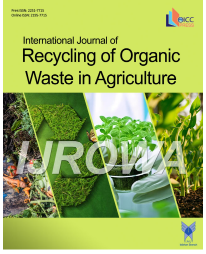

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Determination of growth, leaf yield, quality and safety of potted *Ocimum gratissimum* L. cultivated using different fertilizer types

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Original Research

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Abstract:

Purpose: The purpose of the study was to produce compost and compare the effect with other fertilizer types on scent leaf vegetative growth, yield, nutrient contents and heavy metal accumulation for safety of consumers.

Method: Cow dung, compost, NPK fertilizer and urea were applied to scent leaf stem cuttings at 2 weeks after planting. Control was zero application of fertilizer. Treatments were replicated four times in a completely randomized design. Concentrations of Cu, Fe, Pb, Cd, Zn and Ni in the leaves were determined at 8 weeks after treatment application (WATA).

Results: Compost increased plant height from 32.40 to 66.25 cm while zero application of fertilizer increased plant height from 20.75 to 38.25 cm between 2 to 8 WATA. Compost (3.88 t/ha) significantly ($p < 0.05$) produced highest leaf yield than zero application of fertilizer (1.29 t/ha). Fe, Cu, Pb accumulation were lowest in scent leaf produced with NPK fertilizer while Zn, Ni and Cd accumulation were lowest in scent leaf produced with cow dung. Pb was higher in scent leaf produced with compost (0.48 ± 0.09 mg/kg) and lower in scent leaf cultivated with NPk fertilizer (0.11 ± 0.06 mg/kg). Despite the high content of heavy metals in scent leaf produced with compost, heavy metal bioaccumulations were below FAO/WHO permissible values.

Conclusion: Soils amendment with 5 t/ha of compost showed superiority over other fertilizer types in terms of growth and leaf yield of scent leaf. Cow dung and NPK fertilizer suppressed bioaccumulation of heavy metals in scent leaf and promoted nutrient quality and safety of the scent leaf.

Keywords: Compost; Heavy metals; Inorganic fertilizer; Organic manure; Food safety

1. Introduction

Food wastes and agricultural wastes are generated in both rural and urban communities. Poor management and utilization of these wastes impact negatively on our environment by increasing greenhouse gases, pollution of the soils and nearby water bodies (Souri et al., 2018; Souri and Hatamian, 2019). Food wastes and cow dung can be harnessed into useful organic ameliorant for crop growth and yield. Composting food wastes and animal manures is a sustainable method of waste recycling and environmental management (Oguntade et al., 2019). Composts as organic soils amendment improved soils physical, chemical and biological properties for improved growth and yield of crops (Moral et al., 2009). Composts from food wastes and cow dung help to improve growth, yield and mineral composition of crops such as pepper (Samah et al., 2020) and lettuce (Hernandez et al., 2016).

However, beside the usefulness of compost to soils and crops, components of the compost can be a potential source of heavy metals and can reduce the quality of the crops and make the crop unsafe for human consumption. Cow dung is noted for containing heavy metals which come from feed additives and even when composted or used in its original form can still be a significant source of heavy metals (Vukobratovic et al., 2014). Compost from food wastes contains minerals in excessive amounts that could be harmful to soils, plant and human (Samah et al., 2020). Conventional farmers use inorganic fertilizers to improve crop growth and yield. Inorganic fertilizers have higher specific nutrient concentration than organic fertilizers but are not sustainable, expensive and also contain heavy metals (Mortvedt, 1995). Agricultural soils contain heavy metals as a result of anthropogenic activities, spread of heavy metals from pesticides, dust, leachates or through the use of heavily contaminated organic and inorganic fertilizers (Mortvedt, 1995). Crops absorb heavy metals from soils and high bioaccumulation of heavy metals in edible plant parts can lead to health challenges in humans when consumed (Iyama et al., 2021). Apart from dangers posed to human life, high root uptake of heavy metals by crop can hinder photosynthesis, growth and yield of crops (Wang et al., 2020).

Scent leaf (*Ocimum gratissimum*) belongs to the group of plants known as spices. The family of scent leaf is labiatae and the genus *Ocimum* occurs in large quantities. Scent leaf is an aromatic plant that grows as a wild plant and also cultivated for culinary, medicinal and ornamental purposes. The proximate composition of scent leaf as reported by Anjili et al. (2018) showed that scent leaf contains crude protein (7.61%), crude fibre (32.00%), crude fat (18.66%) and ash (15.33%). According to Alexander (2016), scent leaf is rich in phyto-chemicals such as alkaloids, tannins, phytates, flavonoids, oligosaccharides, terpenoids, thymol and saponin. The anti-inflammatory and antimicrobial properties of the bioactive compounds in scent leaf increased its use in herbal medicine for the treatment of stomach-related illness such as diarrhea and dysentery (Edo et al., 2023).

Scent leaf production in southeastern Nigeria is greatly at subsistence level and most documented research works on scent leaf are on phyto-chemistry and pharmacological compounds (Edo et al., 2023). There is no known documented information on heavy metal accumulation in scent leaf as a result of different fertilizer types. Information on the effect of fertilizer types on growth and yield of scent leaf is scanty. However, the use of different fertilizer types on the growth, yield and quality of vegetable crops like lettuce (Al-romian, 2020; Elgubshawi, 2019) and amaranth (Kunene et al., 2019; Sanni, 2016; Olaniyi et al., 2008) are well documented.

Considering the importance of scent leaf as food and medicine to man and the role different fertilizers play on the growth, yield and heavy metal contamination of vegetables, this study was therefore conducted to generate documented information on the effect of different fertilizer types on growth, yield, heavy metal accumulation and quality of scent leaf.

