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Original Article

Effects of altitude and harvesting dates on morphological characteristics, yield and nutritive value of desho grass (*Pennisetum pedicellatum* Trin.) in Ethiopia

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ABSTRACT

The effects of altitude and harvesting period on the performance of desho grass were evaluated in Ethiopia. A factorial arrangement of treatments was employed with a combination of two altitudes and three harvesting dates. Planting and management of desho grass was undertaken according to recommendations for the species. The data collected consisted of plant height, number of tillers, number and length of leaves, leaf-to-stem ratio and fresh yield. Chemical analysis of the constituents of desho grass samples was completed according to standard procedures. All data were subjected to two analysis of variance procedures and Pearson correlation analysis, with significance tested at $p < 0.05$. Results indicated that most morphological characteristics were not significantly different due to altitude except the leaf length per plant. Harvesting dates significantly affected the number of leaves per plant, leaf-to-stem ratio and dry matter yield. Both altitude and harvesting date significantly affected the crude protein content, yield and fiber fractions. Calcium content was significantly different only regarding harvesting date and phosphorus content was significantly affected by altitude. Dry matter content and yield were positively correlated with parameters such as plant height, leaf length per plant, crude protein (CP) yield, fiber fractions (neutral detergent fiber and acid detergent fiber) and with each other. Crude protein content was positively correlated with the CP yield. Overall results indicated that desho grass was affected more by harvesting date than altitude. Generally, desho grass performed well both at mid and high altitude in Ethiopia and could be a potential livestock feed in the country.

Introduction

Despite Ethiopia having a large livestock population (Central Statistical Agency, 2015), the productivity of livestock is low. The major setback is shortage in quantity and quality of feed resources (Adugna, 2007; Tegegne and Assefa, 2010; Yayneshet, 2010). To combat existing livestock nutritional constraints, the use of locally available forage plants as feed resources is highly recommended as they are familiar to smallholder farmers, grow with low inputs and are adaptable to local agro-ecological conditions (Anele et al., 2009). Desho grass (*Pennisetum pedicellatum*) is among the locally available, multipurpose and potential feed resources in Ethiopia (European Plant Protection Organization, 2014; Leta et al., 2013). It is a perennial grass found in the Southern Nations Nationalities and Peoples' Region of the country. The grass is also available in other tropical countries and is palatable to cattle, sheep and other herbivores (Food and Agriculture Organization of the United Nations, 2010). Desho grass has the ability to recover after water stress even under severe drought conditions (Noitsakis et al., 1994). Moreover, the grass serves as a business opportunity for farmers in Ethiopia (Shiferaw et al., 2011; Leta et al., 2013).

The yield and nutritional qualities of forage are influenced by numerous factors representing ecological conditions and management activities (Enoh et al., 2005). Moreover, the nutritive value of fodder crops is also a function of seasonal variations and the stage of maturity (Papachristou and Papanastasis, 1994). According to

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Lukuyu et al. (2011), it is very important to understand the chemical composition and utilization information of locally available feeds for their inclusion into livestock feeding regimens. However, there is limited information on agronomic characteristics, productivity, management practices and chemical composition of locally available desho grass in Ethiopia. Therefore, this study was conducted to evaluate the effects of altitude and harvesting date on the morphological fractions, chemical composition and yield of desho grass.

Materials and methods

Description of the experimental sites

The agronomic component of this study was conducted in two agro-ecologies (mid altitude and high altitude) using a rain fed system. The mid altitude area was represented by Andassa Livestock Research Center located at 11°29″ N and 37°29″ E at an altitude of 1730 m above sea level. Farta District Office of Agriculture (2014) provided summary climatic data for the area which receives about 1434 mm of rainfall annually. Mean annual temperature varies from a maximum of 29.5 °C to a minimum of 8.8 °C. The soil type is dark clay and seasonally waterlogged with 3.4% organic matter, 0.17% total nitrogen and pH of 6.9. The highland area was represented by Farta district, Tsegure Eyesus *Kebele* (*Kebele* is the local administration in Ethiopia) at a site called Melo located near Debre Tabor Town, at 11°11' N and 38°E and at an altitude of 2650 m above sea level. The soils of Melo site are characterized by clay and sand mixture with chemical composition of 2.26% organic matter, 0.11% total nitrogen and pH of 5.47. The mean annual rainfall is about 1570 mm and the mean maximum and minimum annual temperatures were reported to be 21.5 °C and 9.6 °C respectively.

