Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

Comparative Effect of NPK Fertilizer, Poultry Manure and Rice Mill Waste on Soil Chemical Properties, Nutrient Content and Performance of Ginger (*Zingiber officinale* Roscoe) in Umudike, Southeastern Nigeria

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ARTICLE INFO

Article history:
Received February 24th, 2022
Received in revised form April 7th, 2022
Accepted April 7th, 2022
Available online April 7th, 2022

Keywords:
Ginger
Nutrient content
Poultry manure
Rice mill waste
Soil chemical properties
Yield

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https://doi.org/10.36265 njss.2022.320103

ISSN– Online **2736-1411**
Print **2736-142X**

ABSTRACT

The study examined the comparative effect of NPK fertilizer, poultry manure and rice mill waste on soil chemical properties, nutrient content and performance of ginger in 2018 and 2019 at the National Root Crops Research Institute Farm, Umudike, Southeastern Nigeria, using ginger variety (UG 1) as the test crop. There were seven treatments consisting of sole and combinations of NPK15:15:15, poultry manure and rice mill waste with a rate of 45 kg N/ha regarded as a full dose. They were arranged in RCBD with three replications. Results showed that the application of the amendments significantly ($p<0.05$) increased soil chemical properties with the combined application of NPK and poultry manure, giving the highest value for most of the parameters determined. The NPK and poultry manure significantly reduced soil acidity from a very strong acidic level of 4.80 and 4.90 (initial values before the experiment) to 5.30 each year. It increased available phosphorus from 18.50 mg/kg to 23.50 mg/kg and exchangeable calcium from 3.60 cmol/kg to 4.40 cmol/kg in 2018 and it increased total nitrogen from 0.98 g/kg to 1.30 g/kg and exchangeable calcium from 3.20 cmol/kg to 4.00 cmol/kg in 2019. The combined treatment of NPK and poultry manure equally gave the highest nutrient content for both planting seasons; (N: 0.38%, P: 0.78%, K: 0.32%, Ca: 0.44% and Mg: 0.24%) in 2018 and (N: 0.34%, K: 0.31%, Ca: 0.31% and Mg: 0.19%) in 2019, except in the phosphorus content in 2019 was plot treated with the sole treatment of NPK gave the highest nutrient content of 0.72% and was significantly ($p<0.05$) higher than other treatments. The growth parameters were highest in the plot treated with NPK and poultry manure for both seasons. The highest yield of 49.6 t/ha and 51.0 t/ha were obtained from NPK and poultry manure in 2018 and 2019, respectively. Therefore, it can be concluded that the combination of NPK fertilizer and poultry manure is a promising amendment for increasing soil chemical properties, nutrient content, growth parameters and yield of ginger in Umudike.

1.0. Introduction

Ginger (*Zingiber officinale* Roscoe) is a member of the family Zingiberaceae. Ginger is a rhizomatic herbaceous perennial crop grown as an annual crop and is propagated vegetatively using the rhizome. It is an economically important plant cropped mainly for its variety of uses, especially its medicinal and flavouring potential (Schweitzer and Rio, 2007). Portuguese introduced it to West Africa in 1547 (Okwuowulu, 2005). In Nigeria, ginger cultivation started in 1927 in southern Kaduna before spreading to other parts of the country. Among the top countries that produce ginger, Nigeria ranks second in ginger production (FAO, 2009). The name given to ginger by the major tribes of Nigerians are; *Chitta* by the Hausas, Yoruba's *Ata'le*, Ibibios *Yinya* and Ibos *Ose-ala* (Udo *et al.,* 2005). There are two varieties of ginger commonly grown in Nigeria. They are yellow ginger (UG 1) and black ginger (UG 2). Among the root and tuber crops grown in Nigeria, ginger is the only one cultivated on a large scale for export. It is an important cash crop in Nigeria and is produced for export (Emehute, 2003).

