Effects of fertilizer application and season on the yield and quality of natural pasture at Magadu Dairy Farm, Sokoine University of Agriculture

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Abstract

More than 90% of Tanzania national ruminant livestock herd thrive on natural pastures. Improvement of natural forage productivity as well as its quality, would have a significant impact on the production of this national ruminant livestock herd. Fertilizer application as a management tool to improve tropical natural pastures has rarely been reported. A study was therefore conducted to test fertilizer as a management tool to improve natural pastures on an existing one hectare of mixed natural pastures, mainly of natural grasses at Magadu Dairy Farm of Sokoine University of Agriculture. The main aim of this study was to find out if fertilizer application can be to improve the yield and quality of the natural pastures. The one-hectare plot was divided into two sub- plots. The first sub-plot was used in the short rains, while the second sub-plot was used in the long rains as the study area falls under bimodal rainfall regime. The pasture in each sub-plot was mowed down at the beginning of each rain season and thereafter the sub-plot was again divided into two equal sub-sub-plots. One sub-sub-plot was applied with a mixture of nitrogenous (174 kg N/ha) and phosphorus (92 kg P/ha) fertilizers at once and the second was a control. Pastures at both rainfall regimes were harvested at 50 % flowering and thus, pasture regrowth was harvested at 90 days old in the short rains those in the short rains was harvested at 65 days old. Dry mater yield estimation was conducted by throwing a quadrat of 0.25 m^2 randomly ten times at an equal distance along the two diagonals of each sub-sub plot.

Pasture samples were collected and sent to the laboratory for oven drying, chemical composition analysis and determination of in vitro dry matter and organic matter digestibility (IVDMD and IVOMD). Fertilizers application increased significantly (P≤ 0.01) the natural pastures dry matter yield. regardless of the rain seasons. Fertilizers improved crude protein of natural pastures significantly (P≤0.001). Short rain season natural pastures had significantly (P≤ 0.001) higher NDF contents than those of long rain season regardless of fertilizer application. The energy contents ME (MJ/kg DM) for both fertilized and unfertilized long rain forages were significantly (P≤ 0.001) higher than all pastures of the short rain. Long rain fertilized pastures had significantly (P≤ 0.001) higher IVOMD than unfertilized forages of the same season. In the short rain fertilized forages had significantly (P≤ 0.001) higher IVOMD than unfertilized pasture. The long rain fertilized forages had significantly (P≤ 0.001) higher IVOMD than all other pastures. From this study it can be concluded that fertilizer application significantly improves both the quantity and quality of natural pastures and that fertilizers can be applied at any season as long as there is sufficient soil moisture. However, harvesting at 50% flowering compromised forage quality in short rains due to extended period to flowering stage of growth as compared to long rains.
Keywords: Short rain season, Long rain season, fertilized pasture, unfertilized pasture, Forage production, Energy content.

1.0 Introduction

In Tanzania like other tropical developing countries the major source of feed for ruminant livestock is the natural pastures. The major limitation to constant supply of forage for the ruminants, however, is uneven seasonal growth due to poor distribution of the rainfall and poor pasture management. The productivity of available grazing lands has also decreased over the years due to overgrazing resulting in land degradation, loss of fertility and proliferation of obnoxious weeds (Yayneshet, 2010). Soil fertility depletions coupled with climate change have affected the

composition of natural pasture species, leading to less palatable natural pasture in the grasslands (Bezabih et al., 2014; Tessema et al., 2010). One of the main objectives in pasture management is to supply enough forages of good quality throughout the year (Humphreys, 1991). This can be achieved through strategic application of fertilizer, weeding and over sowing with improved pasture species. Fertilizer can be applied in the beginning of the rain season after weeding and removing the old sward or applied after a pasture harvest in the mid-rain season. Fertilizer application strategies can improve both forage productivity and quality substantially (Brink et al. 2004). Nitrogen (N) fertilizer in pasture management practices brings the best production since it is the most important macro nutrient for growth and development of pastures. Nitrogen fertilizer provides the plant with a faster growth, increase in number, weight and size of shoots and foliar area index (Soares et al., 2015). Plants need phosphorus for growth utilization of sugar and starch, photosynthesis, nucleus formation and cell division. An adequate supply of available P in soil is associated with increased root growth, which means roots can explore more soil for nutrients and moisture. The aim of this experiment was therefore, to evaluate the effect fertilizer application as management tool in two rain seasons on natural pastures productivity and quality in the eastern humid agricultural zone of Tanzania.

