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RESEARCH ARTICLE

Influence of harvesting height and fertilizer rate on morphological characteristics and yield performance of desho grass (*Pennisetum glaucifolium*) under supplementary irrigation in southern Ethiopia

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The study was conducted to evaluate the effect of using different fertilizer rates and harvesting heights on morphological characteristics, biomass yield and economic feasibility of desho grass (*Pennisetum Glaucifolium*) under supplementary irrigation in Southern Ethiopia. The experiment was conducted in a randomized complete block design in a factorial arrangement with three replications. The factors of the treatments were four NPS fertilizer rates (0, 50, 100 and 150 kg/ha) and four harvesting heights (25, 50, 75 and 100 cm). Data on morphological characteristics and forage yield at each harvesting height were collected and analyzed using the general linear model procedures of SAS version (9.4) and the Duncan multiple range test was used for mean comparison. The tiller number was higher ($P<0.05$) when harvested at 100 cm height compared to those harvested at 75,50 and 25 cm height of harvesting after planting and 150 kgNPS/ha applied during the combined analysis. The tiller number found at the second harvest was higher ($P<0.05$) than at the first harvest. The number of leaves per plant was significantly increased with increasing NPS fertilizer rate ($P<0.001$), increment of harvesting height ($P<0.001$) and harvesting cycle ($P<0.001$). The leaf number per plant counted at 25 cm height was lower ($P<0.05$) than the other heights of harvest with no significant differences between 75 and 100 cm heights of harvesting at combined analysis. The leaf number was higher ($P<0.05$) at the application of 150kgNPS/ha than the others at the combined analysis. The leaf number found at the second harvest was higher ($P<0.05$) than at the first harvest. Leaf length was significantly increased with an increase of NPS fertilizer rate and increment of cutting height ($P<0.05$) but not affected by the harvesting cycle ($P>0.05$). At the combined analysis result, the leaf length at 100cm height was longer ($P<0.05$) than those harvested at 75, 50 and 25 cm heights of harvesting. The leaf length was higher ($P<0.05$) at the application of 150kgNPS/ha than the others while there was no significant difference between 50 and 100 kgNPS/ha. Days to forage harvest was higher ($P<0.05$) than those harvested at 75, 50 and 25 cm height when harvested at 100 cm height while lower by application of 150 and 100 kgNPS/ha when compared with unfertilized and 50kgNPS/ha during combined analysis. The leaf stem ratio was higher ($P<0.05$) when harvested at 25 cm than three harvesting heights while intermediate result was found at 50 and 75 cm during the combined analysis result. A higher ($P<0.05$) leaf stem ratio was found by application of 150kgNPS/ha when compared with 100 and 50 kgNPS/ha or no fertilizer. Dry matter yield was increased with increasing NPS fertilizer rate and increased with increment of harvesting height ($P<0.05$). The leaf percentage found at 25cm was higher ($P<0.05$) than those later three heights of harvesting while the higher leaf percentage was found by application of 150 kgNPS/ha when compared with 100 and 50 kgNPS/ha or no fertilizer. The stem percentage found at 100 cm was higher (P<0.05) than at 75, 50 and 25 cm heights of harvesting. The lower stem percentage was at the application of 150 kgNPS/ha than 100, 50 kgNPS/ha, or no fertilizer. The partial budget analysis result revealed that the net benefit-cost ratio found at the application of 150 kgNPS/ha at 75 cm height was higher than other combinations while the least benefit-cost ratio was at 25 cm height with no fertilizer. Based on the findings of this research, it can be concluded that utilization of 150 kg/ha NPS fertilizer rate combined with 75 cm height of harvesting could be used in the cultivation of desho grass to achieve higher at the most agronomic performance, biomass yield and Cost-benefit ratio (6.04). Further investigation is needed using different organic and inorganic fertilizers in different agroecological zones across years under rain-fed and irrigation conditions.

Keywords: Desho grass, Dry matter yield, Fertilizer rate, Harvesting cycle, Harvesting height.

Introduction

Livestock plays a crucial role in Ethiopian agriculture. Currently, productivity per animal is very low and the contribution of the livestock sector to the overall economy is much lower than expected. Despite many factors constraining the development of this sector, the major constraint of low productivity of Ethiopian livestock is a shortage of feeds in terms of quantity and quality (Shapiro, BI., et al., 2015). The major causes of feed shortage are diminishing natural pastures/grazing land, population growth, expansion of cropping at the expense of grazing lands and expansion of degradable lands, which can no longer support either annual crops or pastures. 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 (Tessema, Z and Baars, RMT. 2004; Zewdu, T., et al., 2002). To improve livestock production, sustainable solutions to seasonal deficiencies in feed availability and quality are required through proper management and utilization of forage crops. The use of indigenous forage as a feed source is among the options under the present conditions of tropical countries to increase the production and productivity of livestock. According to Anele, UY., et al., 2009, indigenous forages are familiar with smallholder farmers, grow with low inputs and are adaptable to different agroecological conditions. 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 (Asmare, B., et al., 2017). Desho is an indigenous grass of Ethiopia belonging to the family Poaceae (Smith, G. 2010; Welle, S., et al., 2006). Currently, the grass is utilized as a means of soil conservation practices and animal feed in the highlands of Ethiopia. Desho grass is drought-resistant and used as feed for ruminants. 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. Desho grass is suitable for intensive management and performs well at an altitude ranging from 1500 to 2800 masl (Leta, G., et al., 2013). 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 (Genet Tilahun, GT., et al., 2017). 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 and height of harvesting on biomass yield and morphological characteristics of desho grasses under supplementary irrigation is lacking. Therefore; the current study was designed to evaluate the morphological characteristics, yield performance and economic feasibility of desho grass under different fertilizer levels and harvesting heights across the harvesting cycle.

Materials and Methods

Description of the study area

The field 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 an altitude of 1780 meters above sea level. The area has 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) is sandy clay loam with 0.14% total N, pH of (6.4%), Organic carbon (2.2%), low available phosphorus (12.21%) and sulfur (14.12).

