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Desho grass (*Pennisetum pedicellatum* Trin.) evaluation based on plant characteristics, yield and chemical composition under irrigation in Northwestern Ethiopia

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Abstract: A study on the effect of altitude and harvesting dates (HD) on plant morphological characteristics, yield, and chemical composition of *Desho* grass (*Pennisetum pedicellatum* Trin.) was carried out during 2015/2016 under irrigation at Mecha (mid altitude) and Farta (high altitude) districts, northwestern Ethiopia. The objective of the study was to determine the optimum harvesting date (HD) and suitable altitude for maximum biomass yield and better nutritional value of the *Desho* grass. The harvesting dates used in the study were 75, 105 and 135 days after planting. Furrow irrigation was employed throughout the experimental period. The experimental design employed was factorial design with two factors altitude (mid and high) and HD (75,105 and 135) with three replications consisting of 6 plots in each block/replication. The morphological data collected from were plant height (PH), number of tiller per plant (NTPP), number of leaves per plant (NLPP), number of leaves per tiller (NLPT), and leaf length per plant (LLPP). Chemical composition data such as crude protein (CP), organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed and forage dry matter yield per hectare was quantified. Plant characteristics such as PH, NTPP and NLPT were significantly ($P< 0.001$) affected by altitude and HD. The higher PH, NTPP, and NLPT were recorded for Mecha district (mid altitude) location with increasing trends of HD. HD significantly ($P<0.001$) affected the NLPP, LLPP and biomass yield; with highest value recorded at 75, 105 and 135 dates, respectively. Chemical composition parameters were not significant ($P>0.05$) by altitude but CP, NDF and ADF were significant ($P<0.001$) by HD; the highest value recorded at 75, 135 and 135 dates, respectively. Pearson correlation analysis showed that PH was significantly ($P<0.01$) and positively correlated with majority of plant characteristics. Overall, from the harvesting dates, the intermediate HD (105

day) could be selected for better CP without compromising the biomass yield as far as this experiment is concerned. Therefore, it can be concluded from the study that Desho grass could be produced substantially both in high and mid lands as long as irrigation scheme are available.

Keywords: mid altitude, high altitude, crude protein, forage biomass yield

Introduction

Despite Ethiopia has large livestock population (CSA, 2016), the productivity of livestock is low with the major hindrances being shortage of feed resources in terms of quantity and quality of (ILRI, 2009; Tegegne and Assefa, 2010; Demeke et al., 2017). To combat these nutritional constraints, the use of locally available forage species which are adaptable to the local agro-ecological conditions and used as feed resources are highly recommended as they are familiar with the smallholder farmers grown with low inputs (Anele *et al*., 2008). Among locally available multipurpose and potential feed resource in the country, *Desho* grass *(Pennisetum pedicullatum)* is the most appropriate one (EPPO, 2014; Leta *et al.*, 2014). *Desho* is a perennial grass and is palatable to cattle, sheep and other herbivores (FAO, 2010). The grass has the ability to recover after water stress even under severe drought conditions (Noitsak is *et al*., 1994). Moreover, Desho grass serves as a business opportunity for farmers in Ethiopia (Shiferaw *et al*., 2011; Tilahun *et al.*, 2017). The yield and nutritional qualities of forage are influenced by numerous factors such as seasonal variations, stage of maturity, ecological conditions and management practices (Giovanni et al., 2011). According to Lukuyu *et al*. (2011), it is very important to have chemical composition and utilization information of locally available feeds for their inclusion into livestock feeding programs. However, to the knowledge of the authors, there is no adequate information on the agronomic characteristics, productivity, management practices and chemical composition of Desho grass under irrigation management in Ethiopia. Therefore, the current study was conducted with the objective of characterizing Desho grass for its agronomic performance, yield and chemical composition at different agro-ecologies and harvesting dates.

Materials and Methods

Description of the experimental sites

The study was conducted in Mecha and Fart districts representing mid and highland areas of northwestern Ethiopia, respectively. Mecha district is one of the 15 districts of West Gojjam Zone located at a distance of 524 km north-west of Addis Ababa the capital of Ethiopia and 37 km from Bahir Dar, the capital of Amhara

National Regional State. The total area of the district is 144,582 hectares (CSA, 2014). According to the traditional agro-climatic zonation of the area, midland covers about 80% and the rest 17% and 3% of the area is covered by highland and lowlands, respectively (MDARDO, 2015). The geographical location of the study area is 11° 10 N-11° 25' N latitude and 37° 02' E-37° 17' E longitude with an altitude ranging from 1,500 to 3,200 masl. The mean annual rainfall of the district is 1750 mm with the mean temperature being 18.25°C (Eleni *et al.*, 2013). The topography of the district is predominantly plane having the value of 75% rugged land 13%, gentle slope 8% and 4% valley (MDARDO, 2015).

