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The Potential Use of Rabbit Urine as a Bio Fertilizer Foliar Feed in Crop Production

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Abstract

The study was conducted at CITC Kapsabet College in Nandi Central District-Nandi County, Kenya. The objective was to determine the potential use of rabbit urine as a foliar feed fertilizer in crops. Rabbit urine was collected from a gutter fitted to a slatted floor of rabbit hutch and two replicate samples of concentrated urine 1000 ml each was collected and taken to National Agricultural Research Laboratory (NARL) Kabete, for nutrient urinalysis. Two samples of the control (commercial foliar feed fertilizer - CF) were also taken to NARL for nutrient analysis. Other 50 ml. samples were collected in duplicate and diluted at 0% (neat urine-F0%), 25%(F-25%) and 75% (F-75%). Undiluted urine and commercial fertilizer (CF) 100 ml were diluted at the recommended rate of 5 ml per liter and collected and taken to the same laboratory. The results of the rabbit urine laboratory nutrient analysis indicated that rabbit urine had better nutrients than CF since rabbit urine had 1.05% nitrogen, 0.01% phosphorus, 0.85% potassium and 0.12% calcium. Results also indicated that sample extracts from the different proportion of rabbit urine was the same [F (3, 30) =0.13, P>0.05]. The average yield per plot was highest for desmodium (2507 g), followed by oats (1790 g) and finally spinach (620 g) at F50 concentration, respectively and there was no significant difference of different proportions of rabbit urine on the biomass yield [F (3,8)=0.24, p>0.05]. The commercial fertilizer had N, P, K and Ca percentages of 0.70, 0.02, 0.02 and 0.002, respectively. The rabbit urine was basic (pH 8.5) while CF was acidic (pH 5.0). Rabbit urine was therefore determined to have a better nutrient composition than commercial foliar fed fertilizers. Desmodium had the highest yield of 2507 g. The urine was basic and hence it be integrated with the use of chemical fertilizers to improve crop yield and soil fertility by reducing soil acidity since it is a foliar feed. The study recommends that farmers should use the right proportion of water and rabbit urine on plants to promote better yield.

Keywords: Rabbit Urine Biomass Yield on Crops Rabbit urine, yield, CF, Bio-fertilizer

INTRODUCTION

The world's population was projected to increase to 9 billion in mid of this century (Godfray *et al.,* 2010). The increasing population leads to higher demand for food security globally. This has resulted in adoption of better farming methods as crops form part of the food security. Better farming methods involve the use of fertilizers to improve the quality of the continually degraded soil from several human activities. However, it is difficult to estimate exactly the contribution of mineral fertilizers to the increase in agricultural production due to the interactions of many factors, but fertilizers will continue to play a decisive role in food production irrespective of which new technology may yet emerge. It is estimated that globally, about 40% (37-43%) of the world's dietary protein supply in the mid 1990's originated in the nitrogen produced by the laboratory process of the Haber, Bosch process for the synthesis of ammonia (Wang *et al.,* 2020). The use of rabbit urine as animal waste in form of a bio-fertilizer in crop production is a relatively new venture. Rabbit production in Kenya is now an emerging livestock enterprise and rabbit population is estimated at over 600,000 in Kenya (Serem *et al.,* 2013). They are mainly kept in the rural areas and they supply good quality meat, fur, rabbit skin, rabbit manure, feaces and rabbit urine (Mutai *et al.,* 2018).

Macronutrients

Nitrogen (N) is the motor of plant growth and makes up to 1- 4% of dry matter of the plant and taken up in the form of nitrate (NO_3^-) or ammonium (NH_4^+) and in the plants it combines with compounds produced by carbohydrate metabolism to form amino acids and proteins. It is also responsible for uptake of other nutrients (Mengel *et al*., 2001; L'hirondel, 2002).

Phosphorous (P) makes up to 0.1 – 0.4% of the dry matter of plants and plays a major role in energy transfer and is responsible for photosynthesis and other chemico physiological processes in the plant. It is indispensable for cell differentiation and tissue development forming the growing points of plants (Chaudhary *et al.,* 2008; Wu *et al.,* 2013).

