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Research Paper

Effect of Nitrogen Fertilizer Application on Biomass yield and Nutritive Value of Desho grass (*Pennisetum glaucifolium* Hochst. Ex A. Rich.) Varieties at Assosa, North Western Ethiopia

Workneh Tezera[1]*, Solomon Mengistu[2], Mengistu Urge[3], Diriba Geleti [1]and Mitiku Eshetu[3]

[1]*Ethiopian Institute of Agricultural Research (EIAR), P.O.Box 2003, Addis Ababa,Ethiopia*
[2]*Holetta Agricultural Research Center, Holetta,P. O. Box 31 Holetta, Holetta, Ethiopia*
[3]*Haramaya University, P.O.Box 138, Dire Dawa, Ethiopia*
[*]*Correspondence Author email: - workzer@yahoo.com*

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Desho Grass (Pennisetum glaucifolium Hochst. Ex A. Rich) 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. An experiment was therefore, conducted to evaluate effects of nitrogen fertilizer levels on agronomic performance, forage yield and chemical composition of desho grass (Pennisetum glaucifolium Hochst. Ex A. Rich) varieties under rain fed condition during 2018 and 2019 cropping seasons at Assosa, Ethiopia. The field experiment consisted of a two-factor factorial, in a randomized complete block design (RCBD) with three replications. The first factor consisted of three desho grass varieties (Kindo kosha-DZF#591, Kulumsa-DZF#592, Areka-DZF#590) and the second, four nitrogen fertilizer levels (0, 50, 100 and 150 kg/ha. The result indicated that the three desho varieties exhibited significant difference (P < 0.001) in the majority of agronomic characteristics. Level of nitrogen fertilizer showed highly significant effects (p<0.001) on all of the agronomic characteristics and chemical composition of desho grass. Overall, significantly higher (P < 0.001) dry matter yield (16.53 t/ha) was recorded for Kulumsa-DZF-592 variety while the lowest dry matter yield (12.29 t/ha) was recorded for Kindo kosha-DZF-591. Regarding fertilizer levels, maximum dry matter yield (16.78 t/ha) was recorded from the 150 kg/ha N application level while the lowest (11.73 t/ha) was recorded from the control treatment (0 kg level). The highest crude protein yield (CPY) (1.60 tone/ha) was recorded from Kulumsa-DZF-592 variety, while the lowest (1.21 t/ha) was from Kindo kosha-DZF-591. With regard to effect of fertilizer levels, the highest CPY (1.84 t/ha) was recorded from 150 kg/ha fertilizer level while the lowest (1.01 t/ha) CP was recorded from the control (0 kg level). There was better yield recorded at Assosa and applying 150 kg per hector Nitrogen fertilizer is economical in desho grass production. Therefore, Kulumsa-DZF-592 could be recommended with 150 kg per hector Nitrogen fertilizer at Assosa and similar agro-ecology to have economical Desho grass yield.

Key-words: Agronomy, Crude protein, Dry matter, Plant height, Varieties

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INTRODUCTION

Agriculture is the major economic sector in Ethiopia, and livestock production is one of the major components of agriculture in the country. In Ethiopia livestock are important component of nearly all farming systems providing the community with milk, meat, draught power, transport, manure, hides, skins, and as source of household income (Funk *et al.,* 2012). Furthermore, the livestock sector accounts for about 15-17% of the total gross domestic product (GDP) and 35-49 of the total agricultural gross domestic product (AGDP) (ATA, 2012). However, livestock productivity in Ethiopia is hindered by many constraints, of which feed unavailability both in quantity and quality being the major one (Manaye *et al.,* 2009). The main feed resources for livestock in Ethiopia are natural pastures and crop residues (CSA, 2021). In some areas, the latter accounts for more than 90% of the total feed available to livestock (Alemayehu, 2004). These feed resources are low in quality and quantity (Tessema *et al.,* 2002a; Tessema and Baars, 2004) as a result of which livestock growth rates and fertility are low (Odongo *et al*., 2002).

In order to improve livestock productivity in the country, it is necessary to increase feed availability through introduction and cultivation of high-yielding and quality forage crops tolerant to local biotic and abiotic stresses (Tessema and Halima, 1998 and Tessema *et al.,* 2002b).

Among the high-yielding forage grasses, **desho** (*Pennisetum glaucifolium*), an indigenous perennial grass, received considerable emphasis in the current research and development endeavors. Desho is a panicoid (tribe Panicae) grass species endemic to the central and the south-western Ethiopian highlands (Hedberg, I. and S., Edwards, 1995). It has been traditionally used by Wolayta people in the Southern Nations, Nationalities and Peoples Region (SNNPR), well ahead of its evaluation and release by the Debre Zeit Agricultural Research Center (DZARC) (Solomon M. *et al*, 2017; Mekasha C. *et al*, 2015). Due to its fast growth and rapid ground cover, desho has been locally used as cut-and-carry fodder and as gully-stabilizing plantings in Wolayta area (MoANR-PVRPSQCD, 2018).