Treatments and experimental design

The experiment was conducted as a Randomized Complete Block Design (RCBD) in factorial arrangements (4 × 4) with four harvesting heights (25, 50, 75 and 100 cm), four fertilizer levels of NPS fertilizer (0, 50 100 and 150 kgNPS/ha) and two harvesting cycle each with three replications. It consisted totally 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 (Worku et al. 2017). The space between the plot and block was 1 and 1.5 m, respectively with plot size 3 × 4 m (12 m^2). The study was carried out using a desho grass (*Pennisetum glaucifolium*) variety called Kulumsa. Land preparation, planting, weeding and harvesting were done according to the recommendations (Leta, G., et al., 2013). The experimental field was ploughed using a tractor and plots were 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 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 (Kefyalew, A., et al., 2020). Each block and plot were irrigated separately.

Data collection and forage sampling

Data on the physical appearance of plant growth was taken from the row next to the border row on both sides, five plants per plot were selected and tagged randomly for the various measurements according to Tarawali, SA., et al. (1995). The tiller number per plant was carried out by counting the number of tillers on five randomly selected plants and the average was calculated. The number of leaves per plant was carried out by counting the number of leaves within the tillers of five plants and the average was calculated. Length of leaf per plant was measured by measuring tape taken from five plants and the average was calculated. Dry matter yield 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 were taken to the laboratory. The sample taken from each plot was manually fractionated into leaf and stem. The morphological parts were separately weighed to know the fresh weight, oven-dried for 24 hours at a temperature of 105 °C and separately weighed to estimate the dry weight of these morphological parts. The leaf-to-stem ratio was determined by dividing the leaf dry weight by the stem dry weight. Days to forage harvesting were recorded for each plot when the grass reached the (25, 50, 75 and 100 cm) heights of harvesting.

Data analysis

The data collected from two harvesting cycles and combined across the harvesting cycle were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (Statistical Analysis System) 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

Agro-morphological parameters of desho grass as affected by harvesting height, fertilizer rate and harvesting cycle

The effects of harvesting height, fertilizer level, harvesting cycle and interaction between harvesting height, fertilizer level and harvesting cycle on agronomic characteristics of Desho grass are shown in Table 1, 2 and 3. The Number of Tillers Per Plant (NTPP) was significantly affected by harvesting height ($P<0.001$) and fertilizer level ($P<0.001$) as well as by the interaction of fertilizer levels and heights of harvesting ($P<0.01$) at the first harvest. However, at the second harvest, the NTPP was significantly ($P<0.001$) affected by height at harvesting and fertilizer rates ($P<0.01$) but the interaction had no effect ($P>0.05$). The mean value of NTPP found at the second harvest was higher ($P<0.001$) than the value found at the first harvest. Similarly, during the combined analysis, NTPP was significantly affected ($P<0.001$) by NPS fertilizer level, harvesting height and harvesting cycle but the interaction was not (P>0. 05). From the combined analysis, the highest NTPP was found at 100 cm and the least value was found at 25cm harvesting heights while intermediate value was found at 50 and 75 cm cutting heights. The Number of Leaves Per Plant (NLPP) was significantly affected by harvesting height ($P<0.001$) and NPS fertilizer level ($P<0.001$) at both harvests. The interaction of harvesting height and fertilizer level had a significant effect on NLPP at the second harvest ($P<0.01$) but not at the first harvest ($P>0.05$). The NLPP found at the second harvest was higher ($P<0.001$) than the value found at the first harvest. During the combined analysis result, NLPP was significantly affected by harvesting height, NPS fertilizer level and harvesting cycle ($P<0.001$). The NLPP counted from 100 and 75 cm cutting height by application of 150 kg ha^{-1} fertilizer level was higher than other values and the least NLPP was found from 25 cm cutting height at unfertilized treatment. The NLPP counted was significantly ($P<0.05$) affected by the interaction of harvesting height-fertilizer level and harvesting height-fertilizer level-harvesting cycle at $P<0.05$ but not significantly ($P>0.05$) affected by the interaction of harvesting height-harvesting cycle and fertilizer level-harvesting cycle. Leaf Length (LL) was significantly ($P<0.001$) affected by harvesting height and the interaction of harvesting height and fertilizer level but not ($P>0.05$) by NPS fertilizer level during the second harvesting cycle. At the first harvest, LL was significantly affected by harvesting height ($P<0.001$) but not ($P>0.05$) by fertilizer level and interaction of harvesting height-fertilizer level. The results of the combined analysis showed that the harvesting height, NPS fertilizer level and interaction of fertilizer level and harvesting height had a significant ($P< 0.001$) effect while the interaction of harvesting cycle, harvesting height and fertilizer level had a significant effect on LL at ($P<0.05$). However, the interaction between the harvesting cycle with harvesting height and fertilizer level did not show a significant ($P>0.05$) difference in leaf length. In the combined result, the highest ($P<0.001$) mean of LL was measured at 100 cm by application of 150 kg ha^{-1} and the lowest value was measured from 25 cm height of harvesting at all fertilizer levels. The height of harvesting ($P<0.001$) and NPS fertilizer level ($P<0.05$) affected on days to forage harvesting (DH) but the interaction was not ($p>0.05$) at both harvests.

Table 1. Agronomic characteristics of Desho grass as affected by fertilizer level, harvesting height, harvesting cycle and their interaction.

