ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

Assessment of Integrated Poultry Manure and Synthetic Fertilizer Effects on Maize (*Zea mays*) Growth and Soil Properties: A Study from Bayero University, Kano

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Abstract:- The study investigated the effects of organic and inorganic nutrients on crop productivity and soil health, with a focus on maize growth and soil properties. It was conducted at Bayero University, Kano and comprised six treatments laid out in a Completely Randomized Design (CRD) with three replications. The treatments included poultry manure, synthetic fertilizers, and their combination. The research aimed to assess the impact of these treatments on maize growth and their residual effects on soil physical and chemical properties. Various plant growth parameters and soil properties were evaluated, and the data obtained were analyzed using Analysis of Variance (ANOVA) and Student-Newman-Keuls test (SNK). The results indicated that all treatments significantly influenced morphological parameters, including plant height, number of leaves, stem girth, and leaf area, compared to the control. Maize growth was notably higher with the application of integrated poultry and inorganic fertilizer or solely inorganic fertilizers. Additionally, soil organic carbon, total nitrogen, phosphorus, and potassium contents increased when poultry manure was applied alone or in combination with inorganic fertilizer. The application of poultry manure significantly raised soil pH, organic carbon content, total nitrogen, available phosphorus, exchangeable potassium, calcium, magnesium, and effective cation exchange capacity (ECEC) of the soil. Furthermore, the exchangeable acidity of the soil was reduced by the application of poultry manure alone. Soil texture was improved, soil bulk density decreased, and porosity increased due to the application of poultry manure. The study concluded that the combined application of poultry manure and inorganic fertilizer enhanced the growth of maize and could serve as a good soil management practice for tropical soils. It also suggested that integrating inorganic fertilizers with organic manures at optimum rates could improve crop productivity on a sustainable basis. The findings of this study may contribute to the development of sustainable nutrient management programs aimed at enhancing crop productivity with high efficiency and minimal nutrient loss in the future.

***Keywords**:- Poultry Manure, Synthetic Fertilizer, Physical and Chemical Soil Properties and Maize Growth Parameters.*

I. INTRODUCTION

Agriculture is a soil-based industry that continuously mines nutrient elements from the soil. In tropical regions, agricultural productivity is often hindered by soil fertility constraints and a deteriorating nutrient status due to both natural and managerial factors. This decline can occur through leaching, nutrient loss, and soil degradation, posing a significant threat to successful agricultural enterprises in Nigeria. The application of inorganic fertilizers has been shown to improve crop performance and affect soil chemical properties such as pH, total nutrient content, and nutrient availability (Ojeniyi, 2000). However, continuous application of such fertilizers can lead to nutrient imbalance and decreased soil pH (Doran et al., 1996). Excessive fertilization in crop production systems may exceed plant utilization capacity and contribute to nitrate leaching (Cul et al., 2008; Hong et al., 2007).

While inorganic fertilizers are known for their ability to quickly increase crop growth and yield due to their readily available nutrients, their continuous and inappropriate use is harmful to both soil and the environment. This practice can decrease soil pH, create nutrient imbalances, and pollute groundwater (Mikkelsen, 2020). In contrast, organic manures are valuable nutrient sources, and their yield-increasing effects are well established. Organic manure enhances soil fertility by improving its physical, chemical, and biological properties, such as water retention, soil aeration, and moisture-holding capacity (Nyle and Brady, 2003).

Organic manure, particularly poultry manure (PM), has been found to be highly effective due to its rich nutrient content, including high levels of nitrogen (N), phosphorus (P), and potassium (K) (Farhad et al., 2009). Poultry manure supplies phosphorus more readily than other organic sources (Garg and Bahla, 2008). Studies have reported that PM increases soil pH, organic matter content, available phosphorus, exchangeable cations, and micronutrients while

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

reducing exchangeable aluminum and iron contents and bulk density (Ano and Agwu, 2006; Uwah et al., 2011; Uwah et al., 2012). It has been shown to increase soil nitrogen levels by 53%, with appreciable increases in exchangeable cation contents (Boateng et al., 2006). To sustain crop productivity, soil fertility replenishment should utilize all available plant nutrient sources in an integrated manner (FAO, 1993). The combined use of organic and inorganic fertilizers is considered the best option for sustaining productivity and enhancing farmers' current production levels.

Maize (Zea mays) is a critical cereal crop in Nigeria, primarily as an energy-giving food, with a total production of 7.3 million tons (FAO, 2007). Its diverse uses as food for humans and livestock and as raw materials for industries have made it a continuously produced crop. Compared to other arable crops, maize has higher nutrient requirements, particularly for nitrogen, phosphorus, and potassium, which poses major constraints to its production (Katerji et al., 1996). Maize thrives in soils with a pH of 5.5-5.7, while strongly acidic soils (pH ≤ 5.0) are unsuitable for good yields.

Given the documented detrimental effects of inorganic fertilizers, their rising costs, and limited availability among poor farmers in Nigeria (Taminu et al., 2007), attention has shifted towards the use of organic manure. Therefore, this research aims to evaluate the influence of complementary applications of poultry manure and synthetic fertilizer on soil properties and the growth of maize.

II. MATERIALS AND METHODS

A. Experimental Location and Conditions

The experiment was conducted at the Centre for Dryland Agriculture Screen House, Faculty of Agriculture, Bayero University, Kano (latitude 11°58'N and longitude 8°26'E). This location is situated in the Sudan savannah ecological zone of Nigeria, which is characterized by distinct dry and wet seasons. The rainy season typically begins in May or June and ends in September or October, while the dry season extends from November to April, with harmattan winds occurring between November and January. The screen house was selected for the experiment to ensure controlled environmental conditions and to prevent pest attacks.

B. Experimental Materials

The experiment utilized one maize variety, EVDT 2009 (Early Variety Drought Tolerant), sourced from the International Institute of Tropical Agriculture (IITA) Kano station. The materials used in the experiment included pots, NPK 15:15:15 fertilizer, urea, poultry manure, a screen house, measuring tape, vernier caliper, shovel, broom, masking tape, and marker. For laboratory analyses, the following materials were used: analytical balance, beaker, conical flask, volumetric flask, pipette, burette, dropper, funnel, test tube, filter paper, stirring rod, pH electrode, retort stand, wash bottle, distillation apparatus, digestion block, digestion tube, plastic container, centrifuge, and mechanical shaker. The equipment utilized included a pH meter, electrical conductivity (EC) meter, atomic absorption spectrophotometer (AAS), flame photometer, and UV-Vis spectrophotometer.

