Effects of Nitrogen Fertilizer Rate and Cutting Height on Morphological Characteristics and Yield of Elephant Grass (*Pennisetum purpureum* L.)

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Abstract
Background: Elephant Grass (*Pennisetum purpureum* L.) is a forage grass with high potential to improve livestock production. However, the dry matter yield of the forage crop is low because of poor agronomic and soil fertility management practices.
Objectives: This study was, therefore, conducted to evaluate the effects of nitrogen fertilizer rate and cutting height on morphological characteristics and yield of elephant grass (*P. purpureum* L.).
Materials and Methods: Treatments were arranged in a 3 x 4 factorial arrangement in a randomized complete block design with three replications (3 cutting heights i.e., 7.5, 15, and 22.5 cm; and 4 nitrogen fertilizer rate i.e., 0, 69, 115, and 161 kg N ha^{-1}). Data on morphological characteristics and yield of elephant grass (*P. purpureum* L.) were collected and subjected to the analysis of variance using the general linear model procedure of the statistical analysis system version 2004.
Results: Most morphological characteristics of elephant grass increased ($P < 0.05$) as cutting height and nitrogen fertilizer rate increased, except for weight per tiller, tiller diameter, and internode length. Forage dry matter yield was in the order of 0 < 69 < 115 = 161 kg N ha^{-1} and 7.5 < 15 = 22.5 cm. Looking at the combination of the two factors 115 kg N ha^{-1} x 22.5 cm and 161 kg N ha^{-1} x 15 cm treatments resulted in greater dry matter yield of 6.25 and 6.45 ton DM ha^{-1} cut^{-1}, respectively, and 115 kg N ha^{-1} was economically feasible.
Conclusions: This study suggests that the rate of 115 kg N ha^{-1} x 22.5 cm cutting height is optimum for intensive cultivation of the forage crop with high dry matter yield at reduced nitrogen fertilizer cost.

Keywords: Forage dry matter; Internode length; Tiller diameter; Tiller weight

1. Introduction

One of high yielding potential improved forage to increase the productivity of animals, which can be cultivated both in the dry and wet seasons of Ethiopia, is elephant grass (Feleke Assefa *et al*., 2015). In spite of the potential for high yields, on-farm yields of elephant grass are much lower and variable depending on management factors such as the application of manure and/or fertilizer, cutting management, and weed control (Rahetlah *et al*., 2014; Feleke Assefa *et al*., 2015). Furthermore, soil fertility, environmental factors, disease and pest, planting method, and variety largely determine the biomass yield and nutritive value of elephant grass (Kabirizi *et al*., 2015). Appropriate nitrogen fertilizer rate and cutting management are also essential for high production and quality of elephant grass (Jorgensen *et al*., 2010; Tessema Zewdu *et al*., 2010b). The rate of nitrogen fertilizer application determines the cost and biomass production of elephant grass where inhibition of plant growth and unprofitability are the main results caused by the deficit and excessive use of nitrogen fertilizer (Sant'Ana *et al*., 2018). Nitrogen fertilizer at the doses of 200 to 600 kg ha^{-1} tended to increase the harvested herbage of elephant grass by 30 to 50% (Singh *et al*., 2013). On the other hand, as documented by Na *et al*. (2014), this grass removed about 183 kg N ha^{-1} $year^{-1}$ when cutting to a 12 cm stubble height. Therefore, there is a need to find the appropriate rate of N fertilizer that provides greater efficiency in dry matter production and quality of elephant grass as animal forage.

Information on the effects of cutting height on elephant grass is either scarce or lacking in different parts of Ethiopia (Tessema Zewdu *et al*., 2010a). Applying appropriate cutting height is among the major agronomic practices to maximize the yield of elephant grass (Wijitphan *et al*., 2009; Jorgensen *et al*., 2010). Cutting of elephant grass close to the ground level may negatively affect the re-growth ability by reducing tiller development. The optimal cutting height of this grass reported for higher dry matter yield and leaf content is 30 cm and 20 cm, respectively (Jørgensen *et al*., 2010). Even though little information is available about the

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separate effect of N fertilizer as well as cutting height, the combined effects of nitrogen fertilizer rate and cutting height on morphological characteristics and yield of elephant grass are not well understood. Hence, this study was carried out to evaluate the effects of nitrogen fertilizer rate and cutting height on morphological characteristics and yield of elephant grass (*P. purpureum L.*) and determine economically feasible N fertilizer rate to produce the forage crop.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Mersa College of Agriculture Campus, Woldia University, Northeastern Ethiopia, from June to November 2018. The campus is located at an altitude of 1600 meters above sea level between 11°40'N–11°66.7'N latitude, and 39°39.5'E–39°65'E longitude. The area has a bimodal rainfall pattern (long summer and short autumn seasons) which ranges between 650 to 700 mm with an average annual temperature of 21 ^{o}C. The soil classification of the experimental area is clay loam.

