

Evaluation of the Differences in Morphometry and Biomass of *Abelmoschus Esculentus* (L.) Moench Cultivated under Three Conditions of Manuring in Abakaliki Peri-Urban Area, South-Eastern Nigeria

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Abstract

The difference in morphometry and biomass of *Abelmoschus esculentus* (Okra) cultivated under different conditions of manuring; cow dung, chicken droppings, NPK fertilizer and control was evaluated. The experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The germination rate of *Abelmoschus esculentus* treated with three different manure showed that the highest percentage of germination rate was (97.66 ± 10.40 %) among those treated with NPK fertilizer followed by (93.23 ± 5.20 %) of those treated with cow dung, While the least was (61.66 ± 2.88 %) of the control. The morphometric parameters measured showed a significant increase in the height of okra among the treated groups than the control groups. The highest plant height was (73.10 ± 12.12cm) among the treatment group with the application of NPK fertilizer. The lowest plant height (51.21 ± 3.21 cm) was recorded among the control group. There was an increase in leaf length (26.24 ± 4.03cm) of NPK fertilizer than chicken dropping and cow dung but the lowest leaf length was observed among the control group with mean value of (23.01 ± 1.10 cm). The girth of okra showed a significant increase with the okra treated with chicken dropping, cow dung and NPK fertilizer. Hence the highest girth of (6.87 ± 0.34 cm) was recorded among the okra treated with NPK fertilizer. While the girth of those treated with cow dung (5.26 ± 0.81 cm) was higher than the girth (4.98 ± 0.54 cm) measurement of the control groups. There was a gradual increase in the leaf area of okra moving from control to the treatments. The highest leaf area was (48.72 ± 4.31cm) among the okra plant treated with NPK fertilizer while lowest leaf area was (36.31 ± 1.21 cm) among the control. There was a significant difference among the fresh weight and dry weight moving from the control to treatments. The biomass of okra had the highest (137.54 ± 73.30 cm) among the group treated with NPK fertilizer while a lower value of (101.45 ± 25.51 cm) was observed among those treated with chicken dropping. The results indicate that the growth parameter of the okra treated with NPK fertilizer had the highest growth in height, girth, leaf area and biomass. This is because of the essential nutrients contained in NPK fertilizer which are released more quickly and readily available for plants growth. Therefore, NPK fertilizer is recommended to farmers since its application boosts the yield performance of crops.

Introduction

Vegetable growing is one of the major enterprise in horticulture which is becoming more popular due to the greater appreciation of their food values [1], vitamins and minerals [2]. Vegetables contribute an important part of the diet to many people in the tropics more especially in South-Eastern Nigeria. Okra is essentially a tropical crop and among the most commonly grown vegetable throughout Nigeria. It is cultivated for its fresh fruits in both tropical and sub-tropical countries. The stem yield is useful as fiber. While the leaves are considered good cattle feed and are consumed sometimes. The seeds however can be roasted and used as substitute for coffee [3]. The essential and non-essential amino acid which Okra contains is comparable to that of soybean [4]. Okra production in the South East of Nigeria often recorded low yield. The low yield experience has been attributed to poor soil fertility and deficiency in important mineral nutrients. This is because fertilizer has become a scarce commodity, even when available, is beyond the reach of the poor resource farmers due to its high costs. For example over 70 % of vegetable farmers in Enugu State, South East Nigeria have no access to mineral fertilizer due to high cost and scarcity. Hence Animal wastes that result to animal manures is better alternative and a necessary option [5].

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Abelmoschus esculentus (okra) known in many English-speaking countries as ladies fingers, bamia, ochro or gumbo is one of the most important vegetables grown in Nigeria. It belongs to the Malvaceae family. It is an annual crop growing mainly as fruits and leafy vegetables in both fresh (green) and dried state in the tropics [6]. Okra is a coarse, erect, branched, more or less hairy, annual herb, 0.6 to 1.5 m high. Leaves are long petiole, orbicular or orbicular ovate, about 25 cm long or less; corolla large and yellow, and inside, deep purple at the base. Fruit is elongated, 10 to 25 cm long 1.5 to 3 cm in diameter tapering to a blunt point and containing rows of rounded, kidney shaped seeds [7,8].