Variables	Frt (Kg ha^{-1})	Hh (cm)				Mean	SL					
		25	50	75	100		Ht	Frt	HC	Ht*Frt	Ht*HC	Ht*Frt*HC
NTPP(H1)	0	35.73^{g}	35.33^{g}	44.20^{efg}	36.80^{g}	38.02^{D}	***	***		**		
	50	43.00^{efg}	41.07^{fg}	42.80^{efg}	48.47^{cdrf}	43.84^{C}						
	100	40.27^{fg}	50.67^{cde}	46.93^{def}	59.60^{ab}	49.37^{B}						
	150	41.13^{fg}	56.93^{bc}	55.60^{bcd}	67.53^{a}	55.30^{A}						
	mean	40.03^{C}	46^{B}	47.38^{B}	53.1^{A}	46.63						
	SE											
NTPP (H2)	0	79.63^{d}	91.53^{bc}	97.07^{bc}	98.27^{abc}	91.63^{C}	***	**		NS		
	50	86.67^{cd}	95.87^{bc}	101.27^{ab}	98.73^{abc}	95.64^{BC}						
	100	92.33^{bc}	96.27^{bc}	100.40^{ab}	102.47^{ab}	97.86^{AB}						

	150	92.00^{bc}	99.87^{ab}	103.20^{ab}	110.27^{a}	101.33^{A}						
	mean	87.66^{C}	95.89^{B}	100.49^{AB}	102.44^{A}	96.62						
	SE											
NTPP (C)	0	57.68	63.43	70.63	67.53	64.82^{D}	***	***	***	NS	NS	NS
	50	64.83	68.47	72.03	73.6	69.73^{C}						
	100	66.3	73.47	73.67	81.03	73.62^{B}						
	150	66.57	78.4	79.4	88.9	78.32^{A}						
	mean	63.85^{C}	70.94^{B}	73.93^{B}	77.77^{A}	71.62						
	SE											
NLPP (H1)	0	188.16^{g}	266.27^{f}	310.40^{f}	279.52^{f}	261.09	***	***	NS			
	50	262.05f	301.84^{ef}	314.64^{def}	354.99^{cde}	308.38						
	100	262.80^{f}	390.77^{bc}	378.76^{cd}	405.64^{bc}	359.49						
	150	289.15^{ef}	475.71^{a}	455.63^{ab}	490.60^{a}	427.77						
	mean	250.54	358.65	364.86	382.69	339.18						

Means Followed by the same Subscript within a column are not significantly different (p>0.05). NTPP= Number of Tillers Per Plant; NLPP= Number of Leaves Per Plant; Hh=Harvesting height; Frt=Fertilizer rate; C=Combined; SL=Significance level

The DH at the first harvest was higher than the DH at the second harvest. DH of the first harvesting cycle was longer days than the second harvest of desho grass. The results of the combined analysis of variance showed the harvesting height (P<0.001); fertilizer level (P<0.01); harvesting cycle (P<0.01); and interaction of harvesting height and harvesting cycle had significant (p<0.01) but the interaction of height of harvesting and fertilizer level; fertilizer level and harvesting cycle and height of harvesting, fertilizer level and harvesting cycle had no significant (p>0.05) effect on DH. DH at 100 cm height was longest (p<0.001) while DH at 25 cm height of harvesting was shortest (p<0.001) than the others. About fertilizer level, the longer (p<0.05) DH were obtained at 0 and 50 kg /ha while the shorter (p<0.05) were obtained at the 100 and 150 kg/ha of NPS fertilizer levels.

Table 2. Agronomic characteristics of Desho grass as affected by fertilizer level, harvesting height, harvesting cycle and their interaction (Second harvest).

Variables	**Frt (Kg ha^{-1})**	**Hh (cm)**				**Mean**	**SL**					
		25	**50**	**75**	**100**		**Ht**	**Frt**	**HC**	**Ht*Frt**	**Ht*HC**	**Ht*Frt*HC**
NLPP(H2)	0	414.09^{f}	555.23^{cde}	613.20^{bcd}	550.03^{de}	533.14^{C}	***	***		**		
	50	497.13^{ef}	600.43^{bcd}	657.83^{bc}	569.75^{bcde}	581.29^{B}						
	100	570.67^{bcde}	625.45^{bcd}	669.47^{b}	615.24^{bcd}	620.21^{B}						
	150	627.87^{bcd}	646.89^{bcd}	786.10^{a}	841.10^{a}	725.49^{A}						
	mean	527.44^{C}	607^{B}	681.65^{A}	644.03^{AB}	615.03						
	SE											
NLPP (C)	0	301.1	410.75^{b}	461.80^{a}	414.77^{b}	397.11	***	***	***	*	NS	*

		3^{d}	cd	bcd	cd	D				
	50	379.59^{cd}	451.13^{abcd}	486.24^{abcd}	462.37^{abcd}	444.83^{C}				
	100	416.73^{bcd}	508.11^{abcd}	524.11^{abc}	510.44^{abcd}	489.85^{B}				
	150	458.51^{abcd}	561.30^{abc}	620.86^{ab}	665.85^{a}	576.63^{A}				
	mean	388.99^{C}	48.82^{B}	523.25^{A}	513.36^{A}	477.11				
	SE									
LLPP (H1)	0	15.29^{d}	28.22^{c}	29.24^{C}	40.85^{b}	28.4^{C}	***	***		NS
	50	15.62^{d}	30.24^{c}	32.98^{c}	40.31^{b}	29.79^{BC}				
	100	17.20^{d}	31.10^{c}	32.55^{c}	46.71^{a}	31.89^{B}				
	150	17.83^{d}	32.20^{c}	37.45^{b}	50.11^{a}	34.40^{A}				
	mean	16.49^{D}	30.44^{C}	33.06^{B}	44.49^{A}	31.12				
	SE									
LLPP (H2)	0	18.57^{h}	22.59^{h}	36.05^{cde}	40.11^{bc}	29.33	***	NS		**
	50	18.32^{h}	29.15^{gf}	35.30^{cde}	38.55^{bcd}	30.33				
	100	21.14^{h}	28.31^{g}	34.02^{def}	41.28^{b}	31.19				
	150	22.31^{h}	29.49^{gf}	31.05^{efg}	47.16^{a}	32.5				
	mean	20.09^{D}	27.39^{C}	34.11^{B}	41.78^{A}	30.84				

Means Followed by the same Subscript within a column are not significantly different (p>0.05). NTPP= Number of Tillers Per Plant; NLPP= Number of Leaf Per Plant; H=Harvest; C=Combined; SL=Significance level; SE=Standard Error

Table 3. Agronomic characteristics of Desho grass as affected by fertilizer level, harvesting height, harvesting cycle and their interaction (Combined analysis of both first and second harvest).

