International Journal of Plant & Soil Science
7(6): 329-337, 2015; Article no.IJPSS.2015.159
ISSN: 2320-7035

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Influence of Organic and Inorganic Fertilizers on Soil Chemical Properties and Nutrient Changes in an Alfisol of South Western Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. This work is part of my PhD research work with authors MTA, JOA and TAA as members of supervisory team. Authors NOO and AFA contributed in the initial data collection and preparation of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2015/18355
Editor(s):
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Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=1098&id=24&aid=9704

Original Research Article

Received 16th April 2015
Accepted 21st May 2015
Published 11th June 2015

ABSTRACT

Temporal changes in soil organic matter and other chemical properties influence the availability of nutrients to plants with or without the application of fertilizers. For proper soil management, these changes must be accounted for. Pot experiment was conducted to assess changes in soil organic carbon, pH and soil nutrients using both inorganic and organic fertilizers. The experiment was a 2 x

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3 factorial experiment arranged in completely randomized design with three replicates, using five soil samples collected from Abeokuta, Igboora, Ikenne, Kobape and Odeda of Nigeria. Maize (var. SUWAN 1) was planted in the pots and grown for three consecutive cycles of six weeks each. Soil samples were analyzed for total N, soil organic carbon (SOC), NH_4^+-N, NO_3^--N, available P, K, Na, Ca, Mg and pH at pre-planting, at 6 weeks after planting (WAP). The results showed a decrease in average SOC and total N with time in all the soil types. Decrease in total N with time which could be attributed to the crop utilization, ammonia volatilization and bacteria denitrification was also observed. Addition of poultry manure improved the K, Ca, Na, Mg content of the soil and also present a potential to act as lime especially in short time. Combined application of poultry manure and NPK fertilizer reduced susceptibility of soils considered to acidification. Complementary application of 10 t ha^{-1} of poultry manure with 120 kg ha^{-1} NPK 20-10-10 proved to improve the soil fertility.

Keywords: Organic; inorganic; fertilizers; soil organic carbon; pH; alfisol.

1. INTRODUCTION

Improper agricultural management reduces organic matter content [1] and decreases soil structure stability [2]. To prevent the decrease in organic matter content, soil can be amended with organic wastes such as poultry manure, which are commonly recycled in agriculture. They are used both as a source of nutrients for plants, and as an element to improve the stability of soil aggregates [3] and to maintain the organic status of the soil. Incorporation of organic matter either in the form of crop residues or farmyard manures has been shown to improve soil structure and water retention capacity [4], increase infiltration rates [5], and decrease bulk density [6]. Although organic manure addition and the strengthening of soil biological practices can alleviate nutrient constraints, the problem of soil fertility decline is so serious [7] that it may not be possible to cover all of it with these approaches alone. Chemical fertilizers with instant ability to refurbish depleted nutrients in necessary quantities and forms have come to be recognized as a key component of sustainable soil fertility management and sustainable development of agriculture. The inorganic fertilizers have been reported to increase rooting depth and root proliferation in cereals [8,9]. In addition, the fertilization may also affect the volume of the soil exploited by the roots.

Inorganic fertilizers have become more popular, because they are easier to manage, handle and apply. It is also easier to synchronize the release of the nutrients and plant uptake with inorganic fertilizers than with manure [10]. In an Alfisol of southwestern Nigeria Azeez et al. [11] shows that maize yield was significantly higher in plots with NPK and N, P and ash in an experiment to demonstrate the effect of residue burning and fertilizer application on soil nutrient dynamics and dry grain yield of maize. Poultry manure application (7.5 t ha^{-1}) in combination with tillage was found to increase grain yield of sorghum by 39.5% compared with tillage only in Southwestern Nigeria [12] and similarly, application of maize stover at 5 t ha^{-1} with NPK (120 kg ha^{-1}) has been found to increase maize grain yield significantly by 22.8% over control [13]. The objectives of this study was to evaluate the influence of inorganic and organic fertilizers applied alone or in combination on soil chemical properties and nutrient changes.

