Research article

Effects of nitrogen fertilizer application rate on desho grass (*Pennisetum glaucifolium*) herbage yield and nutritional compositions across harvest days

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Abstract

This study evaluated the effect of nitrogen fertilizer application rates on desho grass (*Pennisetum glaucifolium*) morphology, dry matter accumulation and nutritive values across three harvests. The experiment was conducted in a randomized complete block design with 0, 50, 100, and 150 kg ha^{-1} nitrogen (N) rates across 90, 120, and 150 days of harvests. Average plant height (PH), number of tillers per plant (NTPP), number of leaves per plant (NLPP), and leaf length per plant (LLPP) were recorded. Leaf-to-stem ratio (LSR), fresh forage mass (FFM), dry matter accumulation (DMA), and nutritional contents were assessed. Average PH, NTPP, NLPP, LSR, and DMA were significantly higher across N rates and harvest days. The interaction effect was significant for LLPP and FFM. At 150 kg ha^{-1}, the highest DMA value was recorded at 150 days, whereas crude protein (CP) content, *in-vitro* dry matter digestibility (IVDMD) and metabolizable energy (ME) were at 90 days of harvest. N rates and harvest days had a significant effect on phosphorous and calcium contents. However, higher acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) values were obtained with low fertilizer rates and later harvests. Therefore, greater than 100 kg ha^{-1} N rates and above 100 days of harvest resulted in higher DMA, CP, IVDMD, and ME of desho grass, which should be recommended to obtain feed with optimum nutritional value.

Keywords: Crude protein, Desho grass, Dry matter accumulation, Metabolizable energy, *Pennisetum glaucifolium*

Introduction

Ethiopia is home to the largest number of Africa's livestock, with 70 million cattle, 42.9 million sheep, 52.5 million goats, 13.3 million horses, 8.1 million camels, and 57 million poultry (CSA, 2021). They play a vital role in agricultural practices as a source of income, food and nutrition security, and poverty reduction. The sector contributes 25.3% of total GDP and 45% of agricultural GDP (Shapiro *et al.*, 2017). Despite the large livestock population, its contribution to the economic growth of the country falls below its full potential. Moreover, livestock-based livelihoods are fragile due to degraded grazing land, limited watering spots, drought risk, and inadequate livestock market and health facilities (Mwakalonge and Chingonikaya, 2023).

Nowadays, the livestock sector faces challenges associated with restricted feed supply and demand for quantity and nutritious feed resources (Kebede *et al.*, 2023). Thus, the primary issue in livestock development is substantial feed availability and consistent supply throughout the year. In a highland crop-livestock farming system, where a high number of human and livestock populations are maintained, a supply of high-quality feed is crucial to increase livestock output (Tezera *et al.*, 2024). In such agroecology, primary sources of animal feed are crop residues and natural pastures, which are scarce and poor in quality (Feyissa *et al.*, 2022) and have a direct impact on sustainable livestock production. Moreover, natural pastures are only accessible during the rainy season, and fluctuate in quantity and quality owing to grazing area conversion to cultivation and shortage of rainfall (Turmel *et al.*, 2015).

Consequently, animal feed supply and feed resources are changing and are obtained from crop residues and low-quality natural pastures. Moreover, there has been little advancement in improved fodder crop cultivation due to the rise of interest in cash crop cultivation and the degradation of community pasture lands (Gashaw and

Defar, 2017). However, morphological characteristics, environmental factors, stage of maturity, and level of fertilizer applications influence forage biomass production and nutritive value of different forage crop species. Thus, several studies indicated that the potential and nutrient content of native grass species vary seasonally due to agroecology, climatic conditions, soil types, and leaching levels for mineral compositions (Siri-Prieto *et al.*, 2021). Hence, forage crops such as grasses and legumes, either annuals or perennials, are naturally found in various agroecology systems and differ in their broad range of adaptation and growth patterns, developments and blooming stages (Oljira, 2022).