C. Treatment and Experimental Design

The experiment evaluated the effects of different rates of poultry manure and sole inorganic fertilizer, as well as various combinations of both. The six treatments included: one synthetic fertilizer treatment, two doses of poultry manure (1 ton/ha and 2 tons/ha), and combinations of poultry manure and micro-doses of NPK fertilizer (2 tons/ha poultry manure + micro-dose NPK, and 1 ton/ha poultry manure + micro-dose NPK). The experimental design was a Completely Randomized Design (CRD) with three replications, resulting in a total of 18 treatments. Each treatment was randomly assigned to a plastic pot. The micro-dose NPK treatments were 50% of the full recommended dose for maize production. Details of the treatments are shown in Table 1.

Table 1: Treatments for Organic and Inorganic Fertilizers

Treatments	Description
T_1	NPK Full dose
T_2	1 ton poultry manure
T_3	2 ton poultry manure
T_4	1 ton poultry manure + micro dose NPK
T_5	2 ton poultry manure + micro dose NPK
T_6	Control

Note: T = Treatment, NPK = Nitrogen, Phosphorus, Potassium (Chemical fertilizers).

D. Soil and Fertilizer Sampling and Preparation

The soil utilized in this investigation was sourced from the Faculty of Agricultural Research farm situated adjacent to the Faculty Animal farm at Bayero University Kano. Samples were extracted from the same site at a depth of 0-15 cm and meticulously combined to ensure a comprehensive representation before their placement in pots. These soil samples were subsequently subjected to air drying, followed by crushing using a pestle and mortar, and finally passed through a 2 mm sieve. The processed samples were then securely stored in polythene bags for subsequent laboratory analyses. The poultry manure employed for this experiment was acquired from the University's Research farm. The manure underwent a maturation process under a shed for a period of one week to facilitate rapid mineralization. Post-maturation, the samples were air dried, crushed to achieve a particle size suitable for passage through a 2 mm sieve, and prepared for further analytical procedures.

E. Plant Sampling and Preparation

At 56 days after planting, maize plant per pot was uprooted and severed from the base to separate the plant from the soil. The shoot, leaves and tassel parts of each sampled plant was washed with clean water, bagged in brown envelope and labeled accordingly for nutrient determination. The samples were dried in the oven at 65°c until constant weight was recorded. The dried plant samples were ground with mill to pass through 0.5mm sieve.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

F. Cultural Practices

- *Crop Variety*

The variety used in the experiment was maize (EVDT 2009) from international institute of tropical Agriculture (IITA) Kano office. It's a medium sized (height) with white cob, developed for tropical condition. It's grown in West African countries because of its tolerant drought character.

- *Sowing*

The maize seeds were sown manually using drilling method in the respective pots after irrigation, at 2cm depth below the soil. Two seeds were sown and later thinned to one after emergence.

- *Fertilizer Application*

The application of poultry manure took place five days prior to sowing, involving meticulous mixing with the soil to fill the pots at a predetermined rate per treatment. Subsequently, the soil-poultry manure mixture underwent irrigation three times before the seeds were sown. Additionally, NPK 15:15:15 fertilizer was administered, with the full NPK treatment supplemented by urea. The application of these fertilizers employed a broadcasting method.

- *Irrigation*

Water was applied to the plants at 2-days intervals using Watering cans.

- *Weed Control*

The pots was kept weed free which was carried out manually by hand.

G. Data Collection

Three plants in each pot were tagged for the purpose of recording growth data for periodic observations. Data was collected at 2nd 3rd, 4rth, 5th & 6weeks after planting. The experiment was monitored and data were recorded on:

- Number of leaves
- Plant height
- Leaf area
- Plant girth

- Plant height; Plant height is the shortest distance between the soil surface and upper boundary of the main photosynthetic tissues (excluding inflorescence) on a plant. The height was taken from the surface of the pot soil to the highest tip of the tassel. It's measured using a measuring tape in centimeters. The stand in which are record are taken from are tag with broom.

- Plant girth; this is the measure of the thickness of stem. This parameter was measured using Vernier caliper.

- Number of leaves; it's the total number of visible leaves per plant. All leaves are counted including those that were senesced as long as they were identifiable. This parameter is manually counted and it's recorded.

- Leaf Area; Leaf Area were also measured using a measuring tape. The leaf length and breadth were measured to obtain the leaf area. The leaf area was estimated as its length multiplied by its maximum width multiplied by 0.75 (maize leaf calibration factor), Elings (2000). The formula is given below;

LA = L * W * A (Dwyer and Steward, 1986).
Where LA = leaf area (cm^3)
W = leaf maximum width (cm^3)
A = constant = 0.75

H. Laboratory Analysis

Standard methods of physical and chemical analysis for soils were used to analyze these parameters;

- pH and Electrical conductivity were determined in distilled water using a soil-to-liquid ratio of 1:1. After stirring for 30 minutes, the pH values were measured using a glass electrode pH meter (Mclean, 1965).

- Organic carbon was obtained by the wet dichromate acid oxidation method (Nelson and Sommers, 1982).

- Phosphorus was determined bray 1 method as described by Bray and Kurtz (1945).

- Exchangeable acidity was analyzed by shaking the soil with 1MKcl and titrates with 0.5M NaOH (Juo, 1979). In which the effective cation exchange capacity ECEC was obtained by summation of exchangeable bases and exchangeable acidity.

- Particle size distribution was determined using Hydrometer method (Gee and Or, 2002). In which the percent clay, silt and sand were determined, the USDA textural triangle was used to know the textural class of each soil sample.

- Exchangeable bases (Ca, Mg, K and Na) were extracted with 1M NH4OAC solution buffered at pH 7.0 as described by *Aderson and ingram* 1998. Calcium and magnesium I the leachates were determined with an Atomic Absorption Spectrophotometer (AAS).

- Total nitrogen was determined using the kjeldhal distillation method as described by Bremmer and Mulvaney (1960). The ammonia from the digestion was distilled with 45% NaOH into 25% boric acid and determined by titrating 0.05N HCl.

- Bulk density and porosity was determined by the value of weight (mass) of dry in soil sample that occupy a core of known volume. The core sampling method usually determines bulk density (Abu-Hameedeh and Al-Jalil 1999).

- Moisture content was determined using gravimetric method.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

I. Manure and Plant Analysis

Maize plants harvested from all pots within each treatment at 56 days post-sowing were subjected to chemical analysis. The plant samples were first dried in an oven at 65°C until a constant weight was achieved. Subsequently, the dried plant samples were finely ground using a mill to pass through a 0.5 mm sieve. Plant nitrogen (N) content was determined employing the micro-Kjeldahl digestion method, while plant phosphorus (P) content was assessed using the vanadomolybdate method, and potassium (K) content was measured utilizing a flame photometer.

