



## Early Growth Response of Noni (*Morinda citrifolia* L.) Seedlings to Ranging Levels of Organic and Inorganic Fertilizers on an Alfisol

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### Authors' contributions

This work was carried out in collaboration among all authors. Authors FOA and JOA designed the study and wrote the protocol. Author FOA performed the statistical analysis and wrote the first draft of the manuscript. Author CII managed the analyses of the study. Authors NCI, JOI and VAO managed the literature searches. All authors read and approved the final manuscript.

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### ABSTRACT

**Aim:** To investigate the early growth response of *Morinda citrifolia* to varying levels of Aleshinloye compost and N:P:K 15:15:15 in a degraded Alfisol in a tropical Nigerian environmental condition.

**Study Design:** The study was laid out in a completely randomized design (CRD) with twelve (12) treatments replicated six (6) times with a total of seventy two (72) experimental units.

**Place and Duration of Study:** The study was carried out in the greenhouse of Soil and tree Nutrition department of the Forestry Research Institute of Nigeria Ibadan (FRIN) and it lasted for a period of 6 month.

**Methodology:** Degraded top soil used for the experiment was collected within FRIN arboretum. The soil was air dried and passed through a 2 mm diameter sieve before being filled into polythene

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pots of 15 cm x 20 cm dimension having a 3 kg soil capacity. The organic fertilizer was applied at 4 weeks before transplanting while the inorganic fertilizer was applied at 2 weeks after transplanting and pre-germinated seedlings of Noni were transplanted at four leaves stage. The data collected include Stem Girth (mm), plant height (cm) and Number of leaves starting from 30 Days After Transplanting (DAT).

**Results:** The result revealed that the soil sample used for this study had pH value of 6.06 and the total N value of 0.11%. Noni plant with treatment T11 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + Aleshiloye compost (AC) at 80 Kg Nha<sup>-1</sup>) had the highest plant height values of 48.17, 65.67 and 77.87 cm respectively which are significantly higher ( $P = .05$ ) than T1 (control) with 37.17, 47.50 and 55.33 cm respectively that are the least values observed from 120 DAT to 180 DAT. The Plant Dry Matter (PDM) for leaves, stem and root (3.593, 2.720 and 4.220 g/plant) respectively from the control (T1) plant was the least when compared to every other treatment in the study.

**Conclusion:** The use of composted manure in combination with N:P:K 15:15:15 ensured early and continuous supply of nutrient with resultant higher growth performance of Noni over a period of six months as shown in the study.

**Keywords:** Growth response; *Morinda citrifolia*; compost; fertilizer and soil.

## 1. INTRODUCTION

*Morinda citrifolia* L., known commercially as Noni, grows widely throughout the Pacific and is one of the most significant sources of traditional medicines among Pacific island societies. It is a fruit species of the Rubiaceae family that produces fruits all year round during its productive stage in all its productive branch [1,2]. Noni has a rooting habit similar to that of citrus and coffee, with an extensive lateral root system and a deep taproot. Due to paucity of information, noni nutritional requirements are estimated using coffee trees (*Coffea arabica*) as a reference, given that both belong to the same family [1,3]. Noni cultures positively respond to the application of organic matter to the soil in the form of cattle manure, resulting in nutritionally balanced plants and fruits with adequate post-harvest quality [2,3,4]. As reported by [5], management of soil organic matter by using composted organic waste is the key for sustainable agriculture. Increasing soil organic matter has the added benefit of improving soil quality and thereby enhancing the long-term sustainability of agriculture [6]. Among the practices recommended for improvement of the soil quality and soil fertility in tropical regions is the application of composted organic wastes, which slowly release significant amounts of nitrogen and phosphorus [7]. International research has shown that municipal compost can be beneficial as both a soil conditioner and a slow release nutrient source [8]. Since the establishment of adequate levels of nutrients is necessary to assist fertilization and nutritional requirement for noni cultivation plans [3,4], this study aims to investigate the early growth

response of *Morinda citrifolia* L. to varying levels of Aleshiloye compost and N:P:K 15:15:15 in a degraded Alfisol in a tropical Nigerian environmental condition.

## 2. MATERIALS AND METHODS

### 2.1 Study Location

The study was carried out in the greenhouse of Soils and Tree Nutrition department of the Forestry Research Institute of Nigeria Ibadan (FRIN). The study site is located on longitude 07°23'18" N to 07°23'43"N and latitude 03°51'20"E to 03°23'43"E. The climate of the area is West African monsoon with dry and wet seasons. The mean maximum temperature of the area at the period of the study was 31.11°C, minimum 22.76°C while the mean daily relative humidity was about 71.8% [9].