The experimental site for the highland agro-ecoloy was Melo Kebele in Farta district, found at a geographical location of 11°11' N and 38°E and at an altitude of 2, 650 meters 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 1,570 mm and the mean maximum and minimum temperatures are 21.5° and 9.6, respectively (FDoA, 2016).

Land preparation and planting

A total area of 88 m^2 was selected from each of the two locations. The land was ploughed in December and harrowed in January 2015. The prepared experimental land was divided in to three blocks each of which consisted of 9 plots with a size of 16 m^2. Desho grass was planted using vegetative root splits in 6 rows on a well-prepared soil. The spacing between rows and plants were 50 and 10 cm, respectively. Land preparation, planting, weeding and harvesting were done according to the recommendations made by Leta *et al*. (2013). DAP and urea were applied at planting and after establishment, respectively at the rate of 100 and 25 kg per ha. Weeding and related management practices were applied according to the grass's requirements.

Data collection

The morphological data such as number of tillers leaves were recorded from ten randomly selected plants from the middle rows of each plot at 75, 105 and 135 days after planting in both locations. The leaf to stem ratio was determined by harvesting the whole plant parts taken from the middle of two consecutive rows and, randomly selected at the of each plot and separated in to stem and leaf. Harvesting was done by hand using a sickle, leaving a stubble height of 8 cm according to the recommendations made by Leta *et al*. (2013). A fresh herbage yield of Desho grass was measured immediately after each harvest using portable balance with sensitivity of 0.01g. Representative samples taken from each plot at each site were dried in air drought oven at 65°C for 72 hours before sent to laboratory for chemical analysis.

Chemical analysis

The chemical analysis was done at Bebre Berhan Agricultural Research Center. Samples were dried in an oven set at a temperature of 60°c for 48 hours, ground to pass through a 1 mm sieve screen. Ash, Dry mater (DM) and Crude Protein (CP) were determined according to the procedures described by AOAC (1990). The Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were determined following the procedures of Van Soest and Robertson (1985). The dry matter yield (DMY) t/ha was determined by multiplying percent dry matter content by total area of land. The crude protein yield (CPY) t/ha was also determined by multiplying DMY by CP content.

Experimental design and data analysis

The experiment was laid out in a factorial arrangement of two altitudes (mid and high altitudes) and three harvesting dates (75, 105 and 135 days) using randomized complete block design with three replications. The experiment was laid out with a factorial arrangement of 2*3 = 6 treatment combinations with 6 plots in each replication and a total of 18 plots. The forage was planted in January 2015 under irrigation using furrow irrigation system. Pearson correlation analysis was also done to determine the association between plant characteristics with selected nutritional parameters and yield of the grass. The following mathematical model was applied to analyze the effect of all possible factors in the two sets of analysis: two altitudes (mid and highland) and three harvesting dates (75, 105 and 135 days).

$Y_{ijk} = \mu + R_i + A_j + H_k + (AH)_{jk} + eijk,$

Where,
Y_{ijk} = the response variable
μ = over all mean
R_i = the $_i$th factor effect (replication)
A_j = the $_j$th factor effect (Altitude)
H_k = the $_k$th, factor effect (Harvesting dates)
$(AH)_{jk}$ = the $_{jk}$th interaction effect (Altitude x harvesting dates)
eijk = the random error

The data were analyzed using the General Linear Model (GLM) of SAS 9.2 (2002). Turkey's honest significant test was employed for separation of treatment means.

Results

Effects of altitude and harvesting dates and their interactions on morphological characteristics of Desho grass

The results of the effect of altitude and harvesting dates and their interactions on plant morphological characteristics of *Desho* grass are presented in Table 1.The result indicates that plant height (PH) was significantly ($P<0.05$) affected by altitude and harvesting dates. The PH was also significant ($P<0.05$) due to the interactions of harvesting date and altitude. The highest PH was observed at the mid altitude (39.40 cm) and in terms of harvesting dates as the date of harvesting increased the height of plant was proportionally increased.