Variables	**Frt (Kg ha^{-1})**	**Ht (cm)**				**Mean**	**SL**					
		25	**50**	**75**	**100**		**Ht**	**Frt**	**HC**	**Ht*Frt**	**Ht*HC**	**Ht*Frt *HC**
LLPP(C)	0	16.93^{g}	25.40^{f}	32.64^{de}	40.48^{bc}	28.86^{C}	***	***	NS	**	***	*
	50	16.97^{g}	29.69^{e}	34.14^{d}	39.43^{c}	30.06^{BC}						
	100	19.17^{g}	29.70^{e}	33.28^{de}	43.99^{b}	31.54^{B}						
	150	20.07^{g}	30.84^{de}	34.25^{d}	48.64^{a}	33.45^{A}						
	mean	18.29^{D}	28.91^{C}	33.58^{B}	43.14^{A}	30.98						
	SE											
DH (H1)	0	65.00^{g}	108.00^{cde}	119.33^{bc}	137.33^{a}	107.42^{A}	***	*		NS		
	50	65.00^{g}	99.33^{def}	110.00^{cde}	134.00^{ab}	102.08^{AB}						
	100	60.00^{g}	94.67^{ef}	113.33^{cd}	130.67^{ab}	99.67^{AB}						

	150	60.00^{g}	90.00^{f}	104.00^{cdef}	130.67^{ab}	96.17^{B}						
	mean	62.50^{D}	98.00^{C}	111.67^{B}	133.17^{A}	101.34						
	SE											
DH (2)	0	49.00^{gh}	63.00^{efgh}	95.00^{bc}	120.00^{a}	81.75	***	*		NS		
	50	47.00^{h}	71.33^{def}	81.33^{cd}	120.00^{a}	79.92						
	100	47.00^{h}	59.33^{fgh}	78.67^{cde}	98.67^{b}	70.92						
	150	47.00^{h}	56.00^{fgh}	66.67^{defg}	109.33^{ab}	69.75						
	mean	47.5	62.42	80.42	112	75.59						
	SE											
DH (C)	0	57.00^{fg}	85.50^{cde}	107.17^{abc}	128.67^{a}	94.59^{A}	***	**	***	NS	**	NS
	50	56.00^{fg}	85.33^{cde}	95.67^{bcd}	127.00^{a}	91.00^{A}						
	100	53.50^{g}	77.00^{def}	96.00^{bcd}	114.67^{ab}	85.29^{B}						
	150	53.50^{g}	73.00^{efg}	85.33^{cde}	120.00^{a}	82.96^{B}						
	mean	55.00^{D}	80.21^{C}	96.04^{B}	122.59^{A}	88.46						

Means Followed by the same Subscript within a column are not significantly different (p>0.05). NTPP= Number of tillers per plant; NLPP= Number of Leaf Per Plant; H=Harvest; C=Combined; SL=Significance Level; SE=Standard Error of mean

Dry matter and botanical fractions yields of desho grass as affected by harvesting height fertilizer rate and harvesting cycle

The effect of harvesting height, fertilizer level and the interaction on dry matter yield (DM, Y), Leaf Dry Matter Yield (LDMY) and Stem Dry Matter Yield (SDMY) of desho grass was presented in Table 4. The DMY obtained from both the first and second harvest was affected by harvesting height (P<0.001) and fertilizer level (P<0.01) but the interaction was not (P>0.05). DMY produced from the second harvest was higher than DMY produced from the first harvesting cycle. The total DMY obtained from the two harvests was affected by harvesting height (P<0.001) and fertilizer level (P<0.01) but the interaction was not (P>0.05). From the total analysis result, the highest DMY was found for a harvesting height of 100 cm with regard least for a harvesting height of 25 cm. Regarding fertilizer level, the highest DMY was lowest for 150 kg/ha followed by 100 kg/ha and the lowest DMY was found for 0 kg/ha followed by 50 kg/ha the fertilizer rates. The LDMY obtained from both the first and second harvests was affected by harvesting height (P<0.001) and fertilizer level (P<0.01) but the interaction was not (P>0.05). LDMY produced from the second harvest was higher than LDMY produced from the first harvest. Total LDMY obtained from two harvests was affected by both main factors at (P<0.001) but not at the interaction (P>0.05). From the total analysis result, the highest LDMY was found for a harvesting height of 100 cm and the least for a harvesting height of 25 cm. Concerning fertilizer levels, the highest LDMY was found for 150 kg/ha and the least LDMY was found for 0 kg/ha followed by 50 kg/ha fertilizer levels.

Table 4. Effects of NPS fertilizer rates, harvesting heights and their interactions on biomass yield of Desho grass.

Yield (t/ha	**Frt (Kg ha$^{-1)}$**	**Hh (cm)**				**Mean**	**SL**					
		25	**50**	**75**	**100**		**Ht**	**Frt**	**HC**	**Ht*Frt**	**Ht*HC**	**Ht*Frt*HC**
DMY (H1)	0	3.67	8.06	10.36	13.66	8.94^{C}	***	**		NS		

