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# Performance and Nutritional Quality of Roselle (*Hibiscus sabdariffa* L.) and Jute Mallow (*Corchorus olitorius* L.) under Organic Soil Amendments (Composts)

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***Authors' contributions***

*This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** The aim of the study was to determine the performance and nutritional quality of roselle and jute mallow under organic soil amendments (composts).
**Study Design:** The experiments were conducted in a Randomised Complete Block Design (RCBD) with four replications.
**Place and Duration of Study:** The experiments were conducted at the CSIR – SARI upland field, Changnaayili near Nyankpala in the Northern Region of Ghana during the rainy season (from June to October) in 2014 and 2015.
**Methodology:** The composts used were Decentralized Company (DeCo) compost, Accra Compost and Recycling Plant (ACARP) compost and Composted Deep Litter Chicken Manure (CDLCM)

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applied onto prepared raised beds. The composts were incorporated into the beds at a rate of 10 t / ha two weeks before seedlings of roselle, and jute mallow were transplanted onto the prepared beds. Plant height, numbers of leaves per plant and leaf yield were taken for both vegetables. Protein, moisture and ash contents were also determined by proximate analysis.
**Results:** For both crops, significant differences (p = 0.05) in plant height and number of leaves were recorded at 8 weeks after transplanting. Cumulative leaf yield was significantly (p = 0.05) different between CDLCM, DeCo, ACARP composts and the control plot. Proximate analysis of leaf samples of the roselle and jute mallow showed that percent moisture and ash content were not affected significantly (p = 0.05) by the application of compost. However, percent protein in the roselle varied significantly (p = 0.05) with highest (29.2%) in the control followed by ACARP compost (28.6%), CDLCM (27.6%) and DeCo compost (26.4%).
**Conclusion:** Application of organic soil amendment resulted in improved agronomic and yield parameters of roselle and jute mallow. However, their application did not have much effect on the nutritional status of both crops except on protein in roselle.

*Keywords: Leaf yield; soil amendments; nutritional quality; DeCo compost; ACARP compost.*

## 1. INTRODUCTION

Roselle and jute mallow are among vegetables commonly cultivated and consumed throughout the country. The leaves of these vegetables are used in making soup and eaten with fermented maize paste popularly called “tuo zaafi or TZ”. They are among the cheapest and most readily available sources of important food proteins, vitamins, minerals roughage, carbohydrates, water and essential amino acids among rural and urban dwellers [1,2]. Roselle (*Hibiscus sabdariffa* L.) and jute mallow (*Corchorus olitorius* L.) are both reported to contain proteins, carbohydrates, fats, flavonoids, minerals and vitamins and have medicinal properties such as antihypertensive, hepatoprotective, anticancer, antihyperlipidemic and antioxidants [3,4].

The nutritional composition of roselle leaves per 100 g edible portion is estimated to be 85.6 g water, 180 kJ (43 kcal) energy, 3.3 g protein, 0.3 g fat, 9.2 g carbohydrate and 1.6 g dietary fibre [5].

Due to continuous cultivation, soils especially in the Guinea Savannah agroecological area lose their productive capacity and hence require replenishment [6]. Organic fertilisers such as poultry manure, compost from solid urban waste and sewage sludge have been used by farmers to amend their poor soils. For this reason, some private companies in Ghana are involved in municipal urban waste biotransformation for use by urban and peri-urban gardeners. Notably, the Accra Compost and Recycling Plant (ACARP) located in the national capital of Ghana, Accra, a wing of the Zoomlion Company limited produces the ACARP compost (ACARP, n.d) while the DeCo Company located in the Tamale Metropolitan area in the Northern Region produces the DeCo compost [7]. These composts are both from mixed solid waste materials, but the DeCo compost is source-separated into organic component and co-composted with other organic waste materials [8], unlike the ACARP compost.

These composts have been recommended for vegetable and food crops production. Most often, the composts are utilised in the cultivation of vegetables for both domestic consumption and urban markets. Though the composts have been patronised locally by farmers with high assurance of improved yield, it has a high potential for trans-border utilisation. However, there is a paucity of research to establish crop yields associated with their use. Therefore, the experiment was carried out to assess the effect of composts on the performance and nutritional quality of roselle and jute mallow.

