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Effects of Plant Leaf Wastes on the Growth and Yield Performance of Three *Amaranthus* Species

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Abstract

The aim of this work was to study the effect of leaf wastes from *Moringa oleifera* (MO), *Terminalia catappa* (TC) and *Terminalia mantaly* (TM) on the growth and yield performance of three parameters of *Amaranthus* species: *A*. *tricolor* (AT), *A*. *blitum* (AB) and *A*. *dubius* (AD). This experiment was carried out in a randomised complete block design. Data were collected on visible characters before and after treatment applications and analysed using descriptive and inferential statistics (ANOVA). Highest seedling vigour (6.00±0.01) was recorded in the control AT plants (without treatments) while the tallest plants were observed (20.12±0.02) in AB species treated with TC (100g). The shortest plant height was 18.12±0.10 recorded in AT species treated with TC at 200g application. Number of leaves was highest (31.02±0.11) in AC plant treated with TC at 100g while number of leaves was lowest (24.89+0.12) in the same species treated with NPK (1.5g). Plant was highest (15.33±0.04) in the AB plant under the TC treatment at 200g. Stem circumference was highest (1.44+0.00) in AC under TC treatment at 100g application and lowest (0.9+0.04) in AC under the same treatment at 100g application. No significant difference was ($p > 0.05$) was obtained in all parameters under study. Application of TM leaf wastes had no significant effect ($p > 0.05$) on the germination of *Amaranthus* seeds across the different treatment rates. Almost the same germination count and germination percentage (3.00+0.00) (100.00+0.34)) was recorded across the different levels of varieties except in AT variety under the NPK (1.5g) treatment and control experiment. Highest seedling vigour (6.00+0.03) was recorded in AT plants. Therefore, *Terminalia catappa* was the most effective organic manure compared to other compost types. The *Amaranthus tricolor* (AT), and *Amaranthus cruentus* (AC) species responded better to the application of leaf manures followed by the *Amaranthus blitum* (AB). A combination of the three organic manures produced better growth output than their single nature. Therefore, the use of leaf compost is recommended in the sustainable production of leafy vegetables and to avert the environmental problems associated with inorganic fertilizers.

Keywords

Amaranthus, Leaf Litters, Productivity, Manure, Animal Wastes, Environment

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1. Introduction

Amaranth belongs to the family *Amaranthaceae*. They are considered as the most highly popular group of vegetables. Amaranth family consists of more than 60 species most of which are widely dispersed weeds. Amaranth does not belong to the grass family as other cereals do but produce seeds which are grains and are classified into the family of pseudo cereals. Most of the amaranths species are harvested in the wild as food source. Only a few are grown for the seeds. This is the case of some introduced varieties of American origin [1]. Both leaves and seeds contain protein of an unusually high quality. The leaves of both the grains and vegetable

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types may be eaten raw or cooked. Amaranths grown principally for vegetable use have better tasting leaves than the grain types. Grain Amaranths is not commonly cultivated in Africa [2]. Vegetable amaranths is usually grown commercially as a sole food crop and in home gardens. Over 400 varieties within the species are found throughout the world in both temperate and tropical climate and fall roughly into one of the four categories: grain, vegetable, ornamental or weed. Amaranths is a crop that can grow on poor soils, it can withstand drought and heat, early maturating hardly attacked by pest, widely adaptable and above all nutritious and high yielding in South western Nigeria, under dry conditions, seed yields from 1 to 6.7 tones/ha and a green material of up to 70 tonnes are harvestable [3]. Thus this is promising future crop with potential to contribute due to large amount of biomass produced in a short period of time and it is a vegetable crop which can be a cheap alternative rich source of protein and nutrients for poor people in developing countries [4].

The presence of organic matter in the soil is fundamental in maintaining the soil fertility and decreasing nutrient losses. Organic matter continues to enhance soil fertility, soil structure and soil holding capacity. The compost adds air space to the soil and incorporating it alleviates compacted conditions [5]. Adding compost increases the water holding capacity of sandy soils, reducing drought damage to plants. When added to heavy clay soils compost improve drainage and aeration. Amending soils with compost may also reduce the incidence of damping off diseases and root rots [6]. Some of the problems encountered by amaranth growers in Nigeria are the low soil fertility and lack of capital to buy chemical fertilizers for optimum crop productivity. Most African soils are inherently low in organic carbon, slightly acidic and relatively sandy. Litters improve soil quality through adding the organic matter and nutrients to the soil. Leaf litter is the main and fastest source of organic matter and nutrients to soil compared to other litter types. The nutrients in litters were added to the soil through microbial decomposition and physical leaching of soluble components followed by microbial oxidation of refractory components [7]. Presently in Nigeria, vegetable farmers always heap poultry droppings around them that they need not pay money for the collection this is compared to litter collection where the litters are seen as waste in our environments. Amaranths respond well to good soil fertility and organic matter. To increase the availability of high quality amaranth there is need to use organic fertilizers such as manure and composts which is the most available or can be found in large quantities in local areas. This study therefore, sought to assess the growth and yield performance parameters of three species of *Amaranthus* (*A. tricolor*, *A. blitum*, *A. dubius*). under application of organic manure from decaying leaf litters.