2. Materials and methods

Experimental site

To determine the effect of fertilizer types on the growth and yield of scent leaf, field experiment was conducted in the Teaching and Research Farm of Crop Science and Horticulture Department, Nnamdi Azikiwe University, Ifite Ogwari, Annex, Nigeria. The research farm lies at the latitude 6.604°1 N and longitude 6.9507° E. Ifite Ogwari has an average annual rainfall of 5798 mm, relative humidity of 74.00%. Average minimum and maximum temperatures of the field were 25.4 ºC and 30.6 ºC.

Treatments and experimental design

Treatments were five fertilizer types control (zero application of fertilizer sources), cow dung, compost, urea and NPK 20-10-10. Compost and cow dung were applied at 5 t/ha while NPK and urea fertilizers were applied at 400 kg/ha. The experimental design was a completely randomized design and treatments were replicated four times. Mid stem cuttings with five nodes were used for planting. Scent leaf cultivar used for the experiment has adapted to Ifite Ogwari environment and is commonly used by the farmers.

Composting process

Food wastes were gotten from Madonna Eatery at Nnamdi Azikiwe University, Awka Annex. Cow dung, wood ash and dried grass were obtained from Nnamdi Azikiwe University, Ifite Ogwari Annex. Each compost pile consisted of food waste, grasses and cow dung in the ratio of 3:2:1. Wood ash of 1 kg was sprinkled on top of each compost pile and 1 litre of water was sprinkled on the compost pile. Four buckets of compost pile were made for the experiment. The compost piles were turned every evening for four weeks and were air-dried to 10% moisture content under shade on a clean poly sheet.

Agronomic operations

Top soils of $0-20$ cm depth were excavated, mixed together and solarized using black polythene nylon. Perforated poly bags of 20 cm $\times$ 30 cm were filled with 15 kg of soils. Stem cuttings of 20 cm length were planted by inserting a 5 cm portion of the stem cutting inside the soils. NPK 20-10-10 and urea were bought from the fertilizer unit of Agricultural Development Programme (ADP), Anambra State. Soils were irrigated before and after planting of the stem cuttings. Four stem cuttings of 20 cm length were planted per bag and were later thinned to two stands per bag at two weeks after planting (2 WAP). Cow dung and compost of 110 g each and NPK and urea fertilizers of 140 g each were applied to scent leaf stem cuttings at 2 WAP using ring method at 15 cm away from the stem cuttings. Stem cuttings were planted in late February and irrigated evenly till rain became steady and were harvested at 73 days after planting.

Sampling

Biomass and yield data were taken on two sample plants per treatment per replication. Growth parameters measured were plant height, number of leaves, leaf area and number of branches at 2, 4, 6 and 8 weeks after treatment application (WATA). Destructive samplings were done at 8 WATA to determine fresh weights of a whole plant, leaf, stem, root and root length. Digital scale (Electronic Kitchen Scale SF-400) was used to determine the fresh weights of samples and yield. Leaf yield and harvest index were done at 73 days after planting of stem cuttings. Harvest index was calculated according to Smith MR (2018) method.

$$\text{Harvest index}(\%) = \frac{\text{leaf weight}}{\text{plant weight}} \times 100$$

Plate 1. Compost pile.

Plate 2. Four weeks old compost.

Laboratory analysis of food waste, compost, grass, wood ash, top soils and cow dung

Soils were collected randomly from five spots at the experimental site at 0 – 20 cm depth and bagged in the poly bags. Soils pH (H_2O) was determined using 1:1 soils/water ratio with pH meter (Hendershot et al., 1993). Versenate titration method was used to assay Ca^{2+}, Mg^{2+} and K^{2+}. Concentration of K^{2+} in the extract was read from a flame photometer while Ca^{2+} and Mg^{2+} concentrations were read from Atomic Absorption Spectrometer (AAS). Bray-1 method was used to assess available P (Olsen and Sommers, 1982). Dichromate wet oxidation was used to determine organic carbon (Nelson and Sommers, 1982) and total nitrogen was determined using micro kjeldhal method (Bremner and Mulvaney, 1982). Cow dung, wood ash, grasses and compost were analyzed for nutrient contents using the same procedures as in the soils analysis.

Methods for the heavy metal analysis in scent leaf

FS240AA Atomic Absorption Spectrometer (AAS) was used to analyze heavy metal contents of the scent leaf (APHA, 1995).

Working principle

The working principle of AAS was based on aspiration of a sample into the flame and atomized when AAS's light beam was directed through the flame into the monochromator and onto the detector that measured the amount of light absorbed by the atomized element in the flame. A source lamp composed of each heavy element was used because each metal has its own absorption wavelength and to prevent spectral or radiational interferences. The concentration of the heavy metal in the sample was determined by the amount of energy of the characteristic wavelength absorbed in the flame. The wavelengths of lead, cadmium, zinc, copper, manganese and nickel were 217.30, 228.80, 213.90, 324.80, 279.50 and 233.00 nm respectively on 0.2 nm slit each using air-acetylene flame.

Wet digestion

2 g of the sample was weighed and transferred onto a digestion flask and 20 mL of the acid mixture (650 mL conc. HNO_3; 80 mL perchloric acid; 20 mL conc. H_2SO_4) was added. The digesting flask was used in heating the mixture until a clear digest was obtained. The clear digest was diluted with distilled water to the 50 mL mark.