Continuous cultivation of the crop in our limited land has led to nutrient deficiency that reduces crop uptake, growth and yield (Akinrinde, 2006). The continuous use of mineral fertilizer like NPK lead to soil acidity, nutrient imbalance, stunted growth and low yield (Ojeniyi,2000); presently, organic manures are being used as an alternative to mineral fertilizers. The neglect of these organic manures as a soil amendment has partly been attributed to their bulkiness, low nutrient quality, high Carbon: Nitrogen and lignin/N ratios, high cellulose and pectin content, and these make them comparatively longer to decompose and release nutrients to crops (Moyin-Jesu, 2008). These organic manures, therefore, need appropriate utilization in view of their plant nutrient potentials through scientific investigation. Based on this, the best approach to the utilization of these carbonaceous wastes is by complementing them with high nitrogen source materials to increase their mineralization process (Motavalli *et al*., 2001). This will prevent temporary nitrogen drain by microbes (Ogbodo, 2009). Organic manures have boosted crop growth, nutrient uptake and yield (Brower and Powel, 1995). The comparative effect of poultry manure and rice mill waste and their combinations with mineral fertilizer has helped to cushion the effect of soil acidity and provide most of the macronutrients (N, P, K, Ca and Mg) for plant consumption (Awodim, 2007). The objective of this study was to investigate the effects of sole and combined treatments of NPK 15:15:15, poultry manure and rice mill waste on soil chemical properties, nutrient content, growth and yield of ginger in Umudike Southeastern Nigeria.

2.0. **Materials and Methods**

2.1. Study Area

The field experiment was conducted in 2018 and 2019 at the National Root Crops Research Institute, Eastern Farm, Umudike Abia State. Umudike is located on latitude -05^{0}27$'$ North and longitude -07^{0}32$'$ East with an altitude of 123 meters above sea level. The locations had been under cultivation with a planned bush fallow system since the inception of the institute in 1923. Umudike is located within the tropical rainforest zone with a mean rainfall range of 1512 – 2200 mm, distributed over nine to ten months in a bimodal rainfall pattern. These are the early rain (April-July) and late rain (August-October) with five months of the dry season and a short dry spell in August. The monthly minimum air temperature ranged from 20^{0}C to 24^{0}C, while the monthly maximum air temperature ranged from 28^{0}C to 35^{0}C (NRCRI, Umudike Meteorological Station, 2014). Both soils were classified as Typic Paleudults by USDA classification (Chukwu, 2013).

2.2. Soil Sampling, Planting Material and Amendments

Soil samples were collected randomly at 0-20 cm depth from the two years trial before the commencement of the experiment, bulked, and a composite sample was taken for analysis. At the end of the experiment, three auger samples were taken per plot at the same depth, bulked, and a composite sample was taken for analysis. The composite soil samples were air-dried and passed through a 2 mm sieve for laboratory analysis. Ginger (*Zingiber officinale* Rosc) UG 1 variety was obtained from National Root Crops Research Institute, Maro sub-station, Kaduna State. The poultry manure was collected from a commercial poultry farm in Umudike. Rice mill waste was obtained from the Bende Local Government Area of Abia State, while the NPK fertilizer was purchased from an open market in Umuahia town.

2.3. Experimental Layout and treatments

The treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The study area was mapped out into 21 experimental plots. Each plot measured 1 m × 2 m with inter plot distance of 0.5 m and inter replicate distance of 2 m. The experimental plots were manually tilled into beds. In both 2018 and 2019 studies, the treatments were:

Control (no treatment)

NPK15:15:15 (45 kg N/ha)

Poultry manure (PM) (45 kg N/ha)

Rice mill waste (RMW) (45 kg N/ha)

NPK (22.5 kg N/ha) + PM (22.5 kg N/ha)

NPK (22.5 kg N/ha) + RMW (22.5 kg N/ha)

