Economic assessment of Napier grass production using different fertiliser combinations under smallholder farming conditions in the Central Highlands of Kenya

ABSTRACT

Aims: The objective of the study was to evaluate the cost effectiveness of using different fertiliser combinations to improve Napier grass Production within the smallholder farms.
Study design: The experimental design was a Randomised Complete Block Design (RCBD) with three replicates per treatment. The treatments were: Di-Ammonium Phosphate (DAP), rabbit (*Oryctolagus cuniculus*) manure; rabbit manure plus rabbit urine, DAP plus Calcium Ammonium Nitrate (CAN), DAP plus rabbit urine, Control and Conventional method.
Place and Duration of Study: The study was done in Embu County, Kenya from March 2015 to January, 2016.
Methodology: The economic analysis to determine the most cost-effective fertiliser was done using gross margins and cost-benefit ratios approach The economic analysis to determine the most cost-effective fertiliser was done using gross margins and cost-benefit ratios approach.
Results: Rabbit manure plus urine had the highest cost of production averages at US$.154 8.13 per year at $p<0.05$ while the conventional method was US$ 494.59 at $p<0.05$. The study revealed that the most cost-effective fertiliser in Embu County was DAP plus rabbit urine treatment under ‘‘*Tumbukiza*’’ pits.
Conclusion: The projections are that by the end of the second cropping year, the treatment top-dressed with either rabbit urine or CAN would be having higher gross margins since the initial cost would have been recovered. Farmers in Embu County are encouraged to integrate the use of both organic and inorganic fertilisers to achieve high production in a cost-effective way.

Keywords: Cost, Fodder, inputs, profitability

1. INTRODUCTION

The dairy industry is an integral sub-sector of livestock production in Kenya, which supports the key players within the entire value chain [1]. Total annual milk production in Kenya is approximated at 3.43 billion litres, of which more than 80% is from the smallholder farms [2]. Currently, the milk production per cow per day is averaged at 6 Kgs, which is way below the expected 15 Kgs [3]. Dairy production performance in most smallholdings is below optimal due to some factors associated with dairy production systems. These factors comprise of low quality feeds, poor feeding, a declining genetic base, animal diseases, poor access to credit facilities, effects of climate change and diminishing land [4, 5, 6].

To realise milk from a lactating cow, the animal genetic base and environment are critical. The environment consists of housing and Feeding of which feeding stands at 70% of the production cost. Studies have been done on improving milk production, but the yields have remained low with the milk unit cost being comparatively high, which makes it unaffordable to most consumers [7, 8]. A research done in Embu County [3] showed that the average cost of producing a litre of milk was US$ 0.374. Further studies indicated that the highest percentage of the cost of producing milk is from fodder constituting 55-70% [5, 9].

Napier grass is the most popular perennial fodder used within the smallholder crop-livestock farming systems in Kenya, where over 80% of the national milk is produced [10]. The reason for these is because of its advantageous traits such as vigorous growth, high biomass productivity, deep root system for drought tolerance, a wide range of soil conditions, high photosynthetic and its water-use efficiency [11]. Napier grass acts as a windbreak in crop fields and stabilises the soil by holding particles together in this manner, preventing soil erosion [12]. Milk production in smallholdings could be increased by reducing the cost of production, especially for fodder. There is limited empirical data on the economic assessment of Napier production to achieve high production. Hence we evaluated the Economic assessment of using different fertiliser combinations to improve Napier grass Production within smallholder farming conditions.

2.0 MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

2.1 study site

The study was done in Kirigi (0°24’14.71” S, 37°32’10.6” E), Embu County, Eastern Kenya. Kirigi is located in Agro-Ecological Zone (AEZ) UM1 (Upper midland zone 1), a coffee-tea zone and lies at an altitude of 1650 m above sea level. The average temperature is 18.7°C, and the precipitation pattern is bimodal with an annual average rainfall of 1677 mm [13]. The daily rainfall pattern and amounts experienced during the study period is shown in Figure 1.