Sub-samples of the poultry manure utilized were air-dried and crushed through a 2 mm sieve. These samples were then analyzed for nitrogen (N), phosphorus (P), and potassium (K) content using methods akin to those employed for plant samples. Additionally, sodium (Na) and potassium (K) content of the manure samples were determined via flame photometry, while calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu), iron (Fe) content were assessed using Atomic Absorption Spectrophotometry. The sulfur content was also determined, organic carbon was analyzed using the Walkley-Black method, and pH and electrical conductivity (EC) were measured using a pH meter and electrical conductivity meter, respectively.

J. Statistical Analysis

Data generated from field experiment and laboratory analyses were subjected to analysis of variance (ANOVA) using the GenStat software version 17.1 and the treatment means was separated using Student-Newman-Keuls test (SNK) at 5% probability level.

III. RESULTS

➢ *Initial Soil and Poultry Manure Analyses*

The initial analyses of both the soil and poultry manure used in this study are summarized in Table 2. The soil's physico-chemical properties indicate a sandy loam texture, characterized by a relatively low organic carbon content of 0.419%. Despite this, the soil exhibits elevated levels of total nitrogen (0.315%) and moderate availability of phosphorus, averaging at 31.97 mg/kg. The pH of the soil is close to neutral, as per the ratings provided by the Soil Research Institute (CSIR), registering at 6.49. The electrical conductivity of the soil is measured at 0.0536 dS/m. Elemental analysis reveals the presence of calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), and exchangeable acidity, with values of 1.355 cmol/kg, 0.4099 cmol/kg, 0.78 cmol/kg, 0.128 cmol/kg, and 0.33 cmol/kg, respectively. The cation exchange capacity of the soil is relatively low at 3.006 cmol/kg.

The poultry manure used in this study is notably rich in macro nutrients essential for plant growth. Its pH is slightly alkaline, measuring at 7.13, and it exhibits an electrical conductivity value of 3.65 dS/m.

Table 2: Physico-Chemical Properties of the Soil and Chemical Properties of Poultry Manure Used

PROPERTIES		
Physical Composition	**Values (SOIL)**	**Values (MANURE)**
% sand	75.52	-
% silt	16.36	-
% clay	8.12	-
Textural Class	Sandy loam	-
G. moisture content (g/g)	0.014127	-
dry bulk density (g/cm3)	1.419608	-
wet bulk density (g/cm3)	1.439662	-
Porosity	0.464299	-
Chemical characteristics	-	-
PH (H20)	6.49	7.13
pH (CaCl2)	4.61	-
E.C (ds/m)	0.0536	3.65
N (%)	0.315	4.41 (%)
P (mg Kg-1)	31.97	32.34(g Kg^{-1})
O.C (%)	0.4191894	33.93 (%)
Exchangeable bases	-	-
K (cmol/kg)	0.4099937	0.87(g Kg^{-1})
Ca (cmol Kg^{-1})	1.355	25.01(g Kg^{-1})
Mg (cmol Kg^{-1})	0.78	7.86(g Kg^{-1})
Na (cmol Kg^{-1})	0.12824326	0.60(g Kg^{-1})
Exch. Acidity (cmol Kg^{-1})	0.33	-
C.E.C (cmol/kg)	3.00687029	-
Micro Nutrients	-	-
S (g/kg)	-	0.39
Fe (g/kg)	-	0.67

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

Mn (g/kg)	-	0.10
Cu (g/kg)	-	0.03
Zn (g/kg)	-	0.15

- *Effect of NPK 15:15:15, Poultry Manure and their Combination on Plant height (cm) of Maize at 2, 3, 4, 5 and 6 WAP*

Table 3 illustrates the impact of NPK 15:15:15 fertilizer, poultry manure (PM), and their combination on maize plant height (cm) at 2, 3, 4, 5, and 6 weeks after planting (WAP). Significant effects were observed on plant height across these time points. Maize plants exhibited a gradual increase in height from 2 to 6 WAP. At 2 WAP, plants treated with NPK combined with 2 tons of poultry manure (NPK + 2T PM) displayed the tallest height at 45.33 cm, whereas the control group, devoid of NPK and poultry manure, exhibited the shortest height at 29.43 cm. The NPK + 1T PM and 2T PM treatments resulted in heights of 41.66 cm and 41.72 cm, respectively, while the full NPK dose treatment yielded a height of 39.58 cm.

At 3 WAP, a shift in trend occurred, with plants receiving NPK + 2T PM and the full NPK dose attaining the greatest heights at 75.39 cm and 65.78 cm, respectively. Conversely, plants grown without NPK and poultry manure had a height of 37.55 cm, followed by the 1T PM treatment at 46.78 cm. By 4 WAP, plants treated with NPK + 2T PM again demonstrated the tallest height at 107.66 cm, whereas the control group had a height of 45.66 cm. The full NPK dose treatment resulted in a height of 97.39 cm, and the NPK + 1T PM treatment recorded 96.07 cm.

At 5 WAP, the superiority in height was maintained by plants treated with NPK + 2T PM, reaching 117 cm, while those without NPK and poultry manure reached 48.5 cm. The full NPK dose treatment resulted in a height of 108.99 cm, and the NPK + 1T PM treatment achieved 105 cm. By 6 WAP, the NPK + 2T PM treatment again exhibited the tallest mean height at 122.55 cm, with the control group at the lowest mean height of 51.82 cm. The full NPK dose treatment recorded 116.61 cm, and the NPK + 1T PM treatment achieved 110 cm. The ranking of superiority in maize plant height, based on the application of NPK 15:15:15, poultry manure, and their combinations per ton/kg per hectare, was as follows: NPK + 2T PM > full NPK dose > NPK + 1T PM > 2T PM > 1T PM > control.

Table 3: Effect of Comparative Rates of Poultry Manure and NPK 15:15:15 on Plant Height (cm) at 2, 3, 4, 5 and 6 WAP
Values with the same letter in the column are not statistically different at 5% level of probability using Student-Newman-Keuls test (SNK).

Treatments	**Weeks after sowing (WAP)**				
	2WAP	**3WAP**	**4WAP**	**5WAP**	**6WAP**
NPK	39.58c	65.78c	97.39d	108.99d	116.61e
1TPM	33.94b	46.78b	55.66b	59.61b	63.16b
2TPM	41.72c	61.33c	77.05c	84.33c	88c
NPK+1TPM	41.66c	64.72c	96.07d	105.05d	110d
NPK+2TPM	45.33c	75.39d	107.66e	117e	122.55f
CONTROL	29.43a	37.55a	45.66a	48.5a	51.82a
s.e.d	2.009	2.763	2.786	1.855	1.696

- *Effect of NPK 15:15:15, Poultry Manure and their Combination on number of leaves of Maize at 2, 3, 4, 5 and 6 WAP*

Table 4 displays the impact of NPK 15:15:15 fertilizer, poultry manure (PM), and their combination on the number of leaves of maize plants. The number of leaves consistently increased from 2 to 6 weeks after sowing, with significant differences noted among the treatments.

