Nitrogen Mineralization Rate of Industrially Manufactured Organic Fertilizers on Alfisol in Southwestern Nigeria

Ayeni Leye Samuel

***Abstract*—**Greenhouse study was carried out at Adeyemi College of Education, Ondo Southwestern Nigeria to determine the rate of NO_3-N, NH_4-N, total N, OC and available P released to the soil samples collected from Alfiisol with addition of manufactured organic fertilizers. The soil samples were incubated with organic (OG), organomineral (OMF) and NPK 15:15:15 (NPKF) fertilizers. Organic and organomineral fertilizers were separately applied at the rate of 0, 0.25 and 0.5mg/100 g soil to represent 0, 5 and 10t/ha while NPKF was applied at the rate of 0.002g/100g soil (400kg/ha). The treatments were replicated three times and arranged on CRD. The treatments were incubated for 90 days. Compared with control, OG and NPKF at all rates significantly increased ($p<0.05$) soil NH4-N, NO_3-N, total N and available P. Application of 0.25 and 0.5mg organomineral fertilizer/100gsoil would not affect water bodies if applied to soil for crop production.

***Keywords*—**water bodies, nitrate-nitrogen, ammonium nitrogen, total nitrogen, incubation.

I. Introduction

ADDITION of nitrogen fertilizers enhance growth and yield performances of virtually all crops. It enhances enlargement of leaf areas of plants, vegetative growth of other parts of the plants and chlorophyll formation. Its deficiency results in stunted growth and chlorosis which can adversely affect growth and yield of the crop which is the utmost aim of the farmer. Most Nigerian soils are low in major plant nutrients especially N, P and K. Nitrogen been the most important plant nutrients is the most deficient nutrient in Nigeria soils. Nitrogen can be made available to crops in the form of ammonium nitrogen and nitrate nitrogen. The organic nitrogen has to be converted into the inorganic forms before it can be utilized by crops. Excess forms of N can affect water bodies and also cause environmental pollution. Adequate N fertilizer needs to be applied with caution to avoid its over application that can lead to water pollution and nutrients imbalance.. Agboola [1] recommended 1.5% N and 30 mg kg-1 NO3-N as the critical level for optimum production of crops especially arable crops in southwestern Nigeria. Many soils of southwestern Nigeria fall below the critical levels. The N deficiency aggravates the use of external inputs by farmers to increase soil N. Among the external inputs include the use of various mineral fertilizers such as CAN, NPK of various formulations and host of others. Also, common organic manures include poultry manure, cattle dung, swine dung and plant residues. Records have shown that farmers use these materials without soil test thereby leading to nutrient imbalance [2,3,4]. Apart from nutrient imbalance, the indiscriminate application of these external inputs especially nitrogenous fertilizers increase soil acidity, bulk density and micronutrients.

Ayeni Leye Samuel, Department of Agricultural Science, Adeyemi College of Education, Ondo, Ondo State, NigeriaE mail: leye_sam@yahoo.com.

In order to curb inappropriate use of fertilizers, some State Governments in Nigeria embark on industrial production of organic fertilizers that have standard formulation. There are no known researches on the rate at which theses fertilizers release nutrients especially N to the soil. There is a new fertilizer called organomineral fertilizer which combines attributes of organic and mineral fertilizers. There is scanty information on which of the organic, organomineral and mineral fertilizer most increase soil forms of nitrogen. Integrated use of organic fertilizer and inorganic fertilizer has been confirmed to be an excellent and balanced nutrients supply; application of organic fertilizer and mineral fertilizer improve soil fertility, reduce the quantity of fertilizer required by plant and its helps with the release of nutrient into the soil from natural organic sources. Hence there is need to study the mineralization rate of manufactured organic and organomineral fertilizers on forms of N in Ondo southwestern Nigeria. Hence, the objectives of this study were to determine the effect of organic, organomineral and NPK fertilizer on soil forms of nitrogen and rate of nutrients interactions when organic, organomineral and NPK fertilizers are mixed with soil constituents.

II. Materials and Method

The laboratory incubation study was conducted in the laboratory of Agricultural Science Department of Adeyemi College of Education, Ondo. Soil sample was collected from farmers field with Auger from Ore, South-Western Nigeria. The composite soil sample was air dried, sieved through a 2 mm diameter sieve. 250 g of well labeled plastic cups. The soil sample was weighed into eighteen different well labeled plastic cups. The required amount of organic, organomineral and nitrogen, phosphorus potassium (15:15:15) fertilizers corresponding to the treatment were added at the rate of 5 t/ha and 10 t/ha for organic and organomineral fertilizers and 400 kg/ha of NPK (15:15:15 in replicate. The control experiment was also without fertilizer conducted alongside (i.e. soil samples only without fertilizers).

