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Effect of Different Levels of Cattle Manure on Biomass, Seed Yield and Crude Protein Content opf Rhodes Grass

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Abstract
The experiment was conducted at Adami Tulu Agricultural Research Center (ATARC) and Negele Arsi Farmers Training Center (FTC) with the objective of assessing the effect of different levels of cattle manure on biomass and seed yields and crude protein (CP) contents of Rhodes grass. The treatments were three levels of manure application (5, 10 and 15 t/ha) and a control (with no manure application). The result indicated the highest ($p<0.05$) biomass, seed yield and CP contents for the treatments with cattle manure as compared to the control, The values increased with the increment in the rate of the cattle manure. However, treatments with higher levels (10 t/ha and 15t/ha) of cattle manure application didn't produce significant differences in yields and CP contents as compared to the lower level (5t/ha) of manure application. The lower yields and CP contents of the control treatment indicates that the soil did not have enough nutrients to sustain optimal performance of the grass. Economic analysis also indicated that the benefits from Rhodes grass can be increased through application of cattle manure. The marginal rate of returns of 3.33 and 20.90 were produced for forage biomass and seed yields respectively at 5 t/ha of cattle manure application. This indicated that cattle manure application at the rate of 5 t/ha is the most economical when compared with the other rates. Further study is required to determine the seasons and manure application frequencies in the year for optimum yield, minimizing the risk of nutrient leaching, and environmental impact.
Keywords: Biomass yield, Cattle manure, Seed yield, Rhodes grass
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Introduction

Livestock production is an important component of nearly all farming systems in Ethiopia and it provides milk, meat, draught power, transport, manure, hides and skins (Funk *et al*., 2012) and it serves as a source of income. The livestock sector contributes about 15-17% of the total gross domestic product and 35-49% of the total agricultural gross domestic product (ATA, 2012). However, the productivity per animal is very low and the contribution of the livestock sector to the overall economy is much lower than expected. Despite enormous contribution of livestock to the livelihood of farmers, they are faced with multifaceted problems in the production system, among which the major one is inadequacy of feed supply both in quantity and quality (Manaye *et al*., 2009). Crop residues are the major sources of livestock feed however, most of them could not meet the nutritional requirements of animals due to their low protein and high fiber contents. On the other hand, both the area and productivity of grazing lands have greatly declined due to expansion of cropping, disappearance of valuable species, spread of unpalatable species and land degradation which are associated with overstocking and overgrazing (Ayana 2014). Hence, if any significant production level is expected from livestock, these feed resources have to be complemented with cultivated pastures of high forage yields and quality.

Improved forage grasses constitute one of the most important feed sources for grazing animals. The intensity of forage production depends basically on the plant tillering and leaf development and growth processes (DeBona and Monteiro, 2010). Such plant processes are genetically controlled and can be altered by management of the plant growth conditions. Among the changeable plant growth conditions, growth medium such as water and nutrient availability play a major role in determining forage dry matter yields. Rhodes (*Chloris gayana*) grass is among the very few perennial pasture species selected for its adaptation and herbage yield in the mid rift valley of Ethiopia. Once established very well, it stays green for most part of the year and resumes active growth during the short rains in the area. Herbage yield of Rhodes grass under mid rift valley condition is 5.2 ton DM/ha (ATARC annual report 2017). However, this grass can yield up to 15 ton/ha with the application of nitrogen fertilizer (Getnet *et al*. 2003).

Fertilizer is one of the most important nutrient for encouraging grass growth and has great influence on growth and development of crops. Fertilization with manure has paramount importance for successful establishment of grasses and then for both biomass and seed production. Animal manure is an important source of major and minor plant nutrients. On average a tone of cattle manure contains 8.55 kg of N (Douglas Beegle, 1997), but different batches may contain different percentage of nutrients depending on sources and storage (Murwira *et al*., 1995). Besides nutrient provision, manure has a beneficial role in improving the soils physical characteristics.