At 2 WAP, there were no significant differences in the mean number of leaves among plants treated with NPK + 2T PM, NPK full dose, NPK + 1T PM, 2T PM, and 1T PM, although 2T PM displayed the highest number of leaves. The control group exhibited the lowest mean number of leaves at 4.773.

By 3 WAP, the mean number of leaves was highest in plants treated with the NPK full dose (6.88), although no significant difference was observed compared to those treated with NPK + 2T PM. The control group had the lowest mean number of leaves at 5.44.

At 4 WAP, there were no significant differences between the mean number of leaves in plants receiving the NPK full dose, NPK + 2T PM, and NPK + 1T PM, although NPK + 1T PM showed a higher mean of 7.44. Plants without NPK and poultry manure had the lowest mean number of leaves at 5.43.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

At 5 WAP, no significant differences were observed between the mean number of leaves in plants treated with the NPK full dose, NPK + 2T PM, and NPK + 1T PM, although NPK + 2T PM had the highest mean at 10.77. There was also no significant difference between plants treated with 1T PM and 2T PM, respectively, while the control group had the lowest mean at 5.77.

By 6 WAP, plants treated with NPK + 2T PM exhibited the highest number of leaves at 11.77, while the control group had the lowest at 5.88. There were no significant differences between the mean number of leaves in plants treated with the NPK full dose and those receiving NPK + 1T PM, although NPK + 1T PM had a higher mean at 10.99.

The ranking of superiority in maize plant leaf number, based on the application of NPK 15:15:15, poultry manure, and their combinations per ton/kg per hectare, was as follows: NPK + 2T PM > NPK full dose > NPK + 1T PM > 2T PM > 1T PM > control.

Table 4: Effect of Comparative Rates of Poultry Manure and NPK 15:15:15 on Number of Leaves at 2, 3, 4, 5 and 6 WAP

Treatments	**Weeks after sowing (WAP)**				
	2WAP	**3WAP**	**4WAP**	**5WAP**	**6WAP**
NPK	5.663b	6.887bc	7.42b	10.42c	10.777d
1TPM	5.663b	5.993ab	6ab	7.11b	7.887b
2TPM	5.997b	6.22bc	6.44ab	7.217b	8.44c
NPK+1TPM	5.993b	6.763c	7.44b	10.553c	10.997d
NPK+2TPM	5.773b	6.773bc	7.22b	10.777c	11.777e
CONTROL	4.773a	5.44a	5.433a	5.733a	5.883a
s.e.d	**0.3175**	**0.2771**	**0.538**	**0.414**	**0.2197**

Values with the same letter in the column are not statistically different at 5% level of probability using Student-Newman-Keuls test (SNK).

- *Effect of NPK 15:15:15, Poultry Manure and their Combination on stem girth (mm) of maize at 2, 3, 4, 5 and 6 WAP*

Table 5 delineates the impact of NPK 15:15:15 fertilizer, poultry manure (PM), and their combination on maize stem girth. Stem girth exhibited a consistent increase from 2 to 6 weeks after sowing, with gradual increments noted throughout this period.

At 2 WAP, there were no significant differences between the mean stem girth values of plants treated with 2T PM and NPK + 2T PM, although 2T PM displayed the highest mean value at 4.75 mm. Similarly, no significant differences were observed between treatments receiving the NPK full dose, 1T PM, and NPK + 1T PM.

By 3 WAP, there was no significant difference between the mean stem girth values of plants treated with NPK + 2T PM and NPK + 1T PM, although NPK + 2T PM had the highest mean value at 7.45 mm. Plants without NPK and poultry manure had the lowest stem girth at 4.89 mm.

At 4 WAP, plants treated with the NPK full dose exhibited superior girth at 11.42 mm, while those in the control plot had the lowest mean girth at 5.317 mm. There were no significant differences between treatments receiving 1T PM and 2T PM, respectively, in the fourth week.

At 5 and 6 WAP, no significant differences were observed between treatments receiving the NPK full dose, NPK + 2T PM, and NPK + 1T PM, with the NPK full dose displaying the highest means at 12.16 mm and 12.48 mm, respectively. Plants in the control plot, where no NPK and poultry manure were applied, exhibited the lowest mean girths at 5.98 mm and 6.167 mm, respectively.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

Table 5: Effect of comparative rates of poultry manure and NPK 15:15:15 on stem girth (mm) at 2, 3, 4, 5 and 6 WAP
Values with the same letter in the column are not statistically different at 5% level of probability using Student-Newman-Keuls test (SNK).

Treatments	**Weeks after sowing (WAP)**				
	2WAP	**3WAP**	**4WAP**	**5WAP**	**6WAP**
NPK	4.077ab	7.417c	11.427b	12.16c	12.48c
1TPM	4.217ab	5.133a	6.422a	7.033ab	7.223ab
2TPM	4.757b	6.097ab	7.22a	7.673b	7.983b
NPK+1TPM	4.193ab	6.647bc	10.7b	11.36c	11.767c
NPK+2TPM	4.46b	7.45bc	11.207b	12c	12.38c
CONTROL	3.753a	4.893a	5.317a	5.980a	6.167a
s.e.d	**0.2117**	**0.448**	**0.736**	**0.605**	**0.614**

- *Effect of NPK 15:15:15, Poultry Manure and their Combination on leaf area (cm^2) of maize at 2, 3, 4, 5 and 6 WAP*

Table 6 presented herein delineates the impact of NPK 15:15:15 fertilizer, poultry manure (PM), and their combination on the leaf area of maize plants. Leaf area exhibited a consistent increase from 2 to 6 weeks after sowing.

At 2 WAP, plants treated with NPK + 2T PM displayed the highest mean leaf area at 77.88 cm2, while those without NPK and poultry manure had a mean leaf area of 40.8 cm2. No significant differences were observed between the mean leaf area of plants treated with the NPK full dose and those receiving NPK + 1T PM and 2T PM, with the NPK full dose treatment showing a higher mean at 69.13 cm2.

By 3 WAP, there were no significant differences between the mean leaf area of plants treated with the NPK full dose and those receiving NPK + 2T PM and NPK + 1T PM, although NPK + 1T PM displayed the highest mean at 96.98 cm2. Plants in the control plot exhibited the lowest mean leaf area at 44.73 cm2, with no significant differences between the mean leaf areas of plants treated with 1T PM and 2T PM, respectively.

At 4 WAP, there were no significant differences between the mean leaf area of plants treated with the NPK full dose and those receiving NPK + 2T PM, although NPK + 2T PM displayed the highest mean at 232 cm2. There were no significant differences observed between the mean leaf areas of plants treated with 1T PM, 2T PM, and the control group. The control group had the lowest leaf area mean at 50.7 cm2 by the end of week 4.

