Effects of Organic and Inorganic Fertilizers on Some Physical and Chemical Properties of Ultisols and Growth Parameters of Okro (*Abelmoschus esculentus*)

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ABSTRACT

This study was carried out at the Rivers State University Teaching and Research Farm, Port Harcourt to assess and evaluate the effect of organic and inorganic fertilizer on some Physical and Chemical Properties on Ultisol and growth of Okra. Recommended rate of NPK 15:15:15 was applied at the rate of 0.25kg/10kg of soil, poultry dropping and cow dropping were also applied at the rate of 5kg/10kg of Soil and it was replicated Four times. Soil samples were collected at the end of the study and analysis were carried out. The results obtained from the study revealed that Sand particles had the highest particle size distribution, ranging from 884g/kg in both control and poultry dropping/cow dropping combine to 916g/kg in the plot treated with NPK. It was also observed that Silt particle increased from 2g/kg in the plot treated with NPK to 34 g/kg in the control plot and plot treated with poultry dropping/cow dropping combine, Clay content ranged from 62g/kg in the plot treated with cow dropping to 82g/kg in the control plot and plot treated with cow dropping, poultry dropping and poultry dropping/cow dropping combine. The results show that the soils were acidic with the pH ranging from 4.54 to 5.21. The organic matter content ranges from 8.6 to 18.1g/kg, organic carbon ranges from 5.1 to 10.5g/kg Total N ranges from 0.1 to 18.1g/kg, Ava. P increases from 49.61 to 70.18g/mg. Total exchangeable acidity ranges from 0.96 to 2.56Cmol/kg. This study shows that soils amended with poultry dropping had more positive effect on both soil and growth of okra, The use of Poultry dropping by farmers will give optimum yield, when making use of poultry dropping or cow dung as fertilizer, it should be applied at least 2 weeks before planting for optimum yield.

Keywords: *Organic and Inorganic Fertilizers; Physical and Chemical Properties; Ultisols; Growth Parameters; Okro; Abelmoschus esculentus*

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INTRODUCTION

Soil is a complex combination of organic matter, minerals, gases, liquids and organisms that work together to support the growth and development of plants and other soil organisms. One significant challenge faced by numerous countries in sustaining agricultural production and productivity lies in the depletion of soil fertility (Hartemink, 2006). Soil fertility refers to the ability of a given soil to provide nutrients in balanced quantities for sustainable biological productivity while promoting environmental preservation as well as plant and animal health (Karlen *et al.*, 2008). The cultivation of crops on a sustainable basis requires proper management of nutrient resources alongside the preservation of soil fertility.

One method of providing nutrients to soil is through the application of fertilizer, which can be either organic or inorganic. Plants need various nutrients for healthy growth, just like all living things. Soil microbes are typically present in healthy soil, but when they're lacking, plants suffer. Fertilizers were created to make up for any soil deficiencies, so plants can thrive in less-than-ideal conditions. The three macro nutrients in fertilizer are: Nitrogen (N), Phosphorus (P), Potassium (K) plant makes use of them in form of nitrate, phosphates and potassium ion(k^+).

Fertilizers serve to supply plants with essential nutrient elements for optimal growth and yield (Ali *et al.*, 2009). A fertilizer refers to any naturally occurring or synthetic material that is added to plant tissues or soil to provide nutrients necessary for plant development. Most fertilizers contain a variety of macro elements.

Fertilizers can be broadly categorized into two types: organic and inorganic. Organic fertilizers are derived from plant and animal sources and sometimes they contain living organisms. They release nutrients through decomposition by microorganisms. On the other hand, inorganic fertilizers are manufactured and contain minerals like nitrogen, potassium, and phosphorus. They are easier to produce and have higher nutrient concentrations, but also come with some drawbacks, in that their nutrient elements are not easily released into the soil for plant use. Organic fertilizers aid in improving soil structure and increasing its organic matter content, they may not provide sufficient nutrient levels; on the other hand, inorganic fertilizers are able to supply ample amounts of nutrients.