Crops can only assimilate inorganic forms of N, such as nitrate and ammonium. However, most of N in manures is applied in organic form. Organic N remains in the soil until it mineralizes. Mineralization is a

continuous process and a number of factors such as temperature influence the rate at which it occurs (David, 2004). An increase in soil temperature increases nitrogen mineralization. The increased mineralization with increase in soil temperature is ascribed to the increased microbial activities and decomposition of organic matters which resulted in increased mineralization of soil organic nitrogen (Nicolardot *et al*., 1994 and Leiros *et al*., 1999)

The existing pressure of feed shortage and high prices of agro-chemical inputs necessitates the use of farmyard manure for both backyard and field production of improved perennial pasture species. Using manure for perennial pasture species is also advantageous in that, because of their long life cycle, they can efficiently exploit the residual fertilizer value of the manure. Moreover, the importance of farmyard manure is being realized because of the high cost of commercial fertilizers and its long term adverse effect on soil chemical properties. Besides supplying macro- and micronutrients to the soil (Negassa *et al*., 2001; Tirol-Padre *et al*., 2007), farmyard manure also improves the physico-chemical properties of the soil (Tirol-Padre *et al*., 2007). So the use of organic manure offers the best and affordable opportunities to alleviating the soil fertility problems and thus improving the pasture productivity under smallholder farmers condition. Although *Chloris gayana* is identified as the most promising perennial forage grasses, there is lack of information on seed and herbage yield responses of the species to manure fertilizer application. Moreover, the optimum rate that can maximize both seed and herbage outputs of this grass has not been established under the conditions of mid rift valley areas. Hence, the study was initiated to assess the effect of different levels of cattle manure on the establishment, herbage and seed yields CP contents of *Chloris gayana* in mid rift valley of Oromia, Ethiopia.

Materials and methods

Study area

The experiment was conducted at Adami Tulu Agricultural research Center and Negele Arsi Farmers Training Center for three consecutive years (2016-2018 E.C). Adami Tulu and Negele Arsi districts are located in the mid rift valley of Oromia, at about 167 and 225 km respectively south of Addis Ababa on Hawasa road. Adami Tulu research center lies at latitude of 7º 9’ N and 38º 7’ E longitude. Its altitude is about 1650 meters above sea level (m.a.s.l). It has an average annual rainfall of 727.1 mm, whereas its average annual minimum and maximum temperatures are 11.8ºc and 28.3ºc, respectively (ATARC metrology data, 2015-2017). Negele Arsi district is located at 38º 25' E to 38º 54' E longitude and 7º 09' to 7º 41' N latitude. It has borderlines with Southern Nations, Nationalities and Peoples Regional State (CSA, 2017/18). Negele Arsi district is grouped into three climatic zones based on altitude. These are low, mid and high altitude ranging from 1500- 3070 m.a.s.l. It has a bimodal rainfall pattern with a short rainy season from March to May and the main rainy season from late June to September. The dry season in the area is mostly from October to February. The mean annual rainfall of the district is 825 mm while the annual temperature varies from 16 - 25ºC (CSA, 2017/18).

Experimental treatments and design

Adapted Rhodes grass (*Chloris gayana* Cv. Masaba) was established on a well prepared seedbed using a recommended seeding rate of 15 kg/ha. Different rates of decomposed cattle manure were used in the experiment. A total of four treatments; Rhodes with no manure application (T1), 5 t/ha of cattle manure (T2), 10 t/ha of cattle manure (T3), 15 t/ha of cattle manure (T4) were used. The treatments were laid out in RCBD with three replications. Treatments were arranged based on the recommended level of cattle manure for Rhodes grass production by different authors (ESGPIP 2008, Getnet *et al.* 2003). Moreover cattle manure treatments were set according to Douglas Beegle (1997) who stated that a tone of cattle manure contains 8.55 kg of Nitrogen.

All necessary data including planting date, days to 50% flowering, plant height, total forage biomass, dry matter and seed yield were recorded. Forage yield were estimated by harvesting the grasses at the stage of 50% flowering. The 50% flowering is the recommended harvesting stage for perennial grasses for compromised herbage yield and quality. The mature inflorescences were harvested 10-15 cm below the panicle; then sun dried, piled for few days and manually threshed and cleaned to estimate seed yields. Herbage samples were dried to constant weight using forced air-drying oven to determine the dry matter using methods described by AOAC (2000). Total nitrogen was determined following Kjeldahl procedure as described by Cottenie (1980).

Partial budget analysis

Simple partial budget analysis was employed for economic analysis of different levels of cattle manure application for biomass and seed yield data. The price of Rhodes seed, labor costs for transportation and preparation of cattle manure were considered to determine the economic feasibility of cattle manure fertilizer application (CIMMYT, 1988). Market price of Rhodes grass herbage and seed were also taken at harvest. The economic analysis was based on the following formula developed by CIMMYT (1988).