Land preparation, planting and experimental design

A total area of 88 m^2 was selected from each of the two locations. The land was ploughed in May and harrowed in June 2014. The land was divided into three blocks each of which comprised three plots (3 m × 6 m each). Desho grass obtained from Southern Nationals and Nationalities by the CASCAPE (capacity building for scaling up of evidence-based best practices in agricultural production in Ethiopia) project was planted in rows using root splits on a well-prepared soil. The grass was planted in June 2014 and lasted until December 2014 for the experimental period of five months. The experiment was laid-out in a factorial arrangement of two altitudes (mid and high) and three harvesting dates (90 d, 120 d and 150 d) in a randomized complete block design with three replications. The spacing between rows and plants was 50 cm and 10 cm, respectively. Land preparation, planting, weeding and harvesting were undertaken according to the recommendations of Leta et al. (2013). Artificial fertilizers (di-ammonium phosphate at 100 kg/ha and urea at 25 kg/ha) were applied during planting and after establishment. After planting, weed control and related management practices were applied according to standard practice for the grass.

Data collection

Morphological parameters consisting of plant height and leaf length were measured from 10 plants that were randomly selected from middle rows of each plot at 90 d, 120 d and 150 d after planting at both locations. The numbers of tillers and leaves were computed as mean counts taken from 10 plants that were randomly selected from middle rows of each plot at 90 d, 120 d and 150 d after planting at both locations. The re-growth date (time required in days for full vegetative development after harvest) was recorded after harvesting at 90 d, 120 d and 150 d in each plot. The leaf-to-stem ratio was determined by harvesting all plants in two consecutive rows, randomly selected in the middle of each plot and separating these plants into stem and leaf. Harvesting was done by hand using a sickle leaving a stubble height of 8 cm according to recommended practice (Leta et al., 2013). Soon after first harvest, for each of the three harvesting dates, a follow-up study was made to determine the re-growth potential and subsequent harvesting. A fresh herbage yield of desho grass was measured immediately after each harvest using a portable balance with a sensitivity of 0.01 g. Representative samples were taken from each plot at each site and were dried in a draft oven at 65 °C for 72 h before being sent to the laboratory for chemical analysis.

Chemical analysis

The chemical analysis and *in vitro* organic matter digestibility were determined at the International Livestock Research Institute (ILRI) Animal Nutrition Laboratory, Addis Ababa, Ethiopia. Samples were dried in an oven at 60 °C for 48 h, ground and passed through a 1 mm sieve. Ash/organic matter (OM), dry matter (DM) and crude protein (CP) were determined according to Association of Analytical Chemists (1990). The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest and Robertson (1985). *In vitro* organic matter digestibility (IVOMD) was determined according to Tilley and Terry (1963). The metabolizable energy (ME) was estimated from digestible energy (DE) and *in vitro* organic matter digestibility (IVOMD), based on the National Research Council (2001) formula using the following steps:

First, DE was obtained using Equation (1):

$$DE = [0.01 \times (OM/100) \times (IVOMD + 12.9) \times 4.4] - 0.3 \quad (1)$$

where DE is the digestible energy in calories, OM is the organic matter and IVOMD is the *in vitro* organic matter digestibility in joules.

Then, ME = 0.82 × DE (Mcal/kg) was calculated and converted to SI units (MJ/kg) by multiplying by 4.184.

Data analysis

Pearson correlation analysis was performed to determine the association between plant parameters with selected nutritional parameters of the grass. The mathematical model in Equation (2) was applied to analyze the effect of all possible factors in the two sets of analysis:

$$\gamma_{ij} = \mu + A_i + H_j + (A \times H)_{ij} + \varepsilon_{ij} \quad (2)$$

where Y_{ijk} is the response (plant morphological parameters, chemical composition, yield and *in vitro* organic matter digestibility of desho grass) at each altitude and harvesting period, μ = overall mean, A_i is the altitude (i = mid and high), H_j is the effect of harvesting period (j = 90 d, 120 d and 150 d), $(A \times H)_{ij}$ is the interaction between altitude and harvesting period and ε_{ijk} is the residual error.

The data were analyzed using the general linear model (GLM) of Statistical Analysis System (2002). Turkey's honest significant test was employed for separation of treatment means at the $p < 0.05$ level.

