Chapter

Top Dressing of Fertilizers: A Way Forward for Boosting Productivity and Economic Viability of Grasslands

Tessema Tesfaye Atumo, Milkias Fanta Heliso, Derebe Kassa Hibebo, Bereket Zeleke Tunkala and Yoseph Mekasha

Abstract

Grasslands in the Ethiopian highlands have been degrading with grazing loads. Fertilizers like nitrogen, phosphorus and sulfur improves the soil fertility and species composition of the grazing lands. This study justifies, evaluation of top dressing nitrogen and phosphorus fertilizers on biomass yield of grass lands for market-oriented livestock production studied at Chosha kebele, Southern Ethiopia in 2017. Three fertilizer levels ((T1), 150 kg ha^{-1} urea (T2) and combination of 110 kg ha^{-1} urea and 100 kg ha^{-1} NPS (T3)) were laid out in randomized complete block design with 6 replications in summer and winter cropping seasons. Dry matter yield was significantly ($P<0.001$) different among treatments and higher results were obtained for combination of urea and NPS, followed by urea and the control one. Higher grasses species composition between application of combination of urea and NPS than urea alone. Net revenue is higher in nitrogen alone application than nitrogen and phosphorus. Therefore, better marginal rate of return (MRR=828%) recorded in Urea application for grazing land improvement in Gamo highland areas. It is recommendable to apply 150 kg/ha urea fertilizer to bring optimum yield of grazing land in Southern Ethiopian Highlands.

Keywords: Nitrogen, Phosphorus, grazing land, dry matter, species composition

1. Introduction

Sub-Saharan livestock production is increasingly constrained by feed shortage, both in quantity and quality [1]. Livestock production can be improved through good management of natural grasslands and introduction of improved fodder species [2] with the supply of fertilizer and water to maintain high productivity that the high cost and low availability of good quality animal feed is a critical constraint to increasing productivity of livestock in dairy farms and feedlots, improved family and specialized poultry, and smallholder mixed crop-livestock and extensive livestock production systems [1].

Nutrient dynamics in tropical soils sustaining forage grasses are still poorly understood [3]. Lack of nutrients, inadequate management of pastures, and inappropriate cultural practices are responsible for pasture degradation. Applying fertilizers in large quantities increase the productivity of grasslands [4]. Low nitrogen availability has been identified as a major cause of degradation of tropical pastures [5] and the constant removal of forage without proper supply of nutrients extracted by plants emphasizes the problems of grazing land degradation [6]. The application of nitrogen and phosphorus has proved to be effective in maximizing the production of dry matter [7] and nutritional status [8] of grasses.

Grazing lands in Ethiopia play great role in livestock production. However, grazing land degradation in Ethiopia is a serious problem [9]. Since a few decades ago, the country is not only known for the severity of grazing land degradation and related problems, but also for concerted efforts to confront the problems using land rehabilitation measures such as enclosures [10]. Enclosures have been widely established particularly in the midland and highland agro-ecologies. They are among the green spots with considerable species diversity and higher biomass production compared the unclosed areas [11] .

Nitrogen and phosphorus fertilizers have been used for long period of time in agricultural system [12]. Nitrogen fertilizer application improves above ground biomass of any plant crops [13]. Phosphorus improves the growth of legumes and plant species composition generally and a Poaceae pasture in specific [14]. Nitrogen and phosuphorus fertilizers combined application could improve the aboveground plant biomass [15] and have positive effects on composition diversity of plant species [16]. Primary mineral fertilizers such as nitrogen, phosphorus, and sulfur etc. are favoring the growth of plants through improving soil fertility [17]. Though enclosures produced better biomass than the freely grazed areas, production is still limited. This probably is because of limited plants growth related to nutrient deficiency. Addition of nitrogen and sulfur fertilizers increased shoot dry matter production in the second and third growth of forage plants [3]. Nitrogen availability maximizes plant growth and productivity [6]. Nitrogen deficiency in the grazing areas of Ethiopian highlands due to land degradation was, which probably could be the leading constraint for limited plant growth and reduced biomass yield, affecting crop production [18]. Hence, application of nitrogen and phosphorus with sulfur seems imperative to enhance plant growth and increase herbage biomass production. The first and foremost beneficiaries of the research findings are small holder farmers, policy makers, researchers and NGOs. The hypothesis of the study was fertilizing grazing lands improve the herbage biomass and economic feasibility and applicability of grazing lands under small holder farmers condition. Therefore, this study was planned to evaluate top dressing of grazing lands in terms of biological gain and assess economic gain and the applicability of pasture fertilization under smallholder private or communal grazing lands.

