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Effect of Height at Harvesting and Fertilizer Rate on Yield Performance and Quality of Desho Grass (*Pennisetum glaucifolium*) Under Supplementary Irrigation in Southern Ethiopia

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Abstract: The study was conducted to evaluate the effect of fertilizer rate and height at harvesting on biomass yield and chemical composition of desho grass (Pennisetum glaucifolium) under supplementary irrigation in the Wondogenet district of Southern Ethiopia. The experiment was conducted in a randomized complete block design in a factorial arrangement with four NPS fertilizer rates (0, 50, 100 and 150 kg/ha) and four harvesting heights (25, 50, 75 and 100 cm). Data were analyzed using the general linear model procedures of the Statistical Analysis System. Dry matter yield, crude protein yield (CPY), digestible yield (DY), crude protein concentration (CP) and ash content were significantly increased with increasing NPS fertilizer rate ($p<0.01$) and increment of harvesting height ($p<0.001$). Relative feed value (RFV), increased with increasing NPS fertilizer rate ($p<0.001$) as well as increases with increment of harvesting height ($p<0.001$).In vitro dry matter digestibility (IVDMD) was significantly decreased with an increment of harvesting height ($p<0.001$) but not affected by NPS fertilizer level ($P>0.05$). The neutral detergent fiber (NDF) was increased with the increment of harvesting height ($P<0.001$) while it was affected by the NPS fertilizer rate ($p<0.01$). Acid detergent fiber (ADF) and Acid detergent lignin (ADL) were increased with increment of harvesting height ($p<0.001$) and also affected by NPS fertilizer rate ($p<0.001$). The harvesting cycle had a significant effect on NDF ($P<0.001$), ADF ($P<0.001$), ADL ($P<0.001$), IVDMD ($p<0.001$), RFV ($p<0.001$), Ash ($p<0.001$) and CP concentration ($p<0.01$) of desho grass. Based on the findings of this research, it can be concluded that utilization of 150 kg/ha NPS fertilizer level combined with 75 cm height of harvesting could be used in the cultivation of desho grass to achie ve high er at the CPY and DY. However, further study is needed using different organic and inorganic fertilizers in different agroecological zones across years under rain-fed and irrigation conditions.

Key words: Biomass Yield · Desho Grass · Fertilizer Rate · Harvesting Height · Harvesting Cycle Nutritional Value

INTRODUCTION

Livestock production is an integral part of the subsistence crop-livestock systems of the Ethiopian highlands. It plays a crucial role in Ethiopian agriculture. However, productivity per animal is very low. The major constraint of low productivity of Ethiopian livestock is a shortage of feeds in terms of quantity and quality [1]. The main feed resources for livestock in Ethiopia are natural pasture and crop residues, which are low in quantity and quality for sustainable animal production [2, 3]. Forage intake and forage nutritive value are two forage-related parameters that influence animal performance and these components work together to influence the forage's quality [4]. To improve livestock production, sustainable solutions to seasonal deficiencies in feed availability and quality are required through proper management and utilization of forage

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crops. The utilization of locally accessible forage plants as feed resources is highly suggested to address existing livestock nutritional limits because they are familiar to smallholder farmers, grow with minimal input and adapt to local environments [5, 6]. Thus, one of the major interference areas to boost livestock production in Ethiopia is the use of indigenous forage like desho grass as the major source of feed [6]. Desho is an indigenous grass of Ethiopia belonging to the family Poaceae [7, 8]. Desho grass is utilized as a means of soil conservation practices and animal feed in the highlands of Ethiopia [9, 8]. Desho grass is drought-resistant and used as feed for ruminants [10]. Desho has the potential to meet the challenges of feed scarcity since it provides more forage per unit area and ensures regular forage supply due to its multi-cut nature and it provides high yields of green herbage ranging between 30-109 t/ha [9].

Desho grass is suitable for intensive management and performs well at an altitude ranging from 1500 to 2800 masl [11]. The combined benefits of desho grass suggest the use of the grass as a potential feed source, sold as fodder for income generation and means of soil conservation in the mixed crop-livestock production systems of Ethiopia [6]. Desho grass is found in different parts of the country and is the most productive grass. There is some information on the management practices of desho grass that influence dry matter yield and morphological characteristics when grown with diammonium phosphate (DAP) fertilizer, Urea fertilizer and harvesting date. However, information regarding the effect of NPS fertilizer rate and height of harvesting on biomass yield and chemical composition of desho grasses under supplementary irrigation is lacking. In forage crops, plant height is an essential factor that influences yield. Determining the best height to harvest desho grass will require striking a balance between productivity and feed quality [12].Therefore; the current study was designed to evaluate the yield performance and Chemical composition of desho grass under different heights of harvesting and fertilizer rates across the harvesting cycle.

MATERIALS AND METHODS

Description of the Study Area: The experiment was conducted at Wondogenet Agricultural Research Center from September 2019 to May 2020 under supplementary irrigation. The Wondogenet is located about 264 kilometers southeast of Addis Ababa and 23 kilometers east of Hawassa, the capital city of the Sidama Regional state. The experimental site is located at 07°19.1' North latitude, 38°30' East longitude with an altitude of 1780 meters above sea level. The area receives a mean annual rainfall of 1128 mm with a minimum and maximum temperature of 11 and 26°C, respectively. The soil type (0-30 cm) was sandy clay loam with 0.14 % total N, pH of 6.4, Organic carbon (2.2%) and Sulfur (14.12).

The experiment was conducted as a randomized complete block design (RCBD) in factorial arrangements (4 × 4) with four harvesting heights and four levels of NPS fertilizer application each with three replications. The treatment consisted of four fertilizer rates and four heights of harvesting (4 * 4) total of 16 treatments with a total of 48 experimental plots. The spacing between the rows and plants of desho grass was 50 and 25 cm, respectively [13]. The space between plot and block was 1 and 1.5 m, respectively. The experimental plot size was 3 * 4 m (12 m2). The study was carried out using a desho grass (*Pennisetum glaucifolium)* variety called Kulumsa- DZF 592 which was released in March 2017. Land preparation, planting, weeding and harvesting were done according to the recommendations [11]. The experimental field was plowed using a tractor and leveled manually. Desho grass vegetative root splits were planted in` rows on well-prepared soil in rain-fed conditions and carried out by supplementary irrigation. Based on the experimental design, each treatment was randomly assigned to the experimental unit within a block. Blended NPS fertilizer with four rates (0, 50, 100 and 150 kg/ha) was applied at the establishment of the experiment. Irrigation was applied three times a week for the first month and one time a week afterward [14]. Each block and plot were irrigated separately.

