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Effect of Nitrogen Fertilizer Application on in Sacco Rumen Degradability and Invitro Dry Matter Digestibility of Cenchrus Ciliaris and Panicum Maximum Grown Under Irrigation

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I. Introduction

Ethiopia is one of the east African countries that constitute the majority of the pastoralists. There are an estimated 23 million pastorals in the country that cover about 37 % of the national population. In terms of proportion, about 17 % are mobile pastoralists and 20 % are agro-pastoralists Amha (2002). The pastoralists inhabit the semi-arid and arid agro-ecologies that are located around the periphery of the country Kidane (1993). These areas are classified as marginal arable and non- arable land which consist of about 67 % of the national land area. Most of these areas are below 1500 m.a.s.l. with the southwest and southeastern areas having an altitude of around 1000 meters and southeastern and southwestern rangelands rising up to 1700 meters and above Kidane (1993) and EARO (2000). In arid and semi-arid rangelands of Ethiopia, the primary livelihoods of the pastoralists are the management of livestock such as cattle, goats, sheep, and camels. Thus, as stated by Alemayehu (2004) livestock is vital to the well being of lowland households in terms of income, food security, employment, and, social prestige. The livestock production in these areas thus contributes about 50 % of the agricultural GDP, and 90 % of the annual live animal export earnings. According to EARO (2000), the pastoral livestock production also consists of about 45-55 % of the cattle, 75 % of the small ruminants, 20 % of equines and 100 % of camels out of the national livestock population.

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 Mnaye et al. (2009). The main feed resources for livestock in Ethiopia are natural pasture and crop residues, which are low in quantity and quality for sustainable animal production Tessema et al. (2002a), Tessema and Baars (2004). Alemayehu (2004) 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 Odongo et al. (2002), Shem et al. (2003).

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 Tessema and Halima (1998), Tessema et al. (2002b), Kahindi et al. (2007). 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

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plant including Crude protein (CP) content and digestibility, which can improve livestock production Peyraud and Astigarraga (1998). Nevertheless, information regarding the effect of fertilizer on Invitro dry matter digestibilty and Insacco Dry matter degradability of improved forage grasses in the study area is lacking.

II. Materials and Methods

a) 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 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.

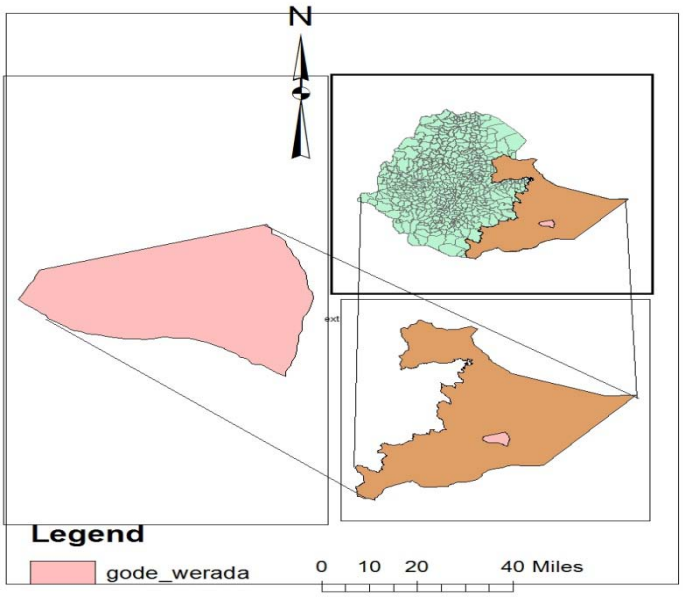

Figure 1 : Map of the study area, Gode Zone, Eastern Ethiopia.

The experimental site is located at an elevation of 300 meter above sea level (m.a.s.l.) with latitude of 5 ^{0}N and longitude of 43 ^{0}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 ^{0}C and 22.9 ^{0}C, respectively. The mean annual rainfall of the area is 150 to 344.06 mm NMA (2013).

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 Ayele (2005).

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 Ayele (2005).

Gode Woreda has an estimated livestock population of 165,277 cattle; 517,668 sheep; 985,869 goats and 115,498 camels CSA (2009). The district has an estimated total human population of 179,444 of which 99,466 are males and 79,978 females CSA (2007).

b) Experimental Layout, Design and Treatments

The study was conducted using 2 x 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 table1.

c) Plot preparation and Management

The land was prepared by a tractor and levelled 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 5cm above the ground excluding the border rows.

d) 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 and Sommers (1982). Total nitrogen in the soil was analysed by using Kjeldhal procedure Barmner and Mulvaney (1982) and Olsen's procedure was used to determine the available P Olsen et al. (1954). 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 Mclean (1982). Soil texture was determined by using the hydrometer method Black et al. (1965). The soil chemical analysis was under taken at Haramaya university soil laboratory.