## 2. MATERIALS AND METHODS

### 2.1 The Study Area

The study was conducted at the upland field of the Council for Scientific and Industrial Research – Savanna Agricultural Research Institute (CSIR-SARI), Changnaayili near Nyakpala, in the Tolon District of the Northern Region of Ghana. The upland field is about 200 m from Changnaayili village (Latitude: 09° 25’ N, Longitude: 00° 58’ W, and altitude of 183 m above Mean Sea Level). The soils of the upland field are ferric luvisols [9], reported to have derived from concretionary ground water laterite soil described as Kpalsawgu series (imperfectly drained, occurring within the east on the low lying uplands) and Changnayili series (poorly drained, occupying the lower slopes and valley bottoms) which are both sandy loam soils and slightly acidic in nature (pH= 5.8) [10]. The experiment was conducted on the Kpalsawgu soil series. The experimental site has been cultivated to a variety of crops including cereals, legumes and vegetables under different experimental treatments.

The study area has two distinct seasons (rainy/wet season and dry season). The rainy season is mono-modal which begins around May and ends around October. The amount of rainfall recorded annually varies between 750 mm to 1050 mm with a cropping period of 180– 200 days [11]. The dry season starts around November and ends around March/April with maximum temperature (°C) occurring around March-April and minimum around December/January. The harmattan (north-east trade winds) occurs around December to early February and has a considerably low temperature effect in this region; i.e., normally 14°C during night and 40°C during day. However, relative humidity is very low during harmattan, mitigates the effect of the daytime temperature. The vegetation mostly consists of vast areas of grassland, interspersed with guinea savannah woodland, characterised by drought-resistant trees such as acacia, baobab, shea nut, dawadawa, mango, and neem.

### 2.2 Source of Seeds and Composts

Seeds of local cultivars of roselle and jute mallow were obtained from farmers at Builpela and Gbulahgu irrigation sites in the Tamale metropolitan area and Tolon district, respectively. Samples of ACARP compost was obtained from a sales agent in Tamale while the DeCo compost and CDLCM were obtained from the DeCo Company near Tamale.

### 2.3 Chemical Analysis of Soil and Composts

Ten soil samples were randomly taken from the experimental plot at 15 cm depth by using a soil auger. Samples were dried in an oven at 104°C for 24 h and then pulverised into finer particles, sieved, mixed thoroughly and composited.

Three laboratory samples were taken from the composite sample for analysis. The soil and the composts were analysed for their compositions of percent nitrogen by the Kjeldahl method; percent organic carbon by Walkley and Black method; elemental phosphorous by using the UV–Vis (model 7305, Bibby Scientific, Staffordshire, UK); potassium using the flame photometer (model PFP7, Bibby Scientific, Staffordshire, UK) and pH using the research pH meter (model 3330, Jenway Ltd., Essex, UK) by following standard protocol.

### 2.4 Land Preparation and Application of Compost

The experimental field was mechanically ploughed and harrowed to a fine tilth. A total area of 20 m × 15 m was then lined and pegged to carve out the experimental plots. The organic soil amendments were incorporated into the top 10–15 cm of the soil by using a hand hoe. The composts were spread manually on each plot at a rate of 10 t/ha and worked into the top soil using the hoe. This was done two weeks before transplanting. The seeds of roselle and jute mallow were nursed in nursery boxes. The seedlings at 31 days in the nursey were transplanted onto the field at 40 × 40 cm spacing. Each experimental plot had a plant population of twenty five. Harvesting was done on the nine inner plants when the leaf cover was considered economical at each point in time of the plant's growth for further processing and analysis.

### 2.5 Experimental Design and Field Layout

The treatments were ACARP, DeCo, CDLCM and control (which was without any amendment). The experiment was laid out in a Randomised Complete Block Design (RCBD) with four replications.