2. Materials and Methods

2.1. Study Area

The experiment was conducted in the botanical garden of the Federal university of Agriculture, makurdi, Benue state. A suitable area was chosen within the garden close to the school water works for irrigation The soil type was loamy, rich in humus with a texture comprising of sand, slit and clay. It was very suitable for growing vegetables.

2.2. Sample Collection and Identification and Preparation

Amaranthus seeds varieties were obtained from the University Seed Centre, University of Agriculture makurdi. Fresh leaf of *Moringa oleifera, Terminalia catappa* and *Terminalia mantaly* were collected from uncultivated field within the campus. All plant samples were identided ny taxonomists in the Department of Botany, University of Agriculture Makurdi Leaves were rinsed with distilled water to remove any external contaminants. They were soaked in clean water for two weeks until they decomposed and were set ready for the experiment.

2.3. Experimental Design

This experiment was carried out in a completely randomized block design. Three species of *Amaranthus* seeds were used for this experiment. The seeds were planted in polythene bags. The three verities were code named A, B, and C. Variety A was planted in thirty six bags labelled Ax_1, Ax_2, Ax_3,..... Ax_{36} respectively. The same arrangement was done for sample B and C which was labelled Bx_1, Bx_2, Bx_3,..... Bx_{36}, and Cx_1, Cx_2, Cx_3..... Cx_{36}. The treatment was done singly and in combined form. The treatment was done as follows. NPK fertilizer was used as a positive control in the experiment, where it was applied at the same rate in four different experimental set up respectively across the three species of *Amaranthus* planted. A neutral control in which no treatment was applied was also among the experimental set. The total number of experimental set up (bag) for this experiment was 108 bags comprising of all treatments and their respective replicates for the three species. All treatment were applied 21 days after planting.

2.4. Experimental Procedure and Data Collection

Seeds were sown in 5kg of soil in polythene bags at 5 seeds per bag. The soil was properly sorted to remove dead plants and other materials that may alter the result of the

experiment.. The soil containing the seeds was watered twice daily, morning and evening throughout the period of the experiment. Data on growth yield were collected and recorded weekly starting from week three throughout the period of the experiment.

2.5. Data Analysis

The data collected from this experiment were subjected to analysis of variance (ANOVA) using Genstat statistical package (3rd edition).

Table 1. Effect of Decomposition of Leaf Litter of *T. catappa* on germination of *Amaranthus* plant.

Varieties	Treatments	Germination count	%germination	Seedling vigour
	Tc (100g)	3.00±0.01	50±0.33	2.100±0.00
	Tc (200g)	3.00±0.03	60±0.01	2.355±0.02
AT	NPK (1.5g)	2.50±0.01	50±0.33	3.605±0.04
	NPK (3.00g)	3.00±0.00	60±0.02	2.755±0.032
	CLT	3.00±0.00	60±0.00	4.56±0.012
	Tc (100g)	3.00±0.00	60±0.01	3.500±0.043
	Tc (200g)	3.00±0.01	60±0.01	3.375±0.02
AC	NPK (1.5g)	2.00±0.00	40±0.02	1.785±0.01
	NPK (3.00g)	2.50±0.00	50±0.02	2.335±0.03
	CLT	3.00±0.00	60±0.00	4.16±0.04
	Tc (100g)	3.00±0.00	60.00±0.10	2.055±0.02
	Tc (200g)	3.00±0.00	60.00±0.01	2.500±0.03
AB	NPK (1.5g)	3.00±0.00	60±0.20	2.925±0.31
	NPK (3.00g)	2.50±0.00	50±0.031	2.425±0.12
	CLT	3.00±0.00	60±0.11	3.057±0.434
LSD (≤0.05)		0.2191	4.381	0.4095

Amaranthus tricolor (AT), Amaranthus cruentus (AC), Amaranthus blitum (AB).

3. Results

3.1. Effect of Decomposition of Leaf Litter of *T. catappa* on Germination of *Amaranthus* Varieties

The germination of *Amaranthus* varieties in response to the different rate of *Terminalia catappa* is presented in Table 1. No significant differences (p>0.05) were obtained in all the parameters under study. The *Terminalia catappa* treatment had no a significant effect (p> 0.05) on the germination of the *Amaranthus* seeds across the different treatment and treatment rates. Seedling vigour on the other hand, however showed significant differences cross the different varieties and manure types. The highest seed germination count for *Amaranthus* seeds however was recorded in the AT varieties were more of 100% was recorded more than all other verities, this percentage was recorded in all the treatment and treatment rates except for seeds planted in the NPK (3.00g). Highest seedling vigour (6.00±0.01) was recorded with AT seeds planted in the control experiment.

Table 2. Effect of Decomposition of Leaf Litter of *Terminalia catappa* on Growth of *Amaranthus* Varieties.

