



Evaluation of maize varieties for fodder and silage production in the eastern terai region of Nepal

Sujaya Upreti^{1*}, Ram Prasad Ghimire¹ and Santosh Marahatta²

¹National Pasture and Fodder Research Program, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal

²Agriculture and Forestry University, Rampur, Chitwan, Nepal

*Corresponding author's email: sujayaupreti824@gmail.com

*Sujaya Upreti: <https://orcid.org/0009-0005-5831-017X>

ARTICLE INFO

Research Paper

Received: July 10, 2026

Revised: July 20, 2026

Accepted: July 26, 2026

Published: September 4, 2026

Contents available at
<http://www.sasnepal.org.np>

Copyright 2026 © The Author(s).

Published by Society of Agricultural Scientists Nepal (SAS-Nepal).

This is an open access article under the CC BY-NC 4.0 license (<https://creativecommons.org/licenses/by-nc/4.0/>).

ABSTRACT

Feed deficit and the availability of low-cost fodder for dairy animals especially during winter and early summer is crucial in Nepal. Growing dairy industries are demanding more fodder to reduce the expensive concentrate feed. The intervention of maize (*Zea mays*) silage could be one of the options helping with the availability of quality fodder at low cost throughout the year. An experiment was conducted at the National Buffalo Research Program, Tarahara, Sunsari from September to March, 2025 to assess the production potential and nutrient composition of maize varieties for fodder and silage production. The experiment was executed in a Randomized Complete Block Design (RCBD) with eleven treatments considering maize varieties Arun-2, Arun-4, Rampur Hybrid-10, Rampur Hybrid-12, Rampur Hybrid-14, Rampur Hybrid-16, Poshilo Makai-1, Rampur Composite, African Tall, J1006 and Collection-1 and replicated four times. The biomass-attributing characters, biomass yield, nutrient composition and polyphenolics of maize and maize silage were recorded. The results showed that, African tall and J1006 were found promising maize ($p < 0.001$) with the highest dry matter yield of 20.71 and 20.67 t/ha respectively. Biomass-attributing characters, nutrient composition and polyphenols exhibited highly significant variation ($p < 0.001$). African tall and Rampur Composite had similar 10.69% and 10.68% respectively. The production performance of maize silage varied significantly ($p < 0.001$), where Rampur Composite was found to be likely considering dry matter yield (15.30 t/ha) and had statistically similar dry matter of J1006 (14.88 t/ha) and African Tall (14.79 t/ha). Besides, the nutrient composition and polyphenolic content of maize silage were varied significantly ($p < 0.001$). African Tall had the highest CP (8.91%) which was statistically similar to J1006 (8.48%) and Collection-1 (8.57%). Correlation analysis showed significant associations among key morphological and biomass-related traits, and that aroma and pH may provide more reliable indicators of fermentation quality than colour alone. This study revealed key insights for farmers in selecting the most suitable maize varieties for maize silage production ensuring better yield and nutrient composition for livestock.

Keywords: Biomass, nutrient composition, polyphenolic, dry matter, farmer

Cited as: Upreti S, R Ghimire and S Marahatta. 2026. Evaluation of maize varieties for fodder and silage production in the eastern terai region of Nepal. Nepal Agriculture Research Journal 17(1): 250-260. DOI: <https://doi.org/10.3126/narj.v17i1.99487>

INTRODUCTION

Fodder is the cheapest and obligatory source of carbohydrates, protein, vitamins, and minerals for ruminant animals. The production and quality characteristics of fodder and forage crops are strongly influenced by agronomic management practices (Rai 2024). These

parameters are also influenced by planting season. As the winter season is the lean period for forage production in the country most of the feeding materials are crop residues and crop byproducts which are poor in digestibility and low in nutrient content, especially in terms of crude protein (Pandey 2022, MoALD 2019). Nepalese farmers have small number of alternative fodders for the harsh winter. Thus, it is necessary to work towards developing technologies that would address the need for more green fodder (with high nutrient and digestibility) and silage production especially for winter seasons (Garg and Upreti 2019).

Maize is considered ideal fodder because it grows quickly, produces high yields, is palatable, rich in nutrients, and helps to increase body weight and milk quantity and quality in cattle (Sattar et al 1994). Maize harvested for fodder is both palatable and nutritious, with a crude protein (CP) content ranging from 7 to 11.4%. When processed into silage, its CP content increases to approximately 9.0% (Chaudhary et al 2012). Maize is a valuable source of energy-rich forage for dairy animal diets and can be safely fed at all growth stages without the risk of oxalic acid or prussic acid toxicity, unlike sorghum (Dahmardeh et al 2009). In its green stage, maize contains high levels of soluble sugars, making it well suited for silage preservation (Chaudhary et al 2014). Consequently, maize is increasingly prioritised to support the growing dairy industry and to support year-round feed availability. Several maize varieties have been released and used over the decades in production systems in Nepal, but what could be the suitable varieties, packages of cultivation practices of maize and production potential for Nepalese Terai and mid-hill ecology has not yet been identified. Given the importance of maize in livestock feed, it is essential to identify better varieties, and have information regarding their production potential as biomass and silage, nutrient content and morphological traits.

