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The Effects of Rabbit Compost Tea and NPK Fertilizer on the Growth Parameters of Maize (*Zea mays* L.)

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ABSTRACT

This study evaluates the effects of rabbit compost tea and NPK (15-15-15) fertilizer on the growth parameters of maize (*Zea mays* L.) at the Teaching and Research Farm of Ekiti State Polytechnic, Isan-Ekiti. The treatments were laid out in a randomized complete block design (RCBD) with three replicates. Each replicate consisted of four (4) treatments. Total land area measured 88 m^2 (11 m by 8 m) with 12 plots, and each plot size measured 3 m by 2 m (6 m^2) with 1 m alleyways between plots and replicates. The treatments and application rate were the control, rabbit compost tea at 400 l ha^{-1}, a combination of NPK at 100 kg ha^{-1} and rabbit compost tea at 200 l ha^{-1}, and the application of NPK (15-15-15) fertilizer at the rate of 200 kg ha^{-1}, which was incorporated as the experiment's standard treatment. In the experiment, growth parameters of maize (*Zea mays* L.) were monitored and evaluated. Findings showed that the application of rabbit compost tea and NPK (15-15-15) fertilizer significantly ($p < 0.05$) increased the plant height, stem girth, number of leaves, and leaf area when compared with the control, especially when combined. According to this study, rabbit compost tea is an effective and sustainable organic amendment that smallholder maize farmers should consider using to improve growth and output.

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Introduction

Worldwide, maize, sometimes known as corn, is a crop that is cultivated in large quantities (Suleiman et al., 2013). According to Badu-Apraku & Fakorede (2017), maize (*Zea mays* L.) is a member of the grass family. Around the world, maize is a major grain crop that is planted in both temperate and tropical regions with a range of soil types and climates (Khaeim et al., 2022). In the world's cereal production, the three foremost cereal crops are maize, wheat (*Triticum aestivum*), and rice (*Oryza sativa*) but because of its affordable price, easy digestion and processing, and excellent yields, maize is most frequently eaten (Awopegba et al., 2017). According to Araújo et al. (2023), maize is a very nutritious crop that is commonly consumed by humans and animals, as well as utilized as a raw ingredient in the biofuels industry. But to have the best yields, maize needs careful fertility management because it uses a lot of nutrients. According to Gul et al. (2015), nitrogen, phosphorus, and potassium are the three major nutrients that maize needs. Nevertheless, many micronutrients, including calcium, magnesium, and sulfur, are needed in very small amounts.

Nigeria's fast urbanization has reduced the amount of land available for agriculture and, as a result of continuous cultivation, has also reduced the nutrient availability for crop growth (Aliyu & Amadu, 2017). The decrease in agricultural productivity makes it necessary for the bulk of Nigeria's smallholder farmers, which make up the country's farming population, to rely primarily on organic fertilizers that are locally sourced due to the inability to afford inorganic fertilizers (Vanlauwe et al., 2015). Over time, it has been discovered that the continuous use of inorganic fertilizers alone frequently lowers soil fertility, which ultimately results in poor crop growth. Since inorganic fertilizers leave behind heavy metal residues, some of which are deadly, the continuous use of these fertilizers to increase productivity in agriculture has become more dangerous for man, livestock, and the environment (Awopegba & Awodun, 2023). While both organic and inorganic fertilizers are needed for massive food production, it has been established that organic fertilizers are safe for the environment because they support the fragile environment (Fayose, 2022).

One excellent, nutrient-packed fertilizer that has numerous nutrients for crop growth is rabbit manure (also known as rabbit poop or pellets). Most importantly, rabbit compost tea and vermicompost, which are easy to make from rabbit manure, can be utilized as organic fertilizers to boost crop yields and quality. Dianita et al. (2022) found out that rabbit manure contains high levels of nitrogen. According to Dixie (2016) and Adi et al. (2020), fresh rabbit manure is a well-balanced fertilizer that contains roughly 2% nitrogen, 1% potassium, and 1% phosphorus; however, Minnich (2005) confirmed that fresh rabbit manure has 1.4% phosphorus, 2.4% nitrogen, and 0.6% potassium and also has the highest nitrogen content compared to other livestock manures. The nitrogen concentration of other animal manures, including cow dung, is just 0.4%; that of goat dung is 0.6%; and that of chicken dung is 1%. In terms of nutrients, rabbit manure is twice as rich as chicken manure and four times richer than cow or horse manure (Ame, 2021). According to Li et al. (2022), rabbit manure often has low water content and a good granule structure; this makes the utilization of rabbit manure simpler when compared to some other animal and poultry excrement. Other minerals contained in rabbit manure, including calcium, sulfur, magnesium, and other micronutrients, are also abundant in rabbit manure.

