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Effect of Nitrogen Fertilizer Application on Nutritive Value of *Cenchrus ciliaris* and Panicum Maximum Grown under Irrigation at Gode, Somali Region

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Abstract

The study was conducted to determine the chemical composition, of Cenchrus ciliaris and Panicum maximum grown under irrigation at Gode, Somali region. The study was executed using 2 x 3 factorial arrangements in randomized complete block design with three replications. The treatments were three level of fertilizer application (0, 50, 100 kg ha^{-1} of urea) and two grass species (Cenchrus ciliaris and Panicum maximum), which make up six treatments. The plot size used for each treatment was 3 meter length and 2 meter width. The Contents of crude protein (CP), Calcium (Ca), Phosphorus (P), Ash, NDF, ADF and ADL, were significantly different (P<0.01), for grass species and urea fertilizer level, but not for interaction effect. The highest crude protein content was observed for the treatments received urea fertilizer levels. It can be concluded, that the addition of urea fertilizer with the grass species in the present study improved the chemical composition of the forage grasses. As matter of fact, it could be recommended that of Cenchrus ciliaris with urea fertilizer application of 50 and 100 kg ha^{-1}, because it has more crude protein content than Panicum maximum, so that agro-pastoral farmers along the Wabi-Shabelle River could increase the livestock production and productivity.

Keywords: *Cenchrus ciliaris*; Chemical composition; Nitrogen fertilizer; Nutritive value; Panicum maximum

Introduction

Ethiopia is home for more than 12-15 million pastoralists who reside in 61% of the nation's landmass these are mostly found below 1,500 meter above sea level (m.a.s.l.). They inhabit by arid and semi-arid agro-ecologies. The pastoralists belong to 29 different ethnic groups which are Cushitic, Omotic, and Nilotic stock in origin (Pastoral Areas Development Study [1]. The main pastoral communities are the Somali (53%), Afar (29%) and Borena (10%) living in the Southeast, Northeastern and Southern parts of Ethiopia, and the remains (8%) are found in South western, Gambella and Benshangul Gumez regions. The majority of these are pastoralists engaged in extensive livestock herding [2]; Pastoralist Forum Ethiopia [3].

Livestock are an important component of nearly all farming systems in Ethiopia and it provide milk, meat, draught power, transport, manure, hides, skins [4] and it serves as a source of income. The livestock sector contributes about 15-17% of the total gross domestic product (GDP) and 35-49 of the total agricultural gross domestic product (GDP) [5]. Currently, productivity per animal is very low, and the contribution of the livestock sector to the overall economy is much lower than expected.

The development of the livestock sub-sector in Ethiopia is hindered by many constraints, of which the unavailability of both quantity and quality feed is a major factor [6]. The main feed resources for livestock in Ethiopia are natural pasture and crop residues, which are low in quantity and quality for sustainable animal production [7-9] also noted that more than 90% of the livestock feed is contributed by crop residues and natural pasture, this results in low growth rates, poor fertility and high mortality rates of ruminant animal [10,11].

In order to solve the shortage of feed and increase livestock productivity, it is necessary to introduce and cultivate high-quality forages with high yielding ability and adaptability to the biotic and a biotic environmental stresses [12-14]. Among the improved forage crops introduced in Ethiopia, *Panicum maximum* and *Cenchrus ciliaris* could play an important role in providing a significant amount of quality forage both under the smallholder farmers and intensive livestock production systems.

Nitrogen fertilization is one of the most common practices since this nutrient was found to be one of the most limiting factors influencing yield and chemical composition of grass pasture. It is also the major factor for increasing the pasture yield and nutritive value of the plant including Crude protein (CP) content and digestibility, which can improve livestock production [15]. Nevertheless, information regarding the effect of fertilizer on biomass yield and nutritive value of improved forage grasses in the study area is lacking. Thus, the present study was designed to determine the effect of nitrogen fertilizer rate on nutritive value of *Panicum maximum* (Guinea grass) and *Cenchrus ciliaris* (Buffle grass).

Materials and Methods

Description of the study area

The field experiment was conducted from September to December, 2013 using irrigation at Gode, one of the nine administrative zones of

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the Somali Regional State. The experimental site was located about three Km west of Gode town, the main town of Gode Zone, which is located in the southern part of the region and the Wabi-Shabelle River forms the southern and the eastern boundaries of the district (Figure 1).

