



(RESEARCH ARTICLE)



Effects of integrated application of inorganic and organic fertilizer on properties of soil planted with rice

Dania, Stephen Okhumata *, Edukpe, Esther Uzezi and Eniola, Rita Idowu

Department of Soil Science, Faculty of Agriculture, Ambrose Alli University, Ekpoma.

World Journal of Advanced Research and Reviews, 2021, 11(02), 117–123

Publication history: Received on 12 May 2021; revised on 02 August 2021; accepted on 04 August 2021

Article DOI: <https://doi.org/10.30574/wjarr.2021.11.2.0230>

Abstract

Fertilizer application is essential in the improvement of soil quality and crop yield; it was therefore necessary to investigate the effects of integrated application of inorganic and organic base fertilizer on the soil chemical and physical properties. This experiment was conducted at the Ambrose Alli University Teaching and Research Farm, Ekpoma, Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) with seven treatments, replicated three times; the treatments were; control (zero application), Indorama granular urea (GU), prilled urea (PU), full dose of P&K+75% Indorama granular urea (GUPK), full dose of P&K+75% prilled urea (PUPK), full dose of P&K+75% Indorama granular urea + 25% FYM (GUP&K+FYM), and full dose of P&K+75% prilled urea + 25% FYM (PUP&K+FYM). The rice variety cultivated was FARO 59. The initial results of the soil analyses showed that the soil was low in nutrient below critical values, the combine application of organic and inorganic fertilizer significantly ($p \leq 0.05$) improved soil nutrient status compared to the other treatments. The combined application of inorganic and organic fertilizer increased soil pH value from 5.64 in control to 6.92. There was a significant ($p \leq 0.05$) improvement of the macro and micronutrient from the integrated application of inorganic and organic based fertilizers compared to other treatments. The application of GUP&K+FYM and PUP&K+FYM significant ($p \leq 0.05$) improved the Aggregate stability of the soil. The integrated applications of organic and inorganic fertilizer (GUP&K+FYM and PUP&K+FYM) will significantly ($p \leq 0.05$) improve the chemical and physical properties of soil.

Keywords: Aggregate stability; Inorganic fertilizer; Macronutrient; Micronutrient; Organic fertilizer; Rice

1. Introduction

Soil nutrient depletion as a result of soil degradation is one of the major causes of decrease in crop yield and food production globally (1). It is therefore necessary to improve the soil quality by the application of fertilizer. Fertilizer is the most widely used materials in agricultural production and it can be categorized into three types, based on the production process; chemical, organic and organomineral fertilizers and each has its advantages and disadvantages. Chemical fertilizers such as urea and NPK are rich in nitrogen, phosphorus and potassium. Urea fertilizer is extensively used in agricultural production and addition of urea to soil compensates for the soil nitrate and stimulates the absorption of other nutrients. Applications of urea base fertilizer significantly increase the crop yield as it rapidly hydrolyzed to ammonium (2). Chemical fertilizers are easily leached into the underground water without full benefit to the plants and its long-term use affects soil organisms and organic matter (3). Although chemical fertilizers are important input that significantly increases crop production, but sole reliance on chemical fertilizers results in decline of soil properties, crop yields overtime and causes serious soil degradation (4).

Organic fertilizers are materials of definite chemical composition with a high analytical value that supply plant nutrient in available forms (5). Organic fertilizers are cheap and readily available but bulky and required in large quantity.

*Corresponding author: Dania SO

Department of Soil Science, Faculty of Agriculture, Ambrose Alli University, Ekpoma.

Organic fertilizer (manure) improves soil structure, texture, aeration, soil water retention abilities and stimulating healthy root development. Incorporation of manure into soil can significantly influence bulk density, enhanced infiltration, hydraulic conductivity, and plant available water (6). Soil P, K, Ca, Mg and Zn contents increased significantly with manure application and create a healthy environment for the soil over a long period of time. Organic manure is eco-friendly which can maintain the soil health in terms of soil biology and productivity besides quality produce with high market price.

Complementary use of mineral fertilizers with organic manures has been proved to be an important soil fertility management strategy in many countries of the world. The combine application of organic manures with inorganic fertilizer increased soil organic matter, soil structure, water holding capacity, improve nutrient cycling, maintain soil nutrient status, cation exchange capacity (CEC) and soil organisms (7). Combine application of inorganic and organic manure increased organic carbon, nitrogen, phosphorous and potassium contents in the soil. The favorable effect of various components of integrated nutrient management practice is to be considered holistically rather than looking for short term benefits. Therefore, the integrated use of inorganic and organic fertilizer is a sustainable approach for efficient nutrient usage which enhances the efficiency of the chemical fertilizer while reducing nutrient losses (8). Therefore the objective of this study was to investigate the effects of the combined application of inorganic and organic fertilizer on soil properties.