### 2.2 Soil Collection and Preparation

Degraded top soil used for the experiment was collected within FRIN arboretum. The soil was air dried and passed through a 2 mm diameter sieve before 3 kg soil each were being filled into polythene pots of 15cm x 20cm dimension . A subsample of the soil was taken to the Laboratory of Soils and Tree Nutrition Department of the Institute for both physical and chemical properties determination.

### 2.3 Soil and Compost Analysis

The soil pH was determined with the pH meter (SM-3H Microfield England) using glass electrode in 1:2 soil to water ratio. The organic

carbon of the soil was determined using the Walkley Black wet oxidation method. Total nitrogen was determined using micro-Kjeldahl method. Available P was determined using Bray-1 method. A sub sample was also extracted with ammonium acetate and the solution was filtered with Whatman no. 1 filter paper while the extract was analysed using flame photometer to determine its sodium and potassium contents. The concentrations of calcium and magnesium in the extract were determined using Atomic Absorption Spectrophotometer (AAS). Likewise, another subsample of the soil was extracted with 1N HCl for the determination of Iron, Copper, Zinc and Manganese concentrations using AAS. A sample of the organic fertilizer (Aleshinloye compost) was also digested with Nitric and perchloric acid combination and the digest was analysed for essential plant nutrients concentrations.

## 2.4 Experimental Design

The study was laid out in a completely randomized design (CRD) with twelve (12) treatments replicated six (6) times with a total of seventy two (72) experimental units. The treatments are: T1 (Control), T2 (Aleshinloye compost (AC) at 80 Kg Nha<sup>-1</sup>), T3 (AC at 160 Kg Nha<sup>-1</sup>), T4 (AC at 240 Kg Nha<sup>-1</sup>), T5 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup>), T6 (N:P:K 15:15:15 at 40 Kg Nha<sup>-1</sup> + AC at 40 Kg Nha<sup>-1</sup>), T7 (N:P:K 15:15:15 at 40 Kg Nha<sup>-1</sup> + AC at 80 Kg Nha<sup>-1</sup>), T8 (N:P:K 15:15:15 at 40 Kg Nha<sup>-1</sup> + AC at 120 Kg Nha<sup>-1</sup>), T9 (N:P:K 15:15:15 at 160 Kg Nha<sup>-1</sup>), T10 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 40 Kg Nha<sup>-1</sup>), T11 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 80 Kg Nha<sup>-1</sup>) and T12 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 120 Kg Nha<sup>-1</sup>). The organic fertilizer was applied at 4 weeks before transplanting while the inorganic fertilizer was applied at 2 weeks after transplanting and pre-germinated seedlings of Noni were transplanted at four leaves stage.

## 2.5 Data Collection

The data collected include Stem Girth (mm), plant height (cm) and Number of leaves starting from 30 days after transplanting (DAT) which were also repeated at 4 weeks intervals while plant dry matter were obtained at the 180<sup>th</sup> DAT. The Number of leaves was determined through physical counting of the number of leaves per plant; the plant height was measured from soil surface with the aid of a meter rule while Venire caliper was used to measure the diameter at

breast height and recorded in millimeter. The plant was harvested at 180 DAT and gently rinsed in clean water before separating into leaves, stem and root parts. These parts were oven dried at 65°C until a constant weight were recorded for the plant Dry matter (g/plant) for stem, root and leaf portions of the seedlings at the end of the experiment.

## 2.6 Statistical Analysis

Data collected were subjected to statistical analysis of variance (ANOVA) using GenStat9<sup>th</sup> Edition while significantly different means were separated using the Duncan Multiple Range Test (DMRT) at 5% probability.

## 3. RESULTS AND DISCUSSION

### 3.1 Soil and Compost Properties

The result revealed that the soil sample used for this study had pH value of 6.06 and the total N value of 0.11% which is classified to be low [10]. The available P value was 2.12 mg/kg, Exchangeable bases; K<sup>+</sup>, Na<sup>+</sup>, Ca<sup>2+</sup> and Mg<sup>2+</sup> had the values of (0.13, 0.38, 3.61 and 2.00) cmol<sup>+</sup> kg<sup>-1</sup>, respectively which according to [11] are in a very low critical range except for Ca<sup>2+</sup> that is low. The micro-nutrients; Mn<sup>2+</sup>, Fe<sup>2+</sup>, Cu<sup>2+</sup> and Zn<sup>2+</sup> had the values of (57.7, 20.8, 10.5 and 16.9) mg kg<sup>-1</sup>, respectively (Table 1). The proportion of sand, silt and clay were 836, 96 and 68 g kg<sup>-1</sup>, respectively while the nutrient composition of the compost used were generally high and it has a pH value of 7.03 which is neutral (Table 1).