NPK (22.5 kg N/ha) + PM (11.25 kg N/ha) + RMW (11.25 kg N/ha)

2.4. Total N Content in the Organic Amendments used in the experiment

The organic amendments were applied to specified plots based on their N concentration (Table 2). The N concentration of each amendment was calculated to the quantity of 45 kg N/ha using the following equation:

100 kg of amendment ----------- N concentration in kg

ϰ amendment (kg N/ha) ------------ 45 kg N/ha

ϰ amendment (kg N/ha) =

$$\frac{100 \text{ kg of amendment} \times 45 \text{ kg N/ha}}{\text{N Concentration (kg)}}$$

In 2018, 45 kg N/ha Poultry manure (PM) = 2.1 t/ha and 45 kg N/ha Rice mill waste (RMW) = 3.8 t/ha

In 2019, 45 kg N/ha Poultry manure (PM) = 1.6 t/ha and 45 kg N/ha Rice mill waste (RMW) = 3.4 t/ha

2.5. Planting and data collection

The poultry manure and rice meal waste were incorporated into specified plots one week before planting, as stated by Iren *et al.,* 2011. One seed of ginger was planted per stand at a spacing of 0.2 m by 0.2 m (0.04 m^2), giving a plant population of 250 000 plants ha^{-1}. The NPK fertilizer was applied to specified plots in two doses (split application) 6 and 12 weeks after planting. Mulching was done between 24 to 48 hours after planting with dry leaves of guinea grass (*Panicum maximum*) at 50 t/ha. The farm was kept weed-free throughout the experiment. The ginger plant was planted in May for the 2018 and 2019 planting seasons, and it lasted for eight months in the field. Plant height was obtained as the length of the longest tiller from the base to the tip of the plant using a measuring tape, the number of leaves was counted in all the tillers per plant, and the total number of tillers per plant was taken, all at 5 months after planting. The weights of the fresh rhizomes were taken at harvest, and the nutrient content of the ginger rhizome was determined after that.

2.6. Laboratory Analyses

The particle size distribution was done using the Bouyoucos hydrometer method (Sheldrick and Wang, 1993). Soil pH was determined using a ratio of 1: 2.5 in soil water medium and read with a Digital pH - meter (Ibitoye, 2006). Soil total nitrogen was determined by the micro - Kjeldahl method (Bremner, 1996). The available phosphorus was extracted by the Bray - 2 extractants (Bray and Kurtz, 1945). The exchangeable bases (K^+, Ca^{2+}, and Mg^{2+}) were extracted with IN NH_4OAc, using a soil: solution volume ratio of 1:10. The K in the extract was read using a flame photometer, while Ca and Mg were determined by the EDTA titration method (IITA, 1989).

2.7. Ginger Rhizome and Organic Manure Analysis

The fresh samples of the ginger rhizome at harvest, at different treatment levels, were oven-dried at 70 ^{0}C for 72 hours and milled. 0.2g each of the powdered ginger at different treatment levels, and the poultry manure and rice mill waste used for the experiment were extracted using sulphuric acid and perchloric acid. The N, P, K, Ca and Mg in the extract were determined using the standard methods listed above.

2.8. Statistical analysis

Analysis of variance was carried out on each observation using GENSTAT Statistical package. Significant means were separated using Duncan's New Multiple Range Test (DNMRT) at a 5% level of probability.

3.0. **Results and Discussion**

3.1. Physical and Chemical Properties of the Soil before the Experiment

The properties of soils used in the experiment are presented in Table 1. The soils of the experimental sites for 2018 and 2019 were texturally classified as loamy sand. The soils were strongly acidic, low in total nitrogen and exchangeable bases. These results show that the soils need amendments to boost the fertility components of the soil for better performance; hence the nutrients were below the critical levels as stated by some researchers (Enwezor *et al*., 1990; FAO, 2006; Chude *et al*., 2004). Adequate management procedures are needed to improve the yielding capacity of these soils.