2. Material and methods

2.1. Study sites

This study was carried out at the Teaching and Research Farm, Ambrose Alli University, Ekpoma. The research farm is located on latitude 6° 45'N and longitude 6° 8'E of the Equator, with a mean annual rainfall of 1500mm and temperature of about 15°C – 34°C.

2.2. Experimental Design

It was a Randomized Complete Block Design (RCBD) consisting of seven treatments, replicated three times. Faro 59 variety of rice was used for planting. The planting distance was 25cm x 25cm within and between rows. The treatments were; Control (zero application), GU, PU, GUPK, PUPK, GUPK+FYM, PUPK+FYM.

2.3. Cultivation and management practices

The pre-planting operations carried-out includes; site selection, clearing of vegetation, packing of debris, mapping and herbicide application. The planting area measured 35m x 22m, the trial was laid in 21 plots; each plot size (consisting of flatbeds) measured 4m x 4m. Selective herbicide and insecticide were applied after emergence to control pest and weed.

2.4. Fertilizer application

The various organic manures were initially composted before used in combination with inorganic fertilizer. The fertilizers were applied four weeks after planting using the band method of application. Rice seeds were sown four seeds per hole and thereafter thinned to one plant per stand at three weeks after planting. Weeding was done thrice manually before harvest.

2.5. Soil samples collection

Composite soil samples were collected from the experimental site prior to planting and after harvesting.

2.6. Laboratory Studies

The soil samples were air-dried, crushed and sieved with a 2.0 mm mesh sieve. Percentage sand, silt and clay (particle size fractions) were determined using the hydrometer method (9), pH of the soil was determined using pH meter (10), and Organic carbon, total nitrogen, available phosphorus, exchangeable bases and exchangeable acidity were determined by the standard procedures (11). ECEC was determined by the summation of exchangeable bases and exchangeable acidity.

2.7. Aggregate stability

Percentage aggregate stability (% AS) was carried out using the sieving method (12). Sieved air-dry soil samples weighing 200 g from each replicates were placed in nest of sieve and immersed in a bowl of water. The sieve was oscillated vertically and rhythmically so that water was made to flow up and down through the sieve and the assemblage of aggregates. In this manner the action of flowing water was simulated. At the end of the specific period of sieving (20 minutes), the nest of sieves was removed from the water, oven dried and weighed. The results were corrected for the coarse primary particles retained on each sieve to avoid designating falsely as aggregates. This was done by dispersing the materials collected from sieve, using a mechanical stirrer and a sodic dispersing agent (calgon) then washed through the same sieve. The weight of sand retained after second sieving was subtracted from the total weight of the undispersed material retained after the first sieving.

Percentage of Stable Aggregate (%SA) was estimated as follows: % SA = (Wt. retained) - (Wt. of Sand) / (Total sample wt.) - (Wt. of Sand) x 100.

2.8. Statistical Studies

All data obtained were statistically analyzed using ANOVA (analysis of variance). LSD (least significant difference) test at 5% level of probability was used to determine differences in means of treatments (13).

3. Results and discussion

The initial soil test before planting showed that its nutrient status were generally below critical levels (14). The soil was slightly acidic and sandy loam in texture and the distribution of sand, silt and clay in the soil were 820g/kg, 65g/kg and 115g/kg (Table 1). The initial pH of the soil was 5.68 which indicated that the soil was slightly acidic. The pH of the soil after harvest from the plots with application of GU+P&K+FYM had the pH value of 6.92, PU+P&K+FYM was 6.76 and it has been reported that the addition of organic fertilizer increase the pH of the soil to near neutral or alkaline (15). Application of organic manure reduced acidity of the soil and sustains the organic matter of the soil (19). Addition of organic matter to acid soil was reported to reduce soil acidity; therefore, organic manure has liming effects due to high content of Ca and Mg (16).

Organic carbon content was lower than the critical level (10g/kg) in the control and in plots where GU, PU, GUPK and PUPK were applied. The combined application of inorganic with organic fertilizers (GU+P&K+FYM and PU+P&K+FYM) significantly ($p \leq 0.05$) increased the organic matter content of the soil, with the highest value of 27.40g/kg and 26.10g/kg respectively. It has been reported that the application of organic manure increases the organic matter content of the soil (17). The application of organic base fertilizer improved the organic carbon, nitrogen and available phosphorus content of the soil and these findings corroborate with the application of GU+PK +FYM and PU+PK+FYM as observed in the experiment.

