

The effects of organic fertilizers and NPK on growth and yields of cowpea (*Vigna unguiculata. L*) in Kano plains Kisumu, Kenya

Abstract.

Excessive use of inorganic mineral fertilizers as an agronomic practice has resulted in the depletion of soil organic matter of soils of many regions thereby rendering such soils infertile and unable to maintain sustainable production. The use of organic amendments provides the immediate strategy for compensating for soil carbon depletion thereby reducing land degradation. The purpose of this study was to evaluate the effects of six organic amendments and the inorganic NPK fertilizer on the growth and yield of Cowpea (*Vigna unguiculata L*). The organic amendments were Boom Max, Ecoplanting, Evergrow, Dung slurry, Filter mud, and Market waste slurry applied to the soil at 8.33 t/ha. The experiment was laid in a RCBD. Data on growth and yields was collected on 10 tagged plants per plot. The results showed a significant difference among treatments. Mature composts (Boom Max, Ecoplanting, and Evergrow) resulted in a significantly higher germination percentage (53.49% on average) compared to that of Filter mud (41.50%) and the slurries (34.18% on average) while all the composts resulted in 25% higher number of branches on the average in season two as compared to the bio-slurries. In season three, Boom Max gave the highest germination percentage (41.02%) which was significantly higher than those of Evergrow (29.80 %), Filter mud and Dung slurry (27.18% on average) and NPK and Market waste slurry (5.64% on average) but not different from that of Ecoplanting. Five of the amendments had significantly better germination rates than NPK by an average of 20%. There were no significance differences ($P \leq 0.05$) in growth parameters between the mature composts and the NPK fertilizer, suggesting that the mature composts were equally efficient in nutrient supply to the crop as did the NPK fertilizer for plant growth. The application of organic amendments produced significant improvements in fresh leaf yields of the cowpea crop, with the highest yield recorded from the Boom Max applied plot (5781 kg on average), which was not different from others in seasons one and three but significantly different from that of NPK in season three. It can be concluded that depending on choice or type of amendment, organic manures are capable of producing similar or better results of crop growth and yields as the inorganic fertilizers.

Key words; organic, amendment, soil health, regenerative agriculture

Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a tropical annual herbaceous grain and fodder crop and the most prominent grain legume that belongs to the family Papilionaceae (Fabaceae), order Leguminosae and genus *Vigna* (Maletsema *et al.*, 2020). Cowpea is grown in eastern and southern Africa both as grain and leaf (Keller *et al.* 2005). It originated in Africa and has grown in various parts of the world, including tropical and sub-tropical regions covering Africa, Asia and the United States, Europe, and Central and South America (Carvalho *et al.*, 2017). It is well adapted to drought-prone areas, and has a short maturity period and a variety of uses which makes it an attractive alternative crop for farmers in arid and semi-arid regions where rainfall is low and unreliable (Hallsnsleben *et al.*, 2009). Cowpea is a warm-weather, dual-purpose legume providing food for human consumption and fodder for livestock (Mfeka *et al.*, 2019). It is a versatile and hardy legume crop, valued mainly for its seeds, pods, and leaves, and more than serves as feed fodder, hay, and silage for livestock and green manure and cover crop (Kebede *et al.*, 2020), adaptable to areas with water scarcity and low fertile soils (Padhi *et al.* 2002).

Cowpea grain contains 23% protein and 57% carbohydrate, while the leaves contain 27-34% protein (Belane and Dakora, 2009). Due to its high adaptability to different environments, low input costs and high protein content, it is highly suited for cultivation in countries with protein deficiency. Among legumes, cowpeas are the most cultivated and most consumed especially in Asia and tropical Africa (Danis *et al.* 2013). In addition to their importance in human food, cowpeas are also useful for soil fertilization through symbiotic nitrogen fixation and are useful in providing nitrogen, especially in areas where poor soil fertility is a problem (Diouf Diaga, 2011; Sheahan, 2012) therefore provides soil nitrogen to cereal crops, particularly maize, millet, and sorghum when grown in rotation or mixed in areas of poor soil. (Nkaa *et al.*, 2014).

The nutritional value of cowpea is a rich source of protein, a good source of vitamins A, B and C and also contains a high rate of minerals (Baloch, 1994), such as phosphorous, calcium and iron (Anonymous, 2007). The protein in cowpeas is rich in amino acids viz lysine and tryptophan as compared to cereal grains (Deepa Joshi *et al.* 2016).