2. MATERIALS AND METHODS

The experiment was carried out at research and teaching farm of Federal University of Agriculture, Abeokuta. Composite soil samples (0-15 cm depth) were collected from five locations (Abeokuta, Igboora, Kobape, Ikenne and Odeda). The samples were mixed, air-dried and sieved using a 2 mm size screen. The soil samples were analyzed for pH in soil: water slurry of 1:1 using glass electrode pH meter (14). Nitrogen was determined by regular Macro – Kjeldahl method [14]. The organic carbon (OC) of the soil was determined using the chromic acid digestion method of [15]. Available P was determined by Bray -1 P extraction and analysed colorimetrically by Molybdenum blue procedure [16]. Exchangeable bases in the soil were extracted using 1N ammonium acetate. Sodium and K in the extract was determined using flame photometer, while concentration of Ca and Mg in the extract was analyzed using atomic absorption spectrophotometer (AAS), [12]. Nitrate-nitrogen and NH_4^+-N were also determined colorimetrically after an extraction in 0.5M K_2SO_4. Particle size analysis of the soil was determined by hydrometer method [12]. The proportion of sand, clay and silt was used to determine the textural class of the soil using USDA textural triangle.

The experiment was 2 X 3 factorial experiment arranged in Randomized Complete Block Design in three replicate using five soil samples collected from Abeokuta, Igboora, Kobape, Ikenne and Odeda. The treatments consisted of 3 rates of organic manure (0, 5, 10 t ha^{-1}) applied as poultry manure and 2 rates of inorganic fertilizer (0, 120 kg ha^{-1}) applied as NPK 20:10:10. Ten kilograms of air-dried, sieved (2 mm) soil samples were weighed into pots. Poultry manure was incorporated two weeks before planting and water was applied to the soil until it attained field capacity and this was repeated when necessary while the inorganic fertilizer was applied a week after planting so as to ensure its availability for the crop. Three seeds of maize (SUWAN 1) were sown and thinned to two plants per pot at 2 weeks after planting. It was grown for 3 cycles of 6 weeks from sowing per cycle. Soil samples were collected and analyzed for total N, NO_3^- -N, NH_4^+-N, organic carbon (OC), available P, K, Na, Ca, Mg and pH at the end of each cycle using standard procedure. Data collected were subjected to analysis of variance (ANOVA) using SAS and means were separated using Duncan's Multiple Range Test, though the means of the three cycles were presented. The coordinates of the collection points and sub-group of the soil used for the trial are shown in Table 1.

3. RESULTS AND DISCUSSION

3.1 Properties of the Pre Cropping Soils Collected from Different Locations

The physical and chemical properties of the soils collected for the experiment are shown in Table 2. The soils are generally low in total nitrogen. The available P has highest value in soil from Igboora (34.0 mg kg^{-1}) while Abeokuta had the least. Soils from Kobape and Ikenne had relatively higher organic carbon compared to other soils. Generally, the soils distribution of exchangeable basic cations follows the order: Ca>Mg>K>Na. Ammonium-nitrogen is consistently higher than nitrate-nitrogen in the soils. The highest NH_4^+-N is observed in soil from Abeokuta while the least NO_3^--N is recorded for soil also from Abeokuta. The pH of the soils ranged from slightly acidic to slightly alkaline; these fall within the optimum soil pH range for maize cycle production [17]. The soils belong to the textural class loamy sand.

3.2 Nutrient Composition of the Poultry Manure and Inorganic Fertilizer Used for the Study

The manure used was high in total N, total P, Organic carbon and exchangeable bases with slightly acidic pH. The result of the chemical composition of the NPK fertilizer used showed that the analyzed grades are 17-9-9 instead of specified grade of 20-10-10 (Table 3). Thus, the NPK fertilizer has nutrient contents lower than the stipulated. This may be due to poor or ineffective quality control by the manufacturer of this fertilizer. The quality issues have been identified as a major supply constraint to fertilizer use in Nigeria and farmers have indicated interest in fertilizer despite the cost if they were assured of quality [18]. A similar observation was made by [19].

3.3 Changes in Soil pH

Table 4 shows the changes in soil pH after treatments application. Sole application of 10 t ha^{-1} poultry manure consistently recorded the highest mean pH value in all the soil types considered except in the soil from Ikenne where the combination with 120 kg ha^{-1} NPK gave highest value (6.54). The control gave lowest mean value in the soil sample from Igboora and Kobape which were 10.66 and 5.15%, respectively lower than the highest value which was at sole application of 10 t ha^{-1} poultry manure.