MATERIALS AND METHODS

The experiment was conducted from September to March, 2025 to assess the production potential and nutrient composition of maize varieties for fodder and silage production. Experimental maize varieties African Tall, J1006 and Collection-1 received from Punjab State Co-operative Milk Producers Federation Limited, Ludhiana and Arun-2, Arun- 4, Rampur Hybrid-10, Rampur Hybrid-12, Rampur Hybrid-14, Rampur Hybrid-16, Poshilo Makai-1 and Rampur Composite received from the National Maize Research Program, Rampur, Chitwan and replicated four times. The study site was situated at 136 m asl in a subtropical climate with warm humid summers and mild winters with an average annual rainfall of 1750 mm and an average temperature of 24.5°C. The soil type was clay loam with 6.5 pH. The varieties chosen were on the basis of maturity period; as early, mid and late varieties and suitability for the study sites. The experiment was executed in Randomised Complete Block Design (RCBD) with eleven treatments and four replications. The row-to-row distance was maintained at 60 cm and the plant-to- plant distance, at 25 cm in net plot size of 4.8 × 2.5m and the plant population was of 66,666.66 per hectare as a density. Before 10 days of sowing farmyard manure was applied at the rate of 10t/ha, followed by chemical fertiliser at the rate of 100:50:50 kg/ha where nitrogen was applied in two splits at the time of sowing and pre-flowering stage. The morphological characteristics (plant height, leaf area, leaf length, leaf breadth and leaf numbers) were determined by randomly selecting 5 plants from each plot. The standing crop was harvested at milking stage by using a 1x1 m quadrat. The treatment-wise green biomass yield was taken from each plot and averaged to get green biomass yield per plot whereas for dry matter, harvested weight of green matter was used to calculate dry biomass yield. Maize varieties and maize silage were analyzed in the laboratory of the National Animal Nutrition Research Center, Khumaltar, Lalitpur. The dry matter (DM) was estimated by using the continuous heating method. Crude protein fraction was analysed by using the AOAC protocol

(AOAC 1980) and NDF, ADF and ADL of the sample were analysed by using Georing and Van Soest protocol (Georing and Van Soest 1970). The energy content in sample was analysed by using Bomb calorimeter.

The studied maize varieties harvested at the dough stage (milking stage) were wilted and chopped to a length of 1-3 cm. The chopped fodder was filled rapidly in the plastic bag silage of size 6 kg with measurements of length - 60cm, breadth - 40cm and thickness - 30 micron. The air was evacuated by a vacuum pump to create anaerobic conditions in the silage bag. The hedonic table was used to score the physical properties (colour, taste and aroma) of the silage. The data from the experiments were examined for ANOVA. It was done to test the significance among treatments. LSD ($p < 0.05$) was used as a post hoc analysis for mean comparison. GenStat Discovery 18th edition (VSNi 2015) was used for data analysis.

RESULTS

Maize dry matter yield and biomass-attributing characters in milking stage considering varieties of maize

Among the studied 11 maize varieties biomass-attributing characters, plant height and leaf area showed highly significant variation ($p < 0.001$), with African Tall attaining the tallest height of 246 cm followed closely by J1006 of height 240.60cm and the shortest height was that of Rampur Composite with of 161.80 cm (Table 1). The highest leaf area was of 519.90cm² observed in African Tall and the lowest was that of Rampur Composite of 262.10cm². African Tall and J1006 were found promising ($p < 0.001$) with the highest dry matter yield of 20.71 and 20.67 t/ha correspondingly and lowest yield was of Arun-2 with dry matter of 12.04 t/ha.

Table 1. Morphology and production performance of maize in milking stage at NBRP, Tarahara in FY 2025.

Maize varieties	Plant height (cm)	Leaf number/plant	Leaf area (cm ²)	Stem Diameter (cm)	Fodder dry matter yield (t/ha)
Arun-2	199.60 ^b	10.85	405.60 ^{ab}	7.87	12.04 ^f
Arun-4	175.40 ^{bc}	10.65	411.10 ^{ab}	91.75	14.34 ^{ef}
Rampur Hybrid-10	182.60 ^{bc}	11.50	326.50 ^{bc}	7.97	17.87 ^{abcd}
Rampur Hybrid-12	199.60 ^b	10.85	275.50 ^c	7.45	17.04 ^{bcde}
Rampur Hybrid-14	180.10 ^{bc}	11.60	434.20 ^{bcd}	8.4	15.41 ^{de}
Rampur Hybrid-16	177.70 ^{bc}	10.95	465.00 ^{cd}	8.30	15.93 ^{cde}
Poshilo Makai-1	201.80 ^b	10.85	460.00 ^{ab}	9.05	18.58 ^{abc}
Rampur Composite	161.80 ^c	11.40	262.10 ^c	7.97	19.15 ^{ab}
African Tall	246.0 ^a	10.00	519.90 ^a	8.4	20.71 ^a
J1006	240.60 ^{ab}	10.30	477.60 ^{ab}	8.32	20.67 ^a
Collection-1	238.60 ^a	10.05	465.60 ^{ab}	9.02	19.54 ^{ab}
SEM	10.16	0.37	24.70	0.31	0.93
p-value	***	NS	***	NS	***
LSD _{0.05}	19.36	1.08	30	0.90	2.7
CV, %	4.20	6.90	19.80	2.8	10.8