Data Collection*:* Data was taken from the two rows next to the destructive sampling rows on both sides. The weight of the total fresh biomass yield was recorded from each plot in the field and about 0.5 kg of representative samples was taken from each plot to the laboratory. The samples were oven-dried for 24 hours at a temperature of 105°C and weighed to estimate the dry matter content. Then dry matter yield (t/ ha) was estimated by multiplying the dry matter content of the sample by the total fresh herbage yield (t/ha), then divided by 100. Crude protein yield was calculated: by multiplying dry matter yield (t/ha) by crude protein concentration (%) divided by 100. Digestible Yield: was calculated NDF content multiplying by ADF content divided by 100. The samples were oven-dried at 65°C for 48 hrs and ground to pass through a 1 mm sieve size screen for chemical and IVDMD analysis. Before scanning, the samples were dried at 65° overnight in an oven to standardize the moisture and then 3 g of each sample was scanned by the Near Infra-Red Spectroscopy (NIRS) with an 8 nm step. Ash, crude protein (CP), Neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and in-vitro dry matter digestibility (IVDMD) were predicted using a calibrated NIRS (Foss 5000 apparatus and WinISI II software). NIRS is now recognized as a valuable tool in the accurate determination of the chemical composition, digestibility parameters and gas production parameters of a wide range of forages [4].

Statistical Analysis: The collected data were subjected to the analysis of variance procedures of the SAS general linear model statistical software version 9.4. Treatment means were separated using Duncan's Multiple Range Test. The statistical model for analysis of variance of the RCBD design for individual harvesting cycles is given by:

$$Yijk = \mu + Fi + Hj + (FH)ij + \beta k + eijk$$

The statistical model for combined analysis of variance of the RCBD design across the harvesting cycle is given by:

$$Yijkl = \mu + Fi + Hj + Hck + (FH)ij + (FHC)ik + (HHC)jk + (FHHC)ijk + \beta l + eijkl$$

where, Yijkl = the response variable, μ = Over the mean, Fi= the factor effect (Fertilizers), Hj= the factor effect (Harvesting heights), HCk= the factor effects (Harvesting cycle), (FH) $_{ij}$= the ijth interaction effect (Fertilizers x harvesting heights), (FHC)ik = the ikth interaction effect of (Fertilizer x Harvesting cycle), (HHC) jk= the jkth interaction effect of (Harvesting height x Harvesting cycle), (FHHC)ijk= the ijkth interaction effect of (Fertilizers x Harvesting height x Harvesting cycle), (βl = the block effect and eijkl = the random error.

RESULTS

Dry Matter Yield, Crude Protein Yield and Digestible Yield of Desho Grass as Affected by Harvesting Height, Fertilizer Rate and Harvesting Cycle: The effect of fertilizer rate, harvesting height and harvesting cycle on DMY, CPY and DY of desho grass are presented in Table 1. The highest and lowest ($p<0.001$) DMY were found in 100 and 25cm, respectively at the first and second harvest and also at the combined analysis. Regarding fertilizer rate, the higher ($p<0.01$) DMY was found for 150 kg/ha followed by 100 kg/ha and the least DMY was found for 0 kg/ha in the first and second harvests while the highest DMY was found by application of 150kg NPS/ha and least from unfertilized at combined analysis. The CPY was higher ($p<0.001$) in 100 and 75cm than in 50 and 25cm heights of harvesting while the least value was found in the 25cm height of harvesting at both harvest and the combined. CP yield was higher ($p<0.001$) in 150 and 100kg NPS/ha than in 50kgNPS/ha and unfertilized treatment at the first harvest. At the second and the combined, the higher ($p<0.001$) CPY was found in 150kgNPS/ha while the lowest value was in unfertilized treatment. CPY found from the second harvest was higher ($p<0.001$) than CPY from the first harvest with the mean CPY of 1.01 t/ ha and 0.80 t/ ha, respectively. The highest ($p<0.001$) DY was found at 100cm and the lowest value was at 25cm height of harvesting at the first harvest. At the second harvest and the combined, the higher ($p<0.001$) DY was in 100 and 75cm while the least value was in 25cm heights of harvesting. Higher DY was found by application of 150kgNPS/ha while the lowest value was in unfertilized treatment at the first harvest. At the second harvest, the DY found, in unfertilized treatment was lower ($p<0.001$) than at 50, 100 and 150kgNPS/ha rates of fertilizer application with no significant differences between the latter three rates. The combined analysis showed that the DY found in 150 and 100kgNPS/ha fertilizer application was higher ($p<0.001$) than in unfertilized treatment while the intermediate result was found in 150 and 100kgNPS/ha; 100 and 50kgNPS/ha; 50kgNPS/ha and 0kgNPS/ha. DY found from the second harvest was igher ($p<0.001$) than DY found from the first harvest.

