Effect of Grazing Land Improvement Practices on Herbaceous production, Grazing Capacity and their Economics: Ejere district, Ethiopia

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Abstract— *The effects of different grazing land improvement practices on herbaceous production, grazing capacities and their economics were studied in Ejere district, west Shoa zone, Ethiopia. Four different treatments, i.e., application of Urea and Diammonium phosphate (DAP), cattle manure, wooden ash, and a control/no application) were randomly applied to the study plots in three replications for each treatment. All experimental plots were fenced throughout the study period. The application of urea and DAP significantly increased grass (3620.86 kg ha^{-1}) and total biomass production (5742.93 kg ha^{-1}). Of the 6 herbaceous species recorded in the Urea and DAP plots, four of them were grasses with Setaria verticellata having the highest percentage composition (35.54%) while the control plot was dominated by Cyperus rotundus (31.5%) and Cerastium octandrum (31.5%). Less land is required to maintain a tropical livestock unit (TLU) in Urea and DAP applied plots (0.03 ha TLU^{-1}) than in plots applied with other treatments (mean = 0.09 ha TLU^{-1}). Similar to the result of the biological data, the participants of the grassland day rated the Urea and DAP applied treatment best because of the high production of grass. Considering total biomass production, application of manure was advantageous to the farmers due to increased net benefits and the marginal rate of return is above the minimum accetable rate for this sort of treatment. On the other hand, considering grass production alone, application of Urea and DAP was more profitable for farmers as far as they store and sell it in the dry seasons. In conclusion, we recommend a long-term study to examine the effects of the different treatments on productivity of grazing lands, herbaceous species composition, grazing capacities, livestock, the environment, and their economics.*

***Keywords*— Ash, grazing land improvement, manure, Urea, DAP.**

I. INTRODUCTION

Ethiopia holds the largest livestock population in Africa estimated at about 54 million heads of cattle, 25.5 million sheep, 24.06 million goats, 0.92 million camels, 4.5 million donkeys, 1.7 million horses, 0.33 million mules, 54 million chicken and 4.9 million beehives [1]. It is also among the 28 smaller countries (25 in Africa) where grazing land accounts greater than 60% of the total land area [2]. Despite these huge resources, the productivity of livestock in general is low and its contribution to the national economy is below expected. Among the major problems affecting livestock production and productivity in Ethiopia, feed shortage in terms of quantity and quality is the leading problem [1].

The major feed resources in Ethiopia are natural pasture (grasslands) and crop residues with varying proportion among the different zones of the country. Similar to the other parts of Ethiopia, the role of grazing lands as a major livestock feed resources is diminishing from time to time because of natural and human induced factors (increased conversion of grazing lands to crop land) which created heavy grazing pressure on the remaining grazing lands although the extent of degradation varies from site to site [4, 5, 6]. In addition, grazing land improvement practices are relatively less common particularly in the highlands of Ethiopia owing to the lack of awareness and appropriate training, lack of appropriate improvement methods and little attention given to grazing lands by the agricultural extension system. The pressure is likely to intensify in the coming decades creating more pressure on the remaining grazing lands justifying the need to improve the available remaining grazing lands to increase their livestock holding capacity [1]. Thus, the current study examined the effect of applying different grazing land improvement techniques on biomass production and herbaceous species composition, grazing capacities of the grazing lands and the economics of the different treatments. This paper will contribute to better understanding of grazing land rehabilitation techniques in Ethiopia and for similar ecosystem elsewhere.

II. MATERIALS AND METHODS

2.1 Description of the study area

This study was carried out in Ejere district, West Shoa zone, Ethiopia. The district was selected due to its potential for livestock production (dairy, small ruminant, poultry and apiculture) and it is one of the intervention districts for Livestock and Irrigation Value Chain for Ethiopian smallholders (LIVES) project of the International Livestock Research Institute (ILRI). The altitude ranges from 2063 to 3158 meters above sea level (m.a.s.l). The rainfall of the area is distinctly bimodal pattern, viz-a-viz. the main rainy season occurs from June to end of September and the short and small rainy season is in February and March. The mean annual rainfall ranges from 900 to 1200 mm.