2. Materials and methods

2.1 Study area

The study was conducted at the highland of Chosha kebele, Bonke district, Gamo Gofa zone, Southern Ethiopia (**Figure 1**). The altitude of the area is 2350 meter above sea level with annual average rainfall of 2017.06 mm and mean daily temperature ranging between 10.0–23.3°C (**Figure 2**). The rainfall is bi-modal with the winter rain (short rains) occurring in March to May and the summer (main season) rains lasting from June to October. Major crops such as potato, wheat, barley,

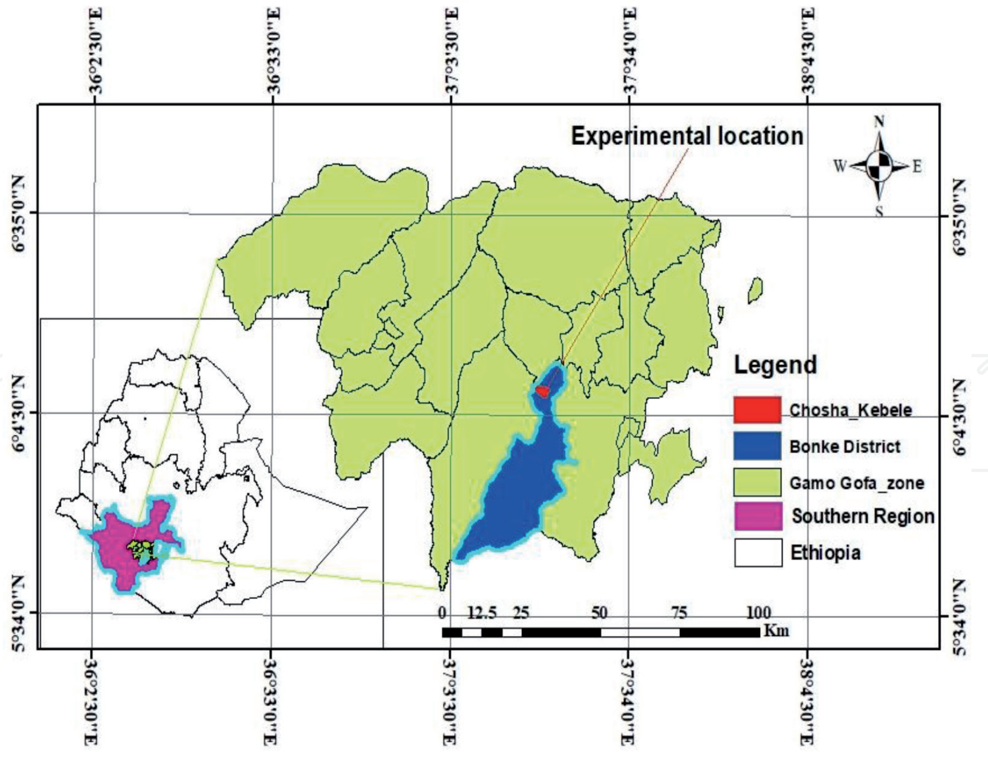

Figure 1.
Location map of experimental site.

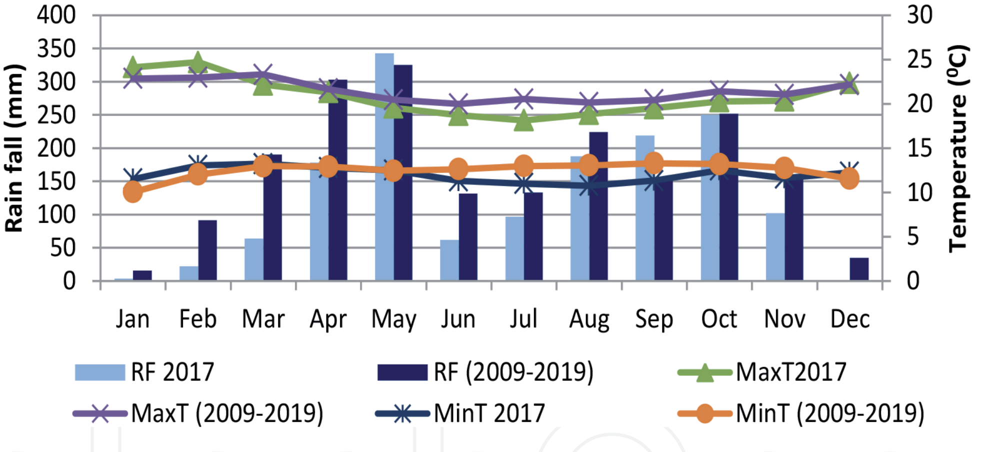

Figure 2.
Rainfall, maximum and minimum temperature of experimental season and ten years average in the location.

bean, onion, paper, cabbage, fruits are grown widely in the study area according to site observation and district report. Natural pasture is the major feed source in the area and farmers using cut and carry system of livestock feeding mainly because of shortage of farming and grazing land. The soil of study area is characterized as strongly acidic with pH < 5.0, low organic carbon contents which ranged from 0.25% to 1.05%, moderate calcium carbonate with 0.88%, high organic matter with 13.56%, low catain exchange capacity with 16.69 cmolc/kg and sandy-loam [19].