Chemical Composition, In-vitro Dry Matter Digestibility and Relative Feed Value of Desho Grass as Affected by Harvesting, Height, Fertilizer Rate and Harvesting Cycle: Crude protein concentration, ash, NDF, ADF and ADL content of desho grass are presented in Table 2. The highest and lowest ($p<0.001$) CP concentration was found at 100 and 25cm height of harvesting respectively, while no significant difference between 50 and 75cm at both harvest and the combined result. The second harvest had more ($P<0.01$) CP concentration than the first harvest. CP content in 150kgNPS/ha fertilizer application was higher ($p<0.01$) than CP content in 100kgNPS/ha and in unfertilized treatment and CP in 50kgNPS/ha fertilizer application was higher than in unfertilized treatment but no significant ($p>0.05$) difference within 100kgNPS/ha fertilizer application at the

Table 1: Dry matter yield, CPY and DY of desho grass as affected by the height of harvesting, fertilizer rate and harvesting cycle

		Fert (kg/ha)						SL						
Yield (ton/ha)	Hh (cm)	0	50	100	150	Mean	SEM	Ht	Frt	HC	Ht*Frt	Ht*HC	Frt*HC	Ht*Frt*HC
DMY (H1)	25	3.67	4.81	5.75	5.88	5.03^{D}	0.69	***	**		NS			
	50	8.06	9.09	9.29	10.7	9.28^{C}	0.49							
	75	10.4	11.3	12.9	13.7	12.0^{B}	0.39							
	100	13.7	14.7	15.5	18.8	15.7^{A}	1.59							
	Mean	8.94^{C}	9.96^{BC}	10.9^{AB}	12.3^{A}	10.5								
	SEM	0.49	0.83	0.53	1.32									
DMY (H2)	25	5.52	6.35	7.14	8.10	6.78^{D}	0.77	***	**		NS			
	50	8.76	8.93	9.43	11.7	9.70^{C}	0.72							
	75	12.7	15.9	15.9	16.7	14.9^{B}	1.32							
	100	15.6	17.3	19.8	20.1	18.2^{A}	1.37							
	Mean	10.6^{C}	11.9^{BC}	12.9^{AB}	14.1^{A}	12.4								
	SEM	0.82	1.35	0.98	1.03									
DMY (C)	25	4.59	5.58	6.45	6.99	5.90^{D}	0.63	***	***	***	NS	NS	NS	NS
	50	8.41	9.01	9.36	11.9	9.49^{C}	0.42							
	75	11.5	13.2	14.0	15.2	13.5^{B}	0.89							
	100	14.7	15.9	17.7	19.5	16.9^{A}	1.22							
	Mean	9.79^{C}	10.9^{B}	11.9^{B}	13.2^{A}	11.5								
	SEM	0.58	0.91	0.50	0.97									
CPY (H1)	25	0.37	0.49	0.52	0.61	0.50^{C}	0.08							
	50	0.55	0.66	0.79	0.95	0.74^{B}	0.08							
	75	0.67	0.97	0.91	1.03	0.89^{AB}	0.12							
	100	0.89	0.91	1.24	1.26	1.08^{A}	0.16							
	Mean	0.62^{C}	0.76^{BC}	0.87^{AB}	0.96^{A}	0.80								
	SEM	0.04	0.10	0.12	0.17									
CPY (H2)	25	0.49	0.66	0.68	0.83	0.67^{C}	0.08							
	50	0.75	0.58	0.89	1.13	0.84^{B}	0.06							
	75	0.88	1.44	1.23	1.49	1.26^{A}	0.12							
	100	1.06	1.31	1.36	1.44	1.29^{A}	0.09							
	Mean	0.80^{C}	1.00^{B}	1.04^{B}	1.22^{A}	1.02								
	SEM	0.03	0.13	0.09	0.10									
CPY (C)	25	0.43	0.58	0.60	0.72	0.58^{C}	0.06	***	***	***	NS	NS	NS	NS
	50	0.65	0.62	0.84	1.04	0.79^{B}	0.06							
	75	0.78	1.20	1.07	1.26	1.08^{A}	0.16							
	100	0.98	1.11	1.30	1.35	1.19^{A}	0.11							
	Mean	0.71^{C}	0.88^{B}	0.95^{B}	1.09^{A}	0.91								
	SEM	0.05	0.10	0.08	0.11									
DY (H1)	25	1.90	2.61	3.18	3.35	2.76^{D}	0.08							
	50	3.76	4.35	4.48	5.63	4.56^{C}	0.08							
	75	4.46	5.65	6.41	6.74	5.82^{B}	0.12							
	100	6.30	6.12	6.72	8.01	6.79A	0.16							
	Mean	4.11^{C}	4.68^{BC}	5.20^{B}	5.93^{A}	4.98								
	SEM	0.04	0.09	0.12	0.17									
DY (H2)	25	3.96	3.65	5.12	4.64	4.93^{C}	0.62							
	50	6.00	5.55	6.14	7.47	6.29^{B}	0.97							
	75	7.04	9.84	9.62	11.1	9.40^{A}	1.14							
	100	8.30	9.02	11.5	11.3	10.1^{A}	1.21							
	Mean	6.33^{C}	7.28^{AB}	8.10^{A}	8.96^{A}	7.67								
	SEM	0.69	0.55	1.33	1.39									
DY (C)	25	2.93	3.65	4.15	4.64	3.84^{C}	0.62	***	***	***	NS	NS	NS	NS
	50	4.88	4.95	5.31	6.55	5.42^{B}	0.49							
	75	5.75	7.75	8.01	8.93	7.61^{A}	1.02							
	100	7.30	7.57	9.12	9.68	8.42^{A}	1.03							
	Mean	5.22^{C}	5.98^{BC}	6.65^{AB}	7.45^{A}	6.33								
	SEM	0.59	0.78	0.85	0.95									

Means Followed by the same subscript within a column are not significantly different (p>0.05, DMY= Total Dry Matter Yield; DY= Digestible Yield; CPY=Crude protein yield; C=Combined mean; H= Harvesting; HC= Harvesting cycle; Ht=Height; Frt= Fertilizer rate

Table 2: Chemical composition of desho grass as affected by the height of harvesting fertilizer level and harvesting cycle