2.2. Description of Experimental Materials

The source of the plant material, Elephant grass, was Mersa College of Agriculture Campus where the grass is well adapted. Nitrogen fertilizer was used in the form of urea (46% nitrogen).

2.3. Experimental Design and Treatments

The experiment consisted four levels of nitrogen fertilizer (0, 69, 115, and 161 kg N ha^{-1}), and three cutting heights (7.5 cm, 15 cm, and 22.5 cm) above the ground, resulting in 12 treatment combinations per block (5 x 41.5 = 207.5 m^2). The experimental plot was laid out as a randomized complete block design in a factorial arrangement and replicated three times per treatment. The plot size was 5 m x 3 m (15 m^2) and there were 36 plots. The spacing between plots and blocks were 0.5 and 1 m, respectively. While the spacing between rows and plants was 1 m and 0.5 m, respectively (Tessema Zewdu, 2008) and hence each plot accommodated 30 stems or plants (5 rows per plot).

The required land was plowed by using a tractor once and bullock twice and the experimental plots were prepared after the land was smoothened. The parent plants were cut into stems with three nodes as equal to the pits and were planted (20 cm depth) at an angle of about 45^{o} to bury two nodes into the soil. Then treatment plots were fertilized with half of the nitrogen at the rate of 0, 69, 115, and 161 kg ha^{-1} in the form of urea (46% N) after 7 days of the first harvest (90 days of planting) and the other half was applied after 35 days of the first harvest. The entire plot area was kept weed-free with hand hoeing at the time of land preparation, and the weed was removed manually at 30 and 60 days after planting, 5, and 35 days after the first harvest.

2.4. Data Collection

All samples were taken from the net plot area of 2 m x 3 m (6 m^2) (three middle rows) a day before the second harvest to minimize the effect of border rows. A sample of five plants was randomly selected from the net plot area of each plot and used for the evaluation of all morphological parameters, except for tillers per plant, the basal circumference of the plant, and tiller weight, which were measured from other five representative tillers of plant samples. Plant height was determined by measuring the plant beginning from its base to the longest leaf with a steel tape. Tiller number was determined by direct counting of the tillers from five plants that were randomly selected. The basal circumference of the plant is the circumference of a collection of tillers per plant and was measured using meter around the base of elephant grass. The number of nodes per plant and internodes length (cm) was taken from those randomly selected stems or tillers per plot. The tiller diameter was measured with a caliper approximately 10 cm above the soil surface. Since elephant grass stems are oval-shaped, stem diameter was measured at its widest point.

Green forage yield per hectare was estimated from the net plot area at 60 days after the first harvest based on green herbage cut with a sickle (Wangchuk *et al.*, 2015). Then the harvested green forage was weighted using a balance, recorded and about 400 gram subsamples were taken from each plot for the determination of dry matter yield (DMY). The samples were oven-dried at 65 ^{0}C for about 72 hours in an air circulating electric oven (AOAC, 1990) and were used to calculate the total DMY in terms of tons per hectare.

2.5. Data Analysis

Data were analyzed using analysis of variance (ANOVA) of the General Linear Model (GLM) procedure of the statistical analysis system (SAS, 2004). Treatment means were separated using Turkey HSD (honestly significant difference) test at $P < 0.05$. The ANOVA model for data analysis consisted of the effects of the block, N fertilizer rate, cutting height, and interaction of fertilizer rate and cutting height. The model used for the analysis was:

$$Y_{ijl} = \mu + B_l + F_i + C_j + FC_{ij} + e_{ijl}$$

Where; Y_{ijl} = Individual observations

μ = Overall mean

B_l = Effect of the l^{th} block

F_i = Effect of nitrogen fertilizer rate

C_j = Effect of cutting heights

FC_{ij} = Interaction effect of nitrogen fertilizer rate and cutting heights

e_{ijl} = Standard error of the mean

2.6. Partial Budget Analysis

Partial budget analysis for this experiment was performed according to Upton (1979) to evaluate the profitability of the treatments. It was assessed by the variable costs of fertilizer and labor. The sale price of elephant grass was estimated using local market observations. The difference in the sale and purchase of all inputs in each treatment was considered as a total return (TR). The net return (NR) was calculated by subtracting the total variable cost (TVC) from the total return (TR):

