Bangladesh Journal of Animal Science
Journal homepage: http://www.banglajol.info/index.php/BJAS

Herbage mass of Teosinte (*Euchlaena mexicana*) grown as mono and mixed with legumes

B Khanal[1,4]✉, NR Devkota[2], MR Tiwari[3] and NA Gorkhali[4]

[1]Agriculture and Forestry University, Rampur, Chitwan, Nepal; [2]Gandaki University, Kaski, Pokhara, Nepal; [3]Former Principal Scientist of Nepal Agricultural Research Council, Nepal; [4]Nepal Agricultural Research Council, Nepal

ARTICLE INFO

Article history:
Received: 04 April 2022
Revised: 29 May 2022
Accepted: 08 June 2022
Published: 30 June 2022

Keywords:
Teosinte, green herbage, dry herbage, quality, quantity

Correspondence:
B Khanal
✉: birkhanal@gmail.com

ISSN: 0003-3588

OPEN ACCESS

ABSTRACT

The popular summer cereal fodder is Teosinte (*Euchlaena mexicana*) which has low productivity and chemical constituents. The quality and quantity of teosinte fodder can be enhanced by adjusting cultivation practices including use of appropriate sowing dates and by following an appropriate mixed cropping cultivation with legumes. This study was conducted to identify the fodder quantity and quality under a commonly practiced mixed cultivation of legumes with teosinte with varied sowing dates. Three combination of fodder; teosinte, teosinte+cowpea and tesosinte+rice bean was arranged in four sowing dates in Split Plot Design, replicated five times. Sowing dates were arranged as main plot while combination of fodder species was arranged as sub plot. Growth parameters of teosinte (tiller numbers/m^2, plant height), green herbage mass, dry herbage mass, crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined. The results showed significantly highest ($p<0.05$) cumulative green and dry herbage mass was obtained from teosinte+cowpea, if sown in 18th April followed by 28th April for the same combination of treatments. Significantly the highest ($p<0.001$) average value of CP was obtained from teosinte+cowpea whereas the highest ($p<0.001$) average value of NDF and ADF were obtained from teosinte mono crop. The effect of date of sowing and treatments interaction/combination on average value of CP, NDF and ADF were statistically similar ($p>0.05$). The result of this experiment indicated that teosinte sown with cowpea in 18th April might be the best combination to produce high herbage mass as well as better quality of fodder.

Introduction

Livestock related enterprises are considered as an important sources of livelihood support to the majority of farmers in Nepal. However, our animals are in general, low producing having poor productive performance. The main reason of low production of the ruminant animal is due to low quality fodder and feeds (Tulachan and Neupane, 1999; Osti, 2020). Jeremiah *et al*. (2015) stated that the poor feed resources available to ruminants is especially due to low nutritional diets. The popular summer fodder in Nepal is Teosinte (*Euchlaena mexicana*) which contents low crude protein and high energy (Upreti and Shrestha, 2006). Devkota *et al*. (2015) also reported that teosinte has profuse tillering capacity, multi-cut potentiality and can yield high fodder biomass. Likewise, legumes in overall contents low dry matter and high protein percentage (Asangla and Gohain, 2016; Eskandari *et al*., 2009). The presence of fodder legumes in cereal fodder could improve the nutritional status of fodder and fulfill the cereal protein deficiency (Rao and Willey, 1980; Ibrahim *et al*., 2006, Ahmad *et al*., 2007; Geren *et al*., 2008). Iqbal *et al*. (2006) and Iqbal *et al*. (2019) also stated that mixed cultivation of

How to Cite
B Khanal, NR Devkota, MR Tiwari and NA Gorkhali (2022). Herbage mass of Teosinte (*Euchlaena mexicana*) grown as mono and mixed with legumes. *Bangladesh Journal of Animal Science*, 51 (2): 47-54. https://doi.org/10.3329/bjas.v51i2. 60494.

cereals and legumes enhanced the protein proportion with more biomass contribution. Cereal-legume mixtures have a number of positive traits in comparison to cereal monoculture. Among different suitable agro technique, date of sowing and mixed cropping with locally available legumes has prime importance for quality and quantity of fodder yield. The most commonly available legume fodders in Nepal are cowpea (*Vigna unguiculata*) and rice bean (*Vigna umbellate*). Cultivation of legumes such as cowpea and rice bean could increase animal productivity through better herbage harvest with quality product (Anele *et al*., 2011). Therefore, this research was done to identify appropriate sowing dates of teosinte in a mixed crop technique with locally available popular fodder legumes to produce maximum possible herbage harvest with its quality consideration.