### 2.6 Data Collection

Data were collected in respect to plant height, number of leaves per plant and leaf yield. Nine plants were sampled from each plot and the plant height taken from the base to the tip of the shoot and averaged. The total number of leaves per plant was counted and averaged over the nine sampled plants for each plot. The leaves were harvested in three tranches with a two-week interval between harvests. At each harvesting period, the leaves were weighed for each plot and the cumulative yield was computed at the end of the last harvest. Samples of the harvested leaves were also analysed for nutrient composition.

## 2.7 Statistical Analysis

Statistical analysis was carried out by using the 9th edition of Genstat Discovery [12] statistical package. The analysis of variance was used to determine the significance of the results with means separated by the Fisher least significant difference (p= 0.05).

## 3. RESULTS

### 3.1 Chemical Composition of Soil and Composts

Table 1 shows the chemical composition of both the soil at the experimental site and that of the composts used as treatments. The pH values with the exception of that of CDLCM did not vary from what has been reported for Northern region soils i.e. 4.5 – 6.7 [13]. Phosphorous was higher in all the samples in compared to 2.5 – 10 mg/kg of soil indicated by MoFA [13]. Carbon: Nitrogen (C: N) ratio of the soil, as well as the composts were far below typical adequate levels of 17:1 and 20:1 respectively [14].

The pH in the soil indicated an acidic condition with low organic carbon and nitrogen contents (Table 1). The P and K in the soil were sufficient to support crop production as reported by Antonio and John [15], Pariera and Clain [16].

The ACARP, DeCo composts and CDLCM were analysed for pH, N, P, K, and C content. All the composts were slightly acidic in nature, had low nitrogen content though slightly higher than that in the soil and low carbon content. P and K in all the composts were higher than in the soil.

### 3.2 Performance of Roselle and Jute Mallow Cultivated with CDLCM, ACARP, and DeCo Composts

#### 3.2.1 Plant height

Analysis of variance revealed that there were no significant differences among the soil amendments on plant height of roselle at 4WAT (Fig. 1). However, at 6WAT, there was a significant difference between the ACARP and the control. Also at 8WAT, there was a significant difference in plant height between DeCo compost treated plot and CDLCM.

**Table 1. Concentration of chemical constituents in CDLCM, ACARP, DeCo composts and soil**

| Chemical constituents | CDLCM | ACARP Compost | DeCo compost | Soil |
|---|---|---|---|---|
| pH | 3.9 | 4.3 | 4.8 | 4.4 |
| C (%) | 7.5 | 1.6 | 3.6 | 2.0 |
| N (%) | 0.6 | 0.3 | 0.3 | 0.2 |
| P (mg/kg) | 72.3 | 59.6 | 79.1 | 38.7 |
| K (mg/kg) | 446.9 | 368.6 | 494.4 | 261.3 |

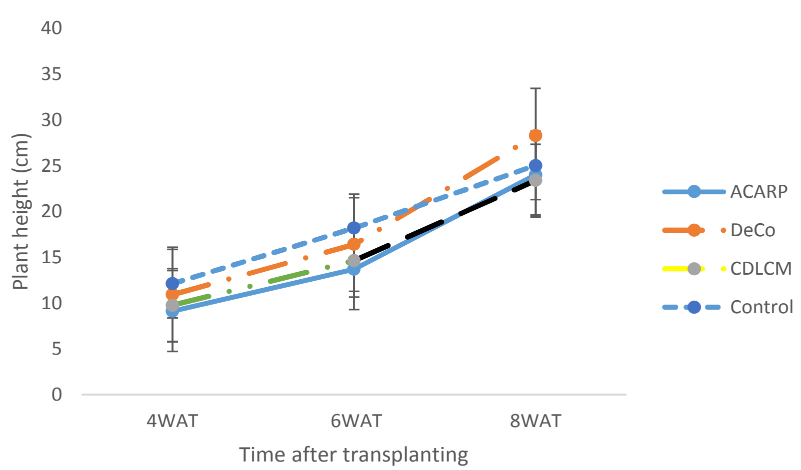


**Fig. 1. Effect of different organic soil amendments on plant height of Roselle**

For jute mallow, there were no significant differences among the various soil amendments and the control on plant height at 4 and 6WAT (Fig. 2). At 8WAT, CDLCM with the highest plant height of 53.4 cm was significantly different from the ACARP soil amendment and the control, but not with DeCo. The DeCo compost was also significantly different from the control with the least plant height of 36.7 cm.