Results

Effect of altitude and harvesting dates on plant morphological characteristics and length re-growth days of desho grass

Table 1 presents the effect of altitude and harvesting date on plant morphological characteristics and re-growth potential of desho grass. Except for leaf length per plant (LLPP), other plant characteristics were not significantly affected by altitude and harvesting date. The number of days required for re-growth was significantly affected by altitude where a relatively shorter duration (17.78 d) was observed at mid altitude compared to the longer duration (20.00 d) observed at high altitude. Plant height is an important parameter contributing to yield in forage crops (Tessema et al., 2002). Mean plant height was low in early stages of growth, but for harvesting after 120 d, enhanced growth was observed.

Altitude had no significant effect on number of tillers but harvesting date significantly affected number of tillers per plant. The largest number of tillers (50.92) was observed at later (150 d) stage of harvest while early harvesting (90 d) showed a relatively low (40.75) number of tillers per plant. The number of leaves per plant was significantly affected by harvesting date. The highest number of leaves per plant (336.33) was observed at late stage of harvesting (150 d) while lowest number (274.33) was observed at early stage (90 d) of harvesting. Leaf-to-stem ratio was significantly affected due to harvesting date; however, altitude had no significant effect on the ratio. Early harvesting (90 d and 120 d) resulted in significantly higher leaf-to-stem ratios compared to the late harvesting date (150 d). Intermediate harvesting date also resulted in a higher ($p < 0.01$) leaf-to-stem ratio than for plants harvested at 150 d. The number of days required for full re-growth was significantly affected by altitude and harvesting period. Desho grass required relatively less time (17.78 d) at mid altitude than at higher altitude which required relatively more time (20.01 d) to reach full vegetative growth.

Effect of altitudes and harvesting dates on chemical composition, dry matter yield and in vitro organic matter digestibility of desho grass

The effects of altitude and harvesting date on chemical composition, DM and CP yield and IVOMD of desho grass are shown in Table 2. There was a significant difference between the DM content of desho grass attributed to the difference in altitude, while there was significant difference between the DM content of desho grass attributed to the difference in harvesting date. Desho grass harvested at 150 d after planting produced a significantly higher DM content compared with grass harvested at 90 and 120 d.

Table 1
Effect of altitude and time to harvest on mean plant morphological characteristics and number of re-growth days of desho grass.

Parameter* / Factor	PH (cm)	NTPP	NLPP	LLPP (cm)	LSR	RGD(d)
Altitude						
Mid	94	48	310	29[a†]	1.08	17.78[b]
High	87	50	312	22[b]	1.06	20.00[a]
Days to harvest						
90	71[b]	41[b]	274[b]	20[b]	1.24[a]	17.00[b]
120	94[a]	51[a]	322[ab]	27[ab]	1.17[a]	18.83[ab]
150	106[a]	54[a]	336[a]	29[a]	0.82[b]	20.83[a]
Mean	91	49	311	25	1.07	18.89
SD	18.36	9.15	39.75	7.47	0.22	2.47

*PH = plant height, NTPP = number of tillers per plant, NLPP = number of leaves per plant, LLPP = leaf length per plant, LSR = leaf to stem ratio, RGD = re-growth date, SD = standard deviation; †Mean values followed by a different lowercase superscript letter in the same column are statistically significant at $p < 0.05$.

Significant differences in dry matter yield due to harvesting period were recorded, however, there was no significant difference due to altitude. The total dry matter of the longest harvesting period (150 d) was the highest (20.75 t/ha), whereas the lowest dry matter yield (12.71t/ha) was produced from the shortest harvesting period (90 d). There were significant effects of altitude and harvesting period on CP content of desho grass which significantly decreased with increasing age of plants. Highest CP content (9.38%) was obtained at 90 d harvest and the lowest (6.9.3%) at 150 d harvest. The CP content was significantly different between mid and high altitude sites with the higher (9.38%) amount recorded at mid altitude and the lower amount (7.33%) at high altitude.

Neutral detergent fiber and ADF were significantly affected by altitude and harvesting period. The NDF content was higher for desho grass planted at mid altitude (76.0%) than at high altitude (73.5%). The NDF content of grass was highest (77.68%) from late harvesting (150 d after planting) while it was comparatively lower for earlier harvesting periods (72.78% at 90 d and 73.96% at 120 d). Similarly, grass planted at mid altitude had a slightly higher ADF (43.7%) than that planted at high altitude (41.29%). Desho grass harvested at 150 d after planting had a higher ADF (45.06%) than for samples harvested at 90 d and 120 d after planting (40.27% and 42.15%, respectively). The ADL fraction was not significantly affected by altitude and harvesting date, but showed numerical variation. The ADL increased from 4.61% to 5.95% when harvested at 90 and 150 d, respectively. The Ca content was not significantly affected by altitude but differed due to harvesting date with significantly high Ca observed for earlier harvesting periods (90 d and 120 d). Phosphorus content was significantly affected by altitude but not by harvesting period, with a higher level of P (2.86 g/kg DM) recorded at higher altitude than at mid altitude (2.34 g/kg DM).