Cowpea grains show a wide range of total carbohydrate content (22.3 -66.5g 100g⁻¹) and the highest starch content among legumes with a good amount of dietary fibre and resistant starch (Ali *et al.*, 2013; Goncalves *et al.*, 2016). The high starch content makes cowpeas suitable for the preparation of many processed products (Mamiro *et al.*, 2011). Cowpea is also rich in dietary fibre (16-20.9g 100g⁻¹) making its consumption useful in keeping the digestive system healthy and reducing the risk of diabetes and cardiovascular diseases (Goncalves *et al.*, 2016). A wide variation in sugar content (3.26-8.61g 100g⁻¹) was reported in cowpea (Wenget *et al.*, 2018). Cowpea grains are also rich in phenolic compounds, tannins, and flavonoids and show considerable antioxidant and radical scavenging activity (Awika and Duodu, 2017).

Even though cowpea is commonly grown in Kenya due to the rise in demand and therefore consumption and market value, many production challenges has led to reduced productivity and production. Cowpea yield remains one of the lowest despite this dramatic increase in cowpea production among the food legumes in sub-Saharan Africa; remaining at 450kg/ha in 2006 -2008 which is only 50% of the estimated yields in all other developing regions. Its yields are very low due to several constraints including poor soil (inadequate N, P, K, Ca, Mg, S and Organic Matter, use of low yielding variety of seeds as planting material, plant nutrients imbalances, low soil moisture content (Nkaa *et al.*, 2014; Ecocrop, 2009).

A positive response of cowpeas to both organic and inorganic fertilizers has been reported by several authors. It has also been established that cowpeas do not require a high rate of nitrogen fertilization because of their ability to fix their own (Nkaa *et al.*, 2014). The use of organic fertilizer is popular for reducing the environmental impacts of wastes while increasing organic matter and nitrogen in soils. Fertilizer is any material of natural or artificial origin (other than liming material) that is applied to soil or plant tissues to provide one or additional plant nutrients essential to the expansion of plants, maturity of time, size of plant parts and biochemical content of plants and seed capabilities (Subedi *et al.*, 2022).

To maintain consistency in high biomass productivity, soil nutrient management is essential, and fertilization is the only way to supply soil nutrients within a short period (Si Ho Han, *et al.*, 2016). Adegbidiet *al.*, (2003), reported that fertilization costs accounted for 20-30% of the total production costs in biomass production. Soil fertility is the most important constraint limiting crop yield among resource-poor farmers in the developing world (Ansa *et al.*, 2019). Fertilizers play an important role in increasing crop production (Stewart *et al.*, 2012). It has also been proved that organic fertilizers improve crop qualities especially those of vegetables and fruits (Larson *et al.*, 2000; Xu *et al.*, 2000). The use of chemical fertilizers and organic manure or fertilizer has both positive and negative effects on plant growth and the soil. Chemical fertilizers are relatively expensive, have high nutrient content and are rapidly taken up by plants (Si Ho Han *et al.*, 2016). However, the use of excess fertilizer can result in several problems, such as nutrient loss, surface and groundwater contamination, soil acidification and basification, reduction in useful microbial communities and increased sensitivity to harmful insects (Chenet *al.*, 2006). Organic manure has several shortcomings, including low nutrient content, slow decomposition and different nutrient compositions depending on its organic materials, compared to chemical fertilizers.

Organic farming is defined as a production system that avoids or largely excludes the use of synthetically compounded fertilizers (Panda, 2010) and depends mainly on organic recycling of biological and industrial waste nutrient energy. The system is based on the perception that tomorrow's ecology is more important than today's economy. It aims to utilize local resources present in abundance with enormous potential for application to maintain the long-term fertility of the soil. According to Peiet *al.*, (2021), organic fertilizer is an alternative to chemical fertilizer with no loss in crop yield and quality, and its use will avoid all forms of pollution, and reduce

fossil fuel energy in agricultural practices while providing foodstuffs and maintaining a rural environment and preserving non-agricultural ecological habitats.

Materials and methods

Study Area

This investigation was conducted during the 2022 and 2023 cropping seasons at the field farm of the Great Lakes University of Kisumu (GLUK) agricultural farm. The site is located in Kibos within the Miwani West Sublocation of the Miwani ward of Muhoroni Subcounty of Kisumu County Kenya.