MATERIALS AND METHODS

Experimental Site

This research was done at the Directorate of Agricultural Research, NARC, Khajura, Banke during April to August, 2019. The station lies an altitude 181 meters above sea level.

Experimental design

Four sowing dates 8th April, 18th April, 28th April and 8th May were assigned as main plots. Three fodder combinations teosinte, teosinte+cowpea and teosinte+rice bean was used in the sub-plots. The experiment was conducted at Split Plot Design with five replications. Each treatment plot size was 12 m^2.

Raising of fodder crops

First sowing was done at 8th April, 2019 and subsequent other three sowing was done at each 10 days interval. Row to row spacing for teosinte fodder was maintained at 50 cm. Legume was sown between row of teosinte fodder. Seed rate of teosinte was 40kg/ha (Relwani, 1979; Kumar *et al*., 2012). The seed rate of cowpea was 40kg/ha (Relwani, 1979; Kumar *et al*., 2012) and 20 kg/ha seed was used for rice bean (Khadka and Acharya, 2009). Seed proportion of teosinte: legumes was 100:50. Farm yard manure (FYM) was applied @ 10 t/ha and the chemical fertilizer was used @ 60:40:00 NPK kg/ha. Full amount of FYM, phosphorus and half dose of nitrogen was applied at the time of field preparation, and the remaining half dose of nitrogen was applied at two split doses. First half was top dressed at 30 days after sowing, and the remaining half was applied after first harvest at 70 days after sowing. All other agronomic practices (field preparation, irrigation, weeding) was done by following the similar practices for each treatment. To assured the better germination, one irrigation was applied a day after sowing the seed, then irrigation was applied (total amount of irrigated water 1183 m^3/ha) at each 8 days' interval. After first harvest single irrigation was applied.

Plant sampling and harvesting

Plant height and tiller number of teosinte was recorded by selecting five plants from each experimental plots. The cutting height of teosinte and legumes fodder were maintained at 10 cm and 20 cm height respectively from ground level. Total two harvests were taken, first at 70 days after sowing and others one at 30 days after first harvest. The green herbage was harvested from 1m^2 from each experimental plot. The harvested mass was weighed. The collected samples from each experimental plot were dried in oven at constant heat (72°C for 24-48 hours) in the laboratory of Directorate of Agricultural Research, Khajura, Banke, Nepal.

Chemical analysis

The major chemical constituents (CP, ADF and NDF) was analyzed at National Animal Nutrition Research Centre, Khumaltar. Nitrogen content was determined by Micro Kjeldahl method (AOAC, 1990). Crude protein (CP) was calculated by multiplying N x 6.25. Neutral detergent fiber (NDF) and Acid detergent fiber (ADF) fractions were determined as procedure developed by Goering and Van Soest (1970).

Statistical analysis

The collected data of split plot design were analyzed with the help of statistical software R, version 4.0.0. (R core Team, 2020). Data were evaluated using analysis of variance (ANOVA) technique and mean separation by Fisher's least significant difference (LSD) test at 5% significance level.

RESULTS

Growth parameters of teosinte

The average plant height of teosinte at different dates of sowing and fodder combination is presented in Table 1. Date of sowing had significant effect ($p<0.001$) to the plant height of teosinte at first harvest. Accordingly, highest plant height (144.81 cm) was obtained for 18th April, but this was statistically similar ($p>0.05$) to the 28th April sowing. Plant height of teosinte in all fodder combination was non-significant ($p>0.05$) at this harvest. Similarly, treatments interaction/combination effect was also statistically non-significant ($p>0.05$) at this

harvest. Sowing date had no significant effect ($p>0.05$) to the plant height of teosinte at second harvest. Likewise, at second harvest plant height of teosinte with fodder combination and treatments interaction/combination effect showed statistically similar ($p>0.05$) (Table 1).