Varieties	Treatments	Plant height			Number of leaves		Plant spread		Leaf length	Stem circumference
		2WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP		
	Tc (100g)	9.33±0.01	14.25±0.03	19.89±0.31	21.12±0.32	29.46±011	11.10±0.11	15.40±0.04	3.27±0.02	0.9±0.04
	Tc (200g)	8.67±0.21	13.21±0.06	18.12±0.10	20.40±0.04	30.53±0.09	10.30±0.02	13.04±0.40	3.51±0.12	1.02±0.04
AT	NPK (1.5g)	7.12±0.01	13.00±0.13	18.03±0.51	19.30±0.11	28.10±0.20	8.60±0.23	12.30±0.24	3.10±0.11	1.05±0.00
	NPK (3.00g)	7.21±0.05	12.42±0.09	17.30±0.11	18.44±0.01	25.20±0.01	7.70±0.02	13.30±0.04	2.10±0.10	1.13±0.01
	CLT	7.03.±0.13	11.75±0.04	18.01±0.00	17.70±0.05	26.25±0.03	9.45±0.10	13.10±0.00	3.20±0.20	1.10±0.02
	Tc (100g)	7.91±0.12	15.60±0.07	20.12±0.02	21.88±0.30	31.02±0.11	8.45±0.11	14.00±0.03	2.05±0.00	1.44±0.00
	Tc (200g)	8.67±0.10	15.20±0.09	19.44±0.01	18.70±0.11	28.00±0.21	9.21±0.63	15.16±0.00	3.10±0.04	1.01±0.02
AC	NPK (1.5g)	7.50±0.00	14.10±0.21	18.32±0.05	17.80±0.01	27.20±0.02	8.20±0.21	13.50±0.11	2.90±0.08	1.30±0.01
	NPK (3.00g)	8.23±0.19	13.50±0.08	19.11±0.10	18.00±0.01	24.89±0.12	8.45±0.15	14.00±0.10	3.42±0.01	1.60±0.05
	CLT	7.53±0.93	12.76±0.12	20.01±0.02	16.40±0.06	26.82±0.32	9.90±0.12	13.75±0.04	3.03±0.07	1.15±0.01
	Tc (100g)	9.10±0.22	14.11±0.01	19.42±0.22	20.45±0.11	29.43±0.24	12.99±0.62	14.10±0.00	3.01±0.00	1.30±0.00
	Tc (200g)	8.20±0.15	13.04±0.00	19.88±0.04	19.71±0.10	29.07±0.21	13.00±0.10	13.91±0.32	4.54±0.30	1.10±0.90
AB	NPK (1.5g)	8.22±0.04	12.31±0.11	18.21±0.11	16.00±0.02	27.67±0.42	12.20±0.40	12.70±0.11	3.00±0.02	1.30±0.32
	NPK (3.00g)	7.45±0.13	13.50±0.12	18.57±0.23	18.00±0.03	27.23±0.01	8.40±0.66	13.50±0.02	3.82±0.01	1.05±0.01
	CLT	7.12±0.00	14.05±0.11	19.45±0.11	16.00±0.03	28.11±0.11	5.05±0.81	9.75±0.02	2.44±0.00	1.25±0.00
LSD (≤0.05)		0.000	0.0023	0.0043	0.0002	0.0002	0.0029	0.0053	0.0002	0.0003

Amaranthus tricolor (AT), Amaranthus cruentus (AC), Amaranthus blitum (AB).

3.2. Effect of Decomposition of Leaf Litter of *Terminalia catappa* on Growth of *Amaranthus* Varieties

The result for the effect of *Terminalia catappa* on growth performance of *Amaranthus* plant is as presented in Table 2. Significant differences ($p \leq 0.05$) were observed across the parameters measured due to the effect of the different manure type and treatment levels. Plant height was highest (20.12±0.02) in AC treated with *Terminalia catappa* (100g). The shortest plant height (18.12±0.10) was recorded at AT in the *Terminalia catappa* at 200g application. Number of leafs was highest (31.02±0.11) in AC with *Terminalia catappa* application at 100g. Number of leaf was however lowest (24.89±0.12) in the same seed variety but in the NPK (1.5g) experiment. Plant spread was highest (15.33±0.04) in the AB variety under the *Terminalia catappa* experiment of 200g application rate. It was however lowest (9.75±0.02) in the same seed variety in the control. Leaf length was highest (4.54±0.30) with the AB seed variety under the treatment at 200g application while it was lowest (2.05±0.00) at AC under the *Terminalia catappa* treatment at 100g application. Stem circumference was highest (1.44±0.00) at AC under the *Terminalia catappa* treatment at 100g application and lowest (0.9±0.04) AC under the same treatment at 100g application.