Table 1. Sub-group and coordinates of point of collecting soil samples

	Latitude	Longitude	Sub-group
Abeokuta	N 07º 14.30'	E 003º 26.21'	Kandic Paleustalf
Igboora	N 07º 26.48'	E 003º 15.72'	Kandic Paleustalf
Ikenne	N 06º 50.87'	E 003º 41.58'	Oxic Paleustalf
Kobape	N 07º 02.45'	E 003º 25.91'	Oxic Paleustalf
Odeda	N 07º 14.17'	E 003º 31.79'	Typic Hapludalf

Table 2. Physical and chemical properties of the pre cropping soils

Soil location	Abeokuta	Igboora	Ikenne	Kobape	Odeda
Properties					
pH	6.7	6.9	7.3	7.7	7.4
Total N (g kg^{-1})	1.2	1.1	1.9	2.1	1.4
Av. P (mg kg^{-1})	9	34	24	12	16
Org. C (g kg^{-1})	14.4	13.4	24.5	28.7	19.0
Exchangeable bases (c mol kg^{-1})					
K^+	0.46	0.30	0.24	0.15	0.28
Na^+	0.17	0.17	0.13	0.13	0.15
Ca^{2+}	6.10	4.58	4.14	6.43	2.08
Mg^{2+}	0.60	0.42	0.62	0.89	0.24
NH_4^+-N (mg kg^{-1})	49.85	38.40	48.30	46.35	47.20
NO_3^--N (mg kg^{-1})	3.65	4.20	8.16	8.20	9.14
Sand (g kg^{-1})	828	848	858	838	858
Silt (g kg^{-1})	48	38	8	38	28
Clay (g kg^{-1})	124	114	134	124	114
Textural class	Loamy sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand

Table 3. Chemical properties of the poultry manure and inorganic fertilizer used

Parameters	Poultry manure	Inorganic fertilizer
pH	6.80	7.5
Total N (%)	2.49	17
Total P (%)	0.14	-
Org. C (%)	4.64	-
K (%)	0.49	-
Na (%)	0.52	-
Ca (%)	9.28	-
Mg (%)	1.18	-
P_2O_5 (%)	-	9
K_2O (%)	-	9
CaO (%)	-	1
MgO (%)	-	0
NaO (ppm)	-	57

3.4 Changes in Soil Organic Carbon (SOC)

In the soil sample from Abeokuta, the highest mean of the three cycles (11.9 g kg^{-1}) was observed in the treatment with combined application of 10 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK (Table 4). In the soil taken from Igboora site, the lowest means (1.0 g kg^{-1}) was observed in treatment with combined application of 5 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK. In the soil sample from Kobape, application of 10 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK gave the highest mean of the 3 cycles (11.6 g kg^{-1}) which was 39.75 and 24.73 % higher than sole application of 120 kg ha^{-1} NPK fertilizer (8.3 g kg^{-1}) and the control (9.3 g kg^{-1}), respectively. Soil organic carbon (SOC) was generally high in the soil sample taken from Odeda site in all the treatments and this was evident in highest mean recorded when compared to other soils. The highest mean of the 3 cycles in the soil sample from Abeokuta, Kobape and Odeda was observed at combined application of 10 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK. [20] reported drastic reduction in organic carbon concentration on continuous application of chemical fertilizer whereas addition of 5 t FYM ha^{-1} along with fertilizer N helped in maintaining the original organic matter status in soil. Rapid mineralization of the poultry manure as result of improved activities of soil organisms could probably cause decline in SOC content of organic amended soil with time as observed in this research work.

3.5 Changes in Total Nitrogen, Available P and K Concentrations

The changes in total nitrogen are shown in the Table 5. The mean concentration of the 3 cycles was highest at Odeda soil compared to soils from other locations. Combined application of 10 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK (2.0g kg^{-1}) was 45% higher than the control (1.1g kg^{-1}) in Odeda soil. Though not shown in the table, decrease in total N concentration was observed from the soil collected from the five locations and this could be as a result of cycle utilization of N, ammonia volatilization, bacteria denitrification, effect of runoff and nitrogen leaching loss. [21] indicated that for every 100 kg N ha^{-1} applied to tropical soil, as much as 29.5 kg could be lost through leaching below the cycle root zone especially in loose soils.