Table 1: Plant height (cm) and tiller density (number/m^2) for main plots and sub-plots, respectively of different sowing dates and fodder combination

Treatments	Plant height		Tiller density	
	First harvest	Second harvest	First harvest	Second harvest
Sowing date (A)				
First sowing 8th April (A1)	131.59[b]	120.21	124.80[d]	134.93[b]
Second sowing 18th April (A2)	144.81[a]	116.21	137.06[a]	148.53[a]
Third sowing 28thApril (A3)	143.87[a]	120.99	132.00[b]	151.47[a]
Fourth sowing 8th May (A4)	135.62[b]	122.30	127.47[c]	148.26[a]
Fodder combination (B)				
Teosinte	139.17	120.19	130.60	144.70
Teosinte +cowpea	138.61	119.98	129.60	147.80
Teosinte+rice bean	139.14	119.61	130.80	144.90
Mean	138.98	119.93	130.33	145.80
Analysis of variance				
Sowing date (A)				
p-value	<0.001	0.349	<0.001	0.014
$LSD_{0.05}$	5.66	7.37	2.49	9.87
Fodder combination (B)				
p-value	0.844	0.887	0.845	0.353
$LSD_{0.05}$	2.20	2.47	4.51	4.82
Interaction/combination (AxB)				
p-value	0.839	0.957	0.833	0.506
$LSD_{0.05}$	4.40	4.94	9.01	9.63

LSD, least significant difference

The average tiller density (numbers/m^2) of teosinte at different dates of sowing and fodder combination is presented in Table 1. At first harvest, significantly ($p<0.001$) the highest tiller density of teosinte (137.06) was obtained for 18th April. At second harvest, significantly highest ($p<0.05$) tiller density of teosinte (151.47) was obtained for 28th April but it was statistically similar to 18th April and 8th May sowing. Tiller density of teosinte was statistically similar ($p>0.05$) at both the harvests on all fodder combination. The treatments interaction/combination effect on tiller density was statistically non-significant ($p>0.05$) on both harvest (Table 1).

Green herbage mass production

Green herbage mass (t/ha) production at different dates of sowing and fodder combinations is presented in Table 2. At both harvests and cumulative figure green herbage mass production was significant ($p<0.001$) with date of sowing. The highest cumulative green herbage (66.25 t/ha) was obtained when fodder was sown in 18th April, but it was statistically non-significant with 28th April sowing. Likewise, on both harvests and also for cumulative, teosinte+cowpea produced the highest ($p<0.001$) green herbage mass than other fodder combination. The highest cumulative green herbage (67.30 t/ha) was obtained from teosinte+cowpea. At both harvest and cumulative, the lowest green herbage mas was recorded for teosinte mono crop. At both harvests and cumulative value, the interaction/combination effect on green herbage mass production was statistically significant ($p<0.05$). Accordingly, the highest cumulative green herbage mass (75.34 t/ha) was produced from teosinte+cowpea when sown in 18th April (Table 2).

Dry herbage mass production

Dry herbage mass (t/ha) production at different dates of sowing and fodder combinations is presented in Table 2. Statistically the highest ($p<0.001$) dry herbage mass was produced from both harvest if fodder were sown in 18th April, but it was statistically similar to the value produced for 28th April sowing. Significantly the highest ($p<0.001$) cumulative dry herbage (14.64 t/ha) was produced if fodder were sown in 18th April. Likewise, at both the harvests as well as for cumulative value, combination of teosinte with cowpea had produced the highest ($p<0.001$) dry herbage mass compared to the other fodder

combination. The highest cumulative dry herbage (14.73 t/ha) was obtained for fodder combination teosinte+cowpea. At both harvests and cumulative, the lowest dry herbage mass was produced from teosinte mono crop. The treatments interaction/combination effect for dry herbage production was statistically non-significant ($p>0.05$) at first harvest, significant ($p<0.01$) at second harvest and significant ($p<0.05$) for cumulative value. The treatments interaction/combination showed significantly highest ($p<0.05$) cumulative dry herbage mass (16.89 t/ha) if teosinte were sown with cowpea in 18th April (Table 2).