Germplasm collection was undertaken for four desho ecotypes that were sampled as root splits from selected locations that represented its natural distribution. Three of the sampling locations are clustered around the medium-highlands of Wolayta Zone of SNNPR, where the three ecotypes: Areka, Kindokosha-1 and Kindokosha-2 were collected; the fourth highland ecotype was collected at Kulumsa (Arsi highland, 2,200 m.a.s.l.). The exact origin of the latter ecotype is doubtful; it is suspected to be one of the native grass species collected by the Chilalo Agricultural Development Unit (CADU) (Carlson, 1972), some 45 years ago. Since then, it became naturalized in the cool highland environment of Arsi highland, unlike the other three ecotypes whose habitat is clustered in lowlands. The collected ecotypes were evaluated for their growth characteristics, fodder yield and nutritional attributes at four locations, namely, Debre Zeit, Kulumsa, Holeta and Wondo, under supplemental irrigation (Solomon M. *et al*, 2017; Tekalign, Y., 2017). Mean fodder yield over locations was the highest for Kindo Kosha1-DZF-591 (23.59 t/ha DM) followed by Areka-DZF-590 (21.70 t/ha DM). While Kulumsa DZF-592 and Kindo Kosha2-DZF-589 ranked third and fourth in DM yield, giving 20.69 and 17.00 t/ha, respectively. Overall, *Desho* varieties were reported to perform excellently as was evident from the agronomic performance and nutritional composition. As a result, three of the promising desho ecotypes were released officially under the variety names: Kulumsa-DZF-592, Areka-DZF-590; and Kindo Kosha-1-DZF-591 (MoANR-PVRPSQCD, 2018).

Whereas the growth and agronomic potential of the desho grass varieties had been determined in several studies (Solomon M.*et al*, 2017; Tekalign Y. *et al*, 2017; Minichl Y. *et al,* 2019), important attributes of a sound forage variety were missing: nutrient requirements were not defined; compatible legume species in a mixed stand were not selected, and feeding values were not carried out using ruminant animals.

Consequently, experiments were carried out at Assosa to fill some of the information gaps on the three released varieties of desho grass, namely, Kindo kosha-DZF-591, Kulumsa-DZF-592 and Areka-DZF-590. The objective of this study was, therefore, to determine the effects of N fertilizer levels on biomass yield and nutritive value of desho grass varieties at Assosa under rain fed conditions.

Materials and Methods

Environment of the study site

Experiments were conducted under rain-fed conditions during the main cropping season for two consecutive years (2018/19 and 2019/20) in the forage experiment field of Assosa Agricultural Research Center located in Benishangul Gumuz Region in north-western Ethiopia. Assosa is located at 10^0 02ˈ 47’’N latitude and 34^0 34ˈ27’’ E longitude with an altitude of 1560 meters above sea level. The soil texture of the experimental site is clay loam and strongly acidic with pH value of 5.04. The climate is hot to warm moist lowland plain with uni-modal rainfall distribution.

Table 1. Monthly total rainfall (mm) and number of rainy days during the study, 2018-2019.

Month	Rainfall (mm)		Temperatures (^{0}C)			
			Minimum		Maximum	
	2018	2019	2018	2019	2018	2019
Jan	10.3	0	13.7	14.0	29.2	31.5
Feb	8	1.4	14.4	15.3	31.6	31.5
March	28.7	0	14.1	15.1	30.8	32.8
April	22	43.8	16.4	15.9	29.9	30.9
May	235.2	82.2	17.0	17.1	28.1	27.6
June	422.7	235.4	16.2	16.3	24.2	25.2
July	88.4	184.1	16.3	16.0	23.9	24.1
August	218.9	275.3	15.9	15.8	24.7	24.2
September	215.5	246.9	15.6	15.8	25.8	25.1
October	167.1	173.5	15.1	14.4	25.7	26.3
November	17.8	24.3	14.5	13.2	28.1	27.6
December	1.8	2.1	14.6	12.2	28.9	29.0
Total (mean)	1436 **(119.6)**	1269 (105.75)	15.3	15.1	27.6	28

The rainy season starts at the end of April and lasts at the end of October, with maximum rainfall from June to October. The mean maximum and minimum temperatures of the district during the season of the experiment were 27.6 and 15.3 °C, respectively; the total annual rainfall was 1,436 mm.

Experimental Materials

Three desho grass varieties,Kindo kosha-DZF-591, Kulumsa-DZF-592 and Areka-DZF-590 were used in the experiment. The source of the plant materials were Debre Zeit Agricultural Research Center (DZARC), where the varieties were developed and released. Nitrogen fertilizer was used in the form of urea (46% N).

Soil Sample Analysis

Before planting, soil samples were taken randomly from each plot at the depth of 0-30 cm and bulked to make a composite sample. The sample was air-dried, crushed in a mortar and sieved through a 2 mm sieve. A subsample weighing 1 kg was analyzed for determination of soil texture, soil pH, organic carbon, total nitrogen, and available phosphorus and cation exchange capacity (CEC) using standard laboratory procedures at Hollota Agricultural Research Center Soil Testing Laboratory, Ethiopia.

Soil pH was measured from the supernatant suspension of a 1:2.5 soil to water ratio using a standard glass electrode pH meter (Rhoades, 1982). The Walkley and Black (1934) method was used to determine the organic carbon (%). Total N was determined using Kjeldhal method as described by Bremner and Mulvaney (1982). Available P (mg kg-1) was determined by employing the Olsen et al. (1954) method using ascorbic acid as the reducing agent. Cation exchange capacity (CEC) in cmol (+) kg^{-1} was measured using 1M-neutral ammonium acetate method (Jackson, 1973). Electrical conductivity (EC) was determined in a soil-to-water suspension of 1:5 (Jackson, 1973).

Table 2. Some physicochemical properties of soil of the experimental field at Assosa Agricultural Research Center sampled before planting (depth, 0-30 cm) in 2018.