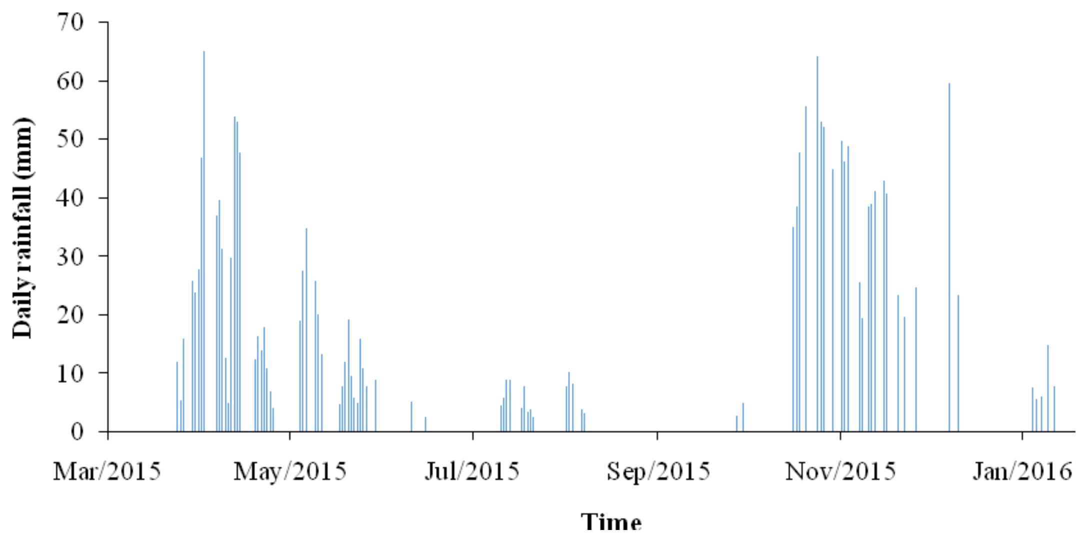

Figure 1: Daily rainfall during the study period.

2.2 Experimental design

The field trial was laid in a randomised complete block design replicated thrice. The test crop was Napier grass, Kakamega 1 variety. The treatments were: Di-Ammonium Phosphate (DAP), rabbit manure, rabbit manure plus urine, DAP plus Calcium Ammonium Nitrate (CAN), DAP plus rabbit urine, conventional method and Control (no fertiliser input). The treatments were assigned randomly within the three replicates, and the blocking was done based on slope and soil homogeneity as the major influencing factors. The fertiliser application rate was based on N nutrient at 45kg of N ha^{-1}from the assorted sources: DAP, CAN, rabbit manure, and rabbit urine. The plot size measured 3m by 2.1 m consisting of five *"Tumbukiza"* pits measuring 0.9m length by 0.6m width by 0.6m depth. On the other hand, the conventional method pits measured 0.2 m length by 0.15 m width by 0.2 m depth. Five cuttings of Napier grass were planted in each "*Tumbukiza"* pit while one cutting was planted in the conventional method pit.

2.3 Data collection

The economic analysis to determine the most cost-effective fertiliser was done using gross margins and cost-benefit ratios approach. The gross margin (GM) was calculated by subtracting total variable cost (TVC) from total revenue (TR) of Napier production per hectare (equation 1).

$$GM = TR - TVC \qquad \text{Equation 1}$$

Where: GM is gross margin (US$/ha), TR is total revenue or the total value of output from the Napier Production (US$/ha). It is the product of average output per hectare multiplied by the market price, and TVC is total variable cost or the costs that are specific in producing Napier (US$/ha). TVC varies according to output and is incurred on variable inputs. This includes the cost of inputs like canes, fertiliser, and hired/family labour per treatment.

2.4 Data analysis

Data were subjected to analysis of variance (ANOVA) using SAS 9.2. Mean separation was done using Tukey's Kramer Honest significant difference (HSD) at P = 0.05. Differences between means were considered significant if P values were less than 0.05. Data were analysed using SAS edition 9.2.

$$Y_{ijk} = \mu + B_i + T_j + E_{ijk} \qquad \text{Equation 2}$$

Where: Y_{ijkl} is the dependent variable, μ is the mean, B_i is the effect due to i^{th} replication, T_j is the effect due to j^{th} treatment and ε_{ijk} is the residual effect.

3.0 RESULTS AND DISCUSSION

3.1 cost of production

During the study, it was observed that all means were significantly different from the control in the 1st crop while DAP and rabbit manure were not significantly different from the control in the 2nd, 3rd and 4th crops. The highest costs incurred were observed in the 1st crop while during the other crops the costs were almost constant. The conventional method had the lowest cost of production while rabbit manure plus urine had the highest cost.

