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Research article

Evaluation of growth and nutrients of *Telfairia occidentalis* Hook, f. Grown on dumpsite soil in Umudike area

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Anthropogenic activities have led to build up of dumpsites. Organic matters are found in compost and waste site soils which are seldom used, and there is a high demand for leafy vegetables such as fluted pumpkin. The study was designed to investigate the impact of dumpsite soil on *Telfairia occidentalis's* proximate composition, vitamin levels, heavy metal and vegetative growth. The study was conducted at Michael Okpara University of Agriculture, Umudike. Soils were obtained from the dumpsite of the campus cafeteria and the forest reserve. The study adopted a 5x5 Completely Randomized Design. Each of the 25 plastic pots had a varied percentage of regular soil mixed with dumpsite soil. Two seeds were planted in each of the buckets. Physicochemical analysis showed that dumpsite soil had relatively elevated chemical contents compared to normal top soil. The measured plant growth features in the dumpsite soils showed a significant increase when compared to the control. The treatment with combined equal percentage of normal top soil with an equal amount of dumpsite soil (T3) produced the highest growth. *T. occidentalis* grown on 100% dumpsite soil had higher dry matter and carbohydrate contents compared to lower ash, moisture, fibre, and protein levels in the control. However, there was no significant difference in the Dry matter, Ash, Fat and Protein contents of dumpsite and normal soil grown *T. occidentalis*'s leaves. From the result, vitamin content of *T. occidentalis* grown in the dumpsite soil was not significantly affected. The dumpsite soil significantly increased the plants Cu, Pb, Cd and Zn content when compared to the control plants, but they were all below the tolerable standard. Dumpsite soil is rich in nutrient content, and cultivating on it increases plant vegetative growth while solving the problem of agro-land scarcity.

Key words: Dumpsite; Nutrient; Heavy metal; Vegetable; Waste soil

Introduction

Compost rich soil is an important resource to maintain and improve soil fertility and is of great value nowadays, particularly in areas where the organic nutrients in the soil are reduced. Soil organic matter is essential for plant growth. These organic matters can be found in compost and waste sites. Dumpsite soils, which contain these wastes, are a major environmental threat to most Nigerian cities (Awomeso *et al.,* 2010). Rapid population growth, industrialization, and technological changes and patterns have increased solid waste challenges (Magaji, 2005). In addition to being unsightly and unhygienic, open garbage disposal harbours rats, flies, mosquitoes, and other disease-carrying vectors and contaminates plants and soils, posing a major threat to human health and the environment (Sajjad *et al.,* 2022). The decomposition of organic materials produces methane, which is produced by dumpsites and poses a concern for public health. Additionally, plants are harmed by heavy metal deposition and overall plant growth (Khan *et al.,* 2008; Uwalaka *et al.,* 2018; Wan *et al.,* 2019).

Most dumpsites are found in areas where anthropogenic activities are rife. Waste from households, markets, agriculture farms, and industries is disposed at a dump-site and most of these items decay and decompose. Dumpsite soil is rich in nutrients due to nutrient and non-nutrient elements degraded into the soil, which most plants utilize for growth (Osuagwu *et al.,* 2015).

In order to convert the waste land into wealth, the dumpsite is usually used for cultivation purposes. Repurposing unused dumpsites for agricultural space is an ideal thing that needs to be promoted. Cultivation on the dumpsite or its soil will also help in increasing the yield and quality of plants grown and in eradicating the problem of food insecurity. Various studies have been carried out to assess the properties of dumpsite soils as they affect plant growth and their chemical composition (Ozdemir, 2005; Audu and Aremu, 2011; Gautam *et al*., 2012; Ogbemudia *et al*., 2013; Osuagwu *et al.*, 2015; Oyakhilome *et al.*, 2019; Bassey *et al.*, 2021; Asare and Száková, 2023). It has been established that dumpsite soils provide plants with the nutrients needed for their growth.