Soil property	Composition before planting
pH	5.26
OC (%)	1.77
Total N (%)	0.16
Available P (mg kg $^{-1}$)	3.23
Available K (mg kg $^{-1}$)	1.35
CEC (cmol$_c$ kg $^{-1}$)	33.92
Exchangeable Acidity (cmol$_c$ kg $^{-1}$)	1.30
Exchangeable Al (cmol$_c$ kg $^{-1}$)	0.71
Percent Acid saturation (%)	3.83
Sand (%)	14.00
Silt (%)	23.00
Clay (%)	63.00
Textural class	Heavy clay
Dry bulk density (g cm^{-3})	1.32

Experimental design and treatments

The experiment consisted four levels of nitrogen fertilizer (0, 50, 100, and 150 kg N ha^{-1}), and three varieties (Kindo kosha-DZF-591, Kulumsa-DZF-592 and Areka-DZF-590), making up 12 treatment combinations per block (4 x 47=188 m^2). The experiment was laid out in a randomized complete block design in a factorial arrangement, replicated three times. Plot size was 4 m x 3 m (12 m ^{2}). Spacing between plots and blocks were 1 and 1.5 m, respectively. While the spacing between rows and plants were 50 cm and 20 cm, respectively. Each plot accommodated 120 plants (6 rows per plot).

Plot Preparation and Planting

Desho grass varieties were planted using root splits in rows on a well-prepared seed beds in July 2018. Root splits were planted in rows at a depth of 15 cm. Nitrogen fertilizer was applied in the form of urea, one month after planting by placing near the base of plants along the row. Plots were hand-weeded twice per year to reduce the effect of coarse weeds. Single harvest was made for the first year of production while double harvests were made for the next production year. The first harvest was made early August while the second was done in November.

Observation and Measurements for Growth Characteristics

Observations were taken every six weeks for plot cover, stand vigor by scoring on a scale of 1-10. Plant height was determined by measuring the length of the culm from the base up to the tip in centimeters.

Sampling for Herbage Yield and Nutritional Quality

Herbage yield was determined by harvesting and measuring the growth from each treatment plot at about initial heading stage when maximum above ground was expected. Sampling was accomplished by placing an open ended quadrat measuring 1.5 by 0.5 m on the central row of the plots. Three random quadrats were harvested. Fresh material was bulked and weighed using a sensitive field balance, which represented the total fresh herbage yield per plot. From the fresh material, 500 g sample was taken and sorted into botanical components of sown grass (desho), weed grass, weed legume, and other weed species. Fresh weight of each component was taken and recorded, and placed in a perforated paper bag, and dried in a forced draught drying oven at 65 ^{0}C for 72 hours period to a constant dry weight to determine dry matter (DM) weight and nutritional composition. Yield per unit area were then converted to DM yields per hectare. From the dried sown matter, representative sample was taken and ground to pass through a 1mm sieve and subjected to analysis in a laboratory for nutrient composition, and in-vitro digestibility using standard procedures. Another fresh sample of harvested material containing at least ten intact plants of sown desho grass was taken, and fractioned into leaf and stem components. Fresh weights of the components were taken and then the material dried in a forced drought drying oven for twelve hours periods at 105 ^{0}C. The dried material was weighed, from which leaf-to-stem ratio (LSR) was calculated on dry matter basis.

Chemical Analysis and In vitro Dry Matter Digestibility

For forage quality analysis, a homogenous representative sub-sample was taken for each of desho grass varieties. The DM and ash contents were determined by oven drying at 105 ^{0} C overnight and by igniting in a muffle furnace at 500 ^{0}C for six hours, respectively. Nutrient compositions were determined from the sample dried at 65 ^{o}C for 72 hrs. Nitrogen content was determined by Kjeldahl method and then crude protein (CP) was calculated as N x 6.25 (AOAC, 1995). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) fractions were analyzed according to Van Soest and Robertson (1985). The modified Tilley and Terry *in vitro* methods (Van Soest and Robertson, 1985), was used to determine digestibility (IVDMD). The ME content was estimated using the following equation: ME (MJ kg DM) = 0.15*IVOMD (Pikrton, 2005).

Statistical Analysis

The collected data were subjected to the analysis of variance procedures of SAS general linear model statistical software package (SAS, 2014). Only tests that show a significant difference in ANOVA were promoted to mean comparisons using the least significant difference (LSD) at a 5% probability level. The data were analyzed using the model: $\mathbf{Y_{ijk} = \mu + V_i + Y_J + N_k + (VY)_{ij} + (FV)_{ik} + (B)_l + e_{ijk}}$, where, $\mathbf{Y_{ijk}}$ is the dependent variable; $\boldsymbol{\mu}$ the overall mean; $\mathbf{V_i}$ the effect of variety; $\mathbf{Y_J}$the effect of year j; N_k the effects of Nitrogen fertilizer rate k$\mathbf{(VY)_{ij}}$ the interaction effects of variety i and year j; (FV)ik the interaction effects of variety i and Nitrogen fertilizer rate; the effects of the block k and e_{ijk} is the random error.