Note: Means with letter NS= Not Significant, *** = Significant at 0.001 percent level, SEM=Standard Error of Mean, LSD=Least Significance Difference, CV=Coefficient of Variation, superscript value with same letter = not significantly different from each other, superscript value with different letter = significantly different from each other.

Nutrient composition and polyphenolic compounds of maize varieties in milking stage

The nutrient composition and polyphenolic compounds were analysed at the milking stage in which CP, NDF, ADF and ADL exhibited highly significant variation ($p < 0.001$). African Tall and Rampur Composite had highest CP content 10.69% and 10.68% respectively and

lowest was that of Arun-2 (8.80%) (Table 2). The NDF was observed highest in Rampur Hybrid-16 (72.33%) while ADF and ADL were highest in Arun-2 with of 44.02% and 11.79% respectively and the lowest NDF, ADF and ADL were found in African Tall with of 56.31%, 32.58% and 6.04% respectively. The energy content was higher ($p<0.05$) in Rampur Composite (3337 Kcal/kg) which was similar to J1006 (3333 Kcal/kg) maize variety, and lower in Arun-4 (3140 Kcal/kg).

Table 2. Nutrient composition and polyphenolic (%) of maize varieties in dough stage at NBRP, Tarahara in FY 2025.

Maize varieties	CP	NDF	ADF	ADL	Energy (Kcal/kg)
Arun-2	8.80 ^c	71.29 ^{ab}	44.02 ^a	11.79 ^a	3161 ^b
Arun-4	8.99 ^c	71.51 ^{ab}	42.83 ^{ab}	11.32 ^a	3140 ^b
Rampur Hybrid-10	9.67 ^{abc}	70.79 ^{ab}	36.40 ^e	7.66 ^{cde}	3158 ^b
Rampur Hybrid-12	9.52 ^{bc}	70.90 ^{ab}	40.16 ^{bcd}	10.32 ^{ab}	3169 ^b
Rampur Hybrid-14	8.98 ^c	70.69 ^{ab}	40.92 ^{abc}	9.29 ^{bc}	3161 ^b
Rampur Hybrid-16	9.34 ^c	72.33 ^a	41.45 ^{abc}	8.51 ^c	3141 ^b
Poshilo Makai-1	9.66 ^{abc}	69.36 ^{ab}	40.74 ^{abc}	8.50 ^c	3256 ^{ab}
Rampur Composite	10.68 ^a	67.64 ^b	42.65 ^{ab}	8.26 ^{cd}	3337 ^a
African Tall	10.69 ^a	56.31 ^d	32.48 ^f	6.04 ^e	3148 ^b
J1006	9.63 ^{abc}	61.47 ^c	36.92 ^{de}	6.05 ^e	3333 ^a
Collection-1	10.62 ^{ab}	61.79 ^c	38.48 ^f	6.66 ^{de}	3181 ^b
SEM	0.34	1.78	1.66	0.55	39.70
p-value	***	***	***	***	*
LSD _{0.05}	0.99	3.65	3.39	1.61	11.46
CV, %	2.6	3.7	5.9	1.5	2.5

Note: Means with letter NS= Not Significant, * = Significant at 0.05 percent level, *** = Significant at 0.001 percent level, SEM=Standard Error of Mean, LSD=Least Significance Difference, CV=Coefficient of Variation, superscript value with same letter = not significantly different from each other, superscript value with different letter = significantly different from each other.

Production potential, nutrient composition and polyphenolics of maize silage

The production performance of maize silage varied significantly ($p<0.001$), where Rampur Composite was found to be likely considering dry matter yield (15.30 t/ha) and had statistically similar dry matter of J1006 (14.88t/ha) and African Tall (14.79t/ha). The lowest dry biomass was that of Arun-2 (9.24 t/ha). Besides, the nutrient composition and polyphenolics of silage maize were analysed at the milking stage, in which CP, NDF, ADF, ADL, energy and pH varied significantly ($p<0.001$). African Tall had the highest CP (8.91%) which was statistically similar to J1006 (8.48%) and Collection-1 (8.57%) (Table 3).

The energy content was highest of Rampur Composite (3484 kcal/kg) which was similar to J-1006 (3462 kcal/kg). Similarly, pH was highest of Rampur Composite (4.15%) and the lowest CP and pH was of Arun-2 6.20% and 3.82% respectively. The lowest energy was observed in Arun-2 (3270 kcal/kg). Rampur Hybrid-16 had the highest NDF and ADF 68.22% and 40.81% respectively. ADL content was more of Arun-4 (9.76%) which was close to Arun-2 (9.75%). The lowest NDF, ADF and ADL content was of African Tall 54.32%, 30.39% and 5.77% respectively.

