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Research Article

Responses of Worowo [Senecio biafrae (Oliv. & Hiern.) S. Moore] to Composts enriched with Organic Nitrogen Sources

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Abstract

Worowo (*Senecio biafrae*) is a semi-wild, indigenous and nutritious vegetable. Demand for worowo vegetable is increasing due to its nutritional values, thus necessitating its domestication for increased production. However, there is limited information on soil fertility requirements of worowo and the use of inorganic fertilizers could be expensive and detrimental to environment. Composts, on the other hand are environment-friendly and effective, but their use is constrained by low nitrogen contents, thereby necessitating enrichment with various nitrogen sources. Responses of worowo to organically enriched composts were therefore investigated.

Composted Cattle Dung+Sawdust (CDS) and Poultry Droppings+Sawdust (PDS), at 1:1 (w/w) were enriched to 60 g N/kg with meals from dried bone-BnM, blood-BM, hoof-HM, and horn-HnM, neem-NM and Tithonia leaves-TM. Compost treatments obtained were: CDS and PDS (no enrichment added), CDSBnM, CDSBM, CDSHM, CDSHnM, CDSNM and CDSTM; PDSBnM, PDSBM, PDSHM, PDSHnM, PDSNM and PDSTM. Worowo was raised in pots with CDS, PDS and 60 g N/kg enriched composts at 30 t/ha and control (soil alone), compared with 60 kg N/ha NPK 15-15-15 in a completely randomized design with three replicates. Data generated from the growth indices and edible Shoot Yield (ESY) of worowo (t/ha), which were measured at 60, 120 and 180 Days After Planting (DAP) were analyzed using ANOVA at $\alpha_{0.05}$. ¬¬¬¬¬¬The ESY (t/ha) of 60 g N/kg CDSNM (54.93) was significantly higher than NPK (36.53) and others but similar to CDS (50.93) while pots treated with PDS were lowest (8.00). The CDSDNM at 60 g N/kg applied at 30 t/ha could hence be adopted for worowo production.

Introduction

Green leaf vegetables, which are the succulent parts of plants grown in gardens, are an essential part of the African diet [1]. They are usually consumed alongside with starchy staple food [2] and are valuable components of many Nigerian families' diets. Leaf vegetables are notable sources of essential food nutrients like protein, minerals, vitamins and fiber, often lacked by the regular diets, especially in rural areas [3]. Although, reliable statistics on production and consumption are scarce, the abundance of various types of vegetables in most food markets in Nigeria is a pointer to their usefulness in human diets [4].

There are several neglected and under-exploited indigenous vegetables found growing spontaneously in the wild/semi-wild state and not given any cultivation attention. One of these neglected and under-exploited indigenous leaf vegetables is Senecio biafrae (Oliv. & Hiern, S. Moore). It is called worowo in Yoruba (Nigeria) and bologi in Sierra Leone [5]. Worowo *(Senecio biafrae)* grows wild in West Africa's forest zone, where the fresh succulent leaves are prepared for consumption as a vegetable, after seasoning with pepper, tomato, and onions. In Sierra Leone, worowo leaves are steamed or boiled before being served as a vegetable with okra and fish. The increasing awareness of the potentials of worowo in terms of yield, nutrient compositions and roles in nutritional health which compare favourably with or exceed the routinely-cultivated leaf vegetables are stimuli to their domestication for regular cultivation. However, they are often scarce in most urban markets which is an indication of their being threatened by extermination. Therefore, for optimum production and hence, increased availability of these indigenous vegetables in markets at reasonable and attainable prices, an urgent move to develop management practices which farmers will be encouraged to adopt becomes necessary.