2.2 Treatments and experimental design

The fertilizer treatments for the study were T1 = control, T2 = urea and T3 = combined urea and NPS in both summer and winter major cropping seasons of Ethiopia. The amount of urea and NPS that were used in the experiment was 150 kg; and 110 and 100 kg per ha for T2 and T3, respectively. Factorial combination of two seasons and 3 fertilizer treatments laid out in RCBD with four replications. The plot size consisted of an area of 400 m^2 (20m x 20 m) and the space between plots was 3 m. Nitrogen fertilizer applied in the form of urea as a split dressing i.e., one-third at about 7 days of the first rain and two-thirds after about a month of the first rain and P fertilizer in the form of NPS applied at about 7 days of the first rain together with the nitrogen applied at 7 days after the first rain. The trial is replicated in winter and summer seasons with fertilizer application in March for winter and in June for summer. The fertilizers applied manually in the field determined for experiment.

2.3 Data collection and sampling procedures

2.3.1 Forage yield

Herbage biomass was measured as the herbaceous vegetation harvested at ground level using manual sickle from five 0.5 m quadrates (four at the corner and one at the center of the 10 m x10m plots) using sickle in each of the 100m^2 plots. Fresh biomass weighed immediately using weighing scale of 0.1 g. Then, a sub-sample of 15–20% of the total weight was separated and put into a paper bag for dry matter determination and oven dried at 105°C for 24 hours.

2.3.2 Species composition

Species composition was determined by using quadrate count method and identified in the field with farmers for local name and taxonomic classification. Species that were difficult to identify in the field recorded and collected to herbarium for identification.

2.3.3 Economic considerations

Partial budget analysis was performed to evaluate the economic advantage of fertilization by using the procedure of Upton (1979). The partial budget analysis involves calculation of the variable costs and benefits. The benefits are calculated based on market value of green or cured grass for all expenses recorded at the beginning of the study.

The amount of herbage obtained used to calculate the income earned (TR). The calculation of the variable costs and the expenditures incurred on various activities were taken into consideration.

The partial budget method measured profit or losses, which is the net benefits or differences between gains and losses for the proposed change and includes calculating net return (NR), i.e., the amount of money left when total variable costs (TVC) are subtracted from the total returns (TR):

$$NR = TR - TVC \tag{1}$$

Total variable costs included the costs of all inputs that change due to the change in production technology. The change in net return (ΔNR) calculated by the difference between the change in total return (Δ TR) and the change in total variable cost (Δ TVC), and this is used as a reference standard for decision on the adoption of a new technology.

$$\Delta NR = \Delta TR - \Delta TVC \tag{2}$$

The marginal rate of return (MRR) measured the increase in net income (Δ NR) associated with each additional unit of expenditure (Δ TVC). This is expressed by percentage

$$MRR\% = \frac{\Delta NR}{\Delta TVC} * 100 \quad (3)$$

2.3.4 Statistical analyses

The experimental data was subjected to analysis of variance using the General Linear Model Procedure of Genstat statsitcal software [20]. Tukey HSD test applied for mean comparisons and statistically significant differences were accepted at $P < 0.05$.

3. Results and discussions

3.1 Herbage biomass

For the present experiment dry matter yield significantly ($P < 0.001$) varied among treatments and higher results were obtained from combination of urea and NPS followed by urea than the control one (**Figure 3**). This may be due to the application of nitrogen, phosphorus and sulfur in the form of urea and blended NPS fastened the growth of grasses, legumes and other species. Nitrogen Fertilizer application increased dry matter yield. Dry matter yield in summer was by far greater than in winter (**Figure 3**) that may be due to moisture stress in winter season which could demonstrate that the growth of pastures improved in rainy season than dry. Dry matter accumulation is physiological index related to photosynthesis of leaves in which legumes respond less to N than grasses; grass dominant pastures well responded to N [21]. The increase in the proportion of grass reflects the role of nitrogen fertilizer in influencing the grass-legume botanical composition in favor of