Among tropical natural forage crops, desho grass (*Pennisetum glaucifolium*) is an indigenous grass of Ethiopia utilized as ruminant feed resources in the southern part of Ethiopia and performs well at altitude ranges of 1500 to 2800 m.a.s.l (Ecocrop, 2010). This perennial grass is planted as a soil conservation strategy in areas where soil erosion is prevalent because of its vast root system, which anchors the soil (Asmare *et al.*, 2016a). It grows upright with the potential of reaching 90 to 120 cm for harvesting based on soil fertility and moisture contents (Shiferaw *et al.*, 2011). Moreover, it reaches its harvesting height of 50 cm for regeneration and expansion of the root system on the farmland, whereas for feeding up to its 120 cm and above height (Ijara, 2024; Mengistu *et al.*, 2024). It has a high dry matter accumulation capacity that varies from 30 to 109 tons/ha (Ecocrop, 2010). Desho grass has a profound potential to provide multi-cut herbage, helping to tackle feed scarcity and ensure regular feed supply (Mengistu *et al.*, 2024). Desho grass is also resistant to drought stress and regenerates under repeated harvests. So stages of harvesting for optimal DMA and nutritive values are determined by soil properties, number of mature nodes and soil moisture contents (Leta *et al.*, 2013).

Therefore, the use of indigenous forages such as desho grass as a livestock feed resource is appealing under the present scenario of a mixed crop-livestock system and climatic ups and downs to achieve sustainable livestock productivity. The remarkable quantity and quality of the forage crops were obtained through fertilizer application and agronomic management at the best stage of harvest to obtain high herbage yield and nutritive values (Abdena, 2013). Moreover, desho grass grows regeneratively and its herbage yield continues until harvested repetitively (Ecocrop, 2010). However, little is known about the effects of nitrogen fertilizer application rate and harvesting stages on the morphology, herbage yield, and nutritive value of desho grass in the highlands of the Bale areas. Therefore, this study was conducted to evaluate the effects of the nitrogen fertilizer rates on desho grass morphological traits, fresh forage mass, dry matter accumulation and nutritional composition across harvest days in the highlands of the Bale zone, Ethiopia.

Materials and Methods

The study area: The field experiment was conducted at Madda Walabu University research site during 2022 in the highlands of the Bale Zone, Ethiopia. The experimental site is located in Robe Town ($6^0 5'55"$ N and $39^0 56'57"$ E at an altitude of 2400 m. a. s. l., located 430 km from Addis Ababa, Ethiopia. This area is characterized by a bimodal rainy season. The main cropping season (summer) is from July 15 to December, and the short cropping season (winter) is from March to June. The experimental areas had a mean annual rainfall of 1150 mm and minimum and maximum temperatures of 5.2 and 26.2°C, respectively.

Soil properties: Before planting, soil samples were taken from each plot at a depth of 0–30 cm at every corner and center of the plots using an auger (Carter and Gregorich, 2008; Acharya, 2018). The collected samples were mixed to form one composite sample and used to analyze soil profiles. The soil texture was determined using the hydrometer method (Bottomley *et al.*, 2020). Soil chemical properties, such as soil organic matter (SOM) was calculated by multiplying %SOC by a factor of 1.724 (Nelson and Sommers, 1982), total N (Alem, 2021), available phosphorous (P) (Olsen, 1954), soil pH (Biswas, 2017) and cation exchange capacity (CEC) (Cottenie, 1980) were determined as described below (Table 1). The study site soil texture was dominated by clay soil (> 50%), followed by silt soil type. The pH of the experimental soil was slightly acidic, with medium OC, OM, TN, and P contents, and high CEC, which allows the plant to take up sufficient moisture, particularly during the early dry season from December to January (Table 1).

Experimental design and treatment combination: The experimental plots were prepared by plowing and leveling with oxen to create a good seedbed during the short rainy season, as recommended by Worku *et al*.

Table 1. Soil properties of the experimental site

Soil texture (%)	Sand	21.97
	Silt	25.91
	Clay	52.12
	Texture class	Clay
Soil chemical properties	Soil pH (1:2H_2O)	6.28
	Organic carbon (OC; %)	1.75
	Organic matter (OM; %)	3.02
	Total nitrogen (TN; %)	0.15
	Available phosphorous (P; ppm)	14.34
	Cation exchange capacity (CEC; mol +; kg^{-1} soil)	26.11

