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Nitrogen Fractions, Microbial Population and Maize Yield as Affected by Type of Animal Manure Applied in Agricultural and Wetland Soils at Abeokuta and Bodako farms, Ogun State, Nigeria

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ABSTRACT: Soil differs in nitrogen (N) fractions mineralized and available for uptake by crops, which are facilitated amongst others factors by the microbial nature of the soil. Hence the objective of this paper was to investigate the nitrogen fractions, microbial population and maize yield as affected by type of animal manure applied in agricultural and wetland soils at Abeokuta and Bodako farms, Ogun State, Nigeria. Poultry manure and cowdung at $65kgNha^{-1}$, and no amendment/control were applied to the experimental fields of agricultural soil (*Typic Tropudalfs*) and wetland soil (*Aqualfs*). Data obtained show that there were variability among the N fractions irrespective of sampling time. The N fractions were abundance at postharvest as compared to at 2 Weeks after application (WAA). Soil Ammonium-N and Nitrate-N immobilize by 60.3% – 65.5% and 59.2% - 69.2%, respectively. Total N and Organic-N mineralize by 49.3% - 76% and 42.6 - 45.8%, respectively. Consequently, a ratio of isolated bacteria to fungal (3:1) was identified. Where estimated population counts (*Epc*) were higher in harvested soils [115.5 x 10^{-6} Colony Forming Unit per gram (*CFU/g)* soil bacteria, and 103.4 x 10^{-6} CFU/g soil fungi] of applied Agricultural soil/cowdung. It was different at 2 WAA, where wetland soil/cowdung applied was 108.8 x 10^{-6} CFU/g soil bacteria, and Agricultural soil/cowdung applied 89.2 x 10^{-6} CFU/g soil fungi. Evidently, the build-up of soil organic carbon (SOC) was significantly low in wetland soil/*Aqualfs* (27%). All fractions, however, had strong positive relationship with SOC. Plant tissue N (1.21%), dry matter yield (0.034t/ha) and grain yield (2.37t/ha) were significantly high and productive in Agricultural soil (*Typic Tropudalfs*) due to higher Epc. Therefore, N mineralization and its uptake can be improved through increased activities of soil microbes for optimum crop yield.

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Maize (*Zea mays* L.) is a cereal crop grown mainly in a developing country like Nigeria which provides a source of income to the large population of small holder farmers. No cereal crop is produced annually more than maize in the country due to its high demand from consumers and its great nutritional value (Adeyemo *et al*., 2019). Crops such as maize need nutrients such as N, P, K, Mg, Ca, Na, and S to produce well. These nutrients are functional and must be given to the plant at the right time and in the right amount for proper growth and reproduction (Asfaw, 2022). However, there is a renewed interest in the efficient and effective use of natural fertilizers to maintain soil fertility. Apart from being a source of plant nutrients, organic fertilizers, e.g. poultry manure and other animal manures have improved agricultural productivity in African countries. Organic fertilizer helps to increase the number of micro-organisms that have a specific effect on protecting plants from germs such as nematodes, and soil-borne insects and provides plant growth hormones such as auxins (Uwah *et al*., 2011). Organic fertilizers also help to improve the condition of the soil and provide much-needed plant nutrients. Animal manure is an important source of nitrogen (N) that provides nutritional needs of growing crops. Nutrients contained in organic manures are released slowly and stored for a longer time in the soil, thereby ensuring a long residual effect (Agbede and Ojeniyi, 2009). Nitrogen (N) is typically the nutrient of most concern because it has a strong influence on cereal crop yields. Mineralization and N recycling begin as soon as the manure is incorporated into the soil. The rate of mineralization however varies with N sources, but the highest rate is at application and the rate decreases with time (Alade *et al*., 2019). However, an understanding of N mineralization from organic manure is required to predict both the short and long term release of N, and to avoid high levels of soil N accumulation that may be subjected to nitrate leaching and denitrification losses. Appropriate nitrogen fertilization serves as the principal factor of nutrient management in high-yielding maize production systems (Alade *et al*., 2019).

On field, the mineralized N is often neutralized by microbial immobilization. Mineralization is more rapid in warm, moist soils and slower in soils that are dry or cold. Even under uniform soil and environmental conditions, manures from the same animal species display wide range of N mineralization (Dalias and Christou, 2020); Sradnick and Feller, 2020). Therefore, signify variability depending on the type or condition of the soil. Crops take up nitrogen in the form of NH^{4+}, a result of mineralization and NO^{3-}, a result of nitrification. The ammonium is incorporated into crop tissues and is thus rendered temporarily unavailable (immobilization) until those tissues becomes decomposed. Immobilization also occurs when the inorganic N is assimilated back into the microbial population, thereby temporarily reducing the plant-available N pool (Daly *et al*., 2021). Studies relating to the effect of manure as affecting the distribution of nitrogen fractions, release of nutrients as a result of microbial activities, with the cumulative effect on maize yield are scanty; hence, the objective of this paper is to investigate the nitrogen fractions, microbial population and maize yield as affected by type of animal manure applied in agricultural and wetland soils at Abeokuta and Bodako farms, Ogun State, Nigeria.