Rabbit compost tea is a natural, organic fertilizer made from rabbit manure, which is considered “cold” manure (Fitriyanto et al., 2022); that is, it can be added directly to plants immediately after collecting from the rabbit hutch without burning the plants (Wilson, 2023). Compost tea is a nutrient-rich solution obtained by fermenting compost in water to extract soluble organic matter (Affendy-Lee, 2022), beneficial microorganisms, and nutrients. It has been suggested as a potential alternative to synthetic fertilizers for promoting plant growth and improving soil health (Abou-El-Hassan & El-Batran, 2020). Ame (2021) suggests that rabbit compost tea can be produced by pouring one gallon of rabbit manure into a five-gallon bucket filled with water. Then, the bucket should be covered and put in a warm place, preferably under the sun, and the mixture should remain for three to five days. Finally, the liquid is obtained as compost tea after straining it, and it can be applied directly to the plants. Compost tea can be sprayed on leaves (foliar spray) or applied to the soil towards the roots of plants (soil drench). When used as a soil drench, it introduces beneficial organisms and nutrients into the soil, enhancing its overall fertility (Ralph, 2023). As a foliar spray, it provides nutrients directly to the plant and can help control foliar diseases (Rick, 2020). Little or no attention has been drawn to the use of rabbit compost tea for the growth of crops. However, this study will help to evaluate the effects of rabbit compost tea on maize growth parameters and compare the combined use of rabbit compost tea and NPK fertilizer on the growth parameters of maize.

Materials and Methods

Description of Experimental Site

The research work was conducted at the Teaching and Research Farm of Ekiti State Polytechnic, Isan-Ekiti, Nigeria. At an elevation of roughly 542 meters, this study region is situated between latitude 15° 39′ and longitude 70° 12′. It is located in the southwest of Nigeria, in a rainforest. There are two distinct seasons—the rainy and the dry—with an annual rainfall of about 1524 mm, distributed bimodally, with June and July seeing the most amounts of rainfall. The climate is hot and humid. There are approximately 2000 hours of sunlight and 81% relative humidity annually. The daily average temperature ranges from 27 to 37 degrees Celsius. Potential evapotranspiration is estimated to be 4.87 mm d^{-1}, whereas wind speed is 1.96 km d^{-1} (Akintola, 1986).

The experimental site was consistently planted with maize, cassava (*Manihot esculenta*), leafy vegetables, and okra (*Abelmoschus esculentus* L.) over the years. *Sita acuta, Panicum maximum, Thitonia diversifolia, and Chromolaena odorata* were among the prominent weed species identified. The experimental field was harrowed and cleared mechanically. After completion, the experimental layout was divided into plots and blocks.

Source of Materials

An improved maize hybrid (Ife Hybrid-5) was obtained from the International Institute of Tropical Agriculture. Rabbit pellets were collected from the Damilola Rabbitry Production Unit in Ibadan, Nigeria, and NPK (15-15-15) fertilizer was purchased from Let’s Farm Agricultural Inputs in Akure.

Preparation of Rabbit Compost Tea

The rabbit compost tea was prepared by adding 5 kg of rabbit pellet to 20 liters of water, and it was placed under the sun for four days with an enclosed lid. The mixture was stirred twice a day. Finally, the liquid strained from the mixture was known as compost tea, and it was sprayed onto the foliar part of the maize plants.

Planting and Cultural Practices

In an experimental field that had already been set up, the maize (*Zea mays* L.) seeds were manually planted at a depth of 3 cm. Twenty-five (25) maize plants were planted per plot, with a spacing of 75 cm x 45 cm (29,630 plants/ha) between each seeding. Hand-pulling and hoeing were the manual methods used to control weeds. Two rounds of weeding were conducted during the cropping period. The first and second weeding were carried out in the third and sixth weeks after planting. To avoid tampering with the experiment's outcomes, uprooted weeds were packed out of the experimental plots.

Experimental Design

Each treatment was replicated three times over the ten-week trial, which was set up using a randomized complete block design (RCBD). There were four (4) treatments in each replicate. With 12 plots measuring 2 m by 3 m (6 m^2) and 1 m of alleyways separating the plots and replicates, the total land area was 88 m^2 (11 m by 8 m). The experiment was conducted in 2023, from September 26 to December 5. Treatments were the control, NPK (15-15-15) fertilizer at 200 kg ha^{-1}, rabbit compost tea at 400 l ha^{-1}, and NPK (15-15-15) fertilizer at 100 kg ha^{-1} plus rabbit compost tea at 200 l ha^{-1}.