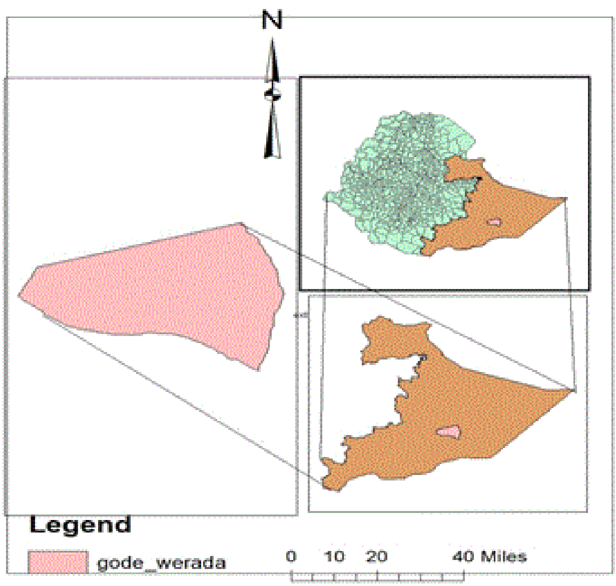

Figure 1: Map of the study area, Gode Zone, Eastern Ethiopia.

The experimental site is located at an elevation of 300 meter above sea level (m.a.s.l.) with latitude of 5°N and longitude of 43°E. The climate of Gode is characterized as arid to semi-arid agro-ecology, where livestock is the main occupation and cultivation is undertaken along Wabi-Shabelle river bank. Rainfall pattern is characterized by two rainy seasons and two dry seasons. The main rainy season termed locally as Gu, in Somali language extend from April to June and the short rainy seasons (Deyr) stretches from October to December. The mean maximum and minimum annual temperatures are 35°C and 22.9°C, respectively. The mean annual rainfall of the area is 150 to 344.06 mm [16].

The soil characteristic in the study site was sandy loam. The topography of Gode district is an extensive flat to gently sloping. It accounts for about 94% of the district's total area. Areas with steep to very steep topography are very small and accounts about 2.4% of the district's total area. Several soil types exist in the Gode district. The predominant soil types are Calcic xerosols, Orthic solonchacks, Gypsic yemosols and Fluvisols [17].

Gode woreda, where this study was conducted, is one of the nine woreda of Gode Zone of Somali regional sate (SRS), the farming system in Gode district mainly characterized by livestock production and crop farming practices along the river bank of Wabi-Shabelle River. The majority of the populations are pastoralists and agro-pastoralists [17].

Gode Woreda has an estimated livestock population of 165,277 cattle; 517,668 sheep; 985,869 goats and 115,498 camels [18]. The district has an estimated total human population of 179,444 of which 99,466 are males and 79,978 females [19].

Experimental layout, design and treatments

The study was conducted using 2 × 3 factorial arrangements in randomized complete block design with three replications. The factors were three levels of urea fertilizer application (0, 50 and 100 kg ha^{-1}) and two species of grass, *Panicum maximum* (Guinea grass) and *Cenchrus ciliaris* (Buffle grass) forming six treatments. The treatments were laid out as below in the Table 1.

block1	Panicum* 0 kg urea ha^{-1}	Panicum*50 kg Urea ha^{-1}	Panicum*100 kg Urea ha^{-1}	Cenchrus*0 kg Urea ha^{-1}	Cenchrus*50 kg Urea ha^{-1}	Cenchrus100 kgUrea ha^{-1}
block2	Cenchrus*50 kg Urea ha^{-1}	Panicum* 100 kg Urea ha^{-1}	Cenchrus *0 kg Urea ha^{-1}	Panicum*50 kg Urea ha^{-1}	Cenchrus*100 kg Urea ha^{-1}	Panicum 0 kgUrea ha^{-1}
block3	Panicum* 100 kg Urea ha^{-1}	Panicum*0 kg Urea ha^{-1}	Cenchrus*50 kg Urea ha^{-1}	Cenchrus* 100 kg Urea ha^{-1}	Cenchrus*0 kg Urea ha^{-1}	Panicum* 50 kg Urea ha^{-1}

Table 1: Treatment arrangement layout, There were 3 blocks, each containing 6 plots resulting to eighteen plots in total, with each plot measuring 2 × 3 meter. Distance between plot and replications (blocks) were 0.50 and 1 meter, respectively. Plots in each block were randomly assigned to the six treatments.