Table 1: Some Physical and Chemical Properties of Soil before Experimentation

Soil Properties	**Value**	
	2018	2019
Sand (g/kg)	814.00	850.00
Silt (g/kg)	106.00	46.00
Clay (g/kg)	80.00	104.00
Textural class	Loamy sand	Loamy sand
pH (H_2O)	4.80	4.70
Total nitrogen (g/kg)	1.12	0.98
Available phosphorus (mg/kg)	18.50	24.00
Exchangeable potassium (cmol/kg)	0.08	0.10
Exchangeable calcium (cmol/kg)	3.60	3.20
Exchangeable magnesium (cmol/kg)	1.60	1.20

3.2. Chemical Composition of the Manures used in the study

The chemical compositions of the poultry manure and rice mill waste are presented in Table 2. From the analysis of the organic amendments used for the studies, poultry manure had higher levels of total nitrogen and potassium than the rice mill waste in the amendments used for the 2018 and 2019 planting seasons, while phosphorus was highest in poultry manure in 2018 and highest in rice mill waste in 2019. Calcium was highest in rice mill waste in 2018 and 2019, respectively. The poultry manure and rice mill waste had high contents of potassium in 2018 and 2019, respectively. These are capable of improving the buffering potentials of the soil. Their high nitrogen content showed the level of nutrient reserve in poultry manure and rice mill waste which will be released during mineralization.

Table 2: Nutrient Composition of Organic Manures used For the two Planting Seasons

	2018		2019	
Parameter	Poultry manure (PM)	Rice mill waste (RMW)	Poultry manure (PM)	Rice mill waste (RMW)
Total Nitrogen (%)	2.1	1.19	2.87	1.33
Phosphorus (%)	4.55	3.20	2.58	3.53
Potassium (%)	2.90	1.97	1.66	1.07
Calcium (%)	1.24	2.41	1.60	2.20
Magnesium (%)	0.49	0.74	0.61	0.61

3.3. Properties of the Soil after Harvest for 2018 and 2019 Planting Seasons

Effects of sole and combined application of NPK (15:15:15), poultry manure and rice mill waste on soil chemical properties are presented in Table 3. The results obtained from these studies showed that the application of inorganic and organic fertilization significantly ($p < 0.05$) improved the soil's chemical properties (soil pH, available phosphorus, exchangeable; potassium, calcium, and magnesium). The combined application of 22.5 kg N/ha NPK 15:15:15 + 22.5 kg N/ha poultry manure gave the highest for most of the parameters measured in 2018 and 2019, respectively.

In 2018, 22.5 kg N/ha NPK 15:15:15 + 22.5 kg N/ha poultry manure significantly ($p<0.05$) reduced soil acidity from a strongly acidic level of 4.80 to 5.30. It increased available phosphorus from 18.50 mg/kg to 23.50 mg/kg and exchangeable calcium from 3.60 cmol/kg to 4.40 cmol/kg. In 2019, 22.5 kg N/ha NPK 15:15:15 + 22.5 kg N/ha poultry manure significantly ($p<0.05$) reduced soil acidity from a strongly acidic level of 4.70 to 5.30, increased total nitrogen from 0.98 g/kg to 1.30 g/kg and exchangeable calcium from 3.20 cmol/kg to 4.00 cmol/kg (Table 1) and (Table 3). These results align with what Ibeawuchi *et al. (*2006) stated that in the deteriorated soil of Nigeria, poultry manure application boosts the unconsumed soil calcium, magnesium and potassium. It is also in agreement with Hoffman *et al*., 2001, who stated that if inorganic fertilizer, especially nitrogen carrier, when combined with manure, the manure reduces soil acidification and improves the nutrient buffering capacity and the release of nutrients.