MATERIALS AND METHODS

Location of the experiment: The field experiments were conducted at two different locations of different soil types in 2011 (Figure 1). The first location was at the Federal University of Agriculture, Abeokuta (FUNAAB) experimental field (Latitude 7.235951 N - Latitude 7.235951 N, Longitude 3.427102 E – Longitude 3.427335 E). This was the agricultural soil, classified as *Typic Tropudalfs* – Temidire series (IUSS Working Group WRB, 2006; Aduayi *et al*., 2002); a deep, well-drained, loamy-sand textured. While the second location was conducted at Bodako farms (Latitude 7.243034 N – Latitude 7.243034 N, Longitude 3.532178 E - Longitude 3.532960 E), a wetland soil classified as Aqualfs / *Oxic Paleustalf* – Owutu series (IUSS Working Group WRB, 2006; Aduayi *et al*., 2002); aquic moisture regime, alluvial nature, poorly drained, loamy-sand textured. Both fields are located in the Rainforest agro-ecological zone (Table 1) in Odeda Local Government Area of Ogun state, Nigeria.

Experimental design and procedure: The experiment was conducted using randomized completely blocked design in 2 × 3 factorial arrangements. It consisted of 2 blocks which were the soil types (agricultural/well-drained and wetland/hydromorphic). The 3 treatments were the sources of animal manures (cowdung and poultry manure) and control. The experiments had three replicates thus giving a total of 18 experimental units.

The matured animal manures were collected free of bedding/litter materials. They were obtained from the Federal University of Agriculture, Abeokuta (FUNAAB) – College of Animal Science's poultry farms (battery cage system) and Kara for cowdung, respectively. Poultry manure and cowdung were applied at the rate of 65 $kgNha^{-1}$ (20 t ha^{-1}) (Payebo and Ogidi, 2021) once at the onset of a 16-week study.

Table 1: Sites of the experiment

Location	State	Coordinates	Vegetation	Soil series	Soil class: (USDA)
Alabata	Ogun	Lat. 7.235951 - 7.235951 N Long. 3.427102 -3.427335 E	Rainforest	Temidire	*Typic Tropudalfs*
Lufowora	Ogun	Lat. 7.243034 - 7.243034 N Long. 3.532178 - 3.532960 E	Rainforest	Owutu	*Aqualfs*

(Source: Field survey, 2011).

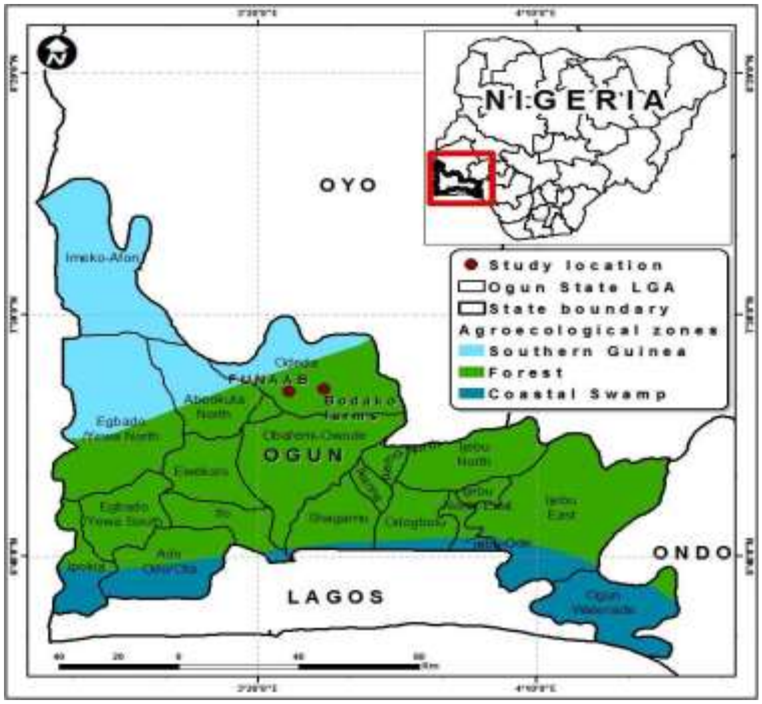

Fig.1: Study location map (*Source*: Field survey, 2011).

The soil samples obtained from the experimental setup were analysed for mineral content before applications of animal manure, at 2 Weeks after application (WAA) of manures, and after harvest of maize grains. These collections (except for the before application) were used to determine the N fractions released (Table 2) and, the estimated population counts of fungi and bacteria. While the maize yield were determined from the harvested cobs by weight of grains per experimental setup. Each treated plot size was 5 × 4 (20 m^2). Three seeds of maize *Zea mays* L. (SUWAN 1) were planted after 2 weeks of treatment incorporation. The seedlings were thinned to two per stand two weeks after planting.

Selected Soil Physicochemical Analysis: The soil samples were collected from the top-soil 15 cm layer, air-dried at room temperature for 24 hours, and later sieved by passing through a 5 mm sieve. Then it was packed in air-tight zipped lock bags for further analyses using the following methods. Soil pH was determined with 1:1 soil: water ratio and measured using glass pH meter electrodes. Organic and total nitrogen were determined by Kjeldahl method (Cerdà and Estela, 2008), the digests are then used to determine total N directly and organic nitrogen by difference. Soil organic carbon (SOC) content was determined by Walkley–Black method (1934) and particle size by hydrometer method (Ashworth *et al*., 2001). Available phosphorus was extracted by Bray-1 extraction method (Bray and Kurtz, 1945) and analysed colorimetrically (Murphy and Riley, 1962). Exchangeable bases were extracted with 1 N ammonium acetate (pH = 7) solutions, K+ and Na+ were analysed with a flame photometer, while Ca^{2+} and Mg^{2+} were analysed with atomic absorption spectrophotometer (AAS) (Sparks, 1996).