Total nitrogen content of the control plot was below critical values of 1.5-2.0g/kg. Total nitrogen in plots with the application GU+PK+FYM and PU+PK+FYM were higher compared to other treatments with values 3.66g/kg and 3.63g/kg respectively. The application of granular and prilled urea also significantly ($p \leq 0.05$) increased soil nitrogen content compared to the control. The application of either combined or sole chemical fertilizer also increased the soil nitrogen content. It was reported that the application of nitrogen fertilizer to nitrogen deficiency soil will increase nitrogen content of the soil for improved growth and yield of crops (18).

The application of GU+PK+FYM and PU+PK+FYM significantly ($p \leq 0.05$) increased the Ca, Mg and K content of the soil compared to other treatments. Also application of urea alone increased the value of Ca, Mg and K than the control. The application of fertilizer significantly ($p \leq 0.05$) increase the Ca, Mg and K content of the soil as also previously reported (19).

Available phosphorus (P) of the initial soil samples was 8.01mg/kg which was below critical value of 15mg/kg. The application of GU+PK+FYM and PU+PK+FYM increased its value to 25.35mg/kg and 23.31mg/kg respectively and the values were above critical levels. Nitrogen and phosphorus were increased with the combined application of inorganic and organic fertilizers (GU+PK+FYM and PU+PK+FYM). The combination of inorganic fertilizer and FYM will not only increase the soil organic matter also the trace elements such as iron, manganese, copper, zinc and boron necessary for rice growth (20).

Table 1 Initial Physicochemical Properties of Soil, Compost and Organo-mineral Fertilizer

Parameter	pH →	OM g/Kg	N ←	P mg/kg	Ca ²⁺ ↔	Mg ²⁺ Cmol/kg	K ⁺ ↔	Na ⁺	E.A	CEC	ECEC	E.B	Mn ↔	Fe ²⁺ mg/kg	Cu ²⁺ ↔	Zn ⁺	Practical size Sand silt clay g/kg			Textural class
Soil	5.68	7.88	1.31	8.01	2.03	0.40	0.18	0.24	0.99	2.85	3.84	80.55	57.10	28.21	1.14	810	820	65	115	Sandy loam
Compost	8.13	37.23	4.01	31.35	10.78	6.37	8.14	8.14	4.00	33.43	37.43	89.48	20.24	20.24	83.10	94.00				
OMF	8.18	47.18	4.16	38.37	5.45	13.35	19.62	6.42	9.20	44.84	54.19	83.46	8.60	8.60	11.10	23.3				

Emaudo Soil, CEC: Cation Exchange Capacity, ECEC: Effective Cation Exchange Capacity, E.B: Exchangeable Bases, E.A: Exchangeable Acidity.OMF- Organomineral Fertilizers

Table 2 Effects of inorganic and organic fertilizer on the chemical and physical properties of soil cultivated with rice

Treatments	pH (H ₂ O)	E.C25 μs/cm	O.C g/kg	T.N g/kg	Av.P Mg/kg	Ca	Mg	K	Na Cmol/kg	Ex. acidity	ECEC	B.S %	Mn ←	Fe Mg/kg	Cu	Zn	Sand ←	Clay g/Kg	Silt →
Control	5.64	5.00	6.18	0.74	9.71	2.12	0.36	0.25	0.03	0.60	3.36	93.94	69.50	6.10	0.47	0.62	894	40	66
PU	5.67	5.00	6.60	0.64	10.15	4.44	1.13	0.19	0.37	0.60	6.73	85.73	78.10	6.40	0.37	12.25	864	60	76
GU	5.96	1.00	6.7	0.66	10.48	4.52	1.10	0.20	0.31	0.80	6.93	90.57	73.40	4.80	0.21	11.56	836	58	106
GU+PK	6.04	3.00	6.81	1.68	18.84	4.64	2.09	0.31	0.49	0.60	7.89	93.75	91.90	7.50	0.30	11.16	854	46	100
PU+PK	5.84	3.00	6.89	1.65	15.63	5.15	2.06	0.46	0.51	0.80	8.98	92.22	79.80	9.80	0.39	13.73	843	60	97
GU+PK+ FYM	6.92	4.00	27.40	3.66	25.35	5.95	2.52	0.49	1.39	0.80	11.15	95.07	95.50	11.40	0.51	13.74	850	45	105
PU+PK+FYM	6.76	3.00	26.10	3.63	23.31	5.49	2.44	0.49	1.33	0.60	10.35	94.03	98.80	13.90	0.46	14.66	845	40	115 SandyLoam