Most agricultural crops require soils that have high nutrients contents to attain maximum growth. Organic manures from plants' or animals' wastes which are more readily available to peasant farmers have long been used to improve the soil fertility for increased productivity. This requirement could be adequately met by using inorganic manure since they are good sources of nitrogen. However, extensive use of inorganic fertilizer has a depressing effect on yield. It leads reduction in number of fruits, delays and reduces fruits setting, which consequently results in delay ripening and heavy vegetable growth [9]. The undesirable effects of inorganic fertilizers has encouraged farmers and scientists toward making use of organic materials (both organic manures as well as organic waste) for improving the physical properties of soils that allow profitable crop production [10]. However, the relative positive effect of these manures on crops has not been well documented especially among staple crops and vegetables like okra, watermelon, cucumber, etc., grown for both household and commercial consumption in Nigeria [6].

Cultivation

Okra is cultivated under rain-fed and in irrigated areas on a wide range of soils. The production is seriously affected by the use of local varieties (low yielding), sub-optimal and inappropriate manure doses. The use of inorganic fertilizer has not been helpful under intensive agriculture because it is often associated with reduced crop yield, soil acidity and nutrients imbalance [11,12,8]. Furthermore, the extent to which farmers can depend on this input is constrained by unavailability of the right type of inorganic fertilizers at the right time, high cost, lack of technical know-how and lack of access to credit [13]. This has encouraged scientists towards making use of organic materials (both organic manures as well as organic wastes) for improving the physical properties of soils that allow profitable crop production [14]. Currently, the utilization of these organic materials in soil fertility management in Africa is not encouraging when compared with the countries in Asia [15]. Published works on the organic manure use in Nigeria is rather scanty [8]. The need to use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic fertilizers worldwide. Improvement of environmental conditions and public health are important reasons for advocating increased use of organic materials [16].

Animal manure had been used as a source of local fertilizer in the many developing countries across the globe for many centuries. Proper use of manure and compost is essential for both a production and environmental standpoint. Applying rates that are too low can lead to nutrient deficiency and low yields [8]. On the other hand, too high a rate can lead to nitrate leaching, phosphorus runoff, accelerated

eutrophication of lakes, and excessive vegetative growth of some crops [17]. Thus, understanding how to manage manure is important for any farming operation with livestock that relies on manure as a major source of nutrients, as well as for vegetable producers who have access to an economical supply of manure, compost, or other organic nutrient sources. The use of inorganic fertilizers has drastically declined due to the energy crisis, which has immensely affected most of the developing countries. Nutrients contained in manures are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yields [17,5].

Manure application

Manures are usually applied at higher rates, relative to inorganic fertilizers. When applied at higher rates, they give residual effects on the growth and yield of succeeding crops [18]. Improvements of environmental conditions as well as the need to reduce cost of fertilizing crops are reasons for advocating use of organic materials [19]. Organic manures improve soil fertility by activating soil microbial biomass [20]. Application of manures sustains cropping system through better nutrient recycling [21]. Manures provide a source of all necessary macro and micro nutrients in available forms, thereby improving the physical and biological properties of the soil [5]. This study thus aimed to establish the better organic manure source by estimating the growth rate and yield potentials of these vegetable crops using three different kinds of organic manures. The morphometric growth and crop yield of okra (*Abelmoschus esculentus*), which is a staple vegetable in Nigeria was analyzed and reported.

Origin and Distribution

Abelmoschus esculentus commonly known in many English-speaking countries as ladies' fingers, ochro or gumbo, is a flowering plant in the mallow family. It is valued for its edible green seed pods [22]. The geographical origin of okra is disputed, with supporters of South Asian, Ethiopian and West African origins. Supporters of a South Asian origin point to the presence of its proposed parents in that region. Supporters of a West African origin point to the greater diversity of okra in that region [2].

The Egyptians and Moors of the 12th and 13th centuries used the Arabic word for the plant, bamyia, suggesting it had come into Egypt from the Arabia, but earlier it was probably taken from Ethiopia to Arabia. The plant may have entered southwest Asia across the Red Sea or the Bab-el-Mandeb strait to the Arabian Peninsula, rather than north across the Sahara, or from India. One of the earliest accounts is by a Spanish Moor who visited Egypt in 1216 and described the plant under cultivation by the locals who ate the tender, young pods with meal [4]. From Arabia, the plant spread around the shores of the Mediterranean Sea and eastward. The plant was introduced to the Americas by ships plying the Atlantic slave trade by 1658, when its presence was recorded in Brazil. It was further documented in Suriname in 1686. Okra may have been introduced to southeastern North America from Africa in the early 18th century. By 1748, it was being grown as far north as Philadelphia. Thomas Jefferson noted it was well established in Virginia by 1781. It was commonplace throughout the southern United States by 1800, and the first mention of different cultivars was in 1806 [2,6].