The area falls within the Lake Victoria lowlands and flood plains called the Kano plains, a vast lowland flat area experiencing a subhumid climate. The plain is mainly an extending lacustrine deposit characterized by montmorillonite clay with a blackish colour. The surface soil texture is clay with poor drainage.

The general aspects of the climatic conditions of the study area were done using climatological statistics of one full meteorological station, Kenya Sugar Research Institute in Kibos, Kisumu County. Climatic conditions of the study area are such that the mean maximum temperature ranges from about 27⁰C to about 32⁰C and the mean minimum temperature ranges from about 14⁰C to 18⁰C. the relative humidity (0900Hrs) East African Standard Time ranges from 56% to 75% with the peak being in May and July months of the year. The average annual rainfall ranges from 1100mm to about 1600mm and the climate is described as semi-humid and fairly warm with an altitude of about 1150m above sea level.

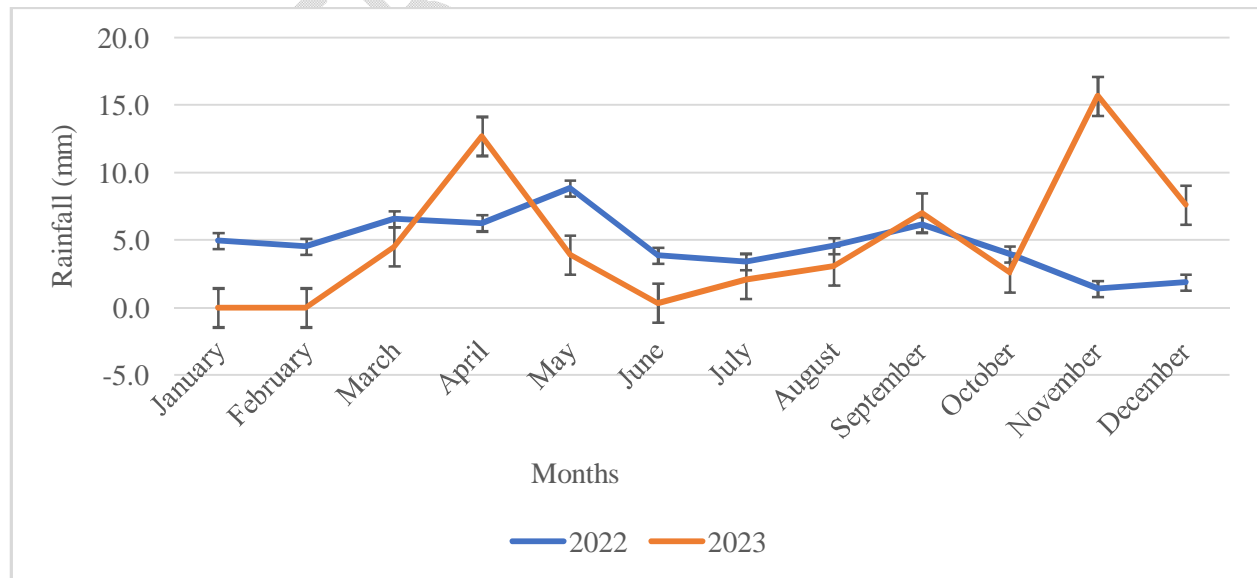


Figure 1. The average rainfall distribution in the study area during the study period

The experiment was set up in a randomized complete block design (RCBD) with three (3) replications. There were five treatments in the long rains and seven treatments in the short rains including control (T₁). The following were the treatments.

Table 1. Treatment Details

Long Rains 2022 Treatments	Short Rains 2022 treatments
T ₁ = Eve @8.33t/ha per season	T ₁ = Ds @ 8.33 t/ha per Season
T ₂ = Eco @8.33t/ha per season	T ₆ =MWS@8.33kg/ha per season
T ₃ = Bx @8.33t/ha per season	
T ₄ =Fm @ 8.33t/ha per season	
T ₅ =NPK @ 250 kg/ha per season	

Where; Eve =Evergrow, Eco= Ecoplanting, NPK = Nitrogen, Phosphorus and Potassium, DS = Dung slurry, Fm = Filter Mud, Bx = Boomax, and MWS = Waste Slurry Market

Each organic fertilizer was soil applied in furrows and soil incorporated before planting. Planting was done on the same day as incorporation. The layout, therefore, represented soil amendments with different types of organic fertilizers.