Block 1	50 kg N ha⁻¹ & 150 H	0.5 m	150 kg N ha⁻¹ &120 H	0.5 m	0 kg N ha⁻¹ & 90 H	0.5 m	0 kg N ha⁻¹ & 120 H	0.5 m	150 kg N ha⁻¹ & 90 H	0.5 m	100 kg N ha⁻¹ &150 H
	0.5m										
	100 kg N ha⁻¹ & 90 H	0.5 m	50 kg N ha⁻¹ &120 H	0.5 m	0 kg N ha⁻¹ &150 H	0.5 m	100 kg N ha⁻¹ & 120 H	0.5 m	50kg N ha⁻¹ & 90 H	0.5 m	150 kg N ha-1 &150 H
	1m										
Block 2	100 kg N ha⁻¹ & 120 H	0.5 m	150 kg N ha⁻¹ & 150 H	0.5 m	0 kg N ha⁻¹ & 90 H	0.5 m	100 kg N ha⁻¹ & 150 H	0.5 m	0 kg N ha⁻¹ & 120 H	0.5 m	150 kg N ha⁻¹ & 120 H
	0.5m										
	50 kg N ha⁻¹ & 150 H	0.5 m	50 kg N ha⁻¹ & 120H	0.5 m	50 kg N ha⁻¹ & 90 H	0.5 m	0 kg N ha⁻¹ & 150 H	0.5 m	100 kg N ha⁻¹ & 90 H	0.5 m	150 kg N ha⁻¹ & 90 H
	1m										
Block 3	150 kg N ha-1 & 120 H	0.5 m	100 kg N ha⁻¹ & 90 H	0.5 m	50 kg N ha⁻¹ & 150 H	0.5 m	100 kg N ha⁻¹ & 150 H	0.5 m	150 kg N ha⁻¹ & 150 H	0.5 m	0 kg N ha⁻¹ & 90 H
	0.5m										
	0 kg N ha⁻¹ & 150 H	0.5 m	150 kg N ha⁻¹ & 90 H	0.5 m	0 kg N ha⁻¹ & 120 H	0.5 m	100 kg N ha⁻¹ & 120 H	0.5 m	50 kg N ha⁻¹ &120 H	0.5 m	50 kg N ha⁻¹ & 90 H

Fig 1. Plot layout and treatment allocation

(2017). The experiment was conducted in a randomized complete block design (RCBD) with treatments of N (urea) application rates in three replications in one block for each harvest. Twelve (12) plots were set up in one block for three harvests with a total of 36 (4NH*3 replications *3 H) plots on 432 m² total area (each plot has an area of 3 m x 4 m = 12 m²) for standard agronomic practices in three blocks (r1 - r3) (Fig 1). Plots in a block received four N rates of 0 (N1), 50 (N2), 100 (N3), and 150 (N4) kg ha⁻¹ at random once at the time of the planting in rows. The treatment effects were assessed under three harvest days of 90 (H1), 120 (H2), and 150 (H3) days. The treatment combination arrangements were N1H1, N2H1, N3H1, N4H1, N1H2, N2H2, N3H2, N4H2, N1H3, N2H3, N3H3, and N4H3. The spaces between plots and blocks were 50 cm and 1 m, respectively. The desho grass was planted with 50 and 30 cm row spacing and plant spacing, respectively. For planting, root splits and stem cuts of matured desho grass that has ≥ 3 nodes were used by opening the soil with hoes and placing the split in the soil before pressing the basal soil around with a hand. Diammonium phosphate (DAP) was applied at the rate of 25 kg/ha in all plots after 21 days of planting to improve soil phosphorus levels.

Data collection: Plant morphological characteristics, including plant height (PH), number of tillers per plant (NTPP), number of leaves per plant (NLPP), and leaf length per tiller (LLPT), were measured from 10 plants selected from the middle rows of each plot at each harvest among three blocks. Fresh forage mass (FFM) was determined from a 1m × 1m quadrant from the center of each plot at approximately 3 cm above ground from three blocks, excluding a 0.5 m border from all sides to avoid edge effects at each growth stage (90, 120, and 150 days after planting). The fresh forage weight was recorded immediately after sample harvests from the block of N rate plots and oven-dried at 105°C for 24 h to obtain dry weight. Dry weight of forage was divided by fresh forage mass and multiplied by 100 to determine dry matter accumulation %. DMA% was used to calculate dry matter accumulation (DMA) for each plot, which was then converted to tons per hectare.