At 5 and 6 WAP, no significant differences were observed between the mean leaf area of plants treated with the NPK full dose and those receiving NPK + 2T PM and NPK + 1T PM, with the NPK full dose treatment exhibiting the highest means at 283.8 cm2 and 317.5 cm2, respectively. Plants without NPK and poultry manure had the lowest mean leaf area at 63.3 cm2. The control plot, where no NPK and poultry manure were applied, had the lowest mean leaf area of 71.9 cm2.

Table 6 Effect of comparative rates of poultry manure and NPK 15:15:15 on leaf area (cm^2) at 2, 3, 4, 5 and 6 WAP
Values with the same letter in the column are not statistically different at 5% level of probability using Student-Newman-Keuls test (SNK).

Treatments	Weeks after sowing (WAP)				
	2WAP	3WAP	4WAP	5WAP	6WAP
NPK	69.13bc	88.21c	222.5c	283.8c	317.5c
1TPM	55.62b	63.19b	74.4a	100ab	108.7ab
2TPM	64.62bc	73.23b	88.8a	131.7b	143.6b
NPK+1TPM	63.66bc	96.98c	153.1b	249.7c	286.5c
NPK+2TPM	77.88c	91.91c	232c	279.2c	301.7c
CONTROL	40.8a	44.73a	50.7a	63.3a	71.9a
s.e.d	**5.01**	**5.27**	**19.62**	**20.18**	**17.34**

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

➢ *Effect of NPK 15:15:15, Poultry Manure and their Combination on soil chemical properties after harvest*

The soil's post-harvest chemical properties, influenced by the application of NPK 15:15:15 fertilizer, poultry manure (PM), and their combination, are outlined in Tables 7. The use of poultry manure, both solely and in combination, led to significant ($P \leq 0.05$) increases in soil pH, organic carbon content, total nitrogen (N), exchangeable bases, and effective cation exchange capacity (ECEC). Soil available phosphorus was notably higher in the NPK full dose treatment, although there were no significant differences compared to treatments receiving NPK + 2T PM, NPK + 1T PM, 2T PM, and 1T PM. The control group, where no poultry manure or NPK was applied, exhibited the lowest mean phosphorus content at 13.88 mg/kg.

Exchangeable acidity did not differ significantly among treatments receiving the NPK full dose, NPK + 2T PM, NPK + 1T PM, and the control, all sharing an equal mean value of 0.22 cmol/kg. However, treatments with 1T PM and 2T PM displayed lower mean values of exchangeable acidity at 0.1667 cmol/kg, which appeared to be the lowest.

The electrical conductivity (EC) of the soils varied significantly, with the control treatment showing the highest mean at 0.04293 dS/m. There were no significant differences in EC between soils treated with NPK + 1T PM, 2T PM, and NPK + 1T PM, while treatments receiving the NPK full dose had a slightly higher EC mean of 0.03371 dS/m.

Calcium, magnesium, potassium, and sodium levels, along with ECEC, increased significantly with incremental rates of poultry manure application, with the control plots recording the lowest values. Thus, the application of nutrients from both organic and mineral fertilizers was justified based on these findings.

Table 7: Effect of comparative rates of poultry manure and NPK 15:15:15 on Soil Chemical Properties after harvest
Means with the same letter (s) under the same column are not significant using Student-Newman-Keuls test (SNK).

Treatments	**PH(H2O)**	**pH($CaCl_2$)**	**EC (dS/m)**	**Av.P (mg/kg)**	**% O.C**	**% N**	**E.A (cmol/kg)**	**Ca (cmol/kg)**	**Mg (cmol/kg)**	**K (cmol/kg)**	**Na (cmol/kg)**	**CEC (cmol/kg)**
NPK	5.45a	3.53a	0.026a	20.32c	0.330a	0.117ab	0.222	1.229	0.519ab	0.273ab	0.09ab	2.34abc
1T PM	6.48c	4.74b	0.025a	15.99b	0.434ab	0.152bc	0.167	1.166	0.656d	0.345d	0.108d	2.44bcd
2T PM	6.50c	4.64b	0.033b	19.89c	0.475b	0.198c	0.167	1.143	0.752e	0.395e	0.124e	2.580d
NPK+1T PM	6.03b	4.06a	0.026a	20.51c	0.398ab	0.15bcd	0.222	1.290	0.605c	0.318c	0.099c	2.54cd
NPK+2T PM	6.00b	3.92a	0.021a	20.38c	0.507b	0.128ab	0.222	1.105	0.559b	0.294b	0.092b	2.27ab
CONTROL	6.44c	4.66b	0.026a	13.88a	0.335a	0.093a	0.222	1.067	0.496a	0.261a	0.082a	2.128a
s.e.d	**0.09**	**0.21**	**0.002**	**0.95**	**0.044**	**0.017**	**0.068**	**0.083**	**0.020**	**0.011**	**0.003**	**0.083**

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

- *Effect of NPK 15:15:15, Poultry Manure and their Combination on soil physical properties after harvest*

Table 8, presented below, illustrates the impact of NPK 15:15:15 fertilizer, poultry manure (PM), and their combination on soil physical properties. Post-cropping soil analysis revealed significant effects on soil bulk density and porosity across various treatments. Application of poultry manure led to a decrease in bulk density and a subsequent increase in total porosity and moisture content. The NPK full dose treatment exhibited a slightly higher bulk density than the control, while treatments receiving the NPK full dose tended to have the lowest porosity mean value.

There were no significant differences observed in soil texture, although there was a slight variation with an increase in the percentage of silt and a decrease in the percentage of sand with increasing rates of poultry manure application, both solely and in combination.

Table 8: Effect of comparative rates of poultry manure and NPK 15:15:15 on on Soil physical Properties after harvest

Treatment	**G. moisture content (g/g)**	**Dry bulk density (cm^3)**	**Wet bulk density (cm^3)**	**Porosity**	**% sand**	**% silt**	**% clay**	**Textural class**
NPK	0.027	1.58b	1.63c	0.40a	79.40b	8.48a	12.12	sandy loam
1T PM	0.015	1.43a	1.44a	0.46b	73.52a	17.51b	8.97	sandy loam
2T PM	0.029	1.38a	1.38a	0.48b	73.52a	19.20b	7.28	sandy loam
NPK + 1TPM	0.015	1.45a	1.48ab	0.45b	74.19a	15.39b	10.40	sandy loam
NPK + 2T PM	0.018	1.36a	1.38a	0.49b	73.52a	18.96b	7.52	sandy loam
CONTROL	0.012	1.56b	1.59bc	0.41a	76.19a	13.69b	10.12	sandy loam
s.e.d	**0.013**	**0.04**	**0.0531**	**0.02**	**1.29**	**2.01**	**1.47**	

Values with the same letter in the column are not statistically different at 5% level of probability using Student-Newman-Keuls test (SNK).