Preparation of reference solution

A series of standard metal solutions in the optimum concentration range (2 – 6 ppm) was prepared. Single stock element solutions (0.2 mL, 0.4 mL and 0.6 mL. note conc. of stock 1000 ppm) was diluted with water (99.8 mL, 99.6 mL, 99.4 mL) containing 1.5 mL concentrated nitric acid per liter to obtain the reference solutions. A calibration blank was prepared using all the reagents except for the metal stock solutions. Calibration curve for each metal was prepared by plotting the absorbance of standards versus their concentrations.

Analysis of data

GENSTAT (2007) was used to analyze all data collected and means were separated by Least Significant Difference at 5% level of probability.

3. Results and discussion

The compost used in the experiment had high copper (18.10 mg/kg) and low mercury (0.55 mg/kg) contents (Table 1). The pH level of the compost was 7.09, while nitrogen and organic matter contents were 2.91% and 3.84% respectively. The soils used in the experiment had pH of 7.40 while nitrogen and organic matter contents were 2.80% and 3.46% respectively (Table 1). The soils had low copper content (2.30 mg/kg) and low lead content (0.42 mg/kg) in comparison to compost.

Effect of fertilizer types on the growth parameters of scent leaf

Plant height of scent leaf was significantly affected by fertilizer types at 2 weeks after treatment application (WATA) (Table 2). Scent leaf produced with compost had the tallest plant (32.40 cm), followed by NPK 20-10-10 (32.25 cm) and cow dung (32.23 cm). Scent leaf produced with com-

Table 1. Chemical properties of soils, grass, food waste, cow dung and compost used in the experiment.

Nutrient contents	Soils	Grass	Food waste	Cow dung	Wood ash	Compost	Testing method
Lead (mg/kg)	0.42	0.00	2.18	2.35	0.91	2.93	APHA (1995)
Mercury (mg/kg)	0.85	0.00	2.40	0.55	1.10	0.55	APHA (1995)
Copper (mg/kg)	2.30	0.00	5.38	4.85	10.30	18.10	APHA (1995)
pH (water)	7.40	7.17	6.45	7.40	9.63	7.09	Hendershot et al. (1993)
Carbon (%)	16.98	28.58	26.89	24.93	18.72	19.98	Nelson and Sommers (1982)
Nitrogen (%)	2.80	2.52	2.18	2.30	3.58	2.91	Bremner and Mulvaney (1982)
C/N ratio	6.06	11.34	12.31	10.60	5.22	6.86	
Phosphorus (mg/kg)	15.88	13.83	12.58	16.33	18.10	21.56	Olsen and Sommers (1982)
Potassium (cmol/kg)	0.42	0.72	0.59	0.78	0.47	1.01	Flame photometer method
Calcium (cmol/kg)	0.76	0.85	0.66	0.86	0.94	0.99	Versenate titration method
Magnesium (cmol/kg)	1.10	0.78	0.62	0.43	1.25	1.02	Versenate titration method
Organic matter (%)	3.46	7.37	5.28	5.98	4.16	3.84	Nelson and Sommers (1982)

Source: Docchy Laboratories and Environmental Services Limited. Nigeria.

post was significantly taller than the scent leaf produced with urea (23.88 cm) and control (20.75 cm). Similar patterns of increase in height were observed at 4, 6 and 8 WATA. The observed differences in height could be attributed to poor nutrient contents of the soils in control plot (Table 1) while tall plants observed in soils amended with NPK 20-10-10 in comparison with soils amended with urea could be attributed to balanced supply of nitrogen, phosphorus and potassium by NPK 20-10-10 fertilizer.

Nitrogen, phosphorus and potassium are essential for optimum growth in plants. Heights of maize (Tamakloe et al., 2021), lettuce (Elgubshawi, 2019) and amaranth (Olaniyi et al., 2008) were improved using compost, cow dung and nitrogen fertilizer respectively.

Application of compost produced significantly ($p \leq 0.05$) thick stem while control produced thin stem at 2, 4, 6 and 8 WATA (Table 2). Stem girth declined at 8 WATA in control scent leaf. Decrease in stem girth could be attributed to poor soils fertility in control plot (Table 1). Growing of okra in ultisol without soils amendment resulted in poorly performed crops (Okoli et al., 2015). Width of the bush in lettuce performed poorly when grown in soils without amendment (Kumngen et al., 2023). Stem of tomato grown without fertilizer was thin while vermicompost produced thick stem in tomato (Vijantie et al., 2021).

There was a significant ($p \leq 0.05$) difference between the number of leaves produced with compost and control at 2, 4, 6 and 8 WATA (Table 3). However, there was no significant difference among the number of leaves produced with compost, cow dung, NPK 20-10-10 and urea at 2, 4, 6 and 8 WATA. Soils amendment using compost, cow dung, urea and NPK fertilizer supplied a high amount of nitrogen which increased the number of leaves in scent leaf. Organic manure produced a higher number of leaves in amaranth (Sanni, 2016) and okra (Okoli et al., 2015) than inorganic fertilizer. This observation disagrees with the work of Gudugi (2013) who reported that 120 kg/ha of NPK fertilizer produced higher number of leaves in okra than 5 t/ha of cow dung and that no significant difference was recorded between NPK fertilizer and 15 – 20 t/ha of

Table 2. Effect of fertilizer types on plant height (cm) and stem girth (mm) at 2, 4, 6 and 8 weeks after treatment application (WATA).