Fresh stems and leaves were separated and weighed, and each leaf and stem sample was oven-dried for 72 h at 65°C. The leaf-to-stem ratio (LSR) was estimated by dividing the leaf dry weight by the stem dry weight.

Chemical analysis: Fresh samples were taken from each experimental plot and weighed separately, chopped into short lengths (2–4 cm) to minimize bulkiness, and placed individually in airtight paper bags, labeled, and dried for 72 hours at 65°C in a forced air-drying oven for chemical analysis. At this temperature, more of the volatile compounds are retained in the feed for further analysis. The samples were further ground to fit a 1 mm sieve screen for chemical composition and nutrient analysis. Samples were also analyzed for total ash contents by combusting the samples in a muffle furnace at 550°C for 6 hours (AOAC, 2005). The N content was determined by the Kjeldahl method and the CP content was calculated as N x 6.25 (Van Soest *et al.*, 1991). Neutral detergent fiber (NDF) was determined as described by

Van Soest and Robertson (1985). Acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Terrill *et al.* (2010) using an ANKOM fiber analyzer (ANKOM Technology®, Macedon, NY, USA). IVDMD was determined using the procedures outlined by Tilley and Terry (1963). The metabolizable energy (ME) content was estimated from the IVDMD suggested by AOAC (2005).

ME (MJ kg^{-1}DM) = 0.17 IVDMD % -2.

The phosphorus and calcium contents were determined using an auto-analyzer and an atomic absorption spectrophotometer (Lacy, 1965).

Data analysis: All data were analyzed using ANOVA of SAS software version 9.4 (SAS, 2012). Mean separation was done using the Least Significant Difference (LSD) test at the 5% level. The effects of N rate and harvest day on morphological traits, fresh forage mass, dry matter accumulation, and nutritive values of desho grass were evaluated using the following model: $Y_{ijk} = \mu + H_i + F_j + (H_i{}_*F_j) + e_{ijk}$

where: Y_{ijk} = response variable of morphological traits, dry matter accumulation and nutritive value; μ = the overall mean; H_i = effect of the ith N rate (0, 50, 100, and 150 kg ha^{-1}); F_j = effect of the jth harvest day (90, 120, and 150); $H_i{}_*F_j$ = Interaction effects of N rate and harvest day; e_{ijk} = the random error.

Results and Discussion

Effects of nitrogen fertilizer rates and harvesting day on morphology of desho grass: The effects of nitrogen fertilizer rates across harvest days had a significant (p <0.0001) effect on plant height (PH). These variations can be attributed to differences in soil profile characteristics and treatment responses. Consequently, desho grass performance varied with soil water-holding capacity, while nitrogen supplementation markedly enhanced growth performance. Consistently, studies by Mekonnen *et al.* (2022) and Desta (2024) reported that desho grass yield varies widely across agroecologies, reflecting its strong regrowth ability and multiple-harvest potential under conditions of adequate rainfall or irrigation. The highest PH was recorded from the N4H3, followed by N4H2 and N3 and H3; however, the shortest PH was obtained from the N1H1 (Fig 2).

Table 2 illustrates the recorded values of morphological traits NTPP, NLPP, LLPP, LSR and DMA of desho grass across fertilizer rates and harvest day. Nitrogen fertilizer rate and harvest day significantly affected the number of tillers per plant (NTPP), number of leaves per plant (NLPP), leaf length per plant (LLPP), leaf-to-stem ratio (LSR), and herbage yield components (fresh forage mass,

dry matter percentage, and dry matter accumulation) of desho grass (p <0.05). The effect on LLPP was highly significant (p <0.001). The highest NTPP, NLPP, and LLPP were recorded under the highest nitrogen rate combined with the latest harvest (N4H3), whereas the lowest values occurred at low nitrogen rates with early harvests (N1H1 and N2H1). In this study, increases in plant height, tiller number, and leaf development with advancing harvest days and higher nitrogen rates indicate improved nutrient uptake and vegetative growth. Similar responses were reported by Asmare *et al.* (2017), who observed greater plant height under higher nitrogen application and delayed harvests. Variations across studies may be attributed to differences in soil fertility, moisture availability, and site conditions (Kefyalew *et al.*, 2020; Ijara, 2024).