### 3.2 Plant Height (cm)

The application of organic and inorganic fertilizers had no significant effect ( $P = .05$ ) on Noni plant height at 30 days after transplanting (DAT). However, at 60DAT, the combination of N:P:K 15:15:15 at 40 Kg Nha<sup>-1</sup> + AC at 40 Kg Nha<sup>-1</sup> (T6) significantly influence Noni plant height with recorded 9.85 cm that was significantly higher than those of treatments T1 (control) (7.77 cm) and T2, T3 and T4 (7.97, 7.98 and 7.90 cm) respectively which were solely organic fertilizer. This result supported that of some International researches that the use of municipal compost could be beneficial as both a soil conditioner and a slow release nutrient source [8,12]. At 90DAT, plant height with treatment T12 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 120 Kg Nha<sup>-1</sup>) recorded a significantly higher value (26.07 cm) compared to those of

T1 (control) (19.67 cm) and T2, T3 and T4 (21.25, 21.25 and 19.75 cm) respectively (Table 2). Similarly, from 120DAT to 180DAT, Noni plant with treatment T11 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 80 Kg Nha<sup>-1</sup>) which consisted the recommended rate (160 Kg Nha<sup>-1</sup>) for coffee production which belongs to the same family (Rubiaceae) with Noni [1,3] had the highest values of 48.17, 65.67 and 77.87 cm respectively which were significantly higher than T1 (control) with 37.17, 47.50 and 55.33 cm respectively that were the least values observed from 120 DAT to 180 DAT (Table 2).

### 3.3 Plant Stem Girth (mm)

Response of Noni plant stem girth to soil applied different treatments in this study revealed that there was significant difference at  $P = .05$  from

30DAT. The highest value (1.657 mm) recorded at this period was from plant with treatment T8 (N:P:K 15:15:15 at 40 Kg Nha<sup>-1</sup> + AC at 120 Kg Nha<sup>-1</sup>) while the least value (1.272 mm) was that of plant from T6 (N:P:K 15:15:15 at 40 Kg Nha<sup>-1</sup> + AC at 40 Kg Nha<sup>-1</sup>) (Table 3). This was in line with [5] who reported that organic waste (composted manure) application enhanced the use efficiency of mineral N fertilizer by crops when the two were applied in combination. The T6 combination does not measure up to the recommended rate (160 Kg Nha<sup>-1</sup>) for coffee production [1,3] which could be responsible for the minimal increase in Noni stem diameter. From 90DAT to 150DAT, the stem diameter of Noni plant with treatment T12 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 120 Kg Nha<sup>-1</sup>) recorded the highest stem diameters of 4.667, 7.973 and 9.573 mm respectively and was significantly

**Table 1. Pre-planting soil and compost chemical and physical properties**

Properties	Soil	Compost
pH (H <sub>2</sub> O, 1:2)	6.06	7.03
Organic C (g/kg)	11.0	109.7
Total N (g/kg)	1.10	20.8
Available P (mg/kg)	2.12	15.5
K (Cmol/kg)	0.13	2.1
Ca (Cmol/kg)	3.61	7.4
Mg (Cmol/kg)	2.00	10.0
Na (Cmol/kg)	0.38	1.2
Fe (g/kg)	57.7	185
Mn (mg/kg)	20.8	60.7
Zn (mg/kg)	10.5	29.0
Cu (mg/kg)	16.9	10.6
Sand (g/kg)	836	
Clay (g/kg)	96	
Silt (g/kg)	68	
Textural class	Loamy sand	