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 desho 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 (∆NR) was calculated as the difference between the change in total return (∆TR) and the change in total variable cost (∆TVC) as:

∆NR = ∆TR – ∆TVC

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

MRR = ∆NR/∆TVC*100

Results and Discussion

Growth and establishment

Plot cover and vigour

Plot cover increased as nitrogen fertilizer rate increased in both years (2018 and 2019) (Table 2). During the 2018 cropping season the highest plot cover recorded was 91.78 % and it was from application of nitrogen fertilizer at a rate of 150 kg h^{-1}.The observed change in plot cover was 7.5 % when compared to the control one. The rapidly and highly potential of plot cover were recorded from Kulumsa-DZF#592 (93.87 %) variety. This can be a good indication of adaptability for desho grass with soil, water and environment of the study area. Clara (2013) reported that ground cover is an important attribute of any vegetation, especially in relation to soil and water conservation, which is in support of this study. It is an important parameter in restoration of degraded areas, where moisture is the limited factor.

The result of the analysis of variance also showed that vigor score was highly significantly influenced by the main effects of nitrogen fertilizer application (p<0.001) both in 2018 and 2019. However, variety and the interaction of variety and nitrogen fertilizer rate did not show significant effects on vigor score (p>0.05). The application of nitrogen fertilizer at a rate of 150 kg N ha $^{-1}$ resulted in significantly higher vigour score (91.44 %) compared to other rates (Table 2), which was followed by 100 kg N ha $^{-1}$ (89.11 %) and 50 kg N ha $^{-1}$ (87.33). The control group (0 kg N /ha) recorded the lowest vigor score (77.56). However, variety did not show significant effect on vigor score (p>0.05).

Variety showed significant difference in plot cover (p<0.05) in both 2018 and 2019 cropping seasons. The highest plot cover observed were 90.92 and 96.8 5% in 2018 and 2019 cropping seasons, respectively , and these were from the desho grass variety Kulumsa-DZF#590. At the same time, the lowest cover was recorded from the Desho grass variety Kindo koisha-DZF#591 in both years (85.75 and 90.25%).

Table 3: Plot cover and vigor scores (%) of Desho grass as influenced by nitrogen fertilizer rate and variety during 2018 and 2019 cropping seasons at Assosa Agricultural Research Center

Treatment	Plot cover (%)			Vigor score (%)		
	2018	2019	Mean	2018	2019	Mean
Fertilizer (kg N ha^{-1})						
0	85.33^{b}	89.11^{c}	87.22^{c}	73.33^{b}	81.78^{c}	77.56^{c}
50	87.44^{b}	93.22^{b}	90.33^{bc}	83.89^{a}	90.78^{b}	87.33^{b}
100	89.44^{a}	93.67^{ab}	91.56^{ab}	85.89^{a}	92.69^{ab}	89.11^{b}
150	91.78^{a}	94.39^{a}	94.39^{a}	87.78^{a}	95.11^{a}	91.44^{a}
LSD (0.05)	4.34	3.42	3.25	3.34	3.25	2.89
F-test	*	**	***	***	***	***
Variety						
Kulumsa-DZF#592	90.92^{a}	96.8^{a}	93.87^{a}	84.17	90.67	87.42
Areka-DZF#590	88.83^{ab}	92.67^{b}	90.75^{b}	81.91	89.58	85.96
Kindo Kosha-DZ#591	85.75^{b}	90.25^{b}	88.00^{b}	91.83	90.00	85.71
LSD (5%)	3.76	2.96	2.81	3.85	3.75	3.34
F-test	*	**	***	Ns	Ns	Ns
CV (%)	5.02	3.7	3.67	4.77	4.26	3.96
F X V	Ns	ns	ns	ns	ns	Ns

Means followed by different superscript letters in a column are significantly different from each other at p< 0.05, LSD=Least significant difference, Ns = non-significant. *, **, ***, significant at 5%, 1% and <1% respectively.

Plant height and number of tillers per plant

The analysis of variance showed that plant height was highly significantly (P< 0.01) affected by both varieties and N fertilizer application rate. Desho grasses grown on the plots that received N fertilizer were significantly taller than the plants which were grown on control plot (without N fertilizer) (Table 3). The result showed that the plant height of desho grass varieties varied significantly (p<0.05) in both production year and the combined over year analysis. In the combined analysis the highest mean of plant height was recorded from Kulumsa DZF-592 (89.96 cm) variety followed by Areka DZF-590 (82.79 cm) while Kindu Kosha-1DZF-591 (75.62 cm) produced the lowest plant height. From the combined means of N rates, plant height increasing the level of N such that the maximum plant height (88.44 cm) was obtained from the maximum N level (150 Kg/ha) while the lowest plant height (76.11 cm) was obtained from the control plot.

Table 4: Plant height and number of tillers per plant of Desho grass varieties as influenced by nitrogen fertilizer rate and variety at Asossa Agricultural Research Center during 2018 and 2019 cropping seasons.

Treatment	Plant height (cm.)			Number of tillers per plant		
	2018	2019	Mean	2018	2019	Mean
Fertilizer (kg N ha^{-1})						
0	63.00^{b}	89.22^{c}	76.11^{c}	47.56^{b}	70.33^{b}	58.94^{b}
50	65.22^{ab}	93.78^{bc}	79.50^{bc}	49.00^{b}	72.11^{b}	60.56^{b}
100	67.00^{ab}	99.22^{b}	83.11^{b}	54.11^{ab}	78.11^{ab}	66.11^{ab}
150	70.00^{a}	106.89^{a}	88.44^{a}	57.78^{a}	84.78^{a}	71.28^{a}
LSD (0.05)	4.43	5.12	3.93	6.27	8.33	7.12
F-test	*	***	***	***	**	**
Variety						
Kulumsa-DZF#592	70.75^{a}	103.00^{a}	89.96^{a}	53.83	79.75	66.79
Areka-DZF#590	65.25^{b}	100.33^{a}	82.79^{b}	52.25	75.33	63.79
Kindo Kosha-DZ#591	62.92^{c}	88.33^{b}	75.62^{c}	50.25	73.92	62.08
LSD (0.05)	4.77	6.01	4.54	5.43	7.21	6.16
F-test	**	***	***	Ns	Ns	Ns
CV (%)	7.36	6.32	5.68	12.32	11.17	11.34
F x V	Ns	Ns	Ns	Ns	Ns	Ns

