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Economic Assessment of Napier Grass Production Using Different Fertilizer Combinations under Smallholder Farming Conditions in the Central Highlands of Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. Author BWN did the investigation and wrote original draft of the manuscript. Author EEA supervised, wrote, reviewed and edited. Author FKN supervised did formal analysis, wrote, reviewed and edited. All the authors read and approved the final manuscript.

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ABSTRACT

Aims: The objective of the study was to evaluate the cost-effectiveness of using different fertilizer 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.

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Methodology: The economic analysis to determine the most cost-effective fertilizer 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 fertilizer 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 fertilizers 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 has been 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 averaged at 6 Kgs, which lay 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 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 made 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 was from fodder for animal creation, constituting 55-70% [5,9].

Napier grass has been 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 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 are limited empirical data on the economic assessment of Napier production to achieve high production. Hence the study was based on the economic assessment of using different fertilizer combinations, to improve Napier grass production within smallholder farming conditions.

2. MATERIALS AND METHODS

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 local 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 Fig. 1.

2.2 Experimental Design

The field trial was laid in randomized 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 (applied DAP) and Control (no fertilizer 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 fertilizer application rate was based on N nutrient at 45 kg of N $ha^{-1}$from the assorted sources: DAP, CAN,

rabbit manure, and rabbit urine. The plot size measured 3 m by 2.1 m consisting of five *''Tumbukiza''* pits measuring 0.9 m length by 0.6 m width by 0.6 m 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 which was for all the treatments apart from the conventional method where one cutting was planted in each pit. Topdressing of Napier grass was done fourteen days after every harvest. First crop harvest was done 120 days after the crop establishment and subsequent harvests were done after 60 days.

2.3 Data Collection

The analyze to determine the most cost-effective fertilizer 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).

$$GM = TR - TVC \quad (1)$$

Where: GM is gross margin (US$/ha), TR is total revenue or the total value of output from the Napier production (US$/ha). It was the product of average output per hectare multiplied by the market price, and TVC was 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, fertilizer, 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 analyzed using SAS edition 9.2.

$$Y_{ijk} = \mu + B_i + T_j + E_{ijk} \quad (2)$$

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. RESULTS AND DISCUSSION

3.1 Cost of Production

During the study, it was observed that all means were different from the control in the 1st crop while DAP and rabbit manure were not different from the control in the 2nd, 3rd and 4th crops. The highest costs incurred were observed in the 1st crop; 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.

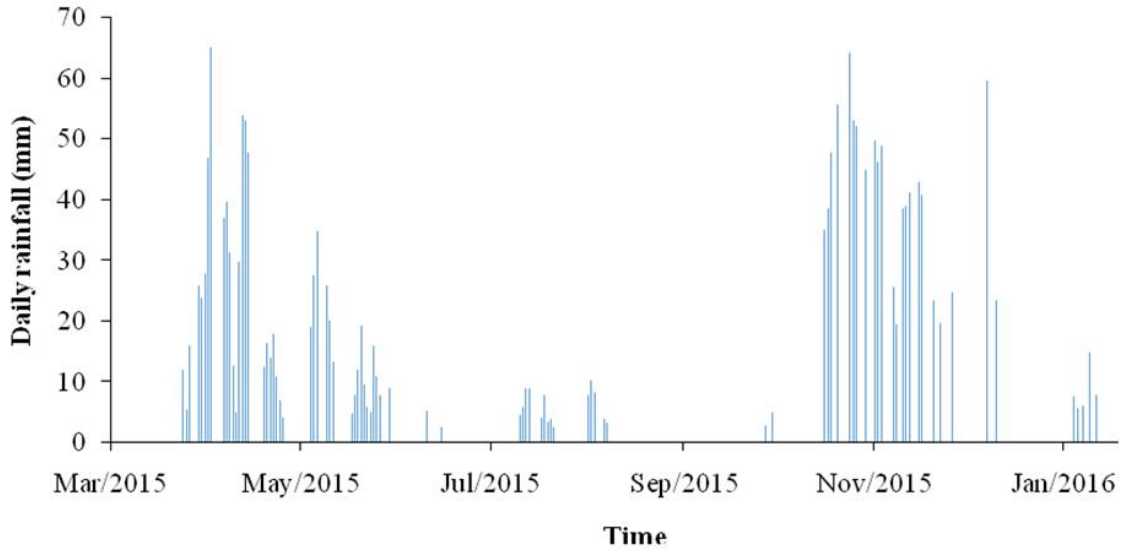

Fig. 1. Daily rainfall during the study period

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

Treatment	Production costs/Ha (US$)			
	1st crop	2nd crop	3rd crop	4th 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 different at P<0.05

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

Treatment	Gross Margins/Ha (US$)			
	1st crop	2nd crop	3rd crop	4th 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 different at P<0.05

The study showed that the highest cost was incurred during the 1st crop since planting material, fertilizers and more labour were used due to the land preparation. The market price for the fertilizers was used to calculate the cost of fertilizers for every season which was 0.9 US$/kg, 0.6 US$/kg, 0.3 US$/kg and 1.05 US$/kg for DAP, CAN, rabbit manure and rabbit urine respectively. In the 2nd 3rd and 4th crop, more cost was incurred where topdressing was done since there was the cost of fertilizer and extra labour for the application. On the other hand, the conventional method was cheaper to establish since it used less labour which was costing 134.85 US$/ha compared to the rabbit manure plus urine which had the highest cost at 625.03 US$/ha. 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. Although 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 1st crop, all the gross margins were negative with the conventional method having the lowest gross margin though, in the 2nd, 3rd and 4th crop positive gross margins were realised. All the treatments means were different from the control throughout all crops apart from the conventional method, which was not different from control apart from the 1st 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.

The study on the economic evaluation of the most cost-effective fertilizer in Embu County revealed that DAP plus rabbit urine combinations were leading, followed closely by rabbit manure plus rabbit urine combinations all under ''*Tumbukiza*'' plots. Both treatments realized high dry matter yields in all the harvests ranging from 12.15 to 24.51 Mg ha^{-1} Per harvest. The reason

why the first was leading compared to the latter was that the first had less labour and time for fertilizer application, unlike the manure. The control and conventional method had low gross margins in all the harvests due to their low yields which ranged from 1.8 to 9.09 Mg ha^{-1} Per harvest 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 that was done by [14] who found the gross margins for the ''*Tumbukiza*'', and the conventional method was similar. The reason for the difference in this study could be due to top dressing of the Napier that was done after every harvest hence high Napier yields resulting in higher gross margins in the *''Tumbukiza"*.

4. CONCLUSION

The study revealed that the most cost-effective fertilizer in Embu County was DAP plus rabbit urine under ''*Tumbukiza*'', treatment that present better performance compared to the others. The reason as to why the treatment was doing well was because it used less labour and time for fertilizer 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 rabbit urine would be having higher gross margins since the initial cost would have been recovered. Farmers in Embu County should be encouraged to integrate the use of both organic and inorganic fertilizers to achieve high production in a cost-effective way.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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