**Table 2. Effect of organic and inorganic fertilizers on the early growth performance of Noni plant height (cm)**

Treatment	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
T1	3.48 <sup>a</sup>	7.77 <sup>bc</sup>	19.67 <sup>c</sup>	37.17 <sup>d</sup>	47.50 <sup>e</sup>	55.33 <sup>c</sup>
T2	3.70 <sup>a</sup>	7.97 <sup>bc</sup>	21.25 <sup>c</sup>	39.67 <sup>cd</sup>	50.67 <sup>de</sup>	63.67 <sup>bc</sup>
T3	3.37 <sup>a</sup>	7.98 <sup>bc</sup>	21.42 <sup>c</sup>	43.17 <sup>abcd</sup>	53.00 <sup>cde</sup>	64.08 <sup>bc</sup>
T4	3.52 <sup>a</sup>	7.90 <sup>bc</sup>	19.75 <sup>c</sup>	40.83 <sup>bcd</sup>	54.18 <sup>cde</sup>	65.30 <sup>b</sup>
T5	3.45 <sup>a</sup>	8.00 <sup>bc</sup>	21.92 <sup>c</sup>	45.50 <sup>abc</sup>	55.08 <sup>cde</sup>	68.00 <sup>ab</sup>
T6	3.93 <sup>a</sup>	9.85 <sup>a</sup>	25.37 <sup>ab</sup>	47.50 <sup>ab</sup>	57.67 <sup>bcd</sup>	67.92 <sup>ab</sup>
T7	3.75 <sup>a</sup>	7.72 <sup>bc</sup>	20.00 <sup>c</sup>	44.33 <sup>abc</sup>	56.75 <sup>bcd</sup>	68.82 <sup>ab</sup>
T8	4.08 <sup>a</sup>	9.18 <sup>ab</sup>	22.83 <sup>abc</sup>	45.67 <sup>abc</sup>	59.58 <sup>abc</sup>	71.67 <sup>ab</sup>
T9	3.47 <sup>a</sup>	7.65 <sup>c</sup>	22.90 <sup>bc</sup>	46.50 <sup>ab</sup>	58.83 <sup>abc</sup>	71.75 <sup>ab</sup>
T10	3.38 <sup>a</sup>	7.83 <sup>bc</sup>	22.62 <sup>bc</sup>	48.75 <sup>a</sup>	63.33 <sup>ab</sup>	76.72 <sup>a</sup>
T11	3.30 <sup>a</sup>	8.17 <sup>bc</sup>	22.48 <sup>bc</sup>	48.17 <sup>a</sup>	65.67 <sup>a</sup>	77.87 <sup>a</sup>
T12	3.93 <sup>a</sup>	9.03 <sup>abc</sup>	26.07 <sup>a</sup>	47.08 <sup>ab</sup>	60.17 <sup>abc</sup>	70.12 <sup>ab</sup>

Means value within a column followed by the same letter(s) are not significantly different at  $P = .05$

**Table 3. Effect of organic and inorganic fertilizers on the early growth performance of Noni plant stem girth (mm)**

Treatment	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
T1	1.437 <sup>abc</sup>	1.538 <sup>cd</sup>	2.872 <sup>i</sup>	5.965 <sup>e</sup>	6.728 <sup>e</sup>	8.24 <sup>d</sup>
T2	1.643 <sup>a</sup>	1.493 <sup>d</sup>	3.117 <sup>i</sup>	5.693 <sup>e</sup>	7.353 <sup>de</sup>	9.34 <sup>cd</sup>
T3	1.565 <sup>ab</sup>	1.597 <sup>bcd</sup>	3.197 <sup>ef</sup>	6.702 <sup>cde</sup>	7.923 <sup>cd</sup>	10.17 <sup>abc</sup>
T4	1.523 <sup>abc</sup>	1.557 <sup>cd</sup>	3.020 <sup>i</sup>	6.300 <sup>de</sup>	7.623 <sup>d</sup>	9.60 <sup>bc</sup>
T5	1.317 <sup>bc</sup>	1.518 <sup>cd</sup>	3.397 <sup>def</sup>	7.848 <sup>ab</sup>	8.538 <sup>bc</sup>	10.92 <sup>ab</sup>
T6	1.272 <sup>c</sup>	1.918 <sup>a</sup>	4.318 <sup>ab</sup>	7.72 <sup>abc</sup>	8.877 <sup>ab</sup>	10.69 <sup>ab</sup>
T7	1.643 <sup>a</sup>	1.788 <sup>ab</sup>	3.482 <sup>cdef</sup>	6.695 <sup>bcde</sup>	7.892 <sup>cd</sup>	10.05 <sup>abc</sup>
T8	1.657 <sup>a</sup>	1.722 <sup>abc</sup>	4.205 <sup>abc</sup>	7.258 <sup>abcd</sup>	8.650 <sup>bc</sup>	10.82 <sup>ab</sup>
T9	1.522 <sup>abc</sup>	1.640 <sup>bcd</sup>	3.893 <sup>bcde</sup>	7.233 <sup>abcd</sup>	8.727 <sup>abc</sup>	10.25 <sup>abc</sup>
T10	1.585 <sup>ab</sup>	1.713 <sup>abcd</sup>	3.870 <sup>bcde</sup>	7.640 <sup>abc</sup>	9.063 <sup>ab</sup>	10.75 <sup>ab</sup>
T11	1.587 <sup>ab</sup>	1.678 <sup>bcd</sup>	4.053 <sup>abcd</sup>	7.658 <sup>abc</sup>	9.565 <sup>a</sup>	11.34 <sup>a</sup>
T12	1.577 <sup>ab</sup>	1.797 <sup>ab</sup>	4.667 <sup>a</sup>	7.973 <sup>a</sup>	9.573 <sup>a</sup>	10.93 <sup>ab</sup>