2.0 Materials and methods

One hectare plot of natural pasture at Magadu dairy farm in Sokoine University of Agriculture (SUA) was used in this experiment. The plot consisted of a mixed stand of mainly natural grass *pastures species dominated by Heteropogon conturtus, Bothriocloa species, Brachiaria species, Hyperrhenia rufa*, Heteropogon conturtus, *Chloris gayana* and a few legumes; *Rynchocia species*, *Neonotonia wightii* and *Macroptilium atropurpureum*. The contribution of leguminous pasture species to the total stand was very little and was regarded as a trace. Among

the prominent woody weed that was weeded in the beginning of the experiment was *Vernonia glabra.*

The experiment was conducted both in short rains of Oct - Jan 2011 - 2012 and long rains of Feb - May 2012 after mowing out the sward and weeded the plot. The plot was divided into two equal sub-plots; one was used in the short rains and another in long rains. Each subplot in each season was weeded and divided into two sub-sub plots. One sub-sub plot in each season was applied with fertilizer and the second was a control. Fertilizers were applied at a rate of 174 kg N/ha (Urea) and 92 kg P/ha (Triple Super Phosphate). Dry matter yield was determined by throwing a 0.25 m2 quadrat ten times at an equal distance along sub- plot diagonally at 90 days and 65 days, regrowth, in the short rains and long rains, respectively. Days of harvest was determined at 50 % flowering of growth as such a phonological stage has been earmarked as the best utilization time to balance quality and optimum quantity of the produced herbage according to McDonald et al. (1995).

Forage samples weighing 500 g were taken from each quadrat to the laboratory for dry matter content determination and chemical composition analysis including CP, NDF and determination of digestibility as IVDMD and IVODMD. Metabolizable energy (ME) contents (MJ/kg DM) was calculated according to MAFF (1976) as follows: DOMD % = 0.98 DMD % - 4.8; ME (MJ/kg DM) = 0.16 DOMD %. The experiment was arranged in 2 x 2 factorial designs (two season x two treatments).

The statistical model for data analysis: $Y_i = \mu + F_i + S_i + (FS)_{ij} e_{ij}$; where Y_i = Yield/Quality, μ = overall mean.; F_i = Effects of fertilizer; Sj = effects of season; $(FS)_{ij}$ = Interactions of effects fertilizer and season; e_{ij} = random error effects. GLM was used to perform analysis of variance (ANOVA) and means contrasted with significance assumed when $P \leq 0.05$ according to SAS (1998).

3.0 Results and discussion

The weather condition during the experimental period is given in Tables 1. Mean monthly rainfall of the short rains was rather lower than for the long rain season. Contrary mean monthly maximum temperatures were higher in the short rain than in long rain season. Mean monthly solar radiation trend was similar to mean monthly rainfall. The variation of mean monthly relative humidity was rather low ranging from 71 in short rains to 82 %in long rain season.

Table 1. Mean monthly rainfall, temperature, relative humidity and solar radiation during the experiment from October 2011 to May 2012

Month	**Rain (mm)**	**Temperature (°c)**		**R.H (%)**	**Radiation (MJm^2)**
		Min	**Max**		
October	23.20	19.70	31.60	71.00	18.00
November	37.00	21.30	32.40	72.00	19.10
December	191.1	20.20	34.00	75.00	19.20
January	70.30	21.50	33.10	76.00	18.20
February	71.70	21.50	33.10	71.00	20.80
March	105.90	21.30	31.60	76.00	18.70
April	124.90	20.50	29.90	81.00	15.30
May	134.60	19.30	28.70	82.00	14.20

Source: SUA meteorological station

The soil from experimental field was clay loam in texture, with low total Nitrogen, medium in Phosphorus and rather acidic (Table 2).