Vegetative Growth, and Yield.

Data on plant growth were collected, that is germination percentage, plant height (cm), and number of branches as indicators from ten plants randomly selected and tagged from each treatment replicate. To evaluate crop yield, bi-weekly harvests were carried out on the leaves of the tagged plants from age 30 days from sowing until the plants were 75 days from sowing. Harvesting was therefore done four times at different growth stages. First, second, third, and fourth harvests were done at 30, 45, 60, and 75 days after sowing (DAS) the seeds respectively.

Different yields contributing data were recorded from ten plants which were randomly selected from each unit plot of every harvesting stage. The leaf-picking or leaf-peeling harvest method was used instead of a once-over harvest to prolong the growth and harvest period (Xu *et al.*, 2003) and much higher harvest was obtained than by one harvest method, since nutrition is stored in the root production and supplied to the remaining young leaves. The growth of the young leaves is faster than that of seedlings started from seed.

Statistical Analysis

The data collected were then subjected to Analysis of variance (ANOVA) and procedures general linear model (PROC GLM) were used in the analysis using the SAS version (9.04.01M7P03062020)

The effects of the organic amendments and NPK on germination percentage, number of branches, height (cm) as well as yields (g), were tested for level of significance using the F-

test. Significant means at F-test were separated using the least significant difference (LSD) and all the analyses were performed at a 5% significance level. Additionally, Microsoft Excel software was used to develop tables and figures.

Results and Discussions

The effects of different organic amendments and NPK on the germination percentages of cowpeas (*Vigna unguiculata L.*)

The germination percentages of cowpea (*Vigna unguiculata L.*) as affected by the various organic fertilizer amendments and NPK are presented in Table 2.

Table 2. Vegetative growth of cowpeas as affected by different organic amendments and NPK

Growth		Germination (%)			
Fertilizers	Season 1	Fertilizers	Season 2	Fertilizers	Season3
Filter mud	65.42a	Ecoplanting	63.00a	Boom Max	45.17a
Evergrow	61.67a	NPK	51.48ab	Ecoplanting	36.87ab
Ecoplanting	55.21a	Boom Max	50.87ab	Evergrow	29.80b
Boom Max	53.08a	Evergrow	49.60ab	Dung slurry	18.90bc
NPK	39.64a	Filter mud	41.50b	Filter mud	16.36bc
Dung slurry		Dung slurry	34.99b	NPK	5.71c
Market W. slurry		Market W. slurry	33.37b	Market W. slurry	5.57c

Means covered by the same letters are not significantly different at ($P \leq 0.05$)

In season one (short rains of 2022), the germinability averaged about 46.4% and was different from that of season two (long rains of 2023) which averaged about 22.63%. The seasonal differences must have arisen from the differences in precipitation levels, being higher and better during season one or the long rains of 2023 (Figure 1). During season one of the short rains 2022, the highest germination values were obtained from Filter mud (65.42%) and Evergrow (61.67%) applications while the lowest value (39.64%) was obtained from the inorganic fertilizer NPK application. No statistical differences were recorded among all the treatment applications despite the wide difference. This implies that cowpea seeds would equally germinate despite the organic amendment type or fertilizer (Table 2).

During the second season (long rains of 2023), germination values ranged from 63.00 % to 33.37%. The highest germination values were obtained from Ecoplanting (63.00%) and NPK (51.48%) applications, while the lowest values were obtained from Dung slurry (34.99%) and Market waste slurry (33.37%) applications. Ecoplanting amended plots performed best of all other amended plots at 60.00% but which was not significantly different from that of NPK at 51.48%, Boom Max at 50.48%, and Evergrow at 49.60% but significantly different from those of

Filter mud at 41.50%, Dung slurry at 34.99% and Market waste slurry at 3.7% ($P \leq 0.05$). During the third season (first rains of 2023) the germination percentages ranged from 45.17 to 5.57. The highest germination percentage was obtained from the Boomax (45.17%) application, while the lowest value (5.57%) was obtained from the Market waste slurry.