Potassium (K) makes up to 1- 4% of the plant dry matter and activates more than 60 enzymes hence it plays a vital role in protein and carbohydrate synthesis and improve the water regime of the plant and increase its tolerance to drought, frost, salinity and disease resistance (Zahedi, 2016).

Micronutrients

Calcium (Ca) is essential for root growth and as a constituent of cell wall material (structural role) and deficiency may occur on strongly calcium depleted tropical soils and hence the aim of calcium application is that of soil-liming to reduce soil acidity (Huang *et al.,* 2017).

Cobalt (CO) is essential for nitrogen fixation. It is important to know that all the plant nutrients, be the Macro or Micro nutrients fulfills a specific role in plant growth and food production and that one nutrient cannot be substituted for another one (Li *et al.,* 2009).

Historically farmers have alternated cultivation with long fallow period or rotation with other crops to manage soil fertility; however, in response to rising demand for food and reduced land for agricultural production, farmers have shortened or abandoned fallow period and crop rotation in favour of continuous cropping which has resulted in use of fertilizers to improve soil fertility (Esilaba *et al., 2016*). Early findings from another study showed that one of the major causes of low maize yield in Western Kenya is soil acidity precipitated by intensive use of chemical fertilizers (Ichami *et al*., 2020). Through soil sampling the KARI researchers found out that the average potential of Hydrogen (pH), levels in soils in that region was 4.5, which is too acidic for maize production. This has impacted negatively on soil fertility (Wamalwa, 2018). An organization sponsored by the USAID supports the application of integrated soil fertility management systems (ISFM); by emphasizing site-specific soil analysis and fertilizer selection; precision fertilizer application and increased use of lime blended and customized fertilizer (Vanlauwe *et al.,* 2017).

There is therefore need to improve soil fertility through strategic interventions e.g., through optimization and balancing of use of chemicals and organic fertilizers through fertilizer application techniques, e.g. foliar feeds; increasing the number of bio fertilizers policy supplies and support by the Kenya Government. The national average maize yield has declined over the years from 2.2 metric tons (MT) per hectare in the 1990's to 1.73MT in 2013 (Onono *et al.,* 2013). Also, a value chain study revealed that aggregated demand for maize is expected to increase from 3.21 million (MT) to 3.48 million (MT) in the next decade mainly aggravated by population growth (Mumo *et al.,* 2018). However, in the high potential (Kenya's grain basket) areas of the North and South Rift Valley regions, soils are becoming more acidic due to prolonged use of inorganic (chemical) fertilizers, especially ammonium phosphate (DAP) (Makone *et al.,* 2015).

Kenya in the pursuit to meet the national food security has embarked on the construction of a first chemical fertilizer factory in Ngeria-Eldoret in Uasin-Gishu County as was reported by Kenya's Standard Newspaper of 1.8.2016 (Silah, 2016). In this publication the Kenya government has embarked on a multi-billion fertilizer processing plant which is expected to churn out an average of 20,000 kg of fertilizer per day. The national government is said to work in collaboration with the respective county governments in verifying soil samples for pH analysis especially in regions where farmers have exhausted soil fertility through the use of persistent tillage and chemical fertilizers that lead to soil acidity and poor crop productivity. In order to integrate the use of chemical fertilizers and bio fertilizers the following organic manures can be considered: Cow dung, pig and poultry wastes and lately the use of rabbit urine. The use of rabbit urine as a bio-fertilizer as was the objective in this research study is an idea whose time has come to reduce the use of chemical fertilizers in an integrated interventional approach to improve soil fertility and to meet specific customer demand in agricultural products.

Researchers now recommend farming with less use of chemicals fertilizers (Zhou *et al.,* 2010; Savari & Gharechaee, 2020; Morris *et al.,* 2007). It is also reported by the research institute of organic agriculture (FIBL) that organic farming is viable strategy in the tropics due to its significance in improving soil fertility by improving such parameters as soil pH, potassium; calcium and magnesium bioavailability as compared to conventional use of mineral (chemical fertilizers (Studer *et al.,* 2014). A senior scientist at Farming Systems – India, reports that a parallel study in India and Bolivia on cotton and coffee production indicated positive results in organic farming (Forster *et al.,* 2013).