Correlation analysis of morphological and nutritional parameters in desho grass

Simple linear bivariate correlation analysis among the morphological, quality, yield and IVOMD parameters of desho grass is presented in Table 3. The DM content and DMY were positively correlated to PH, LLPP, NDF, ADF and with each other, but negatively correlated ($p > 0.05$) to LSR. Crude protein content was positively correlated to CPY. Neutral detergent fiber content was positively correlated with ADF while it was negatively correlated with LSR and P. Acid detergent fiber was positively correlated with NLPP, LLPP, and LSR while it was negatively correlated with P content. The NTPP was positively correlated to NLPP and re-growth dates (RGD). PH was positively correlated to NLPP, LLPP, DM, DMY, ADF and ADL but negatively correlated to P content. NLPP was positively correlated to ADF, ADL and RGD but it was negatively correlated to LSR. LLPP was positively correlated to DM, DMY, CPY and ADF but it was negatively correlated to P. LSR was positively correlated to the fiber fractions (NDF, ADF and ADL), Ca and P but negatively correlated to DMY, CPY and NDF. The total ash (TA) content was positively correlated to mineral fractions (Ca and P).

Discussion

The higher mean leaf length per plant (28.98 cm) at mid altitude compared to high altitude (21.81 cm) may be attributed to a complex phenomenon controlled by a number of environmental factors such as temperature, precipitation and soil characteristics (Paking and Hirata, 1999).

The larger number of leaves recorded at mid altitude may be due to environmental conditions more suitable for the grass at mid altitude compared to high altitude. A greater leaf length was recorded for later harvesting (150 d) than for the earlier periods

Table 2
Mean chemical composition, yield and *in vitro* organic matter digestibility of desho grass.

Parameter measured*	DM (%)	DMY (t/ha)	OM (%)	CP (%)	CPY (t/ha)	NDF (%)	ADF (%)	ADL (%)	IVOMD (%)	ME (MJ/kg)	Ca (g/kg)	P (g/kg)
Factor												
Altitude												
Mid	31.42^{a†}	16.84	91.27^{a}	9.38^{a}	1.53^{a}	76.03^{a}	43.69^{a}	5.49	44.81	6.23	3.96	2.34^{b}
High	28.98^{b}	14.62	88.29^{b}	7.33^{b}	1.04^{b}	73.58^{b}	41.28^{b}	5.24	43.06	6.13	3.44	2.86^{a}
Harvesting day												
90	29.10	12.71^{b}	89.12	9.38^{a}	1.21	72.78^{b}	40.27^{b}	4.68	45.62	6.48	3.67^{a}	2.69
120	29.40	13.73^{b}	89.66	8.75^{ab}	1.21	73.96^{b}	42.15^{b}	5.53	43.37	6.19	3.34^{a}	2.57
150	31.99	20.75^{a}	90.57	6.93^{b}	1.44	77.68^{a}	45.06^{a}	5.95	42.85	5.87	3.07^{ab}	2.53
Mean	30.16	15.73	89.78	8.35	1.28	74.81	42.49	5.36	43.94	6.18	3.70	2.59
SD	2.55	4.78	2.68	1.94	0.39	3.29	2.85	1.26	5.52	0.93	0.77	0.48

*DM = dry matter, DMY = dry matter yield, CP = crude protein, CPY = crude protein yield, NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin, IVOMD = *in vitro* organic matter digestibility, ME = metabolizable energy, Ash = ash content, Ca = calcium, P = phosphorous; † Mean values followed by a different lowercase superscript letter in the same column are statistically significant at $p < 0.05$.

Table 3
Correlation coefficients among morphological parameters, chemical composition, yield and *in vitro* organic matter digestibility of desho grass.