Means followed by different superscript letters in a column are significantly different from each other at p< 0.05, LSD=Least significant difference, Ns = non-significant. *, **, ***, significant at 5% , 1% and <1% respectively

The variation in plant height of desho grass varieties reported by different studies was also reported (Birmaduma *et al.,* 2019; Solomon *et al.,* 2019; Denbela *et al.,* 2020). However, non-significant variation in plant height of desho grass varieties were reported by different studies (Tekalign, *et al.,* 2017, Denbela and Bimrew, 2021).Many studies revealed significant influence of N on plant height as it play vital role in vegetative growth of plants since it promotes plant growth, increase the number and length of the internode which result in progressive increase in plant height. The interaction effects of Nitrogen fertilizer rate and variety were not statistically different from each other (P>0.05).

Data presented on the number of tillers per plant revealed highly significant (p<0.001) difference among the different rates of nitrogen fertilizer during both cropping seasons. However, there were no significant differences observed among the three desho grass varieties during the cropping seasons (Table 3). The combined analysis indicated that the highest number of tillers per plant (71.28) was obtained from 150 kg N ha^{-1} fertilizer application and this was statistically superior to the control. The lowest number of tillers per plant (58.94) from the control might be due to lack of nitrogen to play role of accelerating vegetative growth. However in the present study, the highest number of tillers per plant obtained from application of 150 kg N ha^{-1} wassuperior to that of the number of tillers obtained from the control by 18%. This result was in agreement with the findings of Bimrew et *al,* (2017) who reported that there was increasing number of effective tillers with an increase in application of nitrogen fertilizer.

Number of leaf per plant

Results of the mean number of leaves as influenced by fertilizer rates and Desho grass verities are presented in Table 4. The number of leaves increased with increase in nitrogen fertilizer rates significantly (P<0.05), more number of leaves were recorded in both - cropping seasons from the highest doses of fertilizer nitrogen application followed by that of application of 100 kg ha^{-1}.

Nitrogen fertilizer rate had significant effect on the number of leaves per plant (P<0.05). Maximum number of leaves (352.44) was observed by the application of 150 kg/ha N, whereas the minimum was recorded from the control (0 kg/ha N) treatment (Table 4). Application of 150 kg/ha and 100 kg/ha N gave statistically similar results. The result indicates that optimum level of N results in more number of leaves. This is because N favors good development of chlorophyll, and it increases the rate of photosynthesis. Hence, it increases the number of leaves. The effect of variety did not show any significant effect on the number of leaves per plan (P>0.05).

Table 5: Number of leaf per plant and leaf-to-stem ratio (LSR) of desho grass (*Pennisetum glaucifolium*) as influenced by nitrogen fertilizer rate and variety at Asossa Agricultural Research Center during 2018 and 2019

Treatment	Number of leaf per plant (Count)			LSR (%)		
	2018	2019	Mean	2018	2019	Mean
Fertilizer (kg N ha^{-1})						
0	234.00^{c}	332.78^{b}	283.40^{c}	0.95^{b}	0.84^{b}	0.89^{b}
50	247.89^{bc}	386.00^{b}	301.94^{bc}	1.10^{ab}	0.88^{ab}	0.99^{a}
100	272.22^{ab}	371.11^{ab}	321.67^{ab}	0.92^{a}	0.92^{a}	1.05^{a}
150	294.78^{a}	410.11^{a}	352.44^{a}	0.93^{a}	0.93^{a}	1.07^{a}
LSD (5%)	30.92	39.66	31.77	0.15	0.07	0.08
F-test	***	***	***	*	***	**
Variety						
Kulumsa-DZF#592	272.5	381.75	327.13	1.06	0.96^{a}	0.90
Areka-DZF#590	263.92	364.25	314.08	1.10	0.90^{a}	0.91
Kindo Kosha-DZ#591	256.25	356.5	303.38	1.16	0.82^{b}	0.85
LSD (5%)	26.78	34.35	27.54	0.13	0.06	0.07
F-test	Ns	Ns	Ns	Ns	*	Ns
CV (%)	12.06	11.03	10.32	14.38	8.44	11.62

Means followed by different superscript letters in a column are significantly different from each other at p< 0.05, LSD=Least significant difference, Ns = non-significant. *, **, ***, significant at 5% , 1% and <1% respectively

Protein content of Desho grass varieties in both the years, 2018 and 2019 cropping seasons is shown in Table 5. Among the three Desho grass varieties, variety Kulumsa-DZF-592 produced significantly higher (P< 0.05) crude protein yields of 1.11 and 2.09 tone ha^{-1} in years 2018 and 2019, respectively when compared to that of the desho grass varieties Areka-DZF-590 and Kindokoisha-DZF-591.