$$NR = TR – TVC$$

The change in net return (ΔNR) was calculated as the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC) as:

$$\Delta NR = \Delta TR – \Delta TVC$$

The marginal rate of return (MRR) measures the increase in NR and is associated with each additional unit of expenditure (ΔTVC), which was the difference among the three rates of nitrogen fertilizer excluding positive control and normally expressed as a percentage.

$$MRR = \Delta NR/\Delta TVC*100.$$

3. Results and Discussion

3.1. Effects of Nitrogen Fertilizer and Cutting Height on Morphological Characteristics

The number of tillers per plant of elephant grass was significantly ($P < 0.05$) affected by cutting height, rate of N fertilizer, and their interaction effects (Table 1). Generally, the number of tillers per plant increased with increasing N fertilizer rate and cutting height. This may be attributed to a consequence of higher nutrient synthesis and reserve in the stem of the plant at higher N fertilizer application that might have promoted more tiller production per plant. The effect of N fertilizer on the number of tillers per plant of elephant grass in previous studies was not consistent. While some reported increases in the number of tillers per plant due to the N fertilizer rate (Oliveira *et al.*, 2015; Stida *et al.*, 2018), others noted no effect (Norsuwan *et al.*, 2014). Contrary to the results of this study, Jørgensen *et al.* (2010) and Tessema Zewdu *et al.* (2010a) reported no effect of cutting height on the number of tillers per plant. The numbers of tillers per plant noted in this study were within the range of 20.9 to 47.6 obtained by Sollenberger *et al.* (2014), although others noted higher tiller number per plant ranging from 50 to 125 with dwarf varieties (Rengsirikul *et al.*, 2013; Wangchuk *et al.*, 2015).

Cutting height and rate of N fertilizer application had a significant ($P < 0.05$) effect on tiller weight of elephant grass, and tiller weight decreased as the cutting height and rate of N fertilizer increased (Table 1), which might be attributed to the higher tiller density per plant that tended to have thinner stems of tillers. The interaction effect of N fertilizer application rate and cutting height was also significant ($P < 0.05$) but with no apparent particular trend. The significant decline in mean tiller weight with increased cutting height agrees with other reports (Wadi *et al.*, 2004; Wijitphan *et al.*, 2009). However, Jorgensen *et al.* (2010) observed no statistical differences in the mean weight per tiller among cutting heights of 0 and 20 cm.

The interaction of cutting height and rate of N fertilizer had a significant ($P < 0.05$) effect on tiller diameter. The thicker tiller (2.93 cm) was obtained from 22.5 cm x 161 kg N ha^{-1} followed by (2.67 cm) at 7.5 cm x 69 kg N ha^{-1} while the thinnest (1.13 cm) tiller was obtained from 15 cm x 69 kg N ha^{-1} (Table 1). Similar to the results of the current study, Stida *et al.* (2018) reported that the tiller diameter was not affected by the dose of N fertilizer. However, Oliveira *et al.* (2015) observed differences in stem diameter among levels of N fertilizer of 100 to 1600 kg N ha^{-1}). Sollenberger *et al.* (2014) and Wangchuk *et al.* (2015) reported that tiller diameter ranging from 1.1 to 1.9 cm, which was within the range reported in the current study. However, Sinaga *et al.* (2016) found a thicker tiller (3.5–7 cm) without N fertilizer application, which was 146% thicker than the mean results of the current study.

Plant height was increased with increasing cutting height and the rate of N fertilizer ($P < 0.05$). The tallest plant was recorded for the combined treatment of 22.5 cm x 161 kg N ha^{-1} (2.81 m) which was more than threefold than the height of plants obtained from the combined treatment of 7.5 cm x 0 kg N ha^{-1} (0.8 m). This could be due to the high decapitation and death of the plants at 7.5 cm cutting height (Sousa *et al.*, 2010). The grass fertilized with 161 kg N ha^{-1} produced 2.6 times taller plants than the control treatment, and the grass harvested at the cutting height of 22.5 cm produced 1.3 times taller plants than the 7.5 cm cutting height, indicating that plant height is influenced more by N fertilizer rate than cutting height (Na *et al.*, 2014). A similar observation was made for the effects of cutting height (Jørgensen *et al.*, 2010) and N fertilizer rate (IICA, 2016) on plant height. However, Norsuwan *et al.* (2014) and Oliveira *et al.* (2015) found a non-significant difference in plant height of Napier grass due to the rate of N fertilizer. Plant height of elephant grass ranging from 186.7 to 275.8 cm was reported when fertilized with 50 kg N ha^{-1} and cut at a height of 5 cm (Mamaru Tesfaye, 2018), which was within the range of values observed in the current study.