		F(kg/ha)						SL						
Variables	Hh (cm)	0	50	100	150	Mean	SEM	Ht	Frt	HC	Ht*Frt	Ht*HC	Frt*HC	Ht*Frt*HC
CP (H1)	25	100.5	103.9	90.3	101.0	98.9^{A}	3.19	***	NS		NS			
	50	69.1	71.9	84.3	88.6	78.6^{B}	5.72							
	75	64.6	85.2	70.7	74.6	73.8^{B}	6.03							
	100	65.8	61.5	80.1	65.9	68.3^{C}	4.45							
	Mean	74.9	80.7	81.4	82.	79.91								
	SEM	2.69	3.66	5.08	7.96									
CP (H2)	25	88.9	96.2	98.1	109	98.2^{A}	5.67	***	***		NS			
	50	79.6	85.4	94.1	97.4	89.1^{B}	2.08							
	75	70.4	93.8	81.0	89.9	83.8^{B}	4.25							
	100	68.6	75.5	68.7	71.5	71.1^{C}	1.90							
	Mean	76.9^{C}	87.7^{AB}	85.5^{B}	92.1^{A}	85.6								
	SEM	4.93	3.45	2.12	3.39									
CP (C)	25	94.7	100.	94.2	105	98.6^{A}	4.43	***	***	**	NS	*	NS	NS
	50	74.3	78.7	89.2	92.9	83.8^{B}	3.89							
	75	67.5	89.5	75.9	82.2	78.8^{B}	5.14							
	100	67.2	68.5	74.4	68.7	69.6^{C}	3.18							
	Mean	75.9^{B}	84.2^{A}	83.4^{A}	87.32^{A}	82.7								
	SEM	3.81	3.56	3.60	4.84									
Ash (H1)	25	140.4	137	141	136	139^{A}	2.59	***	***		NS			
	50	133	131	138	128	133^{B}	1.61							
	75	129	130	133	129	130^{B}	1.74							
	100	126	121	135	120	126^{C}	2.80							
	Mean	132^{AB}	130^{B}	137^{A}	129^{B}	132								
	SEM	1.83	2.10	1.45	3.37									
Ash (H2)	25	149	154	157	143	151^{A}	1.98	***	NS		NS			
	50	151	151	147	149	149^{A}	0.73							
	75	148	152	152	146	149^{A}	1.24							
	100	145	146	142	142	144^{B}	2.25							
	Mean	148	151	149	146	149								
	SEM	1.06	1.30	1.33	2.53									
Ash (C)	25	145	146	149	139	145^{A}	2.29	***	***	***	NS	*	NS	*
	50	142	141	143	139	141^{B}	1.17							
	75	139	141	142	138	140^{B}	1.49							
	100	136	133	139	131	135^{C}	2.52							
	Mean	140^{AB}	140^{AB}	143^{A}	137^{B}	140								
	SEM	1.43	1.70	1.38	2.95									
NDF (H1)	25	718^{cd}	716^{cd}	712^{d}	647^{e}	698^{C}	5.74	***	***		**			
	50	721^{cd}	735^{bcd}	726^{cd}	721^{cd}	726^{B}	5.43							
	75	774^{a}	736^{bcd}	728^{cd}	726^{cd}	741^{A}	5.74							
	100	771^{a}	754^{ab}	735^{bcd}	741^{bc}	750^{A}	9.12							
	Mean	746^{A}	735^{AB}	725^{B}	709^{C}	729								
	SEM	6.99	9.36	5.16	4.52									
NDF (H2)	25	629^{gh}	621^{h}	615^{h}	579^{i}	611^{D}	5.34	***	***		**			
	50	659^{def}	648^{ef}	642^{fg}	622^{h}	643^{C}	4.73							
	75	681^{c}	678^{cd}	670^{cd}	666^{cde}	674^{B}	4.42							
	100	734^{a}	698.2^{b}	679^{cd}	673^{cd}	696.1^{A}	6.63							
	Mean	676^{A}	661^{B}	652^{C}	635^{D}	655.97								
	SEM	4.43	3.83	5.30	7.55									
NDF (C)	25	674^{bcd}	668^{cd}	663^{d}	613^{e}	654.74^{D}	5.54	***	***	***	***	***	NS	**
	50	690^{bcd}	691^{bcd}	684^{bcd}	672^{bcd}	684.4^{C}	5.08							
	75	727^{ab}	707^{abcd}	699^{abcd}	696^{abcd}	707.22^{B}	5.08							
	100	752^{a}	726^{abc}	707^{abcd}	707^{abcd}	723.18^{A}	7.87							
	Mean	711^{A}	698^{B}	688^{C}	672^{D}	692.39								
	SEM	5.71	6.59	5.23	6.04			***	**		**			
ADF (H1)	25	396^{bcd}	381^{d}	381^{d}	345^{e}	376^{c}	3.76							
	50	389^{bcd}	408^{abc}	391^{bcd}	385^{cd}	393^{b}	7.12							
	75	425^{a}	403^{abcd}	379^{d}	389^{bcd}	399^{ab}	5.99							
	100	411^{ab}	401^{abcd}	407^{abc}	410^{ab}	407^{a}	8.16							
	Mean	405^{A}	398^{AB}	389^{BC}	383^{C}	394								
	SEM	6.99	9.36	5.16	4.52									
ADF (H2)	25	347	321	321	312	325^{D}	2.29	***	***		NS			
	50	368	357	349	344	357^{C}	1.29							
	75	390	379	372	360	376^{B}	3.81							
	100	416	398	387	373	393^{A}	4.68							
	Mean	380^{A}	364^{B}	357^{C}	347^{D}	362								
	SEM	2.24	3.13	3.41	3.29									