Telfairia occidentalis (Hook, F.) is a tropical vine that is grown in West Africa for its edible seeds and as a leaf vegetable, according to Burkill (1985). The plant is also known by the names fluted pumpkin, fluted gourd, and *ugu* in the Igbo language. *Telfairia occidentalis* is native to southern Nigeria and is a member of the Cucurbitaceae family (Akoroda, 1990). Fluted pumpkins are among the most widely consumed vegetables that grow in many nations of West Africa, ranking as one of the three most widely eaten vegetables cultivated in South Eastern parts of Nigeria (Nwanna, 2008). The seeds are eaten roasted or boiled. It can also be pounded and eaten in soup (Akwaowo 2000).

However, fluted pumpkin is widely sought, and its cultivation faces the challenges of the availability of arable, nutrient-rich lands. The various cafeterias within the campus of Michael Okpara University of Agriculture, Umudike (MOUAU) produce a great deal of food waste that gets dumped in the school dumpsite. The soil from this site is rarely used for any meaningful activity, constituting an offensive sight. There is a need to explore the cultivation of this highly demanded vegetable on dumpsite soil. The study aimed to evaluate the effects of dumpsite soil on vegetative growth, proximate content, vitamin content and phytoremediation activity of heavy metals of *T. occidentalis*.

MATERIALS AND METHODS

Study Area

The experiment was carried out at Michael Okpara University of Agriculture, Umudike (MOUAU) campus from May 11 to August 11, 2023. The MOUAU is located in Nigeria's rainforest belt at latitude 05° 28°N and longitude 07° 32°E and 123 meters above sea level.. There are minimum and maximum temperatures in the region ranges from 22.41°C to 30°C, respectively, and 1,245 mm of mean annual rainfall (National Root Crops Research Institute (NRCRI) Metrological Report, 2022). Seeds of *T. occidentalis* (fluted pumpkin) were obtained from the National Seed Research Council. Two types of soil were used: dumpsite soil and normal soil. The dumpsite soil was gotten from the refuse dump site of the MOUAU cafeteria (latitude 05° 28°N and longitude 07° 32°E), while the normal soil was gotten from the MOUAU Forest Reserve (latitude 05° 28°N and longitude 07° 32°E). The study was carried out at the screen House of MOUAU using 25 10 litre perforated buckets. The experiment was arranged in a completely Randomized Design (CRD) experiment design. Five treatments were created by mixing the normal soil and the soil from the dumpsite at varying volumes as follows: 100% of dumpsite soil with 0% of normal soil (T1); 75% of dumpsite soil with 25% of normal soil (T2); 50% of dumpsite soil with 50% of normal soil (T3); 25% of dumpsite soil with 75% of normal soil (T4); 0% of dumpsite soil and 100% of normal soil were used as controls for the experiment. Two seeds of *T. occidentalis* were sown in each plastic pot. After planting the seeds, the plants were watered evenly and regularly.

Collection of data

Plant height: measurement of plant length was done using a measuring tape. Fresh and dry weight: At maturity, (6 weeks after planting) fresh weight was done by collecting the fresh leaf and weighing it using an electronic analytical balance, Scitek BA-E10002X model. The harvested leaves were air-dried and weighed. The average weight of the leaf of each plant was used as mean for each treatment. The number of leaves and stalks were counted and recorded accurately for each treatment.

Determination of Proximate, vitamin and mineral content

The percentage moisture, crude fibre, fat, ash, protein and carbohydrate contents in the leaf of the plant were analyzed according to AOAC (2000) method.

Determination of Heavy Metal Composition (HMC)

The heavy metal composition of soil, roots, and leaves was determined using the method of Osuji *et al.* (2004).

Statistical analysis

Data was analyzed using an analysis of variance (ANOVA). Duncan's multiple range test (DMDT) at 5% confidence level.

RESULTS

Physicochemical content of dumpsite soil and top soil

The result of a pre planting analysis of the soils used in the experiment is contained in table 1. It shows that the dumpsite higher pH, phosphorus, Nitrogen, organic matter, cadmium, copper, lead and zinc values.