The interaction effect of the rate of N fertilizer and cutting height had a significant ($P < 0.05$) effect on internode length. Generally, internode length was in the order of 0 < 69 < 115 = 161 kg N ha^{-1}. On the contrary, Mamaru Tesfaye (2018) obtained lower internode length at a 5 cm cutting height with a mean value ranging from 6.7 to 12.9 cm, which could be attributed to the acidity of the soil (pH 4.2) and agro-ecological zone.

The number of internodes was affected ($P < 0.05$) by cutting height, the rate of N fertilizer application as well as their interaction. The highest number of internodes per tiller was at the highest cutting height and the rate of N fertilizer, and Vice Versa. This could be because of the fastest growth in higher cutting height and N fertilizer rate. Mamaru Tesfaye (2018) noted a similar observation. However, Tessema Zewdu *et al.* (2010a) observed no significant difference among cutting heights for Napier grass with a relatively lower number of internodes per tiller of 2.4 to 2.9.

The basal circumference of the plant increased significantly ($P < 0.05$) as cutting height and the rate of N fertilizer increased but the interaction effect was not significant ($P > 0.05$; Table 1). The increment in basal circumference per plant with an increase in N fertilizer rate and cutting height was in line with the report of Wangchuk *et al.* (2015). The basal circumference of the grass in the current study (90 to 161 cm) was lower than the value reported by Tessema Zewdu (2008) (125–198.7 cm), which could be due to the difference in the agro-ecological zone and soil fertility.

Table 1. Effects of cutting height, rate of nitrogen fertilizer, and their interaction on morphological characteristics of Elephant grass.

Parameter	Cutting height	Nitrogen Fertilizer rate in kg N ha^{-1}					Cutting height in cm				P-value		
		0	69	115	161	SEM	7.5	15	22.5	SEM	C	N	C x N
TN	7.5	21^{c}	30^{b}	35^{a}	37^{a}	0.67	30.8^{c}	33.8^{b}	37.8^{a}	0.33	<.0001	<.0001	0.0041
	15	24^{d}	31^{c}	38^{b}	42^{a}								
	22.5	29^{c}	33^{b}	43^{a}	46^{a}								
	Mean	24.7^{d}	31.3^{c}	38.7^{b}	41.7^{a}	0.39							
TW	7.5	109.5^{b}	93.0^{c}	122.3^{a}	102.1^{bc}	2.20	106.7^{a}	102.3^{b}	91.8^{c}	1.10	<.0001	<.0001	<.0001
	15	109.9^{b}	131.2^{a}	81.3^{c}	86.6^{c}								
	22.5	123.0^{a}	83.7^{b}	92.8^{b}	67.7^{c}								
	Mean	114.1^{a}	102.7^{b}	98.8^{b}	85.5^{c}	1.27							
TD	7.5	2.27^{ab}	2.67^{a}	1.57^{b}	1.40^{b}	0.208	1.98	1.92	2.18	0.104	0.2066	0.0782	<.0001
	15	1.53^{ab}	1.13^{b}	2.53^{a}	2.47^{a}								
	22.5	1.63^{b}	2.40^{ab}	1.73^{b}	2.93^{a}								
	Mean	1.81	1.94	2.07	2.27	0.12							
PH	7.5	0.8^{d}	1.3^{c}	1.9^{b}	2.1^{a}	0.013	1.53^{c}	1.84^{b}	2.03^{a}	0.007	<.0001	<.0001	<.0001
	15	0.95^{d}	1.5^{c}	2.3^{b}	2.6^{a}								
	22.5	1.1^{d}	1.7^{c}	2.5^{b}	2.81^{a}								
	Mean	0.95^{d}	1.5^{c}	2.23^{b}	2.5^{a}	0.008							
INL	7.5	14.3^{c}	16.0^{bc}	20.9^{a}	20.2^{a}	0.67	18.6	18.4	17.8	0.33	0.269	<.0001	0.0305
	15	14.0^{c}	16.3^{bc}	21.7^{a}	21.7^{a}								
	22.5	13.3^{c}	19.3^{ab}	21.5^{a}	20.2^{a}								
	Mean	13.9^{c}	17.2^{b}	21.4^{a}	20.7^{a}	0.39							
NN	7.5	5.33^{c}	7.63^{b}	8.40^{b}	9.80^{a}	0.233	7.79^{c}	9.00^{b}	9.85^{a}	0.116	<.0001	<.0001	0.0008
	15	6.00^{d}	8.60^{c}	10.00^{b}	11.40^{a}								
	22.5	7.00^{d}	8.40^{c}	11.00^{b}	13.00^{a}								
	Mean	6.11^{d}	8.21^{c}	9.8^{b}	11.4^{a}	0.135							
BC	7.5	90	114	129	136	2.47	117^{c}	126^{b}	136^{a}	1.24	<.0001	<.0001	0.1060
	15	101	119	140	145								
	22.5	108	123	150	161								
	Mean	100^{d}	119^{c}	140^{b}	147^{a}	1.43							