Means value within a column followed by the same letter(s) are not significantly different at  $P = .05$

higher than that of control (T1) and those of T2, T3 and T4 (Organic fertilizers) values recorded from 90 DAT to 150DAT (Table 3). At the end of the study (180DAT), the Noni plant with treatment T11 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 80 Kg Nha<sup>-1</sup>) also recorded the highest stem diameter (11.34 mm) value which is significantly higher than those of control (T1) and T2 (AC at 80 Kg Nha<sup>-1</sup>) (8.24 and 9.34 mm) respectively (Table 3). This is similar to the results obtained for plant height in this study and can also be attributed to the enhanced use efficiency of mineral N fertilizer by crops when organic and inorganic fertilizers are combined [5]. Organic fertilizers application alone are expected to be slow nutrient releasing as evident in results obtained from T2, T3 and T4.

### 3.4 Plant Number of Leaves

At 30DAT, all treatments applied did not significantly influence leaves production as all the plants recorded an average of four (4) leaves each which increased to eight (8) leaves at the end of 60DAT. Plants with treatment T12 had an average of Nine (9) leaves that is significantly higher than those of plants of every other treatment who all recorded 8 number of leaves (Table 4). Between 90DAT and 120 DAT, leaves production was significantly influenced by the fertilizer formulations applied to the plant while the control (T1) and T8 (N:P:K 15:15:15 at 40 Kg Nha<sup>-1</sup> + AC at 120 Kg Nha<sup>-1</sup>) recorded the least number of leaves (12 and 13) respectively. Whereas, the highest numbers of leaves within the same period were recorded by plants with T4, T5 and T11 with each have an average of 17 leaves respectively. At 150DAT, leaves production was highest (19) from plant with T11

(N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 80 Kg Nha<sup>-1</sup>) and this was significantly higher than those of T6, T7, T8 and T9 with 15 number of leaves respectively (Table 4). This result was consistent with that obtained for plant height and plant stem diameter in this study which further confirms the report of [1] that 160 Kg Nha<sup>-1</sup> is adequate for coffee production which can also be extended to Noni production as shown in this study. At 180 DAT, few plant defoliation occurrences were observed which distorted the trend of leaves production as influenced by treatments applied in the study and this can be attributed to the plant root tips that had started growing beyond the soil depth of the experimental polythene pots at this stage.

### 3.5 Plant Dry Matter (G)

The results of dry matter obtained clearly showed that application of fertilizer had significant positive influence on plant biomass accumulation. The PDM for leaves, stem and root (3.593, 2.720 and 4.220 g/plant) respectively from the control (T1) plant was the least when compared to every other treatment in the study. These results were also significantly lower ( $P = .05$ ) compared to PDM of leaves, stem and root of T11 (7.270, 6.197 and 9.183 g/plant) and T12 (7.733, 7.937 and 9.887 g/plant) that were the highest data recorded in this study (Table 5). The application of composted organic wastes, which slowly release significant amounts of nitrogen and phosphorus [13,14,7] was suspected to have contributed to the increased plant yield towards the end of the study when compared to the early stage where nutrients from inorganic fertilizer sources were readily available.