3.3. Effect of Decomposition of Leaf Litter from *Terminalia mantaly on* Germination of *Amaranthus* Varieties

Amaranthus varieties performed differently in response to different levels of *Terminalia mantaly* (Table 3). No significant differences ($p>0.05$) were obtained in all the parameters under study. The effect of *Terminalia mantaly* had no significant effect ($p> 0.05$) on the germination of the *Amaranthus* seeds across the different treatment and treatment rates. Almost the same germination count and germination percentage 3.00±0.00 (100.00±0.34) was recorded across the different interaction of varieties and manure application variety except 2.00±0.01 and 2.5±0.00 in AT variety under the NPK 1.5g treatment and control experiment respectively and 2.50±0.00, 1.00±0.00 and 2.500.00 obtained in AC variety under the *Terminalia mantaly* treatment 100g, NPK 1.5g and the control experiment respectively. In AB varieties, 2.00±0.00 was obtained in the *Terminalia mantaly* treatment at 3.00g and control experiment respectively while 2.50±0.03 was obtained under the NPK 3.00g experiment. Seedling vigour on the other hand, however showed significant differences across the different varieties and manure types. Highest seedling vigour (6.00±0.03) was recorded with AT seeds variety planted with *Terminalia catappa* 100g application rate while it was lowest (0.80±0.03) in NPK (3.00g) with AC variety.

Table 3. Effect of decomposition of leaf litter of *Terminalia mantaly* on germination of *Amaranthus* varieties.

Varieties	Treatments	Germination count	%germination	Seedling vigour
	Tm (100g)	3.00±0.00	60.00±0.03	3.235±0.23
	Tm(200g)	3.00±0.00	60.00±0.01	2.865±0.43
AT	NPK(1.5g)	2.50±0.01	50.00±0.33	3.605±0.04
	NPK (3.00g)	3.00±0.00	60.00±0.02	2.755±0.032
	CLT	3.00±0.00	60.00±0.00	4.56±0.012
	Tm (100g)	3.00±0.00	60.00±0.10	2.675.±045
	Tm(200g)	3.00±0.00	60.00±0.00	2.925±0.25
AC	NPK(1.5g)	2.00±0.00	40.00±0.02	1.785±0.01
	NPK (3.00g)	2.50±0.00	50.00±0.02	2.335±0.03
	CLT	2.50±0.00	60.00±0.00	4.16±0.04
	Tm (100g)	3.00±0.00	60.00±0.04	2.725±0.04
	Tm(200g)	2.00±0.00	40.00±0.03	1.715±0.02
AB	NPK(1.5g)	2.50±0.00	60.00±0.01	2.925±0.31
	NPK (3.00g)	3.00±0.03	50.00±0.00	2.425±0.12
	CLT	3.00±0.01	60.00±0.33	3.057±0.434
LSD(≤0.05)		0.0519	0.061	0.0654

Amaranthus tricolor (AT), Amaranthus cruentus (AC), Amaranthus blitum (AB).

3.4. Effect of Decomposition of Leaf Litter of *Terminalia mantaly* on Growth of *Amaranthus* Varities

The result for the effect of *Terminalia mantaly* on growth performance of varieties of *Amaranthus* plant is as presented in table 4 Significant differences ($p \leq 0.05$) were observed across the parameters measured due to the effect of the different manure type and treatment levels. On plant height, the overall best height (26.20±0.61) was recorded for AC variety treated with *Terminalia mantaly* (200g) followed by 24.10±0.02 obtained in the AB variety under the *Terminalia mantaly* 100g application rate. The shortest plant height (17.30±0.11) was recorded at AT variety treated with *Terminalia mantaly* at 200g applications. Number of leaves was highest (37.50±0.30) in AT at 5 weeks after planting treated with *Terminalia mantaly* at 200g application while it was lowest (24.89±0.12) in AC seeds in the NPK (3.00g) experiment. Highest plant spread (16.50±0.03 cm) was obtained at AC in the *Terminalia mantaly* at 200g experiment

followed by 15.00±0.00 recorded in AB under the *Terminalia mantaly* experiment at 100g application. It was however lowest 9.75±0.02 in the AB variety in the control experiment. Leaf length was highest (6.90±0.01) with the AC seed variety under the *Terminalia mantaly treatment* at 100g. Stem circumference was highest (1.70±0.04) at AT variety under *Terminalia mantaly treatment* at 100g.

Table 4. Effect of Decomposition of Leaf Litter of *Terminalia mantaly on* growth performance of *Amaranthus* plant.

