

ASSESSMENT OF NUTRIENT RELEASE RATE AND PATTERN OF ORGANIC FERTILIZER IN ASABA SOILS, DELTA STATE, NIGERIA

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ABSTRACT

Utilization of organic fertilizer as soil amendment requires effective management for enhanced nutrient released rates. The study was initiated to monitor the nutrient release rates of four organic fertilizer materials { Rice husk with water (RH), Rice husk [42 kg] + Cow dung [18 kg] with water (RHCd), Rice husk [60 kg] with cassava mill effluent (RHC) and Rice husk [42 kg] + cow dung [18 kg] with cassava mill effluent (RHCdC)} in Delta State University, Asaba Campus. The materials were applied at three levels (2.5, 5.0 and 10.0 t ha⁻¹) with a control (without soil amendment) in three replicates. Soil samples used were taken at the Agronomy Department Experimental Field, 400 g of soil with the materials were weighed into plastic and water was added to field capacity. These were arranged in completely randomized design in drawer and nutrient released were monitored weekly for 14 weeks. Soil pH, organic carbon, total nitrogen, available phosphorus and exchangeable potassium were evaluated. Data obtained were analysed with standard deviation and coefficient of variation. Results indicated that high immobilization of nutrients measured in all the materials before re-mineralization. The RHCdC at 10 t/ha releases the highest organic carbon (23.4 g/kg), total nitrogen (2.33 g/kg), available phosphorus (81 mg/kg) and exchangeable potassium (0.33 cmol/kg). It can be concluded that immobilization was more severe with higher application at the early stage and it also followed same trend during mineralization.

Keywords: Rice husk, cowdung, compost, Asaba, incubation

INTRODUCTION

Nutrient mineralization is a biological process and the amount released in soil depends on the organic material composition, especially the C: N ratio and soil microbes present (Binh and Shima, 2018). The knowledge of nutrient prediction of organic fertilizer mineralization will play significant role in soil nutrient management. This is because according to Binh *et al.* (2015), nutrient derived from organic fertilizer relied on mineralization and immobilization processes. Information of the mineralization rate is important in crop productivity because crop growth is governed by nutrient availability (Binh and Shima, 2018). The knowledge of nutrient mineralization rate of organic fertilizer in soil management will help to avoid excess application and reduce losses while optimizing residue management for better crop production (Masunga *et al.*, 2016).

Soil amended with organic fertilizer not only improves soil carbon content but also reduces nutrient loss by immobilizing inorganic nutrient to organic form (Binh and Shima, 2018). Organic fertilizer with low C:N ratios and high nitrogen contents decompose faster and releases sufficient nutrient element for crop uptake while immobilization takes place in organic fertilizer with lower N contents and higher C:N ratios (Binh and Shima, 2018). Predicting the amount of nutrients produced by organic fertilizer in the soils is a key factor for proper nutrient management. This is necessary because most arable crops complete their reproductive cycles within three months of cultivation, so it is important when the organic fertilizer releases its nutrient, this information will guide in proper soil management. Nutrients release rates of different types of organic fertilizers that are used as soil amendment for crop growth are often known (Olowoake, 2017). Understanding the nutrient

mineralization of which organic fertilizer will guide fertilizer recommendation and this will prevent inappropriate applications by farmers. Hence, the investigation aims to assess the nutrient release rates of the selected organic fertilizer.

MATERIALS AND METHODS

Experimental Site

The study was conducted in Delta State University, Department of Agronomy Laboratory, Asaba Campus. Asaba is at longitude $6^{\circ} 14^1$ N and latitude $6^{\circ} 49^1$ E with an annual rainfall of 1500 to 1849.3 mm and mean temperature of 24.1°C . Rainfall starts March till November while the dry seasons run from late November to early March.

Treatment, Experimental Design and Procedures

The rice husk and cowdung were used to prepare four different composts for fourteen weeks [Rice husk with water (RH), Rice husk (42 kg) + Cow dung (18 kg) with water (RHCd), Rice husk (60 kg) with cassava mill effluent (RHC) and Rice husk (42 kg) + cow dung (18 kg) with cassava mill effluent (RHCdC)]. The soil used for the incubation was collected from the New Experimental Field, Department of Agronomy at the depth of 0 – 30 cm. Soil samples and the compost were weighed into each plastic and water was added to field capacity. The Plastics were laid out in completely randomised design and the incubation was done according to Masunga *et al.* (2016). Composts were applied at 2.5, 5.0 and 10.0 t ha^{-1} to 400 g of soil and

replicated three times. In control treatment, no compost was applied, though the soil samples were incubated the same way as the soils in compost treatments at room temperature. The plastic containers were checked daily for weight loss and water was added to maintain moisture content. Two hundred and fifty two (259) plastic containers were used for the incubation that is 7 plastic containers for each treatment. Soil samples with the containers were drawn at two weeks intervals.