On the other hand, another study states that there is no difference between organic and conventional farming methods with respect to diseases e.g. Maize-streak virus and Turcicum leaf blight (Ayiga-Aluba *et al.,* 2015). In another report it is stated that organic farming can contribute to Africa's food security but unfortunately has not been embraced fully in Africa because many fertilizers' manufactures that happens to be multinationals have powers to influence agricultural policies which are in their favors (Adamtey, 2016).

In another study, addition of different organic manures in addition to recommended rates of inorganic fertilizer resulted in the higher organic carbon content and available nutrients status of the soil compared to chemical fertilizers alone, the study which was done on sugar cane production in India also recorded a better sugarcane juice quality in manure treated plots than those on recommended chemical fertilizer rates only. The study concluded that integrating use of organic manures and chemical fertilizers produced higher and sustainable cane yields and maintained the soil fertility (Rama *et al.,* 2011). The continuous addition of organic manures along with chemical fertilizers may stimulate mineralization and immobilization of plant nutrients hence affecting their amounts in different organic and inorganic forms in the soil (Bedada *et al.,* 2014). Combined application of organic manure with inorganic fertilizers significantly increased the soil organic carbon content due to addition of organic matter through manures than chemical fertilizers alone.

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Also, the increase in organic carbon content without a reduction in yield on combined use of organic and inorganic nitrogen fertilizers indicated the sustainability of the practice (Muhati *et al.,* 2018).

Problem Statement

A lot of work has not been done on the use of rabbit urine as a bio-fertilizer and yet rabbit keeping is an emerging livestock enterprise in Kenya producing rabbit meat, skin, fur, rabbit feaces and urine as potential organic manure. Rabbit urine is a byproduct of rabbit keeping considered a livestock waste but whose potential as a bio-fertilizer has not been fully tapped and embraced by most crop farmers.

There is also an increased awareness locally and globally on the dangers of using agricultural products fertilized with chemical fertilizers.

The declining crop yields due to prolonged and persistent use of chemical fertilizers calls for an integrated interventional approach to correct soil acidity and boost crop yield. Researchers have attributed declining crop yield to increased soil acidity making nutrients unavailable for plant use.

Justification

There is need to look into the possibility of integrating the use of chemical fertilizers with bio-fertilizers so as to improve on soil fertility by correcting soil acidity. This will improve on nutrients availability to crops.

There is need to reduce cost of crop production by use of organic manures e.g. rabbit urine which is cheap to obtain through rabbit keeping (cunniculture) (Mutai *et al.*, 2018).

There is increasing local and global awareness of the dangers of using chemical fertilizers and hence the new demand for organic products both from crops.

It was therefore one of the objectives of this study to investigate the potential use of rabbits' urine as a bio-fertilizer in crop production and this can set new trends in the field of organic fertilizers and organic products.

Study Hypotheses

H_{O1} Sample extracts are not different in different proportion of rabbit urine

H_{O2} There is no significant difference between different proportion of rabbit urine and water on biomass yield.

MATERIALS AND METHODS This study was done at Christian Intermediate Training College (CITC) Kapsabet College situated in Nandi Central District, Nandi County. It is bound by the Equator to the south and extends northwards to latitude 0^0 34' N.

A rabbit hutch was constructed on the research site using sawn timber as side walls and the roof was covered with iron sheets. It was raised 1m high to have a wire-mesh slatted floor to enable urine to be collected on gutter fitted below with a plastic urine collection container. Twenty rabbits were provided with watering and feeding troughs and were fed on rabbit pellets and given water.

The rabbit urine samples were collected into 100 ml clean and sterile containers. The rabbit urine was stored for around 4 months without expiring; rabbit urine has no expiry so long as it is tightly closed to avoid the loss of nitrogen through evaporation of the ammonia gas (NH^{+4}) (Vennen & Mitchelle, 2009). However, its expiration is determined by the amount of nitrogen in it; very little or no nitrogen means it is expired.