Fertilizer types	Plant height (cm) WATA				Stem girth (mm) WATA			
	2	4	6	8	2	4	6	8
Control	20.75	25.75	34.00	38.25	2.70	2.88	2.95	2.75
Compost (t/ha)	32.40	53.42	58.00	66.25	2.93	3.00	3.10	3.18
Cow dung (t/ha)	30.23	50.85	51.10	58.25	2.90	3.00	3.03	3.13
NPK 20:10:10 (kg/ha)	32.25	53.02	52.60	60.50	2.88	3.00	3.08	3.10
Urea (kg/ha)	23.88	43.10	53.40	58.38	2.95	2.98	3.05	3.10
$LSD_{(0.05)}$	5.58	4.67	6.79	5.54	0.17	0.09	0.09	0.17
Significant level	**	**	**	**	*	*	*	**

NS = Non-significant, ** = Highly significant (0.01), * = Significant (0.05).

Table 3. Effect of fertilizer types on number of leaves and number of branches at 2, 4, 6 and 8 weeks after treatment application (WATA).

Fertilizer types	Number of leaves WATA				Number of branches WATA			
	2	4	6	8	2	4	6	8
Control	36.20	60.00	95.80	115.00	3.75	3.25	3.25	3.25
Compost (t/ha)	74.20	129.50	231.50	234.00	5.25	6.00	6.00	5.50
Cow dung (t/ha)	74.00	101.80	208.50	225.00	4.25	5.25	5.50	5.50
NPK 20:10:10 (kg/ha)	71.80	117.00	173.80	216.00	4.50	4.50	4.50	4.50
Urea (kg/ha)	62.80	119.80	197.20	208.00	4.50	6.00	4.50	3.75
$LSD_{(0.05)}$	16.72	38.12	65.68	82.60	1.66	1.85	2.050	2.15
Significant level	**	*	*	*	NS	*	NS	NS

NS = Non-significant, ** = Highly significant (0.01), * = Significant (0.05).

cow dung. However, on a mean value basis, the number of leaves produced with compost (234.00) was highest followed by cow dung (225.00), NPK 20-10-10 (216.00) and urea (208.00) at 8 WATA. The superior effect of compost and cow dung on number of leaves than urea and NPK fertilizer at 8 WATA could be attributed to their slow-release nutrient nature while inorganic fertilizers are quick release fertilizers, prone to leaching by rainfall and irrigation water and thus could not sustain the growth of scent leaf at 8 WATA.

Number of branches was not significantly affected by fertilizer types at 2, 6 and 8 WATA (Table 3). Number of branches at 4 WATA was significantly highest in soils amended with compost (6.00) and urea fertilizer (6.00) while control produced the lowest number of branches (3.25). Compost had the highest nitrogen, potassium and phosphorus (Table 1) and thus, induced the highest number of branches in scent leaf. There was no significant difference among number of branches in soils amended with compost, cow dung and urea at 8 WATA.

Effect of fertilizer types on fresh weight of scent leaf

Plant weight was significantly affected by fertilizer types at 8 WATA (Table 4). Plant weight was highest in soils amended with compost (89.60 g), followed by cow dung (77.70 g), NPK 20-20-10 (71.50 g), urea (66.30 g) and control (31.80 g). Compost had higher contents of magnesium, calcium, nitrogen, phosphorus and potassium (Table 1) which resulted in high fresh plant weight. The difference between the plant weight of scent leaf produced with NPK 20-10-10 and urea could be attributed to the supply of nitrogen, phosphorus and potassium by NPK fertilizer while urea supplied nitrogen only. Compost and cow dung produced higher fresh plant weight than urea and NPK fertilizer. Organic fertilizers encouraged soils biological activities that resulted in improved soils fertility and structure (Oyeyemi et al., 2017). The near neutral level of organic material helps to neutralize soils acidity and which results in release of soils nutrients like potassium trapped by soils acidity. Several authors have reported improvement in plant growth and dry matter accumulation in crops like maize (Akanbi and Togun, 2002), cucumber (Eifediyi EK, 2010) and jute (Oguntade et al., 2019) with the application of maize-stover compost, farmyard manure and composted kitchen waste respectively.

There was no significant difference among the fresh root weight of compost, cow dung and NPK 20-10-10 (Table 4). However, on mean basis, fresh root weight was highest in compost (17.60 g) and lowest in control scent leaf (5.33 g). Non-significant difference in the fresh root weight could be attributed to high phosphorus content in compost, cow dung and NPK fertilizer while urea produced lowest fresh root

Table 4. Effect of fertilizer types on the fresh weight (g) of scent leaf, leaf yield (t/ha) and harvest index at 8 weeks after treatment application (WATA).

Fertilizer types	FPW (g/plant)	FRW (g/plant)	FSW (g/plant)	FLW (g/plant)	Root length (cm)	Leaf yield (t/ha)	Harvest index (%)
Control	31.80	5.33	12.30	17.10	34.80	1.29	54.10
Compost (t/ha)	89.60	17.60	47.90	51.70	44.10	3.88	58.20
Cow dung (t/ha)	77.70	13.65	35.20	30.20	40.50	2.27	39.30
NPK 20:10:10 (kg/ha)	71.50	15.50	46.60	38.30	36.80	2.87	53.40
Urea (kg/ha)	66.30	10.62	21.30	45.40	25.90	2.87	68.20
$LSD_{(0.05)}$	12.67	4.47	8.63	14.44	10.45	1.08	18.54
Significant level	**	**	**	**	*	**	NS

FPW = Fresh plant weight, FRW = Fresh root weight, FSW = Fresh stem weight, FLW = Fresh leaf weight, NS = Non significant, ** = Highly significant (0.01), * = Significant (0.05).

weight due to absence of phosphorus (Table 1).
Fresh stem and leaf weights followed the same pattern as in fresh root weight (Table 4). Soils amended with compost produced highest fresh stem weight (47.90 g) and leaf weight (51.70 g) while control had lowest stem weight (12.30 g) and leaf weight (17.10 g). Control soils had poor fertility status (Table 1) and thus, could not supply adequate quantities of nutrients necessary for improving stem and leaf weight. Application of compost improved fresh shoot weights in lettuce (Oyeyemi et al., 2017) and amaranth (Kumngen et al., 2023).