Data Collection and Laboratory Analysis

One plastic container with the content was taken from each replicate and bulk together in each treatment and used to determine soil pH, organic matter, N, P and K at the Analytical Laboratory, University of Ibadan.

Data Analysis

The data obtained were analysed with descriptive statistics such as standard deviation and coefficient of variation.

RESULTS

Total Nitrogen

Table 1 shows the effects of composts on nitrogen mineralization. There was decline at 2 weeks of incubation except for the control that increases and peaked at the two weeks. The 5.0 t ha^{-1} of RH peaks at 4 and 8 weeks while 5.0 t ha^{-1} of RHC peaked at 6 weeks. The RHCdC at 5 t ha^{-1} peaks at 10 weeks, at 12 weeks, 2.5 t ha^{-1} of RHCdC had the highest total N while 10.0 t ha^{-1} of RHCdC peaked at 14 weeks of incubation.

Table 1 Effects of compost on total nitrogen (g kg⁻¹) at 0-14 weeks of incubation

Compost	Rate	Weeks of incubation							
		0	2	4	6	8	10	12	14
Control		1.78	1.98	2.21	1.41	2.40	2.08	1.91	0.88
RH	2.5	1.78	1.23	1.94	1.98	2.11	2.21	1.61	1.50
RH	5.0	1.78	1.33	2.33	1.86	2.67	2.34	1.88	1.36
RH	10	1.78	1.01	1.88	2.11	1.88	2.21	1.81	2.08
RHC	2.5	1.78	1.60	1.88	1.37	2.01	1.46	1.35	1.72
RHC	5.0	1.78	0.91	2.21	2.21	0.93	2.30	2.22	2.26
RHC	10	1.78	0.71	1.63	1.45	0.62	2.35	1.94	1.99
RHCd	2.5	1.78	1.05	1.68	1.40	2.33	1.90	1.91	1.98
RHCd	5.0	1.78	0.64	2.17	1.48	0.87	1.81	1.46	1.35
RHCd	10	1.78	1.38	1.91	1.33	1.17	2.33	1.73	2.11
RHCdC	2.5	1.78	0.38	1.96	1.66	1.96	2.21	2.41	2.31
RHCdC	5.0	1.78	1.11	2.10	1.38	1.91	2.37	2.01	2.07
RHCdC	10	1.78	0.81	1.64	2.00	1.47	1.84	1.88	2.33
SD ±			0.43	0.23	0.31	0.62	0.27	0.27	0.43
CV %			39.1	11.0	18.5	36.1	12.9	14.2	23.9

Legend

RH - Rice husk with water, SD- Standard deviation, RHC - Rice husk with cassava mill effluent, CV-Coefficient of variation, RHCd - Rice husk + cow dung with water, RHCdC - Rice husk + cow dung with cassava mill effluent

Organic Carbon

Effects of composts on organic carbon is presented in Table 2. The organic carbon declined at 2 weeks of incubation. The control had its peaks at 2 weeks, 5 t ha⁻¹ of RH peaked at 4

weeks. The RH at 2.5 t ha⁻¹ had its peaks at 6 weeks and 5.0 t ha⁻¹ of RH peaked at 8 and 10 weeks. The t ha⁻¹ RHCdC had highest organic carbon at 14 weeks.

Table 2 Effect of compost on organic carbon (g kg⁻¹) at 0-14weeks of incubation

Compost	Rate	Weeks of incubation							
		0	2	4	6	8	10	12	14
Control		20.4	19.5	21.0	13.6	21.8	20.1	18.3	7.9
RH	2.5	20.4	13.2	19.0	23.7	20.1	21.4	15.7	14.4
RH	5.0	20.4	12.8	21.8	17.6	26.5	23.5	18.3	13.1
RH	10	20.4	9.6	18.3	22.1	17.2	21.4	12.4	20.1
RHC	2.5	20.4	10.0	16.8	13.6	22.9	17.9	18.3	19.2
RHC	5.0	20.4	8.4	21.5	20.5	9.0	22.2	21.4	21.8
RHC	10	20.4	6.0	15.8	14.8	5.0	23.2	18.8	18.3
RHCd	2.5	20.4	10.0	16.8	13.6	22.9	17.9	18.3	19.2
RHCd	5.0	20.4	5.6	21.4	15.2	8.2	16.6	14.0	13.1
RHCd	10	20.4	14.1	18.3	12.0	11.1	22.2	16.7	20.1
RHCdC	2.5	20.4	2.4	18.6	16.0	18.6	21.0	21.4	22.2
RHCdC	5.0	20.4	7.6	19.7	13.6	18.3	22.7	20.9	20.1
RHCdC	10	20.4	9.2	17.2	19.3	14.7	18.3	19.4	23.4
SD ±			4.42	1.85	3.36	6.11	2.74	2.92	4.30
CV %			42.9	9.6	20.2	37.5	13.4	16.62	24.3