Plot preparation and management

The land was prepared by a tractor and leveled by human power. The seed rate used was 5 kg ha-1. The seeds were sown in a plot in a row (6 rows per plot and 30 cm, space between rows within a plot) by drilling method at a depth of about 2.5 cm and lightly covered with soil to ensure adequate emergence. Fifteen days irrigation interval was used throughout the experiment period. The urea fertilizer was applied after the grasses were well established (one month after planting) by placing near root slips depending on the treatment. Grass from all the plots was harvested at 50% flowering stage of 80 days of growth after planting and on the same day. The grass was cut 5 cm above the ground excluding the border rows.

Soil sample

Prior to planting and after harvesting soil samples were taken randomly per replication at a depth of 0 to 20 cm layer at each corner and center of each replication using soil sampling auger. The collected samples were mixed per replication to make one composite sample and used to determine organic matter content (OM), total nitrogen, available phosphorous (P), pH and Electrical conductivity of extracts (ECe). The soil organic matter was calculated indirectly from organic carbon (OC) concentrations by rapid dichromate oxidation technique of Nelson et al. [20]. Total nitrogen in the soil was analyzed by using Kjeldhal procedure [21] and Olsen's procedure was used to determine the available P [22]. The soil pH was measured potentio-metrically using a digital pH meter in the supernatant suspension of 1:25 liquid ratios where the liquid is water [23]. Soil texture was determined by using the hydrometer method [24]. The soil chemical analysis was under taken at Haramaya university soil laboratory.

Sample collection and preparation

The representative plant of the two grass species were collected and weighed in the field. Then the samples were air dry in a well-ventilated room until transported to Haramaya University and further dried in an oven at 105°C for 24 hours. Then the samples were separately ground in a Willey mill to pass through 1 mm sieve for chemical analysis.

Chemical analysis

Dry matter (DM) content was determined by oven drying of all the samples at 105°C for 24 hours. Total nitrogen (N) was determined by the Kjeldhal method [25]. Crude protein (CP) was calculated as Nx6.25. Ash was determined by complete burning of the feed samples in a muffle furnace at 500°C overnight according to the procedure of AOAC [25]. The structural plant constituents such as neutral detergent fiber (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed using the detergent extraction method [26]. Phosphorus content was determined by auto-analyzer [27]. Calcium was determined by atomic absorption spectrophotometer [28]. The chemical analysis was undertaken at Haramaya university nutrition laboratory.

Statistical analysis

Data on chemical composition, was subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of the statistical analysis system by using SAS computer software version 9.1.3. [29]. Means was separated using least significance difference (LSD).

The statistical model used was

$Y_{ijk} = \mu + A_i + B_i + N_j + AB_kN_j + e_{ijk}$,

Where;

Y_{ijk} = individual observation

μ = overall mean

A_i = effect of forage species

B_k = kth block effect

N_j = N-fertilizer rate

AB_kN_j = interaction effect of species and fertilizer rate

e_{ijk} = the random error

Since fistulated animals were used as a replication, the analysis of variance model for the in sacco degradability parameters was:

$Y_{ijk} = \mu + A_i + N_j + AB_kN_j + e_{ijk}$,

Where;

Y_{ijk} = individual observation

μ = overall mean

A_i = effect of forage species

N_j = N fertilizer rate

AB_kN_j = interaction effect of species and fertilizer rate

e_{ijk} = random error

Results and Discussion

Chemical composition

Dry matter (%) and Ash%: The percent dry mater (DM) did not differ between grass species, urea fertilizer levels as well as the interaction between the two factors (P>0.05; Table 2). The present result are supported by the findings of Sodeinde et al. [30] who also observed non-significance difference in DM content of the same species with the same fertilizer levels.