3.4. Comparative Effects of Sole and Combined use of NPK 15:15:15, Poultry Manure and Rice Mill Waste on Nutrient Content of Ginger

The effects of sole and combined treatments of NPK fertilizer, poultry manure and rice mill waste on nutrient content are shown in table 4. The application of NPK fertilizer, poultry manure and rice mill waste in a single or in a combined form significantly ($p<0.05$) increased the nutri-

Table 3: Comparative Effects of Sole and Combined Treatments of NPK 15:15:15, Poultry Manure and Rice Mill Waste on Soil Chemical Properties after Ginger Harvest

Treatment	2018						2019					
	pH H_2O	Total N (g/kg)	Av. P (mg/kg)	K (cmol/kg)	Ca	Mg	pH H_2O	Total N (g/kg)	Av. P (mg/kg)	K (cmol/kg)	Ca	Mg
Control	4.60e	0.60d	12.20d	0.05c	2.00c	0.80e	4.50c	0.70c	14.80d	0.05c	2.40e	0.80e
45 kg N/ha NPK 15:15:15	4.80d	1.30a	20.00bc	0.06bc	2.80b	1.20d	4.90b	1.10b	23.30a	0.06bc	2.80d	1.20d
45 kg N/ha Poultry Manure (PM)	5.20ab	0.80c	19.00c	0.07ab	4.00a	2.40a	5.20a	1.00b	22.80ab	0.07ab	3.60b	1.60c
45 kg N/ha Rice Mill Waste (RMW)	5.00c	1.00b	21.00abc	0.07ab	3.20b	1.60c	4.90b	1.10b	22.50b	0.07ab	3.20c	1.20d
22.5 kg N/ha NPK + 22.5 kg N/ha PM	5.30a	1.10b	23.50a	0.08a	4.40a	2.40a	5.30a	1.30a	23.00ab	0.08a	4.00a	2.00b
22.5 kg N/ha NPK + 22.5 kg N/ha RMW	5.10bc	1.00b	19.50bc	0.08a	4.00a	2.00b	5.00b	1.10b	20.50c	0.08a	3.20c	1.60c
22.5 kg N/ha NPK + 11.25 kg N/ha PM + 11.25 kg N/ha RMW	5.20ab	1.10b	22.00ab	0.08a	4.00a	2.40a	5.20a	1.30a	23.50a	0.07ab	3.60b	2.40a

Table 4: Comparative Effects of Sole and Combined Treatments of NPK 15:15:15, Poultry Manure and Rice Mill Waste on Ginger Rhizome Nutrient Content

Treatment	2018					2019				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
	%					%				
Control	0.28d	0.40c	0.25c	0.26e	0.11c	0.25d	0.46d	0.25d	0.18c	0.09c
45 kg N/ha NPK 15:15:15	0.32bc	0.74a	0.29b	0.29de	0.20a	0.28c	0.72a	0.27c	0.24b	0.15b
45 kg N/ha Poultry Manure (PM)	0.36a	0.71a	0.32a	0.33cd	0.21a	0.28cd	0.57c	0.30ab	0.24b	0.15b
45 kg N/ha Rice Mill Waste (RMW)	0.28cd	0.62b	0.26c	0.28e	0.15b	0.28cd	0.47d	0.27c	0.20c	0.10c
22.5 kg N/ha NPK + 22.5 kg N/ha PM	0.38a	0.78a	0.32a	0.44a	0.24a	0.34a	0.65b	0.31a	0.31a	0.19a
22.5 kg N/ha NPK + 22.5 kg N/ha RMW	0.32bc	0.73a	0.30ab	0.37bc	0.22a	0.28cd	0.59c	0.28c	0.29a	0.18a
22.5 kg N/ha NPK + 11.25 kg N/ha PM + 11.25 kg N/ha RMW	0.35ab	0.73a	0.31ab	0.41ab	0.22a	0.31b	0.66b	0.28bc	0.29a	0.18a

ent content of ginger when compared with the control plot.