Table 2: Continued

		F(kg/ha)						SL						
Variables	Hh (cm)	0	50	100	150	Mean	SEM	Ht	Frt	HC	Ht*Frt	Ht*HC	Frt*HC	Ht*Frt*HC
ADF (C)	25	371^{cdef}	354^{efg}	351^{fg}	328^{g}	351^{D}	3.03	***	***	***	**	***	NS	**
	50	378^{cdef}	382^{bcde}	370^{cdef}	365^{ef}	374^{C}	4.21							
	75	408^{ab}	391^{abcd}	376^{cdef}	375^{cdef}	388^{B}	4.91							
	100	413^{a}	399^{abc}	397^{abc}	392^{abcd}	400^{A}	6.42							
	Mean	393^{A}	382^{B}	373^{C}	365^{D}	378								
	SEM	3.38	6.84	4.69	3.65									
ADL(H1)	25	45.4	42.3	42.9	40.7	42.8^{C}	0.87	***	**		NS			
	50	44.2	49.1	44.8	43.4	45.4^{B}	1.42							
	75	49.0	48.3	43.7	46.2	46.8^{B}	1.45							
	100	55.9	52.5	49.8	49.6	51.9^{A}	1.09							
	Mean	48.6^{A}	48.1^{A}	45.3^{B}	44.9^{B}	46.7								
	SEM	1.18	1.64	1.29	0.74									
ADL(H2)	25	36.6^{f}	35.9^{f}	34.7^{f}	33.3^{f}	35.1^{D}	0.56	***	***		***			
	50	45.4^{de}	44.5^{de}	44.0^{de}	43.0^{e}	44.2^{C}	1.10							
	75	50.1^{bc}	46.6^{de}	46.9^{cd}	44.2^{de}	46.9^{B}	1.18							
	100	58.4^{a}	53.2^{b}	45.4^{de}	43.1^{e}	50.0^{A}	1.13							
	Mean	47.6^{A}	45.1^{B}	43.1^{C}	41.0^{D}	44.2								
	SEM	0.67	1.26	1.19	0.85									
ADL(C)	25	41.0^{ef}	39.1^{f}	38.8^{f}	36.9^{f}	38.9^{D}	1.24	***	***		***	***	NS	*
	50	44.8^{de}	46.8^{cd}	44.4^{de}	43.2^{de}	44.8^{C}	2.18							
	75	49.6^{bc}	47.4^{cd}	45.3^{cd}	45.2^{cd}	46.9^{B}	2.28							
	100	57.1^{a}	52.9^{b}	47.6^{cd}	46.3^{cd}	50.9^{A}	3.86							
	Mean	48.1^{A}	46.6^{B}	44.0^{C}	42.9^{C}	45.4								
	SEM	1.60	2.51	2.15	1.37									

Means followed by the same subscript within a column are not significantly different (P>0.05). CP=Crude protein; NDF= Neutral detergent fiber; ADF=Acid detergent fiber; ADL= Acid detergent lignin

Table 3: IVDMD and RFV of desho grass as affected by the height of harvesting, fertilize rate and harvesting cycle

		Fert (kg/ha)						SL						
Variable	Hh (cm)	0	50	100	150	Mean	SEM	Ht	Frt	HC	Ht*Frt	Ht*HC	Frt*HC	Ht*Frt*HC
IVDMD (H1)	25	51.66^{bcd}	54.17^{abc}	55.42^{ab}	57.31^{a}	54.64^{A}	0.92	***	*		*			
	50	46.62^{efg}	47.94^{def}	48.21^{de}	52.55^{bcd}	48.83^{B}	0.82							
	75	42.88^{g}	50.10^{cde}	49.74^{cde}	49.43^{cde}	48.04^{B}	2.20							
	100	46.20^{efg}	41.82^{g}	43.27^{fg}	42.34^{g}	43.41^{C}	1.19							
	Mean	46.84^{B}	48.51^{AB}	49.16^{AB}	50.41^{A}	48.73								
	SEM	1.19	1.23	1.35	1.35									
IVDMD (H2)	25	71.83	73.88	71.69	71.61	72.25^{A}	2.14	***	NS		NS			
	50	68.23	62.43	65.37	63.80	64.96^{B}	3.34							
	75	55.69	63.53	62.59	66.46	62.07^{B}	3.33							
	100	52.79	52.16	57.84	56.06	54.71^{C}	3.36							
	Mean	62.14	63.00	64.37	64.48	63.49								
	SEM	1.17	2.54	4.66	3.95									
IVDMD (C)	25	61.74	64.03	63.55	64.46	63.45^{A}	12.7	***	NS	***	NS	NS	NS	NS
	50	57.43	55.18	56.79	58.18	56.90^{B}	12.1							
	75	49.29	56.82	56.17	57.94	55.06^{B}	8.41							
	100	49.49	46.99	50.56	49.20	49.06^{C}	10.4							
	Mean	54.49	55.76	56.77	57.45	56.18								
	SEM	11.282	11.3	12.7	11.5									
RFV (H1)	25	75.33^{bcd}	76.67^{bc}	77.33^{b}	89.00^{a}	79.58^{A}	1.00	***	***		**			
	50	75.33^{bcd}	72.33^{cde}	75.00^{bcd}	76.00^{bcd}	74.67^{B}	1.293							
	75	67.33^{f}	72.67^{cde}	76.00^{bcd}	75.00^{bcd}	72.75^{BC}	0.978							
	100	68.67^{ef}	71.67^{de}	72.67^{cde}	71.67^{de}	71.17^{C}	1.512							
	Mean	71.67^{C}	73.34^{BC}	75.25^{B}	77.92^{A}	74.55								
	SEM	1.05	1.79	1.11	0.83									
RFV (H2)	25	91.33^{de}	95.00^{bc}	96.67^{b}	103.67^{a}	96.67^{A}	0.94	***	***		*			
	50	85.00^{gh}	87.67^{fg}	89.33^{ef}	93.00^{cd}	88.75^{B}	0.67							
	75	80.00^{ij}	81.33^{i}	83.00^{hi}	85.33^{gh}	82.42^{C}	0.78							
	100	71.33^{k}	77.33^{j}	80.67^{i}	82.67^{hi}	78.00^{D}	1.05							
	Mean	81.92^{D}	85.33^{C}	87.42^{B}	91.17^{A}	86.46								
	SEM	0.80	0.47	0.83	1.33									
RFV (C)	25	83.33^{bcd}	85.83^{bc}	87.00^{b}	96.33^{a}	88.12^{A}	3.88	***	***	***	***	***	NS	***
	50	80.17^{bcd}	80.00^{bcd}	82.17^{bcd}	84.50^{bc}	81.71^{B}	3.22							
	75	73.67^{de}	77.00^{cde}	79.50^{bcde}	80.17^{bcd}	77.59^{C}	2.24							
	100	70.00^{e}	74.50^{de}	76.67^{cde}	77.17^{bcde}	74.59^{D}	1.86							
	Mean	76.79^{D}	79.33^{C}	81.34^{B}	84.54^{A}	80.50								
	SEM	2.44	2.92	2.79	3.06									