The Ash content significantly differ (P<0.01) between the grass species and Cenchrus ciliaris had the highest ash content than Panicum maximum. The interaction between grass species and urea fertilizer level on Ash content had shown no significant difference (P>0.05; Table 2). But, the effect of urea fertilizer levels on Ash content were significantly different (P<0.01) and was highest for U0 compared to U50 and U100 kg ha^{-1} and also as the Urea level increase the ash content tended to decrease gradually as well. The present result agrees with that reported by Manaye et al. [31] who noted decreased ash content as a result of an increase in the level of urea application.

Neutral detergent fiber (NDF %): The NDF content did not differ between the grass species (P>0.05; Table 2). But the effect of urea fertilizer level on NDF content had shown significant different (P<0.01). The highest mean was recorded for the control species, so it indicates that as the level of urea fertilizer increases the NDF decreases.

This may be elucidate that the urea fertilizer improves the plant growth and raise new leaves and shoots, which minimizes the NDF content as the urea fertilizer level increased, but there is no rejuvenation of leaves and tillers in the non-fertilizer treatments as a result plant tissue matures and accumulate more NDF.

The result obtained in this study is in line with Van Nieker et al. [32], who stated significant decrease in NDF concentration of plants as N-fertilization levels increased. This decrease was however; only occur during vegetative stage and with highest N level of the early bloom stage.

Also by the same author found that Panicum maximum NDF concentration decreased with the increasing level of N-application. The present result are Also supported by the findings of other González et al. [33,34] who noted decreased NDF concentration in *Panicum maximum* and *Cenchrus ciliaris* as urea fertilizer levels increased.

They attributed the decrease in NDF to increased growth rate of new leaves and shoot which are lower in plant structural components as a result of urea fertilization. However, Meissner et al. [35] reported that the threshold level of NDF that affects dry matter intake of forage is ≤60% beyond which voluntary feed intake is decreased and rumination time increased.

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Factor levels	Parameters							
	DM	Ash	NDF	ADF	ADL	CP%	P	Ca
Panicum maximum	91.37	11.82b	67.68	46.54	9.21	16.73	0.53	0.46
Cenchrus celiaris	89.86	13.62a	65.95	45.58	8.23	17.09	0.54	0.44
P-value	0.12	0.008	0.3	0.378	0.093	0.613	0.7107	0.4502
±SE	0.544	0.56	1.72	1.3	0.63	1.01	0.037	0.029
Urea levels								
U0 kg ha^{-1}	89.92	14.43a	70.89a	50.37a	10.26a	13.54c	0.4391b	0.4038b
U50 kg ha^{-1}	91.7	11.85b	68.52a	44.91b	9.30a	17.34b	0.5193b	0.4095b
U100 kg ha^{-1}	90.23	11.89b	61.03b	42.89b	6.59b	19.84a	0.6576a	0.535a
P- value	0.265	0.004	0.001	4.00E-04	6.00E-04	1.00E-04	0.0007	0.0042
±SE	0.54	0.58	0.99	0.86	0.44	0.56	0.025	0.026

Table 2: Means of grasses chemical composition as affected by grass species and Urea fertilizer levels, Means with same latter are not significant different; SE: standard Error of mean; (P<0.01) = Significant; (P>0.01) = non-significant; (P<0.05) = Significant Difference; (P>0.05) = non-significant; DM= Dry Matter; NDF= Neutral Detergent Fiber; ADF= Acid Detergent Fiber; ADL= Acid Detergent Lignin; CP= Crude Protein; P= Phosphorus; Ca= Calcium; U0 kg ha^{-1}= Urea zero kg ha^{-1}; U50 Kg ha^{-1}= Urea 50 kg ha^{-1}; U100 Kg ha^{-1}= Urea100 kg ha^{-1}.

Acid detergent fiber (ADF %): The ADF content is not different (P>0.05) between the two species of grass, but urea fertilizer decreased (P<0.001) ADF content with no difference between 50 and 100 kg urea fertilizer per ha (Table 2). The highest ADF content was observed in the non-fertilized treatments, and it tends that as the urea fertilizer level increased the ADF content decreased. The result of the present study is in line with that noted by Magani et al. [36] who stated that the acid detergent fiber content of Panicum maximum was significantly influenced by nitrogen fertilization and increased nitrogen fertilization significantly decreased ADF content, Acid Detergent Lignin (ADL %).