Average biomass and seed yield (kg ha^{-1}) (AvY): is an average yield of each treatment.

Adjusted yield (AjY): is the average yield adjusted down ward by a 10% to reflect the difference between the experimental yield and yield of farmers. AjY = AvY* (1-0.1)

Gross field benefit (GFB): was computed by multiplying field/farm gate price that farmers receive for the grass when they sale it as adjusted yield. GFB = AjY*field/farm gate price for the grass
Total cost: is the cost of transportation and preparation of cattle manure used for the experiment. The costs were based on the prices during the experimental period. The costs of other inputs and production practices such as labor cost for land preparation, planting, weeding and harvesting were assumed to be the same for all treatments.
Net benefit (NB): was calculated by subtracting the total costs from gross field benefits for each treatment. NB = GFB – total cost
Marginal return (MR): is the measure of increasing in return by increasing input. Marginal rate of return (MRR %): was calculated by dividing change in net benefit by change in cost.

$$\text{MRR} = \frac{\Delta NB}{\Delta \text{TC}}$$

According to CIMMYT (1988), the minimum acceptable marginal rate of return (MRR) should be 1.0. If both net income and variable costs increase, the rate of return should be looked at. The greater increase in net income and the higher rate of return, the more economical an alternative technology is. Hence, the new technology should be accepted only if its rate of return is higher than 1.0.

Statistical analysis
The collected agronomic, herbage DM and seed yields data were subjected to analysis of variance using the SAS statistical procedures. Means were separated using Least Significant Difference (LSD) at 5% significant level.

Result and Discussions
Result of agronomic performances of Rhodes grass in response to different level of cattle manure application are presented in Table 1. Plant height was significantly ($p<0.05$) affected by application of different levels of cattle manure treatments. The longest plant height (95.72cm) was recorded from the highest level of cattle manure treatment (15t/ha) while the shortest (76.48 cm) was recorded from the control treatment. In line with this result, Qamar *et al.,* (2000) also pointed out that the use of cattle manure increased plant height significantly over non fertilized treatment. On the other hands, the tested treatments have no significant ($P>0.05$) effect on plot cover and days to 50% flowering of the grass. However, on average it took shorter days (70.41) at Adami Tulu site to reach 50% flowering as compared to at Negele Arsi site (Table 1). This could be probably due to the agro-ecology differences as the hot climate of Adami Tulu area might have been prompted early maturity of the crops. The higher mean plant height recorded for the tested treatments at Negele Arsi as compared to Adami Tulu site could be mainly due to the better soil fertility and soil moisture in Negele Arsi area.
Table 1.Plot cover, plant height and days to 50% flowering of Rhodes grass in response to different levels of cattle manure

Treatments	Plot cover (%)			Plant height (cm)			Days to 50% flowering		
	Adami Tulu	Negele Arsi	Combined	Adami Tulu	Negele Arsi	Combined	Adami Tulu	Negele Arsi	Combined
With no manure application	63.41	74.5	68.95	71.3^{b}	81.66^{b}	76.48^{b}	72.33	91.33	81.83
5 tone/ha	62.16	87.58	74.87	79.2^{ab}	97.41^{a}	88.31^{a}	68.33	91.33	79.83
10 tone/ha	66.75	83.83	75.29	81.26^{ab}	91.66^{ab}	86.46^{ab}	72.33	90.66	81.50
15 tone/ha	67.00	87.42	77.21	89.6^{a}	101.8^{a}	95.72^{a}	68.66	91.00	79.83
Mean	**64.83**	**83.33**	**74.08**	**80.34**	**93.14**	**86.74**	**70.41**	**91.08**	**80.75**
CV	**18.56**	**14.42**	**20.31**	**8.83**	**7.46**	**11.04**	**4.88**	**2.19**	**14.43**
LSD (5%)	**NS**	**NS**	**NS**	**13.37**	**13.08**	**11.54**	**NS**	**NS**	**NS**

[1]LSD=Least significant difference. CV=Coefficient of variation, NS= Non significant,
[2] Figures having the same letters with in a column are not significantly different, while values followed by different letter (s) are significantly different