Table 3. Production potential, nutrient composition and polyphenolics of maize silage at NBRP, Tarahara in FY 2025.

Maize Silage Varieties	DM (t/ha)	CP (%)	NDF (%)	ADF (%)	ADL (%)	Energy (kcal/kg)	pH
Arun-2	9.24 ^d	6.20 ^e	68.77 ^a	40.34 ^a	9.75 ^a	3270 ^{bc}	3.82 ^f
Arun-4	10.02 ^{cd}	6.88 ^{de}	66.85 ^{ab}	40.11 ^a	9.76 ^a	3209 ^c	3.84 ^f
Rampur Hybrid-10	11.87 ^{bc}	7.31 ^{bcd}	68.35 ^{ab}	34.50 ^c	6.192 ^{de}	3268 ^{bc}	4.14 ^a
Rampur Hybrid-12	11.67 ^{bc}	7.01 ^{cde}	67.20 ^{ab}	38.64 ^{ab}	8.87 ^{ab}	3263 ^{bc}	4.04 ^{bc}
Rampur Hybrid-14	10.70 ^{cd}	7.25 ^{cd}	68.20 ^{ab}	38.82 ^{ab}	8.007 ^{bc}	3269 ^{bc}	3.99 ^{cd}
Rampur Hybrid-16	10.57 ^{cd}	7.13 ^{cde}	68.22 ^a	40.81 ^a	7.88 ^{bc}	3259 ^{bc}	3.95 ^{de}
Poshilo Makai-1	11.79 ^{bc}	8.02 ^{ab}	66.36 ^{ab}	39.30 ^{ab}	6.90 ^{cde}	3370 ^{ab}	3.96 ^{de}
Rampur Composite	15.30 ^a	8.29 ^{ab}	65.31 ^b	39.74 ^a	7.17 ^{cd}	3484 ^a	4.15 ^a
African Tall	14.79 ^a	8.91 ^a	54.32 ^d	30.39 ^d	5.77 ^e	3282 ^{bc}	4.11 ^{ab}
J1006	14.88 ^a	8.48 ^a	60.24 ^c	34.94 ^c	5.82 ^e	3462 ^a	3.89 ^{ef}
Collection-1	13.29 ^{ab}	8.57 ^a	59.89 ^c	36.47 ^{bc}	6.32 ^{de}	3282 ^{bc}	3.94 ^{de}
SEM	1.05	0.45	1.38	1.42	0.58	43.60	0.03
p-value	***	***	***	***	***	***	***
LSD _{0.05}	2.14	0.93	2.83	2.90	1.18	126	0.07
CV, %	3.2	1.2	3.0	2.5	2.1	87.2	1.3

Note: Means with letter NS= Not Significant, *** = Significant at 0.001 percent level, SEM=Standard Error of Mean, LSD=Least Significance Difference, CV=Coefficient of Variation, superscript value with same letter = not significantly different from each other, superscript value with different letter = significantly different from each other.

Physical properties of maize silage

The physical properties of maize silage were given in Table 4.

Table 4. Physical properties of maize silage at NBRP, Tarahara in FY 2025.

Maize Silage	Colour	Taste	Aroma
Arun-2	8.00 ^{ab}	8.25 ^a	7.50 ^{abcd}
Arun-4	8.50 ^a	7.50 ^{ab}	8.00 ^{abc}
Rampur Hybrid-10	7.75 ^{ab}	7.50 ^{ab}	8.00 ^{abc}
Rampur Hybrid-12	7.50 ^{ab}	7.50 ^{ab}	7.75 ^{abcd}
Rampur Hybrid-14	8.50 ^a	7.50 ^{ab}	8.25 ^{ab}
Rampur Hybrid-16	7.50 ^{ab}	8.25 ^a	8.25 ^{ab}
Poshilo Makai-1	7.50 ^{ab}	7.50 ^{ab}	8.00 ^{abc}
Rampur Composite	7.75 ^{ab}	7.50 ^{ab}	7.25 ^{bcd}
African Tall	7.00 ^b	7.50 ^{ab}	7.00 ^{cd}
J1006	8.25 ^a	7.75 ^{ab}	8.50 ^a
Collection-1	7.50 ^{ab}	7.50 ^{ab}	7.75 ^{abcd}
SEM	0.44	0.44	0.47
p-value	*	**	**
LSD _{0.05}	0.91	0.90	0.96
CV, %	1.10	1.20	1.1

Note: 1 = Dislike extremely, 2 = Dislike, 3 = Dislike moderately, 4 = Dislike slightly, 5 = Neither like or dislike, 6 = Like slightly, 7= Like, 8 = Like very much, 9 = Like extremely for Colour, Taste & Aroma. Means with letter * = Significant at 0.05 percent level, ** = Significant at 0.01 percent level, SEM=Standard Error of Mean, LSD=Least Significance Difference, CV=Coefficient of Variation, superscript value with same letter = not significantly different from each other, superscript value with different letter = significantly different from each other.