	50	4.81	9.09	11.29	14.65	9.96^{BC}				
	100	5.75^{f}	9.29	12.86	15.53	10.86^{AB}				
	150	5.88	10.68	13.66	18.84	12.27^{A}				
	mean	5.03^{D}	9.28^{C}	12.04^{B}	15.67^{A}	10.51				
	SE									
DMY (H2)	0	5.52	8.76	12.65	15.63	10.64^{C}	***	**		NS
	50	6.35	8.93	15.18	17.3	11.94^{BC}				
	100	7.14	9.43	15.18	19.79	12.89^{AB}				
	150	8.1	11.68	16.66	20.13	14.14^{A}				
	mean	6.78^{D}	9.70^{C}	14.92^{B}	18.21^{A}	12.4				
	SE									
DMY (T)	0	9.19	16.82	23.01	29.29	19.58^{C}	***	**		NS
	50	11.17	18.02	26.47	31.95	21.90^{BC}				
	100	12.89	18.72	28.04	35.32	23.74^{AB}				
	150	13.98	22.36	30.32	38.97	26.41^{A}				
	mean	11.81^{D}	18.98^{C}	26.96^{B}	33.88^{A}	22.91				
	SEM									
LY (H1)	0	2.11	4.58	5.69	7.64	5.01^{C}	***	***	NS	
	50	2.93	5.15	6.65	7.77	5.63^{BC}				
	100	3.28	5.41	7.77	8.71	6.29^{B}				
	150	3.55	6.33	8.32	10.77	7.24^{A}				
	mean	2.97^{D}	5.37^{C}	7.11^{B}	8.72^{A}	6.04				
	SEM									
LY (H2)	0	4.24	6.18	9.21	10.97	7.65^{C}	***	**	NS	
	50	4.96	6.41	10.86	11.61	8.46^{B}				
	100	5.64	7.05	10.65	12.29	8.91^{B}				
	150	6.15	9.08	12.99	13.48	10.43^{A}				
	Mean	5.25	7.18	10.93	12.09	8.86				
LY(T)	0	6.35	10.75	14.9	18.61	12.65^{C}	***	***		NS
	50	7.88	11.56	17.51	19.38	14.08^{BC}				
	100	8.92	12.45	18.42	21.01	15.20^{B}				
	150	9.71	15.41	21.32	24.25	17.67^{A}				
	mean	8.22^{D}	12.54^{C}	18.04^{B}	20.81^{A}	14.9				
	SE									
SY (H1)	0	1.56	3.48	4.67	6.02	3.94^{B}	***	**		NS
	50	1.89	3.95	4.64	6.88	4.30^{AB}				
	100	2.47	3.89	5.09	6.82	4.57^{AB}				
	150	2.33	4.34	5.34	8.07	5.02^{A}				
	mean	2.06^{D}	3.92^{C}	4.94^{B}	6.91^{A}	4.46				
	SE									
SY (2)	0	1.28	2.59	3.43	4.66	2.99^{B}	**	**		

	50	1.39	2.51	4.33	5.69	3.48^{AB}			NS
	100	1.5	2.32	4.53	7.49	3.96^{A}			
	150	1.95	2.6	3.66	6.65	3.72^{A}			
	mean	1.53^{D}	2.51^{C}	3.99^{B}	6.12^{A}	3.54			
	SE								
SY (T)	0	2.84	6.07	8.1	10.68	6.92^{B}	***	**	NS
	50	3.28	6.46	8.97	12.57	7.82^{AB}			
	100	3.97	6.21	9.63	14.3	8.53^{A}			
	150	4.27	6.94	9.01	14.73	8.74^{A}			
	mean	3.59^{D}	6.42^{C}	8.93^{B}	13.07^{A}	8			

Means followed by the same Subscript within a column are not significantly different (p>0.05). LY= Leaf dry matter Yield; SY= Stem dry matter Yield; LSR= Leaf Stem Ratio; DMY= Dry Matter Yield; H=Harvesting; SL=Significance Level; Ht=Harvesting height

The SDMY obtained from both the first and second harvests was affected by harvesting height (P<0.001) and fertilizer level (P<0.01) but was not by the interaction (P>0.05). The SDMY obtained from the first harvest was higher than the value obtained from the second harvest of desho grass. The total SDMY obtained from two harvests was affected by harvesting height (P<0.001) and fertilizer level (P<0.01) but not by the interaction (P>0.05). From the total analysis result, the highest SDMY was found for a harvesting height of 100 cm and the least for a harvesting height of 25 cm. Regard to fertilizer level, the values obtained at 150 kg/ha and 100 kg/ha were higher than the values obtained in the unfertilized group while a similar (P>0.05) value was found at 50 kg/ha fertilizer levels.

Leaf Percent (LP), Stem Percent (SP) and Leaf Stem Ratio (LSR) of desho grass as affected by harvesting height, fertilizer rate and harvesting cycle

The LP, SP and LSR of desho grass are presented in Table 5. The LP was affected by harvesting height (P<0.001) and fertilizer level (P<0.05) while it was not by the interaction of harvesting height and fertilizer level (P>0.05) at the first harvest. At the second harvest, the LP was affected by harvesting height (P<0.001) and the interaction of harvesting height-fertilizer level (P<0.05) but the fertilizer level was not (P>0.05). LP found from the second harvest was higher (P<0.001) than from the first harvest. During the combined analysis result, LP was affected by harvesting height (P<0.001), fertilizer level (P<0.001), the interaction of harvesting height-fertilizer level (P<0.05), harvesting height-harvesting cycle (P<0.01) and harvesting height-fertilizer level-harvesting cycle (P<0.05) but the interaction of fertilizer level-harvesting cycle was not (P>0.05). The highest and lowest LP were found at 25 cm and 100 cm harvesting heights, respectively. The result found at 50 harvesting height was similar (P>0.05) to the result found at 75 cm cutting height. Regarding fertilizer level, the LP found by application of 150 kg/ha fertilizer level was higher (P<0.05) than LP found by application of 50 kg/ha and unfertilized group while similar (P>0.05) value found by application of 100 kg/ha fertilizer level. The SP was affected by harvesting height and fertilizer level at (P<0.05) but the interaction was not (P>0.05) at the first harvest. At the second harvest, SP was affected by harvesting height (P<0.001) and the interaction of harvesting height-fertilizer level (P<0.05) but fertilizer level was not (P>0.05). SP found from the first harvest was higher (P<0.001) than SP found from the second harvest. During the combined analysis result, SP was significantly affected by harvesting height (P<0.001), fertilizer level (P<0.01), harvesting cycle (P<0.001), interaction of harvesting height-fertilizer level (P<0.05), harvesting height-harvesting cycle (P<0.01) and harvesting height-fertilizer level-harvesting cycle (P<0.05) but the interaction of fertilizer level-harvesting cycle was not (P>0.05) affect SP. The highest and lowest SP were found at 100 cm and 25 cm harvesting heights, respectively. SP found by application of 150 kg/ha was lowest than the others while a similar (P>0.05) value of SP was found at the unfertilized group, 50 and 100 kg/ha fertilizer levels.