Table 1: Physicochemical content of dumpsite soil and top soil

Parameters	Dumpsite Soil	Normal Top Soil
Texture	sandy-loamy	sandy-loamy
Sand %	68.40	70.65
Silt	10.80	12.40
Clay	15.73	17.11
pH	6.33	5.99
Phosphorus (mg/kg)	40.20	38.50
Nitrogen (mg/kg)	0.68	0.60
Organic matter (%)	4.92	3.24
Cadmium (mg/100g)	0.22	0.08
Copper (mg/100g)	0.49	0.19
Lead (mg/100g)	0.25	0.05
Zinc (mg/100g)	2.88	1.93

Dumpsite soil effect on the height of *T. occidentalis*

The result in figure 1 showed that the height of the plants in the soils of dumpsite at weeks 2 and 3 was not affected when compared to the control soil. However as growth progresses to week 4 and 5, the soil treatment with equal volumes of dumpsite soil and normal top soil recorded the highest plant height.

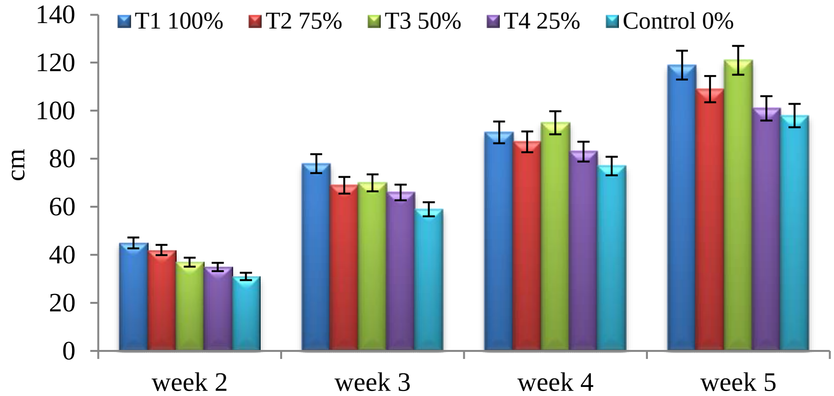

Figure 1: Effect of Dumpsite soil on the height of *T. occidentalis*

Dumpsite soil effect on the number of leaves of *T. occidentalis*

The result on the number of leaves showed that the dumpsite soil did not increase the number of leaves in *T. occidentalis* when compared to the normal top soil of the control at week 2 and 3 (Figure 2). However at week 4 and 5, notable increase was recorded in the dumpsite-soil grown *T. occidentalis* with maximum number of leaves was recorded at T3 (Figure 2). Similar trend was observed in the number of stalks per plants (Figure 3).