Legend

RH - Rice husk with water, SD- Standard deviation, RHC - Rice husk with cassava mill effluent, CV-Coefficient of variation, RHCd - Rice husk + cow dung with water, RHCdC - Rice husk + cow dung with cassava mill effluent

Soil pH

The soil pH increased from 2 to 14 weeks of incubation (Table 3). The RH and RHCd at 10.0 t ha⁻¹ peaked at 2 weeks. The control peaked

at 6 weeks while 10.0 t ha⁻¹ of RH peaked at 8 weeks. The RHCd at 2.5 t ha⁻¹ and 10.0 t ha⁻¹ of RHCdC peaked at 14 weeks of incubation.

Table 3 Effects of compost on soil pH changes at 0-14 weeks of incubation

Compost	Rate	Weeks of incubation							
		0	2	4	6	8	10	12	14
Control		5.2	5.1	5.4	5.5	5.3	5.2	5.3	5.4
RH	2.5	5.2	5.2	5.3	5.2	5.3	5.2	5.4	5.4
RH	5.0	5.2	5.3	5.4	5.2	5.4	5.3	5.4	5.6
RH	10	5.2	5.4	5.4	5.3	6.1	5.4	5.5	5.5
RHC	2.5	5.2	5.3	5.4	5.0	5.3	5.2	5.4	5.4
RHC	5.0	5.2	5.3	5.3	5.3	5.4	5.3	5.4	5.5
RHC	10	5.2	5.3	5.4	5.3	5.1	5.4	5.5	5.5
RHCd	2.5	5.2	5.3	5.3	5.2	5.3	5.3	5.4	5.8
RHCd	5.0	5.2	5.3	5.2	5.3	5.3	5.3	5.4	5.5
RHCd	10	5.2	5.4	5.4	5.4	5.5	5.5	5.5	5.4
RHCdC	2.5	5.2	5.2	5.2	5.1	5.3	5.3	5.4	5.5
RHCdC	5.0	5.2	5.3	5.1	4.9	5.3	5.5	5.5	5.7
RHCdC	10	5.2	5.3	5.3	5.1	5.3	5.4	5.5	5.8
SD ±			0.08	0.10	0.16	0.23	0.10	0.06	0.14
CV %			1.5	1.9	3.1	4.3	1.9	1.1	2.5

Legend

RH - Rice husk with water, SD- Standard deviation, RHC - Rice husk with cassava mill effluent, CV-Coefficient of variation, RHCd - Rice husk + cow dung with water, RHCdC - Rice husk + cow dung with cassava mill effluent

Available phosphorus

Available phosphorus decreased at the beginning (2 weeks) of the incubation except RH and RHCd at 10.0 t ha⁻¹ (Table 4). At 2 weeks, 10.0 t ha⁻¹ of RH had its peaks. The RH at 2.5 t ha⁻¹ peaks at 4, 6 and 8 weeks. The 10.0 t ha⁻¹ of RH peaks at 10 weeks and 10.0 t ha⁻¹ of RHC peaks at 12 weeks while 10.0 t ha⁻¹ of RHCdC peaked at 14 weeks.

Exchangeable potassium

Exchangeable potassium decreased at the initial weeks (Table 5) except for 5.0 t ha⁻¹ of RHC that decreases at 4 and 6 weeks. The 2.5 t ha⁻¹ of RH, 5.0 t ha⁻¹ of RHCdC and 10.0 t ha⁻¹ of RHCdC decreased at 8 weeks. The 2.5 t ha⁻¹ of RHCd peaks at 12 weeks while 10.0 t ha⁻¹ of RHCd peaked at 14 weeks of incubation.