Table 2. Experimental field soil chemical composition and texture before fertilizer application

S/N0	Depth sampling (cm)	Soil pH (in H_2o)	TN-Kjeld (%)	P (mg/kg) $PBry^{-1}$	K^+ $cmolkg^{-1}$	Texture
1	0-20	4.67	0.13	2.39	0.59	Clay
2	20-40	4.74	0.11	3.39	0.67	Loam

Fertilized natural pasture plot produced significantly ($P \leq 0.001$) higher amount of forage (5 186.40 kg DM/ha) than unfertilized plot (2 267.20 kg DM/ha) regardless of the season (Table 3). Despite the yield being lower than those reported by Adane (2003), who reported the DM yield of 9 470 kg/ha and 5 670 kg/ha for fertilized and unfertilized plots respectively in Fogera upland natural pastureland in Ethiopia the same trend showing improved yield of natural pastures due to fertilizer application was observed in this experiment. The reasons of such a variation in yield could be differences in altitude, weather condition, soil characteristics and differences in natural pasture species.

Table 3. LSM and SE for effects of fertilizers application on pastures dry matter yield (kg/ha) regardless of the rain season

Fertilizer application	Pasture dry matter yield
Fertilized pasture plot	5 186.20
Unfertilized pasture plot	2 267.00
SE	623.36
P-value	0.0021
SL	***

LSM-Least square means SL-Significant level SE-Standard error *** * *** = ($P \leq 0.001$)

Pastures dry matter yield regardless of season was slightly higher in the short rain season than in long rain season but were not significantly ($P \geq 0.05$) different (Table 4). In the short rains forage grass reach 50% flowering 25 days later than in the long rain

season. This has been noted elsewhere (Currier and Osvaldo, 2022), that just after the dry season grasses take longer time to flower and thus accumulate more dry matter than after the wet period when the soil was not so well dry. Since the flowering stage of growth is a recommended time of harvesting or grazing forage grasses so as to compromise between dry matter yield and quality (McDonald et al., 1995, Humphreys, 1991), it was adapted in this experiment. However, the results from this study suggests that, livestock farmers may be advised to use fertilizer application as a natural pasture grassland even in the short rains so as to improve productivity and in the long rain season they should be advised to add fertilizer so as to increase number of harvests or grazing cycles.

Table 4. LSM and SE for effects of season on pastures dry matter yield (kg/ha) regardless of fertilizers application

Rain season	Pasture dry matter yield
Short rain	4 211.60
Long rain	3 241.60
SE	623.36
P-value	0.2785
SL	Ns

LSM-Least square means SL-Significant level SE-Standard error ns-Not significant

Results for effects of fertilizer application and season on quality of pasture are given in Table 5. Generally, fertilized natural pastures had significantly ($P \leq 0.001$) higher crude protein (CP) contents than unfertilized pastures, both in the short and long rain seasons. The long rain fertilized pastures had; however, the highest CP content and the unfertilized short rain pastures had the lowest crude protein content. These results were in agreement with those reported by Manangwa (2003) who recorded CP of long rain pastures at 4.8% and that of short rain at 3.45%. On the other hand, Bharahenda (2001) reported higher CP content for the rainy season pastures

(6.4 to 9.6%) in Gairo. The variation of CP contents reported by different authors could be due to the differences in pasture species, weather condition, stage of growth and characteristics of the soil. According to McDowell (1985) and Van Soest (1994), for proper functioning of rumen microbes in ruminants the recommended minimum CP content is 7-8% that in this experiment was only recorded from fertilized pastures in the long rains (7.4%). The results from this study supports protein supplementation for growing and productive ruminant livestock grazing these natural grass forages whether in the dry or rain season so long the forages at the flowering stage onwards.