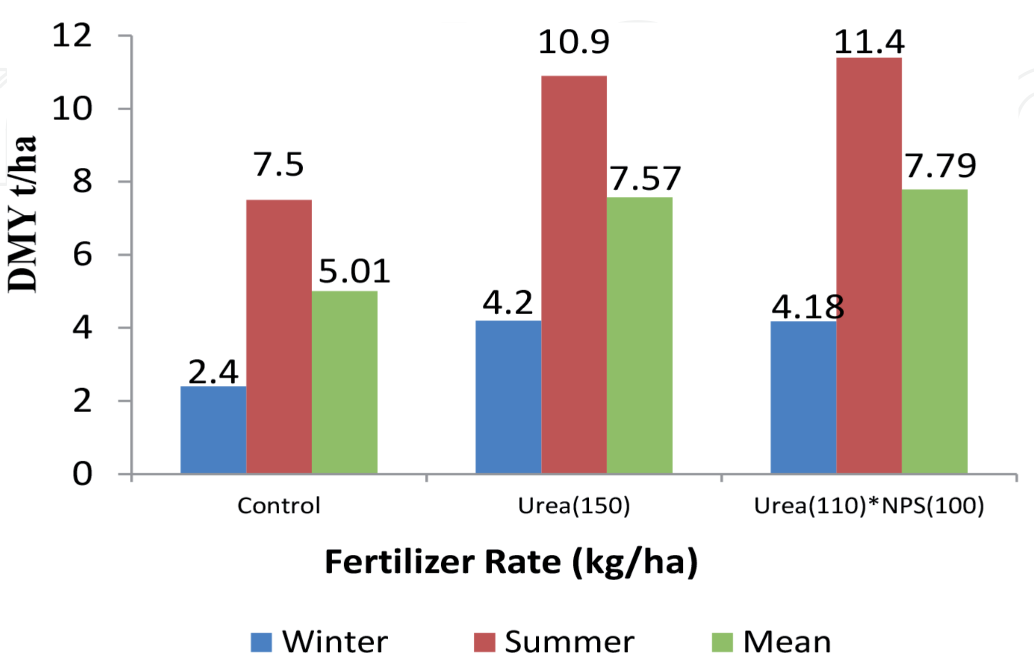

Figure 3.
Dry matter yield (t/ha) as affected by fertilizer application.

grass growth. NPS fertilizer application improved the dry matter yield production of Napier grass in Ethiopia [7] report is in line with the present study. Nitrogen and Phosphorus fertilizers are vital to plant growth and found in every living plant cell and total dry matter yield increment due to nitrogen, phosphorus and potassium fertilizers application reported previously for desho grass production [22]. Nitrogen and phosphorus fertilizers application also improved the growth and crud yield of cauliflower [23]. And also another similar report stated that proper nitrogen and sulfur fertilizer application promotes grass production by improving uptake of nutrients and the dynamics of the organic and mineral fractions in tropical soil [3].

3.2 Species composition

Species composition of the study was presented in **Table 1**. Higher grasses species composition was obtained for combined application of urea and NPS than urea alone. Species composition was being higher for fertilizer application in both levels than control. The difference in species composition of the natural pastureland recorded in this trial is a desirable attribute in terms of pasture quality, quantity and persistence. Hence, the presence of various fodder species in this study would indicate the degree of persistence of some species against recurrent drought, frost and high pasture pressure consistent with the harshness of the prevailing climatic and biotic factors. Application of nitrogen and phosphorus activated growth and development of grasses, legumes and other pastures. Thus, the composition pastures in this study significantly higher in fertilized plots than in control (**Figure 4**). A total of 15 grass species recorded in 9 families with Polygonaceae and Asteraceae taking the highest record and others like Apiaceae the least. Some species like *Bidens macroptera* (Sch.Bip.ex Chiov.) was being very importantly chosen by women of the area for lactating cows. This result invites further immediate investigation of the particular grass species correlation with the milk production and quality. Natural

Local name	Scientific/botanical name	Family	Types
	Agrocharis melanantha Hochst.	Apiaceae	Legume
	Dicrocephala integrifolia (L.f) Kuntze	Asteraceae	
Gocha	Bidens macroptera (Sch.Bip.ex Chiov.)	Asteraceae	Legume(for milk production)
	Gnaphalium rubriflorum Hilliard	Asteraceae	Legume
	Commelina sp.	Commelinaceae	
Gichola	Cyprus triceps Endj,	Cyperaceae	
Donaka	plectranthus punctatus (L.f) L'Her.	Lamiaceae	Legume
Basmamo	Salvia nilotica Jacq.	Lamiaceae	Legume
Dhadhaho	Plantago palmata Hook.f.	Plantaginaceae	Legume
Suda	*D. abyssinica* (Hochst, ex A. Rich.) Stapf	Poaceae	Grass
Hopho	Rumex abyssinicus Jacq.	Polygonaceae	
Shodo	Rumex nepalensis Spreng.	Polygonaceae	
	Persicaria setosula (A. Rich.) K.I. Wilson,	Polygonaceae	Legume
	Alchemilla sp.	Rosaceae	
Tri-folium			Legume

Table 1.
Species' composition identified in the study area, 2017.