Nitrogen Fractions Study: Soil extractions with 2 M potassium chloride were used to estimate NO_3 and exchangeable (plant available) NH_4 by distillation-colorimetric method (Keeney and Nelson, 1987). Fractionation procedure by Mulvaney and Khan (2001) was used to quantify different forms of inorganic N in the studied soils (as shown in Table 3). Fractionation was done on the soil at 2 WAA and after harvest in the field experiment. The non-sequence of the chemical extraction and a brief description of the targeted N forms are shown in Table 2.

Ammonium-N: From the soil extracts, 150 ml was pipetted into the ammonium distillation flask, and 5 ml of 2 % $H_2BO_3^-$ indicator solution was added into an Erlenmeyer flask which was then placed under the condenser of the distillation apparatus. Distillation commences and continued until up to 50 ml distillate was collected. The NH_4-Boric solution obtained was titrated with 0.01 M H_2SO_4 making use of the micro-burette. Color change from green to pinkish-blue indicated the endpoint. A blank sample (distill water) was run for both distillation and titration. Where another sample of the soil extracts was treated with 10 ml of 0.25 M NaOH in the absence of the $KMnO_4$. The previous procedures were carried out. The NH_4-N produced by alkaline $KMnO_4$ oxidation was calculated as the difference between the results of the two analyses.

Nitrate-N: Also from the soil extracts, 0.2 ml was pipetted into a 50 ml conical flask and 0.8 ml of salicylic acid-H_2SO_4 reagent thoroughly mixed. The reaction of this mixture was allowed for about 20 minutes, and then slowly added 19 ml of 2 M NaOH at pH 12. The mixture was stirred and cooled to room temperature (23 ^oC), read and recorded at 410 NM. Nitrate-nitrogen standards containing 0.60 µg of N in 0.2 ml aliquot was analyzed with each set of samples

Table 2: Operational definitions for forms of N (non-sequential extractions)

Operational definition	Targeted fraction	Source(s)
2 M KCl extraction	Plant available NO_3-N and NH_4-N	Bremner, 1996.
Combustion (Kjeldahl distillation method)	Total N	Cerdà and Estela, 2008.
Total N less NO_3-N and NH_4-N	Organic N	Cerdà and Estela, 2008.

Isolation and identification of soil microbial population: All glass wares were washed thrice with distilled water and drained off. These were sterilized in the oven temperature programmed at 150 ^oC for 2 hours. Nutrient agar (NA), Potato Dextrose agar (PDA), and Stephenson's media were prepared and sterilized in an autoclave at 121 ^oC, 12 – 15 Mpa for 15 minutes (Sagar, 2022). An inoculating loop was sterilized by inserting into a naked flame from the Ethanol lamp at each application. About 16.5 g of NA and 22 g of PDA (with a drop of acetic acid added to prevent the growth of bacteria) was weighed into different labeled conical flasks; 500 ml of distilled water was added and dissolved by heating on the heater before sterilizing in an autoclave at 121 ^oC, 12 – 15 Mpa for 15 minutes. Then the mixtures were allowed to cool to about 45 – 50 ^oC before plate pouring. This procedure was also carried out in the preparation of Stephenson media for selective culturing/isolation of Nitrobacter and Nitrosomonas species. The micro-organisms were isolated from the soil samples using the Pour Plate Method (Dahal, 2022). Ten grams of soil subsamples were weighed into 90 ml sterile distilled water in a beaker and stirred. One ml portion of serial decimal dilutions of 10^{-9} was placed onto a NA plate for the determination of the total viable bacterial count, and PDA supplemented with a drop of acetic acid for viable fungal count. The incubation temperature of bacterial plates was 37 ^oC for 48 hours, while fungal plates were at room temperature for 4 days. Colonies forming units developed from the plates were enumerated (Lee, 2021) in the expressions of Colony Forming Unit per gram of soil (CFU/g).

Data collection: The relative meteorological data needed to understudy the growing season during the experiment were taken (Table 3). More so, the chemical, some physical and biological properties of the soils were determined appropriately. Some characteristics of used animal manures were also determined (Table 5).

Table 3: Meteorological data for Abeokuta and environs in 2011

	February	March	April	May	June	July	August	September	October
Rainfall (mm)	140	23.9	74.5	73.7	84.5	350	88.7	204	288
Relative humidity (%)	78.7	80.0	76.4	78.9	82.2	84.6	84.7	84.1	79.5
Sunshine hours	6.20	6.50	6.50	6.60	5.70	3.80	3.10	5.50	5.00
Temperature (mean ^oC)	28.9	29.2	29.2	28.0	26.9	24.5	25.3	26.6	26.9

(Source: NIMET, 2011).

Dry matter yield of maize plant was determined after weighing oven-dried plant biomass at 65 ^oC for 24 hours of each treated plots using a weighing balance. The grain yield of maize was determined from each treated plots in the middle rows, harvested carefully and threshed for full yield recovery. Yield per hectare was computed (oven dried at 12 % moisture content), based on the plant population of 106,666 plants/hectare. This was estimated as per the relationship in equation 1

$$TG = AG * PP \quad (1)$$

Where TG = Total grain yield per hectare; AG = Average grain yield per plant; PP = Plant population per hectare.