Effect of fertilizer types on root length, leaf yield and harvest index of scent leaf

Soils amended with compost produced a scent leaf with the longest root length (44.10 cm) and highest leaf yield (3.88 t/ha) (Table 4). Zero application of fertilizer produced the lowest leaf yield (1.29 t/ha) and soils amended with urea produced short root length (25.90 cm). Poor leaf yield in the control plants could be attributed to poor soils fertility status (Table 1) which reduced the productivity of the soils. Compost nutrient contents had higher nitrogen, potassium and phosphorus (Table 1) and mineralization in compost was fast and more sustainable than inorganic fertilizers. Compost effect on the leaf yield of amaranthus (AdeOluwa and Akinyemi, 2014) and lettuce (Kumngen et al., 2023) was superior to inorganic fertilizer. Harvest index was highest in soils amended with urea (68.20%) and lowest in soils amended with cow dung (39.30%) (Table 4).

Effect of fertilizer types on heavy metal contents of the scent leaf

Fertilizer types significantly ($p \leq 0.05$) affected iron (Fe) content of scent leaf (Table 5). Fe was highest in control scent leaf (63.73 ± 0.58 mg/kg) and was least in scent leaf produced with NPK fertilizer (32.86 ± 0.11 mg/kg). Lower concentration of Fe in scent leaf produced with NPK fertilizer in relation to control could be attributed to the ability of NPK fertilizer to reduce bioavailability of Fe in scent leaf through the addition of phosphorus to the soils that changed the form of heavy metals (Singh et al., 2010). High concentration of Fe in control scent leaf could be attributed to poor organic matter content of the control plot which resulted in poor chelation and higher absorption of Fe by the scent leaf (Brown et al., 2003). Scent leaf produced with compost and cow dung had 41.33 ± 0.14 and 46.84 ± 0.09 mg/kg of Fe respectively while soils amended with NPK and urea produced scent leaves with 32.86 ± 0.11 and 51.79 ± 0.16 mg/kg of Fe respectively. High content of Fe in cow dung and compost (Table 1) contributed to higher absorption and concentration of Fe in organically produced scent leaf than in the inorganically produced scent leaf. Presence of phosphorus and potassium elements reduced phyto-availability and absorption of heavy metals in plant tissues (Huang et al., 2016; Wang et al., 2019).
Zinc (Zn) was highest in control scent leaf (31.89 ± 0.123 mg/kg) and lowest in scent leaf produced with cow dung (22.33 ± 0.38 mg/kg) (Table 5). Control plot without soils amendment contained heavy metals (Table 1) which could have been deposited through heavy metal dusts, previously used organic and inorganic manures and pesticides that contributed zinc, copper and lead to the soils (Al Jassir et al., 2005). However, the ability of cow dung to reduce Zn content could be related to the effectiveness of organic manure in immobilization and reduction of heavy metals bioavailability in soils (Wang et al., 2020). Zn was higher in scent leaf produced with urea than in scent leaf cultivated with NPK fertilizer. Nitrogen in urea causes soils acidification which could have contributed to increased Zn absorption by the scent leaf. Heavy metal availability in the soils is dependent on soils pH, chemical and physical properties of the soils and chemical speciation of the metal (Smith, 2009). NPK fertilizer supplied phosphorus and potassium elements which could have caused Zn immobilization and reduce bioavailability in scent leaf.
Copper (Cu) was highest in control scent leaf (9.62 ± 0.10 mg/kg) and lowest in scent leaf produced with NPK fertilizer (3.89 ± 0.08 mg/kg) (Table 5). The concentration of Cu in control soils (Table 1) and absence of organic amendment to the control soils could have led to increase bioavailability of Cu in scent leaf. Scent leaf produced with urea (6.63 ± 0.11 mg/kg) had higher Cu content than scent leaf produced with NPK fertilizer (3.89 ± 008 mg/kg). Urea is rich in nitrogen which increases soils acidity and lack phosphorus element responsible for immobilizing heavy metals in soils. The use of complete inorganic fertilizers reduced the bioavailability of metals, due to production of binding sites (Puschenreiter et al., 2005). Addition of nitrogen and

Table 5. Effect of fertilizer types on heavy metal contents of the scent leaf at 8 weeks after treatment application.

Fertilizer types	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Cd (mg/kg)
Control	63.73 ± 0.58	31.89 ± 0.12	9.62 ± 0.10	2.07 ± 0.08	6.23 ± 8.03	0.56 ± 0.09
Compost (t/ha)	41.33 ± 0.14	23.89 ± 0.07	4.82 ± 0.06	0.66 ± 0.01	0.48 ± 0.09	0.61 ± 0.04
Cow dung (t/ha)	46.84 ± 0.09	22.33 ± 0.38	4.16 ± 0.05	0.03 ± 0.04	0.85 ± 0.05	0.26 ± 0.09
NPK 20:10:10 (kg/ha)	32.86 ± 0.11	23.15 ± 0.07	3.89 ± 0.08	0.84 ± 0.10	0.11 ± 0.06	0.58 ± 0.08
Urea (kg/ha)	51.79 ± 0.16	26.53 ± 0.14	6.63 ± 0.11	0.97 ± 0.04	2.06 ± 0.04	0.40 ± 0.05
$LSD_{(0.05)}$	0.51	0.35	0.15	0.11	6.53	0.12
Significant level	**	**	**	**	NS	**

NS = Non-significant, ** = Highly significant (0.01), * = Significant (0.05).

phosphorus affect remediation of heavy metals by changing the forms of metals and promoting metabolism in plants (Sun et al., 2007).