The low levels of organic matter and accessible nutrients of the tropical soils had caused a rapid decline in the productivity and sustainability of the soils of the tropics, especially when cultivation is on a regular basis, without proper management [6]. Soil fertility is decreasing very rapidly in Africa, but the expectations for increased crop production are still built on these fragile resources. However, farmers encounter great difficulties in getting plants nutrients supplied from supplementary sources, particularly inorganic fertilizers which are becoming gradually inaccessible to the real farmers; hence, land use intensification to meet food needs, without nutrient inputs from external sources becomes eminent. The continuous use of agricultural lands accentuates soil nutrient 'mining' which has caused crop production to be stagnated or on a rapid decline. The problem of nutrient depletion must therefore be urgently addressed; so as to prevent the rapidly declining agricultural output from jeopardizing the sustainable economic growth. Reduction of soil organic matter content is also becoming a prominent aspect of soil degeneration, particularly in Nigeria, therefore, soil fertility restoration and management must target raising the available nutrient status and maintaining organic matter content at high levels. The relative cost and ease of availability are parts of the factors considered in the choice of fertilizers selected [7]. However, the results of several studies comparing organic and inorganic fertilizers in terms of supplying an equivalent amount of nitrogen (N) have favoured organic fertilizers due to their competence in improving soil's physical attributes and nutritional qualities, including microbiological activities [8]. These positive effects are noticeable in soil fruitfulness and productivity [9]. Proper investigation of organic fertilizers, particularly manures and composts, could be profitable means of soil fertility improvement for sustainable production of vegetables, such as worowo.

Composts, made from the regulated and monitored biological breakdown of organic materials, sterilized, stabilized and cured, had been a valuable ingredient in organic farming. They maintain plant growth through alleviation of the nutritional, physical and biological aspects of soils and by increasing soil organic matter quality and quantity, as well as the number, diversity, and activity of soil organisms [10]. The use of mineral fertilizers alone increases crop yields only for a few years after which yields decline due to increase in soil acidity level which would definitely enhance nutrient imbalance and toxicity [11,12].

In Nigeria, worowo is a common, volunteer, under-storey plant in cocoa plantations found in the lowland rainforest and dry upland forest especially in the south-west zone. The decline in cocoa production due to the concentration of national economy on petroleum resources, as well as seasonal wild fire destroying the farms, had led greatly to a serious decline in the production of worowo. This decline has led to the vegetable becoming scarce and often costlier than Amaranthus spp, Celosia argentea or Corchorus olitorius vegetables [5]. Cultivation of worowo is practised on a small scale mainly in south-western part of Nigeria where sales of the succulent vines, in small bunches, is predominantly in urban markets. Increased and optimum production of this neglected and under-exploited indigenous vegetable will greatly increase the income of farmers and traders, particularly women, and therefore contribute to alleviating rural poverty. This desired enhancement can only be realized through the accelerated production of this vegetable and one of the cultural requirements is soil fertility management. However, there is paucity of information on nutrient requirements for optimum production of worowo. Research investigations therefore become necessitated, to ascertain the soil fertility requirements of worowo vegetable in order to develop recommendations which farmers could adopt to attain optimum production.

Worowo is an important source of nutritive substances, particularly in rural areas, where these are often lacking in regular daily meals. This indigenous, under-exploited leaf vegetable is highly nutritional and medicinal and has valuable nutrient composition [13]. It is medicinally important and had been reportedly used for treatments of diabetes, high blood pressure and infertility [14]. Its increased cultivation, with a view to making it available at cheap prices in food markets then becomes a necessity. This further underscores the need for the development of management practices which will facilitate its optimal production. One of the components of improved cultural practices for crops is nutrient management, especially the use of organic fertilizers [15] whose effects have been more beneficial on soils in the tropics than the supply of nutrients from inorganic fertilizers [8]. Organic agricultural approaches that enhance natural nutrient supply systems are therefore being advocated, in the recent times. Unfortunately, despite the importance and long history of composts in agriculture, low nitrogen contents have been the major limitation. This creates a serious challenge for organic farming when it comes to getting enough nitrogen during the growth and developmental stages of plants [16,17]. The implication is that the extent to which N in the compost would support crop performance is limited and additional N input is inevitable. This thereby necessitates efforts aimed at identifying the possible materials available, for improvement of N content of composts at low cost. Such efforts had been in the: - fortification of manures with inorganic N fertilizers and mineral ores, complementary use of manure-chemical fertilizers, development of organo-mineral soil additives [18], use of microbiotic enzymes to improve decay/rotting woody substances [19] and bio scientifically-energetic materials [20]. However, Fawole et al. [21] reported the use of agricultural wastes: cattle bone, hoof, blood and horn and leaves of plants, such as neem and Mexican sunflower which were collected, desiccated, ground and made into meals, for effective composts' enrichment.

