12.9	1.2	201.0^{a}	5.1^{b}
	2020	13.5	1.3	146.1^{b}	8.0^{a}
Dough stage	Mean	13.2	1.2	173.6	6.6
	CV (%)	10.9	19.1	9.8	17.8
	P-value	0.26	0.3	0.001	0.001

Means within a column followed by different supper script letters are significant different (P<0.05) PH=plant Height; CL=cob length; NCPP=number of cobs per plant; DMY=Dry matter yield; CV=coefficient of variation); ns=non-significant (P>0.05); **=significant (p<0.001); CV=Coefficient of variation.

Cob length and number of cobs per plant

The mean performance of cob length and the number of cobs per plant of the three maize varieties at the milk and dough stages are indicated in Table 4.

Table 4. The mean performances for cob length (CL) and number of cobs per plant (NCPP) of three maize varieties harvested at milk and dough stages during 2019 and 2020 years.

	CL (cm)						NCPP					
Variety	Milk Stage			Dough Stage			Milk Stage			Dough Stage		
	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
Jibat	14.0	13.4	13.7^{b}	13.6	13.7	13.7	1.4^{a}	1.3	1.4^{a}	1.0	1.3^{a}	1.2
Kuleni	12.6	14.7	13.6^{b}	12.1	12.4	12.2	0.7^{b}	0.8	0.8^{b}	1.2	1.1^{b}	1.1
Kolba	17.3	15.0	16.2^{a}	12.9	14.5	13.7	1.1^{a}	1.3	1.2^{a}	1.3	1.4^{a}	1.3
Mean	14.6	14.4	14.5	12.9	13.5	13.2	1.1	1.1	1.1	1.2	1.3	1.2
CV (%)	16.7	9.9	14.1	11.0	11.5	10.9	16.5	27.2	23.1	20.7	12.3	19.1
P-value	0.08	0.29	0.04	0.36	0.3	1.5	0.04	0.1	0.008	0.35	0.04	0.2

Means within a column followed by different supper script letters are significantly different (P<0.05); CL=cob length; NCPP=number of cobs per plant; CV=coefficient of variation.

The CL recorded at the milk stage was not significantly different among the tested maize varieties in both years. On the contrary, the overall mean for CL significantly (P<0.05) varied among the maize varieties at the milk stage.

Accordingly, Kolba attained larger CL than Jibat and Kuleni maize varieties, whereas Jibat and Kuleni scored similar CL. No significant (P>0.05) variations were observed among the varieties for CL at the dough stage in the experimental years.
Similarly, significant (P<0.05) differences appeared among varieties for the number of cobs per plant (NCPP) in 2019 cropping year and the combined mean at milk stage, and this was also achieved in 2020 at the dough stage. consequently, Jibat and Kolba maize varieties had statistically higher NCPP than Kuleni in 2019 and the overall mean at the milk stage. Consistently, these varieties (Jibat and Kolba) attained higher NCPP than Kuleni in 2020 at the dough harvesting stage. This indicates that this trait (NCPP) was not influenced by both milk and dough stages.

Leaf length and number of leaves per plant

The tested maize varieties showed significant (P<0.01) differences for leaf length (LL) at the milk stage of harvesting, whereas they did not show significant differences for LL at the dough stage (Table 5). Jibat and Kolba maize varieties had statistically similar LL and were larger than Kolba variety. The leaf length we found in the present study was between previous records (57.1 and 93.2 cm) reported by Saiyad and Kumar (2018).
Leafy maize variety is an indication of good dry matter yield. Depending on the genotypes and climate maize can produce a total of 20-23 leaves. However, the first five to seven leaves drop off at early stage. The number of leaves per plant (NLPP) obtained both at the milk and dough harvesting stages were statistically insignificant (P>0.05) among the maize varieties. A study done by Tolera and Sundstøl (1999) demonstrate that the leafy maize variety to have good dry matter yield and show better digestibility and increase animal performance.

Table 5. Leaf length (LL) and Number of leaves per plant (NLPP) of the selected maize varieties at the milk and dough stages.

Variety	**LL (cm)**		**NLPP**	
	Milk Stage	**Dough Stage**	**Milk Stage**	**Dough Stage**
Jibat	71.0[a]	66.3	12.7	12.4
Kuleni	62.6[b]	69.6	12.4	12.9
Kolba	67.5[a]	67.7	10.8	12.2
Mean	67.0	67.9	12.0	12.5
CV (%)	4.2	13.5	8.1	8.5
P-value	0.01	0.88	0.06	0.67

Means with different letters of superscripts within column had significant differences at P<0.01; LL=leaf length; NLPP=number of leaves per plant; CV=coefficient of variation.