50 ml of water was added to the content of each plastic cup. The samples were then incubated for three months. 50 ml of water was added at intervals as the incubation progresses. Three months was assumed to be vegetative and reproductive period for most arable crops in South-Western Nigeria. At the completion of the incubation period, the incubated soil samples were dried and analyzed for soil pH, total Nitrogen, NO_3-N, NH_4-N and the normal routine elements.

Soil pH was determined using glass electron pH meter in 1:2 soil water ratio. Ten grams (10g) of the soil sample was weighed into 100ml beakers (in duplicate) and 20ml of distilled water was added. Each beaker was stirred several times for about 30 minutes. The pH of the samples was measured by immersing the glass electrode pH into the clear solution on to suspension. Care was taken not to stir the suspension before taking the measurement.

The method used in determining the nitrogen is called micro-kjedahl analysis. It involves distillation and titration, 10 gm of the air dried soil sieved through 2mm diameter mesh was weighed into 250 mm conical flask. 100 ml of the HCl was added and shaken on

mechanical shaker for 1 hour. The distillation was set up prior to this in which 5 ml of 2% boric acid solution put in the receiving flask which trapped down free ammonia vapour liberated from digest extract. 3 drops of mix indicator was added. The receiving flask was placed below the surface of boric solution. 10 ml of digest was transferred to the reaction chamber and 10 ml of 40% NaOH was added. The joints were closed and distillation started immediately. 50 ml distillate was collected inside the receiving flask and 0.10 m HCl was titrated then blank distillation was carried out.

Available phosphorus was extracted by Bray-1-method, two grams of air dried soil sieved with 2 mm diameter mesh was weighed into 250 conical flask. 30 ml of $HclO_4$ was added and digested on a hot plate in the fume cardboard at $130^{O}C$ until solution became clear. As digested was completed with fume $HClO_4$ appeared and soil residue become white, the flask was removed from the hot plate and allowed to cool to room temperature. 50 ml of distilled water was added and filtered into 100 ml standard flask and phosphorus was determined colometrically.

Exchange bases were extracted with neutral ammonium acetate, ten gram of air dried soil sample sieved through 2 mm diameter was weighed into conical flask, 100ml of ammonia acetate was added. It was shaken for one hour, filtered and made up to 100 ml with ammonium acetate. Exchangeable bases: calcium, magnesium, potassium and sodium were determined from the filtrate by atomic absorption spectrophotometer.

Micronutrients (iron, (Fe) manganese (Mn), copper (Zinc) were directly determined from the sample extraction on atomic absorption spectrohotometre, the extraction was carried out by weighing five grammes of water sieved into air dried sample that passed through 2mm diameter sieve into 100ml plastic bottle and 50ml of 0.1 mole Hcl was added and shaked for 30 minutes. The suspension was filtered and determination was carried out using the filtrate.

Organic carbon was determined by Walkey black wet oxidation method. This was carried out by weighing one gramme of air dried soil into 250mm conical flask. 100ml of 0.167 molar potassium dichromate (vi) was added, 20mm of concentrated H_2SO_4 was added and the flask was swirled gently until the soil and reagent were thoroughly mixed and vigorously swirled for one minute. The flask was allowed to stand on a sheet of asbestos for about three minutes. 10ml of distill water was added followed by three drips of ferroin indicator and titrated with 0.5mole iron (vi) ammonium sulphate. The colour changes from green through blue to red moron then the result of the titration was multiplied by 1.33 to give percentage organic carbon.

III. Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using statistical analysis system institute package. Means were separated using Duncan's multiple range test (DMRT).

IV. Result And Discussion

Tables 1, 2 and 3 show that the chemical and physical characteristics of the soil used for the experiment is slightly alkaline, low in organic matter, N, P, and K. The soil was high in Ca and Mg. The initial soil analysis shows that the soil used for the study has sandy loamy texture with high properties.

TABLE 1
INITIAL SOIL PROPERTIES

Soil Properties	Value
pH	7.66
Na cmol kg^{-1}	0.51
K cmol kg^{-1}	0.26
Ca cmol kg^{-1}	8.44
Mg cmol kg^{-1}	1.77
Al+H cmol kg^{-1}	0.09
Organic C %	0.92
Micronutrients (mg kg^{-1})	
Cu	2.79
Fe	133.8
Mn	19.64
Zn	3.34

Table 2 shows the nutrient composition of mineral, organomineral and organic fertilizers. NPK 15:15:15 fertilizer had higher N, P and K than organic and organomineral fertilizers. Organomineral fertilizer had the highest P and K than organic fertilizer. The nutrient composition showed that NPK had the highest N, P and K followed by organomineral fertilizer.