Statistical Analysis: Data obtained were subjected to Two-way Analysis of Variance (ANOVA) using the General Linear Model procedure of SAS 8. 0. Software version (2000), to determine the effects of treatment on the measured parameters in the soils and plant materials. Means were separated using Duncan Multiple Range Test. The analysis was performed at the 5 % level. Soil N fractions were compared with soil and plant parameters using Pearson's Correlation test at the 5 % level of probability.

RESULTS AND DISCUSSION

Initial Chemical Properties of the Soil Used: The pH of the soil was slightly acidic for Temidire (*Typic Tropudalfs*) and circum-neutral for Owutu (*Aqualfs*). Both are Loamy sand soils (Table 4). In Temidire series, total N was moderately low while P, Soil Organic carbon (SOC) and exchangeable Ca were very low. But in other exchangeable Mg, K and Na, it was detected high (FMARD, 2011). Moderately available P was observed in the Owutu series, from where SOC, total N and exchangeable Ca were low; and high contents of other exchangeable (Mg, K and Na) were found (FMARD, 2011).

Table 4: Chemical and physical properties of field soil.

Parameters	Temidire soil series	Owutu soil series
pH (H_2O)	6.10	7.20
Total Organic Carbon (g kg^{-1})	2.44	2.00
N (%)	1.10	0.90
P ($mgkg^{-1}$)	1.92	11.4
Exchangeable cations (cmol kg^{-1})		
Ca	0.84	1.00
Mg	24.0	29.8
K	11.6	17.2
Na	2.95	3.58
Particle size (g kg^{-1})		
Sand	863	818
Clay	119	114
Silt	18	68

Characteristics of the Cowdung and Poultry manure used: The pH of animal manure was neutral in cowdung, but slightly acidic in poultry manure. Both animal manures had similar C/N ratio. Total P, total N, Organic carbon and the total compositions - Ca, K and Na were observed to be more in the poultry manure used than from cowdung application (Table 5).

Response of N fractions in the soils to soil types and animal manure application: In the soil types, it was observed that Temidire series had high release of the total N and organic N at harvest than at 2 weeks after planting (WAP) (Table 6). But reversal was observed in the releases of ammonium-N and nitrate-N, respectively. Similar observations were observed in the Owutu series. Meanwhile from the soil series, total N was low (FMARD, 2011) at 2 WAP and was not significant ($p > 0.05$), but moderately available after harvest.

Table 5: Characteristics of the cow dung and poultry manure used

Parameters	Cow dung	Poultry manure
pH (H_2O)	7.00	6.20
Organic Carbon (%)	4.40	5.60
N (%)	2.75	3.48
P (%)	1.38	1.84
Ca (%)	2.47	2.98
K (%)	1.19	1.34
Na (%)	0.48	0.54
C/N	2:1	2:1

There were significant ($p > 0.05$) responses from the Owutu serie and poultry manure to the N fractions releases (except on NO3-N from Owutu, on NH_4-N and NO_3-N from poultry manure), while NH_4-N was significant ($p > 0.05$) from cow dung application at 2 WAA. Likewise after harvest, there were significant ($p > 0.05$) effects on the N fractions releases (except on NH_4-N from Owutu serie, on NH_4-N and NO_3-N from cow dung, and on organic nitrogen from poultry manure). The nitrogen fractions at 2 WAA (week after application) was observed to be abundant of Total N > Ammonium-N > Nitrate-N > Organic N (Table 6), unlike after harvest where Total N > Organic N > Ammonium- N > Nitrate-N. Generally, the effects of different soil types and animal manures used had significantly ($p > 0.05$) influenced on the N fractions, whereas at harvest it was not, rather numerical increase was observed with the control.

Effect of soil types and animal manures on soil total microbial population at 2 WAA and after harvest: The average numbers of cultured bacteria to fungal species population found in the treatments used was 3:1 ratio, where the estimated population counts were found higher after harvest in the soils than of the animal manure (Table 7) at 2 WAA.

There were significant ($p > 0.05$) responses in the numbers of isolated bacterial and fungal species from Temidire serie and cow dung, respectively. Also at 2 WAA, there were significant ($p > 0.05$) effects on the estimated counts. The cow dung application had higher estimated counts of bacterial and fungal, Owutu series had higher estimated counts of bacterial and Temidire series had higher estimated counts of fungal at 2 WAA, while Temidire series also had higher estimated counts of fungal after harvest.

Effect of soil types and animal manures on soil organic carbon, plant tissue N concentration, dry matter yield and grain yield: Generally, the availability of organic C decreases regardless of the treatment effects on the soil types or animal manures used across the weeks. However, significant (p > 0.05) increase was observed with the organic C and plant tissue N concentrations from cow dung treatment at 2 weeks after planting (WAP). While poultry manure effect was significantly (p > 0.05) higher on dry matter yield at both 2 WAP and after harvest, respectively (Table 8). Owutu series had significant (p>0.05) effect on plant tissue N concentrations at 2 WAP, and on SOC at both 2 WAP and after harvest, respectively. Temidire series effect was significantly (p > 0.05) higher on plant tissue N concentration, while on dry matter yield at both 2 WAP and after harvest, respectively.