Table 2. Status of green and dry herbage mass harvested (t/ha) for main plots and sub-plots, respectively of different sowing dates and fodder combination

Treatments	Green herbage mass			Dry herbage mass		
	First harvest	Second harvest	Cumulative	First harvest	Second harvest	Cumulative
Sowing date (A)						
First sowing 8th April (A1)	31.96^{b}	23.25^{b}	55.21^{b}	7.02^{b}	5.10^{b}	12.12^{c}
Second sowing 18th April (A2)	37.25^{a}	29.00^{a}	66.25^{a}	8.30^{a}	6.34^{a}	14.64^{a}
Third sowing 28thApril (A3)	35.85^{a}	27.69^{a}	63.54^{a}	7.86^{a}	5.91^{a}	13.77^{b}
Fourth sowing 8th May (A4)	30.54^{b}	23.62^{b}	54.16^{b}	6.64^{b}	4.99^{b}	11.62^{c}
Fodder combination (B)						
Teosinte (B1)	27.46^{c}	23.30^{c}	50.76^{c}	6.08^{c}	5.00^{c}	11.08^{c}
Teosinte+cowpea (B2)	39.13^{a}	28.17^{a}	67.30^{a}	8.60^{a}	6.13^{a}	14.73^{a}
Teosinte+rice bean (B3)	35.11^{b}	26.21^{b}	61.32^{b}	7.68^{b}	5.63^{b}	13.31^{b}
Interaction/Combination (AxB)						
A1B1	25.03^{h}	20.84^{g}	45.87^{h}	5.50	4.50^{f}	10.00^{g}
A1B2	37.69^{c}	24.91^{def}	62.60^{e}	8.31	5.44^{d}	13.75^{c}
A1B3	33.17^{e}	24.02^{ef}	57.19^{f}	7.26	5.36^{d}	12.62^{de}
A2B1	30.04^{fg}	25.45^{d}	55.49^{fg}	6.85	5.45^{d}	12.30^{def}
A2B2	43.44^{a}	31.90^{a}	75.34^{a}	9.71	7.18^{a}	16.89^{a}
A2B3	38.28^{c}	29.66^{b}	67.94^{c}	8.34	6.39^{b}	14.73^{b}
A3B1	29.69^{g}	25.00^{de}	54.69^{g}	6.58	5.40^{d}	11.98^{ef}
A3B2	40.06^{b}	30.50^{b}	70.56^{b}	8.86	6.48^{b}	15.33^{b}
A3B3	37.80^{c}	27.57^{c}	65.37^{d}	8.14	5.84^{c}	13.98^{c}
A4B1	25.09^{h}	21.91^{g}	47.00^{h}	5.41	4.64ef	10.05^{g}
A4B2	35.35^{d}	25.36^{de}	60.71^{e}	7.53	5.40^{d}	12.93^{d}
A4B3	31.19^{f}	23.59^{f}	54.78^{g}	6.97	4.92^{e}	11.88^{f}
Mean	33.90	25.89	59.79	7.46	5.58	13.04
Analysis of variance						
Sowing date (A)						
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD $_{0.05}$	1.76	1.56	2.49	0.45	0.45	0.72
Fodder combination (B)						
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD $_{0.05}$	0.75	0.69	1.14	0.22	0.19	0.33
Interaction/combination (AxB)						
p-value	0.014	0.033	0.018	0.079	0.007	0.018
LSD $_{0.05}$	1.49	1.39	2.28	0.43	0.38	0.65

LSD, least significant difference

Crude protein (CP)

The CP content (g/kg DM) at different dates of sowing and fodder combination is presented in Table 3. CP contents on both harvests and average value of two harvest was non-significant ($p>0.05$) with date of sowing. Likewise, combination of fodder was significant

at first harvest and average value of two harvest ($p<0.001$) and at second harvest ($p<0.01$). The highest CP contents (134.23 g/kg DM) was obtained from teosinte+ cowpea and the lowest (119.02 g/kg DM) CP was obtained from teosinte mono crop. The treatments interaction/ combination effect on CP contents at both harvests and average value of two harvests was statistically non-significant ($p>0.05$) (Table 3).