The results show that when soils have adequate moisture contents, soils amended with mature compost will perform as much as or better than inorganic fertilizers in terms of germination percentages and seedling vigour. This is indicated by the results from seasons one and two when rainfall enabled the soil to have adequate moisture for plant growth (Table 2). All the mature composts, Ecoplanting, Boom Max, and Evergrow showed better or equal seed germinability when compared to chemical the fertilizer NPK. This may be explained by the fact that organic matter application improves the fertility of the soils as it stimulates the activity of the microbes that provide the nutrients and the organic carbon to the soil. Soil properties of organic matter, soil moisture, and other physical characteristics perform key roles in seed germination. During the third season (second rains of 2023) when the moisture contents were inadequate, a reversal in performance as inorganic fertilizer NPK gave one of the lowest germination percentages. Boom Max amendment treatment gave the highest germination percentage which was not significantly different from that of ecoplanting amendment but significantly different from Evergrow, Filter mud, NPK and Market waste slurry applications ($P \leq 0.05$). These results showed that all six fertilizers promoted shoot and root elongation (germination) with the highest being identified in the mature composts as compared to immature compost (Filter mud) and the biodigestates (Dung and Market waste).

This study suggests that organic fertilizers particularly from mature composts could be the most applicable and should be widely used in the agricultural industry for their favourable influences on seed germination rates and shoot and root elongation.

Number of branches.

Table 3. shows the various organic amendments' effects on the cowpeas' ability to grow or form branches.

Table 3. The effects of the applied organic amendments on the number of branches

Growth		Number of branches	
Fertilizer	Season 2	Fertilizer	Season 3
Boom Max	7a	Ecoplanting	6a
Ecoplanting	6ab	Boom Max	6a
NPK	6ab	NPK	5a
Evergrow	6ab	Evergrow	5a
Filter mud	6ab	Filter mud	5a
Dung slurry	5b	Dung slurry	5a
Market W. slurry	5b	Market W. slurry	5a

Means covered by the same letters are not significantly different at ($P \leq 0.05$)

During the second season(long rains or first rains of 2023) the number of branches as influenced by the various organic amendments ranged between 7 and 5 pieces per plant. The highest number of branches was obtained from Boom Max treatment with 7 pieces per plant, while the lowest number of branches was obtained from Dung and Market waste slurries. Boom Max treatment produced the highest number of branches per plant which was not significantly different from those produced by Ecoplantng,NPK, Evergrow and Filer mud respectively, but significantly different from those produced by the Dung and Market waste slurries($P \leq 0.05$).Joshi *et al.*,(2016) reported that organic amendments did not have any effect on the number of branches contrary to these findings.Similarly, results from the third season (short rains or second rains of 2023), all amendment treatments gave results that were not significantly different from other amendment types ($P \leq 0.05$).

These results indicated that the number of branch pieces per plant is soil moisture sensitive and all the composts, mature or immature,because of their high organic matter content were able to absorb and retain moisture to favourably enhance branching compared to the digestates. On the contrary, with less rainfall in season three, all treatments did not show significant differences in the number of branches per plant.

Plant height

Table 4. The effects of the applied organic amendments on plant height

Growth	Plant Height (Cm)	
	Season 2	Season 3
Fertilizer		
Evergrow	14.93a	38.87a
NPK	14.89a	29.40b
Ecoplanting	14.13a	26.63b
Boom Max	12.93a	23.93bc
Dung slurry	12.83a	19.41c
Filter mud	12.27a	18.67c
Market W. slurry	12.17a	17.87c

Means covered by the same letters are not significantly different at ($P \leq 0.05$).

The average height achieved from the various organic amendments during the first (long) rains of 2023 was 13.44cm against the second (short) rains average of 25.40cm. The differences in the seasonal averages could have arisen from the cumulative residual effects of the nutrients contained in the amendments applied. During season two or the first (long) rains of 2023, all six applied organic amendments, and NPK gave results that were not significantly different($P \leq 0.05$). The effects of the amendments on the plant height did not differ from that of the NPK standard on the plant height (Table 4). As a result of this study, plant height varied between 14.89 cm and 12.17cm in the second season. The highest plant height was obtained from Evergrow treatment, while the lowest value was obtained from Market waste slurry treatment (Table 4). This result