Plant height and Dry matter yield

The mean performance for plant height of three maize varieties harvested at milk and dough stages during 2019 and 2020 has shown in (Table 6). The result indicates that the maize varieties were not statistically (P>0.05) differed for plant height at the milk stage both in 2019 and 2020 years and also consistent with the combined mean. In 2019, plant height recorded at dough stages significantly varied among maize varieties. Whereas in 2020 and the combined mean of plant height showed a non-significant (P>0.05) difference among the maize varieties. Kulani and Jibat had significantly recorded the tallest plant height than Kolba in 2019. The present result in agreement with Faji, et al., (2021) found that Kuleni had the tallest plant height in Holetta at the green cob harvesting stage. The feed quality increases with height in maize stover.
There was an insignificant (P>0.05) difference among maize varieties for dry matter yield (DMY) both at milk and dough stages during 2019 and 2020 cropping seasons. Similarly, the overall means of the dry matter yield showed statistically insignificant difference among the evaluated maize varieties. The overall mean for DMY yield achieved at the milk stage ranged from 6.2 to 7.3 while at the dough stage it varied from 6.2 to 6.9 t ha^{-1}. The DMY obtained both at milk and dough stages of the tested maize varieties in the current study was found between 4.4-9.7 t ha^{-1} reported by Ertiro, et al., (2013) conducted in 335 maize genotypes in different sites and years. The DMY of kuleni obtained in this study was lower than the values reported by Geleti, et al., (2011) for this variety 9.37 ± 0.36 t ha^{-1} at Bako. This could be due to variation in soil type and climate conditions of the areas.

Table 6. Mean performance for plant height (cm) and dry matter yield (DMY t ha^{-1}) of maize varieties harvested at milk and dough stages during 2019 and 2020 cropping seasons at Holetta.

Variety	Plant height (cm)						DMY (t ha^{-1})					
	Milk Stage			Dough Stage			Milk Stage			Dough Stage		
	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
Jibat	157.8	136.9	147.3	202.0[a]	139.4	170.7	6.7	7.9	7.3	5.0	8.2	6.6
Kuleni	143.3	137.9	140.6	211.5[a]	150.4	180.9	5.2	7.1	6.2	5.6	8.3	6.9
Kolba	152.0	122.3	137.2	189.5[b]	148.6	169.0	5.5	7.5	6.5	4.8	7.6	6.2
Mean	151.0	132.4	141.7	201.0	146.1	173.6	5.8	7.5	6.7	5.1	8.0	6.6
CV (%)	7.5	14.3	10.4	2.83	14.6	9.9	12.7	20.4	17.5	16.7	10.7	17.9
P-value	0.26	0.47	0.39	0.005	0.74	0.34	0.06	0.77	0.15	0.44	0.44	0.43

Means within a column followed by different supper script letters are significantly different (P<0.05) CV=coefficient of variation.

Nutritional composition

The nutritional compositions of three maize varieties at the milk and dough stage are shown in Table 7. The maize varieties showed significantly (P<0.05) differences in their chemical composition particularly for DM, NDF, ADF, and ADL at the milk stage, whereas a non-significant (P>0.05) difference was exhibited among the maize varieties both at milk and dough stages for ash, crude protein (CP) and *in-vitro* dry matter digestibility (IVDMD).

Table 7. Chemical composition of three maize varieties harvested at milk and dough stages

Harvest stage	Variety	Chemical Composition (%)						
		DM	Ash	CP	NDF	ADF	ADL	IVDMD
	Jibat	92.4[b]	7.8	6.1	70.6[a]	26.9[c]	2.9[b]	74.7
Milk stage	Kuleni	92.4[b]	8.0	5.9	64.9[b]	28.7[b]	3.3[a]	74.5
	Kolba	92.7[a]	7.8	5.4	68.9[ab]	30.2[a]	3.4[a]	73.9
	Mean	92.5	7.9	5.8	68.1	28.6	3.2	74.4
	CV (%)	0.1	8.3	12.8	2.7	2.2	5.0	1.0
	P-value	0.03	0.86	0.50	0.04	0.008	0.03	0.51
	Jibat	92.5[a]	9.9	4.2	65.8	32.6	3.8	71.7
Dough stage	Kuleni	92.5[a]	10.1	4.8	66.3	33.1	3.8	72.0
	Kolba	91.9[b]	9.8	4.5	65.8	33.2	3.7	71.9
	Mean	92.3	9.9	4.5	66.0	33.0	3.8	71.9
	CV (%)	0.3	5.7	17.8	2.4	3.5	8.9	2.1
	P-value	0.05	0.82	0.61	0.93	0.78	0.86	0.95

Means within a column followed by different supper script letters are significantly different (P ≤ 0.05) DM=Dry matter; CP=Crude protein; NDF=neutral detergent fiber; ADF=Acid detergent fiber; ADL=acid detergent lignin; IVDMD=*Invitro*-dry matter digestibility.