This study therefore identified the most suitable organically N-enriched compost for improved and optimum production of worowo *(Senecio biafrae).*

Materials and Methods

The study site

This research was undertaken at Ekiti State University's Teaching and Research Farm, Iworoko Ekiti road, Ado-Ekiti, Nigeria, which is strategically placed between latitude 7°15' and 8°5'N, and longitude 4°45' and 5°13'E, in south-western Nigeria. The site is situated inside the rain forest zone. Mean annual temperatures of 28°C and 27°C were recorded for the assumed hottest months; February and March, respectively. The average sunshine hours per day are approximately 5 hours, per year, while the mean annual radiation is 130 k cal/cm^2/year. The major soil types identified are Iregun, Apomu and Ondo Series, derived from the dominating crystalline igneous and metamorphic rocks, evolving from the pre-Cambrian cellar complex of south western Nigeria [22]. Arable and cash crops, such as vegetables, maize, yam, cassava, cocoa and kola nut, are the major agricultural crops of the area.

The soil of the experimental site was sparingly acidic with pH of 5.8 and 6.6 in KCl and water, respectively. It was loamy sand with organic matter content at 14.6 g/kg. Soil N was 0.8 g/kg; P was 13 mg/kg and the interchangeable cations; K, Ca, Mg and Na were sequentially recorded as: - 0.3, 7.0, 1.8 and 0.1 cmol/kg [21,23].

The treatments

The two composts were alkaline with pH at 8.0 and 8.3 for poultry droppings/sawdust (PDS) and cow dung/sawdust (CDS) respectively. The CDS had higher contents of total N and K (6.4 and 6.1 g/kg) while PDS contained higher total P (23.0 g/kg) [21,23]. The composts, which were enriched to 60 g/kg N using the different enrichment materials, were used in the pot experiment. There were 16 treatments:

CDS- Cow dung/Sawdust with no enrichment.
CDSBM- Cow dung/Sawdust enriched with Blood meal at 60 g/kg N.
CDSBnM- Cow dung/Sawdust enriched with Bone meal at 60 g/kg N.
CDSHnM- Cow dung/Sawdust enriched with Horn meal at 60 g/kg N.
CDSHM- Cow dung/Sawdust enriched with Hoof meal at 60 g/kg N.
CDSTM- Cow dung/Sawdust enriched with Tithonia meal at 60 g/kg N.
CDSNM- Cow dung/Sawdust enriched with Neem meal at 60 g/kg N.
PDS- Poultry droppings/Sawdust with no enrichment
PDSBM- Poultry droppings/Sawdust enriched with Blood meal at 60 g/kg N.
PDSBnM- Poultry droppings/Sawdust enriched with Bone meal at 60 g/kg N.
PDSHnM- Poultry droppings/Sawdust enriched with Horn meal at 60 g/kg N.
PDSHM- Poultry droppings/Sawdust enriched with Hoof meal at 60 g/kg N.
PDSTM- Poultry droppings/Sawdust enriched with Tithonia meal at 60 g/kg N.
PDSNM- Poultry droppings/Sawdust enriched with Neem meal at 60 g/kg N.
NPK- Inorganic fertilizer for comparism.
CONTROL- Soil alone i.e. no nutrient source added

Each treatment was replicated thrice and the experimental design was completely randomized design.

Planting

The pots (of 4 m^3 volume each) contained 5 kg soil which was treated with composts at 60 g/kg N enrichment, applied at 30 t/ha and NPK 15-15-15, which was thereafter utilized in the assigned pots at 400 kg/ha (60 kg N/ha). Bunches of worowo vegetables were obtained from Erekesin market (Oja Oba) in Ado-Ekiti. Worowo stems were defoliated and cut to 20 cm in length, and were thereafter planted at the rate of four stems per pot a week after mixing the enriched composts with the soil and the pots were kept under shade. At 2 weeks after planting, the best two stands were retained in each pot. At 2 weeks after planting, application of NPK 15-15-15 to the allotted pots was done and weeds were uprooted from the pots as necessary at 30, 90 and 150 days after planting. The metrics measured in the study include; vine length, number of leaves and branches on individual plants, vine girth, leaf area index-LAI (which is calculated by dividing the obtained leaf area values of plants with the area of the total space used up by the particular crop plant), and edible shoot yield (ESY). The measurements were taken at 60, 120 and 180 days after planting. Matured edible shoots, at 20 cm away from soil surface were harvested as marketable produce, with stumps left in pots for further studies. The data generated were submitted to analysis of variance test, adopting Duncan's Multiple Range Test at $\alpha_{0.05}$, in separating the means.