PUPK+FYM= Full dose of P&K + 75% N Indorama Granular urea + 25% N through FYM. GUPK+FYM = full dose of P&K+75% N prilled urea + 25% N through FYM.GUPK= Granular urea + phosphorus+potassiumPUPK = Prilled urea + phosphorus+potassiumPU - Prilled Urea, GU- Granular urea

Table 3 Effects of combine application of inorganic and organic fertilizers on soil aggregate stability

Treatments	Aggregate Stability
Control	2.04d
PU	2.60c
GU	2.91c
PUPK	3.43b
GUPK	3.63b
PUPK+FYM	4.66a
GUPK+FYM	4.67a
LSD	0.45

The mean values with the same letter in the vertical column are not significantly ($P \leq 0.05$) different using LSD

LEGEND; PU+PK+FYM= Full dose of PK + 75% N Indorama Granular urea + 25% N through FYM; GUPK+FYM = full dose of PK+75% N prilled urea + 25% N through FYM; GUPK= Granular urea + phosphorus+potassium; PUPK = Prilled urea + phosphorus+potassium; PU – Prilled Urea; GU- Granular urea

The values of magnesium content in the soil were highest in plots with GU+PK+FYM and by PU+PK+FYM application, the values was 2.52cmol/kg and 2.44cmol/kg respectively while lowest value was recorded in control (0.36cmol/kg). Sodium initial value was higher than the critical value of 0.02cmol/kg as reported (21). Sodium increased significantly from the application of GU+PK+FYM (1.39cmol/kg) and PU+PK+FYM (1.33cmol/kg) and lowest value was in control (0.03cmol/kg). ECEC values were below critical level of 15cmol/kg (10). The application of granular, prilled urea and NPK did not increased ECEC significantly. Percentage base saturation was high in plots with application of GU, (85.73%), but higher with the application of PU+PK+FYM (94.03%) and PU+PK+FYM (95.07). The application of organic fertilizer increased the ECEC and this confirmed the results obtained, the application of fertilizer sole or combined application increased the ECEC of the soil (22), It was observed that the ECEC obtained from application of GU+PK+FYM and PU+PK+FYM were higher compared to other treatments.

The cereals crop such as rice influence soil aggregation through the root structure and distribution, quality and quantity of carbon inputs, effects on soil microclimate and microbial communities and their activities (23). Fertilizer applications have the potential of altering soil properties thereby affecting aggregate stability. The application of mineral fertilizer improved soil aggregation compared to the control. It was also evidence that the application of organic base fertilizer, GU+PK+FYM and PU+PK+FYM significantly ($p \leq 0.05$) improved the aggregate stability of soil compared to other treatments. The application of organic base fertilizer resulting to increase of soil organic matter content and soil biota significantly ($p \leq 0.05$) improved the aggregate stability of the soil (24, 25).

4. Conclusions and Recommendations

Soil nutrient management is essential for sustainable crop production and maintenance of soil quality. Integrated application of inorganic and organic fertilizer increased soil pH to near neutral, improved the macro and micronutrients. This study confirmed that the combine application of inorganic with organic manure will not only increase the yield of rice but also improve soil quality.

Therefore, combined application of inorganic and organic manure should be considered as an alternative to application of sole chemical fertilizers and organic manure for sustainable soil management for rice production

Compliance with ethical standards

Disclosure of conflict of interest

There was no conflicting interest among contributors.