may be explained by the fact that under moist and warm conditions, mineralization is faster and organic amendments release nutrients faster including organic nitrogen, and were able to perform equally with inorganic fertilizer NPK. On the other hand, results from the third season (short/second rains of 2023) plant height ranged from 38.87 cm to 17.87cm. The highest plant height value was obtained from the Evergrow application, while the lowest value was obtained from the Market waste slurry application. Evergrow-treated plants were the tallest and whose heights were significantly different from the rest ($P \leq 0.05$). The second in height were plants treated with Ecoplanting which was not significantly different from that of the inorganic fertilizer NPK. It is thought that this beneficial effect of Evergrow and Ecoplanting on the plant height of cowpea may be due to substances and microorganisms in them that makes them useful for the rapid growth of cowpea.

This experiment is in agreement with that of Tigme *et al.*, (2015), in an experiment on the growth and yield of broccoli (*Brassica oleracea L var Italica* Plenck cv top green) reported that among vegetative growth parameters the greater growth parameters may be attributed to the readily available nitrogen in high content. Similarly, Xu *et al.*, (2012), reported nitrogen from nitrate or ammonium forms from soil dominate the growth and development and that high-yield crop production relies heavily on nitrogen fertilization, and that the above ground plant parts are systematically regulated by nitrogen status (O'Brien *et al.*, 2016; Xuan *et al.*, 2017). Fertilization differences emerged when Evergrow amended plots outperformed all other treatments and whose results were significantly different from all including NPK fertilized plots. The second in effect was Ecoplanting but whose effects were not significantly different from those of NPK and boom max amended plots ($P \leq 0.05$).

The growth of plants is a function of the photosynthesis activity of plants and the translocation of the photosynthates within the plant which ultimately depend on their capacity to utilize available nutrients (Joshi *et al.*, 2016). Carbon (C) and Nitrogen (N) are key elements that form the basic components of the plant cells and control for biochemical functioning, growth and energy flow and nutrient recycling (Zeng, 2009). Carbon and Nitrogen are thus primary elements involved in the growth and development of plants and C:N ratio is an indicator of Nitrogen Use Efficiency (NUE) (Zhang *et al.*, 2023). The initial boost of nitrogen resulted in more plant height from mature composts as compared to mineral fertilizer NPK. Nitrogen is also known to contribute to cell elongation (Joshi *et al.*, 2016). Phosphorus application may also help in root elongation and better nutrients and water extraction from the soil as well as cell elongation and hence might have contributed to taller plants (Joshi *et al.*, 2016).

The effects of different organic amendments and NPK on the leaf yields of cowpea (*Vigna unguiculata L.*)

Table 5. shows the results of the effects of organic amendments and NPK on the leaf yields of cowpeas.

Table 5. The effects of various organic amendments and NPK on Cowpea leaf yields (g)

Fertilizers	Season 1	Fertilizers	Season 2	Fertilizers	Season 3
Boom Max	11235.33a	Boom max	4238.67a	Boom Max	1869.00a
NPK	6548.42b	NPK	3805.00ab	Ecoplanting	1681.67a
Evergrow	5915.33b	Evergrow	3725.00ab	Evergrow	1666.00a
Ecoplanting	5515.00b	Ecoplanting	3589.33ab	Market W slurry	976.67a
Filter mud	5191.33b	Filter mud	2944.33ab	Dung slurry	923.33a
Dung slurry		Market W slurry	2652.33ab	Filter mud	889.33a
Market Wslurry		Dung slurry	1866.67b	NPK	710.78a

Means covered by the same letters are not significantly different at ($P \leq 0.05$).

Yields were higher during the seasons of adequate rainfall (season one or short rains of 2022 and second season or long rains of 2023) than from the third season or short rains of 2023. The average yield level achieved was 6,881.86g, 3,260.19g, and 1,245.26g for the three seasons respectively per plot. The yields decreased in the order of season one or short rains 2022 > season two or long rains 2023 > season three or short rains 2023.