- *Effect of NPK 15:15:15, Poultry Manure and their Combination on Nutrient uptake of maize*

The results of the study are presented in Table 9, showcasing the influence of NPK 15:15:15 fertilizer, poultry manure (PM), and their combination on nutrient uptake. Nutrients such as nitrogen (N), phosphorus (P), and potassium (K) were significantly impacted by fertilizer application, with a significance level of $P<0.05$ noted.

The combined application of NPK + 2T PM resulted in the highest tissue nitrogen and phosphorus levels. Conversely, sole NPK treatment exhibited the highest tissue potassium levels compared to the combined applications. The tissue nitrogen, phosphorus, and potassium levels obtained through combined application were statistically different ($P>0.05$) from those obtained from treatments fertilized with sole poultry manure, except in the case of tissue phosphorus, where 2T PM and NPK + 1T PM showed statistical similarity. Plants that were not fertilized displayed the least tissue nutrient uptake across all parameters (N, P, and K).

Table 9: Effect of comparative rates of poultry manure and NPK 15:15:15 on on Nutrient Uptake of maize

Values with the same letter in the column are not statistically different at 5% level of probability using Student-Newman-Keuls test (SNK).

Treatments	%T.N	T.P (mg/Kg)	K (mg/Kg)
NPK	1.1083d	63.39b	4670f
1TPM	0.455b	58.14ab	3305b
2TPM	0.6533c	60.77b	3481c
NPK+1TPM	1.0617d	60.77b	3886d
NPK+2TPM	1.505e	74.2c	4299e
CONTROL	0.3033a	54.92a	2901a
s.e.d	**0.0375**	**1.79**	**39.8**

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

IV. DISCUSSION

Undoubtedly, extensive use of chemical fertilizers in intensive cultivation has enhanced crop productivity but has also disrupted agro-ecosystems, leading to soil and water pollution. Therefore, adopting better management practices that combine judicious fertilizer use with organic manure can improve crop productivity while minimizing environmental damage. This study investigates the individual and combined effects of organic and inorganic manures on maize productivity and soil properties, aiming to enhance understanding and promote sustainable agricultural practices. The results demonstrate that the combined application of organic and inorganic nutrient sources positively influences maize growth and soil properties compared to control conditions. Specifically, the addition of NPK 15-15-15, poultry manure, and their combination enhances maize growth, indicating a synergistic effect on nutrient availability and uptake.

The soil at the experimental site exhibits a sandy loam texture with a substantial proportion of sand. Previous studies by Wapa and Kwari (2004) in the Northern savanna of Nigeria have characterized such soils as sandy, low in active clay content, high in kaolinite, and variable in cation exchange capacity. These soil characteristics may explain the low to medium content of basic cations like Ca, K, Na, and Mg, as leaching of basic cations may occur due to the relatively low organic carbon content and high sand proportion in the soil, extending beyond the rhizosphere. The soil also shows high levels of total nitrogen with moderate available phosphorus, attributes that may be influenced by factors such as inadequate organic litter supply, prolonged dry seasons, and intense mineralization during rainy periods, as reported by FPDD (2002).

The poultry manure utilized in this study exhibits properties typical of poultry manures from various farms and countries, being rich in major nutrients and calcium, which could contribute to the observed high pH levels. Additionally, the manure displays elevated levels of electrical conductivity and nitrogen content, indicating its nutrient-rich composition and potential impact on soil fertility.

A. Effect of inorganic fertilizers, Poultry Manure and their Combination on maize growth parameters

The effect of different types of fertilizer (organic and inorganic) on some external features (plant height, number of leaves, stem girth and leaf area) of the plants was observed. There is a significant difference in the rate of growth and development in the plant as a result of using dissimilar forms of fertilizer.

B. Effect of NPK 15:15:15, Poultry Manure and their Combination on Plant height

Plant height is a crucial indicator of plant growth, often associated with increased productivity. The elevation in maize plant height, attributed to the application of both organic and inorganic fertilizers, likely stems from nutrient release, facilitating robust growth through efficient photosynthesis (Iqtidar et al., 2006). Optimal plant height correlates positively with plant productivity, underscoring its importance in agricultural contexts (Saeed et al., 2001). Notably, treatments significantly influence maize's vegetative performance, with NPK + 2T PM-treated plants exhibiting greater height, possibly due to enhanced nutrient availability and absorption, accelerating growth (Swift, 1997; Gitari & Friesen, 2001; Makinde, 2001).

Contrary to Fagimi and Odebode's (2001) findings on pepper plants, which showed increased height and leaf numbers with higher poultry manure rates, in our study, maize plants treated solely with inorganic fertilizer displayed relatively greater height compared to those receiving only poultry manure. This outcome aligns with Achieng et al.'s (2010) observations of taller maize plants in plots treated solely with inorganic fertilizer, indicating its readily available nutrients for plant uptake.

Changes in leaf numbers significantly impact crop performance as leaves are vital photosynthetic organs (Ayodele et al., 2001). The integration of inorganic fertilizer and poultry manure yielded superior results in terms of maize leaf numbers, possibly due to enhanced nutrient uptake. Makinde (2001) also reported increased leaf numbers with poultry manure incorporation, while Vasanthi and Kumaraswamy (2000) observed greater green fodder yield with poultry manure and half the recommended inorganic fertilizer rate. Similarly, Khaliq et al. (2004) and Chung et al. (2000) highlighted the benefits of combined organic and inorganic fertilizers for maize yield and dry matter production. Asadu and Unagwu (2012) emphasized the necessity of integrated fertilization for sustainable maize productivity in Nigeria.

C. Effect of NPK 15:15:15, Poultry Manure and their Combination on leaf area

Increased leaf area in soil amended with fertilizer is likely attributed to the availability of nitrogen (N), promoting leaf area during vegetative development and sustaining functional leaf area throughout the growth period (Cox et al., 2021). Incorporating poultry manure with inorganic fertilizers significantly enhances maize yield compared to sole poultry manure application. This finding resonates with recent research by Amujoyegbe et al. (2020), which demonstrated that optimal leaf area and total chlorophyll content in maize and sorghum were achieved with a combination of 2.76t/ha organic and 25kg/ha inorganic fertilizer. Similarly, studies by Egerszegi (2020), Sharply and Smith (2021), and Amujoyegbe et al. (2020) affirm that the combined application of organic and inorganic fertilizers enhances leaf area, chlorophyll content, carbon content, water holding capacity, and reduces soil bulk density, leading to improved yield.