Nickel (Ni) was highest in scent leaf produced with zero amendment (2.07 ± 0.08 mg/kg) and lowest in scent leaf produced with cow dung (0.03 ± 0.04 mg/kg) (Table 5). Scent leaf produced with urea had highest Ni content (0.97 ± 0.04 mg/kg). Control soils contained heavy metals and lack organic matter that could have reduced bioavailability of Ni to scent leaf through formation of insoluble complexes and thus, immobilized Ni (Wang et al., 2020). Muhammad et al. (2014) reported that organic amendment of Ni contaminated soils decreased nickel uptake by *Trifolium alexandrinum*.

Lead (Pb) was highest in control (6.23 ± 8.03 mg/kg) and lowest in scent leaves produced with NPK fertilizer (0.11 ± 0.06 mg/kg) (Table 5). Control soils contained Pb (Table 1) which could have been deposited from previously used organic manure or pesticides and thus, lack of soils amendment increased Pb mobilization in the soils and high bioavailability in scent leaf. High Pb content in scent leaf produced with compost and cow dung in relation to Pb content in scent leaf produced with NPK fertilizer could be as a result of high Pb content in cow dung and compost (Table 1). The ability of NPK fertilizer amended soils to reduce Pb content in scent leaf could be attributed to the supply of phosphorus element to the soils which formed binding sites with Pb and thus, caused Pb immobilization and reduced bioavailability in scent leaf (Puschenreiter et al., 2005).

Cadmium (Cd) was highest in scent leaf produced with compost (0.61 ± 0.04 mg/kg) and lowest in scent leaf produced with cow dung (0.26 ± 0.09 mg/kg) (Table 5). There was no significant difference in Cd contents of scent leaf produced without soils amendment (0.56 ± 0.09 mg/kg), compost (0.61 ± 0.04 mg/kg) and NPK fertilizer (0.58 ± 0.08 mg/kg). Cd content was higher in scent leaf produced with NPK fertilizer than in control Scent leaf. Singh et al. (2010) reported high phyto-availability of Cd, Cu, Pb, Zn, Mn, Ni and Cr in Beta vulgaris L. produced with NPK fertilizer, followed by control and least in farmyard manure. Control scent leaf had highest heavy metals above FAO/WHO (2021) maximum permissible values in scent leaf. Scent leaf produced in soils amended with cow dung, compost and NPK fertilizer had heavy metals values below the FAO/WHO (2021) maximum permissible values than scent leaf produced with urea. This disagrees with the report of Alromian (2020) who stated that the use of increasing rates of compost made from residues of chicken, animal and mixed organic residues increased heavy metal concentration in lettuce tissues above national standards and thus, unsafe for human consumption.

4. Conclusion

Organic and inorganic fertilizers are commonly used in crop production for improved growth, yield and nutrient content of crops. The study showed that scent leaves produced with compost had the highest growth and yield in relation to other fertilizer types used in the experiment due to its highly mineralized nature and high N, P, K and organic matter contents. Compost also had higher concentrations of heavy metals than other fertilizer types and this could be the source of high concentration of heavy metals in scent leaf produced with compost in comparison with NPK fertilizer and cow dung. However, the heavy metal bioaccumulation in scent leaf produced with compost was below the FAO/WHO permissible value and lesser than heavy metal bioaccumulation in scent leaf cultivated with urea fertilizer. Therefore, application of 5 t/ha of compost is recommended for improved growth, yield, quality and safe scent leaf production. All fertilizer types are locally and readily available to the farmers and thus do not limit this research. However, the major limitation to the laboratory analysis of heavy metal accumulation in scent leaf was the background interference and if not well managed could interfere with sample absorbance.

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Authors contributions

The authors confirm the study conception and design: Okoli Nneka Angela, data collection: Udoh Elozonachukwu Stella Maris and Lambert Chukwudi Michael; analysis and interpretation of results: Okoli Nneka Angela, draft manuscript preparation: Okoli Nneka Angela. The results were evaluated by all authors, and the final version of the manuscript was approved.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

AdeOluwa OO, Akinyemi O (2014) Amaranths (*Amaranthus viridis*) dry matter and soils qualities: organic vs inorganic fertilizers. In: Building Organic Bridges', at the Organic World Congress. *4th ISOFAR Scientific Conference,* 879–882.

Akanbi WB, Togun AO (2002) The influence of maize- stover compost and nitrogen fertilizer on growth yield and nutrient uptake of amaranth. *Sci Hort* 93:1–8. DOI: https://doi.org/10.1016/S0304-4238(01)00305-3.

Al Jassir MS, Shaker A, Khaliq MA (2005) Deposition of heavy metals on green leafy vegetable sold on roadsides of Riyadh City, Saudi Arabia. *Bulletin Envtal Contam Toxico* 75:1020–1027. DOI: https://doi.org/10.1007/s00128-005-0851-4.

Alexander P (2016) Phytochemical screening and mineral composition of the leaves of *Ocimum gratissmum* (Scent leaf). *Int J Appl Sci Biotechnol* 4 (2): 161. DOI: https://doi.org/10.3126/ijasbt.v4i2.15101.