Means followed by the same subscript within a column are not significantly different (P>0.05). IVDMD= In-vitro dry matter digestibility; RFV= Relative feed value second harvest. At the combined result, the CP concentration in unfertilized treatment was lower ($p<0.001$) than CP concentration in 50, 100 and 150kgNPS/ha fertilizer application but there was no significant difference between the three fertilizer rates. The fertilizer rate had no effect ($p>0.05$) on CP at the first harvest. The ash content was higher ($p<0.001$) when the grass was harvested at 25cm and lower at 100cm while there was no significant difference between 50 and 75cm height of harvesting at the first harvest. At the second harvest, the grass harvested at 100cm contained lower ($p<0.001$) ash than the grass harvested at 50, 75 and 25cm height but the early three heights of harvesting had no significant difference at the second harvest. The grass harvested at 25cm height had ash content higher ($p<0.001$) than the others and the lower ash content was found in the grass harvested at 100cm height while there was no significant difference between 50 and 75cm heights of harvesting at the combined result. Regarding fertilizer rate, the ash content in 100kgNPS/ha was higher ($p<0.01$) than in 50 and 150kgNPS/ha fertilizer applications but similar ($p>0.05$) within unfertilized treatment at the first harvest. At the combined analysis, the ash content in 100kgNPS/ha fertilizer application was higher ($p<0.001$) than the ash content in 150kgNPS/ha wile 0, 50 and 100kgNPS/ha; 0kgNPS/ha with 50kgNPS/ha fertilizer application had similar ($p>0.05$) effect on ash content.

The NDF content at 75 and 100cm height of harvesting was higher ($p<0.001$) than the other two early heights while the lowest value was found at 25cm at the first harvest. At the second harvest and combined result, the highest and lowest NDF content was found in 100 and 25cm heights of harvesting respectively. Regarding fertilizer rate, NDF content in unfertilized treatment and 150kgNPS/ha fertilizer application was respectively highest and lowest at the second harvest and the combined. At the first harvest, the NDF content in unfertilized treatment was higher ($p<0.001$) than NDF content in 100 and 150kgNPS/ha fertilizer application but similar to in 50kgNPS/ha fertilizer application. The ADF content in grass harvested at 100cm height was higher ($p<0.001$) than in 25 and 50cm height but similar ($p>0.05$) within 75cm height of harvesting during the first harvest. At the second harvest and the combined, the highest and lowest ($p<0.001$) ADF content was found in 100 and 25cm heights of harvesting. ADF content in unfertilized treatment was higher ($p<0.01$) than in 100 and 150kgNPS/ha fertilizer applications but similar ($p<0.05$) to in 50kgNPS/ha fertilizer application at the first harvest. At the second harvest and combined, the highest and lowest ADF content was found in unfertilized treatment and 150kgNPS/ha fertilizer application, respectively.

The higher and lower ($p<0.01$) ADL content was found at 100 and 25cm height of harvesting while a similar value was found between 50 and 75cm height of harvesting at the first harvest. At the second harvest, the highest and lowest ($p<0.001$) ADL content was found in 100cm and 25cm heights of harvesting, respectively. However, ADF content at 100cm height was higher ($p<0.001$) than at 75, 50 and 25cm while similar value was found at 50 and 75cm heights of harvesting the combined. The ADL content in unfertilized treatment and 50kgNPS/ha was higher ($p<0.01$) than in 100 and 150kg NPS/ha fertilizer application while a similar value was found between 0 and 50kgNPS/ha; 100 and 150kgNPS/ha fertilizer application at the first harvest. At the second harvest, the highest and lowest ADL content was in unfertilized and 150kgNPS/ha fertilizer applications. At the combined result, the ADL content in unfertilized treatment was higher ($p<0.001$) than 50, 100 and 150kgNPS/ha while similar values were between in 100 and 150kgNPS/ha fertilizer application.

The IVDMD obtained in 25 and 100cm heights of harvesting was higher and lower respectively than in 50 and 75cm heights of harvesting which are not significant ($p>0.05$) differences at both harvest and the combined result. The IVDMD obtained from the second harvest was higher ($P<0.001$) than the IVDMD obtained at the first harvest. IVDMD obtained in 150kgNPS/ha was higher ($p<0.001$) than in unfertilized but similar to in 50 and 100kgNPS/ha fertilizer application at the first harvest while the fertilizer rate had no effect ($p>0.05$) in IVDMD at the second harvest and the combined analysis variance.

RFV is an index which widely used to compare the potential of two or more forages based on energy intake [15]. RFV at 25cm height of harvesting was higher ($p<0.001$) than RFV in 50, 75 and 100cm while similar value was found in 50 and 75cm; 75 and 100cm heights of harvesting at the first harvest. At the second harvest and the combined analysis of variance, the higher and lower ($p<0.001$) RFV was found at 25 and 100cm heights of harvesting, respectively.

The RFV obtained from the second harvest was higher ($p<0.001$) than the value obtained from the first harvest. The RFV in 150kgNPS/ha was higher ($p<0.001$) than the value found in unfertilized treatment, 50 and 100kgNPS/ha while similar value was obtained in unfertilized treatment and 50; 50 and 100kgNPS/ha fertilizer application at the first harvest. In the second and the combined analysis of variances, the higher and lower ($p<0.001$) RFV was in 100 and unfertilized treatment, respectively.