Dry matter and crude protein yields

Dry matter yield

Results on herbage dry matter yield (DMY) as influenced by nitrogen fertilizer application and Desho grass varieties during the 2018, 2019 cropping seasons is presented in Table 5. As shown in the table highly significant effects of Nitrogen fertilizer application was observed on dry matter yield of Desho grass during 2018 and , 2019 cropping seasons (p <0.001). Application of 150 kg N ha $^{-1}$ produced significantly higher dry matter yield compared to that of the rest of the treatments (p<0.001). This indicates that Desho grass requires at least 150kg N ha^{-1} of Nitrogen fertilizer for better performance in soils of the study area. This can be attested from the observed increase in leaf to stem ratio with increased levels of nitrogen application. With application of sufficient amount of fertilizer nitrogen the crop will have dark green foliage that could intercept and utilize incident solar radiation in the production of photosynthates and eventually resulting in higher merstematic activity and thereby increase in leaf to stem ratio. This might also be related to the favorable influence of Nitrogen on cell division and cell elongation with more functional leaves for a higher period of time. Desho grass varieties showed a significant differences in both years 2018 and 2019. As is evident from the data Desho grass variety Kulumsa-DZF-590 gave significantly (P<0.05) higher dry matter yield (p<0.001) when compared to the rest of the two varieties studied.

Table 6: Herbage dry matter (DM) and crude protein yield (CPY) (t ha^{-1}) of desho grass (*Pennisetum glaucifolium*) varieties at Asossa Agricultural Research Center during 2018 and 2019 cropping seasons.

Treatment	DM herbage yield (t ha^{-1})			CPY (t ha^{-1})		
	2018	2019	Mean	2018	2019	Mean
Fertilizer (kg N ha^{-1})						
0	7.98^{c}	15.57^{c}	11.73^{c}	0.66^{c}	1.35^{d}	1.01^{d}
50	9.85^{b}	18.04^{b}	13.59^{b}	0.88^{b}	1.68^{c}	1.28^{c}
100	10.27^{b}	18.86^{b}	14.57^{b}	0.96^{b}	1.93^{b}	1.44^{b}
150	12.47^{a}	21.08^{a}	16.78^{a}	1.29^{a}	2.40^{a}	1.84^{a}
LSD (5%)	1.43	1.22	1.20	0.15	0.19	0.14
F-test	***	***	***	***	***	***
Variety	0.0001	0.001	0.001	0.0004	0.0001	0.001
Kulumsa-DZF#592	11.97^{a}	21.09^{a}	16.53^{a}	1.11^{a}	2.09^{a}	1.60^{a}
Areka-DZF#590	9.82^{b}	18.08^{b}	13.95^{b}	0.93^{b}	1.81^{b}	1.37^{b}
Kindo Kosha-DZ#591	8.85^{b}	16.00^{c}	12.29^{c}	0.80^{c}	1.62^{c}	1.21^{c}
LSD (5%)	1.24	1.06	1.04	0.13	0.16	0.12
F-test	***	***	***	***	***	***
CV (%)	14.47	6.78	8.63	16.84	10.51	10.73
F x V	Ns	Ns	Ns	Ns	Ns	Ns

Means followed by different superscript letters in a column are significantly different from each other at p< 0.05, LSD=Least significant difference, Ns = non-significant. *, **, ***, significant at 5%, 1% and <1% respectively.

Nutrient composition

Crude protein contents

The crude protein **(CP)** content of desho grasses differed significantly (P<0.05) with level of nitrogen fertilizer application in both the years 2018 and 2019 (Table 6). Application of 150 kg N ha^{-1} produced significantly more(P<0.001) compared to that of the rest levels of nitrogen fertilization.

Table 7: Crude protein (CP) and neutral detergent fiber (NDF) composition (% DM) of Desho grass (*Pennisetum glaucifolium*) as influenced by nitrogen fertilizer rate at Asossa during 2018 and 2019 cropping seasons.

Treatment	CP (%DM)			NDF (%DM)		
	2018	2019	Mean	2018	2019	Mean
Fertilizer (kg N ha^{-1})						
0	8.46^{c}	8.72^{c}	8.59^{c}	63.34	63.78	63.56
50	8.90^{bc}	9.34^{c}	9.12^{b}	62.31	62.64	62.48
100	9.34^{b}	10.20^{b}	9.76^{b}	62.45	62.84	62.65
150	10.30^{a}	11.45^{a}	10.85^{a}	62.16	62.36	62.26
LSD (5%)	0.70	0.82	0.60	1.12	1.09	1.10
F-test	***	***	***	Ns	Ns	Ns
Variety						

Table 7: continuation

Kulumsa-DZF#592	9.32	10.10	9.43	64.76[a]	65.11[a]	64.94[a]
Areka-DZF#590	9.32	9.91	9.61	61.73[b]	62.08[b]	61.91[b]
Kindo Kosha-DZ#591	9.11	9.75	9.70	61.52[b]	62.91[b]	62.73[b]
LSD (5%)	0.60	0.71	0.52	0.97	0.94	0.96
F-tesT	Ns	Ns	Ns	***	***	***
CV (%)	7.73	8.51	6.4	1.84	1.78	1.80
F X V	Ns	Ns	Ns	Ns	Ns	Ns

Means followed by different superscript letters in a column are significantly different from each other at p< 0.05, LSD=Least significant difference, Ns = non-significant. *, **, ***, significant at 5%, 1% and <1% respectively.