Table 4 Effects of compost on available phosphorus (mg kg⁻¹) at 0-14 weeks of incubation

Compost	Rate	Weeks of incubation							
		0	2	4	6	8	10	12	14
Control		62.8	63.2	84.2	86.2	71.2	52.8	46.2	52.5
RH	2.5	62.8	73.4	135.5	182.8	149.8	68.3	62.4	66.5
RH	5.0	62.8	78.7	81.2	87.3	139.9	72.4	68.1	59.4
RH	10	62.8	84.1	189.9	86.0	90.6	80.6	82.2	74.0
RHC	2.5	62.8	78.9	84.9	81.3	75.9	65.9	66.7	66.8
RHC	5.0	62.8	70.6	130.1	69.6	59.9	60.7	63.1	66.3
RHC	10	62.8	71.6	73.5	59.5	71.9	64.8	87.1	68.6
RHCd	2.5	68.2	72.2	89.7	80.2	84.1	71.3	84.3	63.5
RHCd	5.0	62.8	71.1	84.6	76.1	90.3	67.9	68.3	66.5
RHCd	10	62.8	83.9	103.5	78.0	86.7	76.3	81.7	69.0
RHCdC	2.5	62.8	65.3	74.9	62.7	130.1	67.1	78.1	80.2
RHCdC	5.0	62.8	66.8	88.2	67.4	100.5	60.5	80.3	79.2
RHCdC	10	62.8	65.9	76.1	62.9	65.5	65.2	82.2	81.0
SD ±			6.6	32.2	30.2	27.8	6.9	11.3	7.9
CV %			9.1	32.3	36.3	29.7	10.2	15.5	11.5

Table 5 Effects of compost on potassium (cmolk⁻¹) at 0-14 weeks of incubation

Compost	Rate	Weeks of incubation							
		0	2	4	6	8	10	12	14
Control		0.20	0.25	0.17	0.16	0.17	0.14	0.12	0.15
RH	2.5	0.20	0.46	0.20	0.26	0.21	0.20	0.20	0.21
RH	5.0	0.20	0.60	0.26	0.26	0.36	0.16	0.24	0.24
RH	10	0.20	0.41	0.31	0.42	0.23	0.29	0.25	0.23
RHC	2.5	0.20	0.34	0.25	0.36	0.24	0.20	0.21	0.25
RHC	5.0	0.20	0.29	0.19	0.21	0.36	0.19	0.20	0.17
RHC	10	0.20	0.35	0.24	0.31	0.39	0.27	0.21	0.19
RHCd	2.5	0.20	0.39	0.23	0.24	0.27	0.19	0.33	0.21
RHCd	5.0	0.20	0.26	0.23	0.25	0.24	0.21	0.25	0.22
RHCd	10	0.20	0.45	0.37	0.37	0.25	0.26	0.32	0.34
RHCdC	2.5	0.20	0.31	0.22	0.32	0.23	0.21	0.24	0.26
RHCdC	5.0	0.20	0.35	0.26	0.27	0.15	0.19	0.30	0.31
RHCdC	10	0.20	0.34	0.37	0.40	0.21	0.18	0.31	0.33
SD ±			0.09	0.06	0.07	0.07	0.04	0.05	0.06
CV %			24.3	24.0	23.3	26.9	19.0	20.0	25.0

Legend

RH - Rice husk with water, SD- Standard deviation, RHC - Rice husk with cassava mill effluent, CV-Coefficient of variation, RHCd - Rice husk + cow dung with water, RHCdC - Rice husk + cow dung with cassava mill effluent

DISCUSSION

Immobilization of organic carbon and nitrogen increased rapidly in the composts (RH, RHC, RHCd and RHCdC) at the beginning of the incubation before mineralization and this was attributed to microbial population that increases due to application of the materials (Binh and Shima, 2018). The composts immobilize nutrient in soil before mineralization of the materials. Murwira and Kirchmann (1993), observed decreased of nutrient element during early plant growth in soil amended with compost. Mineralization and immobilization rate of organic fertilizer depends mostly on nitrogen concentration (Goos, 1995). Micro-organisms in soils such as heterotrophic microbes often use soil carbon as energy source and nitrogen for population increase. This could lead to temporary decline in plant nutrient in soil applied with organic fertilizer (Ojobor *et al.*, 2012).