Number of tillers per plant (NTPP) was significant ($P<0.05$) due to altitude and harvesting dates and interactions of harvesting date and altitude. The higher NTPP was observed for mid altitude location (43.33) and the trend of NTPP increased as harvesting date increased. Number of leaves per plant (NLPP) was significant ($P<0.05$) due to altitude and harvesting date but not significant ($P>0.05$) due to the interaction of these factors. Similar to the above parameter, the larger NLPP (273.24) was observed for mid altitude. The highest NLPP was observed for mid harvesting date (105) days and the lowest were at early harvesting date (75 days).

Table 1 - Effect of altitude and harvesting dates on plant morphological parameters and yield of Desho grass under irrigation

Harvesting dates	PH			NTPP			NLPP		
	MA	HL	Mean	MA	HL	Mean	MA	HL	Mean
75	25.81	27.09	26.45	50.17	25.45	37.81	239.54	146.95	193.24
105	35.81	31.17	33.49	55.17	32.75	43.96	373.83	257.29	315.56
135	56.58	50.71	53.65	24.67	20.96	22.81	206.33	132.78	169.55
Mean	39.4	36.32	37.86	43.33	26.38	34.86	273.23	179.07	226.12
SE = 4.76				SE =7.67			SE= 0.71		
CV= 21.09				CV =36.75			CV=17.76		
Sig=0.004				Sig=0.03			Sig=0.001		
LSD=1.62				LSD =2.17			LSD4.64		
HD*AL=0.03				HD*AL=0.68			HD*AL=0.001		

MA= Mid-altitude; HL= high altitude; SE=standard error; CV=coefficient of variation; LSD=least significant difference; PH=plant height; NTPP=number of tillers per plant; NLPP=number of leaves per plant; NLPT=number of leaves per tiller; LLPP (cm)=leaf length per plant; TDMY (t/ha)=total dry matter yield.

Table 1 - continued

Harvesting dates	NLPT			LLPP (cm)			TDMY (t/ha)		
	MA	HL	Mean	MA	HL	Mean	MA	HL	Mean
75	4.79	5.86	5.33	20.13	15.72	17.93	24.84	20.18	22.51
105	6.79	7.92	7.36	25.13	18.83	21.98	23.47	20.0	21.7
135	8.42	6.39	7.41	28.08	24.98	26.53	19.56	15.36	17.4
Mean	6.66	6.72	6.70	24.45	19.84	22.15	20.99	21.57	21.28
SE = 4.76	SE = 59.26			SE = 21.62			SE = 3.32		
CV= 21.09	CV= 43.72			CV= 43.72			CV= 27.07		
Sig=0.004	Sig=0.5			Sig=0.005			Sig=0.023		
LSD=1.62	LSD=2.17			LSD=2.85			LSD=2.49		
HD*AL=0.03	HD*AL=0.68			HD*AL0.56			HD*AL=0.99		

MA= Mid-altitude; HL= high altitude; SE=standard error; CV=coefficient of variation; LSD=least significant difference; PH=plant height; NTPP=number of tillers per plant; NLPP=number of leaves per plant; NLPT=number of leaves per tiller; LLPP (cm)=leaf length per plant; TDMY (t/ha)=total dry matter yield.

Number of leaves per tiller (NLPT) was significant (P<0.05) due to harvesting dates and altitude interaction but not significant (P>0.05) due to altitude. The larges NLPT (7.4255) was observed for the advanced date of harvesting (135 days) but the two earlier harvesting dates did not show significant(P>0.05) differences. The leaf length per plant (LLPP) was significantly (P<0.001) affected by altitude, and harvesting dates but not significantly (P>0.05) affected by the interaction factors. The largest LLPP (24.44 cm) was observed for mid altitude. The late harvesting date (135 days) showed largest leaf length while earliest (75 days) one showed shortest leaf length (18.02 cm). The total dry matter yield (TDMY) was significantly (P<0.05) affected by altitude and harvesting date but not significant (P>0.05) due to the interactions. The mid altitude location showed higher TDMY than the high-altitude location. The earliest harvesting date showed significant (P<0.001) different yield but the latter harvesting dates did not show significant difference (P>0.05).