In 2018, the plot treated with 22.5 kg N/ha NPK 15:15:15 + 22.5 kg N/ha poultry manure gave the highest nutrient content in all the parameters determined (N: 0.38%, P: 0.78%, K: 0.32%, Ca: 0.44% and Mg: 0.24%). In N content, it did not show any significant difference with the plot treated with 22.5 kg N/ha NPK + 11.25 kg N/ha poultry manure +11.25 kg N/ha rice mill waste (0.35%). The P content showed a significant difference with the plot treated with 45 kg N/ha rice mill waste (0.62%) and the control plot (0.40%). K content did not show any significant difference with the combined plots and sole treatment of poultry manure. Ca content showed a significant difference with all the plots except the plot treated with 22.5 kg N/ha NPK + 11.25 kg N/ha poultry manure + 11.25 kg N/ha rice mill waste (0.41%). Finally, the Mg content showed a significant difference with the plot treated with 45 kg N/ha rice mill waste (0.15%) and the control plot (0.11%).

In 2019, the plot treated with 45 kg N/ha NPK gave the highest P content of 0.72%, and it was significantly ($p<0.05$) higher than other treatments. The plot treated with 22.5 kg N/ha NPK + 22.5 kg N/ha poultry manure gave the highest nutrient content in the other parameters determined (N: 0.34%, K: 0.31%, Ca: 0.31% and Mg: 0.19%). In N content, it showed a significant difference from other treatments. The K content did not show any significant difference with the sole treatment of poultry manure. Ca and Mg contents did not show any significant ($p<0.05$) difference with the combined plots. The results obtained from this research are in agreement with the findings of Odedina *et al*., 2011, who observed that the consistent increase in tissue nutrient contents given by poultry manure explains why it is the only manure that gave a significant increase in growth and yield of cassava. It is also in line with the research of Nweke and Nsoanya (2013), who reported that a combination of poultry manure and inorganic fertilizer gave a better result than the sole application of either poultry manure or inorganic fertilizer.

3.5. Comparative Effect of Sole and Combined use of NPK 15:15:15, Poultry Manure and Rice Mill Waste on Growth Parameter of Ginger

Application of NPK fertilizer, poultry manure and rice mill waste in a single or in a combined form improved growth parameters when compared with the control. In both seasons, the plot treated with the application of 22.5 kg N/ha NPK 15:15:15 + 22.5 kg N/ha poultry manure gave the highest plant height of 48.05 cm and 47.67cm, number of leaves (74.99 and 77.13) and number of tillers (6.07 and 5.65) for 2018 and 2019 respectively. They were closely followed by plots treated with 22.5 kg N/ha NPK 15:15:15 + 11.25 kg N/ha poultry manure + 11.25 kg N/ha rice mill waste in both seasons as follows: plant height (47.12 cm and 46.73), number of leaves (74.23and 76.80) and number of tillers (5.66 and 5.45). Then the plot treated with 22.5 kg N/ha NPK 15:15:15 + 22.5 kg N/ha rice mill waste gave the plant heights of (44.92 cm and 45.93 cm) and the number of leaves (73.82 and 76.47) for 2018 and 2019, respectively. The plot treated with 45 kg N/ha poultry manure only showed a similar trend in plant height (45.37 cm) and the number of tillers (5.40) in the 2018 planting season. Plots with any quantity of poultry manure gave higher plant height, number of leaves and number of tillers. This agrees with Ketkar's (1993) findings that the combination of nitrogen from different organic manures was comparable on an equivalent nitrogen basis in which poultry manure proved to be a better source. This could be the reason for the result gotten from all the treatments having poultry manure in them. The findings of Pool *et al*. (2000) state that there is a complementary nutrient release by both organic and inorganic fertilizer.