On the other hand, varietal difference did not show significant effect on CP contents of the desho grass varieties both the years 2018 and 2019cropping seasons (P<005).Among the three varieties of desho grasses, varietyKulumsa-DZF#592 produced significantly more crude protein content of (9.19 and 9.23% during the 2018 and 2019 cropping seasons, respectively when compared tothe rest of the two varieties (Areka-DZF#590 and Kindokoisha-DZF591).

Significantly higher crude protein contents (P<0.05) were recorded from application of 150 kg N ha^{-1} nitrogen fertilizer both during the 2018 and 2019 cropping seasons (Table 7). This could be an indication of the fact that Desho grass requires high doses of nitrogen fertilizer to produce forage with high CP contents, and this might be related to the positive role played by nitrogen in synthesis of protein, and other nitrogen containing compounds necessary for plant growth and development. Similar results were also reported by Bimrew (2017). Such high contents of crude protein in grasses are important in ruminant nutrition Aderinola (2011). In line to this, Bhoti (1988) reported that crude protein contents of grass below 6-7%, depresses microbial activity in ruminants. On the other hand, varietal differences did not show significant effect on the crude protein contents of the desho grass during both the year 2018 and, 2019 (p>0.05).

Neutral Detergent Fiber (NDF)

The effects of nitrogen fertilizer rate and variety on NDF composition of Desho grass is presented in Table 7. As is evident from the data no significant differences were observed among Nitrogen fertilizer rates both during 2018 and 2019 cropping seasons. However the effect of variety was significant. Significantly more NDF contents of 65.11 and 64.94% were observed in plots assigned to the Desho grass variety kulumsa-DZF#592 during both the years 2018 and 2019, respectively. The quality of feed mainly depends on NDF concentration, and feed with lower concentration of this fiber are more nutritious than feed with high NDF concentration. The value recorded from this study for NDF were lower than the previous reported values which ranges from 65.80 to 72.60% at Guji highland area (Teshale *et al.;* 2020) and from 60.9 to 69.2% ((Denbela and Bimrew, 2021) but it was lower than other scholars (Solomon *et al.,* 2019; Denbela et al., 2020). The NDF content of feed has a detrimental effect on forage intake.

Acid Detergent Fiber (ADF) Content

Nitrogen fertilizer rate had a significant (P<0.05) effect on Acid Detergent Fiber (ADF) contents of Desho grass during 2019 cropping season (Table 7). However, during the year 2018, nitrogen fertilizer rate had no statistically significant effect on Acid Detergent Fiber (ADF) contents of the Desho grass (p>0.05). Such lack of significant effects nitrogen during 2018 as opposed to that of the 2019 could indicate existence of year to year variation on effects of nitrogen rate, On the other hand , varietal difference did not have significant effect on ADF contents of Desho grass varieties. During both the years 2018 and 2019, and this could show that synthesis and accumulation of ADF was unaffected by Desho grass varieties. The ADF content in this study was slightly higher than the values reported previously (Bimrew et al., 2017; Bimrew *et al*, 2018B; Mulisa *et al*., 2022).

Table 8. Acid detergent fiber (ADF) and Acid Detergent Lignin (ADL) composition (% DM) of desho grass (Pennisetum glaucifolium) as influenced by nitrogen fertilizer rate and variety at Assosa Research Center during 2018 and 2019

Treatment	ADF (% DM basis)			ADL (% DM basis)		
	2018	2019	Mean	2018	2019	Mean
Fertilizer (kg N ha^{-1})						
0	38.31	39.19^{a}	38.75	5.43^{a}	5.70^{ab}	5.57^{a}
50	38.36	39.17^{a}	38.77	5.53^{a}	5.79^{a}	5.66^{a}
100	38.70	38.89^{a}	38.80	5.37^{ab}	5.67^{ab}	5.52^{ab}
150	38.09	38.17^{b}	38.12	5.22^{b}	5.55^{b}	5.39^{b}
LSD (5%)	0.57	0.61	0.56	0.16	0.17	0.15
F-test	Ns	**	Ns	**	***	***
Variety						
Kulumsa-DZF#592	38.42	38.89	38.65	5.26^{b}	5.52	5.39^{c}
Areka-DZF#590	38.41	38.93	38.67	5.38^{b}	5.67	5.53^{b}
Kindo Kosha-DZ#591	38.26	38.74	38.50	5.52^{a}	5.84	5.69^{a}
LSD (5%)	0.50	0.53	0.48	0.14	0.15	0.13
F-test	Ns	Ns	Ns	**	Ns	*
CV (%)	1.54	1.61	1.48	3.02	3.05	2.87
F X V	Ns	Ns	Ns	Ns	Ns	Ns

Means followed by different superscript letters in a column are significantly different from each other at p< 0.05, LSD=Least significant difference, Ns = non-significant. *, **, ***, significant at 5% , 1% and <1% respectively

Acid Detergent Lignin (ADL)

The mean ADL content of desho grass was significantly affected by nitrogen fertilizer rate (p<0.001) during both the years 2018 and 2019 (Table 8). Application of the highest dosed of fertilizer nitrogen (150 kg N ha^{-1} and 100 kg N ha^{-1} produced) significantly lower ADL contents when compared to the control (0 kg N ha $^{-1}$ and 50 kg N ha^{-1}). Variety also had a significant effect on ADL contents of desho grass both in the years 2018 and, 2019 cropping seasons (p< 0.01) among the desho grass varieties studied variety. Kindo Koisha-DZF-591 showed more ADF content when compared to that of the two varieties (Areka-DZF-590 and kulumsa-DZF-592). As the ADL contents of the feed increases, the digestibility of its cellulose decrease thereby lowering the amount of energy potentially available to animals. Therefore, ADL cause the forage to be much less digestible and less capable of providing the energy needs of animal. Hence the finding of the current study revealed that by utilizing the optimum level of N fertilizer we can improve the nutrient quality of desho grass as the ADL content decrease linearly as we increase the levels of N application.