The *Abelmoschus esculentus* plant, commonly referred to as okra is a favored vegetable in various parts of the world. Its elongated and slender shape has earned it the nickname "lady's finger"(National Research Council 2006). Okra (*Abelmoschus esculentus*) also known as "lady's finger, "is a vegetable with elongated green pods that contain many seeds. It belongs to the mallow family and has heart-shaped leaves, yellow flowers, and a hairy stem. Its origin is disputed among supporters of West African, Ethiopian, Southeast Asian and South Asian origins. Okra is grown in tropical and warm temperate regions worldwide and used extensively in different countries' cuisines. Okra is a popular vegetable crop known for its nutritional value and adaptability to various soil conditions. Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. Okra is a multipurpose crop due to its various uses of fresh leaves, buds, flowers, pods, stems and seeds. Okra immature fruits, which are consumed as vegetables, can be used in salads, soups and stews, fresh or dried, fried or boiled. Fertilizers play a crucial role in enhancing crop productivity by providing essential nutrients to plants. However, the choice between organic and inorganic fertilizers can significantly impact soil quality and plant growth. Inorganic and organic fertilizers can affect the yield and overall health of okra crops in different ways. This study aims to determine which type of fertilizer is best for okra production, taking into consideration the impact on both plant and soil health. The experiment conducted in Port Harcourt seeks to provide valuable information on the most suitable fertilizer type for okra cultivation in the region, with a focus on minimizing any negative effects on the soil and the plants.

MATERIALS AND METHODS

Brief Description of the study area

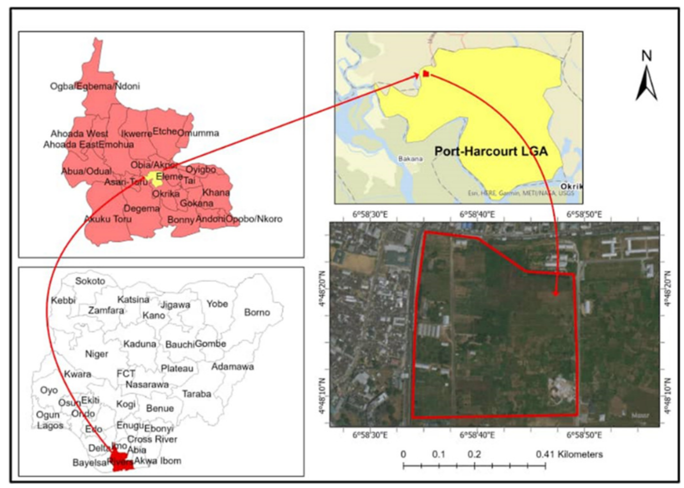

Figure 1 Map of Rivers State University Teaching and Research Farm

The study was carried out at the Teaching and research farm belonging to the Faculty of Agriculture, Rivers State University Port Harcourt, Nigeria. (Figure 1) This land has been under intensive cultivation since the establishment of the University in 1979 according to Ikati and Peter 2019. It lies between latitude of 4°40'50"N and 4°51'40"N, and longitude of 6°57'30"E and 7°5' 0"E. It has a mean annual rainfall of 2000–3000 mm and mean annual temperature of 25–28°C (Peter and Aaron, 2019; Ikati and Peter, 2019); while the relative humidity varied between 70–85 %. A period of low precipitation (dry season) commonly called the harmatan period (late November to February) is also experienced in the study location. (Peter and Aaron, 2019; Ikati and Peter, 2019) The vegetation of the study area, as described by Ikati and Peter (2019) and Peter and Aaron (2019), is that of the humid tropical ever green, but tremendously altered as a result of the continuous cropping system normally practiced in the area. The study area is underlain by the coastal plain sands and alluvium of marine deposits (Peter and Aaron, 2019). These soils of Teaching and Research Farm, Rivers State University are largely Inceptiols or Cambisols and these soils could be sustained for reasonable agricultural productivity.

Land preparation

The Rivers State University Teaching and Research Farm Screen house was used for the experiment. 10kg of topsoil were collected and put into sack bags. The bags were labeled properly according to the different treatments administered and were all arranged and replicated four times according to treatments in a Complete Randomized Design (CRD) giving a total number of Twenty (20) Plots.

EXPERIMENTAL MATERIALS

The treatment administered were N.P.K 15-15-15, Cow dung, Poultry manure and the no pollution plot or control. 0.25kg N.P.K.15-15-15 was applied into 10kg of soil at 2 weeks after planting (WAP) on the experimental plots using the ring method of application , 5kg of Poultry Manure (PM) was also added into 10kg soil on specified plots 2weeks after planting, 5kg of cow dung was added into 10kg of soil to specific plots 2 weeks after planting and 2.5kg of both poultry and cow dungs were applied together to specified plots , The plots that received no treatments served as the control. The manures were dried to prevent decomposition and later analyzed using standard procedures for their chemical compositions.