References

- [1] Henao J, Baanante C, Agricultural Production and Soil Nutrient Mining in Africa Implications for Resource Conservation and Policy Development. An International Center for Soil Fertility and Agricultural Development www.ifdc.org March 2006
- [2] Hepperly P, Lotter D, Ulsh CZ, Seidel R, and Reider C. Compost, Manure and Synthetic Fertilizer Influences Crop Yields, Soil Properties, Nitrate Leaching and Crop Nutrient Content Compost Science & Utilization, 2009, 17 (2,) 117-126
- [3] Christina N, Kranz, Richard A, McLaughlin, Amy Johnson, Grady Miller, Joshua L.Heitman. The effects of compost incorporation on soil physical properties in urban soils – A concise review. Journal of Environmental Management 2020 . 261: <https://doi.org/10.1016/j.jenvman.2020.110209>
- [4] Stewart W, Dibb D, Johnson A,Smyth T. The contribution of commercial fertilizer nutrients to food production. Journal of Agronomy. 2005; 97: 1-6.
- [5] Lombin, G., J.A. Adepetu and K.A. Ayotade, 1991. Complementary use of organic manures and inorganic fertilizers in arable crop production. Paper Presented at the Organic Fertilizer Seminar, Kaduna. March 6-8th, 1991.
- [6] Bouyoucos GJ. Hydrometer method improved for making particle size analyses of soil. Agronomy Journal. 1962; 53: 464-465.
- [7] IITA. Selected methods for soil and plant analysis international institute for Tropical Agriculture.Ibadan. Manual series. 1989; 1.
- [8] Udo EJ, Ibia TO, Ogunwale JA, Ano AO,Esu IE. Manual of Soil, plant and water analysis. Sibon books Ltd, Lagos, Nigeria.2009; 183.
- [9] Kemper WD.Aggregate's stability. In: C. A Black et al (editors). Metjodosf soil analysis. Part 1.Monograph.9: 511 519.America Society of Agronomy. Madison. W.I. 1965.
- [10] sas institute (2005), sas user guide statistics sas institute cary ne.
- [11] Enwezor WO, Udo EJ, Usoroh NJ, Ayotade KA, Adepetu JA, Chude VO, Udegbe CI. Fertilizer use and management practices for crops in Nigeria. Lagos: Federal Ministry of Agriculture and Rural Development. 1989; 20-45.
- [12] Johnson GA, Davis JG, Qian YL, Doseken KC. Topdressing turf with compost manure improves soil quality and protect water quality. Soil Science Society of American Journal. 2006; 70: 2114-2121.
- [13] Lovel P,Webb J. Is there a critical level of organic matter in the agricultural soils of temperate regions: a review? Soil and Tillage Research. 2003; 70: 1-8.
- [14] Ano AO, JA Agwu. Effect of animal manures on selected soil chemical properties, organic matter, pH, Exchangeable Ca, Mg. Nigeria Journal of Soil Science. 2005; 15(1): 14-19.
- [15] Babalola, O. A; Adigun, M.O. and Abiola . I. O (2018). Effect of Urea and Compendments on Soil microbial Activities and Chemical Properties Asian Journal of Research in Crop Science. 1(3):1-7. 2018.
- [16] Sobulo RA, Osiname. Soils and fertilizer use in Western Nigeria.Pp. 20-26. Resource Bulletin No. 11. I.A.R&T, University of Ile-Ife. 1981.
- [17] Li-Na LIU, Han-Song, CHN QY, Peng CAI, Liang W, Ming LI. Poultry manure compost alleviates the phytotoxicity of soil cadmium: influence on growth of pakchoi (*Brassica chinensis* L.). Pedosphere. 2010; 20(1):63-70.
- [18] Fagnao M, Adamo P, Zampella M, Fiorentino N. Environmental and agronomic impact of fertilization withcomposted organic fraction from municipal solid waste: a case in the ragon of Naples, Italy. Agriculture ecosystems. 2011; 141(1-2): 100-107.
- [19] Amalu UC. Food Securirty: Sustainable food production in Sub-Sharan African. 1991.
- [20] Ayoola O T Yield performance of crops and soil chemical changes under fertilizer treatments in a mixed cropping system. African Journal of Biotechnology 2010 9(26), 4018-4021 <http://www.academicjournals.org/AJB> DOI: 10.5897/AJB09.1784
- [21] Reid JB,Gross MJ. Effect of living roots of different plant species on the aggregate stability of two arable soils.Journal of Soil Science. 1981; 32:521-541.

- [22] Scott NA. Soil aggregation and organic matter mineralization in forest and grassland; plant species effects. *Soil Science Society of America Journal*. 1998; 62:1081-1089.
- [23] Tisdall TM, Oades JM. Stabilization of Soil aggregates by the root system of Rygrass *Australian Journal of Soil Science*. 1979; 17:429-441.
- [24] Amezketa E. Soil aggregate stability: A review. *Journal of Sustainable Agriculture*. 1999; 14(2): 83 - 151.
- [25] Debosz K, Peterson SO, Kure LK, Ambus P. Evaluating the effects of sewage Sludge and household compost on soil physical, chemical and microbiological *Applied Soil Ecology*. 2002; 19: 237 248.