Results

Table 1 shows the effect of composts fortified to 60 g/kg N, with the organic N-rich substances on worowo's growth and yield at 60 days after planting. The CDSNM treatment gave the longest vines of 135.00 cm, though not significantly different from PDSBM which

Table 1: Effects of Organic-N-enriched composts on worowo's growth and yield at 60 DAP in pot experiment.

Treatment	Vine Length (cm)	Number of Leaves	Stem Girth (cm)	Leaf Area index	Edible Shoot Yield (t/ha)
CDSNM	135.00a	38.00a	3.23a	3.97a	19.47a
PDSBM	116.33ab	35.67ab	2.93abc	3.07abc	15.07abc
CDS	114.33ab	37.33a	3.10ab	3.50ab	18.00ab
PDSNM	102.33ab	36.00abc	2.87abc	2.40c	14.27abc
CDSBnM	101.33ab	36.33ab	2.80bc	2.30cd	13.20abcd
PDSTM	93.33abc	28.67abc	2.83abc	2.10cd	13.33abcd
CDSHM	88.67abc	32.33abd	2.90abc	3.80ab	12.40abcd
NPK	79.67abc	34.00abd	2.77bc	2.30cd	14.13abc
PDSHM	77.67abc	34.33abc	2.63c	1.90d	12.80abcd
CDSTM	74.00abc	27.00abd	2.93abc	2.40c	10.13abcd
CDSBM	70.33bc	25.00bd	2.67c	1.20cd	9.73abcd
PDSBnM	68.00bc	22.33d	2.83abc	1.50cd	8.40bcd
CONTROL	65.00bc	33.00abd	2.67c	1.70cd	13.87abc
PDSHnM	64.00bc	26.33abd	2.80bc	1.90cd	6.27cd
CDSHnM	55.00bc	26.33abd	2.60c	1.40cd	7.73cd
PDS	36.33c	24.33c	2.67c	1.30cd	3.73d

Means with the same alphabets in the same column do not differ significantly at $\alpha_{0.05}$.

Legend
DAP = Days After Planting
CDSNM = Cattle dung plus sawdust plus neem
PDSBM = Poultry dung plus sawdust plus blood
CDS = Cattle dung plus sawdust
PDSNM = Poultry dung plus sawdust plus neem
CDSBnM = Cattle dung plus sawdust plus bone
PDSTM = Poultry dung plus sawdust plus tithonia
CDSHM = Cattle dung plus sawdust plus hoof
PDSHM = Poultry dung plus sawdust plus hoof
CDSTM = Cattle dung plus sawdust plus tithonia
CDSBM = Cattle dung plus sawdust plus blood
PDSBnM = Poultry dung plus sawdust plus bone
PDSHnM = Poultry dung plus sawdust plus horn
CDSHnM = Cattle dung plus sawdust plus horn
PDS = Poultry dung plus sawdust

Had a vine length of 116.33 cm while the CDSNM produced vine lengths that differed significantly from CDSBM, PDSBnM, PDSHnM, CDSHnM, CONTROL and PDS. The PDS treatment had the shortest plants (36.33 cm) and was only significantly lower than CDSNM, PDSBM, CDS, PDSNM and CDSBnM. The CDSNM treatment produced the leafiest vegetables (38.00) which were significantly leafier than CDSBM, PDSBnM and PDS. Plants treated with CDS produced 37.33 leaves and PDSBnM, the least leaves (22.33). The stem girth followed a similar trend as number of leaves with CDSNM and CDS having the highest values (3.10-3.23 cm) while the thinnest vegetables (2.60 cm) were produced by CDSHnM. The leaf area index showed significant differences at $\alpha_{0.05}$. The highest values were obtained from CDSNM (3.97) followed by CDSHM (3.80) which significantly differed from the values from all other treatments except PDSBM, CDS, PDSNM, CDSBnM, PDSTM, NPK and CDSTM. The least leaf area index value was obtained from CDSBM (1.20). The worowo yield from CDSNM (19.47 t/ha) was best, and significant from yields obtained for PDSBnM, PDSHnM, CDSHnM and PDS treated pots.