They were diluted with water to make 0%, 50%, 75% and undiluted urine sample, i.e. 100% concentration. There was a sample of a commercial fertilizer mixed at 5 ml per liter of water (control sample), at manufacturer's recommended rate. Eight samples representing all the 4 treatments were then taken to the Kenya Agricultural & Livestock Research Organization Laboratories (KALRO), Kabete- Nairobi for nutrient analysis.

Crops Selected for Field Trials

(a) Green leaf desmodium (*Desmodium intortum*)

It is high in crude protein with 21% CP

hence good protein supplement for both ruminants and rabbits (non- ruminants) and it is also low in toxicity compared to other legumes, e.g. Lucerne Vetch, and Beans (Mutai *et al.,* 2018). It is also versatile in terms of soil acidity unlike Lucerne and gives better vegetative growth than the silver leaf desmodium (*D. incanum*). It grows satisfactorily on acidic soil which is the case in most Kenyan soils and can tolerate soil acidity to a large extent compared to Lucerne.

(b) Oats (*Avina sativa*)
Oats is a member of the graminea family and a good forage for livestock. It has no human –animal nutritional competition unlike wheat or maize, hence appropriate for sustainable livestock nutritional regime. It also has a short growth period of four months hence can be used to mitigate the adverse effect of climate change, i.e. short rainy season and prolonged draught. It is rich in carbohydrates and proteins hence support livestock growth and development.

(c) Spinach (*Brassica* family)
It is a nutritious vegetable with good vegetative growth and a short maturity period and can be used by both human and livestock. It is more tolerant to fungal infections than most cereals and legumes. However, a withdrawal period of about two weeks to reduce the smell of rabbit urine will have to be observed just like in other chemical compounds.

Four Field Trial Experiments (Treatments) Conducted
The three crops were planted in a clean, fine and firm seed bed that ensures good germination. They were planted in three plots measuring 2×2 m in each plot and each replicated three times. Establishment was done by seed drilling in four rows at 30 cm between rows for all the crops. Each plot was treated with rabbit urine with different dilution rates, i.e. 100% (undiluted rabbit urine,) 75% dilution, 50% dilution and commercial fertilizer (CF) diluted at manufacturers rate of 5 ml of the commercial fertilizer per 1 liter of water.

The bio-fertilizer (rabbit urine) and 2 l of each dilution were sprayed on all the plots with the respective crops in each plot of Desmodium, oats and spinach, respectively, every fortnight to runoff for a period of 6 months both at top and bottom of leaves.

The following were observed and recorded in terms of ability of the crop to withstand lodging around maturity time, early flowering and tasseling for desmodium and oats. Observation on the greening effects on the different treatments on crops was also done. At the end of the study period, i.e. 6 months, all the crops were cut with a sickle and weighed on a scale of the range 1 gm-5 kg and recorded as the biomass yield of each treatment and each crop.

The research design was a complete random design (CRD) and data analysis was done using ANOVA and Sum of error mean (SEM).

Data Analysis
Data on biomass yield (vegetative growth) was collected and analyzed using ANOVA and SEM.

RESULTS AND DISCUSSION

Parameter 1-Rabbit urine –Nutrient composition

Table 1: Nutrient composition of rabbit urine and commercial foliar feed fertilizer at different dilution rates

	Nitrogen (%)	Phosphorous (%)	Potassium (%)	Calcium (%)	Magnesium (%)	pH
T1(F100)	1.05	0.01	0.85	0.12	0.65	8.5
T2 (F50)	0.70	0.02	0.62	0.06	0.57	8
T3 (F75)	1.05	0.02	0.55	0.01	0.51	8.5
T4 (CF) 5ML/Ltr	0.70	0.02	0.02	0.002	0.56	5
SEM(±)	(±)0.09	(±)0.002	(±)0.47	(±)0.02	(±)0.03	(±)0.73

Table 2: ANOVA Results showing nutrient composition on treatment effect

Number of obs = 24   R-squared = 0.0191
Root MSE = 2.97703   Adj R-squared = -0.1281

Source	Partial SS	df	MS	F	Prob>F
Model	3.4474244	3	1.1491415	0.13	0.9413
var1	3.4474244	3	1.1491415	0.13	0.9413
Residual	177.25371	20	8.8626854		
Total	180.70113	23	7.856571		

Using Stata software, the results of rabbit urine nutrient analysis are shown above.