Planting and Field Maintenance

Planting: The okra seeds were planted directly into the bag containing soil according to their different treatments and watered. Maximum of 2 seeds were planted in a bag.

Weeding: Weeds were removed from each of the experimental plot by hand picking.

Watering: Watering of plants in potting bags was done twice a week.

Fertilizer Application: Fertilizer was applied using the ring method of application. The fertilizers were applied two weeks after planting.

DATA COLLECTION

The following growth parameters were monitored and analyzed:

Percentage Emergence: Percentage emergence was taken 7 days after planting. This was done by counting the number of seeds that emerged, divided by numbers of seeds planted time hundred over one as seen in the equation below

Plant height: This was determined by measuring the individual sampled plants using a meter rule from the base of the plant to the top of the leaves.

Leaf area index

This was calculated by measuring the length and breadth of the leaf as described by (Knudsen, 1982), where Leaf Area (cm^2) = K x length x breadth, where K = Kemp's constant (0.62). Means of each measurement for each replication were recorded as the score for individual treatment.

LABORATRY ANALYSIS

Soil samples were taken from the experimental site before and after experiment. About 7-8 sample points were taken from each block and mixed thoroughly to make a composite sample before commencement of experiment whereas one composite soil sample was taken per plot after the experiment for laboratory analysis. The soil samples were air-dried, grinded and sieved with 2mm mesh size sieve before using them for analysis to determine the following.

Particle size distribution: Particle size distribution was done using the Bouyoucos hydrometer using calgon (Sodium Hexametaphosphate :- (NaPO3)6) as dispersing agent. The different percentages of soil particles were determined (Sand, silt &clay).

Soil pH: The pH of the soil was determined using the electrometric method which makes use of the pH meter. It measures the electrical potential between a reference solution and the solution of the soil using the glass electrodes.

Organic carbon: The determination of soil organic carbon was based on the Walkey-Black chromic acid wet oxidation method (1934).

Organic matter content: The Walkley-Black method (1934) was used for determining organic matter content of the soil. This method uses potassium dichromate (K_2CrO7^{-3}) without external heating and then a back titration to measure the amount of unreacted dichromate.

Total nitrogen: Total nitrogen was determined by using the Macro-kjedahl digestion distillation method

Available P: This was determined using the Xue, *et al* (2021).

Exchangeable cations (Ca, Mg, K and Na): The concentration of exchangeable Ca and Mg was determined using the EDTA titration method, while the concentration of Na and K was determined by using flame photometer.

Effective cation exchange capacity (ECEC): This test was carried out to know the total amount of exchangeable cations which are mostly sodium, potassium, calcium

Table 1: Initial properties of the Soil before planting

Soil Property	Values
Sand (g/kg)	904
Silt (g/kg)	34
Clay (g/kg)	62
Soil pH	4.43
Organic Carbon (g/kg)	5.9
Organic Matter (g/kg)	10.2
Total Nitrogen (g/kg)	0.3
Available Phosporus (g/mg)	59.64
Total Exchangeable Acidity (Cmol/kg)	1.44
Exchangeable Ca^{2+} (Cmol/kg)	1.8
Exchangeable Mg^{2+} (Cmol/kg)	1.2
Exchangeable Na^{+} (Cmol/kg)	0.26
Exchangeable K^{+} (Cmol/kg)	0.01
Effective cation exchange capacity (Cmol/kg)	4.7

Table 2: Percentage germination

Treatment	Control	NPK	Poultry Dropping	Cow dung	Cow dung/ Poultry dropping
%Germination	87.5	100	100	100	100

Table 3: Effects of Amendment Materials on Physical and Chemical Properties of the Soil