Table 6: Effect of soil types and animal manures on N fractions (%) at 2 WAA and after harvest

Soil/Treatments	**Total N (%)**		**Organic N (%)**		**NH_4-N (%)$^{\#}$**		**NO_3-N (%)$^{\#}$**	
	2 WAA	**AH**	**2 WAA$^{\#}$**	**AH**	**2 WAA**	**AH**	**2 WAA**	**AH**
Soil types								
Temidire	0.10	0.18	-0.03	0.15	0.55	0.19	0.52	0.16
Owutu (*Aqualfs*)	0.14	0.21	0.31	0.16	0.58	0.23	0.49	0.20
Animal manure								
Cow dung	0.12	0.20	0.14	0.16	0.55	0.21	0.52	0.18
Poultry manure	0.13	0.20	0.29	0.16	0.51	0.22	0.49	0.19
Control	0.11	0.19	0.14	0.15	0.50	0.20	0.48	0.16
LSD (P > 0.05)								
Soil types	*	NS	*	NS	*	NS	*	NS
Animal manure	*	NS	*	NS	*	NS	NS	NS

**Significant at P > 0.05, NS: not significant, WAA: Weeks after application: AH: After harvest, $^{\#}$= x10^{-1}.*

Table 7: Effect of soil types and animal manures on soil total microbial population (x 10^{-6} CFU/g soil) at 2 WAA and after harvest

Treatments	**No. of Identified Specie**		**Total Bacteria Counts**		**Total Fungal Counts**	
	Bacteria	**Fungal**	**2 WAA**	**AH**	**2 WAA**	**AH**
Soil types						
Temidire (*Typic Tropudalfs*)	13	5	101	112	89.2	103
Owutu (*Aqualfs*)	11	4	104	102	86.3	95.4
Animal manures						
Cow dung	12	4	109	116	87.7	101
Poultry manure	9	3	103	102	83.7	99.1
Control	5	2	94.1	102	79.1	98.6
LSD (P > 0.05)						
Soil types	*	*	*	NS	*	*
Animal manure	*	*	*	NS	*	NS

**Significant at P > 0.05, NS: not significant, WAA: Weeks after application: AH: After harvest.*

Temidire series produced high dry matter yield (0.033 t ha^{-1}) and grain yield (2.37 t ha^{-1}) than Owutu series. Although Owutu series was found to be higher in organic carbon content(5.30gkg^{-1} as at 2 WAP and 3.87gkg^{-1} later after harvest), but was observed to have less plant tissue N concentration of 27 %, dry matter yield (0.024 t ha^{-1}) and grain yield (0.93 t ha^{-1}). This probably resulted from the concurrent flooding in the wetland (Owutu series) as shown in Table 2. Poultry manure treatment produced high dry matter yield (0.05 t ha^{-1}) and grain yield (1.80 t ha^{-1}) than cow dung amended. Although cow dung treatment was found to be higher in organic carbon content (3.72 gkg^{-1} as at 2 WAP but 2.76 gkg^{-1} after harvest from poultry manure), but was observed to have more plant tissue N concentration of 33 %, dry matter yield (0.02 t ha^{-1}) and grain yield (1.68 t ha^{-1}).

Table 8: Effect of soil types and animal manures on organic carbon, plant tissue N concentration, dry matter yield and grain yield

Treatments	**Organic carbon (%)**		**Plant tissue N concentration (%)**		**Dry matter yield (t ha^{-1})**		**Ave. Grain yield (t ha^{-1})**
	2 WAP	**Harvest**	**2 WAP**	**Harvest**	**2 WAP$^{\#}$**	**Harvest$^{\#\#}$**	
Soil types							
Temidire (*Typic Tropudalfs*)	1.32	1.23	0.76	1.21	0.13	0.33	.37
Owutu (*Aqualfs*)	5.30	3.87	0.79	0.86	0.07	0.24	0.93
Animal manures							
Cow dung	3.72	2.56	0.81	1.06	0.10	0.21	1.68
Poultry manure	3.26	2.76	0.76	1.04	0.11	0.46	1.80
Control	2.96	2.31	0.76	1.01	0.07	0.20	1.47
LSD (P > 0.05)							
Soil types	*	*	*	*	*	NS	*
Animal manure	*	NS	*	NS	*	*	NS

Significant at P > 0.05, NS: not significant. WAP: weeks after planting, $^{\#}$= x10^{-2}, $^{\#\#}$= x10^{-1}.

Relationship among N fractions, soil organic carbon, plant tissue N concentration and average grain yield: Soil organic carbon does not have correlation with any of the N fractions or with the dry matter yields of maize plant. The other fractions (nitrate- and ammonium- nitrogen) had a negative correlation with dry matter yields (Table 9). The plant tissue N concentration had a negative correlation with total and organic N, and a significant (p > 0.05) but strong negative correlation with NH_4-N and NO_3-N. While the average grain yield had a negative correlation with all the N fractions.