Structure and Physiology

The species is a perennial, often cultivated as an annual in temperate climates, and often grows to around 2 m tall. It is related to such species as cotton, cocoa, and hibiscus. The leaves are 10-20 cm long and broad, palmately lobed with 5-7 lobes. The flowers are 4-8 cm in diameter, with five white to yellow petals, often with a red or purple spot at the base of each petal. The fruit is a capsule up to 18 cm long with pentagonal cross-section, containing numerous seeds [23].

Abelmoschus esculentus is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. It is among the most heat- and drought-tolerant vegetable species in the world and will tolerate soils with heavy clay and intermittent moisture, but frost can damage the pods [24]. In cultivation, the seeds are soaked overnight prior to planting to a depth of 1-2 cm. Germination occurs between six days (soaked seeds) and three weeks. Seedlings require ample water. The seed pods rapidly become fibrous and woody, and, to be edible, must be harvested within a week of the fruit having been pollinated. The fruits are harvested when immature and eaten as a vegetable. Okra is available in two varieties, green and red. Red okra carries the same flavor as the more popular green okra and differs only in color. When cooked, the red okra pods turn green [25]. The most common disease afflicting the okra plant is verticillium wilt, often causing a yellowing and wilting of the leaves. Other diseases include powdery mildew in dry tropical regions, leaf spots, and root-knot nematodes [26].

Use of Fertilizers

Soil productivity maintenance is a major constraint of tropical agriculture system. Crop cultivation is usually moved between fields to utilize only fertile soils for some years without use of fertilizers. However, this cannot be sustained to meet increased demand of an increasing population. Tropical soils are adversely affected by sub-optimal soil fertility and erosion, causing deterioration of the nutrient status and changes in soil organism populations [27]. Chemical fertilizers are used in modern agriculture to correct known plant-nutrient deficiencies; to provide high levels of nutrition, which aid plants in withstanding stress conditions; to maintain optimum soil fertility conditions; and to improve crop quality. Adequate fertilization programmes supply the amounts of plant nutrients needed to sustain maximum net returns [28]. In essence, fertilizers are used to make certain that soil fertility is not a limiting factor in crop production [28].

Studies conducted by various researchers have shown that the application of fertilizer both from organic and inorganic sources significantly improves the growth and yield of crops. Thus, an integral use of both organic and inorganic fertilizer to ensure adequate supply of plant nutrients and sustain maximum crop yield and profitability has been advocated. However, inorganic fertilizer is expensive and may be largely unaffordable and not available to the resource-poor farmers in Nigeria. On the other hand, organic manure such as poultry droppings is readily available as a cheap source of nitrogen for sustainable crop production. Organic fertilizer supplies the essential macro- and micro-nutrient elements to plants, as well as improves soil physico-chemical conditions for better growth and yield of Okra. The application of poultry manure is expected to enhance soil productivity, increase the soil organic carbon content, soil flora and fauna, improve soil crumb structure and the nutrient

status of the soil towards attaining sustainably high yields [8]. The role of organic manure in maintaining organic matter and raising the growth and yield of cereal crops had long been recognized in most agro-ecological zones. Poultry manure (particularly from chicken) is the richest animal manure in N-P-K (1.1-0.8-0.5 %, respectively) relative to other organic manures such as cow, horse, steer, sheep, swine and rabbit manure. The nutrient value in these manures varies greatly depending largely on the diet and age of the animal.

[14] Somani LL reported that inorganic fertilizers are known to influence the quantity and yield of okra. [18] Makinde EA recommended an optimum plant population of 53,333 plants/ha for maximum Okra yield. Their report indicated that this is obtainable using a spacing of 75cm x 25cm at 1 plant per stand or 75cm x 50cm at 2 plants per stand. [18] Ayoola AA reported that spacing of 75cm x 35cm resulted in increased yield while 75cm x 15cm gave maximum weight. At present, some farmers not only neglect the use of fertilizers or soil amendments but also sow any crop variety of their choice and these do not translate into expected high grain yield. Hence, there are no recommended standards taking into consideration the different combinations of such cultural practices as varietal selection, rates of appropriate organic manure and mineral fertilizer which interplay to influence yield and optimal performance of okra.