Treatment	Particle Size g/kg			Particles properties			Total N							ECEC
	Sand	Silt	Clay	pH	O.C g/kg	O.M g/kg	Total N	TEA cmol/kg	Ava. P g/mg	Ca^{2+} Cmol/kg	Mg^{2+} Cmol/kg	K^{+} Cmol/kg	Na^{+} Cmol/kg	
Control	884	34	82	4.54	5.1	8.6	0.2	2.56	59.65	1.4	0	0.02	0.30	4.28
NPK	916	2	82	4.92	5.9	10.2	0.1	1.60	49.61	4.4	1.2	0.03	0.27	7.50
CD	904	34	62	5.00	7.0	12.1	12.1	1.52	64.91	1.6	1	0.17	0.33	4.62
PD	894	24	82	5.21	10.5	18.1	18.1	1.84	70.18	1.6	0.6	0.15	0.33	4.52
PD/CD	884	34	82	5.08	7.0	12.1	12.1	0.96	64.91	0.2	2.0	0.15	0.43	3.74

PD - Poultry Dropping, CD - Cow Dung, O.C - Organic Carbon, O.M - Organic Matter, ECEC- Effective Cation Exchange Capacity, Ava.P - Available Phosphorus, Total N- Total Nitrogen, TEA - Total Exchangeable Acidity.

and magnesium were determined.

Percentage (%) Base Saturation: The percentage of cation Exchange Capacity that is occupied by Ca^{2+},Na^{+} , Mg^{2+} was tested for.

STATISTICAL ANALYSIS

Data collected were subjected to statistical analysis of variance (ANOVA) using Minitab 16 while comparison among means of the treatments were done using Duncan's multiple range test at 0.05% probability level.

RESULTS AND DISCUSSION

Table.1 revealed the results of initial soil analysis carried out to assess the soil fertility status of the soils before the study. From the result Sand particle was 904g/kg, silt 34g/kg and clay 62g/kg. The soil was acidic with a pH of 4.43. Soil Organic carbon was 5.9g/kg, organic matter was 10.2g/kg. Available phosphorus was 59.64 g/mg. Soil Total nitrogen was 0.4 g/kg. The total exchangeable acidity of the soil was 1.44 Cmol/kg. While soil Ca^{2+}, Mg^{2+}, Na^{+}, k^{+} were 1.8,1.2,0.26, and 0.01 Cmol/kg respectively.

Table 2 shows the percentage emergence of the crop using the five amendments. It revealed that control plots had 87.5% which was the lowest percentage emergence; while plots treated with NPK 15:15:15, poultry dropping, cow dung and cow dung /poultry dropping were 100% respectively.

Effects of Amendment Materials on Physical and Chemical Properties of the Soil

Table 3 shows the results of the effects of amendment materials on physical and chemical properties of the soil. From the results, sand particles dominated the particle size distribution. From the results, sand particles ranged from 884g/kg in both control and poultry dropping/cow dropping combine to 916g/kg. The result also revealed that plot treated with NPK had the highest sand particle distribution (916g/kg), while the least was observed in the plots treated with poultry dropping/cow dung combine and the control (844g/kg) respectively. The results also revealed that silt particles increase from 2g/kg in plot treated with NPK to 34g/kg in the control plot and plot treated with poultry dropping/cow dropping respectively. It was also observed from the result that clay content decreased from 82g/kg to 62g/kg in the plot treated with cow dropping. From the result it was observed that the pH increased from 4.54 in the control plot to 5.21 in the plot treated with poultry dropping.

The plot treated with poultry dropping had the highest (5.21) followed by poultry dropping/cow dropping combine (5.08), cow dung (5.00) and NPK (4.92). It was observed that the least pH was in the control plot (4.54). Observation from the results indicated that organic carbon has reduced from 10.5g/kg to 5.1g/kg. The plot treated with poultry dropping had the highest (10.5g/kg) followed by cow dropping and poultry dropping/cow dropping combine which had 7.0g/kg respectively and NPK (5.9g/kg) in that order. The least organic carbon was observed in the control plot (5.1g/kg). From the results it indicates that organic matter increases from 8.6g/kg to 18.1g/kg.

The highest organic matter was observed in the plot treated with poultry dropping (18.1g/kg) followed by the plots treated with poultry dropping and poultry dropping/cow dropping combine which had 12.1g/kg respectively and NPK (10.2g/kg) in that order. The least organic matter was observed in the control plot (8.6g/kg). From the results obtained, the plot treated with poultry dropping had the highest amount of total nitrogen 18.1g/kg followed by cow dropping and poultry dropping/cow dropping combine which had 12.1g/kg respectively and control 0.2g/kg. The least Total nitrogen was observed in the plot treated with NPK (0.1g/kg).