Table 9: Correlation coefficient relationship between N fractions, soil organic carbon, plant tissue N concentration and grain yield

	Nitrogen fractions			
	Total N (%)	**Organic N (%)**	**NH_4-N (%)**	**NO_3-N (%)**
Soil organic carbon (%)	0.12	0.09	0.18	0.17
Plant tissue N concentration (%)	-0.38	-0.29	-0.54*	-0.50*
Dry matter yield (kg ha^{-1})	-0.01	0.03	-0.09	-0.13
Grain yield (t ha^{-1})	-0.32	-0.29	-0.23	-0.39

**Significant at P > 0.05*

The pH of the soils was near neutral (Owutu series) and slightly acidic (Temidire series), which are low in N, an inherent factor of tropical soils and loamy sand. The applications of the animal manures that are rich in N and having complimentary similar pH characteristics were applied in order to study the effect as soil inputs being practiced by many farmers in Nigeria. The C/N ratio of the animal manures used (2:1) was greater than that found in the soil series used (1:1). These might be due to the decomposition of the animal manure during the curing stage before application to the soil, which acts as a soil improver due to its contribution of organic matter and nutrients, mainly N and others (Ndung'u *et al*., 2021). Most of the N in the environment are unavailable for plant uptake (Fernandez and Kaiser, 2021) and present in various forms. The manures must be mineralized by actions of soil micro-organisms before being made available to plants (Whalen, 2014). Also it can occur when the synergic effect of the plant nutrition-soil microbes' equilibrium relationship existed through mineralization-assimilation-immobilization processes (Adomako, 2020; Ma *et al.*, 2012; Karlen, 2012). The amount of NH_4-N and NO_3-N in the soil at 2 WAA was higher than those observed after harvest in all the treatments. This can happen as N transforms within the soil system (Soldatova *et al*., 2021; Nevins, Strauss and Inglett, 2020) decreasing the inorganic N due to the plant uptake. It was also observed that the amounts of NH_4-N were less than NO_3-N, probably because some NH_4-N was converted to NO_3-N by the soil microbes. Owutu serie had the higher N forms in all the animal manure treatments. Among the animal manure treatment, poultry manure released more of N forms than cow dung. The presence of organic carbon implies a comprehensive diversity of soil microbes' activities that stimulate N transformations. It was observed from the study that cow dung encourages higher diversity of bacteria activities with 12 species discovered, and Temidire serie had the higher diversity of fungal activities with 5 species. The organic carbon and organic nitrogen contributed to other N fractions which in turn contributed to yield. This further confirms the importance of animal manure while considering soil improvement and crop productivity. However, the contributions of mineral-N study (NH_4-N and NO_3-N) decrease significantly, but with an increase in the maize N concentration. It shows the plant available N factions had probably reached its threshold of the effective plant utilization in the plant components build-up; thereby immobilization might be occurring (Stotter *et al.*, 2021).

Conclusion: The N fraction transformation occurs within the soil where the animal manure was broken down by diverse microbial populations, thus releasing plant available N forms. Increased grain yield was encouraged by SOC and abundance bacteria to fungal population ratio in the soil. Therefore, the Agricultural soil (*Typic Tropudalfs*) was more productive in plant tissue N, dry matter yield, and grain yield due to high presence of the estimated soil microbial populations.

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Data Availability Statement: Data are available upon request from the first author / corresponding author

REFERENCES

Aczel, M (2019). What Is the Nitrogen Cycle and Why Is It Key to Life? *Frontier Young Minds*, **7**: 41. DOI: 10.3389/frym.2019.00041.

Adekiya, AO; Ejue, WS; Olayanju, A; Dunsin, O; Aboyeji, CM; Aremu, C; Adegbite, K; Akinpelu, O (2020). Different organic manure sources and NPK fertilizer on soil chemical properties, growth, yield and quality of okra. *Sci. Reports*, 10: 16083. https://doi.org/10.1038/s41598-020-73291-x.

Adeyemo, AJ; Akingbola, OO; Ojeniyi, SO (2019). Effects of poultry manure on soil infiltration, organic matter contents and maize performance on two contrasting degraded alfisols in south western Nigeria. *Inter. J. Recycling. Organic Waste. Agric*. 8:573-580.

Adomako, MO; Xue, W; Tang, M; Du, D; Yu, F (2020). Synergistic effects of soil microbes on *Solidago Canadensis* depend on water and nutrient availability. *Microbio. Ecol.* 80 (4): 837 – 845. Doi: 10.1007/s00248-020-01537-2.

Aduayi, EA; Chude, VO; Adebuseyi, BA; Olayinka, SO (2002). Fertilizer use and management practices for crops in Nigeria. 3rd Edition. Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.

Agbede, TM; Ojeniyi, SO (2009). Tillage and poultry manure effects on soil fertility and sorghum yield in southwestern Nigeria. *Soil. Tillage Res.* 64: 209-215.

Ahmad, AA; Radovich, TJ; Nguyen, HV; Jensen Uyeda, J; Arakaki, A; Cadby, J; Paull, R; Teves, JSA (2016). Use of Organic Fertilizers to Enhance Soil Fertility, Plant Growth, and Yield in a Tropical Environment. In Larramendy, ML; Soloneski S (Eds.), Organic Fertilizers - From Basic Concepts to Applied Outcomes. IntechOpen. https://doi.org/10.5772/62529.

Alade, AA; Azeez, JO; Ajiboye, GA; Adewuyi, SA; Olowoboko, TB; Hussein, SD (2019). Influence of animal manure mixture and soil nitrogen indices on maize growth. *Russian Agric. Sci.* 45 (2): 175-185.

Asfaw, MD (2022). Effects of animal manures on growth and yield of maize. *Journal of Plant Science and Phytopathology*, 6: 33 - 39.

Ashworth, J; Keyes, D; Kirk, R; Lessard, R (2001). Standard procedure in the hydrometer method for particle size analysis. *Communications in Soil Science and Plant Analysis,* 32: 633-642. 10.1081/CSS-100103897.