Contrary to the above, Olowoake et al. (2019) reported a negligible increase in leaf area with poultry manure compared to sole NPK treatment, diverging from the findings of Xu et al. (2018), who found that organic fertilizers promoted better crop growth and quality than synthetic fertilizers. The application of fertilizer or manure

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

likely elevates soil nitrogen levels, positively impacting leaf fresh weight and quality due to nitrogen's role in stimulating vegetative growth and increasing leaf area, consequently enhancing photosynthesis rate, leaf quality, and weight.

D. Effect of NPK 15:15:15, Poultry Manure and their Combination on stem girth

Increase in stem girth reflects the retention of a substantial amount of assimilates in the stem, which contributes to leaf production (Law-Ogbomo & Law-Ogbomo, 2021). In this study, sole NPK fertilization and higher-rate poultry manure, along with microdose NPK, notably enhanced stem girth (see Table 6). A similar investigation conducted at the University of Abuja regarding the impact of organic manure, cow dung, and NPK on maize growth revealed that NPK treatments resulted in significantly thicker stem girth, increased leaf numbers, and taller plants compared to control treatments (Solomon et al., 2020).

The study also found no statistical difference in stem girth between plants receiving sole NPK fertilizer and those in combined ratios with poultry manure. This aligns with the findings of Ndukwe et al. (2014), who reported that integrating organic and inorganic fertilizers in maize production leads to beneficial and sustainable outcomes. Specifically, the application of 5 or 10 t/ha poultry manure alongside 150 kg/ha NPK 15:15:15 resulted in higher maize yield and improved yield components. Similarly, Adeniyan and Ojeniyi (2005) observed that the integrated application of poultry manure and NPK fertilizer increased maize yield compared to individual applications of poultry manure or inorganic fertilizer. Chung et al. (2000) also demonstrated that combining organic manure with adequate inorganic N fertilizers led to higher maize dry matter.

E. Effect of NPK 15:15:15, Poultry Manure and their Combination on soil chemical properties

There was significant difference in all the chemical properties tested in all the treatments that contained either sole or combined application of poultry manure and NPK 15:15:15 fertilizers as shown in Table 7.

- **Soil pH** is a fundamental determinant in soil chemistry, exerting significant influence on various chemical processes and the availability of plant nutrients by modulating their chemical forms and reactions. The progressive rise in soil acidity resulting from the application of inorganic fertilizers at the study's conclusion corroborates the assertions made by Devaney (2010) and Mae-Wan Ho (2010), who discussed the acidifying effects of such fertilizers on soil. The substantial calcium (Ca) content present in poultry manure likely contributed to the comparatively elevated pH levels observed in pots amended with poultry manure and their combined effect. Conversely, the increased supply of poultry manure led to a decline in soil pH, possibly due to the production of organic acids. This trend aligns with findings by Walker et al. (2004), indicating the pivotal role of organic matter in influencing soil pH, albeit with variations depending on the specific organic amendment utilized. Moreover, the decomposition of incorporated manure by microbial action releases basic cations, contributing to an initial pH elevation conducive to optimal crop production, as noted by Pucknee and Summer (1997). Similar outcomes have been reported in studies focusing on organic amendments and their impact on soil pH by researchers such as Okwuagwu et al., Boateng et al. (2006), and Islam et al. (2011).

- **Soil Electrical Conductivity (EC)** serves as a vital gauge of soil salinity, reflecting the salt content in the soil. Elevated EC levels can impede plant growth by disrupting the soil-water balance and diminishing microbial activity, affecting crucial soil processes like respiration and nutrient cycling. In this study, the application of poultry manure as a sole treatment at higher rates resulted in increased electrical conductivity compared to other treatment groups. This finding resonates with the observations of Chang et al. (1991) and Eghball (2002), who reported a similar rise in electrical conductivity with increased manure or compost application rates.

- **Soil nitrogen** is a pivotal element concerning soil fertility and crop growth, playing a crucial role in chlorophyll synthesis, which is essential for photosynthesis and vibrant leaf coloration. In this study, a notable increase in total nitrogen content was observed, surpassing levels found in full NPK treatments or control pots. This elevation can be attributed to the substantial nitrogen content present in the poultry manure utilized. These findings are consistent with the research of Olowoake and Adeoye, who similarly noted that poultry manure positively influences nitrogen, phosphorus, potassium levels, and soil organic carbon. The gradual release of nutrients from poultry manure into the soil after harvest contributes to the observed increases in nitrogen, phosphorus, potassium, and organic carbon content. Additionally, other studies, such as that by Rayar (1984), have reported enhanced nitrogen availability following the application of poultry manure, swine manure, and FYM (Farm Yard Manure).

- **Available phosphorus**, an essential nutrient for various physiological processes in plants, the combined effect of poultry manure and other organic sources led to a more pronounced increase in available phosphorus compared to pots treated solely with poultry manure or the control group. These results align with the findings of More and Ghonsikar (1988), who observed enhanced phosphorus availability when superphosphate was combined with poultry manure compared to the application of superphosphate alone. Similarly, Ravikumar and Krishnamoorthy (1983) reported increased available phosphorus content in soils following the application of poultry manure.

- **Soil organic carbon (SOC)** plays a pivotal role in determining soil fertility by positively influencing soil structure, chemical properties, and biological processes,

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

ultimately enhancing primary production. Recent studies have consistently demonstrated that the application of poultry manure leads to an increase in soil organic carbon, alongside improvements in pH, nitrogen (N), phosphorus (P), and cation exchange capacity (CEC) (Mbah and Mbagwu, 2006; Akanni and Ojeniyi; Islam et al., 2011; Uwah et al., 2012). This increase can be attributed to the organic matter supplied by poultry manure, which is particularly abundant in treatments incorporating poultry manure either alone or in combination with inorganic fertilizers. Several researchers have highlighted a direct correlation between the annual application of organic amendments and the rise in soil organic matter content (Elherradi et al, 2003).

- **Exchangeable acidity (E.A)** measures the retention of H+ and Al+ ions on soil colloids after active acidity measurement, influencing soil conditions and various soil processes. Elevated exchangeable acidity, coupled with low pH, can detrimentally affect soil health and plant nutrient availability, particularly phosphorus. The addition of poultry manure to soil has been shown to reduce exchangeable acidity, as reported by Ano and Ubochi (2007). This reduction is attributed to the mineralization of organic manures, leading to the release of calcium (Ca) ions into soil solutions. Subsequently, the hydrolysis of calcium hydroxide (Ca(OH)2) reacts with soluble aluminum ions in the soil solution, forming insoluble aluminum hydroxide (Al(OH)3). Furthermore, the hydroxide of calcium hydroxide reacts with hydrogen ions to produce water, contributing to the observed decrease in exchangeable acidity in the soil, as evidenced in this study.