Note: Means in a row within a category with different superscripts differ (P<0.05); TN = Tiller numbers per plant; TW = Tiller weight (g DM per tiller); TD = Tiller diameter (cm); PH = plant height (m); INL = Internode length (cm); NN = Number of internodes per tiller; BC = Basal circumference (cm); SEM = Standard Error of the Mean; C = Cutting height; N = Nitrogen fertilizer rate.

3.2. Green Forage and Dry Matter Yield of Elephant Grass

Cutting height, rate of N fertilizer application, as well as their interaction had a significant effect ($P < 0.05$) on green forage yield (GFY) and dry matter yield (DMY) of elephant grass (Table 2). Both GFY and DMY were lower ($P < 0.05$) for the 7.5 cm cutting height than the other cutting height that had similar values ($P > 0.05$). This could be associated with the higher tiller number and plant height with an increase in cutting height. Wadi *et al.* (2004) reported that a higher DMY at 0 cm than at 30 cm cutting height. The application of a higher rate of N fertilizer resulted in double GFY and DMY over the unfertilized group, which could be attributed to the higher number of tillers along with the taller grass (Ansah *et al.*, 2010). However, there was no statistical difference between the N fertilizer rate of 115 and 161 kg N ha^{-1} in DMY. The current result revealed that the combination of 22.5 cm and 161 kg N ha^{-1} and 15 cm and 161 kg N ha^{-1} produced 2.4 and 2.6 times GFY and DMY, respectively as compared to the combined effect of the lowest cutting height and no fertilizer. The current result on GFY was in line with other studies conducted on different accessions of Napier grass (Oliveira *et al.*, 2015; Mamaru Tesfaye, 2018). Oliveira *et al.* (2015) reported that the DMY increased as the N fertilizer increased from 100 to 1600 kg N ha^{-1}. Norsuwan *et al.* (2014), on the other hand, reported that 240 kg N ha^{-1} application was sufficient to produce the highest dry matter yield.

3.3. Partial Budget Analysis of Elephant Grass Growing Under Four Nitrogen Fertilizer Rates

The rate of N fertilizer application determines the cost and biomass production of elephant grass (Sant'Ana *et al.*, 2018) so that Partial budget analysis is very vital to evaluate its' economic feasibility (Oliveira *et al.*, 2015). In the current experiment, the partial budget analysis was done to evaluate the smallholder farmers' profitability by producing elephant grass fertilized with different rates of N (Table 3). The result of the partial budget analysis revealed that fertilizing elephant grass with N resulted in a relatively higher return over the control group. Although the change in net return was positive across all the rates of N fertilizer, it was higher for elephant grass fertilized with 115 kg N ha^{-1} (7501.4 ETB) compared to the other rate of N fertilizer. The result of this study showed that per unit of expenditure could result in a return of 0.648, 0.862, and 0.644 ETB per unit of investment for 69, 115, and 161 kg N ha^{-1}, respectively. Therefore, fertilizing the elephant grass at 115 kg N ha^{-1} was economically feasible because it resulted in a high net return than the other rate of N fertilizer and hence it could be recommended for smallholder elephant grass producers as a fodder crop.