e) 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 Holeta Nutrition Laboratory and further dried in an oven at 105^0C for 24 hours. Then the samples were separately ground in a Willey mill to pass through 1 mm sieve for IVDMD. The Other set of samples were ground to pass through a 2 mm sieve and used for incubation in rumen fistulated cattle to determine *In sacco* degradability parameters of the feed samples. The samples were then put in plastic bags individually and sealed for further analysis.

f) In vitro dry matter digestibility Procedures

In vitro dry matter digestibility (IVDMD) was determined by the two-stage rumen inoculums pepsin method of Tilley and Terry (1963). Dried samples were ground to pass through a 1 mm screen. A duplicate sample of about 0.5 g each was incubated with 30 ml of rumen liquor in 100 ml test tube in water bath at 39 ^{O}C for a period of 48 hour for microbial digestion. This was followed by another 48 hour for enzyme digestion with acid pepsin solution. Blank samples containing buffered rumen fluid only also was incubated in duplicates for adjustment. Drying of samples residues was done at 105^OC for 24 hours. the *In vitro* dry matter digestibility *(*IVDMD) was analyzed at Holeta Agricultural Research Center.

IVDM was calculated as Dry sample weight-(residue- blank) / Dry sample weight x 100.

The sample was then ashed to estimate *In vitro* OM digestibility. The ME content was estimated using the equation: ME (MJ kg DM) = 0.15*IVOMD.

g) In Sacco rumen Degradability Procedure

In sacco rumen degradability of DM was determined by incubating about 3g of duplicate samples contained in nylon bags (41μm pore size and 6.5 x 14 cm dimension) in three rumen fistulated Boran x Holstein Friesian steers for 0, 6, 12, 24, 48, 72, 96 hours. Upon the removal of nylon bags at the end of each incubation hours, all bags including zero hour were washed manually under a running tap water until the water is clean, gently squeezed to remove excess water, and dried at 60 ^{o}C for 48 hours in a forced draft oven. The dried bags were then taken out of the oven and allowed to cool in desiccators and weighed immediately. DM and OM contents were determined in the original samples as well as in the residues according to standard procedure AOAC, (1990).

The disappearance of DM was expressed as percentages and determined for each bag using the following formula:

Dry matter disappearance (DMD) = ((BW+S) – (BW+RW)) / (S x DM) x 100, where;

BW = Bag weight

RW = Residue weight

S = Sample weight

DM = Dry matter content of the original sample

The DMD data were fitted to the equation described by Orskov and McDonald (1979) using the Naway Excel programme Chen, (1995) to get the potential disappearance of DM.

$$Y= a+b\ (1-e^{-ct}),\ \text{where}$$

Y = the potential disappearance of DM at time t; a = rapidly degradable fraction

B = the potentially, but slowly degradable fraction; c = the rate of degradation of b

E = the natural logarithm; t = time

Effective degradability (ED) was calculated following the method of Orskov and McDonald (1979) assuming a passage rate of 0.03/h

The potential degradability, PD = a+b, where as

$$ED = a + bc / k+c$$

k = passage rate

The in sacco dry matter degradability was analyzed at Holeta Agricultural Research Center.

h) Statistical Analysis

Data on *in vitro* digestibility and in *sacco degradability* parameters were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of the statistical analysis system SAS (1999). Means was separated using least significance difference (LSD).

The statistical model used was:-

$$Y_{ijk} = \mu + A_i + B_i + Nj + AB_kNj + e_{ijk},$$

Where;

Yijk = individual observation

μ = overall mean

A_i = effect of forage species

B_k = k^{th} block effect

Nj = N-fertilizer rate

AB_kNj = 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:

$$Y_{ijk} = \mu + A_i + Nj + AB_kNj + e_{ijk},$$

Where;

Yijk = individual observation

μ = overall mean

A_i = effect of forage species

Nj = N fertilizer rate

AB_kNj = interaction effect of species and fertilizer rate

eijk = random error

III. Results and Discusion

a) In vitro dry matter digestibility (IVDMD) and In vitro organic matter digestibility (IVOMD)