Parameters[a]	DM	DMY	CP	CPY	NDF	ADF	ADL	NTPP	PH	NLPP	LLPP	RGD	LSR	TA	P	Ca	IVOMD	ME
DM	1	0.67*[b]	−0.05	0.47*	0.67*	0.68**	0.25	−0.14	0.51*	0.32	0.68**	−0.04	−0.55*	−0.32	−0.59**	−0.41	−0.20	−0.13
DMY		1	−0.24	0.63	0.64*	0.78**	0.31	−0.02	0.58*	0.46	0.48*	0.19	−0.47*	−0.17	−0.37	−0.35	−0.11	−0.02
CP			1	0.54*	−0.03	−0.12	−0.08	−0.12	−0.07	−0.14	0.28	−0.61*	0.39	−0.32	−0.16	0.04	0.02	0.02
CPY				1	0.38	0.57*	0.14	−0.13	0.44	0.22	0.56*	−0.31	−0.03*	−0.42	−0.44	−0.24	0.05	0.14
NDF					1	0.72**	0.17	0.08	0.40	0.33	0.44	0.23	−0.52*	−0.19	−0.52*	−0.38	−0.14	−0.10
ADF						1	0.28	0.03	0.60**	0.47*	0.56*	0.16	0.49*	−0.38	−0.53*	−0.38	−0.01	0.08
ADL							1	0.09	0.55**	0.47*	0.45	0.23	−0.42	0.24	−0.04	−0.31	−0.24	−0.21
NTPP								1	0.46	0.65*	0.28	0.70**	−0.26	0.21	−0.31	−0.04	−0.32	−0.28
PH									1	0.72**	0.84**	0.28	0.50*	−0.07	−0.62**	−0.43	−0.29	−0.17
NLPP										1	0.64*	0.64*	−0.61*	−0.16	−0.46	−0.41	−0.17	−0.11-
LLPP											1	0.05	−0.41	−0.21	−0.63*	−0.35	−0.42	−0.32
RGD												1	−0.47*	0.28	0.04	0.03	−0.23	−0.23
LSR													1	0.08	0.41	0.52*	0.08	0.01
TA														1	0.56*	0.51*	−0.33	−0.37
P															1	0.66*	0.06	−0.05
Ca																1	−0.12	−0.21
IVOMD																	1	0.98**
ME																		1

[a] DMY = dry matter yield, DM = dry matter, DDMY = digestible dry matter yield, CP = crude protein, CPY = crude protein yield, NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin, TA = total ash, Ca = calcium, P = phosphorous, IVOMD = *in vitro* organic digestibility, NLPP = number of leaves per plant, LLPP = leaf length per plant, RGD = re-growth date, NTPP = number of tillers per plant, PH = plant height.
[b] Level of significance:** = $p < 0.01$,* = $p < 0.05$.

(90 d and 120 d). This result is contrary to reports for other species of grasses in which the leaf length was reported to decrease as the result of stem development at a later stage of harvesting (Boonman, 1993; Wijitphan et al., 2009). Moreover, this might have been due to the differences between the physiological changes of plants observed during the growing periods (Alemu et al., 2007). The higher leaf-to-stem ratio observed at the two earlier stages of harvesting (90 d and 120 d) compared to the later stage of harvesting (150 d) might have been due to reduction in leaf proportion and an increase in the stem fraction of the grass at the advanced stage of harvesting (Butt et al., 1993). Such observations were also reported by Van Soest (1982) and Seyoum et al. (1998) for tropical forage grasses. The relatively long period of re-growth at high altitude may be attributed to lower temperature and soil nutrient variation on the two experimental sites.

The DM content increased with delayed harvesting because of decreased moisture content in leaves as the plants aged and became lignified. This result is in agreement with other studies (Berihun, 2005; Alemu et al., 2007) for other types of grasses. The studies reported that the DM content of grasses increased with an increase in growth and development of plants and longer time to harvest. The highest total DM yield observed at the last harvest stage (150 d) was in agreement with Leta et al. (2013) who indicated that the time of harvesting had a high influences on dry matter yield. Yield increment might have been due to additional tillers developed which increased leaf formation, leaf elongation and stem development (Crowder and Chheda, 1982). The highest yield of forage for the longest cutting intervals could also be attributed to the favorable rainfall, temperature and available nutrient in the soil over the extended growing period of the grass in the study area. The significant increase in dry matter yield with advancing age of plants was in agreement with Yasin et al. (2003) and Tessema and Alemayehu (2010) for cultivated grasses and Feyissa et al. (2014) for natural pasture, in Ethiopia.