#### 3.2.2 Number of leaves per plant

From the analysis of variance, soil amendment showed no significant difference in the number of leaves in jute mallow at 4 and 6WAT. However, at 8WAT, CDLCM with the highest number of leaves per plant (123.6) was significantly different from the control having the least leaves per plant (69.7) but not significantly different from DeCo (109 leaves) and ACARP (88 leaves) composts soil amendments.

At 4 and 6WAT, there were no significant differences among all the soil amendments for roselle but at 8WAT, all the treatments were significantly different from the control. The higher leaf count was in the decreasing order of CDLCM> DeCo > ACARP > control.

#### 3.2.3 Leaf yield

The analysis of variance showed that cumulative leaf yield of jute mallow from the CDLCM treated plots were significantly different (p= 0.05) from other amendments. Also, DeCo and ACARP composts were significantly different from the control but were not different from each other. The control had the lowest leaf yield of 319 kg/ha while the CDLCM recorded the highest yield of 799 kg/ha.

For roselle, CDLCM had the highest yield (1495 kg/ha) and was significantly different (p=0.05) from ACARP (1008 kg/ha) and the control (1112 kg/ha) but not significantly different from DeCo (1323 kg/ha) as shown in Fig. 6.

### 3.3 Nutritional Quality of Roselle and Jute Mallow Leaves Cultivated with CDLCM, ACARP and DeCo Composts

In roselle, protein content of the control was higher than the rest of the treatments and was significantly different from the DeCo compost but not significantly different from ACARP and CDLCM. For moisture and ash content, no

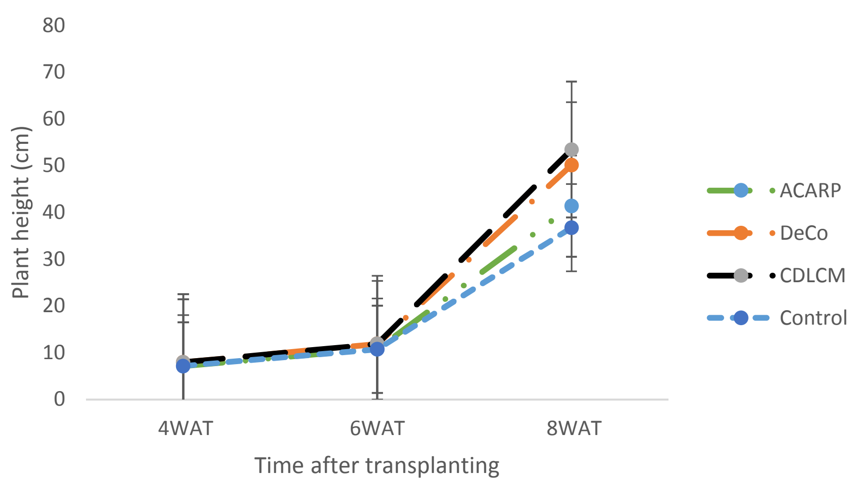


**Fig. 1. Effect of different organic soil amendments on plant height of jute mallow**

**Table 4. Effect of composts amendments on the nutritional content of roselle**

| Treatment | Protein (%) | Moisture (%) | Ash (%) |
|---|---|---|---|
| Control | 29.2 | 13.6 | 15.7 |
| ACARP | 28.6 | 9.9 | 12.4 |
| DeCo | 26.4 | 25.5 | 16.7 |
| CDLCM | 27.6 | 8.7 | 15.7 |
| LSD (5%) | 2.5 | 19.9 | 7.4 |