- **Cation Exchange Capacity (CEC)** characterizes a soil's ability to retain cations on soil colloids due to negative charges, crucial for nutrient retention and availability to plants. Recent studies have consistently demonstrated positive alterations in soil potassium (K), calcium (Ca), magnesium (Mg), and reductions in exchangeable acidity (EA), accompanied by enhanced effective cation exchange capacity (ECEC) upon the application of animal manures (Boateng et al., 2007; Ano and Ubochi, 2007; Adeleye et al., 2010; Uwah et al., 2012). These findings align with the results of this research, which showed improved CEC content in soils treated with sole poultry manure or in combination with inorganic fertilizer, compared to sole NPK or control pots.

Chukwu et al. (2012) also supported these findings, demonstrating significant enhancements in soil available phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg), and effective cation exchange capacity (ECEC) through the combined application of organic and inorganic fertilizers. Studies by Gil et al. (2008) noted substantial increases in potassium due to poultry manure addition to soil, while Patra et al. (2000) reported no significant differences with compost application.

The results underscore the superior nutrient supply on a residual basis through the application of combined organic and inorganic fertilizers, as evidenced by the enhanced soil nutrient elements such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and effective cation exchange capacity (ECEC), surpassing those in the control group (Olatunji and Ayuba, 2012).

F. Effect of NPK 15:15:15, Poultry Manure and their Combination on soil physical properties

Organic manure application combined with inorganic fertilizers resulted in significant changes in the physicochemical properties of the soil (see Table 7). The findings revealed that both sole poultry manure application and its combination with inorganic fertilizer contributed to a reduction in soil bulk density, with higher rates of poultry manure leading to lower bulk density. This aligns with the earlier studies conducted by Agbede et al. (2008), spanning from 2004 to 2006, which demonstrated that poultry manure had a substantial positive impact on soil physical properties by decreasing bulk density. They also noted that continuous yearly application of poultry manure had cumulative beneficial effects on soil physical attributes.

The decrease in bulk density can be attributed to several factors, including enhanced soil biopores and aeration, increased soil organic carbon content, and improved soil aggregation facilitated by the application of bulky organic manures like poultry manure. These improvements ultimately enhance soil porosity and water-holding capacity (Gangwar et al., 2006). The application of poultry manure was also found to significantly increase total porosity, as reported in earlier studies by Ewulo et al. (2008) and Agbede et al. (2008). Moreover, the increased application of poultry manure up to 2 tons per hectare notably enhanced porosity compared to other treatments, indicating a cumulative positive effect of poultry manure on soil porosity.

Furthermore, treatments involving poultry manure exhibited higher moisture retention compared to both the control and NPK fertilizer treatments, suggesting that poultry manure can augment soil moisture content. This enhancement in soil moisture content can be attributed to the increased organic matter content resulting from poultry manure application, as supported by the work of Adesodun et al. (2005), which highlighted the positive impact of poultry manure on soil organic matter content.

While the % silt content showed an increase with poultry manure application, the differences among soil textures were not significant. This could be due to the relatively short duration of the experiment, which might not have allowed sufficient time for the poultry manure to thoroughly integrate with the soil to form stable aggregates. However, previous studies by Ewulo et al. (2008) and Wanas (2002) have reported significant improvements in soil physical properties, including pore size distribution, aggregate stability, and soil moisture retention, with the addition of poultry manure.

In conclusion, poultry manure serves as an effective organic amendment for enhancing soil physical condition, as it positively impacts soil bulk density, porosity, moisture

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY1434

retention, and organic matter content, all of which contribute to improved soil health and potentially higher plant growth and yield attributes.

G. Effect of inorganic fertilizers, Poultry Manure and their Combination on Nutrient content of maize

The synergistic effects of combining organic and inorganic amendments play a crucial role in enhancing nutrient uptake and promoting robust plant growth. A plethora of studies have underscored these synergies between organic and inorganic mineral fertilizers, highlighting their positive impacts on plant biomass production and nutrient concentrations (Palm et al., 1997; Giller, 2001). The data presented in Table 8 illustrates the nutrient (NPK) uptake of maize plants, revealing that the application of poultry manure in conjunction with micro doses of inorganic fertilizers significantly boosted NPK uptake. This phenomenon indicates that plant growth was influenced by nutrient uptake rates.

Among the treatments, NPK combined with 2 tons of poultry manure (NPK + 2T PM) exhibited the highest tissue nitrogen (N) and phosphorus (P) content, while full-dose NPK showed the highest tissue potassium (K) content, followed by NPK + 1 ton of poultry manure (PM). The tissue content of sole poultry manure exhibited a similar trend to its growth pattern. Notably, nutrients such as nitrogen, phosphorus, and potassium played pivotal roles in influencing maize yield, as their higher concentrations corresponded to increased growth rates. This corroborates the findings of Kayode and Agboola (1983), who observed increased dry matter yield in maize with the application of various nutrients including N, P, K, Ca, Mg, Fe, Cu, Zn, and Mn.

The enhanced NPK uptake in maize plants can be attributed to the increased nutrient supply resulting from the combined effects of organic and inorganic fertilization. This observation aligns with the study by Eghball et al. (2004), which noted that N-based composted manure application elevated the plant's available nitrogen concentrations in corn (Zea mays L.). Similarly, Theodora et al. (2003) concluded that manure application boosted the plant's available phosphorus, akin to inorganic phosphorus fertilization. Furthermore, Karki et al. (2005) documented an increase in root potassium concentration in maize with the application of the recommended fertilizer rate along with farmyard manure and zinc. Likewise, Kumar et al. (2011) observed a notable enhancement in nutrient uptake magnitude when organic manures were used alongside inorganic fertilizers compared to treatments receiving only inorganic fertilizers.

V. CONCLUSION

This study highlights the favorable impact of integrating a complementary dose of chemical fertilizer with poultry manure on maize growth. This approach demonstrated the superiority of integrated nutrient supply over relying solely on either inorganic or organic sources. The integrated approach facilitated a balanced nutrient supply, controlled soil acidity, extended residual effects, and enhanced soil physical and chemical properties compared to using only inorganic or organic manure. Additionally, it led to increased crop yield. The application of combined NPK fertilizer and poultry manure resulted in higher availability of essential nutrients such as N, P, K, Ca, Mg, Fe, Cu, Mn, and Zn to maize crops. Notably, poultry manure contains Ca and Mg, which are typically not provided by NPK fertilizer unless present as impurities. Furthermore, the analysis of poultry manure revealed the presence of both micro and macronutrients, contributing to a more balanced nutritional profile. The study found that the combination of poultry manure and NPK fertilizer, particularly at the NPK + 2T PM level, yielded superior results. This underscores the potential of integrating synthetic fertilizer and poultry manure to enhance maize production and promote sustainable soil fertility. However, further research is warranted to investigate the long-term effects of poultry manure application comprehensively.

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