Table 2 displays the consequent effects of the enriched composts on the growth and yield of worowo at 120 DAP. The CONTROL treatment produced the longest vines (73.33 cm), though not significantly different from NPK and CDSNM. The shortest vines were 27.00 cm and obtained from PDSHnM. The CDSNM treatment produced more leaves (45.67) than all other treatments and was significantly higher than CDSBM, PDSBnM, CDSHnM and PDS. Pots treated with CDSNM produced the thickest vegetables at 3.47 cm and was significant to PDSHM, CDSBM, CONTROL, PDSHnM, CDSHnM and PDS. The least stem girths were from the PDSHM and CDSHnM. Pots treated with CDS gave the highest leaf area index (4.94) and was followed by CDSHM and differed significantly from CDSHnM and PDS. Leaf area index values obtained for all other treatments did not differ significantly. The CDSNM and CDS treated pots gave highest yield values (18.80 and 17.20 t/ha respectively).

Table 2: Effects of Organic-N-enriched composts on worowo's growth and yield at 120 DAP in pot experiment

Treatment	Vine length (cm)	Number of leaves	Stem girth (cm)	Leaf area index	Edible shoot yield (t/ha)
CDSNM	65.00ad	45.67a	3.47a	4.51abc	18.80a
PDSBM	30.67bc	42.67abcd	3.20ab	4.47abc	13.33ab
CDS	48.00abc	45.00ab	3.33a	4.94a	17.20ac
PDSNM	52.33abc	41.33abcde	3.07abc	4.77ab	12.67ab
CDSBnM	38.33bcd	43.67abcd	3.30ab	3.53abc	12.00ab
PDSTM	55.67abc	41.67abcde	3.13abc	3.89abc	12.40ab
CDSHM	61.00ab	44.33abc	3.27abc	4.90a	11.33ab
NPK	70.00ad	41.33abcde	3.03abc	4.19abc	12.27ab
PDSHM	52.33abc	43.00abcd	2.83c	3.67abc	11.33ab
CDSTM	37.67bcd	35.00abcde	3.17abc	3.98abc	9.33ab
CDSBM	28.67bc	32.67de	2.90bc	2.49abc	8.13ab
PDSBnM	40.00abc	30.33e	3.07abc	2.82abc	12.00ab
CONTROL	73.33a	41.33abcde	2.93bc	3.76abc	12.27ab
PDSHnM	27.00c	39.33abcde	3.00bc	2.79abc	5.20ab
CDSHnM	48.00abc	33.33cde	2.83c	1.85bc	3.33bc
PDS	56.67abc	32.33de	2.93bc	1.80c	2.67b

Means with the same alphabets in the same column do not differ significantly at $\alpha_{0.05}$.

Legend
DAP = Days After Planting
CDSNM = Cattle dung plus sawdust plus neem
PDSBM = Poultry dung plus sawdust plus blood
CDS = Cattle dung plus sawdust
PDSNM = Poultry dung plus sawdust plus neem
CDSBnM = Cattle dung plus sawdust plus bone
PDSTM = Poultry dung plus sawdust plus tithonia
CDSHM = Cattle dung plus sawdust plus hoof
PDSHM = Poultry dung plus sawdust plus hoof
CDSTM = Cattle dung plus sawdust plus tithonia
CDSBM = Cattle dung plus sawdust plus blood
PDSBnM = Poultry dung plus sawdust plus bone
PDSHnM = Poultry dung plus sawdust plus horn
CDSHnM = Cattle dung plus sawdust plus horn
PDS = Poultry dung plus sawdust

And both differed significantly from CDSHnM and PDS. The least yield (2.67 t/ha) came from the PDS pots.