*NB: the values are means of four replicates expressed in dry weight basis*

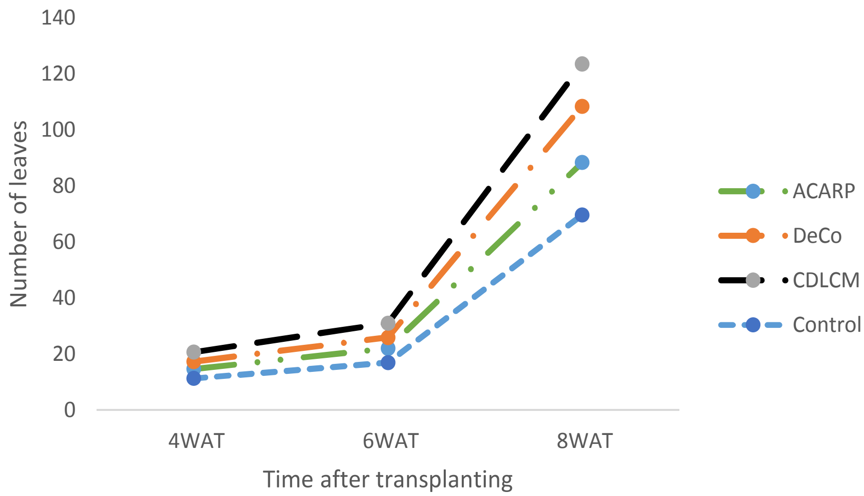


**Fig. 3. Effect of different organic soil amendments on number of leaves in jute mallow**

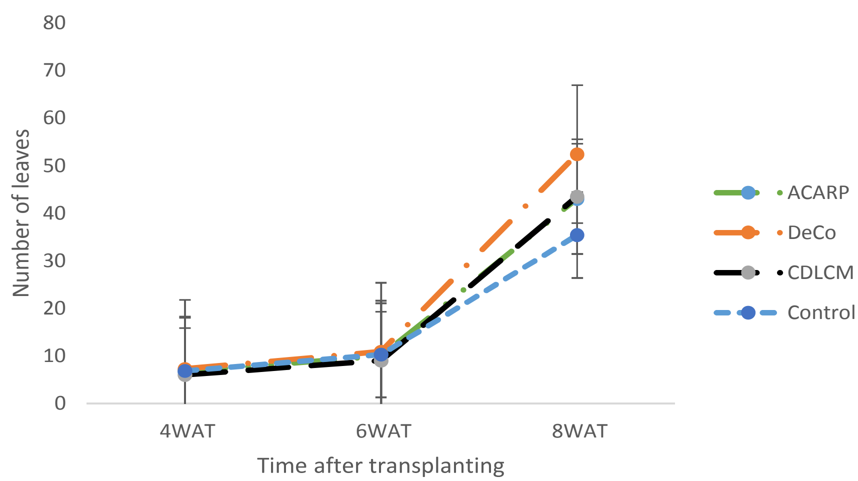


**Fig. 4. Effect different organic soil amendments on number of leaves in roselle**

significant differences among all the treatments were recorded. The ash contents were not significantly different among all the treatments.

Results of analysis of variance shows that there were no significant differences among the soil amendments for all the nutrients determined for jute mallow (Table 5).

**Table 5. Effect of composts amendments on the nutritional content of jute mallow leaves**

| Treatment | Protein (%) | Moisture (%) | Ash (%) |
|---|---|---|---|
| Control | 27.8 | 16.5 | 16.4 |
| ACARP | 27.4 | 19.4 | 14.6 |
| DeCo | 25.2 | 28.5 | 18.2 |
| CDLCM | 27.6 | 26.2 | 16.0 |
| LSD (5%) | 4.4 | 23.9 | 7.7 |