Effects of altitude and harvesting days and their interactions on plant chemical composition of Desho grass

The results of the effect of altitude and harvesting dates and their interactions on chemical composition of Desho grass are presented in Table 2. As indicated in the table, all parameters were no significant (P>0.05) due to altitude whereas CP,

NDF, and ADF were significant (P<0.001) due to harvesting dates; in which highest CP content was observed for earlier harvesting date. The highest NDF fraction was observed for late date of harvesting but the two earlier harvesting dates were not significant (P>0.05). The ADF fraction was also significantly (P<0.05) affected by harvesting dates only in which the earliest harvesting date has significantly (P<0.05) lower amount of ADF while the latter harvesting date were not significant (P>0.05) from each other.

Table 2 - Effect of altitude and harvesting dates on the chemical composition of Desho grass under irrigation

Harvesting dates	DM			OM			CP			Ash		
	MA	HL	Mean	MA	HL	Mean	MA	HL	Mean	MA	HL	Mean
75	29.10	26.50	27.80	89.12	89.17	89.15	9.37	8.30	8.84	10.88	10.83	10.855
105	29.40	27.10	28.25	89.66	88.66	89.16	10.27	6.90	8.59	10.34	11.34	10.84
135	31.99	30.30	31.15	91.57	90.57	91.07	8.52	7.20	7.86	8.43	9.43	8.93
Mean	31.42	27.97	29.07	90.12	89.47	89.79	9.39	7.33	8.36	9.88	10.53	10.205
SE = 0.92				SE =3.49			SE=2.56			SE = 0.87		
CV= 0.61				CV =5.22			CV=1.41			CV= 18.93		
Sig=0.75				Sig=1.83			Sig=0.09			Sig=0.38		
LSD=0.41				LSD =0.07			LSD=1.74			LSD=0.65		
HD*AL=0.55				HD*AL=0.18			HD*AL=4.22			HD*AL=6.3		

Table 2 - continued

Harvesting dates	NDF			ADF			ADL		
	MA	HL	Mean	MA	HL	Mean	MA	HL	Mean
75	58.44	59.20	58.82	47.14	47.20	47.17	18.14	16.45	17.30
105	61.07	58.32	59.70	49.35	46.50	47.93	17.59	17.62	17.61
135	60.13	64.90	62.52	44.60	49.85	47.23	17.89	18.40	18.15
Mean	59.88	60.81	60.34	45.70	48.07	46.89	17.87	17.12	17.50
SE = 0.92	SE =|10.66			SE = 5.24			SE = 11.52		
CV= 0.61	CV= 10.54			CV= 4.74			CV= 3.48		
Sig=0.75	Sig=0.02			Sig=0.03			Sig=0.19		
LSD=0.41	LSD=0.05			LSD=0.61			LSD=1.38		
HD*AL=0.55	HD*AL=0.71			HD*AL=0.8			HD*AL=1.89		

MA= Mid-altitude; HL= high altitude; SE=standard error; CV=coefficient of variation; LSD=least significant difference; DM=dry matter; OM=organic matter; CP=crude protein; NDF=neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin.

Correlation Analysis of Morphological and Nutritional Parameters of Desho Grass

The simple linear bivariate correlation analyses among morphological, quality and yield parameters of Desho grass is presented in Table 3. Plant height (PH) was significantly (P<0.01) positively correlated with NTPP, NLPT, NLPP and TDMY but was not significantly (P>0.05) correlated with other plant characteristics and chemical composition. NTPP was significantly (P<0.01) positively correlated with NLPT, NLPP but ADL was not significantly (P>0.05) correlated with other plant characteristics and chemical composition.

Table 3 - Correlation analysis of morphological, yield and nutritional parameters of Desho grass

	PH	NTPP	NLPT	NLPP	LLPP	TDMY	DM	ASH	OM
PH	1	0.0.61**	0.89***	0.919***	-0.21ns	0.72***	-0.21ns	0.36ns	-0.39ns
NTPP		1	0.65**	0.86***	-0.08ns	0.31ns	0.32ns	-0.09ns	0.13ns
NLPT			1	-0.33ns	0.74***	-0.21ns	-0.22ns	0.31ns	-0.34ns
NLPP				1	0.25ns	0.53*	0.25ns	0.07ns	0.04ns
LLPP					1	0.01ns	-0.06ns	0.33ns	0.36ns
TDMY						1	-0.05ns	0.17ns	-0.15ns
DM							1	0.13ns	-0.06ns
ASH								1	-0.99***
OM									1
CP									
NDF									
ADF									
ADL									