Varieties	Treatments	Plant height			Number of leaves		Plant spread		Leaf	Stem
		2WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP	length	circumference
	Tm (100g)	9.00±0.00	12.25±0.01	21.26±0.01	11.5±0.00	32.00±004	9.40±0.11	14.00±0.04	6.50±0.00	1.70±0.04
	Tm(200g)	8.02±0.24	15.50±0.02	18.10±0.00	10.0±0.08	37.50±0.30	8.30±0.02	13.00±0.12	5.90±0.00	1.60±0.04
AT	NPK(1.5g)	7.12±0.01	13.00±0.13	18.03±0.51	19.30±0.11	28.10±0.20	8.60±0.23	12.30±0.24	3.10±0.11	1.05±0.00
	NPK (3.00g)	7.21±0.05	12.42±0.09	17.30±0.11	18.44±0.01	25.20±0.01	7.70±0.02	13.30±0.04	2.10±0.10	1.13±0.01
	CLT	7.03.±0.13	11.75±0.04	18.01±0.00	17.70±0.05	26.25±0.03	9.45±0.10	13.10±0.00	3.20±0.20	1.10±0.02
	Tm (100g)	11.34±0.00	14.50±0.42	23.30±0.32	5.45±0.07	31.50±0.02	8.10±0.11	16.50±0.03	5.97±0.02	1.06±0.01
	Tm(200g)	10.22±0.32	14.00±0.12	26.20±0.61	7.10±0.03	29.50±0.21	8.55±0.63	14.50±0.00	6.90±0.01	1.23±0.04
AC	NPK(1.5g)	7.50±0.00	14.10±0.21	18.32±0.05	17.80±0.01	27.20±0.02	8.20±0.21	13.50±0.11	2.90±0.08	1.30±0.01
	NPK (3.00g)	8.23±0.19	13.50±0.08	19.11±0.10	18.00±0.01	24.89±0.12	8.45±0.15	14.00±0.10	3.42±0.01	1.60±0.05
	CLT	7.53±0.93	12.76±0.12	20.01±0.02	16.40±0.06	26.82±0.32	9.90±0.12	13.75±0.04	3.03±0.07	1.15±0.01
	Tm (100g)	8.11±0.11	13.50±0.03	24.10±0.02	15.45±0.03	27.13±0.03	9.85±0.03	15.00±0.00	6.88±0.00	1.20±0.00
	Tm(200g)	9.12±0.02	14.60±0.01	22.10±0.32	15.10±0.02	26.43±0.02	8.70±0.43	14.50±0.23	5.40±0.00	1.30±0.00
AB	NPK(1.5g)	8.22±0.04	12.31±0.11	18.21±0.11	16.00±0.02	27.67±0.42	12.20±0.40	12.70±0.11	3.00±0.02	1.30±0.32
	NPK (3.00g)	7.45±0.13	13.50±0.12	18.57±0.23	18.00±0.03	27.23±0.01	8.40±0.66	13.50±0.02	3.82±0.01	1.05±0.01
	CLT	7.12±0.00	14.05±0.11	19.45±0.11	16.00±0.03	28.11±0.11	5.05±0.81	9.75±0.02	2.44±0.00	1.25±0.00
LSD(≤0.05)		0.051	0.031	0.005	0.107	1.451	0.069	0.0032	0.006	1.0114

Amaranthus tricolor (AT), Amaranthus cruentus (AC), Amaranthus blitum (AB).

Table 5. Effect of Decomposition of Leaf Litter of *Moringa oleifera* on germination of *Amaranthus* Varieties.

Varieties	Treatments	Germination count	%germination	Seedling vigour
	Mo (100g)	2.50±0.00	100.00±0.03	2.360±0.23
	Mo (200g)	2.50±0.00	83.34±0.00	2.200±0.43
AT	NPK(1.5g)	2.00±0.01	50.00±0.33	3.605±0.04
	NPK (3.00g)	3.00±0.00	60.00±0.02	2.755±0.032
	CLT	2.5±0.00	60.00±0.00	4.56±0.012
	Mo (100g)	3.00±0.00	66.67±0.33	2.535±045
	Mo (200g)	2.50±0.00	33.33±0.00	1.905±0.25
AC	NPK(1.5g)	2.00±0.01	40.00±0.02	1.785±0.01
	NPK (3.00g)	3.00±0.00	50.00±0.02	2.335±0.03
	CLT	2.5±0.00	60.00±0.00	4.16±0.04
	Mo (100g)	2.00±0.00	66.67±0.33	1.820±0.04
	Mo (200g)	2.50±0.00	75.00±0.03	2.015±0.02
AB	NPK(1.5g)	3.00±0.00	60.00±0.01	2.925±0.11
	NPK (3.00g)	2.50±0.03	50.00±0.00	2.425±0.02
	CLT	2.00±0.01	60.00±0.33	3.057±0.024
LSD(≤0.05)		0.067	0.451	0.0150

Amaranthus tricolor (AT), Amaranthus cruentus (AC), Amaranthus blitum (AB).

3.5. Effect of Decomposition of Leaf Litter of *Moringa oleifera* Germination of *Amaranthus* Varieties

Amaranthus varieties performed differently in response to different levels of *Moringa oleifera* (table 5). No significant differences ($p>0.05$) were obtained in all the parameters under study except for seedling vigour. Highest germination count 3.00±0.00 (100.00±0.03) was recorded in all the variety of *Amaranthus* in the experiment. The lowest germination count (1.00±0.00) was obtained in AC variety under the *Moringa oleifera* treatment at 300g and NPK at 1.4g respectively. Highest seedling vigour (5.46±0.02) was recorded with AB seeds variety planted with NPK fertilizer application at 3.00g application.