LSR was affected by harvesting height (P<0.05) and fertilizer level (P<0.01) but the interaction was not (P>0.05) at the first harvest. At the second harvest, harvesting height (P<0.001), fertilizer levels (P<0.05) and the interaction between harvesting height-significant levels (P<0.05) had a significant effect on LSR. The LSR found from the second harvest was higher (P<0.001) than the LSR found from the first harvest. At the combined analysis variance, LSR was affected by harvesting height (P<0.001), fertilizer level (P<0.0) and harvesting cycle (P<0.001). There was an interaction effect of fertilizer level-harvesting height (P<0.05); harvesting height-harvesting cycle (P<0.001) and harvesting height-fertilizer level-harvesting cycle (P<0.05) while no effect by the fertilizer levels-harvesting cycle (P>0.05)

Table 5. Effects of NPS Fertilizer Rates, harvesting Heights and their interactions on morphological Fraction and Leaf to stem ratio of Desho grass.

Morpho-logical percent age	**Frt (Kg ha^{-1})**	**Hh (cm)**				**Mean**	**SL**					
		25	**50**	**75**	**100**		**Ht**	**Frt**	**HC**	**Ht*Frt**	**Ht*HC**	**Ht*Frt*HC**
LP (H1)	0	57.57	56.86	55.05	55.82	56.33^{B}	*	*		NS		
	50	60.68	56.54	58.86	52.91	57.25^{B}						
	100	57.18	58.15	60.35	56.1	57.95^{AB}						
	150	61.11	59.42	60.79	57.82	59.79^{A}						
	Mean	59.14^{A}	57.74^{AB}	58.76^{A}	55.66^{C}	57.82						
	SE											
LP (H2)	0	76.51^{abc}	70.72^{cd}	72.59^{abcd}	70.38^{cd}	72.55^{AB}	***	NS		*		
	50	77.98^{ab}	71.99^{bcd}	72.10^{bcd}	66.51^{de}	72.15^{AB}						
	100	79.01^{a}	74.99^{abc}	70.28^{cd}	61.57^{de}	71.42^{B}						
	150	76.62^{abc}	77.95^{ab}	77.86^{ab}	66.97^{de}	74.85^{A}						
	mean	77.53^{A}	73.91^{B}	73.21^{B}	66.36^{C}	72.74						
	SE											
LP (C)	0	67.04^{abcd}	63.79^{cde}	63.82^{cde}	63.10^{def}	64.44^{B}						
	50	69.33^{a}	64.27^{bcde}	65.48^{abcd}	59.71^{ef}	64.70^{B}						
	100	68.09^{abc}	66.58^{abcd}	65.31^{abcd}	58.83^{f}	64.70^{B}						
	150	68.86^{ab}	68.68^{ab}	69.33^{a}	62.39^{def}	67.32^{A}						
	mean	68.33^{A}	65.83^{B}	65.99^{B}	61.01^{C}	65.29						
	SE											
SP (H1)	0	42.43	43.15	44.95	44.18	43.68	*	*		NS		
	50	39.32	43.46	41.14	47.09	42.75						
	100	42.82	41.85	39.65	43.9	42.06						
	150	38.89	40.58	39.2	42.18	40.21						
	mean	40.87	42.26	41.24	44.34	42.18						
	SE											

SP (H2)	0	23.49^{cde}	29.28^{bc}	27.40^{bcde}	29.62^{bc}	27.45	*	NS		*			
	50	22.02^{de}	28.01^{bcd}	27.90^{bcd}	33.49^{ab}	27.86							
	100	20.99^{e}	24.34^{cde}	29.72^{bc}	38.43^{a}	28.37							
	150	23.38^{cde}	22.05^{de}	22.14^{de}	33.03^{ab}	25.15							
	Mean	22.47^{C}	25.94^{B}	26.79^{B}	33.64^{A}	27.21							
SP (C)	0	32.96^{cdef}	36.21^{bcd}	36.18^{bcd}	36.89^{abc}	35.56^{A}	***	**	***	*	**	NS	*
	50	30.67^{f}	35.73^{bcde}	34.52^{cdef}	40.29^{ab}	35.30^{A}							
	100	31.90^{def}	33.10^{cdef}	34.69^{cdef}	41.17^{a}	35.22^{A}							
	150	31.14^{ef}	31.32^{ef}	30.67^{f}	37.61^{abc}	32.69^{B}							
	mean	31.67^{C}	34.09^{B}	34.02^{B}	38.99^{A}	34.69							
	SE												
LSR (H1)	0	1.37	1.32	1.23	1.27	1.29^{B}	**	*		NS			
	50	1.55	1.3	1.43	1.14	1.36^{B}							
	100	1.34	1.39	1.53	1.28	1.39^{AB}							
	150	1.58	1.48	1.56	1.38	1.5^{A}							
	mean	1.46^{A}	1.37^{AB}	1.44^{A}	1.27^{B}	1.39							
	SE												
LSR (H2)	0	3.32^{ab}	2.45^{cde}	2.67^{bcd}	2.39^{cde}	2.71^{B}	***	NS		*			
	50	3.56^{a}	2.60^{bcd}	2.63^{bcd}	2.01^{de}	2.70^{B}							
	100	3.77^{a}	3.17^{abc}	2.38^{cde}	1.68^{e}	2.75^{B}							
	150	3.33^{ab}	3.56^{a}	3.56^{a}	2.03^{de}	3.12^{A}							
	mean	3.49^{A}	2.95^{B}	2.81^{B}	2.03^{A}	2.82							
	SE												
LSR (C)	0	2.34^{abcd}	1.89^{cdef}	1.95^{bcdef}	1.83^{def}	2.00^{B}	***	**	***	*	**	NS	*
	50	2.55^{a}	1.95^{bcdef}	2.03^{abcdef}	1.57^{f}	2.03^{B}							
	100	2.55^{a}	2.28^{abcde}	1.96^{bcdef}	1.48^{f}	2.07^{B}							
	150	2.46^{abc}	2.52^{ab}	2.56^{a}	1.71^{ef}	2.31^{A}							
	mean	2.48^{A}	2.16^{B}	2.13^{B}	2.02^{C}	2.1							

Means Followed by the same Subscript within a column are not significantly different (p>0.05). LP= Leaf Percent; SP= Stem Percent; LSR= Leaf Stem Ratio; HC=Harvesting Cycle

The highest and lowest (P<0.001) value of LSR was obtained at 25 and 100 cm height of harvesting, respectively. Regarding fertilizer levels, the highest LSR was 150 kg/ha while the lowest value was obtained from the control treatment.