Bray, RH; Kurtz, LT (1945). Determination of Total Organic and Available Forms of Phosphorus in Soils. *Soil Science,* 59: 39-45. http://dx.doi.org/10.1097/00010694-194501000-00006

Bremner, JM (1996). Nitrogen – Total. In: Sparks, DL; *et al*. (edition) Methods of soil analysis. Part 3. Soil Science Society of America Book Service 5, Madison, WI.

Cerdà, V; Estela, JM (2008). Organic and total nitrogen. Advances in Flow Injection Analysis and Related Techniques. In: On-Line Sample Pre-treatment: Dissolution and Digestion-Chapter 6. Kolev, SD; Mckelvie, ID (Eds): *Comprehensive Analytical Chem.* 54: 129-158 https://doi.org/10.1016/S0166-526X(08)00606-5.

Dahal, P (2022). Pour Plate Method- Definition, Principle, Procedure, Uses: microbenotes.com (Online).

Dalias, P; Christou, A (2020). Nitrogen Supplying Capacity of Animal Manures to the Soil in Relation to the Length of Their Storage. *Nitrogen*, 1: 52 - 66. https://doi.org/10.3390/nitrogen1010006.

Daly, AB; Jilling, A; Bowles, TM; Buchkowski, RW; Frey, SD; Kallenbach, CM; Keiluweit, M; Mooshammer, M; Schimel, JP; Grandy, AS (2021). A holistic framework integrating plant-microbe-mineral regulation of soil bioavailable nitrogen. *Biogeochem.* 154: 211–229. https://doi.org/10.1007/s10533-021-00793-9.

Federal Ministry of Agriculture and Rural Development (FMARD) (2011). Fertilizer use and management practices for crops in Nigeria (4th ed.): Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development. Abuja, Nigeria.

Fernandez, FG; Kaiser, DE (2021). Understanding nitrogen in soils. University of Minnesota, Nutrient Management Extension Crop production Web Site. http://www. https://extension.umn.edu/nitrogen/understanding-nitrogen-soils.

Field Survey (2011). Field works on Effect of Nitrogen Release from Animal Manure on Microbial Community Structure, Maize (*Zea mays*, L) Growth and Yield in Three Soils. In: Progress at the Federal University of Agriculture, Abeokuta. Nigeria.

IUSS Working Group WRB. (2006). 'World Reference Base for Soil Resources 2006'. World Soil Resources Reports No. 103. FAO: Rome.

Karlen, DL (2012). 'Soil Health: The Concept, Its Role, and Strategies for Monitoring', In: Karlen, DL; Andrews, SS; Wienhold, BJ; Zobeck TM (eds), Soil Ecology and Ecosystem Services (Online edition, Oxford Academic) https://doi.org/10.1093/acprof:oso/9780199575923.003.0029.

Keeney, DR; Nelson DW (1987) Nitrogen-Inorganic Forms, sec. 33-3, extraction of exchangeable ammonium, nitrate, and nitrite. pp. 648 - 649. In Page, AL *et al*., (eds.), Methods of Soil Analysis: Part 2, Chemical and Microbiological Properties. Agronomy. A Series of Monographs, no.9 pt. 2, Soil Science Society of America, Madison, Wisconsin USA.

Kumar, M (2020). Social, Economic, and Environmental Impacts of Renewable Energy Resources. In: Okedu, KE; Tahour, A; Aissaou AG (Eds.), Wind Solar Hybrid Renewable Energy System. IntechOpen. https://doi.org/10.5772/intechopen.89494

Lazicki, P; Geisseler, D; Lloyd, M (2020). Nitrogen mineralization from organic amendments is variable but predictable. *J. Environ. Qual.* 49: 483–495. DOI: 10.1002/jeq2.20030.

Lee, A (2021)**.** Introduction to Enumeration of Bacteria. General Microbiology Laboratory (MB352): North Carolina State University. Open Education Resource (OER) LibreTexts Project. https://LibreTexts.org

Liliane, TN; Charles, MS (2020). Factors Affecting Yield of Crops. In (Ed.), Agronomy - Climate Change and Food Security. IntechOpen. https://doi.org/10.5772/intechopen.90672

Ma, L; Huang, W; Guo, C; Wang, R; Xiao C (2012). Soil microbial properties and plant growth responses to carbon and water addition in a temperate steppe: the importance of nutrient availability. *PloS One*, 7 (4): a35165. Doi:10.1371/journal.pone.0035165.

Maitlo, AA; Zhang, S; Ahmed, W; Jangid, K; Ali, S; Yang, H; Bhatti, SM; Duan, Y; Xu, M (2022). Potential Nitrogen Mineralization and Its Availability in Response to Long-Term Fertilization in a Chinese Fluvo-Aquic Soil. *Agronomy*, 12: 1260. https://doi.org/10.3390/agronomy12061260.

Muhereza, I; Pritchard, D; Murray-Prior, R; Collins, D (2020). Nitrogen value of stockpiled cattle manure for crop production. *Afr. J. Agric. Res.* 16 (5): 574-584. https://doi.org/10.5897/AJAR2020.14718

Mulvaney, RL; Khan, SA (2001). Diffusion Methods to Determine Different Forms of Nitrogen in Soil Hydrolysates. *Soil Sci. Soc. Am. J.*, 65: 1284–1292. doi:10.2136/sssaj2001.6541284x.