The physical properties of silage, colour (<0.05), taste, and aroma (<0.01) varied significantly, where Arun-4, Rampur Hybrid-14 and J1006 had preferred colour of yellowish green scored 8.50 (Table 4). The mildly acidic taste was of J1006 (8.50 score), and Rampur

Hybrid-16 (8.25 score) and Arun-2 (8.25 score) had mildly acidic and fruity aroma. The moderate colour, taste and aroma were of African Tall scoring 7, 7.50 and 7 respectively.

Correlation among morphological attributes and biomass productivity

Correlation analysis revealed significant associations among key morphological and biomass-related traits (Table 5). Plant height was strongly and positively correlated with leaf length ($r = 0.771$, $P < 0.01$) and moderately correlated with leaf area ($r = 0.548$, $P < 0.05$), whereas leaf length showed a strong association with stem diameter ($r = 0.849$, $P < 0.01$). Leaf breadth was positively correlated with leaf area and stem diameter ($r = 0.508$ and 0.481 , respectively; $P < 0.05$), indicating coordinated development of vegetative structures. Biomass-related traits exhibited particularly strong interrelationships. Green matter yield measures were perfectly correlated ($r = 1.000$, $P < 0.01$), while dry matter percentage was strongly associated with dry matter yield ($r = 0.815$, $P < 0.01$). Dry matter yield also showed strong positive correlations with Dmonekg ($r = 0.708$, $P < 0.01$) and DMts ($r = 0.818$, $P < 0.01$), with the strongest relationship observed between Dmonekg and DMts ($r = 0.901$, $P < 0.01$). Overall, the results demonstrate strong coordination among morphological attributes and biomass productivity, highlighting the potential of selected plant growth traits as indicators of dry matter accumulation and yield.

Table 5. Correlation among morphological attributes and biomass productivity of maize.

	LL	LB	LA	Stem Diameter	GMKG	GMmt	DMg	DMp	DMt	Dmonekg	DMts
PH	.771**	-0.221	.548*	0.188	0.158	0.158	-0.213	0.376	0.378	.494*	0.423
LL		-0.021	.849**	0.321	0.087	0.087	-0.319	0.153	0.164	0.237	0.2
LB			.508*	.481*	-0.235	-0.235	0.029	-0.087	-0.19	-0.313	-0.333
LA				.523*	-0.051	-0.051	-0.259	0.104	0.057	0.06	0.013
Stem Diameter					0.013	0.013	-0.101	-0.008	0.006	-0.124	-0.092
GMKG						1.000**	0.168	0.03	.601**	0.287	.670**
GMmt							0.168	0.03	.601**	0.287	.670**
DMg								0.223	0.278	0.031	0.106
DMp									.815**	.676**	.535*
DMt									1	.708**	.818**
Dmonekg											.901**

Note:PH= Plant height, LL= Leaf length, LB=Leaf Breadth, LA=Leaf Area, Means with letter * = Significant at 0.05 percent level, ** = Significant at 0.01 percent level, SEM=Standard Error of Mean, LSD=Least Significance Difference, CV=Coefficient of Variation

Correlation among silage physical properties

Correlation analysis showed that pH was negatively correlated with colour ($r = -0.353$, $P < 0.05$), taste ($r = -0.350$, $P < 0.05$), and aroma ($r = -0.356$, $P < 0.05$), indicating a negative association between lower pH and improved silage sensory quality (Table 6). Among sensory attributes, colour was strongly correlated with aroma ($r = 0.541$, $P < 0.01$), whereas its relationship with taste was non-significant ($r = 0.268$, $P > 0.05$). Taste and aroma were moderately correlated ($r = 0.339$, $P < 0.05$). These findings suggest that aroma and pH may provide more reliable indicators of fermentation quality than colour alone.

Table 6. Correlation between the pH and silage colour and taste.

	Taste	Aroma	pH
Colour	0.268	.541**	-.353*
Taste		.339*	-.350*
Aroma			-.356*

Note: Means with letter * = Significant at 0.05 percent level, ** = Significant at 0.01 percent level, SEM=Standard Error of Mean, LSD=Least Significance Difference, CV=Coefficient of Variation

DISCUSSION

Maize varietal response in milking stage for higher herbage mass production

The maize should be harvested when the dry matter content is ranged from 30-38% to achieve higher yield and maize's best quality in which the plants have reached a good starch content and fibre digestibility (Kung 2008). Delay in harvesting may cause root lodging that reduces biomass production from 25 to 40 per cent before 15 days of silking (So et al 2013). In this study, maize was harvested in milking stage with dry matter content from 30-35% and dry biomass yield of 12 to 20%. The dry matter yield of African Tall (20.71 t/ha) and J-1006 (20.67 t/ha) is lower than the study of (Chaudhary et al 2012) as the authors had recorded dry matter production of African tall and J-1006 as 22.24 t/ha and 24.28 t/ha respectively at the milking stage. Andrade et al (1993) and Sangoi et al (2002) reported that plant height significantly impacted on the biomass production. These findings are related to this study that African Tall had the highest plant height among other fodder maize varieties at the milking stage and had the highest biomass production. Physiological development and agronomic processes of crops are affected by leaf area (Gao et al 2012 and Pandey and Singh 2011). Leaf area is a crucial physiological trait which is used to indicate the performance of a plant canopy for growth and production (Roth and Heinrichs 2018). This might be the reason that in our study African Tall having more leaf area has more dry herbage production than other tested varieties.