Partial budget analysis

Table 6. Partial budget analysis (ha basis) of desho grass as affected by fertilizer rate (N & NPS) and harvesting height at combined.

Trt.	Combination	GI (C)	TVC	TFC	TC	NB	BCR
1	0kg/ha × 25cm	55605	0.00	16654	16654	38951	2.34
2	0kg/ha × 50cm	94435	0.00	22060	22060	72375	3.28
3	0kg/ha × 75cm	132825	0.00	22550	22550	85375	3.79
4	0kg/ha × 100cm	166540	0.00	31700	31700	134840	4.25
5	50kg/ha × 25cm	65615	1240	16394	17634	47981	2.72
6	50kg/ha × 50cm	98670	1240	21510	22750	75920	3.34
7	50kg/ha × 75cm	156310	1240	23800	25040	131270	5.24
8	50kg/ha × 100cm	182985	1240	30850	32090	150895	4.70
9	100kg/ha × 25cm	74745	2480	15304	17784	56961	3.20
10	100kg/ha × 50cm	103345	2480	19560	22040	81305	3.67
11	100kg/ha × 75cm	160600	2480	22600	25000	135600	5.42
12	100kg/ha × 100cm	205975	2480	30570	33050	172925	5.23
13	150kg/ha × 25cm	82995	3720	14229	17949	65043	3.62
14	150kg/ha × 50cm	125730	3720	19235	22955	102775	4.48
15	150kg/ha × 75cm	175010	3720	21125	24845	150165	6.04
16	150kg/ha × 100cm	217910	3720	29475	33195	184715	5.56

GI=Gross Income; TVC=Total Variable Cost; TFC=Total Fixed Cost; TC=Total Cost; NB=Net Benefit; BCR=Benefit Cost Ratio

Discussion

Effect of harvesting height and fertilizer level on tillers per plant, Leaves number per Plant, leaf length and days to harvesting of Desho grass

The tillers per plant (NTPP) of desho grass in the current study increased with an increase in plant height at cutting and NPS fertilizer levels as shown in Table 6. It is supported by the findings of Zewdu, T and Baars, RMT. 2003 and Kamel, MS., et al. 1983 who reported an increased number of tillers per plant for Napier grass with increment in plant height at cutting and fertilizer application. Kizima, JB., et al., 2014 also reported that the application of an optimal level of nitrogen fertilization significantly affects the appearance of new tillers and increases the dynamics of the tiller population of *Cenchrus ciliaris*. The enhancement in tiller number with an increase in fertilizer dose is attributed to the rapid conversion of synthesized carbohydrates into protein and consequent to an increase in the number and size of growing cells, resulting ultimately in an increased number of tillers (Singh, R and Agarwal, SK. 2001). The mean value of NTPP (71.62) obtained in the current study was higher than the values (48.57, 63.76) reported by Kefyalew, A., et al., 2020 and Asmare, B. 2016, respectively, for desho grass in Ethiopia. However, it was lower than the values (168.2, 145.3) reported by Teshale et al. (2021) for desho grass in the highland and midland areas, respectively, of Guji Zone Southern Oromiya, Ethiopia. This difference might come from a genetic variation of grasses, soil type and fertility, rainfall condition, harvesting age and method of the establishment where the experiment was conducted (Campos, FP., et al., 2013). The mean value of NTPP at the second harvesting cycle (96.61) was significantly higher than the first harvesting cycle (46.63). This result is in line with Yirgu, T., et al., 2017 who reported the tillers number obtained at the second harvest was higher than the tillers number at the first harvest of desho grass in the Wondogenet agricultural research center. The increase in the number of leaves per plant with increasing heights of harvesting in the current study might be due to the production of leaves from new tillers, which generally increased with an increase in heights and days of harvesting. Butt, NM., et al. 1993 reported that the number of leaves per tiller increased with an increase in days of harvesting due to the production of leaves from the new tiller. With the current finding, other researchers Bukhari, MA., 2009; Tessema, Z., et al., 2010 reported that the number of tillers per tiller increased with an increase in the height of the plant. The result of the present study is also supported by the findings of Mahmood, MM., et al. (2003) who reported that application of phosphorus fertilizer gradually increases plant height and number of leaves per plant. The number of leaves per tiller increased with increasing the application rates of NPS fertilizer is consistent with the findings of Ayub, M., et al. (2002); Ayub, M., et al. (2009) and Keftasa (1996) who reported that the number of leaves per tiller increased significantly at each increased nitrogen fertilizer levels application. The mean value of NLPP (477.11) in the current study is higher than the values (425.93, 261.35 and 310.95) reported by Kefyalew, A., et al 2020 and Asmare, B. 2016, respectively, for desho grass. However, the NLPP value in the current study is lower than the value (508) reported by Genet, T., et al. 2017 for desho grass in the highlands of Ethiopia. This difference might come from a genetic variation of grasses, soil type and fertility, rainfall condition, harvesting age and method of the establishment where the experiment was conducted (Campos, FP., et al., 2013).

The mean value of NLPP at the second harvest (615.03) is significantly higher than the first harvest (339.18). Leaf length is an important component in determining the economic value of different grass species and cultivars. The difference in leaf length between heights of harvesting might be due to the differences in the physiological changes of plants that occurred during the growing periods (Berhanu Alemu, BA., et al., 2007). Tessema, Z., et al. (2010) reported that the leaf length per plant was lowest at the earlier stage than the later stage of harvest in the case of Napier grass. Kefyalew, A., et al., 2020 reported leaf length was significantly affected by harvesting age (90 days, 120 days and 150 days with 20.91 cm, 23.37 cm and 23.38 cm), respectively, for each harvesting date. Increased mean LLPP with increasing levels of fertilizer could be because fertilizer enhanced growth and consequently influences leaf expansion and development. The current mean value (30.96 cm) of LL was smaller than the value (45.5 and 45.6 cm) reported by Jabessa, T., et al., 2021 for desho grass in highland and midland Areas of Guji Zone Southern Oromiya, Ethiopia. This difference might come from a genetic variation of grasses, soil type and fertility, rainfall condition, harvesting age and method of the establishment where the experiment was conducted (Campos, FP., et al., 2013).