In season one fresh leaf yields ranged from 11,235.33g to 5,191.3g. The highest yield of fresh leaves was obtained from the Boom Max application while the lowest value was obtained from the Filter mud application. Boom Max had the highest yield outcome which was statistically significant to the rest ($P \leq 0.05$). It was distantly followed by the yield from the inorganic fertilizer NPK which was not significantly different from those of Evergrow, Ecoplanting, and Filter mud. Boom Max application therefore improved significantly the yield of cowpea and resulted in higher yield as compared to other amendments and NPK. In the second season, the fresh leaf yield values ranged from 4,238.67g to 1,866.67g. The highest yield value was obtained from the Boom Max application while the lowest value was obtained from the Dung slurry. Boom Max treatment once again significantly improved the cowpea yield as compared to other amendments and NPK. Next in performance was NPK whose performance was not significantly different from those of Evergrow, Ecoplanting, Filter mud and Market waste slurry but significantly different from that of Dung slurry. In season three, leaf yields ranged from 1,869.0g to 710.78g. The highest leaf yield value was obtained from the Boom Max application while the lowest value was obtained from the inorganic fertilizer NPK. All the tested organic amendments and NPK showed no significant differences in their performance. Leaf yields per plot showed variation with amendment type or amendment source and the Boom Max application recorded the highest yield in the three consecutive seasons and was observed to be the best in the three seasons. The reduced performance during the third season (short rains of 2023) and the lack of similarity and pattern, as was observed during the first season (short rains of 2022) and the second season (long rains of 2023), could be blamed on the inadequacy of rainfall (Figure 1) as one of the soil factors

that affect crop growth. Water is a principal constituent of the growing plants and helps in the chemical and biological activities of the soil including mineralization, nutrient availability and mobility in the soil (Agricultural Current Affairs, 2023).

The biological and chemical activities failed to effectively perform thereby reducing the performance of the amendments and therefore, reducing yield levels. Insufficient water availability translated into water shortage in the plant body bringing about a profound alteration to physiological processes including photosynthesis, which slowed down growth thereby reducing yielding potential (Dietz *et al.*, 2021) Water deficit during the growing period of a plant reduces vegetative and regenerative yields.

During the same (season three or short rains of 2023) the level of germination percentage achieved by the NPK fertilizer plots was very low compared to the organic amendments treated plots (Table 5). This could have also contributed to the very low levels of yield from NPK-treated plots as compared to organic amendment-treated plots. Dietz *et al.*, (2021) reported scarcity of water during germination and seedling establishment to delay or inhibit germination, photosynthesis, and seedling growth. This lowered the number of rigorous plants, thereby reducing plant yields. Singh *et al.*, (2021) reported water to be a decisive factor for crop production because of its roles in nutrient uptake, transport, temperature regulation and several physiological processes such as photosynthesis. Owing to the shallow root systems and sale of vegetable produce, on a fresh weight basis, vegetable crops are more sensitive to moisture stress than field crops. Similar findings were reported by Lott and Hammond (2013), Serenren, (2005), and Singh *et al.*,(2019).

The yields on average increased in the order Boom Max>NPK>Evergrow>Ecoplanting>Filter mud>Market waste slurry>Dung slurry corresponding to the decreasing order of the C:N ratio among composts and increasing order between the digestates (Table 5) in all the three seasons. The exceptions are those of the positions of the NPK and that of filter mud when rainfall was inadequate in the short rains of 2023 when the two performed poorer than in the previous two seasons. Therefore, the crops grown on digestate-amended plots had diminished yields compared to those grown with composts indicating that the high C:N ratios of the digestates (Market waste slurry and dung slurry) exceeding the ideal C:N ratio of 25:1 resulted in immobilization of inorganic nitrogen otherwise available for crop uptake and yields. This indicated that extra nitrogen was necessary for yields despite the application of adequate rates of nitrogen to all treatments.

The reports compared comparatively with those reported by Pinto *et al.*, (2017) that compost can immobilize mineral nitrogen for only 30-70 days in the first season of application due to high C:N ratios after which organic nitrogen becomes increasingly available thereby pushing up the yields. In addition, compost has already been somewhat mineralized by the time of application and continues to decompose and slowly releases nutrients when added to the soil (Enhart *et al.*, 2005; Antil *et al.* 2011; Pinto *et al.*, 2017).

Boom Max which exhibited the highest and undisputed supremacy in yields had several advantages over the others and NPK. According to Atiyeh *et al.*, (2002) Boom Max is a vermicompost that contains plant growth-regulating materials such as humic acids, auxins, gibberellins and cytokinins responsible for increased plant growth and yields, and provides large particulate surface areas that provide many microsites for microbial activities.