Status of major nutrient composition and polyphenolics of maize varieties in dough stage

The optimum fodder maize harvesting time is in the milk stage (60 to 70 days) after sowing where energy, CP and NDF levels are higher in this stage (Ayub et al 2023). The protein content decreases with the advancing maturity of the plant (Wattiaux, 1994). The overall CP content of maize varieties lies in the range of 5 to 12% as reported by (Feedipedia, 2016) which is in line with this study which ranged from 8 to 10%. More than 35 per cent of NDF is required to improve fat content in the milk (Beauchemin, 1996). However, Varga (2023) recommended a minimum of 28 per cent in dairy diets. Beauchemin (1996) further reported that increased NDF concentration of the diet linearly increases fat content of milk ranging from 2.68 to 3.30 per cent. Both dietary NDF intake and energy intake must be maximised to increase milk yield and milk fat content. In this study, NDF was found twice more than the required amount which could be beneficial for the quality milk production. The energy concentration of fodder is determined by the ADF content (Beauchemin 1996). As the plants mature ADF content increases linearly ranging from 29 to more than 45 per cent (Anderson, 2021). Increasing ADF intakes does not affect the milk production but increases milk fat concentration linearly. Higher ADF content facilitates longer chewing and rumination time which helps in the digestibility of the feed stuffs (Santini et al 2003). Upreti and Shrestha, 2006 documented that feed with 36 to 45 per cent ADF as medium level which is close to the experimental results ranging from 32- 44 % ADF. Lignin is found in cell walls which binds the cell protein along with cellulose and further reduces its availability to microbes

(Holtzaple 2003). It makes difficulty in fibre digestion difficult as it obstructs the enzyme access to the digestible fibre fraction, cellulose, and hemicellulose. Lignin levels increase as the plant matures, which reduces digestibility and deteriorates forage quality (Holtzaple, 2003 and Casli 2016). Normally maize contains 12 to 20 per cent lignin (Wozniak et al 2021) but in this study lignin content ranged from 6 to 11 per cent. Several authors reported that there is inverse correlation between lignin concentration, DM and NDF digestibility (Barsila 2023, Smith 2016). ADL content of more than 20% declines fodder quality (Upreti and Shrestha 2006).

Production potential, nutrient composition and polyphenolics of maize silage

Maize silage is used extensively for lactating dairy cows that require high-energy feed for maximum milk production (Marsalis et al 2010, Irlbeck et al 1993). Desirable forage characteristics include high dry matter yield, high protein concentration, high energy concentration, high intake potential, and optimum dry matter concentration at harvest for acceptable forage fermentation (Carter et al 1991). Late maturing varieties produce significantly higher dry matter yield than early maturing varieties (Graybill et al 1991) which is true with this study that late variety J1006 (14.88 t/ha) and African Tall (14.79 t/ha) produced more dry matter than early variety Arun-2 (9.24 t/ha) and Arun-4 (10.20 t/ha). The decrease in the content of CP and NDF in silage compared to forage in this study is similar with the result obtained by Phiri et al 2007. The variability in CP content of silage could be due to genetic composition, maturity stages and silage preservation process. The energy content of maize silage reported by Khan et al 2024 was in the range of 2340-2470 kcal/kg which was less than of this study (3209-3484 kcal/kg). The pH values obtained in this study (3.8 - 4.15) were within the recommended range of 3.7 - 4.2 stated by Karsten et al 2003. The higher ADF content in maize silage Arun-2 (40.34%) and Arun-4 (40.11%) might be due to the non-solubilization of cell wall components which are less digestible (Nazli et al 2018).

Physical characteristics of maize silage

The quality of silage depends on the stage at which the fodder is harvested. Maize is best suited to be ensiled when the maize is in the milking stage which is usually found in 60–70 days after sowing in the tropical region. The dry matter content of the whole plant should be around 25–30 % Chaudhary et al (2014). The end products of silage fermentation are often monitored to assess silage quality. Karsten et al (2003) and Kung et al (2018) stated that the good fermented maize silage should be leafy, soft to touch, yellowish-brown, mildly pleasant, and have a slightly acidic smell. In addition, the silage must be high in CP and metabolizable energy (ME) contents which was in line with this study. The slightly acidic aroma of the studied silage could be due to the production of organic acids primarily lactic acid, due to the fermentation process.