Higher NTPP, NLPP and LLPP at later harvests and increased nitrogen levels reflect enhanced shoot regeneration and leaf expansion. Comparable responses at N4H3 and N3H3 suggest that moderate nitrogen application (≈100 kg ha^{-1}) combined with delayed harvesting can adequately optimize leaf traits. Leaf length increased with harvest age, likely due to physiological maturation and favorable growing conditions during extended growth periods (Tezera *et al.*, 2024). Nitrogen-induced increases in NLPP enhance photosynthetic capacity and contribute to improved forage quality, as leaves constitute the most nutritious plant fraction (Oljira, 2022). Consistent with previous reports, nitrogen application promoted leaf initiation and tiller development through the activation of dormant buds, resulting in greater tiller replacement and forage accumulation (Kebede *et al.*, 2023; Dereje *et al.*, 2024; Mengistu *et al.*, 2024). Overall, extended growth duration combined with adequate nitrogen supply enhances vegetative traits and maximizes the herbage yield of desho grass (Alem, 2021). Leaf-to-stem ratio (LSR) and fresh forage mass (FFM) were significantly affected by nitrogen fertilizer rate and harvesting stage (p <0.0001 and p <0.001, respectively). Higher nitrogen
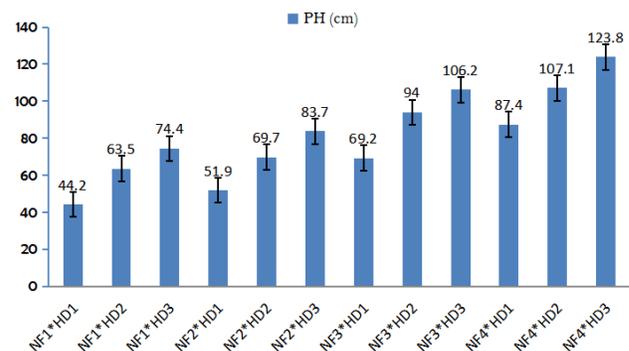
Fig 2. Height of desho grass at different nitrogen fertilizer rates and harvesting days

rates combined with early harvesting (N4H1 and N3H1) produced the greatest LSR, while lower nitrogen rates at late harvest (N1H3 and N2H3) resulted in the lowest values. In contrast, FFM increased with both nitrogen rate and harvest maturity, reaching a maximum at N4H3 and a minimum at N1H1. These patterns are consistent with Kefyalew *et al.* (2020), who reported higher LSR at early harvest under optimum nitrogen application. Overall, maximum nitrogen rates and late harvesting stages yielded the highest total forage accumulation, with no significant interaction effects.

Fresh forage mass and total forage accumulation are governed by forage species, plant anatomy, stage of maturity, weather conditions, and management practices, with leaf components being particularly responsive (Defar *et al.*, 2017; Oljira, 2022). Accordingly, the superior FFM observed under N4H3 can be attributed to an extended growth period coupled with optimum nitrogen supply, which enhances plant height, tiller density, leaf number, and leaf length. Adequate nitrogen stimulates the formation of new shoots, leaves, and nodes, improving the leaf-to-stem ratio and ultimately increasing total forage accumulation (Desta, 2024). Consistent with Mekonnen *et al.* (2022), desho grass can be harvested three to four times annually, producing 10-15 t DM/ha under rain-fed conditions, underscoring its strong potential to mitigate dry-season feed shortages and its suitability as a preferred basal diet (Asmare *et al.*, 2016b).

Nitrogen fertilizer rate had a highly significant effect on dry matter accumulation (DMA) across harvest days ($p <0.0001$), while the interaction effect had a significant influence on DMA by both nitrogen rate and harvest time ($p <0.05$). The highest DMA was recorded under N4H3 and N4H1, while the lowest value occurred at N1H1 (Table 2). This response aligns with established growth dynamics, where increases in DMA are proportional to plant size and maturity over the growth period (Poorter and Garnier, 2007). Given that forage accumulation and nutrient evaluation are essential for formulating safe and balanced livestock diets, the high DMA observed in desho grass highlights its strong adaptive capacity and productivity, with reported dry matter yields reaching up to 25.1 ± 1.7 t/ha under favorable management conditions (Kebede *et al.*, 2023).