The changes in soil available P concentrations in the experiment are presented in Table 5. In the soil sample from Igboora, the mean value of the three cycles of combined application of 10 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK was higher than sole application of 120 kg ha^{-1} NPK and the control by 230.07 and 194.01%, respectively. It was observed that the sole application of 120 kg ha^{-1} NPK gave the least mean value while combined application of 120 kg ha^{-1} NPK and 10 t ha^{-1} poultry manure gave the highest in all the soil type and application of poultry manure gave higher mean values compared with treatment without poultry manure except in soil from Ikenne. In the soil sample from Ikenne, application of 10 t ha^{-1} poultry manure without 120 kg ha^{-1} NPK gave lowest mean values of the three cycles when compared with other treatment combinations. Combined application of 10 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK fertilizer increased available P over the control and sole application of 120 kg ha^{-1} NPK in all the soil types considered except in the soil sample from Ikenne. This increase may be as a result of contribution of both poultry manure and NPK fertilizer to the pool of available P in the treated soil. A general low content of soil available P in control treatments in maize production has been reported by [22]. According to the author, P availability in maize fields soils has generally been related to the amount of P applied and the reported increases in available P from mineral fertilizers or organic amendments are consistent with earlier reports [23,24]. It is noteworthy that, fixation and immobilization of mineralized P from poultry manure has proved to be negligible [25], therefore increase available P as a result of application of poultry manure is probable. The authors attributed this to high total P and low amount of Al and Fe in the poultry manure used. The mean of K concentration value in Abeokuta soil in the control (0.10 c mol kg^{-1}) was observed to be lower than other treatment combinations while sole application of 10 t ha^{-1} poultry manure (0.40 c mol kg^{-1}) gave highest value (Table 5). Combined application of 10 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK and sole application of 10 t ha^{-1} increased mean value K concentrations of the three cycles by 230.30 and 300.00%, respectively over the control. In the soil from Igboora, the least mean values of the three cycles was observed at the control which was 293.75% lower than the highest value at sole application of 10 t ha^{-1} poultry manure.

3.6 Changes in Soil Ammonium- Nitrogen and Nitrate-Nitrogen

Effect of organic and inorganic fertilizers on the changes of NH_4^+-N is shown in the Table 6. The highest mean of the 3 cycles of 53.61 mg kg^{-1} was at sole application of 5 t ha^{-1} poultry manure which is 83.03% higher than the combined application of 5 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK 29.29 mg kg^{-1}which is the lowest in Abeokuta soil. In Igboora soil, the lowest mean of the 3 cycles was at combined application of 5 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK while the highest is at the application of NPK fertilizer alone. Table 6 shows the changes that occur in NO_3^--N as affected by organic and inorganic fertilizer. In the soil sample from Abeokuta, sole application of 10 t ha^{-1} poultry manure gave the highest mean of the 3 cycles (9.20 mg kg^{-1}) which is 829.29% of higher than the value at the control (0.99 mg kg^{-1}). The high NH_4^+-N and low NO_3^--N content observed in this work could probably be that the soils exhibit high ammonification potential which is evident in high pH values. During ammonification of organic N to NH_4^+, one OH^- ion is released, but during nitrification of NH_4^+ to NO_3^--N, two H^+ ions are released [26]. The trend may also be as result of leaching NO_3^--N content of the soil. A number of studies have shown that soil denitrification potentials were significantly affected by soil organic carbon [27-29].

3.7 Changes in Na, Ca and Mg Concentrations

Changes in Na concentration is shown in the Table 7. Combined application of 5 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK gave the lowest Na concentration of the mean of the three cycles (0.19 c mol kg^{-1}) while the highest was the sole application of 5 t ha^{-1} poultry manure (0.29 c mol kg^{-1}) in the soil sample from Abeokuta. Combined application of 5 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK gave the lowest mean of the three cycles in the soil from Ikenne while the highest was observed in sole application of 10 t ha^{-1} poultry manure. In the soil sample from Ikenne, it was observed that the highest mean value of Ca concentration was at combined application of 5 t ha^{-1} poultry manure and 120 kg ha^{-1}NPK (10.22 c mol kg^{-1}) while the lowest was at sole application of 120 kg ha^{-1} NPK (5.55c mol kg^{-1}).