The IVDMD and IVOMD are significantly ($P < 0.05$) different among the grass species (Table 2). This might be explained by the variation between morphology of the grass species such as leaf to stem ratios and variation in growth patterns. The effect of urea fertilizer on IVDMD and IVOMD of the grass species had also revealed highly significant ($P < 0.01$) difference and it increased with increasing level of fertilization. This may be because urea fertilizer application improves and stimulates new growth of tillers, shoots, leaves and accelerates the rate of stem development and accumulation of dead materials, which are low in cell wall and lignin contents, leading to higher digestibility. However, the interaction effect between grass species and level of urea fertilizer application did not show significant difference among treatments ($P > 0.05$). This result is in agreement with that of Tegegn (2001) who reported that the application of different levels of urea fertilizer had significant effects on IVDMD of Panicum at all stages of harvest. The present result is also supported by the findings of Naroon Waramit et al. (2006) who reported that Nitrogen fertilization increased the IVDMD value across four grass species. Owen and Jayasuriya (1989) Noted that the critical threshold level of IVDMD for feeds to be 50% in order to be considered as having acceptable digestibility. Similarly, Mugerwa et al. (1973) stated that digestibility higher than 65% indicates good nutritive value and values below this level limit intake. Hence, the value of IVDMD observed in grass species used in the present study could be considered to be acceptable.

b) In Sacco dry matter degradability and its rumen degradability characteristics

Among the factors considered in the study, differences between the grasses species had revealed significant difference ($P < 0.05$) at 72 hrs incubation time; while the other incubation times had no significant difference on rumen degradability ($P > 0.05$) ((Table 3). Both fertilizer application levels and its interaction and between grass species did not show significant effect on DM degradability and degradability characteristics between grasses at all incubation times ($P > 0.05$), except that readily soluble fraction as influenced by fertilizer applications ($P < 0.05$).

IV. Acknowledgment

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Tables

Table 1 : Treatment arrangement layout

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

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

Table 2 : Means of *In vitro* dry matter digestibility (IVDMD) and *In vitro* organic matter digestibility (IVOMD) of grass species as influenced by urea fertilization and their interaction effect

Factors and levels	Parameters	
	IVDMD	IVOMD
Grass species		
Panicum maximum	67.83 [b]	63.75[b]
Cenchrus celiaris	70.65 [a]	66.17[a]
P-value	0.0372	0.0189
±SE	2.12	1.83
Urea levels		
U0 kg ha^{-1}	62.78[c]	58.34[c]
U50 kg ha^{-1}	68.30[b]	66.41[b]
U100 kg ha^{-1}	76.64 [a]	70.14 [a]
P- value	. 0001	. 0001
±SE	1.06	0.90

[a-c] Means with same latter are not significant different; SE= standard error of mean; (P < 0.01) = highly significant; (P > 0.01) = non significant; (P < 0.05) = significant difference; (P > 0.05) = non significant; IVDMD = in vitro dry matter digestibility; OMD = organic matter digestibility; U0kg ha^{-1} = Urea zero kg ha-1;U50kg ha^{-1}= Urea 50kgha-1; U100kg ha^{-1} =Urea100kg ha-1.

Table 3 : Means of *in sacco* DM degradability (%) and its rumen degradability characteristics of the *Panicum maximum* and *Cenchrus ciliaris* grass species as influenced by urea fertilization

	Parameters											
	Incubation period (hours)							Degradability characteristics				
Factors	0	6	12	24	48	72	96	A	B	A+B (PD)	C	L	ED
Grass species													
Panicum	20.19	23.50	36.04	38.72	50.67	56.59[a]	60.14	20.19	44.45	64.64	0.0296a	-0.42	40.57
Cenchrus	20.33	20.40	35.37	37.83	48.78	53.99[b]	59.05	20.33	41.49	61.82	0.0330a	2.27	38.84
P- Value	0.7483	0.1176	0.5152	0.6743	0.2076	0.0277	0.1874	0.7483	0.3154	0.3466	0.6796	0.3055	0.0614
±SE	0.33	1.16	0.67	1.25	1.29	0.71	0.59	0.33	1.73	1.77	0.005	1.59	0.57
Urea(kg)													
U0 kg ha^{-1}	19.37[b]	21.91	36.34	40.27	49.00	56.27	60.20	19.37[b]	43.38	62.76	0.0345	0.717	40.10
U50kg ha^{-1}	20.41[ab]	20.76	34.61	36.71	49.55	55.02	58.36	20.41[ab]	41.33	61.75	0.0320	2.767	38.70
U100 kg ha^{-}	21.01[a]	23.17	36.17	37.85	50.62	54.59	60.23a	21.00[a]	44.19	65.19	0.0274	0.710	40.31
P- Value	0.0297	0.5718	0.3323	0.3832	0.6412	0.4013	0.1254	0.0297	0.6995	0.6145	0.7736	0.5405	0.2626
±SE	0.29	1.54	0.86	1.58	1.04	1.01	0.66	0.29	2.23	2.24	0.006	1.92	0.73

[a-b] Mean with different superscripts are significant different; A= readily soluble fraction; B= insoluble but fermentable fraction; C= rate of degradation of B per hour; L= lag phase; ED = effective degradability; PD= potential degradability; SE= standard error of mean; (P < 0.05) = significant difference; (P > 0.05) = non significant; U 0kg ha^{-1} ; U50 kg ha^{-} ; U100 kg ha^{-} .