The livelihood of the communities in the study district is based on mixed crop-livestock production system and the human population is about 104 709 (49 829 males and 55 057 females) [1]. The livestock population is estimated to be: 119 854 cattle, 37 423 sheep, 11 600 goats, 9436 mule, 356 donkey, 10 117 horses and 43 125 poultry. Crop residues, natural pasture, improved forage, hay, agro-industrial by-products and others contribute as livestock feed [1]. The district has upland and wetland grazing areas. In addition to grazing, the wetlands are the sources of water for livestock and irrigation for lower riparian's [6]. Particularly, the Berga wetland is one of the two known breeding sites (Weserbi-near Sululta and Berga) for the globally threatened White-winged Fluff tail Sarothrura ayresi [7]. With regard to grazing land ownership, there are two types, i.e., private and communal although the former is larger (80%) than the latter in terms of area coverage (20%) at the current moment while the opposite was true in the past. The private grazing lands (0.25 to 0.5 ha/household on average) are used for hay making and/or grazing [8].

2.2 Site selection

In site selection for the study, which was undertaken with the help of farmers, livestock experts and development agents, the representativeness of the site for grazing lands in the mid altitude (2378 m.a.s.l), and poor herbaceous production condition of the site was taken into consideration.

The treatments described in this study are mainly based on locally available resources (manure, wood ash, enclosing) except Urea and DAP which is imported and can be purchased at the service cooperative level in the villages. Fifteen plots of 4 m x 4 m were laid out to apply 4 treatments (Urea and DAP, wooden ash, cow manure, and untreated/control) randomly in 3 replications. All plots were fenced during the main growing season (June to November, 2015). The distance between plots and replications/blocks was 1 and 2 meters, respectively. The amount of urea and DAP, ash and dry manure applied on 16 m^{-2} plots were 0.24 kg and 0.16 kg, 4.8 kg and 12 kg, respectively. The plots were ripped to incorporate the treatment materials into the soil. The manure, obtained from farmers was decomposed for three months at backyards of farmers and dissolved in water and added into the soil in form of slurry. Wood Ash from farmers was scattered over the plots. Urea and DAP was over sown by broadcasting. The treatments were applied after the beginning of main rainy season. At the end of the growing season, the different plots were harvested using hand sickles and sorted into grass, and non-grass components. Furthermore, they were sorted into different species using field guide [9] and experienced technician from Adami Tulu research center, Ethiopia. The sorted materials were oven-dried at 65 ^{o}C for 72 hours.

2.3 Organization of grassland day and field assessment

Thirty male and nine female model farmers and 23 male and 2 female extension staff drawn from 4 districts (Ejere, AdaBerga, Meta-Robi and Dendi of west Shoa zone) and west Shoa zonal office attended the grassland day which was organized with the objective of creating awareness on the importance of improved grazing land management for the public.

2.4 Statistical and economic analyses

Analysis of variance (ANOVA) was conducted to verify the significant differences among the treatments using the STATA/SE 14 program. The formula proposed by Moore et al. [10], modified by Moore and Odendaal (1987) [11] and Moore (1989) [12], was used for grazing capacity estimation by taking in account the grass and total biomass yields. The equation is as follows:

$$Y = d/(DM \times f)r$$

where Y is the grazing capacity (ha TLU^{-1}), d the number of days in a year (365), DM the grass and total biomass DM yield (kg ha^{-1}), f is the utilization factor, r the daily grass DM required. The grazing capacity was calculated using tropical livestock unit (TLU) which is an animal weighing 250 kg and consuming 2.5% of its body weight. Thus, each TLU will consume 6.25 kg of forage dry matter daily and utilization factor of 0.5 (50%) was used [13].

The partial budget analysis (economic analysis) was done according to Upton 1979 [14] and CIMMYT 1988 [15] to determine economic benefit of the different treatments. Total variable cost, total return (TR), net benefit (NB), change in net benefit and marginal rate of return (%) were calculated for total biomass and grass production separately as grass is the most important feed resource for cattle and sheep. Furthermore, the economic analysis was undertaken considering the price of baled hay at harvest time and during the dry season.

III. RESULTS

3.1 Biomass production, herbaceous species composition and grazing capacities

Grass dry matter yield was highest ($P<0.02$) in Urea and DAP treated plots (Table 1). Compared with the control, application of ash or manure increased grass production although it was non-significant ($P>0.05$). On the other hand, the non-grass biomass was the highest in manure-treated plots although not significant ($P<0.05$). Application of ash produced more non-grass biomass than the control. Urea and DAP application significantly increased ($P<0.02$) total biomass production (TBP). While the control was the least in TBP, ash and manure applications were comparable in TBP.