Nutritional composition: Ash, CP, NDF, ADF, ADL, IVDMD, and ME of desho grass were significantly affected by N rates and harvest days. The highest ash contents were reported from treatments of N4H3 and N4H1, respectively. In addition, the effect of N fertilizer rates and harvest days had a significant ($p <0.001$) effect on CP, NDF, ADF, ADL, IVDMD, ME and P. The interaction effect of equal fertilizer applications on different harvest days was significant for CP, NDF, ADF, and ADL at ($p <0.05$) (Table 3). Results showed that ash content decreased as harvest days increased from 90 to 150 days

Table 2. Effects of fertilizer rate and harvest day on the desho grass morphology and dry matter accumulation

Treatment	NTPP (№)	NLPP (№)	LLPP (cm)	LSR (%)	FFM (t/ha)	DM (%)	DMA (t/ha)
N1*H1	39.5 ± 7.1	250.5 ± 2.5	18.5 ± 2.2	1.3 ± 0.1	42.2 ± 2.3	87.7 ± 2.4	10.0 ± 2.1
N1*H2	45.3 ± 4.4	282.6 ± 1.9	20.8 ± 2.5	0.8 ± 0.1	71.9 ± 2.3	89.8 ± 1.1	13.6 ± 1.8
N1*H3	54.1 ± 9.4	353.4 ± 6.4	22.5 ± 2.0	0.7 ± 0.1	87.6 ± 1.7	90.5 ± 2.1	16.3 ± 1.5
N2*H1	41.7 ± 7.2	248.2 ± 1.7	18.8 ± 2.4	1.4 ± 0.1	47.6 ± 1.9	90.6 ± 3.4	11.1 ± 1.7
N2*H2	56.7 ± 6.7	286.4 ± 2.8	22.5 ± 3.0	0.9 ± 0.1	68.9 ± 2.3	91.1 ± 5.3	14.9 ± 2.0
N2*H3	62.0 ± 3.9	351.0 ± 7.3	21.9 ± 2.6	0.7 ± 0.1	102.0 ± 2.8	91.5 ± 0.8	16.9 ± 2.5
N3*H1	43.5 ± 5.4	277.5 ± 2.9	19.9 ± 2.5	1.7 ± 0.2	52.8 ± 2.3	91.6 ± 2.5	11.2 ± 2.1
N3*H2	59.9 ± 7.6	360.4 ± 3.8	23.8 ± 2.5	0.98 ± 0.1	96.8 ± 1.2	92.3 ± 1.7	17.8 ± 1.1
N3*H3	71.8 ± 8.1	479.9 ± 5.8	30.6 ± 3.0	0.8 ± 0.0	123.5 ± 2.2	92.6 ± 4.2	21.6 ± 1.9
N4*H1	46.7 ± 4.4	308.6 ± 1.8	21.7 ± 3.0	1.7 ± 0.1	55.6 ± 1.9	91.9 ± 0.3	12.9 ± 1.7
N4*H2	76.7 ± 12.2	377.0 ± 4.8	25.8 ± 4	1.1 ± 0.1	101.7 ± 1.9	93.1 ± 3.1	19.6 ± 1.9
N4*H3	89.2 ± 13.1	528.4 ± 4.2	31.2 ± 4.6	0.9 ± 0.1	125.7 ± 1.8	94.2 ± 2.3	25.1 ± 1.7
P value of N	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.0001
P value of H	<0.001	<0.001	<0.001	<0.0001	<0.001	0.003	<0.0001
P value of N*H	<0.004	<0.05	<0.05	<0.02	<0.01	0.04	<0.05
CV (%)	14.2	11.8	16.3	11.3	10.7	1.2	11.8

Mean values in the same column within ($p <0.0001$): Significantly very high; ($p <0.001$): Highly significant; ($p <0.05$): Significant; ($p >0.05$): Non-significant; CV: Coefficient of variation; NTPP: Number of tiller per plant; NLPP: Number of leaves per plant; LLPP: Leaf length per plant; LSR: Leaf to stem ratio; FFM: Fresh forage mass; DMA: Dry matter accumulation; N: Nitrogen fertilizer; H: harvest day

and showed a decreasing trend for N rate from 150 to 0 kg ha-1. This might be associated with earlier dilution and translocation of minerals from leaf to stem and is accompanied by a relatively lower LSR at the later stage of maturity. Ash content was slightly higher than reported by Jabessa *et al*. (2021). These variations might be due to edaphic, climatic and biotic conditions influence on forage maturity and affecting ash content. The total ash content in harvested forages can have a significant role in livestock performance since much of the ash content of forage is made of minerals, which are essential for livestock (Kebede *et al*., 2023).