Kolba maize variety had significantly higher DM percentage than Jibat and kuleni at the milk stage. Conversely, at the dough stage, Jibat and Kuleni showed higher DM compared to Kolba. Kuleni had significantly lower neutral detergent fiber (NDF) content than jibat but statistically exhibited similar to Kolba. At the milk stage, Jibat had the lowest acid detergent fiber (ADF) and acid detergent lignin ADL as compared to Kuleni and Kolba.

The overall mean of CP and IVDMD of the tested maize varieties at the dough stage decreased by 1.3% and 3.5%, whereas NDF, ADF, and ADL increased by 0.3, 4.4, and 0.6% compared to milk stage. This might be due to differences in maturity stage (Neylon and Kung 2003). The mean value of maize varieties for CP obtained at the milk stage was higher than the previous records (Ertiro, et al., 2013; Tolera, et al., 1999). The mean value of NDF and ADF attained in this study both at milk and dough stages is lower than the finding of Geleti, et al., (2011).

The IVDM digestibility obtained in the current study higher than report made by (Tolera, et al., 1999). A study done by Saiyad and Kumar (2018) indicated that the quality of fodder stover is governed by genetic variability. Additionally, several factors including geographical location, soil fertilization, variety, environmental conditions, stage of plant maturity at harvesting, season, and postharvest storage method and duration nutritional can vary the composition of crop residues (Kennington, et al., 2005; Fekede, et al., 2015; Malik, et al., 2015).

Conclusion

Some traits (plant heigh and dry matter yield) of the tested maize varieties were significantly influenced by year in both harvesting stages. The maize varieties showed significant difference for CL and LL harvested at milk stages. Inconsistent variations were observed among the maize varieties for number of cobs per plant at milk and dough stages. However, no significant variation was observed among varieties for dry matter yield (DMY) at the milk and dough stages. Nutritionally, the existence of variations was exhibited in DM% both at milk and dough stages, while Jibat and Kuleni attained better nutritional quality in terms of fiber contents (ADF and ADL) at the milk stage. The study also highlighted no significant differences were observed among maize varieties in chemical compositions harvested at the dough stage. In conclusion, Stover's of Jibat and Kuleni could be used as forage when harvested at milk, however, the three tested maize varieties are also used as animal feed at the dough stage after removing the green cobs for human consumption under the highland areas of Holetta and similar agro-ecologies. Furthermore, their feeding value on the animal performance should be validated.

Conflict of Interest

The authors declare no conflict of interest.

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References

Anandan, S., Khan, A.A., Ravi, D., Rao, M.S.B., Reddy, Y.R., Blümmel, M. (2013). Identification of a superior dual purpose maize hybrid among widely grown hybrids in South Asia and value addition to its stover through feed supplementation and feed processing. Field Crops Research, 153:52-57.

Cochrane, L., Bekele, Y.W. (2018). Average crop yield (2001-2017) in Ethiopia: Trends at national, regional and zonal levels. Data in Brief, 16:1025-1033.

Dejene, M., Dixon, R.M., Walsh, K.B., McNeill, D., Seyoum, S., Duncan, A.J. (2022). High-cut harvesting of maize stover and genotype choice can provide improved feed for ruminants and stubble for conservation agriculture. Agronomy Journal, 114:187-200.

Ertiro, B.T., Twumasi-Afriyie, S., Blümmel, M., Friesen, D., Negera, D., Worku, M., Kitenge, K. (2013). Genetic variability of maize stover quality and the potential for genetic improvement of fodder value. Field Crops Research, 153:79-85.

Faji, M., Kebede, G., Tsegahun, A., Mohammed, K., Minta, M., Feyissa, F., Mengistu, S. (2021). Evaluation of maize (*Zea mays* L.) genotypes for forage biomass yield and nutritional quality. Ethiopian Journal of Agricultural Sciences, 31:65-81.