DISCUSSION

Dry Matter Yield, Crude Protein Yield and Digestible Yield of Desho Grass as Affected by Harvesting Height, Fertilizer Rate and Harvesting Cycle: The dry matter yield increment with increasing harvesting height might be due to the additional tillers developed, which brought an increase in leaf formation, leaf elongation and stem development [16]. Moreover, the increment of forage yield was found to be directly proportional to increasing plant height and number of tillers per plant [17, 18]. The present result is supported by the finding of [3] who reported that the highest dry matter yield of napier grass was obtained at 1.0 m and 1.5 m of cutting heights compared with 0.5 m height of harvesting. The increment of DM yield with an increased level of fertilizer could be due to more tillering and density of leaves, with an increase in fertilizer rate thereby increasing DM yield. It is supported by the findings of Gilbert *et al.* [19] who reported that the application of high rates of nitrogen fertilization produced a high yield of Rhodes grass and the curvilinear effect of N-application rates on grass yield in tropical and subtropical regions of Australia. In the present study, DMY in the second harvest was higher than DMY in the first harvest with a mean of 12.40 t/ ha and 10.51 t/ha, respectively. It is in line with the findings of Yirgu *et al.* [20] who reported that the DM yield obtained during the second harvest (31.29 t/ha) was significantly higher than the first harvest (21.76 t/ha). Gadisa *et al.* [21] also reported a greater biomass yield (t/ha) of desho grass produced in the second harvest (67.33 t/ha) than in the first harvest (59.87 t/ha). The mean DMY (11.45 t/ha) per harvest obtained in this study is higher than the findings of [14] which was 4.11 t/ha for desho grass in Dehana District, Wag Hemra Zone, Ethiopia. But it is comparable with the value (11.40 t/ha) reported by [13] from desho grass in Jinka Agricultural Research Center, Southern Ethiopia. The variation in the findings could be due to environmental conditions such as soil, temperature and moisture, type of fertilizer application and management systems. The mean CP yield increased with increasing cutting height of desho grass might be as plants matured, herbage yield increased, resulting in an increased DM yield which in turn increased CPY of grass at a late height of harvesting. DMY increased as plant density increased and with the emergence of a high number of tillers. The current study result agreed with Kefyalew *et al.* [14] who reported an increasing trend in CPY with extended days of harvesting in the case of Napier grass and Desho grass, respectively. The CPY mean (0.91 t/ ha) obtained in this study was higher than the finding (0.36 t/ ha) of Kefyalew *et al.* [14] for desho grass in Dehana District, Wag Hemra Zone, Ethiopia. However, it was lower than the findings (1.29 t/ ha, 1.57 t / ha and 1.23 t /ha) of Asmare [22], Genet *et al.* [23], Faji *et al.* [24], respectively for Desho grass in Ethiopia. The variation in the findings could be due to environmental conditions such as soil, temperature and moisture, type of fertilizer application and management systems. An increased trend in DY as the height of harvesting forage increases could be due to the function of dry matter yield and dry matter concentration in the plant tissue. The present result is supported by the finding of Berhanu [25] who reported an increasing trend in digestible dry matter yield of grasses with extended days of harvesting. However, it is in contrast to Zewdu *et al.* [26] who found that the digestible dry matter of Napier grass was higher with cutting at 0.5 and 1 m plant height than at 1.5 m. The variation might be from grass species and environmental conditions like rainfall and temperature. The DY increased as application rates of NPS fertilizer level due to fertilizer increasing leafiness and tillers of plants.

Chemical Composition, *In-vitro* Dry Matter Digestibility and Relative Feed Value of Desho Grass as Affected by Harvesting, Height, Fertilizer Rate and Harvesting Cycle: In the present study, the CP content decreased with increasing harvesting height which is in line with Van Soest [27] which is attributed mainly to dilution of the CP contents of the forage crops by the rapid accumulation of cell wall carbohydrates at the later heights of growth. This might also be due to an increase in fiber content as accompanied by a decrease in CP content associated with an increase in the proportion of lignified structural tissue at a later stage of growth according to Van Soest [28]. The increment in CP content with the increment of fertilizer could have been due to an increase in the level of inorganic fertilizer applied according to Adewumi [29]. The mean CP value (8.27%) for desho grass in the current study is higher than the findings (7.12%, 7.33%) reported by Asmare *et al.* [6]and Waziri *et al.* [30], respectively for desho grass in Ethiopia. However, it is lower than the result (10.2 %) reported by Genet *et al.* [23] for desho grass in the highlands of Ethiopia. The difference observed in CP content might be attributable to the stage of the harvest of the desho grass as it has been reported by Asmare *et al.* [6] that young (90 days after planting) desho grass had higher CP content (9.33%) than the mature (150 days) ones (6.93%). The difference observed might be attributable to the difference in altitude associated with photosynthesis and nutrient assimilation as it has been reported by Asmare *et al.* [6] that lowland desho grass had higher CP content (9.33%) than the highland one (7.33%).The variation in ash content of desho grass across the different heights of harvesting is in agreement with the findings of Kitaba, A. and Tamir [31] and Bizelew *et al*. [32] who reported that the declined ash content with increased harvesting height could probably be caused partly due to the dilution effect of higher yields in the presence of a constant amount of available minerals in the soil. Bayble *et al*. [33] reported similar results, suggesting that the ash contents of herbaceous forages decline as the height of maturity advances. Zewdu *et al*. [26] also reported that the ash content obtained from 0.5 m (16.80 %) and 1 m (16.60 %) cutting height was higher than the mean value of ash content obtained at 1.5 m (15.20 %) cutting height of Napier grass. The ash content decreases with increasing fertilizer rates except at 0 and 50 kg/ ha at each height of harvesting in the current experiment which is supported by the finding of Khan *et al*. [34] who reported that application of N fertilizer decreased the ash content of oat (*Avena sativa* L.). Ahmad *et al.* [35] reported ash content increased due to the application of inorganic, organic and mixed types of fertilizer than without fertilizer forage of oat (*Avena sativa* L.). The mean ash content (14%) for desho grass in the current study is higher than the findings (8%, 12.4%) of Genet *et al.* [23] and Teshale *et al.* [36], respectively in the highlands of Ethiopia. However, the mean ash content in the current study was lower than the finding (15.3%) of *et al.* [36] from the midland area. The variation in ash content could be due to plant developmental height, morphological fractions, climatic conditions, soil characteristics and fertilizer regime [37, 38]. The increasing trend of NDF content with advance in harvesting height agreed with the finding of Waramit [39] who reported that the increased NDF content might be associated with an increase in cell wall lignification as forages are matured. This could be due to an increase in fiber content as accompanied by a decrease in CP content associated with an increase in the proportion of lignified structural tissue at a later stage of growth [40, 28]. The current study result agrees with other literature findings of Ansah *et al.* [41] and Moreira *et al.* [42] who reported that NDF content increased consistently as forage maturity increased. The mean value of NDF content decreases with the increasing NPS fertilizer level which might be because chemical fertilizer improves the plant growth and raises new leaves and shoots, which minimizes the NDF content of the desho grass. However, there is no rejuvenation of leaves and tillers in the unfertilized treatments because plant tissue matures and accumulates more NDF content [43].