From the results obtained the Total exchangeable acidity increased from 0.96Cmol/kg to 2.56Cmol/kg. The highest TEA was observed in the control plot (2.56Cmol/kg) followed by poultry dropping (1.86Cmol/kg), NPK (1.60Cmol/kg) and cow dropping (1.52 Cmol/kg) in that order. The least TEA was observed in the plot treated with poultry dropping/cow dropping combine (0.96Cmol/kg). The results shows that Available phosphorus reduced from 70.18g/mg to 49.61g/mg.

The plot treated with poultry dropping recorded the highest (70.18g/mg) followed by cow dropping and poultry dropping/cow dropping combine which recorded 64.91g/kg respectively and control (59.65g/mg). The least Ava.P was recorded in the plot treated with NPK (49.61g/mg).

From (Table 3) it was observed that Ca^{2+} increased from 0.2 Cmol/kg to 4.4Cmol/kg. The plot treated with NPK had the highest (4.4 Cmol/kg) followed by plots treated with cow dropping and poultry dropping both had 1.6Cmol/kg respectively and control (1.4 Cmol/kg),while the plot treated with poultry dropping/cow dropping combine had the least(0.2Cmol/kg).

From the result it was observed that Mg^{2+} increased from 0 Cmol/kg to 2.0Cmol/kg. It was observed that poultry dropping/cow dropping combine recorded the highest (2.0 Cmol/kg) followed by NPK (1.2Cmol/kg), cow dropping (1mol/kg) and poultry dropping (0.6 Cmol/kg) in that order. The control plot recorded the least (0 Cmol/kg).

From the results obtained it was recorded that k^+ increased from 0.02Cmol/kg to 0.17Cmol/kg. The highest was observed in the plot treated with cow dropping (0.17 Cmol/kg) followed by poultry dropping and poultry dropping/cow dropping both had 0.15 Cmol/kg respectively and NPK (0.03 Cmol/kg) in that order. The control plot recorded the lowest (0.02Cmol/kg).

It was observed that Na^+ decreased from 0.43Cmol/kg to 0.27 Cmol/kg. Poultry dropping/cow dropping combine recorded the highest (0.43Cmol/kg) followed by cow dropping and poultry dropping both had 0.33 Cmol/kg respectively and control (0.30 Cmol/kg), the least was recorded on the plot treated with NPK(0.27Cmol/kg). From the result it was observed that the plot treated with NPK had the highest Effective cation exchange capacity (7.50 Cmol/kg) followed by cow dropping (4.62 Cmol/kg), poultry dropping (4.52 Cmol/kg) and control (4.28 Cmol/kg) in that order. The least ECEC was observed in the plot treated with poultry dropping /cow dropping combine (3.74Cmol/kg).

Effect of Amendment Materials on Okra Plant height 2, 4, 6 and 8 weeks after Planting

Table 4: Effect of Amendment Materials on Okra Plant Height (cm) 2, 4, 6 and 8 WAP

Treatments	Weeks After Planting (WAP)			
	2	4	6	8
Control	14.75	15.75	16.25	8
NPK	13.63	15	16.5	17.25
Poultry Dropping	13.5	20.75	18.25	24.75
Cow Dropping	11.75	12.13	11.5	9.25
Poultry Dropping/ Cow Dropping	12.5	10.75	9.25	12.5

The effect of amendment materials on okra plant height 2, 4, 6 and 8 WAP are presented in Table 4. Results obtained on okra plant height 2, 4, 6 and 8 WAP revealed that two weeks after planting, the control had the highest plant height (14.75cm); while the least plant was observed in the plots treated with cow dropping (11.75cm). At four weeks after planting, plant height ranged from 10.75cm in plots treated with cow dropping/poultry dropping to 20.75cm in plot treated with poultry dropping only.

The highest plant height was observed in plot treated with poultry dropping, followed by the control (15.75 cm) and NPK (15cm); while the least plant height was observed in plots treated with poultry dropping/cow dropping combine (11.75 cm).

Six weeks after planting, the same trend was observed. Plant height ranged from 9.25cm in plot treated with poultry dropping/cow dropping combine to 18.25 cm in plot treated poultry dropping only.

Poultry dropping had the highest plant height (18.25 cm), followed by the control (16.25 cm), NPK (16.25 cm) and cow dropping (11.5 cm) respectively.
The plot treated with poultry dropping/cow dropping combine had the least plant height (9.25 cm).