Treatment Application

NPK fertilizer was applied by side placement, while rabbit compost tea application was achieved by foliar spray. The treatments were split into two levels of applications, as illustrated in Table 1.

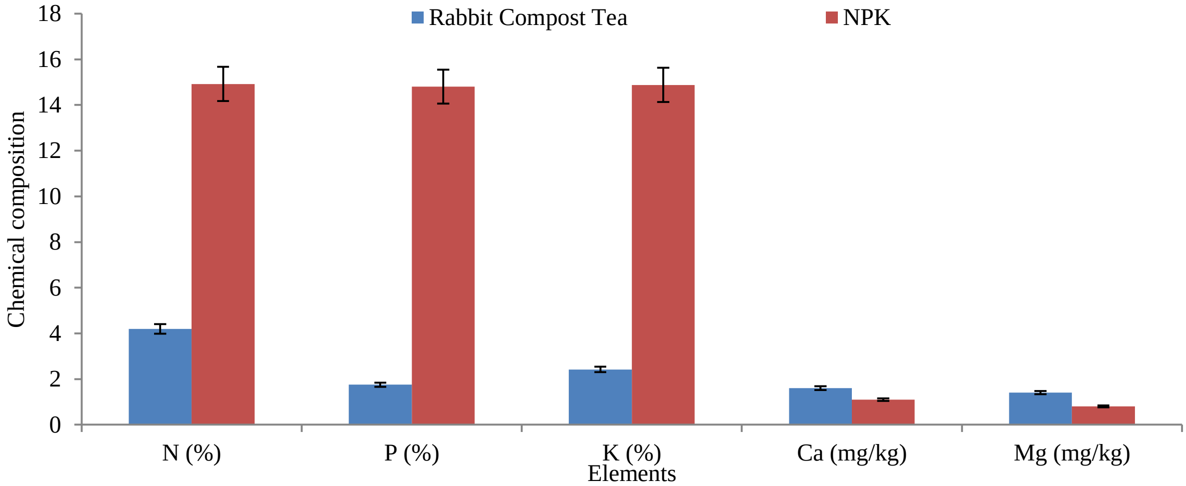

Figure 1. Chemical composition of rabbit compost tea and NPK (15-15-15) fertilizer

Table 1. List of fertilizer treatment combinations

Acronym	Treatment description
T_1	0 RCT + 0 NPK
T_2	100 kg ha-^{1} of NPK applied at 2 WAP + 100 kg ha-^{1} of NPK applied at 4 WAP
T_3	200 l ha^{-1} of RCT applied at 2 WAP + 200 l ha^{-1} of RCT applied at 4 WAP
T_4	200 l ha^{-1} of RCT applied at 2 WAP + 100 kg ha^{-1} of NPK applied at 4 WAP

RCT = Rabbit compost tea, WAP = Weeks after planting; T_1 = Control, T_2 = NPK (15-15-15) fertilizer at 200 kg ha^{-1}, T_3 = Rabbit compost tea at; 400 l ha^{-1} T_4 = NPK (15-15-15) fertilizer at 100 kg ha^{-1} plus rabbit compost tea at 200 l ha^{-1}.

Table 2. Effects of fertilizer treatments and time of application on plant height and number of leaves

Source	DF	PH	NoL
Rep	2	1165.48***	4.65***
Fertilizer	3	3674.73***	74.78***
Time	7	50283.92***	667.16***
Fertilizer*Time	21	1271.78***	20.80***
Error	62	602.01	17.35
Total	95	56997.93	784.74

DF, Degree of freedom; PH, Plant height; NoL, Number of leaves; *, **, *** and NS, significant at 0.05, 0.01, 0.0001, not significant

Table 3. Effects of fertilizer treatments on leaf area and stem girth

Source	DF	LA	SG
Rep	2	12919.05**	0.05**
Fertilizer	3	22300.13***	0.44***
Error	6	2563.22	0.01
Total	11	37782.38	0.5

DF, Degree of freedom; LA, Leaf area (m^2); SG, Stem girth; *,**,*** and NS, significant at 0.05, 0.01, 0.0001, not significant

Agronomic Data Collection

Plant height was measured with the use of the meter rule (cm), and the number of leaves was determined by counting the leaves. At ten weeks after planting, stem girth was measured via vernier caliper (cm), and leaf area (LA, cm^2) was calculated (Elings, 2000).

$$LA = \text{Leaf length x maximum leaf width} \times 0.75 \quad (1)$$

Data Analysis

The data obtained on the growth parameters were subjected to analysis of variance using Statistical Tool for Agricultural Research (STAR) software v2.0.1 (IRRI, 2013). Tukey's HSD test was used for post hoc comparison of means at a 95% confidence level ($P < 0.05$), while a graph was generated using Microsoft Excel 2010 edition.