Table 5: Comparative Effect of Sole and Combined Treatments of NPK 15:15:15, Poultry manure and Rice Mill Waste on Growth of Ginger

Treatment	**2018**			**2019**		
	Plant Height (cm)	Number of Leaves	Number of Tillers	Plant Height (cm)	Number of Leaves	Number of Tillers
Control	37.05d	58.32d	3.67d	35.13e	55.80c	4.00d
45 kg N/ha NPK 15:15:15	41.77c	70.23b	5.27bc	42.60d	74.50a	5.60a
45 kg N/ha Poultry Manure (PM)	45.37abc	69.63b	5.40abc	43.73bcd	70.40b	4.53c
45 kg N/ha Rice Mill Waste (RMW)	43.93bc	66.39c	4.73c	43.00cd	66.93b	4.50c
22.5 kg N/ha NPK + 22.5 kg N/ha PM	48.05a	74.99a	6.07a	47.67a	77.13a	5.65a
22.5 kg N/ha NPK + 22.5 kg N/ha RMW	44.92abc	73.82a	5.07bc	45.93abc	76.47a	4.98b
22.5 kg N/ha NPK + 11.25 kg N/ha PM + 11.25 kg N/ha RMW	47.12ab	74.23a	5.66ab	46.73ab	76.80a	5.45a

3.6. Comparative Effects of Sole and Combined use of NPK, Poultry Manure and Rice Mill Waste on Fresh Rhizome Yield of Ginger at Harvest

The effects of sole and combined treatments of NPK fertilizer, poultry manure and rice mill waste on yield are shown in Table 6. The application of treatments significantly ($p<0.05$) increased the yield of ginger rhizome over the control. The application of 22.5 kg N/ha NPK 15:15:15 + 22.5 kg N/ha poultry manure gave the highest yield of 49.6 t/ha and 51.0 t/ha for the 2018 and 2019 planting seasons. There were no significant ($p<0.05$) differences between plots treated with sole 45 kg N /ha poultry manure (47.5 t/ha and 50.0 t/ha), respectively. This agrees with the findings of Murwira and Kirchmann (1993) and Iren *et al*. (2012), who observed that the nutrient use efficiency of crops is increased through a combined application of organic manure and mineral fertilizer.

Table 6: Comparative Effect of Sole and Combined Treatments of NPK 15:15:15, Poultry manure and Rice Mill Waste on Fresh Ginger Yield

Treatment	**2018**	**2019**
	Fresh Yield t ha^{-1}	Fresh Yield t ha^{-1}
Control	26.8e	28.3d
45 kg N/ha NPK 15:15:15	42.7d	39.8c
45 kg N/ha Poultry Manure (PM)	47.5ab	50.0a
45 kg N/ha Rice Mill Waste (RMW)	44.9c	44.2b
22.5 kg N/ha NPK + 22.5 kg N/ha PM	49.6a	51.0a
22.5 kg N/ha NPK + 22.5 kg N/ha RMW	46.7bc	44.4b
22.5 kg N/ha NPK + 11.25 kg N/ha PM + 11.25 kg N/ha RMW	47.1b	46.0b

4.0. Conclusion

The study confirms the potential of NPK 15: 15:15, Poultry manure and rice mill waste, either singly or combined, to significantly improve the soil chemical properties, nutrient content, growth and yield of ginger in Umudike, Southeastern Nigeria. Poultry manure application at 22.5 kg N/ha in combination with 22.5 kg N/ha NPK 15:15:15 improved the soil chemical properties, nutrient content, growth parameters and yield of ginger.

Poultry manure applied singly at the rate of 45 kg N/ha significantly ($p<0.05$) improved ginger yield and most of the soil chemical properties and nutrient content of ginger. Poultry manure in the application at 11.25 kg N/ha in combination with 11.25 kg N/ha rice mill waste and 22.5 kg N/ ha NPK 15:15:15 significantly improved soil chemical properties, growth parameters and most of the nutrient content of ginger. The study further demonstrates that the efficiency of poultry manure will be improved when combined with NPK fertilizer or in combination with NPK fertilizer and rice mill waste.

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