The p value is 0.9413 which is greater than 0.05. Therefore, the null hypothesis is not rejected meaning sample extracts are the same for all treatments and hence means there is no significant difference [$F(3,20) = 0.13$, $p > 0.05$] in all treatments.

The macronutrients, i.e. Nitrogen (N), Phosphorous (P) and Potassium (K) for both samples taken from each treatment (dilution rate) shows no significant difference ($p > 0.05$), with the F100% (undiluted urine) and F75% dilutions recording the highest N% of 1.05, and the F50% and CF having the same % Nitrogen of 0.70. In spite of the dilution of 25% water for the F75% fertilizer, the nitrogen concentration still remained the same as with the F100% fertilizer. This shows that rabbit urine is a very concentrated solution and has been supported by Wandita & Fitriyanto (2016) who reported that rabbit urine has a very high concentration of nitrogen. The study shows that by diluting rabbit urine by 50% with water, it brings the nitrogen concentration to the figure of 0.70 which actually is equal to that in the commercial fertilizer (CF), which is diluted at a recommended rate of 5 ml. per liter of water. These findings disagree with findings of Sunandra *et al.* (2019) who found out that melon plant grows faster with addition of 300 cc of rabbit urine diluted in 1 liter of water.

The rabbit urine can be collected easily with no extra expense by rabbit farmers meaning it can be sustainable and cost-effective method of improving crop yield and soil fertility. The percentage levels of phosphorous (P) at 0.01 for F 100% (control-untreated), 0.02, 0.02 and 0.02 for F50%, F75%, and CF, respectively had insignificant difference as shown by the p value which is greater than 0.05, and that the F50 fertilizer had same percentage phosphorous as the commercial fertilizer

(CF) while potassium percentage levels were also insignificant meaning there was no significant difference between the proportion of potassium in rabbit urine and CF when different percentage of water was added to them. For calcium it is the same for F50%, F75% and CF at percentage of 0.02 but F100% had slightly more calcium percentage of 0.05 since it was undiluted. Calcium is essential for cell wall development in plants hence good for structural and textural development and helps mainly cereals crops to stand firm and prevent lodging towards maturity stage or incase of strong winds. Rabbit urine has enough calcium for this purpose and can be used in an integrated approach with chemical fertilizers. Similarly, the magnesium contents of 0.57 in F50%, and 0.65 in CF indicates that the same mixing levels of fertilizers can replace each other.

The same case as can be seen with respect to NPK levels in F50% and CF.

Rabbit urine is alkaline (pH 8.5) as shown in Table 1 and in spite of a 25% dilution with water, the pH of the 75% concentrated urine is similar to that of the 100% concentration. However, the pH of 50% concentrated urine is 8.0 which is still alkaline as compared to a pH of 5.0 of the commercial foliar feed fertilizers- acidic.

The Alkaline pH in concentrated urine may explain why the low phosphorous levels in the two solutions occurs since phosphorous (P) and Calcium (Ca) have inhibitory nutrient element availability when the ratio of the two elements is not that of 2:1 (P and Ca, respectively). This is also supported by the fact that once the 100% urine was diluted to be 50% the phosphorous pH level was 8.0 and available phosphorous increased to 0.02.

Table 3: Biomass Yield of the Three Crops after a Growth Period of 6 Months

	Treatments			
Crop	F 0%	F50%	F100%	CF
	Weight (g)			
Desmodium	1587	2507	1775	1673
Oats	1320	1790	1778	1850
Spinach	402	620	450	531

KEY:
F50%=50 percent diluted rabbit urine fertilizer
F75%- 75 Percent dilution rate of rabbit urine fertilizer.
F100%=100% Rabbit urine fertilizer (undiluted)
CF=Commercial fertilizer (Foliar feed diluted at manufactures rate of 5 ml. Mixed with 1 lt. of water)

Table 4: ANOVA Results showing treatment effects

Number of obs = 12 R-squared = 0.0831
Root MSE = 773.425 Adj R-squared = -0.2607

Source	Partial SS	df	MS	F	Prob>F
Model	433757.58	3	144585.86	0.24	0.8649
var1	433757.58	3	144585.86	0.24	0.8649
Residual	4785489.3	8	598186.17		
Total	5219246.9	11	474476.99		

Since the p value is 0.8649 which is greater than 0.05, the H_o is not rejected meaning there is no significant difference (p>0.05) for all treatments on biomass yield, that is, the biomass yield for all treatments are the same.