Results

Figure 1 shows rabbit compost tea has a high N content of 4.2%. as obtained from the laboratory analysis. However, NPK fertilizer had a K content of 14.88%, which was far greater than rabbit compost tea. The highest P level was found in NPK fertilizer, with 14.80%. Rabbit compost tea had a 1.75% P content. Calcium and magnesium were the other elements that were analyzed. Rabbit compost tea contained the highest Ca and Mg content of 1.60 and 1.40 mg/kg, respectively, while NPK fertilizer had 1.10 and 0.80 mg/kg of Ca and Mg, respectively.

Throughout the maize growing period, all treatments produced significantly higher plant heights than the control (Table 2; Table 4). NPK had the tallest plants (26.33) at four weeks after planting (WAP), with rabbit compost tea coming in second (25.50). The combination of rabbit compost tea (RCT) at 200 l/ha and NPK fertilizer at 100 kg/ha could reasonably compete with NPK fertilizer on maize height at five weeks after planting. However, from eight weeks after planting until the end of the research project, the combination of NPK fertilizer at 100 kg/ha and rabbit compost tea at 200 l/ha produced the tallest plants, whereas the control had the shortest plants during the whole growth period of maize in this study.

Table 5 shows that the number of leaves was

significantly ($p < 0.05$) enhanced by both the NPK fertilizer and the combination of NPK and RCT fertilizer used as treatments (Table 2). Throughout the field study, the rabbit compost tea treatment produced more leaves than the control. The NPK and NPK plus RCT fertilizer treatments did not differ significantly ($p > 0.05$). The number of leaves in 10 WAP was found to have decreased in the plots with the NPK plus RCT fertilizer due to leaf shedding.

In Table 6, all the treatments significantly ($p < 0.05$) increased the maize leaf area when compared with the control at 10 WAP (Table 3). There are no significant differences ($p > 0.05$) among the rest of the treatments, but there were variations in leaf area in their response to treatments at 10 WAP, with values of 406.00, 396.75, and 409.00, respectively, for the NPK fertilizer, RCT, and NPK plus RCT.

As measured at 10 WAP, there were significant ($p < 0.05$) differences in stem girth among the treatments (Table 7; Table 3). The combined application of NPK and RCT manifested the highest stem girth. The application of NPK and RCT to maize resulted in a significant increase in stem girth, indicating that RCT is a great source of mineral nutrients required for plant growth. Even though NPK fertilizer at 200 kg/ha was employed as the standard for this research work, it was shown that NPK fertilizer could not compete with the combined usage of NPK and RCT. The application of RCT as a treatment demonstrates that it outperformed the control.

Table 4. Effect of rabbit compost tea and NPK fertilizer on plant height at different stages of maize growth

Treatments	Plant height (cm)							
	Weeks after planting							
	3	4	5	6	7	8	9	10
Control	14.67^{a}	18.83^{c}	23.27^{c}	34.67^{c}	47.80^{c}	58.63^{c}	60.03^{c}	60.33^{c}
NPK (15-15-15)	14.83^{a}	26.33^{a}	37.87^{a}	54.53^{a}	69.27^{a}	74.00^{b}	79.20^{ab}	79.66^{ab}
Rabbit compost tea (RCT)	13.13^{a}	25.50^{ab}	32.50^{b}	48.57^{b}	61.77^{b}	71.37^{b}	75.67^{b}	76.17^{b}
NPK + RCT	13.03^{a}	20.93^{bc}	35.26^{ab}	54.07^{a}	71.33^{a}	81.63^{a}	83.07^{a}	83.30^{a}
S.D	1.668	4.238	7.432	9.295	11.877	9.692	10.308	10.331
SEM	0.482	1.224	2.145	2.683	3.428	2.798	2.976	2.982

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.; S.D = Standard Deviation, SEM = Standard Error of the Mean

Table 5. Effect of rabbit compost tea and NPK fertilizer on the number of leaves at different stages of maize growth