Murphy, J; Riley, JP (1962). A modified single solution method for determination of phosphate in natural waters. *Anal Chem.* 27: 31–36.

Ndung'u, M; Ngatia, LW; Onwonga, RN; Mucheru-Muna, MW; Fu, R; Moriasi, DN; Ngetich, KF (2021). The influence of organic and inorganic nutrient inputs on soil organic carbon functional groups content and maize yields. *Heliyon*, 7 (8), e07881. ISSN 2405-8440. https://doi.org/10.1016/j.heliyon.2021.e07881.

Nevins, CJ; Strauss, SL; Inglett, P (2020). An Overview of Key Soil Nitrogen Cycling Transformations. University of Florida, UF/IFAS Extension - SL471. https://edis.ifas.ufl.edu/

Nigerian Meteorological Agency (NIMET) (2011). Nigerian Meteorological Agency – Seasonal Rainfall, Temperature, Sunshine hours and Relative humidity data for Abeokuta and environs. Nigerian Meteorological Agency, Abuja, Nigeria.

Ntinyari, W; Gweyi-Onyango, JP (2021). Greenhouse Gases Emissions in Agricultural Systems and Climate Change Effects in Sub- Saharan Africa. In: Oguge, N; Ayal, D; Adeleke, L; da Silva, I (eds.) African Handbook of Climate Change Adaptation. Springer, Cham. https://doi.org/10.1007/978-3-030-45106-6_43.

Payebo, CO; Ogidi IA (2021). Evaluation of the effect of Cow Dung and Poultry dropping on Maize Kernel yield. *European J. Agr. Fores. Res.* 9 (1): 1 – 9. ECRTD-UK. ISSN: ISSN 2054-6327(online).

Purbajanti, ED; Slamet, W; Fuskhah, E; Rosyida, I (2019). Effects of organic and inorganic fertilizers on growth, activity of nitrate reductase and chlorophyll contents of peanuts (*Arachis hypogaea* L.). IOP Conference Series: *Earth and Environ. Sci.* 250: 012048, DOI:10.1088/1755-1315/250/1/012048.

Roobroeck, D; Palm, CA; Nziguheba, G; Weil, R; Vanlauwe, B (2021). Assessing and understanding non-responsiveness of maize and soybean to fertilizer applications in African smallholder farms. *Agri. Ecosystems. Environ*, 305, 107165. https://doi.org/10.1016/j.agee.2020.107165

Sagar, A (2022). Potato Dextrose Agar (PDA) - Principle, Uses, Composition, Procedure and Colony Characteristics: Online Microbiology Notes – MicrobiologyInfo.com

SAS Institute Inc. (2000). *SAS User's Guide to the ANOVA and GLM Procedures*: 8.0 Software Version, Cary, NC, USA.

Silva, EFd; Melo, MF; Sombra, KES; Silva, TS; de Freitas, DF; Costa, MEd; Santos, EPdS; Silva, LFd; Serra, AP; de Morais Cavalcante Neitzke, PR (2019). Organic Nitrogen in Agricultural Systems. In: Rigobelo, EC; Serra AP (Eds.), Nitrogen Fixation. IntechOpen. https://doi.org/10.5772/intechopen.90242

Sinha, D; Tandon, PK (2020). An Overview of Nitrogen, Phosphorus and Potassium: Key Players of Nutrition Process in Plants. In book: Sustainable Solutions for Elemental Deficiency and Excess in Crop Plants. Page 85-117: Springer, Singapore. DOI: 10.1007/978-981-15-8636-1_5

Soldatova, E; Dong, Y; Li, J; Liu, Y; Zan, J; Boeckx, P; Sun, Z (2021) Nitrogen transformation and pathways in the shallow groundwater–soil system within agricultural landscapes. *Environ. Geochem. Health*.43: 441–459. https://doi.org/10.1007/s10653-020-00733-w

Sradnick, A; Feller, CA (2020). Typological Concept to Predict the Nitrogen Release from Organic Fertilizers in Farming Systems. *Agronomy*, 10, 1448. https://doi.org/10.3390/agronomy10091448.

Stotter, M; Wichern, F; Pude, R; Hamer, M (2021). Nitrogen Immobilisation and Microbial Biomass Build-Up Induced by *Miscanthus x giganteus* L. Based Fertilisers. *Agronomy*, 11: 1386. https://doi.org/10.3390/ agronomy11071386.

Uwah, DF; Eneji, AE; Eshiet UJ (2011). Organic and mineral fertilizers effects on the performance of sweet maize (*Zea mays* L.) in southeastern rainforest zone of Nigeria *Inter. J. Agric. Sci.* 3(1): 54-61.

Walkley, A; Black IA (1934). An Examination of Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method. *Soil Sci.* 37: 29-38.http://dx.doi.org/10.1097/00010694-193401000-00003.

Weathers, K.C; Groffman, PM; Dolah, EV; Bernhardt, E; Grimm, NB; McMahon, K (2016). Frontiers in ecosystem ecology from a community perspective: the future is boundless and bright. *Ecosystems*, 19: 753–70. DOI: 10.1007/s10021-016-9967-0

Whalen, JK (2014). Managing Soil Biota-Mediated Decomposition and Nutrient Mineralization in Sustainable Agro-ecosystems. *Adv. Agric.* 384604, p 13. https://doi.org/10.1155/2014/384604