The nitrogen concentration in the organic fertilizer ranges from 1.5 to 2.33 g/kg while the critical nitrogen concentration of organic matter was 25 g/kg leading to immobilization. The variation in nutrient content of the organic fertilizer resulted in different peaks observed during the incubation period, these variations in organic fertilizer mineralization was reported by Roy and Kaashem, (2014). The low nitrogen concentration of the organic fertilizer led to immobilization of nutrients most especially nitrogen. If the N concentration is below 20 24 g N/kg, immobilization will exceed mineralization and the decomposing compost will tie up N rather than releasing it. This may explain the reduced N recorded during the initial week of incubation. The different nutrient peaks observed might be due to different formulation. This agreed with the findings of Ojobor (2018) that stated nutrient mineralization differs depending on the compost types since the inorganic/organic fraction and quality of organic N vary. Nitrogen mineralization increased thus: Rice husk with water > Rice husk + cow dung with water > Rice husk with cassava mill effluent > Rice husk +

cow dung with cassava mill effluent. This indicating that rice husk with cassava mill effluent released higher nutrient than rice husk with water. The may be due to lower C:N ratio of the materials though the patterns were similar (Nyamangara *et al.*, 2009).

Compost at higher rate releases more nutrients compared to the lower rate, this implies planning is necessary in time of application to synchronize high crop uptake with nutrient release. The available phosphorus decreased two weeks after incubation and it could be due to immobilization as a result of phosphorus being utilized in microbial population (Masunga *et al.*, 2016). The highest potassium mineralized was observed at fourteen weeks of incubation with rice husk plus cow dung. The increase of potassium values with application of RHCdC at 10 t/ha in fourteen weeks could probably be due to the fact that higher rates of mineralization have taken place in the material (Ojobor *et al.*, 2012). Increase in soil pH values during the study can be explained by the release of NH_3 from organic N mineralization and this is known caused acidifying effect in soil (Ojobor, 2018). Decomposition of soil organic material can result in H^+ and NH_3 production that can have oxidized to strong acids causing decrease in soil pH while the increase could be attributed to effect of accumulated salt contained in the compost materials (Santillan *et al.*, 2014).

CONCLUSION

The study assessed the nutrient mineralization rate and pattern of four composts. The result revealed that nutrients were immobilized in all the compost treatments at the early stage of incubation before re-mineralization. At 14 weeks, RHCdC at 10 t ha⁻¹ released the highest organic carbon, nitrogen and available phosphorus. It could be concluded that alternative nitrogen sources be added to the compost to reduce the rate of immobilization.

REFERENCES

- Binh, N. T. Quynh, H. T. and Shima, K. (2015). Effect of composts combined with chemical N fertilizer on nitrogen uptake by Italian ryegrass and N transformation in soil. *Journal of Agriculture, Chemistry and Environment* 4(2): 37–47.
- Binh, N. T. and Shima, K. (2018). Nitrogen Mineralization in Soil Amended with Compost and Urea as Affected by Plant Residues Supplements with Controlled C/N Ratios. *Journal of Advanced Agricultural Technologies* 5(1): 8-13
- Goos, R. J. (1995). A laboratory exercise to demonstrate nitrogen mineralization and immobilization. *Journal of Natural Resources and Life Science Education* 24: 68-70.
- Murwira, H. K. and Kirchmann, H. (1993). Nitrogen dynamics and maize growth in Zimbabwean sandy soil under manure fertilization. *Soil Science and Plant Analysis* 24: 2343-2359.
- Masungaa, R. H., Uzokweb, V. N., Mlaya, P. D., Odehc, I., Singhd, A., Buchane, D. and Neve, S. (2016). Nitrogen mineralization dynamics of different valuable organic amendments commonly used in agriculture. *Applied Soil Ecology* 101:185–193
- Nyamangara, J., Mtambanengwe, F. and Musvoto, C. 2009. Carbon mineralization from selected organic resources available to smallholder farmers for soil fertility improvement in Zimbabwe. *African Journal of Agricultural Resources* 4(9): 870-877.
- Ojobor, S. A. (2018). Rice husk-based compost as organic fertilizer for upland rice production in Delta State, Nigeria. A Ph.D. Thesis, Department of Agronomy, University of Ibadan, Oyo State, Nigeria pp 153.
- Ojobor, S. A., AdeOluwa, O. O. and .Adeoye, G. O. (2012). Nutrient mineralization of compost manure. *African Journal of General Agriculture*. 8(3): 125-132.
- Olowoake, A. A. (2017). Nutrient Release Pattern from Compost Supplemented with Jatropha Cake on Alfisol of Ilorin, Nigeria. *International Journal of Plant and Soil Science* 15(5): 1-11
- Roy, S. and Kashem, M. A. (2014). Effects of organic manures in changes of some soil properties at different incubation periods. *Open Journal of Soil Science* 4: 81-86.
- Santillan, Y. M., Moreno, F. P. and Garcia, F. P. 2014. Effects of application of manure of cattle on soil chemical properties in Mexico. *International Journal of Applied Science and Technology* 4(3): 67-7