TABLE II
NUTRIENT COMPOSITION OF MINERAL, ORGANOMINERAL AND ORGANIC FERTILIZERS (%)

Nutrient	NPK 15:15:15	Organic Manure	Organomineral Fertilizer
N	15	3.5	3.5
P	15	1.0	2.5
K	15	1.2	4.0

Table 3 showed that organomineral fertilizer applied at 5 and 10t ha^{-1} had the highest pH while the control and NPK 15:15:15 fertilizer had the lowest pH. Compared with the control, organic fertilizers applied at 5 and 10t ha^{-1}, organomineral fertilizer applied at 5 and 10t ha^{-1}, significantly increased soil pH, NH_4-N, NO_3-N, and total N while NPK 15:15:15 fertilizer applied at 400kg ha^{-1} significantly reduced pH.

The order of increase in pH in the soil fertilized with organomineral, organic and NPK 15:15:15 fertilizers were 10t ha^{-1} OMF > 5t ha^{-1} OMF >10t ha^{-1} OG – 5t ha^{-1} OG > Control > 400kg ha^{-1} NPK. Organomineral fertilizer applied at 10t ha^{-1} had the highest pH, NH_4^{-N} while NPK 15:15:15 fertilizer had the lowest $NH_4^{-}N$

Organomineral fertilizer applied at 5 and 10t ha^{-1} had the highest NH_4-N while NPK 15:15:15 fertilizer had the lowest NH_4-N. Compared with control, NPK 15:15:15 fertilizer applied at 400kg ha^{-1} significantly reduced NH_4-N. The order of increase in NH_4-N in the soil fertilized with organic, organomineral and NPK 15:15:15 fertilizer were 10t ha^{-1} OMF > 5t ha^{-1} OMF > 5t ha^{-1} OG > 10t ha^{-1} OG > Control > 400kg ha^{-1} NPK.

Organomineral fertilizer applied at 5t/ha^{-1} had the highest NO_3-N while NPK 15:15:15 fertilizer had the lowest NO_3-N. Compared with control, organomineral fertilizer applied at 5

and 10t ha^{-1} were significantly higher ($p < 0.05$) than the control compared with the control, NPK 15:15:15 fertilizer applied at 400kg ha^{-1} significantly reduced NO_3-N.

The order of increase in NO_3-N in the soil fertilized with organic , organomineral and NPK 15:15:15 fertilizers were 5t ha^{-1} OMF > 10t ha^{-1} OMF > 10t ha^{-1} OG > 5t ha^{-1} OG > Control > 400kg ha^{-1} NPK.

Organomineral fertilizer applied at 5t ha^{-1} had the highest total N while NPK 15:15:15 fertilizer had the lowest total Nitrogen. Compared with the control, organic fertilizer applied at 5 and 10t ha^{-1}, organic fertilizer applied at 5 and 10t ha^{-1}, organomineral fertilizer applied at 5 and 10t ha^{-1} and NPK 15:15:15 fertilizer applied at 40kg ha^{-1} were significantly higher ($p < 0.05$) than the control in term of pH, NH_4-N, NO_3-N and total N. The order of increase in total N in the soil fertilized with organic, organomineral and NPK 15:15:15 fertilizer were 5t ha^{-1} OMF > 5t ha^{-1}OG > 10t ha^{-1}OG >5t ha^{-1} OMF > 400kg ha^{-1} NPK > control.

Compared with control, organic fertilizer applied at 10t ha^{-1} had the highest soil organic carbon while organomineral fertilizer applied at 10t ha_{-1} had the lowest organic carbon. Organic carbon applied at 5 and 10t ha^{-1} significantly increased soil organic carbon and this might be as a result of the presence of organic matter as asserted by Ayeni [5] in an experiment conducted on combined effect of cattle dung and urea fertilizer on organic carbon, forms of Nitrogen and available phosphorus in selected Nigerian soils. The order of increase in the soil treated with organic, organomineral and NPK 15:15:15 fertilizer were 10t ha^{-1} OG > 5t ha^{-1} > 400kg^{-1}>control > 10t ha^{-1}OMF > 5tha^{-1}OMF.

Compared with control, organic fertilizer applied at 10t ha^{-1} had the highest phosphorus to the soil treated with organic, organomineral and NPK while organomineral fertilizer applied at 5t ha^{-1} had the lowest phosphorus. Organic fertilizer applied at 10t ha^{-1} significantly increased soil phosphorus. Ayeni [5] confirmed that presence of N and P in cattle dung might have led to the increase of OC and phosphorus.

The order of increase in the soil treated with organic, organomineral and NPK fertilizer and NPK 15:15:15 were 10t ha^{-1} OG > 10t ha^{-1}OMF > control > 5t ha^{-1} OG > 400kg ha^{-1} NPK > 5tha^{-1} OMF.