Table 3 shows that worowo from CDSNM had the longest vines (33.33 cm) at 180 DAP which were not significantly different from CDSBnM, PDSTM, CDSHM, CDSTM and PDSBnM. The PDSNM gave the shortest vines of 21.33 cm. The highest number of leaves at 180 DAP was observed from CDSNM with 21.00 leaves followed by CDSHM and were not significantly different from CDSBnM, PDSTM, CDSHM, NPK and CDSTM. The lowest number of leaves was from PDSBnM which produced 12.00 leaves. Pots treated with CDSNM produced the thickest vines (4.03 cm) while PDSHM gave the least stem girth (3.13 cm). Leaf area index was highest in CDSNM with leaf area index value of 2.44 but was not significantly different from PDSTM, CDSHM and CDSTM. The least leaf area index (0.74) was obtained in the PDS treatment. Quantity of worowo (16.67 t/ha) harvested from CDSNM treated pots was highest, and more than the vegetables harvested from the CDS treated pots with 15.73 t/ha, but the two were not significantly different. The least yield values were recorded from PDS.

Table 4 shows the sum of these parameters obtained at 60, 120 and 180 DAP. The CDSNM treatment gave the highest values for all the parameters except in leaf area index where CDSNM and CDSHM had same values. The CDS-based treatments gave the best three values for each parameter such that CDS enriched with neem leaf meal gave the best vegetative growth and yield performance of worowo.

Discussion

The low nutrient state of the soils of study site which might have been caused by ceaseless nutrient mining by crop removal without adequate replenishment [24], soil formation processes, geographical location, climate, irrigation water

Table 3: Effects of Organic-N-enriched composts on worowo's growth and yield at 180 DAP in pot experiment.

Treatment	Vine length (cm)	Number of leaves	Stem Girth (cm)	Leaf Area index	Edible Shoot Yield (t/ha)
CDSNM	33.33a	21.00a	4.03a	2.44a	16.67a
PDSBM	20.67d	13.00cd	3.50abcde	1.60bcd	10.67abc
CDS	23.00cd	14.33bcd	3.87abc	1.58bcd	15.73a
PDSNM	21.33cd	12.33cd	3.37cde	1.42bcde	10.27abc
CDSBnM	28.00abc	17.33abcd	3.60abcde	1.13bde	10.00abc
PDSTM	28.33abc	18.33abc	3.77abc	1.95ac	10.27abc
CDSHM	30.67ab	19.67ab	3.77abc	2.17ac	12.93ab
NPK	26.00bcd	15.00abcd	3.37cde	1.55bcd	10.13abc
PDSHM	21.67cd	13.33cd	3.13e	1.17bde	8.80abc
CDSTM	26.67abcd	15.00abcd	3.67abcd	1.70abc	8.00abc
CDSBM	23.67bcd	13.67bcd	3.20de	1.06bde	5.60bc
PDSBnM	26.33abcd	12.00d	3.37cde	1.13bde	5.07bc
CONTROL	23.67bcd	13.33cd	3.23de	1.27bde	10.80abc
PDSHnM	21.67cd	13.67bcd	3.27de	0.90de	3.87bc
CDSHnM	24.67bcd	14.00bcd	3.33cde	1.18bde	2.40c
PDS	25.00bcd	13.33cd	3.23de	0.74e	1.60c

Means with the same alphabets in the same column do not differ significantly at $\alpha_{0.05}$.

Legend
DAP = Days After Planting
CDSNM = Cattle dung plus sawdust plus neem
PDSBM = Poultry dung plus sawdust plus blood
CDS = Cattle dung plus sawdust
PDSNM = Poultry dung plus sawdust plus neem
CDSBnM = Cattle dung plus sawdust plus bone
PDSTM = Poultry dung plus sawdust plus tithonia
CDSHM = Cattle dung plus sawdust plus hoof
PDSHM = Poultry dung plus sawdust plus hoof
CDSTM = Cattle dung plus sawdust plus tithonia
CDSBM = Cattle dung plus sawdust plus blood
PDSBnM = Poultry dung plus sawdust plus bone
PDSHnM = Poultry dung plus sawdust plus horn
CDSHnM = Cattle dung plus sawdust plus horn
PDS = Poultry dung plus sawdust

Table 4: Cumulative effects of composts enriched with organic N-rich sources on worowo's growth and yield at 60, 120 and 180 DAP in the pot experiment.