At eight weeks after planting, there was an increase in plant height in plot treated with poultry dropping (24.75 cm), followed by NPK (17. 25 cm) and poultry dropping/cow dropping combine (12.5 cm). The least height of plants at 8 WAP was observed in plot treated with cow dropping (9.25 cm).

Effect of Amendment Materials on Okra Leaf Area (cm) 2, 4, 6 and 8 WAP

Table 5: Effect of Amendment Materials on Okra Leaf Area (cm) 2, 4, 6 and 8 WAP

Treatments	Weeks After Planting (WAP) cm			
	2	4	6	8
Control	11.53	5.29	6.19	0.47
NPK	22.25	8.60	7.46	11.32
Poultry Dropping	3.00	8.06	23.11	69.44
Cow Dropping	9.10	8.10	9.11	13.02
Poultry Dropping/ Cow Dropping	10.04	2.65	14.44	39.53

Results obtained on Okra plant leaf area revealed that at 2WAP 3.0cm in poultry dropping to 22.25cm in NPK. The highest leaf area was observed in plot treated with NPK (22.25), followed by the control (11.53cm), poultry dropping/cow dropping combine(10.04cm) and cow dropping (9.10) in that order. The least leaf area was observed in plot treated with poultry dropping (3.0cm). At 4WAP, the results obtained from plant leaf area shows that, plant leaf area ranged from 2.65cm in poultry dropping/cow dropping combine to 8.60cm in NPK (Table 5). The highest leaf area was observed in plot treated with NPK (8.60cm), followed by poultry dropping(8.06cm), cow dropping(8.10cm), and control(5.29cm) in that order. The least leaf area was observed in plot treated with Poultry dropping /cow dropping combine (2.65cm). At 6WAP, results indicated that poultry dropping had the highest leaf area (23.11cm) followed by poultry dropping/cow dropping combine(14.44cm), cow dropping(9.11cm) and NPK(7.46cm) in that order. The least leaf area was observed in the control plot (6.19cm). At 8WAP, plant leaf area ranged from 0.49cm in control to 69.44cm in poultry dropping. Poultry dropping had the highest leaf area(69.44cm) followed by poultry dropping/cow dropping combine(39.563cm), cow dropping(13.02cm) and NPK (11.32cm) in that order. The least leaf area was observed in the control plot (0.47cm).

Effect of Amendment Materials on Okra Plant Number of Leaf (cm) 2, 4, 6 and 8 WAP

Table 6: Effect of Amendment Materials on Okra Plant Number of Leaf (cm) 2, 4, 6 and 8 WAP

Treatments	Weeks After Planting (WAP) cm			
	2	4	6	8
Control	3	3.25	2	0.5
NPK	3	4.25	2.5	2.25
Poultry Dropping	3.25	4	5.5	5.5
Cow Dropping	2.75	1.75	2.25	1.75
Poultry Dropping/ Cow Dropping	2.5	3.25	2.25	3

The effect of amendment materials on the number of leaves of Okra plant 2, 4, 6 and 8 WAP are presented in Table 6. At 2WAP results obtained on number of leaves of okra plant ranged from 2.5cm in poultry dropping/cow dropping combine to 3cm in control and NPK respectively. The highest number of leaves was observed in control plot and plot treated with NPK (3cm) respectively followed by poultry dropping (3.25cm) and cow dropping 2.75cm) in that order. The least number of leaves were observed in the plot treated with poultry dropping/cow dropping (2.5cm). At 4WAP, it was recorded that the number of leaves of okra plant ranged from 4.25cm in NPK to 1.75cm in cow dung. The highest number of leaves was recorded in the plot treated with NPK (4.25cm) followed by poultry dropping (4cm), control and poultry dropping/cow dropping combine had (3.25cm) respectively. The least number of leave was recorded in plot treated with cow dung (1.75cm). At 6WAP it was observed that poultry dropping had the highest number of leaves (5.5cm) followed by NPK, cow dung and poultry dropping/cow dropping combine (2.25cm) respectively. The least number of leaves was observed in the control plot (2cm). At 8WAP the result showed that poultry dropping had the highest number of leaves 5.5cm followed by poultry dropping/cow dropping (3cm), NPK (2.25cm) and cow dropping (1.75cm), while control plot (0.5cm) had the least number of leaves.

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