Table 3 - continued

	CP	NDF	ADF	ADL
PH	-0.20ns	0.46ns	0.34ns	-0.31ns
NTPP	0.10ns	-0.10ns	-0.29ns	0.69**
NLPT	-0.36ns	0.54*	0.46ns	-0.46ns
NLPP	-0.02ns	0.03ns	-0.22ns	0.68**
LLPP	-0.51*	0.63ns	0.34ns	-0.08ns
TDMY	0.22ns	0.17ns	0.11ns	0.52*
DM	0.07ns	-0.19ns	-0.18ns	0.40 ns
ASH	0.06ns	0.39ns	0.14ns	0.10ns
OM	-0.05ns	-0.38ns	-0.17ns	-0.05ns
CP	1	-0.41ns	-0.26ns	0.17ns
NDF		1	0.71***	-0.05ns
ADF			1	-0.19 ns
ADL				1

Level of significance: ***=P<0.001; **=P<0.01; *=P<0.05; ns=P>0.05; PH=plant height; NTPP=number of tillers per plant; NLPT=Number of leaves per tiller; NLPP=Number of leaves per plant; LLPP=leaf length; TDMY=Total dry matter yield; DM=Dry matter; OM=organic matter; CP=crude protein; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin.

Discussion

The result of plant height agreed with Asmare et al. (2017) in which plant height was low at early stages of growth, but enhanced growth was observed after 120 days of harvesting, for same grass species. Increment in plant height at late harvest stage could be due to massive root development and efficient nutrient uptake allowing the plant to continue increase in height as mentioned by (Melkie, 2005) for Bana grass in northwestern Ethiopia. Generally, plant height increment was consistent with plant maturity. Similar results have also been reported by other authors (Yasin *et al.*, 2003; Melkie, 2005; Asmare *et al.*, 2017). In addition, the maintenance of adequate intervals between consecutive cuttings for grasses enables them to retain sufficient leaf material and hence more photosynthetic products used for rapid growth over the growing season (Butt et al., 1993). In terms of tiller, highest tillers count (106.36) was recorded at 135 days of harvesting whereas (93.14) and (36.41) were recorded at 105 and 75 days of harvesting, respectively. This result indicated that the number of tillers per plant increased with increasing with increasing of harvesting days. The finding of current study agrees with the results of Asmare e*t al.* (2017) who reported similar values for the same grass species and (Melkie, 2005) in case of Bana grass.

The highest number of leaves per plant (710.2) was observed at late stage of harvesting (135 days) while lowest number (249.3) was observed at early stage (75 days) of harvesting. These results agree with Asmare *et al.* (2017) reports of the same grass species. Similarly, Melkie (2005) reported that similar result in causes of Bana grass (Butt *et al.*, 1993) and Napier grass (Tessema, 2000). Generally, the longer the vegetative phase and the taller the plant, the greater the number of leaves produced (Hunter, 1980). So, it can be concluded that the production of leaves from new tillers generally increased with an increase in days of harvesting.

The total dry matter of late harvesting day (135 days) was the highest (25.4 t/ha), whereas the lowest dry matter yield (7.06t/ha) was produced in the shortest harvesting days (75 days) and an intermediate mean DMY (15.73 t/ha) was obtained from the at 105 days of harvesting. The current result showed DMY increment as harvesting days increased. These results agreed with Asmare et al. (2017) who reported similar results from the same grass species. Ansah *et al.* (2010) reported that increased total herbage yield with increasing of harvesting day (60 days < 90days <120days) this could be attributed to the increase in tiller number, leaf formation, leaf elongation as well as stem development in Napier grass. Similarly, Berihun (2005) reported that Bana grass responded grass in higher morphological and yield parameters as harvesting stage increases. The chemical composition of Desho grass under irrigation was due to harvesting dates in which highest CP content was observed for earlier harvesting date. The finding was in line with earlier reports (Asmare *et al.*, 2017; Tilahun *et al.*, 2017).

Conclusion

This study has revealed the increases higher in plant characteristics and yield of desho grass was more affected by stage of harvest than attitude. As stage of harvest are increased, reduction in quality, especially reduced CP concentrations and increased NDF, ADF and ADL concentrations, with advancing maturity. While delayed harvesting results in increased DMY, this is at the expense of a reduction in quality. This finding suggests that the grass can be one of the most important grasses which can be productive under irrigation in areas where irrigable land is accessible. Both livestock producers and other farmers could use this information to assist in making decisions based on the relative importance of forage yield and quality in their livestock and farming operations.

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