The mean CP content (8.35%) was higher than in reports for the same species (6.5%) in other countries (Waziri et al., 2013; Heuze and Hassoun, 2015). Furthermore, the mean CP content of desho grass in the current experiment was within the range (5.9–13.8%) reported for *Pennisetum* species (Napier grass) by Kanyama et al. (1995) and Kahindi et al. (2007). The CP content was similar to most Ethiopian dry forage and roughage which have a CP content of less than 9% (Seyoum and Zinash, 1989) which is the level required for adequate microbial synthesis in the rumen (Agricultural Research Council, 1980). Of the factors considered, the CP content at mid altitude was higher (9.38%) than at high altitude (7.33%) which may have been associated with differences in temperature, precipitation and soil characteristics as reported by Daniel (1996) where plant growth and quality were affected markedly by temperature and soil moisture conditions. Lignification of forage appeared to occur almost constantly with increased harvesting dates. However, results of the current study were contrary to those of other studies (Whiteman, 1980; Yihalem et al., 2005; Bayable et al., 2007) who reported that lignin content increases when harvesting date is delayed. This might have been due to, there is a greater demand for structural tissue as a result of greater proportion of stem that has higher structural carbohydrates (cellulose and hemicelluloses) and lignin as the plant grows for a longer period. The upper leaves produced by older plants appear to be more lignified than leaves produced earlier (Whiteman, 1980).

Phosphorous and calcium are the most important nutrients required for animals (McDonald et al., 2010). The P content at mid altitude (2.86 g/kg) was significantly higher than at high altitude (2.32 g/kg), which may have been due to the variation in soil characteristics and climate which determine the uptake of soil nutrients by plants (Begum et al., 2015). Harvesting period had no significant effect on P content. The highest value (2.69 g/kg) recorded at the earliest stage of harvesting (90 d) and the lowest (2.53 g/k) recorded at the latest stage of harvesting (150 d), might have been due to the translocation of P to the root parts of herbage as described by Crowder and Chheda (1982). The information obtained from this study was in agreement with Kariuki et al. (1999) who reported that P content in grass declined with advancing stages of cutting. The Ca and P values in the current study were comparable to those reported by Heuze and Hassoun (2015) for the same species. The values of Ca for all harvesting periods were higher than the minimum critical level of Ca for beef cattle (0.18–1.04%) according to National Research Council (1984).

The ME content was not significantly affected by either harvesting period or altitude. The ME and IVOMD were not affected by harvesting period unlike in other reports (Fleming, 1973; McDonald et al., 2010) which indicated that energy content and digestibility decreased in later stages of harvest due to higher accumulation of cell wall components in plant tissue leading to a decrease in digestibility of the plant. The mean ME content (6.18 MJ/kg) of desho grass was comparable to other findings for the same species (Heuze and Hassoun, 2015). The ME content of desho grass was lower than in Bana grass (9.83 M/kg DM) reported by Berihun (2005) and Napier grass (greater than 9 MJ/kg DM) as reported by Tessema and Alemayehu (2010) which may be associated with environmental and species differences.

The positive association of DM and DMY with morphological parameters (plant height and leaf length per plant) may result from better competition for radiant energy with extended days to harvest. A similar correlation was observed in another study (Hunter, 1980). LSR is an important factor associated with digestibility (Yasin et al., 2003) and had a strong negative correlation to plant height, leaf length per plant, DM, DMY, CPY, NDF and ADF in the current study. The direct relationship between leaf-to-stem ratio and CP content, and the inverse association of leaf-to-stem ratio and fiber content were also previously observed by Tessema et al. (2002)for Napier grass. A positive correlation was observed between CP content and CPY, NDF and ADF which was contrary to other findings (Yihalem et al., 2005; Bayable et al., 2007) where a positive correlation among such parameters was reported. This discrepancy may have been related to differences in location, species of grass and plant management.

Most of the morphological and nutritional qualities of desho grass were greatly affected by harvesting period rather altitude. Similarly, DM yield and chemical composition of the grass was much affected by harvesting period rather than altitude. The current study revealed that desho grass performed well both at mid and high altitudes in Ethiopia. Overall, desho grass had a higher biomass yield and better chemical composition than natural pasture. Therefore, it can be concluded that it has potential as an alternative ruminant feed in mid and high altitude areas in Ethiopia. To fully utilize the potential of desho grass, further studies on agronomic and nutritional evaluation involving live-animal experiments are recommended.

Conflict of interest

The authors declare that there is no conflict of interests in publication of this paper.

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