Metabolizable energy (ME) and in-vitro organic matter digestibility (IVOMD)

The ME and IVOMD are highly significantly different among Nitrogen fertilizer rates in both the years 2018 and 2019 (p<0.01) (Table 8). Both the ME and IVOMD increased with an increase in levels fertilizer nitrogen application. This might be because of the fact that urea fertilizer application improves and stimulates new tillers growth, and shoots and leaves development with more dry matter accumulation of dead materials which are low in cell wall and lignin contents, leading to higher digestibility. The variety also revealed significant difference in both the ME and IVOMD contents in both the years 2018 and, 2019 (p< 0.001).

Table 8. Metabolizable energy (ME) and in vitro organic matter digestibility (IVOMD) of desho grass as influenced by nitrogen fertilizer rate and variety at Assosa Agricultural Research Center during 2018 and 2019.

Treatment	ME (MJ/Kg)			IVOMD (%)		
	2018	2019	Mean	2018	2019	Mean
Fertilizer (kg N ha^{-1})						
0	7.97^{b}	7.94^{b}	7.95^{b}	51.69^{c}	51.58^{c}	51.63^{c}
50	8.25^{ab}	8.07^{b}	8.16^{ab}	54.39^{b}	53.12^{bc}	53.75^{b}
100	8.33^{a}	8.11^{ab}	8.22^{a}	55.67^{ab}	54.16^{b}	54.91^{ab}
150	8.46^{a}	8.31^{a}	8.38^{a}	56.98^{a}	55.88^{a}	56.43^{a}
LSD (5%)	0.28	0.23	0.24	2.11	1.62	3.10
F-test	**	**	*	*	***	**
Variety						
Kulumsa-DZF#592	8.48^{a}	8.42^{a}	8.45^{a}	56.40^{a}	56.03^{a}	56.21^{a}
Areka-DZF#590	8.04^{b}	7.79^{c}	7.92^{c}	53.23^{b}	51.38^{c}	53.31^{c}
Kindo Kosha-DZ#591	8.23^{b}	8.11^{b}	8.17^{b}	53.24^{b}	53.64^{b}	54.03^{b}
LSD (5%)	0.24	0.20	0.20	1.83	1.40	3.10
F-test	**	*	**	**	*	**
CV (%)	3.47	2.88	2.90	3.95	3.09	3.25

Means followed by different superscript letters in a column are significantly different from each other at p< 0.05, LSD=Least significant difference, Ns = non-significant. *, **, ***, significant at 5% , 1% and <1% respectively

Partial Budget Analysis of Desho Grass Growing Under Four Nitrogen Fertilizer Rates

The rate of N fertilizer application determines the cost and biomass production of foraget 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 desho grass fertilized with different rates of N (Table 9). The result of the partial budget analysis revealed that fertilizing desho 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 desho grass fertilized with 150 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 50, 100, and 150 kg N ha^{-1}, respectively. Therefore, fertilizing the Desho grass at 150 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 Desho grass producers as a fodder crop.

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

Descriptions	*Kulumsa-DZF#592,*				*Areka-DZF#590*				*Kindo kosha-DZF#591*			
	0	50	100	150	0	50	100	150	0	50	100	150
Total Fixed costs(TFC)	2590	2590	2590	2590	2590	2590	2590	2590	2590	2590	2590	2590
Variable Costs												
Urea (14 ETB/kg)	0	700	1400	1750	0	700	1400	1750	0	700	1400	1750
Labour cost	0	320	320	320	0	320	320	320	0	320	320	320
Total Variable Costs (TVC)	0	1020	1720	2070	0	1020	1720	2070	0	1020	1720	2070
Dry matter yield (t/ha)	13.60	15.73	16.66	20.13	10.83	14.40	13.71	16.85	10.76	11.71	13.33	13.36
Total Revenue (TR=3300ETB/t=50% WB)	43520	51909	54978	66429	35739	47520	45243	55605	35508	38643	43989	44088
Net Revenue	43520	50889	53258	64359	35739	46500	43523	53535	35508	37623	42269	42018
∆NR		7369	2369	11101		10761	-2977	10012		2115	4646	-251
∆TVC		1020	700	350		1020	700	350		1020	700	350
MRR (%)		722.4	338.4	3,172		1,055	D	2861.6		207.4	663.7	D

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.

D = dominated or unacceptable treatments for the farmers.

Conclusion and recommendations

The application of fertilizer had a significant effect on the morphological characteristics, dry matter yield and chemical composition of desho grass varieties. In this regard, the application of nitrogen fertilizer at the rate of 150 kg ha^{-1} was found to be the most appropriate level for better desho grass production as it provided the highest dry matter and improved the nutritive values of desho grass variety as compared to the rest of nitrogen fertilizer levels in the study area. In addition, Kulumsa-DZF#592 variety was the best compared with Areka-DZF#590 and Kindo kosha-DZF#591 in terms of production of high amount of dry matter in the study area. Therefore, it is recommended to use 150 kg N ha^{-1} for Kulumsa-DZF#592 variety to exploit the benefit from this indigenous grass.

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