Alromian FM (2020) Effect of type of compost and application rate on growth and quality of lettuce plant. *J Plant Nut* 43 (18): 2797–2809. DOI: https://doi.org/10.1080/01904167.2020.1793185.

Anjili EM, Nuhu AA, Uba S (2018) Comparative study of nutritional contents of *Ocimum basilicum* and *Ocimum gratissimum* plant leaves and soils samples from Borno and Enugu States, Nigeria. *Bayero J Pure Appl Sci* 12 (1): 40–51. DOI: https://doi.org/10.4314/bajopas.v12i1.7.

APHA (1995) Standard methods for the examination of water and waste water. 19th Edition. *American Public Health Association Inc*

Bremner JM, Mulvaney CS (1982) Nitrogen-total. In: Methods of soils analysis. Part 2: Chemical and Microbiological Properties. 2nd Edition. *Wiley,* 59–624.

Brown SL, Henry CL, Chaney R, Compton H, DeVolder PS (2003) Using municipal biosolids in combination with other residuals to restore metal-contaminated mining areas. *Plant Soils* 249 (1): 203–215. DOI: https://doi.org/10.1023/A:1022558013310.

Edo GI, Samuel PO, Ossai S, Nwachukwu SC, Okolie MC, Oghenegueke O, Asaah EU, et al. (2023) Phytochemistry and pharmacological compounds present in scent leaf: A review. *Food Chemistry Advances* 3:100300. DOI: https://doi.org/10.1016/j.focha.2023.100300.

Eifediyi EK Remison SU (2010) Growth and yield of cucumber (*Cucumis sativum* L.) as influenced by farm yard manure and inorganic fertilizer. *J Plant Breeding Crop Sci* 2:216–220.

Elgubshawi AA (2019) Effects of cow manure on growth and yield of lettuce (*Lactuca sativa* L) in salty affected soils and drip irrigation system, Bhrain Kingdom. *J Agric Res* 5 (4) DOI: https://doi.org/10.53555/ar.v5i4.2795.

FAO/WHO (2021) Joint FAO/WHO food standards programme. Codex committee on contaminants in foods. *14th Session; Codex Alimentarius Commission*

GENSTAT (2007) GENSTAT for Windows. Release 7.2DE Discov¬ery Edition 3. Lawes Agricultural Trust (Rothamsted Experi¬mental Station). VSN International Ltd., Hemel Hempstead, UK.

Gudugi LAS (2013) Effect of cow dung and variety on the growth and yield of okra (*Abelmoschus esculentus* L.). *Euro J Exp Bio* 3 (2): 495–498.

Hendershot WH, Lalande H, Duquette M (1993) Soils reaction and exchangeable acidity. In: Soils sampling and methods of analysis. *Lewis Publishers,* 141–145.

Hernandez T, Chocano C, Moreno JL, Garcia C (2016) Use of compost as an alternative to conventional inorganic fertilizers in intensive lettuce (*Lactuca sativa* L.) crops-Effects on soils and plant. *Soils Till Res* 160:14–22. DOI: https://doi.org/10.1016/j.still.2016.02.005.

Huang M, Zhu Y, Li Z, Huang B, Luo N, Liu C, Zeng G (2016) Compost as a soils amendment to remediate heavy metal-contaminated agricultural soils: Mechanisms, efficacy, problems and strategies. *Water Air Soils Pollut,* 227–359. DOI: https://doi.org/10.1007/s11270-016-3068-8.

Iyama WA, Okpara K, Techato K (2021) Assessment of heavy metals in agricultural soils and plant (*Veronia amygdalina* Delile) in Port Harcourt Metropolis, Nigeria. *Agric* 12 (1): 27. DOI: https://doi.org/10.3390/agriculture12010027.

Kumngen A, Jutarut L, Usmana M, Sudarat S, Sujunya A, Wilaiwan C, Pattamavadee K, Noodchanath K, Siwapong L, Seppo K (2023) Effects of compost from food waste on growth of lettuce (*Lactuca sativa Var Crispa* L.). *Int J Recycl Org Waste Agricult* 12:247–258. DOI: https://doi.org/10.30486/IJROWA.2022.1960507.1481.

Kunene EN, Masarirambi MT, Gadaga TH, Dlamini PS, Ngwenya MP, Vilane VS (2019) Effects of organic and inorganic fertilizers on the growth and yield of amaranth (*Amaranthus hybridus*). *Acta Hortic* 1238:31–37. DOI: https://doi.org/10.17660/ActaHortic.2019.1238.4.

Moral R, Paredes C, Bustamante MA, Marhuenda-Egea F, Bernal MP (2009) Utilisation of manure composts by high-value crops: safety and environmental challenges. *Bioresour Technol* 100 (22): 5454–5460. DOI: https://doi.org/10.1016/j.biort ech.2008.12.007.

Mortvedt JJ (1995) Heavy metal contaminants in inorganic and organic fertilizers. *Fertilizer Research* 43:55–61. DOI: https://doi.org/10.1007/BF00747683.

Muhammad S, Muhammad S, Muhammad AA, Abul G (2014) Effect of organic amendments on phyto availability of nickel and growth of berseem (*Trifolium alexandrinum*) under nickel contaminated soils conditions. *Chem Spec Bio* 26 (1): 37–42. DOI: https://doi.org/10.3184/095422914X13886890590610.

Nelson DW, Sommers LE (1982) Total carbon, organic carbon and organic matter. In: Methods of Soils Analysis. Part 2: Chemical and Microbiological Properties. 2nd Edition. *Wiley,* 539–579.