3.6. Effect of Decomposition of Leaf Litter of *Moringa oleifera* on Growth of *Amaranthus* Varieties

The result for the effect of crab shell on growth performance of *Amaranthus* plant is as presented in table 6 Growth performance of the *Amaranthus* seed varieties showed significant differences in response to the different manure types in this experiment. At five days after planting, plant height was highest (28.50±0.01) in AT variety under the *Moringa oleifera* experiment at 100g application rate. The shortest plant height (17.30±0.11) five weeks after planting was recorded at AT variety in the NPK fertilizer experiment

at 3.00g application rate. Number of leafs was highest (28.88±004) in AT at 5 weeks after planting treated with *Moringa oleifera* at 100g application while it was lowest (23.41±0.30) five weeks after planting in AT seeds in the *Moringa oleifera* experiment 200g**.** Highest plant spread (17.22±0.04) was obtained at AT with 200g application of *Moringa oleifera* and lowest (9.75±0.02) in control experiment with the AB seed variety. Leaf length was highest (6.82±0.01) with the AT seed variety under the *Moringa oleifera* experiment at 100g, closely followed by 6.80±0.12 obtained in the *Moringa oleifera* experiment at 200g application. The shortest leaves length (2.44±0.00) was recorded in the AB variety under the control experiment. Stem circumference was highest (1.60±0.05) at AC under NPK fertilizer experiment of 3.00g while it was lowest (1.05±0.00) in the AT variety under the NPK fertilizer treatment at 1.5g application rate.

Table 6. Effect of the Decomposition of Leaf Litter of *Moringa oleifera* on growth performance of *Amaranthus* plant.

Varieties	Treatments	Plant height			Number of leaves		Plant spread		Leaf length	Stem circumference
		2WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP		
	Mo (100g)	8.20±0.23	19.65±0.21	28.50±0.01	10.93±0.00	28.88±004	9.10±0.11	17.22±0.04	6.12±0.02	1.24±0.04
	Mo (200g)	9.52±0.24	16.70±0.42	22.30±0.10	10.30±0.08	23.41±0.30	9.30±0.02	14.51±0.4	6.80±0.12	1.22±0.04
AT	NPK(1.5g)	7.12±0.04	13.00±0.13	18.03±0.51	19.30±0.11	28.02±0.20	8.60±0.23	12.30±0.24	3.10±0.11	1.05±0.00
	NPK(3.00g)	7.21±0.03	12.42±0.09	17.30±0.11	18.44±0.01	25.20±0.01	7.70±0.02	13.30±0.04	4.10±0.10	1.13±0.01
	CLT	7.03.±0.13	11.75±0.04	18.01±0.00	17.70±0.05	26.25±0.03	9.45±0.10	13.10±0.00	3.20±0.20	1.10±0.02
	Mo (100g)	8.34±0.00	17.10±0.42	23.00±0.02	11.32±0.07	25.10±0.02	8.45±0.11	15.00±0.03	6.17±0.03	1.11±0.01
	Mo (200g)	7.22±0.12\	16.00±0.12	24.50±0.11	12.20±0.03	26.20±0.21	9.34±0.63	16.20±0.00	7.10±0.04	1.21±0.04
AC	NPK(1.5g)	7.50±0.00	14.10±0.21	18.32±0.05	17.80±0.01	27.20±0.02	8.20±0.21	13.50±0.11	2.90±0.08	1.30±0.01
	NPK(3.00g)	8.23±0.19	13.50±0.08	19.11±0.10	18.00±0.01	24.89±0.12	8.45±0.15	14.00±0.10	3.42±0.01	1.60±0.05
	CLT	7.53±0.93	12.76±0.12	20.01±0.02	16.40±0.06	26.82±0.32	9.90±0.12	13.75±0.04	3.03±0.07	1.15±0.01
	Mo (100g)	8.23±0.22	14.50±0.11	23.22±0.02	9.45±0.03	28.43±0.03	9.25±0.03	16.00±0.00	6.01±0.00	1.30±0.00
	Mo (200g)	7.52±0.75	15.50±0.02	25.21±0.32	10.72±0.02	27.43±0.02	9.80±0.43	15.00±0.23	6.70±0.00	1.50±0.00
AB	NPK(1.5g)	8.22±0.04	12.31±0.11	18.21±0.11	16.00±0.02	27.67±0.42	12.20±0.40	12.70±0.11	3.00±0.02	1.30±0.32
	NPK(3.00g)	7.45±0.13	13.50±0.12	18.57±0.23	18.00±0.03	27.23±0.01	8.40±0.66	13.50±0.02	3.82±0.01	1.05±0.01
	CLT	7.12±0.00	14.05±0.11	19.45±0.11	16.00±0.03	28.11±0.11	5.05±0.81	9.75±0.02	2.44±0.00	1.25±0.00
LSD(≤0.05)		0.0017	0.0251	0.2455	0.2117	14.71	74.29	0.324	14.71	1.2117

Amaranthus tricolor (AT), Amaranthus cruentus (AC), Amaranthus blitum (AB).

Table 7. Germination and vigour responses of *Amaranthus* to combined effect of *Moringa orifera, Terminalia catappa* and *Terminalia mantaly*.