Neutral detergent fiber (NDF)

The NDF content (g/kg DM) at different dates of sowing and fodder combination is presented in Table 3. NDF contents on both harvests and average value of two harvests was non-significant ($p>0.05$) with different sowing dates. Likewise, combination of fodder was significant at first harvest as well as for average of two harvests ($p<0.001$) and at second harvest ($p<0.01$). At average of two harvests, the highest NDF contents (594.38 g/kg DM) was obtained when teosinte was sown as mono crop and the lowest NDF contents (540.56 g/kg DM) was obtained when teosinte sown with cowpea. The treatments interaction/interaction effect on NDF contents at both harvests and average of two harvests was statistically non-significant ($p>0.05$) (Table 3).

Table 3: Status of CP, NDF and ADF for main plots and sub-plots, respectively of different sowing dates and fodder combination

Treatments	Crude protein (g/kg DM)			NDF (g/kg DM)			ADF (g/kg DM)		
	First harvest	Second harvest	Average	First harvest	Second harvest	Average	First harvest	Second harvest	Average
Sowing date (A)									
First sowing 8th April (A1)	137.47	118.37	127.41	544.07	569.58	556.83	421.43	403.01	412.22
Second sowing 18th April (A2)	135.06	120.11	127.58	559.33	575.22	567.27	418.89	404.99	411.95
Third sowing 28thApril (A3)	131.96	121.64	126.8	548.03	581.47	564.75	420.15	408.10	414.13
Fourth sowing 8th May (A4)	131.76	118.88	125.32	556.55	582.93	569.74	401.97	414.16	408.07
Fodder combination (B)									
Teosinte (B1)	123.75^{c}	114.3^{c}	119.02^{c}	591.98^{a}	596.79^{a}	594.38^{a}	431.62^{a}	416.10	423.86^{a}
Teosinte+ cowpea(B2)	142.8^{a}	125.66^{a}	134.23^{a}	522.13^{c}	558.98^{b}	540.56^{c}	406.68^{b}	401.87	404.28^{b}
Teosinte+ rice bean(B3)	134.86^{b}	119.30^{b}	127.08^{b}	541.89^{b}	576.13^{b}	559.01^{b}	408.54^{b}	404.73	406.64^{b}
Mean	133.8	119.75	126.78	552.00	577.30	564.65	415.62	407.57	411.59
Analysis of variance									
Sowing date (A)									
p-value	0.069	0.233	0.065	0.391	0.312	0.071	0.333	0.468	0.844
$LSD_{0.05}$	11.71	9.83	2.15	27.06	20.26	9.49	31.41	20.87	21.98
Fodder combination (B)									
p-value	<0.001	0.002	<0.001	<0.001	0.004	<0.001	0.003	0.111	<0.001
$LSD_{0.05}$	4.94	4.63	3.68	13.95	17.99	10.77	12.41	14.36	8.02
Interaction/combination (AxB)									
p-value	0.235	0.273	0.166	0.243	0.704	0.675	0.080	0.961	0.139
$LSD_{0.05}$	9.88	9.25	7.36	27.90	35.98	21.54	24.83	28.72	16.05

LSD, least significant difference

Acid detergent fiber (ADF)

The ADF content (g/kg DM) at different dates of sowing and fodder combination is presented in

Table 3. ADF contents on both harvests and average of two harvests was non-significant ($p>0.05$) with different sowing dates. ADF contents in all fodder combination remained significant ($p<0.01$) at first harvest and ($p<0.001$) for average value, but was non-significant ($p>0.05$) at second harvest. The low ADF contents (404.28 g/kg DM) was obtained from fodder combination when teosinte sown with cowpea but it was statistically similar with teosinte+rice bean. The high ADF contents (423.86 g/kg DM) was obtained from teosinte mono crop.

The treatments interaction/combination effect on ADF contents on both harvests and for average value of two harvests was statistically non-significant ($p>0.05$) (Table 3).