Results of dry matter, seed yield and CP analyses of Rhodes grass in response to different level of cattle manure treatments are presented in Table 2. The results indicated that all these parameters are significantly affected by manure application. The highest values of dry matter (10.80t/ha), seed yield (500.75kg/ha) and CP (11.47%) were recorded from the highest level (15t/ha) of cattle manure treatment. Even though increasing the level of application of cattle manure increased yields and CP of the grass, the values were not significantly different among the three cattle manure treatments. Hence, increasing the amount of cattle manure above 5 t/ha didn't significantly increased CP, dry matter and seed yields of Rhodes grass. This indicates that the maximum nutrient requirements of the grass is already met by the manure level of 5 t/ha. On the other hand, the higher yield performance observed from manure fertilized Rhodes could be due to improvement in the soil nutrients availed for the crop as a result of applied fertilizer. Kumar *et al.* (2004) and Debele *et al.,* (2001) also reported organic manures, especially farmyard

manure, have a significant role for maintaining and improving the chemical, physical and biological properties of soils. In line with this study, Irshad *et al.,* (2002) also reported that the application of manure fertilizer enhanced plant growth performances as compared with non-treated control. Similarly, Obied (2003) and Ismael (2007) reported that manure significantly increased the dry matter yield of different forage species. Generally, better yields and CP content were recorded for the tested treatments at Negele Arsi as compared to Adami Tulu sites. This could be mainly due to better soil fertility and soil moisture in Negele Arsi than in Adami Tulu site. In this regard, Diriba *et al*., (2014) indicated that variation of experimental areas in climate and/or soil types or their interactions have effects on performance of forage crops. Other authors (Debele *et al.,* 2001) also pointed out that climatic condition is one of the factors determining herbage biomass production of the grasses.

Table 2. Dry matter and seed yields and Crude Protein content of Rhodes grass in response to different levels of cattle manure

Treatments	Dry Matter yield (t/ha)			Seed yield (kg/ha)			Crude Protein (%)		
	Adami Tulu	Negele Arsi	Combined	Adami Tulu	Negele Arsi	Combined	Adami Tulu	Negele Arsi	Combined
With no manure application	7.80^{b}	9.16^{c}	8.48^{b}	338.26^{b}	402.84^{c}	370.55^{b}	6.93	7.66^{b}	7.30^{b}
5 tone/ha	9.34^{ab}	11.09^{b}	10.22^{a}	395.71^{ab}	520.61^{b}	458.16^{a}	9.37	10.34^{a}	9.86^{a}
10 tone/ha	9.63^{a}	11.63^{a}	10.63^{a}	420.76^{ab}	555.74^{ab}	488.25^{a}	9.67	11.6^{a}	10.66^{a}
15 tone/ha	9.76^{a}	11.85^{a}	10.81^{a}	430.68^{a}	570.81^{a}	500.75^{a}	10.77	12.16^{a}	11.47^{a}
Mean	**9.13**	**10.93**	**10.03**	**396.35**	**512.5**	**454.43**	**9.18**	**10.45**	**9.82**
CV	**20.2**	**10.70**	**17.62**	**22.53**	**9.07**	**20.38**	**22.83**	**12.87**	**17.73**
LSD (5%)	**1.77**	**1.12**	**1.17**	**85.74**	**44.67**	**61.63**	**NS**	**2.53**	**2.09**

[1]LSD=Least significant difference. CV=Coefficient of variation, NS= Non significant,

[2] Figures having the same letters with in column are not significantly different, while values followed by different letter (s) are significantly different

Partial Budgeting Analysis

The cost benefit analysis result for herbage biomass and seed yield production of Rhodes grass in response to different levels of cattle manure application are presented in Table 3 and 4 respectively. The result of herbage biomass production indicated that the highest net benefit of 18367.5 Birr/ha was recorded from the medium level of cattle manure application (10 t/ha) while the least (15330.0 Birr/ha) was recorded from the control treatment. However, the highest marginal rate of returns (3.33) was recorded from lower level (5 t/ha) of cattle manure application. It means that investment of 1 Birr in 5 tone/ha of cattle manure on Rhodes grass production recouped the 1 Birr and gave an additional 3.33 Birr. The values for marginal rate of return for cattle manure treatments with 10 and 15 t/ha rates were 0.04 and -0.56, respectively. The lower values recorded for medium and higher level of cattle manure application could be due to the increase in the total input costs and reduction in the revenue obtained from the treatments as compared to minimum level of cattle manure application. Since the MRR for the medium and higher rates of manure application are below 1, the changes were inferior to that of the lower level of cattle manure (5 t/ha) and would not be considered. Hence, the optimum level of cattle manure application for Rhodes grass biomass production should be at 5 t/ha.