Treatment	Vine length (cm)	Number of leaves	Stem girth (cm)	Leaf area index	Edible shoot yield (t/ha)
CDSNM	233.33a	104.67a	10.73a	11.00a	54.93a
PDSBM	167.67ab	91.33ab	9.63ab	9.10abc	39.07ab
CDS	185.33ab	96.67ac	10.30abc	10.00ab	50.93ab
PDSNM	176.00ab	89.67ab	9.30bc	8.60bc	37.20ab
CDSBnM	167.67ab	97.33ab	9.70ab	6.90ce	35.20abc
PDSTM	177.33ab	88.67abcd	9.73ab	8.00c	36.00abc
CDSHM	180.33ab	87.67abcd	9.93ab	11.00a	36.67abc
NPK	175.67ab	90.33ab	9.17b	8.00c	36.53abc
PDSHM	151.67b	90.67ab	8.60b	6.70cd	32.93abc
CDSTM	138.33b	77.00bc	9.77ab	8.10bc	27.47abc
CDSBM	122.67b	71.33bd	8.70b	4.80df	23.47bc
PDSBnM	134.33b	64.67d	9.27bc	5.50def	25.47bc
CONTROL	162.00ab	87.67abcd	8.83b	6.70cd	36.93ab
PDSHnM	112.67b	79.33bc	9.06bc	5.60def	15.33bc
CDSHnM	127.67b	73.67bc	8.77b	4.40f	13.47bc
PDS	118.00b	70.00bd	8.83b	3.84f	8.00c

Means with the same alphabets in the same column do not differ significantly at $\alpha_{0.05}$.

Legend
DAP = Days After Planting
CDSNM = Cattle dung plus sawdust plus neem
PDSBM = Poultry dung plus sawdust plus blood
CDS = Cattle dung plus sawdust
PDSNM = Poultry dung plus sawdust plus neem
CDSBnM = Cattle dung plus sawdust plus bone
PDSTM = Poultry dung plus sawdust plus tithonia
CDSHM = Cattle dung plus sawdust plus hoof
PDSHM = Poultry dung plus sawdust plus hoof
CDSTM = Cattle dung plus sawdust plus tithonia
CDSBM = Cattle dung plus sawdust plus blood
PDSBnM = Poultry dung plus sawdust plus bone
PDSHnM = Poultry dung plus sawdust plus horn
CDSHnM = Cattle dung plus sawdust plus horn
PDS = Poultry dung plus sawdust

Applied, cropping history and tillage practices (including continuous cropping) made them to be suitable for the experiments [25].

In this research work, composts made from poultry dung integrated with sawdust and cattle dung integrated with sawdust were enriched with organic N-rich sources up to 60 kg N/ha and utilized for cultivation of worowo. The experiment indicated that

CDSNM gave the highest values in all growth indices measured. It notably increased the plant height, number of leaves, stem girth, leaf area index and output of worowo. This superior performance of CDSNM might not be unconnected with the best N quantity it mineralized, among others and which incessantly increased throughout the period of incubation to investigate the nutrient statuses of these different enriched composts [21].

The better performance of some of the compost treatments, most especially cow dung mixed with sawdust which was enriched with neem CDSNM and CDS compost over inorganic fertilizer (NPK) recorded in this study had been earlier observed and reported by Omolayo et al. [25] and Fawole [26] who observed that additions of various organic wastes, including plants and animal manure, especially poultry droppings could be effective for sustainable production of vegetables. The more excellent performance of CDSNM over NPK could also further be ascribed to the enrichment of the composts with the various N-rich organic sources. Adediran et al. [27] concluded that the performance of composts was enhanced when the N level was supplemented with urea as N source. More still, the notable impact of CDSNM, which was closely followed by CDS in this study, on the growth and yield of worowo *(Senecio biafrae)*, could also be explained in terms of the restoration power of the organic materials used; both the soil treatments and the enrichments are environment friendly and would ensure proper soil management and interactions in the soil community and environment. Khosro et al. [28] submitted that organic manure increased yield by altering soil physical properties, increasing soil fertility, increasing beneficial microbial populations and activity. This submission is also in line with the findings of Ahn [8] who submitted that many experiments conducted to compare organic manure with chemical fertilizers to supply an equivalent amount of N, had often ended in favour of manure application because of the ability of manure to modify the soil physical, biological and chemical properties. This might be due to the fact that some of the microorganisms which could help to improve the soil physical and chemical structures and hence aid plant growth might have been adversely affected by the addition of NPK fertilizer which at times tends to be hot and toxic to the micro-organisms.