CONCLUSIONS

The findings suggested that selecting appropriate maize varieties can substantially improve both fodder availability and silage quality, thereby enhancing livestock productivity and reducing seasonal feed shortages. This study showed that among the eleven varieties of maize tested, African Tall, J006 and Rampur Composite were found best as a fodder and silage in the eastern terai region of Nepal. However, multi-location and multi-season research trials, including animal feeding trials and economic evaluation should be conducted to confirm suitability and adaptation of the selected maize varieties before making wide recommendations. This study provides valuable information for farmers, and researchers in choosing maize varieties best suited for fodder and silage production.

Acknowledgements

The authors are thankful to the Nepal Agricultural Research Council (NARC), for providing financial support; National Bovine Research Program, Tarahara, NARC for making available research trial plots and managerial support throughout the experimental period; and National Animal Nutrition Research Centre, NARC, Khumaltar for nutrient analysis.

Authors' Contributions

Sujaya Upreti: Experimentation of study maize varieties at research plot, data processing and manuscript preparation.

Ram Prasad Ghimire: Supervision and review of manuscript.

Santosh Marahatta: Statistical analysis and interpretation of the result.

Conflicts of Interest

The author(s) declare that they have no potential conflicts of interest with respect to the research, authorship, or publication of this article.

Publisher's Note

All claims made in this article are those of the authors alone; they do not necessarily reflect the views of any affiliated organizations, the publisher, the editors, or the reviewers.

REFERENCES

- Anderson J. 2021. Forage Nutrition 101: Acid Detergent Fibre & Neutral Detergent Fibre. <https://www.anderson-hy.com/blog/forage-nutrition>.
- Andrade FH, SA Uhrt and A Cirilo. 1993. Temperature affects radiation use efficiency in maize. *Field Crops Res.*, **32**: 17-25.
- Ayub M, A Muhmmad, M Nadeem, R Ahmad and J Farhn. 2003. Response of maize fodder to different nitrogen level and harvesting time. *Pak. j. life soc. sci.* **1**(1): 45-47.
- Barsila SR, MS Dhami, BK Shrestha and LN Pandey. 2023. Effect of short-term grazing exclusion on herbage species composition, dry matter productivity, and chemical composition of subtropical grasslands. *Open Agriculture* **8**(1): 20220223.
- Beauchemin K. 1996. Using ADF and NDF in dairy cattle diet formulation—a western Canadian perspective. *Animal Feed Science and Technology* **58** (1–2): 101-111.
- Carter PR, JG Coors, DJ Undersander, KA Albrecht and RDS Shaver 1991. Corn hybrids for silage: an update. Roth. In: *Proceedings of annual corn & Sorghum research conference, 46th*. Chicago. American Seed Trade Association, Washington DC; **Pp**: 141–164
- Casli, MM. 2016. What is lignin? How does it affect alfa alfa quality and yield? *Feed Management. Progressive Dairy Digital Magazine*.
- Chaudhary DP, A Kumar, SS Mandhnia, P Srivastava and RS Kumar. 2012. Maize as Fodder? An alternative approach. *Techn. Bull.* **04** 32.
- Chaudhary SK, RN Singh, RK Upadhyay, HR Chaudhary, and Pal V. 2014. Effect of Vegetable Intercrops and Planting Pattern of Maize on Growth, Yield and Economics of Winter Maize (*Zea mays* L.) in Eastern Uttar Pradesh. *Environment & Ecology* **32** (1): 101—105.
- Dahmardeh M. 2011. Effect of plant density and nitrogen rate on PAR absorption and maize yield. *Am. J. Plant. Physiol.* **6**: 44-49.
- development for grazing heifers. *Agronomy Journal*. 2003 Jul 1; **95**(4): 870-7.