[29] Sonetra S suggested that subsistence farmers should apply organic manure directly to the soil as a natural means of recycling nutrients in order to improve soil fertility and yield of crops. Manures and fertilizers are the life wire of improved technology contributing about 50 to 60% increase in productivity of food grains in many parts of the world, irrespective of soil and agro-ecological zone [29]. [8] Ojeniyi SO remarked that the downward trend in food production should prompt farmers to amend the soil with different materials in order to enhance growth and yield of crops. Several organic materials such as cattle dung, poultry dropping, pig dung and refuse compost have been recommended to subsistence farmers in West Africa as soil amendments for increasing crop yield. [19] Bayu W recommended the application of 450kg/ha-1 of NPK 20:10:10 or 30 tha-1 of poultry manure for increased grain yield of okra. The report further argued that poultry dropping and cattle dung increases root growth of maize and the crop extracts soil water more efficiently for increased grain yield.

Materials and Methods

Study Area

Field experiments were carried out at Presco campus of Ebonyi State University, Abakaliki, Ebonyi State. The study area lies latitude 7° 19'36"N and longitude 8°04'44"E. The vegetation of Ebonyi state is luxuriant of the mosaic of the Low land tropical rainforest and Savanna vegetation. The experiment was conducted during the 2016 cropping season in a typical tropical environment that is characterized by a bimodal rainfall pattern with peaks in June and November and an interrupted dry spell in December otherwise called (Harmattan). The average annual rainfall range from 1,150 mm to 2,000 mm while the mean annual temperature range from 21°C to 29°C [30]. By nature of its geomorphologic settings, the study area falls within the classification of ancient meta-morphic crystalline basement complex formation which is more acidic than basic. The vegetation of the study area is of sub-savannah region and the soil is sandy loam.

Collection of Sample

Seeds of *Abelmoschus esculentus* was sourced from Faculty of Agricultural Sciences in the Department of Crop Science and Landscape Management, (CAS campus), Ebonyi State University (EBSU) and was identified by a renowned Plant Taxonomist and Ecologist, Prof. J.C. Okafor of Applied Biology Department, Ebonyi State University, Abakaliki. The materials used for the study include 2000 g of each organic and inorganic manure (cow dung, poultry dung and N.P.K. fertilizer), hoe and cutlass, measuring tape, pegs and hand gloves.

Field Layout and Experimental Design

A land measuring 150 m² was selected for the study and prepared by using a hoe to cultivate the land. The land was cleared with cutlass, pegged and bed preparation was done with hole on the same day. Each block consist of four beds and each bed was replicated into three equal parts and measured 1m with 2m path between each bed. The manures were added in each bed apart from the control which is the first bed, the second bed chicken droppings were added in the soil, the third bed cow dung were added in the soil and fourth bed fertilizer (N.P.K) were added as well in the soil and was left to mingle very well with the soil for a week before cultivation took place.

The treatments consisted of three types of organic manure (cow dung, poultry dung and NPK). The experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Manure was applied by broadcasting and thoroughly worked into the earth within the experimental plot. The beds measuring 60 x 30 cm were watered and left for two days before planting the seeds on them. This was to enable the dissipation of carbon-dioxide thus preventing burning and scorching on the tender seedlings. After viability test, the seeds of *Abelmoschus esculentus* were sown at a depth of 2cm. After germination, seedlings were thinned to one plant per stand three weeks after planting. Cultural operations such as spraying of ash, weeding were strictly observed. However, the control received no manure treatment.

Applications of Treatment

The manures were added in each bed apart from the control which is the first bed, the second bed chicken droppings were added in the soil, the third bed cow dung were added in the soil and fourth bed fertilizer (N.P.K) were added as well in the soil. The design was a randomized complete block which had 3 replicates and 3 treatments: T1: Control (No treatment) T2: Chicken dropping T3: Cow dung T4: Chemical Fertilizer (NPK fertilizer).

Data Collation and Statistical Analysis

Control stands were used as reference point. Data collated were rate of germination, plant height, plant girth, leaf area and biomass

Table 1: Effects of cow dung, chicken dropping and NPK fertilizer on okra germination rate.