DISCUSSION

The fodder combination, teosinte+cowpea sown in 18th April followed by 28th April had produced the highest cumulative green and dry herbage mass. This might due to favorable environmental effects that reflected to increase the growth parameters and yield components. The tiller density and plant height of teosinte could affect the herbage production. The reasons behind high dry herbage production due to high green herbage production from fodder combination. It was found that sowing date affected significantly to the growth parameter of fodders as well as both green herbage and dry herbage mass yield. This sort of findings is reported by many researchers (Van Roekel and Coulter, 2011; Shrestha *et al*., 2016; Devkota *et al*., 2017; Abd El- Lattief, 2011). Devkota *et al*. (2017) reported that higher herbage biomass was obtained if teosinte sown in 15th to 23rd April in western mid-hill, Nepal that reduced the energy deficit to ruminants. Our study findings also revealed that the growth parameters were well affected by the dates of sowing and mid-April sowing was the best dates. Devkota *et al*. (2017) reported that fodder production could be well affected by growth parameters. Devkota *et al*. (2017) also reported that growth parameters of teosinte fodder, such as numbers of leaves/plant, plant height, number of tillers/hill and fodder yield was affected by sowing dates. Result of our study revealed that cowpea is better combination with teosinte in term of herbage production. This might due to cowpea yielded highest herbage mass than other legumes. This finding is supported by Sharma *et al*. (2009). Teosinte with rice bean marked the lowest green and dry fodder production as compared to teosinte with cowpea, which might be due to contribution of least additional fodder by rice bean in the treatment combination with teosinte. There was no additional fodder contribution from legumes if teosinte sown as mono crop, therefore it yielded less cumulative green herbage and dry herbage. Mixed cropping yielded more fodder than mono cropping. This sort of finding are well reported by several researchers (Ram and Singh, 2001; Iqbal et al., 2006; Geren et al., 2008; Iqbal et al., 2019).

It was found that dates of sowing not affected the fodder quality but affected by fodder combinations. Teosinte+cowpea yielded the highest amount of CP and the lowest amount of NDF and ADF. The highest amount of ADF and NDF and lowest amount of CP was found from mono crop, teosinte. Patil *et al.* (2018) stated that mainly carbohydrate (energy) is obtained from cereals and CP from legumes crops. Thus, implementing both cereal and legumes crops in cropping systems provides nutritionally rich fodder for the livestock. The combination of teosinte and cowpea enables to make an ideal canopy, which can utilize available resources most efficiently. The reasons of yield advantage of this cropping system may due to effective utilization of accessible resources such as water, light and nutrients than mono cropping systems (Jing Hui *et al*., 2006). Cropping of maize with legumes can substantially increase forage quality and decrease the requirements of protein supplements as compared maize mono crops (Javanmard *et al*., 2009). Bekele *et al*. (2013) stated that legumes with maize as mixed cropping found significantly enhancement of total fodder protein yield as compared to the mono cropping. Herbert *et al*. (1984) stated that cereal legume cropping system yielded 8-17% more protein/ha than corn monoculture. Lauriault and Kirksey (2004) noted that NDF and ADF concentrations reduced by addition of fodder legumes to fodder maize, representing quality of fodder. Dahmardeh *et al*. (2009) also reported maize mono crop yielded maximum ADF contents while increasing seed proportion of cowpea on maize crop, the ADF contain reduced. Rebole *et al*. (1996) stated that ADF contents indigestible plant materials like cellulose and lignin. Good quality forage contents low amount of ADF. The basic concept is that low-quality forage contents high amount of ADF and NDF as compared to high quality forage.

CONCLUSION

Teosinte is the popular summer cereal fodder with low amount of chemical constituents. Thus this experiment was carried out to determine the best combination of common fodder legume to be grown with teosinte to increase quality as well as quantity harvest. The results showed that the highest cumulative green and dry herbage mass were obtained from teosinte+cowpea if sown in 18th April followed by next best harvest if sown in 28th April. The highest mean value of CP and lowest mean value of NDF and ADF was also obtained from fodder combination of teosinte + cowpea. Thus cultivating teosinte with cowpea could be considered as best practice in terms of both quality as well as quantity harvest if mid-April to last week of April could be managed for appropriate sowing dates.