The increase in ADF content with increasing height of harvesting could be due to the maturation of desho grass which is supported by other researchers [44, 45, 46] who reported that ADF, ADL and cellulose increases with increased height of cutting in Napier grass. The significant decrease in ADF content with increasing the level of fertilizer could be a shortening of days to forage harvest. It is supported by the findings of Okwori and Magani [47] and Abdi *et al.* [48] who stated that the acid detergent fiber content of *Panicum maximum* decreased with increasing urea fertilizer application rates significantly. The mean value of ADF in the current study is within the favorable range of 333 g/ kg DM to 594 g/ kg DM which is considered medium-quality roughages according to Nsahlia *et al.* [49]. It is comparable with the finding (378 g/kg DM) of Genet *et al.* [23] for desho grass in the highlands of Ethiopia. On the other hand, it is lower than the findings (425.1 g/kg DM, 450.01 g/kg DM) by Kefyalew *et al.* [14] and Asmare [22], respectively for desho grass in northern Ethiopia. The variation could be due to environmental conditions such as soil, temperature and moisture, altitude, type of fertilizer application and management systems like harvesting time and height of harvesting.

The ADL content of desho grass is increased with increasing height of harvesting in the current study which is consistent with the findings of Kabuga and Darko [44], Kidunda et al. [45] who reported that ADF, ADL and cellulose content increases with increased height of cutting, due to maturation of Napier grass. This result is also supported by the finding of Zewdu *et al.* [3] who studied other grass. Fertilizers promote the growth of new leaves and shoots resulting in low lignin, which compensates for the increased lignin content of the other tissue. This result is in line with Kefyalew *et al.* [14] who reported that the ADL content of desho grass decreased with increasing fertilizer levels. The present result also agrees with the findings of Yirgu *et al.*[50] who reported that the ADL content of grasses (Desho, Buffel and Setaria) declined significantly when applied different fertilizers in combined or alone, compared to no fertilizer. The mean ADL content obtained from the current study is comparable with the finding (44.8 g/ kg DM) by Faji *et al.* [24] for desho grass in the highlands of Ethiopia. Higher ADL content (52.9 g/ kg DM) was reported by Mergia *et al.* [51]. The variation in the findings might be due to environmental conditions (rainfall, temperature and altitude), cropping season and management systems like harvesting time and height of forage at cutting. An increment in desho grass cutting height resulted in a reduction of IVDMD which might be due to an increase in the proportion of cell wall and its constituent fractions and a decline in the ratio of leaf to stem that is prevalent with increasing maturity. As plants mature, the stem comprises an increasing proportion of the whole plant than the leaf in the later days of harvesting [40, 44, 28]. The present result is supported by the finding of Zewdu *et al.* [3] who reported that the IVDMD decreases with increasing cutting height of Napier grass (1.5 m<1 m>0.5 m) in north-western Ethiopia. The increased IVDMD with increasing levels of fertilizer application in the current study might be due to fertilizer application improving and stimulating new growth of tillers, shoots and leaves and accelerating the rate of stem development and accumulation of dead materials, which are low in the cell wall and lignin contents, leading to higher digestibility as suggested by Waramit *et al.* [52]. Abdi *et al*. [48] reported that urea fertilizer level increased the IVDMD value in *Panicum maximum* and *Cenchrus ciliaris*. Gudeta [52] also reported that the application of different levels of urea fertilizer had significant effects on IVDMD of Panicum at all stages of harvest which is IVDMD increased with increasing levels of urea fertilization. The current study value of IVDMD is comparable with the finding of Faji *et al.* [24] which reported 56.44 % of IVDMD for desho grass at the Holeta agricultural research center on the station. The present result is lower than the finding of Geberemariyam and Gezahegn [54] who reported 63.08% IVDMD for desho grass. This could be due to the environmental conditions, harvesting stage and seasonal effect. In the present study, RFV decreased with increased heights of harvesting which might be due to harvesting height being related to days to forage harvesting (harvesting stage), which affects the quality of forage crops. Early-harvested forage crops contain higher RFV than late-harvested forage crops. The RFV is calculated based on NDF and ADF. NDF is used as an indicator of forage intake and ADF is used as an indicator of digestibility. Thus, together, ADF and NDF estimate intake potential and digestibility. As with NDF, higher forage ADF results in reduced digestibility of dry matter as a consequence of increased lignification of cellulose in the plants [55]. Waramit [52] and Abdi [48] reported that fertilizer application improves and stimulates new growth of tillers, shoots and leaves and accelerates the rate of stem development and accumulation of dead materials, which are low in the cell wall and lignin contents, leading to higher digestibility.

CONCLUSION

The interaction of fertilizer rate, harvesting height and harvesting cycle had a significant ($p<0.01$) effect on NDF, ADF ADL and RFV, while crude protein content, ash content and IVDMD were affected by the main factors) at combined analysis result. The dry matter yield obtained in 100cm by application of 150kgNPS/ha was higher than the other combination. However, CPY and DY obtained in 100 and 75cm by application of 150kgNPS/ha were higher than other combinations in the combined analysis of the result. Based on the findings of this research, it can be concluded that utilization of 150 kgNPS/ha fertilizer level combined with 75 cm height at harvesting could be used in the cultivation of desho grass to achie ve high er at the CPY and DY. Further research is needed on different organic and inorganic fertilizers in different agroecological zones under rain-fed and irrigation conditions. Further investigation is also needed in different locations across years and using animal performance trials.

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