- Feedipedia. 2016. Maize green forage, Tables of chemical composition and nutritional value.
- Gao M, G Heijdena, J Vosb, B Eveleensc and L Marcelis. 2012. Estimation of leaf area for large scale phenotyping and modelling of rose genotypes. *Scientia Horticulturae* **138**.
- Goering HK and PJ Van Soest. 1970. Fodder fibre analysis. USDA Agriculture Handbook (No. 379.) Washington DC: USDA, ARS.
- Graybill JS, WJ Cox and DJ Otis. 1991. Yield and quality of forage maize as influenced by hybrid, planting date, and plant density. *Agronomy Journal* **83**(3): 559-564.
- Grg MR and CR Upreti. 2019. Assessment of Feed Resources, Feeding Practices, Nutritional Status, and Future Strategies for Improving Productive and Reproductive Efficiency of Dairy Animals including Standard Operation Procedure. NLSIP; **pp.** 1-136.
- Holtzaple MT. 2003. In: Encyclopedia of Food Sciences and Nutrition (Second Edition).
- Irlbeck NA, JR Russell, AR Hallauer and DR Buxton. 1993. Nutritive value and ensiling characteristics of maize stover as influenced by hybrid maturity and generation, plant density and harvest date. *Animal Feed Science Technology* **41**:51–64.
- Karsten HD, GW Roth and LD Muller. 2003. Evaluation of corn hybrids at two stages of development for grazing heifers. *Agronomy Journal*. 2003 Jul 1; **95**(4):870-7.
- Karsten HD, GW Roth and LD Muller. 2003. Evaluation of corn hybrids at two stages of
- Khan N, TA Shah, HMS Akhtar, AM Salamatullah, M Bourhia, AB Mekonnen, MZ Khan, M Nazar and NA Khan. 2024. Influence of maize genotypes and harvest stages on in-silo fermentation quality and nutritional value of corn silage during hot summer conditions of the tropics. *BMC Plant Biol.* 2024 Jun 3; **24**(1):490. doi: 10.1186/s12870-024-05179-1. PMID: 38825718; PMCID: PMC11145827.
- Kung L, R Shaver, R Grant and R Schmidt. 2018. The preservation and nutritional quality of silage. *Journal of Dairy Science*, 101(7), 6056-6071.
- Kung L, R Shaver, R Grant and R Schmidt. 2018. The preservation and nutritional quality of silage. *Journal of Dairy Science*, 101(7), 6056-6071. Kung, L., Shaver, R., Grant, R., & Schmidt, R. (2018). The preservation and nutritional quality of silage. *Journal of Dairy Science* **101**(7): 6056-6071.
- Marsalis MA, SV Angadi, FE Contreras-Govea FE. 2010. Dry matter yield and nutritive value of corn, forage sorghum, and BMR forage sorghum at different plant populations and nitrogen rates. *Field Crop Res* **116**:52–57
- MoALD/DLS. 2019. Balance Sheet of Animal Feed and Forage Seed of Nepal and Impact Study of Forage Mission Program. 1-102.
- Nazli, MH, RA Halim, AM Abdullah, G Hussin and AA Samsudin. 2019. Potential of four corn varieties at different harvest stages for silage production in Malaysia. *Asian-Australasian Journal of Animal Sciences* **32**(2): 224–232. <https://doi.org/10.5713/ajas.18.0175>.
- Pandey LN, NR Devkota, BN Devkota, SR Barsila and MR Tiwari. 2022. Effects of seasons and feed on serum minerals of goats reared in Mid-Hills of Nepal. *Nepalese Journal of Agricultural Sciences* **22**: 143-154
- Pandey SK, and H Singh. 2011. A simple, cost-effective method for leaf area estimation. *Journal of Botany* 7. Article ID 658240 | <https://doi.org/10.1155/2011/658240>.
- Phiri MS, NT Ngongoni, BV Maasdorp, M Titterton, JF Mupangwa and A Sebata. 2007. Ensiling characteristics and feeding value of silage made from browse tree legume-maize mixtures *Tropical and Subtropical Agroecosystems* **7**:149-56.
- Rai S. 2024. Improved Agronomic Practices on Enhancement of Quality Forage Production for Livestock Farming. *Agronomy Journal of Nepal* **8**: 226-236.
- Roth GW and AJ Heinrichs. 2018. Maize silage production and management. *Agronomy fact-18*. Pub. Information and Communication Technology in the College of Agricultural Sciences, Pennsylvania State University.

- Sangoi L, MA Gracietti, C Rampazzo and P Bianchetti. 2002. Response of Brazilian maize hybrids from different eras to changes in plant density. *Field Crops Res.* **79**: 39–51.
- Santini F, CD Lum, ML Potchoiba and SW Coleman. 2003. Effect of Acid Detergent Fiber intake on early postpartum milk production and chewing activities in dairy goat fed alfalfa hy. *Small Ruminant Research* **69**1-2: 63-71.
- Sattar MA, MF Haque, and MM Rahman. 1994. Intercropping maize with broadcast rice at different row spacing. *Bangladesh J Agric Res* **19**:159–164.
- Smith R. 2016. Reduced or Low lignin alfalfa: Advantages for Hay and Grazing. uky.edu/cgi/viewcontent.cgi?article=1005&context=ky_grazing.
- So YS, VO Adetimirin and SK Kim. 2013. Observational study on the recovery from root lodging at flowering time and yield reduction in maize (*Zea mays* L.). *Plant Breeding and Biotechnology*, **1**:171– 177.
- Upreti CR and BK Shrestha, B.K 2006. Nutrient Content of Feeds and Fodder in Nepal. NARC, **Pp.** 1-179.
- Varga GA.2023. In Vivo digestibility of Forages, NRC.
- Wattiaux M.1994. Nutrition and feeding, in technical dairy guide, The Board of Regents of the University of Wisconsin System. 1-121.
- Wozniak M, I Ratajczak, D Wojcieszak , A Agnieszka Waskiewicz, K Kinga Szentner, J Pryzbl, S Borysiak , S Piotr and P Golinski 2021. Chemical and structural characterization of maize stover fractions in aspect of its possible applications. PMID: PMC800400 DOI: 10.3390/ma14061527.