During the two seasons when bioslurry was used as a fertilizer or an amendment, it did demonstrate itself as a soil conditioner but was unable to perform to the level of NPK under favourable climatic conditions. Both types of bio-slurry (Dung slurry and Market waste slurry) performed poorer than NPK and all other composts. This conforms to the reports of several researchers that although bioslurry is a potential fertilizer in agriculture, but has shortcomings relating to its bulkiness (Kumar *et al.* 2015; Devarenjan *et al.*, (2019), and The Annual Hague, (2013) contributed by water (about 93%) which limits its transportation and utilization, limited potential to meet the entire nutrient demand in agricultural fields and subject to nitrogen loss as ammonia volatilization, reduced rates of C:N ratio, and high pH (Kumar *et al.*, 2015). Moller and Muller (2012) also reported that digestates of various feedstocks have higher ammonium Nitrogen (NH_4^+ - N) to total Nitrogen, lower carbon contents, elevated pH values and lower C:N ratios. The authors also reported the process of anaerobic digestion through which various feedstocks pass exhibit low water soluble phosphorous probably caused by a shift of HPO_4^{2-} to PO_4^{3-} with possible precipitation of phosphorous complexes. the bioslurry as an alternative organic fertilizer may only be useful as an integration and not on its own. The levels of yields as compared to that of NPK could be related to the increase in the amount of soil organic matter contributed by each amendment to the soil as was suggested by Rattan, (2020) that organic application can have different effects on soil properties by adding 'less dense material' or by changing soil aggregates. Bolten *et al.*, (2014) reported organic fertilizers to have enhanced soil fertility, plant growth and yields through sustainable health of the soil which relies on carbon-rich amendments that will feed the biological processes that are the core foundation (Lal, 2009) and support plant growth, yields and quality of crops (Hughes and Veneria 2005) by rebuilding/rooting fertility and improving the physical, chemical and biological function of soils. Responses to cow dung by red amaranth (*Amaranthus hybridus*) and garlic (*Allium sativum L.*) to organic manure were reported by Sanni (2016) and Mondal *et al.*, (2016) respectively and are further evidence of the ability of organic amendments to improve soil conditions for crop production this result is consistent with those reported by Jiang *et al.*, (2006) and Urrea *et al.*, (2019) that yield responses to organic amendments vary by amendment type or amendment source. Onunwa *et al.*, (2021) reported results indicating that organic amendments significantly improved the growth and yield of cowpea and maize (*Zea mays*) and where poultry manure was the most effective organic amendment in improving soil chemical properties as well as the growth and yield of cowpea. On another outcome, Vinnoli *et al.*, (2018) reported a mixture of farmyard manure plus vermicompost and panchagavya to have recorded the highest yield of vegetable cowpea and declared the best treatment in two successive seasons.

Conclusions and recommendations.

Organic amendments considerably influenced the growth and yield of cowpea crop by significantly increasing the germination percentage, plant height and the number of branches per plant ($P \leq 0.05$) which culminated into greater and or equal leaf yield to that of NPK fertilizer. It is therefore concluded that organic amendments as sole sources of nutrients need not necessarily give reduced yields as generally perceived if applied at the right dosage, and as the sole source of nutrients can give yields that are higher or comparable to those of inorganic fertilizers if the correct rate is applied and other environmental factors are favourable. As sources of organic matter, organic amendments are therefore indicators of soil quality and can affect many of the physical, chemical and biological processes that determine soil productivity by replenishing soil nutrients that maintains soil fertility. Based on the changes in the levels of extractable and available macro and secondary nutrients BoomMax amendment was declared the best treatment and which was followed closely by the other composts corresponding to the order of decreasing c:n ratio .The digestates, because of their unfavourable C: N ratios were not able to perform to the level of the NPK fertilizer .In the case of inadequate moisture in the soil as was the case in season three, there appeared to be no significant differences ($P \leq 0.05\%$) in yield among all treatments despite significant differences in plant percentage germination and plant height between the composts on one hand and the NPKfertilizer and the digestates on the other.

This experiment was done in a black cotton soil (vertisol). It would be desirable to repeat the same under dissimilar conditions in order to confirm the validity of the above outcomes. Similarly, the results from Filter mud are those from uncomposted material. It would therefore befitting to include a mature alternative in the subsequent trial to expose its full potential.

Data availability.

Data will be made available on request.

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