Varieties	Treatments	Germination count	%germination	Seedling vigour
	Tc+Tm+Mo (100g)	3.00±0.00	100.00±0.03	2.085±0.23
	Tc+Tm+Mo (200g)	3.00±0.00	100.00±0.03	3.040±0.43
AT	NPK(1.5g)	3.00±0.01	100.00±0.04	3.605±0.04
	NPK (3.00g)	3.00±0.00	100.00±0.03	2.755±0.032
	CLT	2.5±0.00	83.34±0.00	4.56±0.012
	Tc+Tm+Mo (100g)	2.00±0.00	66.67±0.33	2.180±045
	Tc+Tm+Mo (200g)	2.5±0.00	83.34±0.00	1.715±0.25
AC	NPK(1.5g)	2.00±0.01	66.67±0.33	1.785±0.01
	NPK (3.00g)	3.00±0.00	100.00±0.03	2.335±0.03
	CLT	2.5±0.00	83.34±0.00	4.16±0.04
	Tc+Tm+Mo (100g)	2.00±0.00	66.67±0.33	2.180±0.04
	Tc+Tm+Mo (200g)	3.00±0.00	100.00±0.03	2.200±0.02
AB	NPK(1.5g)	3.00±0.00	100.00±0.03	2.925±0.11
	NPK (3.00g)	2.50±0.03	83.34±0.00	2.425±0.02
	CLT	2.00±0.01	66.67±0.33	3.057±0.024
LSD(≤0.05)		0.4217	0.3421	0.0015

Amaranthus tricolor (AT), Amaranthus cruentus (AC, Amaranthus blitum (AB).

3.7. Germination and Vigour Responses of Amaranthus to Combined Effect of *Moringa oleifera, Terminalia catappa* and *Terminalia mantaly*

Germination and vigour of *Amaranthus* varieties performed differently in response to the combined effect of *Moringa orifera, Terminalia catappa* and *Terminalia mantaly* (Table 7). No significant differences (p>0.05) were obtained in all the parameters under study. The effect of *Moringa oleifera*, *Terminalia catappa* and *Terminalia mantaly* had no a significant effect (p> 0.05) on the germination of the *Amaranthus* seeds across the different treatment and treatment rates. Highest germination count 3.00±0.00 was recorded in all the treatments and treatment combinations in the AT variety except for the control experiment were germination of 2.5±0.00 was recorded. Highest seedling vigour (6.11±0.43) was recorded with AT varieties in the Tc+Tm+Mo (100g) experiment while it was lowest (3.90±0.024) in the AB seeds treated in the control experiment.

3.8. Growth Responses of *Amaranthus* to Combined Effect of Plant Treatments

The result of the combined effect of *Moringa oleifera, Terminalia catappa and Terminalia mantaly* on growth performance of *Amaranthus* seeds is as presented in table 8. Significant differences ($p \leq 0.05$) were observed across most of the parameters measured due to the effect of the different treatment and treatment levels. The interaction of the different *Amaranthus* varieties with the manure types also resulted in significance changes on the growth parameters. Plant height was highest (32.76±0.22) in AT under the Tc+Tm+Mo (100g) experiment while it was lowest (17.30±0.11) in the same variety under the NPK (3.00g) experiment. Number of leafs was highest (31.08±0.22) at AT under the Tc+Tm+Mo (200g)) treatment. Plant spread was highest in the (18.82±0.32) in the AT variety under the Tc+Tm+Mo (100g) experiment. It was however lowest (9.75±0.02) in the AB variety under the control experiment. All other parameters showed significant difference across different treatments. However the combined effect of the three manure type showed reduction in the growth of the plant compared to the single effects of the manures.

Table 8. Growth responses of *Amaranthus* to combined effect of plant treatments.

Varieties	Treatments	Plant height			Number of leaves		Plant spread		Leaf length	Stem circumference
		2WAP	3WAP	5WAP	3WAP	5WAP	3WAP	5WAP		
AT	Tc+Tm+Mo (100g)	10.11±0.03	21.44±0.09	32.76±0.22	21.11±0.00	31.08±0.22	10.10±0.11	18.82±0.32	7.12±0.33	1.76±0.04
	Tc+Tm+Mo (200g)	9.82±0.12	19.20±0.11	28.45±0.09	19.30±0.08	29.41±0.00	10.11±0.02	16.91±0.45	7.00±0.08	1.09±0.04
	NPK(1.5g)	7.12±0.04	13.00±0.13	18.03±0.51	19.30±0.11	28.02±0.20	8.60±0.23	12.30±0.24	3.10±0.11	1.05±0.00
	NPK (3.00g)	7.21±0.03	12.42±0.09	17.30±0.11	18.44±0.01	25.20±0.01	7.70±0.02	13.30±0.04	4.10±0.10	1.13±0.01
	CLT	7.03.±0.13	11.75±0.04	18.01±0.00	17.70±0.05	26.25±0.03	9.45±0.10	13.10±0.00	3.20±0.20	1.10±0.02
AC	Tc+Tm+Mo (100g)	11.34±0.23	17.10±0.42	23.00±0.02	11.32±0.07	25.10±0.02	8.45±0.11	15.00±0.03	6.17±0.03	1.11±0.01
	Tc+Tm+Mo (200g)	10.52±0.03\	16.00±0.12	24.50±0.11	12.20±0.03	26.20±0.21	9.34±0.63	16.20±0.00	7.10±0.04	1.21±0.04
	NPK(1.5g)	7.50±0.00	14.10±0.21	18.32±0.05	17.80±0.01	27.20±0.02	8.20±0.21	13.50±0.11	2.90±0.08	1.30±0.01
	NPK (3.00g)	8.23±0.19	13.50±0.08	19.11±0.10	18.00±0.01	24.89±0.12	8.45±0.15	14.00±0.10	3.42±0.01	1.60±0.05
	CLT	7.53±0.93	12.76±0.12	20.01±0.02	16.40±0.06	26.82±0.32	9.90±0.12	13.75±0.04	3.03±0.07	1.15±0.01
AB	Tc+Tm+Mo (100g)	10.40±0.02	19.20±0.02	29.09±0.02	20.45±0.03	28.43±0.03	9.25±0.03	16.00±0.00	6.01±0.00	1.30±0.00
	Tc+Tm+Mo (200g)	12.52±0.10	18.40±0.22	24.06±0.32	19.72±0.02	27.43±0.02	9.80±0.43	15.00±0.23	6.70±0.00	1.50±0.00
	NPK(1.5g)	8.22±0.04	12.31±0.11	18.21±0.11	16.00±0.02	27.67±0.42	12.20±0.40	12.70±0.11	3.00±0.02	1.30±0.32
	NPK (3.00g)	7.45±0.13	13.50±0.12	18.57±0.23	18.00±0.03	27.23±0.01	8.40±0.66	13.50±0.02	3.82±0.01	1.05±0.01
	CLT	7.12±0.00	14.05±0.11	19.45±0.11	16.00±0.03	28.11±0.11	5.05±0.81	9.75±0.02	2.44±0.00	1.25±0.00
LSD (≤0.05)		0.0017	0.0251	0.2455	0.2117	14.71	74.29	0.324	14.71	1.2117