The vine length and ESY of the vegetables decreased for all treatments at 120 DAP, with the CDSNM remaining the best in all parameters, while the number of leaves, vine girth and leaf area index however increased. The same trend was observed at 180 DAP as the vine length, number of leaves, leaf area index and the edible shoot yield (ESY) decreased in values. The reduction in these parameters was thought to be due to the effect of cutting of the vines during harvest, on the vegetable growth and yield; more work is however suggested to confirm this occurrence. The vine girth of the vegetables however increased all through the period of the study, thereby indicating that, the longer the worowo vegetables stay on the field, the more likely for the vines to become bigger/thicker. The CDSNM however remains the highest in ESY while PDS remained the lowest. The performance of some of the composts in this study, particularly, the CDSNM is therefore an indication that composts can be used to replace NPK in soil fertility remediation and sustainable cultivation of worowo. The low organic matter contents and fertility status of tropical soils, as well as the nutritive qualities of experimental soil [6], would resultantly negatively affect the productivity and sustainability of worowo vegetables if the soils were not treated with composts/enriched composts. Adediran et al. [27] compared the effectiveness of organic-based fertilizer with mineral fertilizer on crop yield and concluded that the application of organic-based fertilizer improved the nutrient status of the soil and the maize grain yield and also gave high residual effects on soil fertility. This was eminent in the performance of CDS as compost, though not enriched with any of the organic N-rich sources.

The superiority of organic-based fertilizers over the mineral fertilizers could also be attributed to the fact that different bacteria and fungi break down chemicals, plant matter and animal wastes into productive soil nutrients which would make soils treated with any form of organic fertilizer higher in nutrients [29]. Kekong et al. [30] demonstrated and validated the effectiveness of cattle dung and poultry dung in improving the fertility status of savannah and rainforest soils for sustainable vegetable production. In this study, the CDS, and some of the CDS and PMS enriched with organic wastes (CDSNM, PDSBM, PDSNM, PDSTM, and CDSHM) compared well with NPK in all the parameters measured, despite the quick nutrient-releasing ability of NPK. The ESY values (in t/ha) were in the order: - CDSNM- 54.93> CDS- 50.93> PDSBM- 39.07> PDSNM- 37.20> CDSHM- 36.67> NPK- 36.53> PDSTM- 36.00. Edible shoot yield of worowo with Cattle dung+Sawdust compost enriched with neem leaves (CDSNM) at 60 g N/kg was the highest ESY value recorded from the experiment, though not significantly different from CDS, PDSBM, PDSNM, PDSTM, CDSHM, NPK, CDSBnM, PDSHM and CDSTM. With the recorded performance, the persistent use of the organically enriched composts might cause them to outperform the synthetic/inorganic fertilizer [11,12]. The growth indices and ESY of CDSNM which were observed to be higher than those recorded from CDS-treated pots corroborated the findings of Adeyemi and Omotoso (2023) who concluded that the enriched composts were comparable to NPK 15-15-15 and various composts used. They submitted that enriched composts would effectively replace inorganic fertilizers for soil management and improvement, especially while putting the life cycle of crops into consideration, invariably implying that productions of both short and long-seasons crops would be favoured and improved and sustained by the use of the enriched composts.

Conclusion

From the study, it was observed that: -

a) There were significant differences (P =0.05) in the vine length, number of leaves, leaf area index, vine girth and marketable yield of worowo among all the enriched composts applied at 30 t/ha in the experiment.

b) The CDSNM gave the best values in vine length, number of leaves, vine girth, leaf area index and edible shoot yield of worowo.

c) The edible shoot yield (ESY) of worowo with Cattle dung+Sawdust compost enriched with neem leaves to 60 g N/kg was better than that of mineral fertilizer NPK.

d) The longer the worowo stays on the field, the thicker the vines are likely to be.

e) The CDS and PMS enriched with N-rich organic wastes compared well with NPK in all the parameters measured, despite the quick nutrient-releasing ability of NPK.

The enriched composts, particularly 30 t/ha CDSNM, at 60 g N/kg, which produced the highest marketable yield (ESY) of worowo *(Senecio biafrae)* could therefore be recommended for optimum production of worowo. This invariably implies that the enriched composts, CDSNM in particular would effectively replace inorganic fertilizers in soil maintenance, improvement and restoration.

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