TABLE 1
APPLICATION OF DIFFERENT TREATMENTS ON MEAN HERBACEOUS DRY MATTER PRODUCTION (kg ha^{-1}) AND GRAZING CAPACITIES (ha TLU^{-1})

Treatments	Grass	Non-grass	Total biomass (TB)	GC (grass) (ha/TLU)	GC (TB) (ha/TLU)
Control (no treatment)	1042.7^{b}	1786.7^{b}	2829.3 ^{c}	0.11	0.04
Ash	1170.7^{b}	2773.3^{b}	3944 ^{bc}	0.09	0.03
Urea and DAP	3620.80^{a}	2122.13^{b}	5742.93^{a}	0.03	0.02
Manure (cow)	1716^{b}	2986.7^{b}	4702.7 ^{ab}	0.07	0.03
SEM	151	121.6	178		
Significance level	0.0155	0.2361	0.0168		

Means with different letters down the column are significantly different ($P<0.05$); SEM= standard error of the mean.

Cyperus rotundus (31.57%) and *Cerastium octandrum* (31.57%) were the highest in percentage herbaceous species composition in the control plot while *Setaria verticellata* (35.54%) in Urea and DAP applied plots (Table 2). The ash applied plots were dominated by *Cerastium octandrum* (35.16%) and *Trifolium ruppellianum* (35.16%) which are non-grass species. The most abundant herbaceous species in the manure applied plot were *Cerastium octandrum* (28.87%) and *T. ruppellianum* (28.87%). The *T. ruppellianum* is a legume palatable to livestock.

TABLE 2
PERCENTAGE COMPOSITION OF THE DIFFERENT HERBACEOUS SPECIES IN THE TREATMENT GROUPS

Herbaceous species	Control	Ash	Urea and DAP	Manure
Hyperhenia rufa	5.76	3.63	3.44	
Cyperus rotundus	31.57	0.00	28.15	5.77
Eragrostis tenuifolia	6.91	8.48	18.34	13.84
Andropogon abysincus	11.52	3.03	5.73	10.06
Cerastium octandrum	31.57	35.16	0.00	28.87
Setaria verticellata	12.67	10.90	35.54	12.58
Trifolium ruppellianum		35.16	8.80	28.87
Commulina benegalensis		3.63	0.00	
	100.00	100.00	100.00	100.00

The land required per TLU (ha TLU^{-1}) was the lowest for the Urea and DAP applied plots while it was the highest for the control plot (Table 1).

3.2 Assessment and perception of the community

The participants of the grassland day selected plot with Urea and DAP application as the most preferred one which was followed by plots treated with manure. The reasons for their choice of the Urea and DAP applied plot was that it favored the production of grass than other herbaceous plants which corresponds with the herbaceous biomass data.

3.3 Economic Analysis

The partial budget analyses undertaken considering two time periods and total biomass and grass biomass are shown in Tables 3 and 4. Considering the total biomass production, both at the time of harvest and during the dry season (Table 3), application of ash was advantageous to the farmers as the marginal rate of return was so attractive to invest more. Subsquently, it will also be interesting for farmers to invest more in manuring their land as it helps them to fetch additional income though the cost was higher. The dry season would be more encauraging since the price of hay will be better. The next treatment (DAP and Urea) did not yield better net benefits if hay is to be sold in the harvest season. For that of the dry season, the marginal return was not so convincing and it is less likely to shift to this treatment. Considering grass production (Table 4) as a result of Urea and DAP application, during the harvesting time, the marginal rate of return was 53%, while during the dry season the MRR was 113% which is more attractive for farmers to invest in fertilizing, and is the most economical option combined with enclosing the field. Therefore, the decision is sensitive to the price of hay, and hence it is advisable to store and sell in the dry season.

TABLE 3
GRAZING LAND IMPROVEMENT OPTIONS, COSTS AND RETURNS BASED ON TOTAL BIOMASS IN ETHIOPIAN BIRR (ETB) AND USD WHERE 1 USD = 22.63 ETHIOPIAN BIRR AND THE NUMBER IN BRACKETS IN THE TABLE ARE IN USD

Improvement options	Cost of fertilizer	Labor cost *	CVT	Herbaceous production (bales/ha)	Sell of hay harvest time	Sell of hay (dry season)	NB (HT)	NB (DS)	MRR1 (%) (HT)	MRR2 (%) (DS)
Enclosing	0	1381.5 (60.1)	1381.5 (60.1)	166.4	5991.5 (264.8)	8321.5 (367.7)	4610.0 (203.7)	6940.0 (306.7)		
Enclosing + Ash	0	2276.0 (100.6)	2276.0 (100.60)	232.0	8352.0 (369.1)	11600.0 (512.6)	6076.0 (268.5)	9324.0 (412.8)	164	267
Enclosing + manure	0	3213.04 (142)	3213.0 (142)	276.6	9958.7 (440.1)	13831.5 (611.2)	6745.6 (298.0)	10618.5 (469.2)	72	138
Enclosing + Urea and DAP	3065 (135.4)	2777.56 (122.70)	5842.6 (258.1)	337.8	12161.5 (537.4)	16891 (746.4)	6318.9 (279.2)	11048.4 (488.2)	-	16