The IVDMD of fertilized pastures in the long rain season was slightly higher than that of other pastures. More less similar results have been reported elsewhere for natural pastures by Bharahenda (2001) in Gairo during the short and long rains. Long rain fertilized pastures had however significantly ($P \leq 0.001$) higher IVODMD. This could be due to its' highest CP as compared to other pastures. Similar findings were reported by Asfaw (2001) who reported IVODMD of 30.4% during the short rain season and 45.74 % during the long rain season. Similar trend of results was reported by Hughes et al. (2011) who found a significant season influence on IVODMD content in which the long rain season pastures had higher IVODMD than the short rain season. The possible reasons for the difference might be due to differences in the stage of growth during harvesting and the differences in NDF and ADF contents. According to the report by Van Soest (1994) the decline in IVODMD of pastures with age is due to the increase in plant structural carbohydrates and lignin as reflected in increased NDF%.

In this study the short rains natural pastures had higher NDF% than long rain pastures. This could be due to higher temperature and advanced stage of growth in the short as compared to long rain season. Similar results were also reported by Hughes et al. (2011) who also found a significant influence of season on NDF content in which long rain season forages had higher NDF content than the

short rain season. The unfertilized pastures regardless of season had higher NDF content than fertilized pastures. Therefore, fertilizer application can improve the quality of natural pastures when soil moisture is not limiting.

The energy contents (ME) of long rain season fertilized and unfertilized pastures were higher than those of fertilized and unfertilized short rain pastures. Higher ME content associated with long rain season pastures as compared to the short rain season pastures was attributed to higher IVODMD in long rain season. Since ME is calculated from IVODMD (MAFF, 1976), the higher the IVODMD the higher the ME. This implies that long rain season pastures had relatively high energy content since they reached harvesting stage of growth earlier than those of the short rains. These results should encourage livestock farmers either over sow the natural grass pastures with improved grasses and legume species and/or supplement their growing and productive ruminant livestock with both protein and energy supplements regardless of the rain season.

Table 5. LSM and SE for effects of fertilizer application and rain season on the quality of pastures

Parameters	%DM	%CP	%IVDMD	%IVODMD	%NDF	ME(MJ/kgDM)
Short rain fertilized pastures	93.08 ^{D}	5.80 ^{B}	41.66^{A}	39.90 ^{BC}	71.40^{B}	6.38 ^{B}
Short rain unfertilized pastures	95.44 A	3.97 D	38.81A	38.32 C	73.23 A	6.13 C
Long rain fertilized pastures	95.06^{B}	7.40 ^{A}	46.16^{A}	47.42 ^{A}	64.17^{D}	7.59^{A}
Long rain unfertilized pastures	93.78 ^{C}	4.40 ^{C}	40.89^{A}	40.93 ^{B}	67.38^{C}	6.55 ^{B}
SE	0.00	0.01	0.60	0.42	0.0480	0.07
P-value **(**P≤ 0.01**)**	<.0001	<.0001	0.4805	0.0004	<.0001	0.0004
SL	*** * ***	*** * ***	**ns**	*** * ***	*** * ***	*** * ***

LSM with the same letter are not significantly different. SL= Significant level. SE-Standard error, *** * *** = P≤ 0.001, ns-Not significant

4.0 Conclusions

The results from this study have shown that fertilizer application can be used as a management tool to improve the productivity and just slightly the quality of natural pastures in the bimodal lowlands of Tanzania. The ruminant livestock farmers in the area are therefore encouraged to improve their natural pastures through fertilizer application and also over sow the natural pastures with improved pasture species so as to improve the feeding value of these pastures. For improved performance of growing and reproductive ruminant animals subsisting on natural mainly grass forages; protein and energy supplementation is also encouraged.

Fertilizer application as a pasture management tool can significantly improve productivity and quality of natural pastures. In this experiment, fertilizers application increased significantly ($P \leq 0.01$) natural pastures yield by 56.3%. Fertilizer application significantly ($P \leq 0.01$) improved the CP contents of the natural pastures regardless of the season. However, the CP contents of fertilized pastures in long rain season were higher as compared to those of short rain season pastures. Energy content (ME) of pastures was higher in long rain season than in the short rain season regardless of fertilizer application. Both unfertilized and fertilized pastures in the short rain season had higher NDF contents than unfertilized and fertilized pastures in long rain season. Fertilizers can, therefore, be applied at any season as long as there is sufficient soil moisture.

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