**Table 4. Effect of organic and inorganic fertilizers on the early growth performance of Noni plant number of leaves**

Treatment	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
T1	4 <sup>a</sup>	8 <sup>b</sup>	12 <sup>c</sup>	15 <sup>abcd</sup>	18 <sup>abc</sup>	16 <sup>ab</sup>
T2	4 <sup>a</sup>	8 <sup>b</sup>	12 <sup>c</sup>	16 <sup>abcd</sup>	18 <sup>ab</sup>	15 <sup>b</sup>
T3	4 <sup>a</sup>	8 <sup>b</sup>	13 <sup>bc</sup>	16 <sup>abcd</sup>	17 <sup>abc</sup>	18 <sup>a</sup>
T4	4 <sup>a</sup>	8 <sup>b</sup>	12 <sup>c</sup>	17 <sup>a</sup>	18 <sup>a</sup>	17 <sup>ab</sup>
T5	4 <sup>a</sup>	8 <sup>b</sup>	13 <sup>bc</sup>	17 <sup>a</sup>	17 <sup>abc</sup>	18 <sup>ab</sup>
T6	4 <sup>a</sup>	8 <sup>b</sup>	14 <sup>ab</sup>	15 <sup>abcd</sup>	15 <sup>bc</sup>	17 <sup>ab</sup>
T7	4 <sup>a</sup>	8 <sup>b</sup>	13 <sup>bc</sup>	13 <sup>cd</sup>	15 <sup>c</sup>	16 <sup>ab</sup>
T8	4 <sup>a</sup>	8 <sup>b</sup>	13 <sup>abc</sup>	13 <sup>d</sup>	15 <sup>c</sup>	16 <sup>ab</sup>
T9	4 <sup>a</sup>	8 <sup>b</sup>	13 <sup>ab</sup>	14 <sup>bcd</sup>	15 <sup>c</sup>	17 <sup>ab</sup>
T10	4 <sup>a</sup>	8 <sup>b</sup>	14 <sup>abc</sup>	16 <sup>abc</sup>	16 <sup>abc</sup>	17 <sup>ab</sup>
T11	4 <sup>a</sup>	8 <sup>b</sup>	14 <sup>ab</sup>	17 <sup>a</sup>	19 <sup>a</sup>	17 <sup>ab</sup>
T12	4 <sup>a</sup>	9 <sup>a</sup>	14 <sup>a</sup>	16 <sup>ab</sup>	17 <sup>abc</sup>	16 <sup>ab</sup>

Means value within a column followed by the same letter(s) are not significantly different at  $P = .05$

**Table 5. Effect of organic and inorganic fertilizers on the early growth performance of noni plant dry matter (g/plant)**

Treatment	Leaves	Root	Stem
T1	3.593 <sup>c</sup>	2.720 <sup>c</sup>	4.220 <sup>d</sup>
T2	5.017 <sup>bc</sup>	4.190 <sup>bc</sup>	5.937 <sup>cd</sup>
T3	5.713 <sup>ab</sup>	5.127 <sup>abc</sup>	6.900 <sup>bc</sup>
T4	5.210 <sup>bc</sup>	5.273 <sup>abc</sup>	7.933 <sup>abc</sup>
T5	7.787 <sup>a</sup>	4.880 <sup>abc</sup>	7.933 <sup>abc</sup>
T6	6.860 <sup>ab</sup>	4.437 <sup>bc</sup>	7.613 <sup>abc</sup>
T7	6.290 <sup>ab</sup>	5.127 <sup>abc</sup>	6.563 <sup>c</sup>
T8	7.280 <sup>a</sup>	5.140 <sup>abc</sup>	7.313 <sup>bc</sup>
T9	6.717 <sup>ab</sup>	6.213 <sup>ab</sup>	6.923 <sup>bc</sup>
T10	6.770 <sup>ab</sup>	4.827 <sup>abc</sup>	8.120 <sup>abc</sup>
T11	7.270 <sup>a</sup>	6.197 <sup>ab</sup>	9.183 <sup>ab</sup>
T12	7.733 <sup>a</sup>	7.937 <sup>a</sup>	9.887 <sup>a</sup>

Means value within a column followed by the same letter(s) are not significantly different at  $P = .05$

#### 4. CONCLUSION AND RECOMMENDATIONS

The use of composted manure in combination with N:P:K 15:15:15 ensured early and continuous supply of nutrient with resultant higher growth performance of Noni over a period of six months as shown in the study. Since the recommended rate of fertilizer application for coffee production is 160 Kg Nha<sup>-1</sup>, the same is therefore recommended for Noni production provided it is supplied in the combination of organic and inorganic fertilizers as was done with T11 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 80 Kg Nha<sup>-1</sup>) which gave the best growth performance in this study except for T12 (N:P:K 15:15:15 at 80 Kg Nha<sup>-1</sup> + AC at 120 Kg Nha<sup>-1</sup>) that had higher PDM but not significantly different from T11 which is more economically friendly.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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