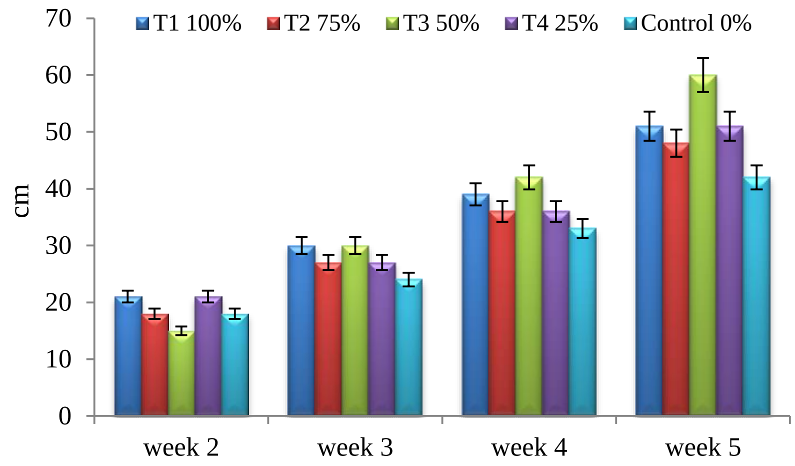

Figure 2: Effect of Dumpsite soil on the number of leaves of *T. occidentalis*

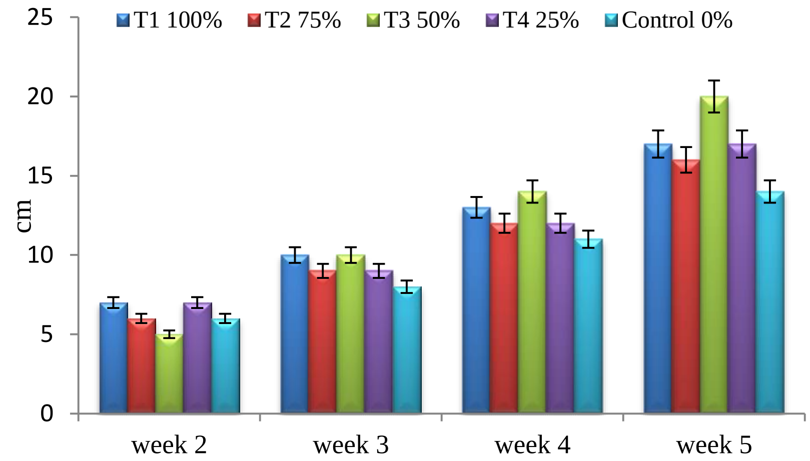

Figure 3: Effects of Dumpsite soil on the number of stalks of *T. occidentalis*

Effect of Dumpsite soil effect on the heavy metal concentration in the leaves of *T. occidentalis.*

The concentrations of cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) accumulated in the leaves of *T. occidentalis* after 5 weeks of planting in top soil mixed with dumpsite soil at various concentrations revealed that the concentrations of heavy metals (Cd, Cu, Pb and Zn) was highest at T1 (100% dumpsite soil), followed by T2 75% > T3 50% > T4 25% > Control 0% (Table 2). The findings indicated that the concentrations of Cu, Pb, and Zn did not significantly differ among the treated samples. Nonetheless, there was a notable difference in the Cd concentration between T4 25% and Control 0% ($p<0.05$).

Table 2: Effect of Dumpsite soil effect on the heavy metal concentration in the leaves of *T. occidentalis* at 6 weeks after planting

Soil Treatment	Cd	Cu (Mg/kg)	Pb	Zn
T1	0.113 ± 0.0014[a]	0.23 ± 0.028[a]	0.094 ± 0.004[a]	2.17 ± 0.020[a]
T2	0.095 ± 0.0424[a]	0.22 ± 0.028[a]	0.070 ± 0.002[a]	1.95 ± 0.025[a]
T3	0.085 ± 0.0071[a]	0.16 ± 0.014[a]	0.045 ± 0.002[a]	1.78 ± 0.020[a]
T4	0.063 ± 0.0424[ab]	0.16 ± 0.014[a]	0.032 ± 0.001[a]	1.53 ± 0.010[a]
Control 0%	0.051 ± 0.0071[c]	0.08 ± 0.014[b]	0.010 ± 0.002[b]	1.31 ± 0.010[ab]

Values are mean ± SD, values with different subscript on the same column are significantly different i.e. $P<0.05$

Dumpsite soil effect on the proximate composition in the leaves of *T. occidentalis*

Proximate composition in the leaves of *T. occidentalis* after 5 weeks revealed that the moisture content (MC) ranged from 8.63% to 8.76%, the dry matter (DM) from 90.22% to 91.47%, ash content from 13.23% to 14.22%, crude fibre (CF) content from 12.39% to 12.62%, ether extract (EE) from 1.83% to 1.92%, crude protein (CP) content from 18.62% to 19.87% and carbohydrate (CHO) content from 42.69% to 45.08%. The moisture content of T2 75% and T3 50% were significantly different ($p<0.05$) while the remaining plant samples were not significantly different. There was no significant difference in dry matter content and ash content of the plant samples. The crude fibre content at T2 75% and T3 50% were significantly different ($p<0.05$) while the remaining plant samples were not significantly different. There was no significant difference in ether extract and crude protein content of the plant samples.

Table 3: Effect of Dumpsite soil on the proximate composition in the leaves of *T. occidentalis* at 6 weeks after planting