REFERENCES

Abd El-Lattief EA (2011). Growth and fodder yield of forage pearl millet in newly cultivated land as affected by date of planting and integrated use of mineral and organic fertilizers. *Asian Journal of Crop Science,* 3: 35-42. https://doi.org/10.3923/ajcs.2011.35.42

Ahmad AUH, Ahmad R, Mahmood N and Tanveer A (2007). Performance of forage Sorghum intercropped with forage legumes under different planting patterns. *Pakistan Journal of Botany,* 39(2): 431-439.

Anele UY, Sudekum KH, Hummel J, Arigbede OM, Oni AO, Olanite JA, Bottger C, Ojo, VO and Jolaosho AO (2011). Chemical characterization, in vitro dry matter and ruminal crude protein degradability and microbial protein synthesis of some cowpea (*Vigna unguiculata L. Walp*) haulm varieties. *Animal Feed Science and Technology,* 163: 161-169. https://doi.org/10.1016/j.anifeedsci.2010.11.005

AOAC (1990). Official methods of analysis. 15th Edition. Association of Official Analytical Chemist, Washington DC.

Asangla HK and Gohain T (2016). Effect of fodder yield and quality attributes of maize (*Zea mays* L.)+cowpea (*Vigna unguiculata* L.) intercropping and different nitrogen levels. *International Journal of Agricultural Science and Research,* 6: 349-356.

Bekele G, Belete K and Sharma JJ (2013). System productivity of forage legumes intercropped with maize and performance of the component crops in Kombolcha, Eastern Ethiopia. *East African Journal of Sciences,* 7: 99-108.

Dahmardeh M, Ghanbari A, Syasar B and Ramroudi M (2009). Effect of intercropping maize (*Zea mays* L.) with cowpea (*Vigna unguiculata* L) on green forage yield and quality evaluation. *Asian Journal of Plant Sciences,* 8: 235-239. https://doi.org/10.3923/ajps.2009.235.239

Devkota NR, Ghimire RP, Adhikari DP, Upreti CR, Poudel LN and Joshi NP (2017). Fodder productivity of teosinte (*Euchlaena mexicana Schrad*) at different sowing dates in western mid hills of Nepal. *Journal of Agriculture and Forestry University*, 1: 129-137.

Devkota NR, Pokharel P, Paudel LN, Upreti CR and Joshi NP (2015). Performance of teosinte (*Euchlaena Mexicana*) as a promising summer forage crop with respect to location and sowing dates considering the scenario of possible climate change in Nepal. *Nepalese Journal of Agricultural Science,* 13:131-141.

Eskandari H, Ghanbari A and Javanmard A (2009). Intercropping of cereals and legumes for forage production. *Notulae Scientia Biologicae*, 1(1): 07-13. https://doi.org/10.15835/nsb113479

Geren H, Avcioglu R, Soya H and Kir B (2008). Intercropping of corn with cowpea and bean: Biomass yield and silage quality. *African Journal of Biotechnology,* 7 (22): 4100-4104.

Goering HK and Van Soest PJ (1970). Forage fiber analysis (Apparatus, reagents, procedures and some applications). USDA, ARS, Agriculture Handbook No 379, pp 8-9.

Herbert SJ, Putnam DH, Poos Floyd MI,Vargas A and Creighton JF (1984). Forage yield of intercropped corn and soybean in various planting patterns. *Agronomy Journal,* 76 (4):507-510. https://doi.org/10.2134/agronj1984.00021962007600040001x

Ibrahim M, Rafiq M,Sultan A, Akram M and Goheer MA (2006). Green fodder yield and quality evaluation of maize and cowpea sown alone and in combination. *Journal of Agricultural Research,* 44(1):15-21.

Iqbal A, Ayub M, Zaman H and Ahmad R (2006). Impact of nutrient management and legume association on agro qualitative traits of maize forage. *Pakistan Journal of Botany,* 38(4):1079-1084.