The highest CP (15.75%) was recorded at 90 days with 150 kg N ha^{-1}, while the lowest was reported at 150 days with 0 kg N ha^{-1}. CP increased with higher N application but declined as the plant matured. This contributed to the formation of an increase in cell walls, while the control treatment (non-fertilized plots) across the harvest days showed low DMA and CP content. This might be due to low availability of N rate in the plant tissue, which contributed to low CP as harvest days increased (Asmare *et al*., 2017). Several researchers confirmed that CP content is the determining factor in feed, while native grasses contain 6 to 8% of CP. This might not support the lower limit of lactation (12%) and growth (11.3%) requirements (Oljira, 2022). The highest CP values were obtained from

N4H1 and N3H1, while the lowest CP was recorded from N1H3 indicates the potential of desho grass as a good animal feed to enhance productivity at higher N rates and earlier harvests. However, as the plant age advanced, the DMA of the grass increased, resulting in variable CP content (Dereje *et al*., 2024).

The highest NDF, ADF and ADL values were recorded from N1H3, N2H3, and N1H3 treatments, respectively. This value shows a gradual increase in the fiber content due to the increase in the harvest period with low or no rate of N use. The increase in NDF, ADF, and ADL contents indicated that maturity progressed. This implies that the optimum N fertilizer rate with earlier harvest minimizes the fiber content and increases nutritional value. Most treatments remained below threshold levels, indicating good digestibility and intake, except at 120 and 150 days with 0 and 50 kg N ha^{-1}. Feed quality is a function of fiber content and digestibility, with relatively more fiber (>18%) categorized as roughage (Goulart *et al*., 2020). Thus, NDF level is a quality determining factor, where the critical value equals 60% results in a decrease of feed intake, feed conversion efficiency, and longer rumination time (Geleti and Gizachew, 2002). Therefore, lignification appeared to occur consistently with an increase in harvest time. However, NDF content was higher than the standard threshold or critical values in N1H2, N2H2, and N2H3, indicating low FFM for low N rates and extended

Table 3. Effect of nitrogen fertilizer rates and harvest days on nutritive values of desho grass

Treatments	Ash (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)	IVDMD (%)	ME (MJ/ kg DM)	P (g/kg DM)	Ca (g/kg DM)
N1*H1	11.0 ± 3.4	10.5 ± 5.7	59.2 ± 4.2	41.4 ± 2.9	6.5 ± 4.1	51.9 ± 3.1	7.9 ± 4.4	2.6 ± 0.3	3.4 ± 0.4
N1*H2	8.8 ± 2.1	7.8 ± 4.9	61.8 ± 4.9	46.4 ± 3.8	8.4 ± 2.4	46.5 ± 2.6	7.2 ± 3.4	2.4 ± 0.3	3.1 ± 0.4
N1*H3	7.9 ± 4.3	5.8 ± 3.9	72.7 ± 3.2	47.3 ± 1.5	9.7 ± 1.6	41.4 ± 4.6	6.5 ± 2.4	2.1 ± 0.3	3.1 ± 0.4
N2*H1	12.6 ± 0.9	11.1 ± 3.3	57.8 ± 4.1	34.8 ± 6.5	6.1 ± 4.3	53.1 ± 2.6	8.1 ± 2.8	3.1 ± 0.3	3.5 ± 0.4
N2*H2	9.8 ± 1.3	9.3 ± 2.8	60.3 ± 4.4	46.3 ± 4.5	6.7 ± 2.2	50.5 ± 2.3	7.7 ± 5.4	2.8 ± 0.3	3.5 ± 0.4
N2*H3	8.7 ± 5.1	7.8 ± 1.7	65.5 ± 6.2	47.9 ± 2.2	9.1 ± 2.9	47.5 ± 2.5	7.3 ± 3.9	2.2 ± 0.3	2.8 ± 0.4
N3*H1	14.6 ± 3.2	15.6 ± 1.9	36.3 ± 2.2	29.5 ± 1.5	4.9 ± 4.6	65.0 ± 4.6	9.7 ± 5.2	3.8 ± 0.3	3.9 ± 0.4
N3*H2	12.4 ± 3.2	10.7 ± 2.2	51.07 ± 1.9	37.7 ± 3.5	6.7 ± 2.3	52.9 ± 6.6	8.1 ± 1.9	3.5 ± 0.3	3.6 ± 0.4
N3*H3	9.7 ± 5.3	8.2 ± 4.2	58.8 ± 1.2	39.1 ± 4.3	6.9 ± 3.9	52.7 ± 5.6	8.0 ± 2.6	2.2 ± 0.3	3.3 ± 0.4
N4*H1	13.4 ± 5.5	15.8 ± 6.3	35.8 ± 5.2	27.7 ± 3.5	4.4 ± 3.5	69.6 ± 1.6	10.4 ± 4.1	4.3 ± 0.3	4.2 ± 0.4
N4*H2	16.6 ± 4.9	10.7 ± 1.8	48.2 ± 3.5	33.4 ± 1.1	6.1 ± 2.5	59.1 ± 3.6	8.9 ± 1.5	3.6 ± 0.3	3.6 ± 0.4
N4*H3	10.7 ± 2.1	9.3 ± 1.4	50.5 ± 3.8	36.1 ± 2.3	6.3 ± 1.4	57.7 ± 3.1	8.7 ± 3.3	2.7 ± 0.3	3.5 ± 0.4
p-value of N	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007
p-value of H	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
CV (%)	14.0	12.0	7.6	4.3	9.3	4.8	4.3	11.6	10.5