Soil Treatment	MC	DM	ASH	CF (%)	EE	CP	CHO
T1	8.76±0.007^{a}	91.47±0.08^{a}	13.23±0.04^{a}	12.39±0.01^{a}	1.83±0.04^{a}	18.72±0.11^{a}	45.08±0.20^{a}
T2	8.72±0.007^{ab}	91.31±0.06^{a}	13.46±0.07^{a}	12.47±0.06^{ab}	1.86±0.03^{a}	18.88±0.06^{a}	44.87±0.57^{ab}
T3	8.63±0.035^{ab}	90.22±0.01^{a}	13.77±0.02^{a}	12.62±0.03^{ab}	1.87±0.01^{a}	19.62±0.03^{a}	43.50±0.04^{ab}
T4	8.76±0.028a	90.83±0.03^{a}	14.05±0.04^{a}	12.53±0.02^{a}	1.88±0.03^{a}	19.87±0.04^{a}	42.77±0.26^{a}
Control	8.73±0.014^{a}	90.9±0.01^{a}	14.22±0.03^{a}	12.57±0.01^{a}	1.92±0.03^{a}	19.87±0.01^{a}	42.69±0.04^{a}

Values are mean ± SD, values with different subscript on the same column are significantly different i.e. P<0.05. MC= moisture content, DM= dry matter, CF= crude fibre, EE= ether extract, CP= crude protein and CHO= carbohydrate.

Effect of Dumpsite soil on the vitamins content of the leaves of *T. occidentalis*

The result in Table 4 showed the vitamins concentration in the leaves of *T. occidentalis* after 5 weeks. The result revealed that the vitamin B1 ranged from 0.65% to 0.76%, vitamin B2 from 0.19% to 0.26%, vitamin B3 from 1.59% to 1.65% and vitamin C from 232.81% to 237.75%. There was no significant difference in the concentration of all the vitamins (Table 4).

Table 4: Dumpsite soil effect on the vitamins concentration in the leaves of *T. occidentalis* at 5 weeks after planting

Soil Treatment	Vitamin B1	Vitamin B2 (mg/100g)	Vitamin B3	Vitamin C
T1	0.74 ± 0.02^{a}	0.22 ± 0.03^{a}	1.65 ± 0.01^{a}	235.57 ± 0.02^{a}
T2	0.69 ± 0.01^{a}	0.23 ± 0.04^{a}	1.62 ± 0.03^{a}	234.93 ± 0.04^{a}
T3	0.76 ± 0.03^{a}	0.26 ± 0.01^{a}	1.64 ± 0.01^{a}	237.75 ± 0.16^{a}
T4	0.76 ± 0.05^{a}	0.23 ± 0.01^{a}	1.63 ± 0.01^{a}	236.74 ± 0.03^{a}
Control 0%	0.65 ± 0.01^{a}	0.19 ± 0.01^{a}	1.59 ± 0.01^{a}	232.81 ± 0.01^{a}

Values are mean ± SD, values with different subscript on the same column are significantly different P<0.05

DISCUSSION

The findings of this research demonstrated that dumpsites soil generally influenced the physicochemical properties of soils. Ndukwu *et al.,* (2008) reported that the physio-chemical changes occurred in the soils and plants associated with refuse dumps. Soils from dumpsite and normal top soils have related features, showing sandy-loam properties (68.40 sand, 10.80 silt: 15.73 clay in dumpsite soil). This ratio is similar to the report of FAO (2008) wherein it was stated that such percentage encourages soil nutrient retention for optimum plant growth. The reduced acidity, increased mineral and heavy metals of the dumpsite soil in the present study was also reported by Bassey *et al*. 2021; Asare and Száková 2023), these may be attributed to decomposition of waste and concentration of the micro and macro elements within a within the pot.

The observed increase in height, number of leaves and number of stalk of *T. occidentalis* grown on the dumpsite at the early period of growth is good agricultural indices showing that dumpsite soil can be employed in seed germination.

Theodoratos *et al*. (2000) and Ozdemir, (2005) reported in their research work that the plant height and area of leaves of *Amaranthus hybridus* increased with increase in the dump site soil proportion. However, at certain concentration and duration, dumpsite soils can have negative effect on plant. This study showed that the T1 soil (100% dumpsite soil) which has highest growth rate at week 1 and 2 declined after week 3. This implies that high concentration of dump may not be sustainable for plant growth. The adverse effects of different waste deposition on soils chemical content was reported by Giao and Minh (2022). They attributed this to the excess accumulation of nutrients in the soil. This may lead to bioaccumulation of excessive nutrient in plants leading to reduced growth rate. The number of leaves and stalks of the plant increased significantly ($p< 0.05$) due to the addition of dumpsite soil at early weeks until the 3^{rd} week where it showed a decline in length of leaves and number of stalks. Excessive compost manure would have negative effect on physical characteristics of a plant (Soheil *et al.,* 2012). Gautam *et al*., (2012) also had similar trend and yield of Indian mustard in a similar study. For optimum plant growth, the right proportion of 50% dumpsite soil and 50% normal soil should be used. From this study, T3 had the highest recorded growth parameters and the right soil proportion for the cultivation of *T. occidentalis*.