Table 1: Analysis of the cost of production using different fertiliser combinations on Napier grass in Embu County

Treatment	Production costs (US$)			
	1^{st} crop	**2^{nd} crop**	**3^{rd} crop**	**4^{th} crop**
DAP	786.47^{d}	92.74^{c}	92.74^{c}	92.74^{c}
Rabbit manure	1178.92^{b}	92.74^{c}	92.74^{c}	92.74^{c}
Rabbit manure+Urine	1201.99^{a}	115.81^{b}	115.81^{b}	115.81^{b}
DAP+CAN	817.31^{c}	123.86^{a}	123.58^{a}	123.58^{a}
DAP+Rabbit urine	809.54^{b}	115.81^{b}	115.81^{b}	115.81^{b}
Control	717.17^{e}	92.74^{c}	92.74^{c}	92.74^{c}
Conventional method	259.33^{f}	78.42^{d}	78.42^{d}	78.42^{d}
P	<.0001	<.0001	<.0001	<.0001

Means in the same column followed by the same letter are not significantly different at $P<0.05$

The study shows that the highest cost was incurred during the 1^{st}crop since planting material, fertilisers and more labour were used due to the land preparation. In the 2^{nd} 3^{rd} and 4^{th} crop, more cost was incurred where topdressing was done since there was the cost of fertiliser and extra labour for the fertiliser application. On the other hand, the conventional method was cheaper to establish since it used less labour to establish. The study found that the labour cost was the highest with estimated at 52% of the production cost. This result is in agreement with [5] who found that labour cost forms a large proportion in the dairy smallholder farms. Despite the fact that Rabbit manure plus urine had the highest cost of production, its gross margins were higher compared to the conventional method, which had the lowest gross margins.

3.2 Cost-benefit analysis

The study found that during the 1^{st} crop, all the Gross margins were negative with the conventional method having the lowest gross margin though, in the 2^{nd}, 3^{rd} and 4^{th} crop positive gross margins were realised. All the treatments means were significantly different from the control throughout all crops apart from the conventional method, which was not significantly different from control apart from the 1^{st} crop. The study on the economic evaluation of the most cost-effective fertiliser in Embu County revealed that DAP plus rabbit urine treatment under *"Tumbukiza"* pits was leading, followed closely by rabbit manure plus urine.

Table 2: Assessment of the cost-effectiveness of using different fertiliser combinations on Napier grass in Embu County

Treatment	Gross Margins (US$)			
	1^{st} crop	**2^{nd} crop**	**3^{rd} crop**	**4^{th} crop**
DAP	-382.68^{b}	129.77^{bc}	224.93^{cde}	4663.97^{a}
Rabbit manure	-948.01^{e}	280.48^{a}	377.77^{ab}	508.60^{a}
Rabbit manure+Urine	-793.43^{d}	314.92^{a}	441.00^{b}	654.00^{a}
DAP+CAN	-585.80^{d}	205.03^{b}	252.37^{bcd}	613.93^{ab}
DAP+Rabbit urine	-445.67^{b}	312.97^{a}	662.00^{a}	803.31^{a}
Control	-624.43^{c}	1.26^{d}	34.64^{de}	34.96^{b}
Conventional method	-177.15^{a}	9.39^{d}	72.50^{de}	22.90^{b}
LSD	118.84	82.19	211.70	355.01
P	<.0001	<.0001	0.001	0.007

Means in the same column followed by the same letter are not significantly different at $P<0.05$

The study on the economic evaluation of the most cost-effective fertiliser in Embu County revealed that DAP and Rabbit urine combinations were leading, followed closely by Rabbit manure and rabbit urine combinations all under ‘‘*Tumbukiza*’’ plots. Both treatments realised high yields in all the harvests. The reason why the first was leading compared to the latter was that the first had less labour and time for fertiliser application, unlike the manure that had more time and labour. The control and Conventional method had low gross margins in all the harvests due to their low yields and high cost involved in their establishment. Gross margins from treatments with ‘‘*Tumbukiza*’’ plots had high gross Margin apart from the control despite their high cost of establishment particularly digging the holes compared to the conventional method. The results differed with a study was done by [14] who found the gross margins for the ‘‘*Tumbukiza*’’, and Conventional method was similar.

4. CONCLUSION

The study revealed that the most cost-effective fertiliser in Embu County was DAP plus rabbit urine under ‘‘*Tumbukiza*’’ pit treatment since it performed better compared to the others. The reason as to why the treatment was doing well is because it used less labour and time for fertiliser application, unlike where manure was used since there were more time and labour involved. The projections are that by the end of the second cropping year, the treatment top-dressed with either rabbit urine or CAN would be having higher gross margins since the initial cost would have been recovered. Farmers in Embu County are encouraged to integrate the use of both organic and inorganic fertilisers to achieve high production in a cost-effective way.

COMPETING INTERESTS

We have no conflicts of interest to disclose.

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