Iqbal MA, Hamid A, Ahmad T, Siddiqui MH, Hussain I, Ali S, Ali A and Ahmad Z (2019). Forage sorghum-legumes intercropping: Effect on growth, yields, nutritional quality and economic returns. *Bragantia* 78 (1): 82-95. https://doi.org/10.1590/1678-4499.2017363

Javanmard A, Nasab ADM, Javanshir A, Moghaddam M and Janmohammadi H (2009). Forage yield and quality in intercropping of maize with different legumes as double cropped

Journal of Food and Agricultural Environment, 7(1):163-166.

Jeremiah K, Nyako HD, Malgwi IH, Yahaya MM and Mohammed ID (2015). Nutrient evaluation of total mixed rations used in ruminant feeding using maize bran, cowpea husk, poultry litter and ground nut haulms in a semi-arid environment of Nigeria. *Annals of Biological Research,* 6(4):14-18.

Jing-Hui LIU, Zhao-Hai ZENG, Li-Xin JIAO, Yue-Gao HU, Ying WANG and Hai LI (2006). Intercropping of different silage maize cultivars and alfalfa. *Acta Agronomica Sinica* 32(1): 125-137.

Khadka K and Acharya BD (2009). Cultivation practices of rice bean. Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Pokhara, Nepal.

Kumar S, Agrawal RK, Dixit AK, Rai AK and Rai SK (2012). Forage crops and their management. Indian grassland and fodder research institute, Jhansi- 284003, Uttar Pradesh, India pp 13-34.

Lauriault LM and Kirksey RE (2004). Yield and nutritive value of irrigated winter cereal forage grass-legume intercrops in the southern high plains, USA. *Agronomy Journal,* 96: 352-358. https://doi.org/10.2134/agronj2004.3520

Osti NP (2020). Animal feed resources and their management in Nepal*. Acta Scientific Agriculture,* 4.1: 02-14.

Patil LM, Kauthale VK, Bhalani TG and Modi DJ (2018). Productivity and economics of different forage production systems in south Gujarat conditions of India. *Forage Research,* 44 (1): 14–18.

R core team (2020). R: A language and environment for statistical computing. R Foundation for statistical computing. Vienna, Austria, URL https://www.R-project.org/.

Ram SN and Singh B (2001). Productivity and economics of forage sorghum (*Sorghum bicolor*) in association with legumes under different harvesting times and nitrogen levels *Indian Journal of Agronomy,* 46 (4): 611-615.

Rao MR and Willey RW (1980). Preliminary studies of intercropping combinations based on pigeon pea or sorghum. *Experimental Agriculture*, 16 (1): 29-39. https://doi.org/10.1017/S001447970001067X

Rebole A, Trevino J, Barro C, Alzueta C and Caballero R (1996). Chemical changes associated with the field drying of oat forage. *Field Crops Research*, 47: 221-226.

Relwani LL (1979). Fodder crops and grasses. ICAR publication, pp 12-22. https://doi.org/10.1016/0378-4290(96)00012-3

Sharma RP, Raman KP, Singh AK, Poddar BK and Kumar R (2009). Production potential and economics of multicut forage sorghum (*Sorghum sudanense*) with legumes intercropping under various row proportions. *Range Management and Agroforestry,* 30: 67-71.

Shrestha U, Amgain LP, Karki TB, Dahal KR and Shrestha J (2016). Effect of sowing dates and maize cultivars in growth and yield of maize along with their agro-climatic indices in Nawalparasi, Nepal. *Journal of AgriSearch,* 3(1): 57-62. https://doi.org/10.21921/jas.v3i1.4106

Tulachan PM and Neupane A (1999). Livestock in mixed farming systems of Hindu Kush-Himalayas: trends and sustainability. International Center for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal. https://doi.org/10.53055/ICIMOD.309

Upreti CR and Shrestha BK (2006). Nutrient contents of foods and fodder in Nepal. Kathmandu: Nepal Agricultural Research Council, pp 139.

Van Roekel RJ and Coulter JA (2011). Agronomic responses of corn to planting date and plant density. *Agronomy Journal,* 103(5): 1414-1422. https://doi.org/10.2134/agronj2011.0071