TABLE III
EFFECT OF ORGANIC, ORGANOMINERAL AND NPK 15:15:15 ON SOIL PH AND SOIL FORMS OF NITROGEN

Treatment	pH	OC	NH_4-N	$N0_3$-N	Total N
Control	5.59c	0.83b	37.50d	8.77e	765.67e
5tha^{-1} OG	6.09b	1.01a	345.51b	259.32d	1591.00b
10tha^{-1} OG	6.54b	1.36a	407.05a	312.39c	1421.00b
5tha^{-1} OMF	7.54a	0.72b	41.36c	611.12a	2331.33a
10tha^{-1} OMF	7.59a	0.78b	38.25d	423.83b	1181.00c
400kgha^{-1} NPK	5.88c	0.86b	16.35e	4.85f	1070.33d

Means with the same letters are not significantly different according to Duncan Multiple Range Test.

OMF – Organomineral Fertilizer
OG – Organimc Fertilizer

V. DISCUSSION

According to Sobulo and Osiname,[1] the soil used for the experiment was slightly acidic, low in pH and Nitrogen. The coarse nature of the soil might have accounted for the slightly acidic nature, and this made the nitrogen in the soil readily available.

The increase in pH of the soil fertilized with organic and organomineral fertilizers showed the lining effect of the organic manures while the low pH recorded by NPK 15:15:15 fertilizer showed the acidic nature of the soil. This work is in line with Ayeni, [5,6,7] who affirmed that organic manures like poultry manure and cocoa pod ash could be used to reduce soil acidity. Samuel et al [8] also supported the assertion that mineral fertilizers have acidifying effect on most soils.

The lower NH_4-N than NO_3-N recorded in the soil fertilized with organomineral and NPK fertilizers might be as a result of rapid conversion of HN_4-N to NO_3-N by microbial activities in the soil [9].

It was found that NPK fertilizers had low forms of N despite the fact that it was higher in N content than organic and organomineral fertilizers [10] . This might be as a result of early mineralization of N by the fertilizers because of its low C/N ratio.

The presence of mineral fertilizer in organomineral fertilizer might have obliterated immobilization effect of organic manure.

VI. CONCLUSION

The incubation study conducted to show the effect of organomineral, organic and NPK 15:15:15 fertilizers in south western Nigeria show that: the soil used for the experiment was deficient in N. Organic and organomineral fertilizer increased Nitrate Nitrogen, Ammonium Nitrogen and Total Nitrogen of the soil used for the experiment in southwestern Nigeria.

REFERENCES

[1] Agboola AA, Corey RB.1973. The relationship between soil pH, organic matter, available P, exchangeable K, Ca, Mg and nine elements in the maize tissue. Soil Science. 115(5):367-375 http://dx.doi.org/10.1097/00010694-197305000-00006

[2] Adeniyan, O.N. and Ojeniyi, S.O. (2005). Effects of poultry manure, NPK 15:15:15 and combination of the reduced levels on maize growth and chemical properties. Nigerian Journal of Soil Science. Vol..15, Pg. 34-41.

[3] Adeniyan, O.N. and Ojeniyi, S.O. (2006). Comparative effectiveness of different levels of poultry manure with NPK fertilizer on soil fertility, nutrient uptake and uptake of maize. Journal of Agricultural Research. 4:194-197.

[4] Ayeni, L.S.2008.Integration of Cocoa Pod Ash, Poultry Manure and NPK 20:10:10 for Soil Fertility Management. Continental Journal of Agronomy 2: 25-30.

[5] Ayeni, L.S. (2012). Combined effect of cattle dung and urea fertilizer on organic carbon, forms of nitrogen and available phosphorus in selected Nigerian soils. Journal of Central European Agriculture, vol 13(3) pp 601-607. http://dx.doi.org/10.5513/JCEA01/13.3.1098

[6] Sobulo, R.A. and Osiname, O.A. (1987). Soil and Fertilizer use in Western Nigeria. Resource Bulletin No. 1 IAR&T, Unife, Ile-Ife, Pp 20-26.

[7] Ayeni, L.S. (2008a). Integrated Application of cocoa pod ash and NPK fertilizer on soil chemical properties and yield of tomato. American Eurasian Journal of Sustainable Agriculture. 2(3). Pg. 336-333.

[8] Samuel, L.; Tisdale, W.L.; James, D.B.; John, L.H. (2003). Soil and Fertility and Fertilizers. Pearson Education, Inc. Prentice-Hall. Pp 634.

[9] Ayeni, L.S. (2011). Effect of sole and combined cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer on soil organic carbon, available P and forms of nitrogen on Alfisols in South Western Nigeria. International Research Journal of Agricultural Science and Soil Science. Vol. 1(3) pp. 077-082.

[10] Ajayi, C.A.; Awodu, M.A. and Ojeniyi, S.O. (2007). Comparative effect of cocoa husk ash and NPK fertilizer on soil and root nutrient content and growth of kola seedlings. International Journal of Soil Science (2) 2,:148-152 http://dx.doi.org/10.3923/ijss.2007.148.153