Treatments	Mean±Std. Deviation of germination rate
Control	20±0.02
Cow dung	20±0.02
Chicken dropping	19.33±1.21
NPK fertilizer	20±0.02

Table 2: Effects of cow dung, chicken dropping and NPK fertilizer on okra height.

Treatments	Mean±Std. Deviation of height
Control	51.21±3.21
Cow dung	53.11±5.32
Chicken dropping	68.15±7.64
NPK fertilizer	73.10±12.12

of the plant. All the data collected were statistically analyzed using procedure described by [31] for Randomized Complete Block Design (RCBD) experiments. All the data were analyzed using mean and standard deviation and confidence intervals attached as recommended.

Results

Percentage of Germination Rate of *Abelmoschus esculentus* (Okra)

There was a significant variation in mean percentage of germination rate of *Abelmoschus esculentus* treated with three different sources of manure. The effects of different manuring on the germination rate revealed that all the twenty (20) plants germinated in the control, cow dung and NPK fertilizer, only in chicken dropping that average 19.33 germinated (Table 1).

Effects of Cow dung, Chicken droppings and NPK Fertilizer on the Height of *A. esculentus*: There was a significant increase in the height of okra among the treated groups than the control groups. The highest average plant height was 73.10±12.12 cm among the treatment group with the application of NPK fertilizer. The lowest plant height 51.21±3.21 cm was recorded among the control group (Table 2).

Effects of Cow dung, Chicken droppings and NPK Fertilizer on the Leaf length of *A. esculentus*

There was a significant variation in the leaf length of okra and there was a higher increase in leaf length 26.24±4.03cm of NPK fertilizer than chicken dropping and cow dung but the lowest leaf length was observed among the control group with mean value of 23.01±1.10 cm (Table 3).

The Effect of Different Manuring Condition (Chicken Droppings, Cow Dung and NPK fertilizer) on *Abelmoschus esculentus* Girth:

The effect of different manuring condition (chicken dropping, cow dung and NPK) fertilizer on okra girth showed a significant increase with the okra treated with chicken dropping, cow dung and NPK fertilizer. Hence the highest girth of 6.87±0.34 was recorded among the okra treated with NPK fertilizer. While the girth of those treated with cow dung 5.26±0.81 was higher than the girth 4.98±0.54 measurement of the control groups (Table 4).

Table 3: Effects of cow dung, chicken dropping and NPK fertilizer on okra leaf length.

Treatments	Mean±Std. Deviation of leaf length
Control	23.01±1.10
Cow dung	25.21±3.67
Chicken dropping	24.29±3.45
NPK fertilizer	26.24±4.03

Table 4: Effects of cow dung, chicken dropping and NPK fertilizer on okra girth.

Treatments	Mean±Std. Deviation of girth
Control	4.98±0.54
Cow dung	5.26±0.81
Chicken dropping	6.34±0.50
NPK fertilizer	6.87±0.34

The Effect of Different Manuring Condition (Chicken Droppings, Cow Dung and NPK fertilizer) on the Leaf Area of *Abelmoschus esculentus*

Nevertheless, a significant variation was observed among the okra treated with different manuring condition. There was a gradual increase in the leaf area of okra moving from control to the treatments. The highest mean leaf area was 48.72±4.31 among the treated group with NPK. The lowest mean value of leaf area was 36.31±1.21 among the control group (Table 5).

The Effect of Different Manuring Condition (Chicken Droppings, Cow Dung and NPK fertilizer) on the Biomass of *Abelmoschus esculentus*:

There was a significant difference among the fresh weight and dry weight moving from left to right or from the control to treatments. The biomass of okra had the highest 137.54±73.30 among the group treated with NPK fertilizer while a lower mean value of 101.45±25.51 was observed among those treated with chicken dropping (Table 6).

Table 5: Effects of cow dung, chicken dropping and NPK fertilizer on okra leaf area.

Treatments	Mean±Std. Deviation of leaf area
Control	36.31±1.21
Cow dung	42.37±18.12
chicken dropping	46.61±2.32
NPK fertilizer	48.72±4.31

Table 6: Effects of cow dung, chicken droppings and NPK fertilizer on okra biomass.