Effect of harvesting height and fertilizer level on dry matter yield, botanical fractions yields and days to forage Harvesting of desho grass

The DM yield increment with increasing height of harvesting might be due to the additional tillers developed, which brought an increase in leaf formation, leaf elongation and stem development (Crowder, LV and Chheda, HR. 1982). Moreover, the increment of forage yield was found to be directly proportional to increasing plant height and number of tillers per plant (Aysen, UZUN and Freitas, FPD, 2012; Shah, SAS., et al., 2015). The present result is supported by the finding of Zewdu, T., et al. 2002 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. DMY produced from the second harvest was higher than DMY produced from the first harvest with the mean DMY of 12.40 t/ha and 10.51 t/ha, respectively. In line with the present result (Yirgu, T., et al., 2017) reported that the average dry matter yield of the second harvest was higher than the first (21.76 and 24.99 kg/ha for the first and 31.29 and 31.72 kg/ha for the second) for Kulumsa and Areka variety, respectively. The increment of DMY with an increased level of NPS fertilizer application could be due to more tillering and density of leaves, with an increase in NPS fertilizer thereby increasing DMY. The present result is in agreement with Adane, K 2003 who reported that the dry matter yield of herbage species at a given age of harvest was reported to be low in unfertilized pasture where an insufficient amount of N-fertilizer is applied. Application of high rates of nitrogen fertilization produced an extremely high yield of Rhodes grass and the curvilinear effect of N-application rates on grass yield has been reported in tropical and subtropical regions of Australia (Gilbert, M A, et al., 1993). The mean DMY (11.45 t/ha) per harvest obtained in the current study is higher than the finding of Kefyalew, A., et al., 2020 which was 4.11 t/ha for desho grass in Dehana District, Wag Hemra Zone, Ethiopia. However, it was comparable with the value (11.40 t/ha) reported by Worku, B., et al. 2017 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, management systems and cropping season. The height of harvesting and NPS fertilizer level were affected on days of forage harvesting at both the first and second harvesting cycles. Increasing days to forage harvest with increasing height of harvesting was due to a positive relationship between height at harvesting and days to forage harvesting. The current study is supported by the study of (Yirgu, T., et al., 2017) which reported, that the early stage of growth showed a low mean plant height, but harvesting after 120 days showed an enhanced growth in desho grass.

Effect of harvesting height and fertilizer level on leaf percent, stem percent and leaf stem ratio of desho grass

Leaf Percentage (LP) showed a decreasing trend with increasing harvesting height but in the case of Stem Percentage (SP), it showed an increasing trend with increasing harvesting height. The significant decreases in LP and increases of stem proportion with increasing height of harvesting might be due to the proportion of stem in grass plants increasing as they mature or progress from the vegetative to the reproductive stage ((Mitchell, RB., et al., 1997). At the combined analysis result, the LSR was affected by harvesting height and fertilizer levels. The increment of LSR with increasing the application of NPS fertilizer levels could be due to an increase in leaf proportion of grass as compared to stem and due to the increase in the number of leaves and leaf area under fertilizer treatments, producing more and heavier leaves. The current result is supported by the findings of Hassen, A., et al. 2010 and Freitas, FPD., et al. 2012 who reported an increase in leaf-to-stem ratio with an increase in the level of urea fertilizer application. The mean value of leaf to stem ratio obtained in the present study during the first and second harvest of desho grass (1.39 and 2.82), respectively is higher than the values reported by Yirgu, T., et al. 2017 during the first (0.47) and second (0.57) harvest, respectively for Kulumsa variety. It is also higher than the result reported by Gadisa, B., et al. 2019 who reported that LSR of 0.6 and 1.07 for desho grass, Kulumsa variety during the first and second harvests. The current result is the mean value of early (25 cm HH), mid (50 cm HH), late (75 cm and 100 cm HH) mature of desho grass. However, the result of the other was measured from matured forage grass. This might be to maximize the current study result when we compare it with the results of the others. The present result is in agreement with mushtaque who indicated that the decline in leaf to leaf-to-stem ratio of the grass with increasing clipping interval might be attributed to the accumulation or synthesis of more cell wall components in plant tissues as a result of stem development with advancing maturity. Gadisa, B., et al. 2019 reported that the second harvesting cycle generated significantly more leaf-to-stem ratio than the first is in line with the present study result.

Conclusion and Recommendations

The morphological characteristics and dry matter yield of desho grass were significantly influenced by NPS fertilizer rates, harvesting heights, harvesting cycle and their interaction. At combined analysis, several leaves per plant and leaf length per plant ($P<0.05$) were significantly affected by the interactions of NPS fertilizer rate, harvesting height and harvesting cycle while the tillers per plant were significantly ($P<0.01$) affected by main factors (NPS fertilizer rates, height of harvesting and harvesting cycle). Similarly, DH was affected by the main factors (NPS fertilizer rates, harvesting heights and harvesting cycle) at combined analysis. The average total DM yield obtained from 100 and 150 kg NPS/ha fertilizer application at 100 cm height of harvesting was higher than the other combinations. In addition to this, the combination of 150 kg/ha NPS fertilizer level and 75 cm height of harvesting was found to be economically feasible as it provides a higher benefit-cost ratio compared to the other fertilizer rates and harvesting heights. Therefore; based on the current findings the livestock keepers and forage producers are advised to apply 150 kg/ha NPS fertilizer and harvest at a height of 75 cm to get better yield and to be profitable from the cultivation of desho grass. Further research is needed on different organic and inorganic fertilizers in different agroecological zones under rain-fed and irrigation conditions. It also needed further investigation in different locations across years and using animal performance trials.

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Conflict of Interest

The authors declare no conflict of interest.

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