Parameter 2-Biomass Yield

The plots under Desmodium (*Desmodium intortum*) plants had an average biomass yield of 1587 g, 2507 g, 1775 gm and 1673 g for treatments F0 (control- no fertilizer added), F50 (50% diluted rabbit urine), F 100 (undiluted rabbit urine) and CF (commercial fertilizer), respectively. However, the 75% concentration was not used because it had the same concentration as 100% dilution. The average yield (g) for the plants in plots under oats *(Avina sativa*) was 1320 gm,1790 gm,1775 gm and 1850 gm, for treatments F0 (control- no fertilizer added), F50 (50% diluted rabbit urine), F 100 (undiluted rabbit urine) and CF (commercial fertilizer), respectively. While the average yield (gm) for the plants in plots under Spinach (*Brassica* family) was 402 gm, 620 gm, 450 gm and 531 gm for treatments F0 (control- no fertilizer added), F50 (50% diluted rabbit urine), F 100 (undiluted rabbit urine) and CF (commercial fertilizer), respectively.

Biomass Yields Analysis

Null Hypothesis H_0: Biomass yields of crops are same for all treatments

Alternative Hypothesis H_1: Biomass yields of crops are not same for all treatments.

There was no significant difference [F (3, 8) =0.24, p>0.05] between biomass yield in all treatments as shown in the ANOVA table above in all the treatments which was observed in the three different crops under the applied treatments. It was noted that the plants under 100% Rabbit urine in desmodium, oats and spinach plots did not perform better than the ones under 50% rabbit urine dilution and these could be attributed to the observed leaf scalding effect of the basic nature of rabbit urine pH. The serious scalding on the leaves of the plants treated with the neat urine caused leaf chlorosis which affected the photosynthetic process in plants resulting in poor growth performance. The performance of the plants under CF (commercial fertilizer) plots was dismal in all the three plant species except in oats compared to those of F50% and F 100% treatments and can be attributed to a less nutrient utilization efficiency on the part of the commercial fertilizer. It can also be attributed to the absence of the glycoprotein referred to as the (Tamm Horsfall glycoprotein) which has been found to be present in rabbit urine and plays an important role in plant nutrient metabolism (Fletcher *et al*., 1970). However, a different scenario was observed on the yield performance of oats at the best yield of 1850 gm on the plants treated with the CF (commercial fertilizer), followed by the oat those treated with 50%and 100% dilutions, respectively. This could have been due to the vulnerability of oats plants to the rabbit urine scalding effect which was not very adverse on the oat plants treated with the CF (commercial fertilizer). The Spinach plants recorded the highest biomass yield of 620 gm. on those plants treated with F50% fertilizer, CF with 531 gm and F 100% with 450 g, respectively.

CONCLUSION

From the results of the study, it can be concluded that rabbit urine had better nutrient composition than some of the commercial foliar fed fertilizers. Rabbit urine has sufficient levels of NPK and can be used to support increased yields in crop production and can be integrated with the use of chemical fertilizers to improve crop yield and soil fertility by reducing soil acidity, since it is a foliar feed only absorbed through leaves of plants unlike chemical fertilizers. The effect of scalding by rabbit urine was gradually observed to diminish as the plants grows. Also, it can be concluded that rabbit urine diluted with water at 50% concentration provides the best biomass yield when used as a foliar feed fertilizer on field crops.

RECOMMENDATION

Rabbit urine is recommended for use at a mixing rate of 50:50 for better crop performance and due to its basic nature can be used for soil acidity amendments to correct low soil pH. which is causing low crop yields in most parts of the country, and it is environmentally friendly. From the findings, it has been shown that there is a proportion of water that should be used in rabbit urine to ensure improved biomass yield and therefore it is recommended that farmers should seek use the right proportion of water and rabbit urine for effective results.

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