Treatment	Number of leaves							
	Weeks after planting							
	3	4	5	6	7	8	9	10
Control	6.67b^{c}	9.00^{b}	9.00^{b}	11.00^{b}	11.67^{c}	12.33^{c}	13.00^{c}	12.67^{c}
NPK (15-15-15)	7.67^{a}	10.33^{a}	11.67^{a}	13.00^{a}	14.00^{ab}	15.33^{a}	15.67^{a}	15.67^{a}
Rabbit compost tea (RCT)	6.00^{c}	9.67^{ab}	11.00^{a}	12.67^{a}	13.3^{b}	14.00^{b}	14.33^{b}	14.33^{b}
NPK + RCT	7.00^{ab}	9.33^{b}	11.33^{a}	12.33^{a}	14.33^{a}	15.67^{a}	16.00^{a}	15.67^{a}
S.D	0.835	0.792	1.215	0.866	1.231	1.435	1.288	1.379
SEM	0.241	0.229	0.351	0.251	0.355	0.414	0.372	0.398

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

Table 6. Effect of rabbit compost tea and NPK fertilizer on leaf area at 10 WAP of maize

Treatments	Leaf area (cm^2)
	10 Weeks after planting
Control	
Mean ± SEM	305.00 ± 28.645^{b}
Mean ± S.D	305.00 ± 49.615^{b}
NPK (15-15-15)	
Mean ± SEM	406.25 ± 30.973^{a}
Mean ± S.D	406.25 ± 53.646^{a}
Rabbit compost tea (RCT)	
Mean ± SEM	396.75 ± 17.250^{a}
Mean ± S.D	396.75 ± 29.878^{a}
NPK + RCT	
Mean ± SEM	409.00 ± 22.426^{a}
Mean ± S.D	409.00 ± 38.843^{a}

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test

Table 7. Effect of rabbit compost tea and NPK fertilizer on stem girth at 10 WAP of maize

Treatments	Stem girth (cm)
	10 Weeks after planting
Control	
Mean ± SEM	1.63 ± 0.057[d]
Mean ± S.D	1.63 ± 0.098[d]
NPK (15-15-15)	
Mean ± SEM	2.05 ± 0.038[b]
Mean ± S.D	2.05 ± 0.066[b]
Rabbit compost tea (RCT)	
Mean ± SEM	1.86 ± 0.059[c]
Mean ± S.D	1.86 ± 0.102[c]
NPK + RCT	
Mean ± SEM	2.12 ± 0.045[a]
Mean ± S.D	2.12 ± 0.078[a]

Means with the same letter in the same column are not significantly ($p > 0.05$) different, as indicated by Tukey's HSD test

Discussion

Over the years, there has been a scarcity of information available on essential nutrients needed by plants in rabbit manure, as most individuals who raise rabbits do so for personal enjoyment or as a source of meat, without utilizing their waste for crop production. Some studies have investigated the use of rabbit urine as a liquid organic fertilizer to enhance the growth and yield of crop plants (Indabo & Abubakar, 2020; Kurnianta et al., 2021). This study has demonstrated that compost tea derived from rabbit pellets or manure contains significant levels of macro- and micronutrients. The presence of certain micronutrients makes rabbit compost tea suitable for maize growth in the study. Micronutrients, such as calcium, magnesium, and sulfur (commonly referred to as secondary macronutrients), are essential for maize growth, albeit required in smaller quantities. The application of rabbit compost tea as a fertilizer provides nutrients and beneficial microorganisms for maize plant growth without causing foliar damage. Rabbit compost tea contains 4.2% nitrogen, a concentration unmatched by other livestock or poultry manures.

The findings of this study reveal that rabbit compost tea, prepared without aeration, contains soluble nutrients and beneficial microorganisms that synergistically combat phytopathogenic organisms (Ramírez-Gottfried et al., 2023) and enhance crop plant growth. It is inferred that plots treated solely with rabbit compost tea outperformed the control group. Abou-El-Hassan & El-Batran (2020) proposed rabbit compost tea as a potential substitute for chemical fertilizers, as it promotes plant growth, enhances soil fertility, and offers an alternative to potentially harmful conventional NPK fertilizers.

Notably, the application of compost tea to maize plants has been associated with significantly increased plant growth and yields (Curadelli et al., 2023). However, this study also examines the combined use of organic manure (rabbit compost tea) and inorganic fertilizer (NPK). All observed growth parameters exhibited significant improvement compared to the control group when compared with other treatments. This study embraces the benefits of rabbit compost tea and reduced chemical fertilizer application for enhancing crop growth and soil health. The decreased use of chemical fertilizers ensures improved crop growth and environmental quality, promoting sustainable and ecologically friendly intensification, and ultimately enhancing local food production and food security.

Conclusion

This study demonstrated the benefits of using rabbit compost tea as a fertilizer for cultivating maize. The pattern of maize growth in this study infers that rabbit compost tea could compete positively with inorganic fertilizers. Preferably, the combination of rabbit compost tea at 200 l/ha and 100 kg/ha of NPK performed better when compared with the use of 200 kg/ha of NPK.

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