Amaranthus tricolor (AT), Amaranthus cruentus (AC), Amaranthus blitum (AB).

4. Discussion

In this present research, the effect of organic manure (*Moringa oleifera*, *Terminalia catappa* and *Terminalia mantaly*) on the early growth performance of *Amaranthus* varieties was experimented. The genetic characteristics of any plant determine its nutritional requirements and these must be manipulated appropriately for growth. The results showed that in this experiment showed that the amount and type of organic manure improved early growth of the seed varieties. The overall indication of the result was that *Amaranthus* seedlings perform better with the application of the organic manure than the NPK fertilizer and the control experiment in which no manure nor fertilizer was applied. A higher number of germination, plant height, number of leaves, plant spread leave length and stem circumference was recorded with the application of the organic manure as compared to the control experiment. The higher performance of plants in this treatments in the organic fertilizer which was significantly ($p<0.05$) higher than the control is in agreement with the findings of Mofunanya and Soonen [8] who recorded the highest number of leaves in lettuce plants amended stimulated nitric and sulphuric acid rain.

The interaction of the different varieties with the manure types also resulted in variation in the growth parameters. The seed variety with the best germination rate and growth parameters was the *Amaranthus tricolor* (AT), and *Amaranthus cruentus* (AC) variety followed by the *Amaranthus blitum* (AB) varieties.

This better performance of seeds with organic manure compared to the other treatment might be due to optimum

and continuous supply and availability of nutrients through organic source which help in better uptake of nutrient that ultimately enhancing cell division and thereby increased all the growth attributes. These findings are in accordance with the results of Wu *et al.* [1]. The combined effect of this three manure types produced a better germination and growth compared to the single effect of the manure, this might be due to adequate supply of nutrient element at the right time from inorganic sources which helped optimum dry matter partitioning from the source to sink during reproductive stage of plant [9].

Organic fertilizers are crucial in enhancing soil fertility [10]. Increased soil fertility following organic fertilizer application might have increased the number of leaves as observed in other crops [11, 12, 13]. Organic fertilizers releases nutrients more slowly but store them longer in the soil, thereby ensure a long residual effect. The nutrients from organic fertilizer support rapid root development which might have enhanced leaf growth towards the end of the study. This finding is in tandem with existing reports in the production of *Amaranthus* [8, 14-15]. Comparative growth performance of *Amaranthus* species in response to the three different types of leaf wastes showed that *Terminalia catappa* leaf waste influenced the growth performance of *Amaranthus*. This may imply that the leaf litter contained more nutrient than in other plant sources (*Moringa oleifera* and *Terminalia mantaly*) or the leaf was highly degradable to quickly release the organic nutrients for plant uptake. This view was earlier reported in the crop (*Amaranthus*) where growth performance was contigent on bioavailability of nutrient within the plant roots [8].

5. Conclusion

Organic manure (leaf litters) gave a better growth performance in *Amaranthus* species than inorganic fertilizer (NPK). *Terminalia catappa* in this experiment was the most effective organic manure compared to other compost types. The *Amaranthus tricolor* (AT), and *Amaranthus cruentus* (AC) variety responded better to the application of the organic manures followed by the *Amaranthus blitum* (AB) varieties. A combination of leaf manure from the three sources produced better growth output than their single nature. Hence, leaf litters from the three sources may be utilized in the production of *Amaranthus* vegetables either by planting the trees/shrubs in gardens or by removing leaf wastes from littered areas and apply to *Amaranthus* gardens thereby helping to clean the environment while ensuring sustainable and healthy production of the vegetable crop devoid of toxic fertilizer residues.

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