Treatments	Control	Chicken dropping	Cow dung	NPK fertilizer
Fresh weight	761.80±223.06	785.26±212.08	896.21±321.40	1021.51±336.42
Dry weight	343.43±18.22	431.53±98.17	640.58±221.48	651.20±362.12
Biomass	148.03±65.40	101.45±25.51	132.44±72.1	137.54±73.30

Discussion

Okra production in Nigeria often recorded low yield. The low yield experience has been attributed to poor soil fertility and deficiency in important mineral nutrients. This is because fertilizer has become a scarce commodity, even when available, is beyond the reach of the poor resource farmers due to its high cost. The organic matter of the soil which can be replenished and maintained by the application of animal manure has been considered by Somani LL [14] to be of immense assistance to farmers. The effects of different manuring on the germination rate revealed that twenty (20) plants germinated in the control (20±0.02), cow dung (20±0.02) and NPK fertilizer (20±0.02), whereas chicken dropping had (19.33±1.21) germination rate.

There was a significant increase in the height of okra among the treated groups than the control groups. The highest plant height was (73.10±12.12) among the treatment group with the application of NPK fertilizer. The lowest plant height (51.21±3.21) was recorded among the control group. There was a significant difference in the leaf length of okra and there was an increase in leaf length (26.24±4.03) of NPK fertilizer than chicken dropping and cow dung but the lowest leaf length was observed among the control group with confidence limit of (23.01±1.10). The results of this study also corroborated the finding of Sonia NM [32] in okra production in which they reported that organic manure and inorganic manure, especially poultry manure could increase plant height of crops when compared with other sources of manures. The increase in number of leaf per plant with organic fertilizer application stressed its importance during the vegetative growth of crop plants Tindall HD [33]. The effect of different manuring condition (chicken dropping, cow dung and NPK) on okra girth showed a significant increase with the okra treated with chicken dropping, cow dung and NPK fertilizer. Hence the highest girth of (6.87±0.34) was recorded among the okra treated with NPK fertilizer. While the girth of those treated with cow dung (5.26±0.81) was higher than the girth (4.98±0.54) measurement of the control groups. Nevertheless, a significant variation was observed among the okra treated with different manuring condition. There was a gradual increase in the leaf area of okra moving from control to the treatments. The highest confidence limit of leaf area was (48.72±4.31) among the treated group with NPK fertilizer. The lowest confidence limit of leaf area was (36.31±1.21) among the control group.

The result of this study is in agreement with the report of Adeleye EO and Ogunwale JA [34,35] who reported that the more readily nutrients are available to a crop, the higher the performance of the crop and vice versa. Though all the manures resulted to significant increase on all the parameters measured when compared to the control but poultry manure which was required at the lowest rate resulted in to highest significant growth and yield parameters.

Schlegel AJ [36] had earlier reported that the use of chicken or poultry manure and cow dung in soil amendment resulted in taller plants and higher number of leaves per plant in grain sorghum because of its high content of nitrogen, phosphorus, and potassium. The higher number of leaves and leaf area at 9 WAP in both years are indications that organic manure supplies the required nutrients to the plants a little later than what was obtained with the inorganic fertilizer. Similar result was reported by Okokoh SJ [37] who obtained taller and more leafy plants of *Amaranthus cruentus* with plots treated with 15 t ha⁻¹ of poultry manure than those treated with urea (20 kg ha⁻¹).

There was a significant difference among the fresh weight and dry weight moving from the control to treatments. The biomass of okra had the highest (137.54±73.30) among the group treated with NPK fertilizer while a lower mean value of (101.45±25.51) was observed among those treated with chicken dropping.

According to Balochgharayi H [38], application of poultry fertilizer significantly increased the biomass yield of okra which is in consonance with the current findings, though lower than the NPK due to its higher solubility, but Poultry manure, sheep manure and cow dung manure are very good sources of organic matters and play a vital role in soil fertility improvement as well as supplying primary, secondary and micronutrients for crop production.

Conclusion

Studies conducted by various researchers have shown that the application of fertilizer both from organic and inorganic sources significantly improves the growth and yield of crops. Thus, an integral use of both organic and inorganic fertilizer to ensure adequate supply of plant nutrients and sustain maximum crop yield and profitability is highly advocated. However, inorganic fertilizer is expensive and may be largely unaffordable and not available to the resource-poor farmers in Nigeria. On the other hand, organic manure such as poultry droppings is readily available as a cheap source of nitrogen for sustainable crop production.

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