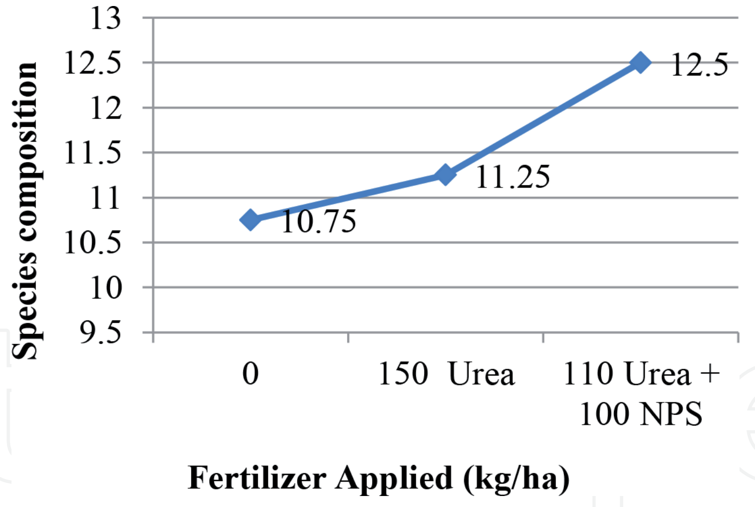

Figure 4.
Response of grass lands on species composition to fertilizer application.

grasslands rich in species composition [24] and fertilizing improves the growth and development of dominated species that higher species composition across all the treatments including the urea applied plots. It was also reported that use of fertilizers increasing plant biomass production and biodiversity in semi-arid grasslands [14]. The average legume proportion was higher in the unfertilized plots than in the fertilized plots and this may indicate nitrogen fertilizer had an indirect suppressing effect on the proportion of legumes by inducing luxuriant growth and hence dominance of the grasses.

3.3 Cost benefit analysis

The partial budget analysis presented in **Table 2** conducted as cost of variable entities was calculated based on cost of fertilizers (Urea and NPS). However, the cost of management like fencing, harvesting, transporting and different activities

Fertilizer kg ha-1			
Descriptions	**0**	**Urea 150**	**110Urea + 100NPS**
Fixed Costs			
Fencing	1.85	1.85	1.85
Harvesting	2.08	2.08	2.08
Total Fixed costs(TFC)	3.93	3.93	3.93
Variable Costs			
NPS(0.29 USD/kg)	0		29.20
Urea(0.24 USD/kg)	0	35.84	26.28
Total Variable Costs(TVC)	0	35.84	55.48
Dry Matter Yield(t/ha)	**5.01**	7.57	7.79
Total Revenue(TR = 29.97 USD/t)	150.15	226.88	233.47
Net Revenue(NR = TR-TVC)	150.15	191.04	177.9
MRR%(ΔNR/ΔTVC*100)		533.09%	320.82%

MRR- Marginal Rate of Return.

Table 2.
Partial budget analysis.

disposed for pasture was not included in calculation of variable costs. The price of one ton in the local area was 29.5 USD. Dry matter yield was increasing from control to different fertilizer application and each ton increment in yield influencing the income driving from the production. Net revenue is higher in nitrogen alone application than nitrogen and phosphorus. Therefore, this report verifies better marginal rate of return (MRR = 828%) recorded in Urea application for pastureland improvement in Gamo Gofa highland areas.

4. Conclusion

Dry matter production was higher for combination of urea and NPS followed by urea than control one. Higher grasses species composition between application of combination of urea and NPS than urea alone. Higher net revenue was obtained in nitrogen alone than combined application of nitrogen and phosphorus fertilizers. Therefore, better marginal rate of return (MRR = 828%) recorded in Urea application for pastureland improvement in Gamo Gofa highland areas. Applying nitrogen to pasture land improves dry matter yield in 34% comparing to not applying. A farmer can have net revenue of more than 191.04 USD per hectare on average per season and it is economical to apply nitrogen for pasture land improvement. It is recommended to apply 150 kg/ha urea fertilizer to fetch optimum economical yield of pasture land in southern Ethiopia highlands.

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