Mean values in the same column within (p <0.0001): Significantly very high; (p <0.001): Highly significant; (p <0.05): Significant; (p >0.05): Non-significant; N: Nitrogen fertilizer; H: Harvest day; CV: Coefficient of variation; DM: Dry matter; CP: Crude protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ADL: Acid detergent lignin; IVDMD: *In-vitro* dry matter digestibility; ME: Metabolizable energy; Ca: Calcium; P: Phosphorus

harvests. ADF and ADL increased with plant maturity but decreased with higher N application rate (Table 3). The IVDMD and ME were significantly (P<0.001) affected by N fertilizer rates and harvest day. These variations among treatments revealed that IVDMD and ME increased with increasing N rate and decreased with longer harvest days. This provides the accumulation of soluble materials, leading to higher digestibility (Abdena, 2013). Likewise, Moore *et al.* (2020) indicated the decrease in ME was linked to the maturity and harvest times beyond their optimal harvest time. Thus, the highest IVDMD and ME were obtained from N4H1 treatment, while the lowest IVDMD was recorded from N1H3. Effects of harvest day and N fertilizer rates had a highly significant (p <0.001) effect on phosphorous (P) content, whereas the effect was significant (p <0.01) for calcium (Ca) content. The highest P and Ca contents were recorded from N3H1 and N4H1, whereas the lowest values of P and Ca were observed from N1H3 and N2H3, respectively (Table 3). Therefore, grazing ruminants' need for P and Ca can easily fulfill the standards from harvests with 0.11 to 0.34% and 0.18 to 1.04%, respectively (Singh *et al.*, 2022). This was due to the effect of DAP at the vegetative stage and the presence of an adequate amount of P and Ca in the soil. Moreover, optimum N rate and earlier harvest days accumulate more P and Ca as recorded in N3H1 and N4H1. Conversely, a decrease in P and Ca content as the grass matures might be due to the translocation of minerals to the stem and root parts (Louw-Gaume *et al.*, 2017).

Conclusion

The study revealed that established desho grass resulted in higher morphological appearances and nutritive value when managed with N4H1 and N3H1. However, the highest DMA was recorded under N4H3 and N3H3, treatments that produced bulky biomass but were associated with comparatively lower nutritive value. Thus, suggests that feeding desho grass harvested earlier age and higher nitrogen fertilizer rates as a basal diet, either by itself or in combination with readily available roughage feeds improve feed resource quality. This can help ease the lack of high-quality and quantity feed resources for livestock year-round. However, the possibility of evaluating the cumulative effects of multi-year data is limited by financial constraints. Furthermore, forage evaluation of desho grass accessions over wider agroecology and cropping patterns (intercropping with forage legumes), as well as on-farm feeding trials, should be recommended for future work in the region.

Acknowledgment

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