The ADL contents observed between grass species had shown no significant difference at (P>0.05) (Table 2). Interaction between grass species and urea fertilizer did not show significant difference (P>0.05). But, the effect of urea fertilizer rate has revealed significant difference (P<0.001). The mean of the ADL content in the treatments applied different urea fertilizer level of 50 and 100 kg ha^{-1}, was shown with average of 9.30 and 6.59. It tends as the urea fertilizer level increase, the ADF content decrease. This is because the urea fertilizer promotes the growth of new leaves and shoots resulting in low lignin, which compensates the increase in lignin content of other tissues. When lignin is lowered it has always produced a marked increase in the digestibility of the plants and lignin are highly resistant to chemical and enzymatic degradation and are not appreciably broken down by the micro flora in the ruminant digestive tract [37].

Crude protein percent (CP %): The CP content observed between grass species had shown no significant (P>0.05) difference (Table 2). But level of urea fertilizer application affected the CP content of the grass and it increased (P<0.001) with increasing level of urea fertilizer. The interaction between grass species and urea fertilizer level has not shown significant difference (P>0.05). It indicates as the level of urea fertilizer increases the CP content increases. This might be due to the fact that continued irrigation and fertilization levels, allowed continuous sprouting of the vegetation, which was a bit fresh even during harvest of forage biomass. The present result agrees with that reported by Kizima et al. [38] who reported that the Crude protein content of Cenchrus ciliaris significantly increases with the addition of urea fertilizer. According to Van Soest et al. [26] CP level of 7.5% is required for rumen function. On the contrary, Minson [39] reported that the critical level of CP content for tropical herbaceous species should be greater than 10.6%. As well, Norton [40] stated that the minimum of 15% CP is needed for lactation and growth. The mean values of CP% observed in the present study for all level of nitrogen fertilizer and without fertilizer were above the threshold level required for rumen function and as well as the present result observed for crude protein % of the grass species was well beyond, the minimum 15% CP needed for lactation and growth of cattle stated by Norton [40]. Based on the CP content of this study, *Panicum maximum* and *Cenchrus ciliaris* could be categorized under medium to high quality forage groups and it could be potentially useful as supplement/substitute to crop residues and natural pasture in the mixed/crop/livestock farming system of Ethiopia.

Phosphorus percent (P %): The P content observed between grass species had shown no significant difference (P>0.05). But the effect of urea fertilizer on P content between grass species had revealed significant difference (P<0.001). The mean P content in the treatments applied different urea fertilizer level of 50 and 100 kg ha^{-1} was shown with a range of 0.52 and 0.66, respectively (Table 2). The interaction effect between grass species and level of urea fertilizer application did not show significant difference (P>0.05). The present result agrees with the finding of Galloway et al. [41] who stated that the phosphorus level increased with the increase of the fertilizer application. Similarly, the present result are also supported by the findings of Aderinola [42] who stated that Panicum maximum P content is increased with increase of nitrogen application significantly. The phosphorus requirement of grazing ruminants as reviewed by McDowell [43] is 0.17%. Similarly Kearl and ARC [44,45] who also reported the phosphorus requirements of ruminants to be between 0.15 to 0.46% and 0.11-0.34%, respectively. Thus the phosphorus percent found in the present study was well above the minimum and maximum requirements of the ruminants. Consequently, feeding these two grass species may not need supplementation of phosphorus and they can be adequately enough for lactating and ruminant animals.

Calcium (Ca %): The Ca content observed between grass species had shown no significant (P>0.05) difference (Table 2). The interaction effect between grass species and urea fertilization level did not significant differ (P>0.05). But the effect of urea fertilizer on Ca content between grass species had revealed significant difference (P<0.01). The mean Ca content in the treatments applied different urea fertilizer level of 50 and 100 kg ha^{-1}, was revealed with a range of 0.41 and 0.53 respectively (Table 2). The present result agrees with that of Garcia [46] who stated that the Ca contents were high in irrigated and fertilized grasses (*Cenchrus* and *Panicum maximum*) than the same grass species without irrigation and fertilization. According to McDowell [43] dietary calcium requirement of cattle is about 0.43%. Thus, the Ca percent of the grass species in the present study was above the calcium recommended for growth.

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