**** Fencing, fertilizing, manuring, harvesting, transport and storage***

HT-price at harvest time = 36 ETB/bale (1.59 USD/bale), DS-price in dry season = 50 ETB/bale (2.21 USD/bale), CVT = Costs that vary by treatment, NB = Net benefit, MRR% Marginal rate of return in percent

TABLE 4
GRAZING LAND IMPROVEMENT OPTIONS, COSTS AND RETURNS BASED ON GRASS PRDUCTION IN ETHIOPIAN BIRR (ETB) AND USD WHERE 1 USD = 22.63 ETHIOPIAN BIRR AND THE NUMBER IN BRACKETS IN THE TABLE ARE IN USD

Management Option	Cost of fertilizer	Labor cost*	CVT	Herbaceous production (bales/ha)	Sell of Hay (HT)	Sell of Hay (DS)	NB (HT)	NB (DT)	MRR % (HT)	MRR % (DT)
Enclosing	0	1381.46 (60.1)	1381.5 (60.1)	61.3	2208.1 (97.5)	3066.7 (135.5)	826.6 (36.5)	1685.31 (74.5)		
Enclosing + Ash	0	2276.0 (100.6)	2276 (100.6)	68.9	2479.1 (109.6)	3443.2 (152.2)	203.1 (8.1)	1167.2 (51.6)		
Enclosing + Manuring	0	3213.04 (142)	3213.0 (142)	100.9	3633.9	5047.1	420.9	1834.0		71.2
Enclosing + Urea and DAP	3065 (135.4)	2777.56 (100.6)	5842.6 (258.2)	213.0	7667.6 (338.8)	10649.4 (470.6)	1825.0 (80.7)	4806.9 (212.4)	53.4	113.1

*** Fencing, fertilizing, manuring, harvesting, transport and storage**

IV. DISCUSSION

The significant improvement in grass production in response to chemical fertilizer application is document in literatures. For instance, increase in grass production with Urea application which is an excellent sources of soluble nitrogen was reported by Cameron et al. [16] and Gagnon *et al*. [17] and nitrogen is also known as the most limiting nutrient for pasture production[16]. Furthermore, the findings of other researchers like Cinar *et al*. [18]; Ayan and Acar (2008) [19] revealed increase in forage production in response to Urea/nitrogen and DAP applications. The higher non-grass biomass in manure and ash applied plots although non-significant among the treatments is possibly associated with mineral composition of the treatments though not investigated in this study [20].

Cyperus rotundus is a species of sedge (Cyperaceae) found in all tropical, subtropical and temperate regions of the world (native to Africa, southern and central Europe and Southern Asia [21] and cattle feed on it when they are forced. *Cerastium octandrum* is an annual herb which is less palatable to livestock and indicator of degraded grazing land. *Seteria verticellata* grows in disturbed (due to overgrazing, trampling or drought) and damp soil. It is also an annual and palatable grass [22]. Although long-term experiments are required to separate the effects of the different treatment on herbaceous species composition, Urea application encourages the production of grasses as evidenced in this study [16, 17]. This result was also supported by the perception of the participants of the field day which justified the findings of the biological study and acted as one means of disseminating knowledge of improved grazing land technologies among different actors. Mamusha (2007) [23] justified the importance of improved flow of information and knowledge to, from and within the extension system as the key to realize agricultural transformation.

The mean grazing capacities revealed that more land was required to sustain a TLU on the control, manure and ash plots than on the Urea and DAP applied plots which is a direct reflection of the increased production in response to Urea and DAP application than in the other treatments which is in agreement with the findings of others [16, 17].

It was shown in the results that the net benefit and minimum MRR (%) favoured manure treated plots when considering total biomass production while it was better for Urea and DAP applied plots when taking into account grass production alone. The cost incurred for the former was lower than the latter and the non-grass production was higher numerically in the former than in the latter. Previous studies in Ethiopia indicated increasing price of grass hay from time to time [24, 25] which favored the Urea and DAP applied plots when considering grass production alone. Nevertheless, as this economic analysis is based on one season data, it is essential to undertaken detailed economic analysis by conducting research for more years and in different seasons of the year.

V. CONCLUSION

The study revealed local wooden ash, cow manure, urea with DAP applications improved total biomass production. Further long-term study is required to examine the effects of the different treatments on productivity of grazing lands, livestock productivity, soil and plant nutrients and economic considerations.

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