Table 4. Effects of organic and inorganic fertilizers on mean values of soil pH and soil organic carbon on soils from different locations

Treatments	Soil pH					Soil organic carbon (g kg^{-1})				
	Abeokuta	Igboora	Ikenne	Kobap	Odeda	Abeokuta	Igboora	Ikenne	Kobape	Odeda
NPK_0 PM_0	6.04	5.72	5.76	5.82	6.42	10.1	5.9	13.0	9.3	17.2
NPK_{120} PM_0	5.84	5.76	5.71	5.83	6.47	8.1	6.5	12.7	8.3	16.9
NPK_0 PM_5	6.56	5.95	6.03	5.84	6.48	8.4	5.6	14.9	10.3	11.2
NPK_{120} PM_5	6.18	6.10	6.33	6.03	4.78	8.2	1.0	13.9	10.3	21.6
NPK_0 PM_{10}	6.63	6.33	6.20	6.12	6.91	9.6	9.9	14.6	9.8	24.4
NPK_{120} PM_{10}	6.20	6.22	6.54	6.01	6.78	11.9	7.0	14.6	11.6	27.2

Key: NPK_0PM_0 – 0 kg $ha^{-1}$of NPK and 0 t ha^{-1} of poultry manure (Control); NPK_{120} PM_0 - 120 kg $ha^{-1}$of NPK and 0 t ha^{-1} of poultry manure; NPK_0PM_5 – 0 kg ha^{-1} of NPK and 5 t ha^{-1} of poultry manure; NPK_{120} PM_5 - 120 kg ha^{-1} of NPK and 5 t ha^{-1} of poultry manure; NPK_0PM_{10} – 0 kg ha^{-1}ofNPK and 10 t ha^{-1} of poultry manure; NPK_{120} PM_{10} - 120 kg ha^{-1} of NPK and 10 t ha^{-1} of poultry manure

Table 5. Effects of organic and Inorganic fertilizer on mean values of NPK concentrations of soils from different locations

Treatments	Total nitrogen (g kg^{-1})					Available phosphorus (mg kg^{-1})					Exchangeable potassium (c mol kg^{-1})				
	Abeokuta	Igboora	Ikenne	Kobape	Odeda	Abeokuta	Igboora	Ikenne	Kobape	Odeda	Abeokuta	Igboora	Ikenne	Kobape	Odeda
NPK_0 PM_0	1.1	0.8	1.4	1.0	1.1	3.67	13.18	11.71	12.27	7.60	0.10	0.16	0.39	0.12	0.54
NPK_{120} PM_0	0.8	0.7	1.2	0.7	1.5	2.53	11.74	38.97	10.18	5.61	0.23	0.24	0.27	0.10	0.44
NPK_0 PM_5	0.9	0.7	1.4	1.0	1.3	20.77	22.82	38.95	26.90	12.24	0.40	0.35	0.25	0.40	0.41
NPK_{120} PM_5	0.8	1.2	1.2	0.9	1.7	21.45	33.29	53.33	32.86	13.52	0.26	0.28	0.18	0.35	0.51
NPK_0 PM_{10}	0.8	1.2	1.3	0.8	1.9	37.23	29.99	9.30	32.34	11.60	0.40	0.63	0.32	0.61	0.85
NPK_{120} PM_{10}	1.1	0.9	1.2	1.0	2.0	39.89	38.75	9.57	38.86	40.01	0.33	0.52	0.39	0.50	1.00

Key: NPK_0PM_0 – 0 kg $ha^{-1}$of NPK and 0 t ha^{-1} of poultry manure (Control); NPK_{120} PM_0 - 120 kg $ha^{-1}$of NPK and 0 t ha^{-1} of poultry manure; NPK_0PM_5 – 0 kg ha^{-1} of NPK and 5 t ha^{-1} of poultry manure; NPK_{120} PM_5 - 120 kg ha^{-1} of NPK and 5 t ha^{-1} of poultry manure; NPK_0PM_{10} – 0 kg $ha^{-1}$of NPK and 10 t ha^{-1} of poultry manure; NPK_{120} PM_{10} - 120 kg ha^{-1} of NPK and 10 t ha^{-1} of poultry manure

Table 6. Effects of organic and inorganic fertilizers on the mean values of inorganic forms of nitrogen in the soils of different locations