Telfairia occidentalis cultivated at a higher proportion of dumpsite soil had a significant increase in heavy metals concentration over the plants in the lower dumpsite soils and control soil, this tends to agree with the results obtained by Voutsa *et al.,* (1996) and Uwalaka *et al.* (2018) who reported that various heavy metal concentrations such as ((Lead (Pb), Copper (Cu), Nickel (Ni), Chromium (Cr) and Zinc (Zn)) were found to be higher at the dumping site and polluted soils than normal top soil because of organic municipal waste and oil waste from various industrial and agricultural waste. The result showed that there was no significant difference in the concentration of Cu, Pb and Zn amongst the treatments. However, Cd showed significant difference among other metals ($p<0.05$), similar findings was reported by Leah *et al.,* (2014). The differential metal content has been reported as a result of the presence heavy metal presence in these soils and the ability of plants roots to absorb, transport and transpire them by phyto-extraction, phyto-accumulation, phyto-volatilization or phyto-sequestration (Raymond and Harrison, 2017; Uwalaka *et a*l., 2018; Asare and Száková, 2023). With the exception of Zn, the Cu, Cd and Pb content of the studied plant were well below the permissible and tolerable range of WHO 1996 and EU regulatory guidelines (2006) for leafy vegetables.

Results from the proximate analysis showed that the dumpsite soil had both positive and negative influence on the proximate composition of *T. occidentalis.* Dumpsite soil increased the dry matter and carbohydrate contents but had a significant decrease on the ash content, ether extract and crude protein content. Similar trend was observed by the work of Osuagwu *et al.,* (2015) which reported that dumpsite soil altered the proximate composition of *P. vulgaris* positively and negatively. There was no significant difference in the dry matter content, ash content, ether extract and crude protein content as the treatment increased. However, the moisture, fiber and carbohydrate content where observed to be significantly different. Similar research reported that the moisture content, fiber, fat, and carbohydrate content of plants grown on dumpsite soil were different (Hanan *et al*., 2009; Osuagwu *et al.,* 2015)

Similarly, vitamin analysis shows that the *T. occidentalis* grown on equal proportion of dumpsite soil and normal top soil had a significant increase in the concentration of vitamin B_1, B_2 and vitamin C over plants grown in control soil, this was supported by a similar work of Osuagwu *et al.,* (2015) which reported that plants grown in soil containing high organic contents often contain higher concentrations of vitamins B_1 (thiamin), vitamin C and B_{12} (cyanocobalamin).

Conclusion

The physicochemical properties of the dumpsite soil were relatively different from the normal top soil. The slight differences in the dumpsite soil were notable in the soil texture, soil pH, mineral element, organic matter and heavy metals and this may be attributed to the presence of organic and inorganic materials in these wastes. This invariably resulted in the dumpsite soil having more desirable agricultural qualities such as lower sand, clay and silt contents; higher minerals and organic matter contents. The result of this study shows that dumpsite soil exerted increased growth rate and heavy metal accumulation on *T. occidentalis.*

The increased growth of the plant in the dumpsite soil is largely dependent on the nutrient rich dumpsite soil. However, appropriate ratio of 50:50 of dumpsite soil and normal top soil should be used during cultivation to avoid bioaccumulation of heavy metals in plants. Although the tested heavy metals were below the tolerable standard, caution must be employed in the consumption of dumpsite grown crops especially when the site might contain toxic and carcinogenic wastes. The presence of quantifiable proximate and vitamin content in leaf grown on the dumpsite soil were of nutritional significance and should be explored in vegetable production. There is an urgent need to utilize dumpsite waste land or its soils found within the school premises to productive land for crop cultivation. However, proper soil and plant analysis should be carried out before putting such land or soil into agricultural use.

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