Table 2. Effects of cutting height, rate of nitrogen fertilizer, and their interaction on green forage and dry matter yield of Elephant grass.

Parameter	Cutting height	Nitrogen Fertilizer rate in kg N ha^{-1}					Cutting height in cm				P-value		
		0	69	115	161	SEM	7.5	15	22.5	SEM	C	N	C x N
GFY	7.5	17.28^{b}	20.94^{b}	22.50^{b}	25.11^{a}	1.318	21.46^{b}	30.38^{a}	31.75^{a}	0.659	<.0001	<.0001	<.0001
	15	18.61^{d}	27.22^{c}	34.19^{b}	41.50^{a}								
	22.5	16.83^{c}	31.37^{b}	37.03^{ab}	41.79^{a}								
	Mean	17.56^{d}	26.51^{c}	31.24^{b}	36.13^{a}	0.761							
TDMY	7.5	2.45^{b}	2.98^{b}	4.36^{a}	4.33^{a}	0.25	3.53^{b}	4.85^{a}	4.7^{a}	0.125	<.0001	<.0001	<.0001
	15	2.80^{c}	5.51^{ab}	4.65^{b}	6.45^{a}								
	22.5	2.95^{c}	4.38^{b}	6.25^{a}	5.24^{ab}								
	Mean	2.73^{c}	4.29^{b}	5.09^{a}	5.34^{a}	0.144							

Note: Means in a column and within a category with different superscripts differ at P<0.05; GFY = Green forage yield (ton ha^{-1}); TDMY = Total dry matter yield (ton DM ha^{-1}); SEM = Standard Error of the Mean; C = Cutting height; N = Nitrogen fertilizer rate.

Table 3. Partial budget analysis of Elephant grass fertilized with different nitrogen rates.

Descriptions	Treatments			
	Control Group	69 kg N ha^{-1}	115 kg N ha^{-1}	161 kg N ha^{-1}
Dry matter yield in ton DM ha^{-1}	2.73	4.29	5.09	5.34
Selling price in ETB ha^{-1}	18741.5	29450.9	34942.9	36659.1
Purchasing price of urea fertilizer in ETB ha^{-1}	0.0	3300.0	5500.0	7700.0
Cost of labor for land and pit preparation in ETB ha^{-1}	6000.0	6000.0	6000.0	6000.0
Cost of labor for planting, harvest, and supplementary irrigation in ETB ha^{-1}	5250.0	5250.0	5250.0	5250.0
Cost of labor for fertilizer application in ETB ha^{-1}	0.0	3200.0	3200.0	3200.0
Cost of labor for weed management in ETB ha^{-1}	5000.0	5000.0	5000.0	5000.0
TVC	0.0	6500.0	8700.0	10900.0
TR	2491.5	13200.9	18692.9	20409.1
NR	2491.5	6700.9	9992.9	9509.1
ΔTVC	-	6500.0	8700.0	10900.0
ΔTR	-	10709.4	16201.4	17917.6
ΔNR	-	4209.4	7501.4	7017.6
MRR	-	64.8	86.2	64.4

Note: TVC = Total Variable Cost (ETB ha^{-1}); TR = Total Return (ETB ha^{-1}); NR = Net Return (ETB ha^{-1}); ΔTVC = Change in Total Variable Cost (ETB ha^{-1}); ΔTR = Change in Total Return (ETB ha^{-1}); ΔNR = Change in Net Return (ETB ha^{-1}); MRR = Marginal Rate of Return (%) and ETB = Ethiopian Birr.

4. Conclusions

This study demonstrated that both cutting height and N fertilizer rate had a significant effect on the morphological characteristics and on forage yield of Elephant grass. Forage yield and morphological characteristics increased in response to increasing the rate of N fertilizer and cutting height. However, the dry matter yield for 115 (5.09 ton DM ha^{-1}) and 161 (5.34 ton DM ha^{-1}) kg N ha^{-1} fertilizer rate and 15 (4.85 ton DM ha^{-1}) and 22.5 (4.7 ton DM ha^{-1}) cm cutting heights were similar. Looking at the combination of the two factors 115 kg N ha^{-1} x 22.5 cm and 161 kg N ha^{-1} x 15 cm treatments resulted in greater DMY and 115 kg N ha^{-1} was observed as an economically feasible N fertilizer rate, suggesting 115 kg N ha^{-1} x 22.5 cm to be recommended for farmers to grow as it may lead to economical forage production due to reduced N fertilizer cost.

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