Treatments	Soil ammonium-nitrogen (mg kg^{-1})					Soil nitrate-nitrogen (mg kg^{-1})				
	Abeokuta	Igboora	Ikenne	Kobape	Odeda	Abeokuta	Igboora	Ikenne	Kobape	Odeda
NPK_0 PM_0	33.37	28.82	44.58	40.65	26.27	0.99	2.19	2.27	1.33	0.65
NPK_{120} PM_0	45.19	37.52	29.65	38.47	30.54	1.85	1.43	1.58	4.14	1.24
NPK_0 PM_5	53.61	33.23	37.24	33.74	31.44	0.81	2.33	2.06	1.56	1.71
NPK_{120} PM_5	29.29	23.81	40.60	53.20	34.04	2.26	4.08	0.93	1.07	0.47
NPK_0 PM_{10}	31.75	37.12	41.92	31.45	32.22	9.20	2.87	1.32	1.94	1.28
NPK_{120} PM_{10}	34.74	29.53	33.71	41.77	23.50	2.13	1.14	1.21	5.41	1.16

Key: NPK_0PM_0 – 0 kg $ha^{-1}$of NPK and 0 t ha^{-1} of poultry manure (Control); NPK_{120} PM_0 - 120 kg $ha^{-1}$of NPK and 0 t ha^{-1} of poultry manure; NPK_0PM_5 – 0 kg ha^{-1} of NPK and 5 t ha^{-1} of poultry manure; NPK_{120} PM_5 - 120 kg ha^{-1} of NPK and 5 t ha^{-1} of poultry manure; NPK_0PM_{10} – 0 kg ha^{-1}ofNPK and 10 t ha^{-1} of poultry manure; NPK_{120} PM_{10} - 120 kg ha^{-1} of NPK and 10 t ha^{-1} of poultry manure

Table 7. Effects of organic and inorganic fertilizers on the mean values of some exchangeable bases concentrations in the soils of different locations

Treatments	Exchangeable sodium (c mol kg^{-1})					Exchangeable calcium (c mol kg^{-1})					Exchangeable magnesium (c mol kg^{-1})				
	Abeokuta	Igboora	Ikenne	Kobape	Odeda	Abeokuta	Igboora	Ikenne	Kobape	Odeda	Abeokuta	Igboora	Ikenne	Kobape	Odeda
NPK_0 PM_0	0.23	0.22	0.23	0.19	0.39	9.31	5.78	9.01	6.61	7.88	1.33	0.88	1.32	1.27	1.08
NPK_{120} PM_0	0.22	0.24	0.22	0.21	0.35	7.87	4.84	5.55	7.48	6.09	1.23	0.71	0.77	1.32	0.99
NPK_0 PM_5	0.29	0.30	0.25	0.22	0.31	7.39	5.19	6.88	6.41	7.14	1.05	0.85	0.92	1.13	1.56
NPK_{120} PM_5	0.19	0.31	0.15	0.20	0.41	7.22	5.30	10.22	7.23	11.71	1.09	1.00	1.38	1.19	1.73
NPK_0 PM_{10}	0.27	0.40	0.35	0.32	0.55	8.19	6.21	7.40	7.54	10.38	1.48	1.38	1.46	1.19	1.66
NPK_{120} PM_{10}	0.26	0.32	0.25	0.28	0.57	6.98	7.05	6.32	8.07	9.20	1.03	1.18	1.24	1.47	1.65

Key: NPK_0PM_0 – 0 kg $ha^{-1}$of NPK and 0 t ha^{-1} of poultry manure (Control); NPK_{120} PM_0 - 120 kg $ha^{-1}$of NPK and 0 t ha^{-1} of poultry manure; NPK_0PM_5 – 0 kg ha^{-1} of NPK and 5 t ha^{-1} of poultry manure; NPK_{120} PM_5 - 120 kg ha^{-1} of NPK and 5 t ha^{-1} of poultry manure; NPK_0PM_{10} – 0 kg ha^{-1}ofNPK and 10 t ha^{-1} of poultry manure; NPK_{120} PM_{10} - 120 kg ha^{-1} of NPK and 10 t ha^{-1} of poultry manure

4. CONCLUSION

The addition of poultry manure present a potential to act as lime especially in short time and also improved the K, Ca, Na and Mg content for non-degraded soil of southwestern Nigeria. Though application of poultry manure did not prevent decrease in soil organic carbon and total nitrogen with time but it was concluded that complementary application of 10 t ha^{-1} poultry manure and 120 kg ha^{-1} NPK 20-10-10 improved soil fertility than other treatment combinations considered.

COMPETING INTEREST

We hereby declare that there is no competing interest among the authors or with any organization.

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