*NB: the values are means of four replicates expressed in dry weight basis*

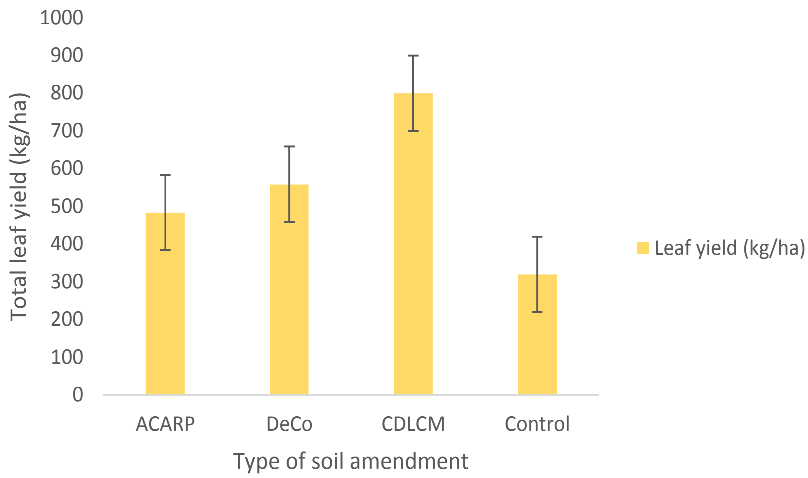


**Fig. 5. Effect of different organic soil amendments on cumulative leaf yield of jute mallow**

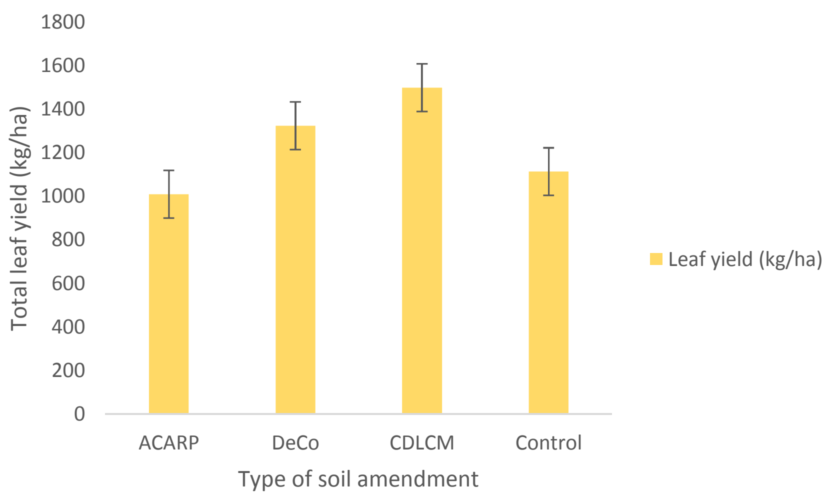


**Fig. 6. Effect of different organic soil amendments on cumulative leaf yield of roselle**

## 4. DISCUSSION

The application of amendments had a positive effect on the performance of both roselle and jute mallow particularly the leaf yield which is the ultimate objective of the gardener. This is supported by Eifediyi et al. [17] where they reported that the application of organo-mineral fertiliser significantly increased the growth parameters in jute mallow. Khatab [18] endorsed that compost application has a significant effect on plant height as well as other growth parameters such as number of leaves and number of branches. Akinfasoye et al. [19] also reported that significant differences were observed in plant height, stem girth and number of leaves as a result of compost application. This study also observed that the organic soil amendments had a significant effect on plant height. However, this was observed at the latter stage of the plant's growth.

As far as the nutritional content is concerned, Asaolu et al. [20] reported that the moisture, protein and ash contents in the fresh leaves of roselle were 12.1%, 46.6% and 7.5% respectively. Except protein content, the moisture and ash contents recorded in this study were higher than that of the above findings. The mean values obtained in this study were 14.4% for moisture content, 28% for protein content and 15.1% for ash content.

In jute mallow leaves, the mean values recorded in this study were 22.7% for moisture content, 27% for protein content and 16.3% for ash content. These values are higher (except moisture content) than that of the study reported by Adediran et al. [21].

## 5. CONCLUSION

Present study showed that both roselle and jute mallow performed better in terms of yield from the CDLCM in compared to DeCo, ACARP and the control. Proximate analysis showed that moisture and ash contents were not significantly affected by composts application in both the crops.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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