Oguntade OA, Olagbenro TS, Odusanya OA, Olagunju SO, Adewusi KM, Adegoke AT (2019) Assessment of composted kitchen waste and poultry manure amendments on growth, yield and heavy metal uptake by Jute mallow *Corchorus olitorius* Linn. *Int J Recycl Org Waste Agricult* 8:187–195. DOI: https://doi.org/10.1007/s40093-018-0232-8.

Okoli NA, Obiefuna JC, Ihejirika GO, Alagba RA, Keyagha ER, Adikuru NC, Emma-Okafor LC (2015) Microbial community in the composting process and its positive impact on the soil biota in sustainable agriculture. *Int J Agric Rural Dev* 18 (2): 2209–2214.

Olaniyi JO, Adelasoye KA, Jegede CO (2008) Influence of nitrogen fertilizer on the growth and yield of quality of grain amaranth varieties. *World J Agric Sci* 4:506–513.

Olsen SR, Sommers LE (1982) Phosphorus.Methods of soils analysis Part 2 Chemical and Microbiological Properties. 2nd Edition. *Wiley,* 403–430.

Oyeyemi AD, Francis I, Anifowose EM (2017) Growth and proximate composition of *Amaranthus cruentus* L. on poor soils amended with compost and arbuscular mycorrhiza fungi. *Int J Recycl Org Waste Agricult* 6:195–202. DOI: https://doi.org/10.1007/s40093-017-0167-5.

Puschenreiter M, Horak O, Friesl-Hani W, Hartl W (2005) Low-cost agricultural measures to reduce heavy metal transfer into the food chain- a review. *Plant Soils Environ* 51 (1): 1–11. DOI: https://doi.org/10.17221/3549-PSE.

Samah MAA, Hassan NS, Hussain MRMH, Ibrahim MZ, Jan NHM, Kamarudin MKA (2020) Determination of heavy metal concentration in food waste compost on root uptake of *Capsicum annum* L. *Int J Adv Sci Technol* 29 (9): 1612–1627.

Sanni KO (2016) Effect of compost, cow dung and NPK 15-15-15 fertilizer on growth and yield performance of Amaranth (*Amaranthus hybridus*). *Int J Adv Sci Res* 2 (3): 76–82. DOI: https://doi.org/10.7439/ijasr.v213.3148.

Singh A, Agrawal M, Marshall FM (2010) The role of organic vs inorganic fertilizers in reducing phyto availability of heavy metals in a wastewater-irrigated area. *Eco Eng* 36 (12): 1733–1740. DOI: https://doi.org/10.1016/j.ecoleng.2010.07.021.

Smith SR (2009) A critical review of the bioavailability and impacts of heavy metals in municipal solid waste compost compared to sewage sludge. *Environ Int* 35 (1): 142–156. DOI: https://doi.org/10.1016/j.envint.2008.06.009.

Smith MR Merchant A Rao IM (2018) Source-sink relationships in crop plants and their influence on yield development and nutritional quality. *Front Plant Sci* 9:1889. DOI: https://doi.org/10.3389/fpls.2018.01889.

Souri MK, Alipanahi N, Hatamian M, Ahmadi M, Tesfamariam T (2018) Elemental profile of heavy metals in Garden cress, Coriander, Lettuce and Spinach, commonly cultivated in Kahrizak, South of Tehran-Iran. *Open Agriculture* 3 (1): 3237. DOI: https://doi.org/10.1515/opag-2018-0004.

Souri MK, Hatamian MH (2019) Aminochelates in plant nutrition; a review. *J Plant Nut* 42 (1): 67–78. DOI: https://doi.org/10.1080/01904167.2018.1549671.

Sun RL, Zhou QZ, Sun FH, Jin CX (2007) Antioxidative defense and proline/phtychelatin accumulation a newly discovered Cd-hypperacunulator in *Solanum nigrum* L. *Environ Exp Bot* 60:468–476. DOI: https://doi.org/10.1016/j.envexpbot.2007.01.004.

Tamakloe M, Koledzi EK, Aziable E, Tacha-Thom M, Krou NM (2021) Impact of composts maturity on growth and agronomic parameters of maize (*Zea mays* L.). *Amer J Analy Chem* 12:29–45. DOI: https://doi.org/10.4236/ajac.2021.122003.

Vijantie RR, Lydia AO, Abdullah AA (2021) Production and effect of vermiwash and vermicompost on plant growth parameters of tomato (*Lycopersicon esculentum* Mill.) in Suriname. *Int J Recycl Org Waste Agricult* 10 (4): 397–413. DOI: https://doi.org/10.30486/IJROWA.2021.1911898.1148.

Vukobratovic M, Vukobratovic Z, Loncaric Z, Kerovac D (2014) Heavy metals in animal manures effect of composting on it. *Acta Hortic* 1034:591–597. DOI: https://doi.org/10.17660/ActaHortic.2014.1034.75.

Wang F, Zhang S, Cheng P, Zhang S, Sun Y (2020) Effects of soils amendments on heavy metal immobilization and accumulation by maize grown in a multiple-metal-contaminated soils and their potential for safe crop production. *Toxics* 8 (4): 102. DOI: https://doi.org/10.3390/toxics8040102.

Wang Y, Zhong B, Shafi M, Ma J, Guo J, Wu J, Ye Z, Liu D, Jin H (2019) Effects of biochar on growth, and heavy metals accumulation of moso bamboo (*Phyllostacy pubescens*), soils physical properties and heavy metals solubility in soils. *Chemosphere* 2019:510–516. DOI: https://doi.org/10.1016/j.chemosphere.2018.11.159.