Feyissa, F., Kebede, G., Assefa, G. (2015). Dynamics in nutritional qualities of tef and wheat straws as affected by storage method and storage duration in the central highlands of Ethiopia. African Journal of Agricultural Research, 10:3718-3725.

Gebre, W., Mohammed, H. (2015). Study on Adaptability and Stability of Drought Tolerant Maize Varieties in Drought Prone Areas of South Omo Zone, SNNPRS". International Journal of Research.

Geleti, D., Tolera, A., Mengistu, A., Hailemariam, M. (2011). Effect of variety of maize on yield of grain, residue fractions and the nutritive value of the whole stover. Ethiopian Journal of Applied Science and Technology, 2:87-91.

Jia, H., Qu, M., Wang, G., Walsh, M.J., Yao, J., Guo, H., Liu, H. (2020). Dough-stage maize (*Zea mays* L.) ear recognition based on multiscale hierarchical features and multifeature fusion. Mathematical Problems in Engineering, pp:1-14.

Kennington, L.R., Hunt, C.W., Szasz, J.I., Grove, A.V., Kezar, W. (2005). Effect of cutting height and genetics on composition, intake, and digestibility of corn silage by beef heifers. Journal of Animal Science, 83:1445-1454.

Malik, K., Tokkas, J., Anand, R.C., Kumari, N. (2015). Pretreated rice straw as an improved fodder for ruminants-An overview. Journal of Applied and Natural Science, 7:514-520.

Worku, M., Twumasi Afriyie, S., Wolde, L., Tadesse, B., Demisie, G., Bogale, G., Prasanna, B.M. (2012). Meeting the challenges of global climate change and food security through innovative maize research. Proceedings of the National Maize Workshop of Ethiopia, Addis Ababa, Ethiopia, CIMMYT.

Neylon, J.M., Kung Jr, L. (2003). Effects of cutting height and maturity on the nutritive value of corn silage for lactating cows. Journal of Dairy Science, 86:2163-2169.

Saiyad, M.M., Kumar, S. (2018). Evaluation of maize genotypes for fodder quality traits and SSR diversity. Journal of Plant Biochemistry and Biotechnology, 27:78-89.

Somegowda, V.K., Vemula, A., Naravula, J., Prasad, G., Rayaprolu, L., Rathore, A., Deshpande, S.P. (2021). Evaluation of fodder yield and fodder quality in sorghum and its interaction with grain yield under different water availability regimes. Current Plant Biology, 25:100191.

Szulc, P., Ambroży-Deręgowska, K., Waligóra, H., Mejza, I., Grześ, S., Zielewicz, W., Wróbel, B. (2021). Dry matter yield of maize (*Zea mays* L.) as an indicator of mineral fertilizer efficiency. Plants, 10:535.

Tegegne, A., Gebremedhin, B., Hoekstra, D., Belay, B., Mekasha, Y. (2013). Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. IPMS Working Paper.

Thornton, P.K. (2010). Livestock production: Recent trends, future prospects. Philosophical Transactions of the Royal Society B: Biological Sciences, 365:2853-2867.

Tilley, J.M.A., Terry, D.R. (1963). A two-stage technique for the *in vitro* digestion of forage crops. Grass and Forage Science, 18:104-111.

Tolera, A., Berg, T., Sundstøl, F. (1999). The effect of variety on maize grain and crop residue yield and nutritive value of the stover. Animal Feed Science and Technology, 79:165-177.

Tolera, A., Said, A.N. (1992). Prospects for integrating food and feed production in Welayita Sodo, Ethiopia. In The Complementarity of Feed Resources for Animal Production in Africa: Proceedings of the Joint Feed Resources Networks Workshop Held in Gaborone, Botswana, p:309.

Tolera, A., Sundstøl, F. (1999). Morphological fractions of maize stover harvested at different stages of grain maturity and nutritive value of different fractions of the stover. Animal Feed Science and Technology, 81:1-16.

Tuturoong, R.A.V., Malalantang, S.S., Moningkey, S.A.E. (2020). Assessment of the nutritive value of corn stover and king grass in complete feed on Ongole steer calves productivity. Veterinary World, 13:801.

Wang, X., Lei, Z., Shimizu, K., Zhang, Z., Lee, D.J. (2020). Improved methane production from corn straw using anaerobically digested sludge pre-augmented by nanobubble water. Bioresource Technology, 311:123479.

Zom, R.L.G., André, G., Van Vuuren, A.M. (2012). Development of a model for the prediction of feed intake by dairy cows: 1. Prediction of feed intake. Livestock Science, 143:43-57.

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