Table 3. Partial budget analysis of different levels of cattle manure application for forage biomass production

Descriptions	**Without fertilizer**	**5 tone/ha**	**10 tone/ha**	**15 tone/ha**
Gross income (Birr)				
Average forage DM yield (ton/ha)	8.48	10.22	10.63	10.81
Adjusted forage DM yield (ton/ha)	7.63	9.19	9.57	9.72
Sale price of forage (Birr/ton)	2500	2500	2500	2500
Sale revenue of forage (Birr)	19080	22983.75	23917.5	24311.25
Input costs (Birr/ha)				
Rhodes seed	3750	3750	3750	3750
Variable costs (transportation and/or preparation)		900	1800	2700
Total input costs	**3750**	**4650**	**5550**	**6450**
Net benefit (Birr)	**15330**	**18333.75**	**18367.5**	**17861.25**
Change in net benefits between two consecutive treatments		3003.75	33.75	-506.25
Change in total variable input costs between two consecutive treatments		900	900	900
Marginal rate of return		**3.33**	**0.04**	**-0.56**

Cost benefit analysis for Rhodes seed production from different levels of cattle manure application showed that the highest net benefit of 106218.75 Birr/ha was recorded from the highest cattle manure application rate (15 t/ha) while the lowest (79623.75 birr/ha) net benefit was obtained from the control treatment. The net benefit increased with increasing rate of cattle manure application most probably due to the better improvement of soil condition that consequently resulted in increased herbage biomass and seed yields. However, the marginal rate of returns revealed that the highest value (20.90) was recorded from the application rate of 5 tons of cattle manure /per hectare. The marginal rate of return for seed production decreased as the application rate of cattle manure is increased from 5 t/ha to 15 t/ha. The maximum values of MRR recorded from cattle manure applications shows the significant contribution of cattle manure to soil fertility improvement for optimum and cost effective Rhodes biomass and seed yield production. The highest marginal rate of returns produced from the rate of 5 tons of cattle manure per hectare indicated that this rate is the most economical among the other rates for herbage biomass and seed production of Rhodes grass.

Table 4. Partial budget analysis of different levels of cattle manure for seed production

Descriptions	**Without fertilizer**	**5 tone/ha**	**10 tone/ha**	**15 tone/ha**
Gross income (Birr)				
Average seed yield (kg/ha)	370.55	458.16	488.25	500.75
Adjusted seed yield (kg/ha)	333.495	412.344	439.425	450.675
Sale price (birr/kg)=250	250	250	250	250
Sale revenue (Birr)	83373.75	103086	109856.25	112668.75
Input costs (Birr/ha)				
Rhodes seed	3750	3750	3750	3750
Variable costs (transportation and/ or preparation)		900	1800	2700
Total input costs	**3750**	**4650**	**5550**	**6450**
Net benefit (Birr)	**79623.75**	**98436**	**104306.25**	**106218.75**
Change in net benefits between two consecutive treatments		18812.25	5870.25	1912.5
Change in total variable input costs between two consecutive treatments		900	900	900
Marginal rate of return		**20.90**	**6.52**	**2.12**

Conclusions

The study indicated that all treatments with cattle manure have produced better dry matter, seed yield and CP content as compared to the non-fertilized treatment. However, the treatments with cattle manure did not significantly differ in CP, dry matter and seed yield production among themselves. Economic analysis result also showed that benefits from Rhodes grass production can be increased through application of cattle manure. However, the highest marginal rate of return produced from 5 t/ha of cattle manure indicated that this rate is the most economical one among the others for herbage biomass and seed production. Hence, it is logical to recommend cattle manure at 5 t/ha for optimum biomass and seed production and improved CP content of the grass at the study sites. Moreover, it is very important to encourage our farmers to use cattle manure as inorganic fertilizers are becoming very expensive for resource poor farmers. Further study is also required to determine the seasons and frequencies of manure application in the year for optimum yield and minimized nutrient leaching and environmental impact.

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