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Response of Jute Mallow (*Corchorus olitorius* L.) to organic manure and inorganic fertilizer on a ferruginous soil in North-eastern Benin

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ABSTRACT

Objective: The study aimed to evaluate the effects of three types of fertilizers (Municipal solids waste compost, cow dung and chemical fertilizer) on growth characters and leaf yield of *Corchorus olitorius* under irrigated conditions

*Methodology and results***:** A field experiment was conducted in Parakou in the dry season using a randomized complete block design with three factors and twelve treatments: 1) Municipal solids waste Compost (MSWC) at 0, 10, 20 and 30 $t.ha^{-1}$; 2) Cow dung at 0, 10, 20 and 30 $t.ha^{-1}$; Urea fertilizer (46% N) at 0, 50, 100 and 200 $kg.ha^{-1}$. The plant height and stem diameter were significantly higher with Compost (20 t/ha) and lowest was recorded in control at all growth stages. The application of compost, cow dung and chemical fertilizer significantly increased the total number of branches at all growth stages. The highest number was recorded in MSWC 20 $t.ha^{-1}$ as compared to the other treatments. The highest marketable leaves yield was obtained with MSWC at 20 $t.ha^{-1}$ (8.1 $t.ha^{-1}$) followed by MSWC at 30 $t.ha^{-1}$ (6.6 $t.ha^{-1}$), cow dung at 30 $t.ha^{-1}$ (5.4 $t.ha^{-1}$) and urea at 100 $kg.ha^{-1}$ (5.4 $t.ha^{-1}$), while control recorded lower values. A significant quadratic response on fresh leaf yield was observed with MSWC leading to a maximum of yield of 8.15 $t.ha^{-1}$ at 23.03 $t.ha^{-1}$.

Conclusion and application of results: The results indicated that the MSWC performs better when used at the optimal rate (23.03 $t.ha^{-1}$), and can be used as a promising fertilizer source in *Corchorus olitorius* production in Benin.

Key words: Leaf yield, waste compost, cow dung, *Corchorus olitorius*, Benin

INTRODUCTION

Jute Mallow (*Corchorus olitorius*) is a popular and leafy vegetable of great importance in Benin (Dansi *et al.,* 2008, 2009). It is an erect annual herb that varies from 60 cm to approximately 150 cm in height depending on the cultivar. It grows in fields next to the houses, on the market garden sites and home gardens around the world. Jute mallow plays an important role in nutrition and household food security. The leaves contain an average of 15% dry matter, 4.8 g of protein, 259 mg of calcium, 4.5 mg of iron, 4.7 mg of vitamin A, 92 µg of folates, 1.5 mg of nicotinamide and 105 mg of ascorbic acid per 100 g of leaves (Grubben and Denton, 2004; Harborne *et al.,* 1999). Despite its nutritional and economic importance, it has been neglected by scientific research and development in Benin. However, there is also a growing international recognition that Neglected and Underutilized Species (NUS) play a role in providing food and nutrition security and income opportunities among smallholder farmers. These NUS crops, trees and animals can help in adapting agriculture and food systems to climate change. Many farmers, especially in marginal areas, rely on NUS for their livelihoods. Consequently, cultivated varieties run the risk of genetic erosion and their cultivation is in serious decline due to low fertility soil, poor yield, pest and diseases. In traditional farming systems, low quantity of fertilizer is applied (Ayodélé *et al.,* 2006). In addition, these systems benefit from only the natural soil fertility and possibly small amounts of fertilizer applied to increase the production of other associated crops. This residual fertility is insufficient to meet the crop nutrient supply. Therefore adequate fertilization is essential to maximize their yields. Indeed, jute mallow requires nutrients such as N, P, K, Mg, Ca, Na and S for a good yielding. These nutrients are specific in function and must be supplied to the plant at the right time and in the right quantity. Jute mallow responds well to fertilization, particularly nitrogen (Ogunrindé and Fasinmirin, 2011). Moreover, this crop is mostly carried out by marginalized producers of whom access to mineral fertilizers is prohibitive because of their low income (Gensch *et al.,* 2011). Besides, excessive and indiscriminate use of chemical fertilizers leads to soil degradation and imposes a serious threat to human health (Fujimoto, 1998). Also, jute mallow is cultivated on a small scale by women only, so that the production cannot pay back the cost of purchase and transportation of mineral fertilizers. All the above reasons underscore the acute need of alternative sources of fertilizer for sustainable crop production. Organic waste could be a viable alternative to chemical fertilizers. The use of organic manure, e.g. municipal waste compost and cow dung has improved agricultural productivity in West African countries. Organic farming has enough positive impacts: the long-term productivity in soil conservation and improvement of soil fertility involves the sustainability of production for future generations, stability and food security in diversity cultures and environmental impact using manure. Indeed, organic manures enhance soil moisture, increased soil organic matter, nitrogen, pH, phosphorus, and cation exchange capacity (CEC), and reduced soil exchangeable acidity (Ngeze, 1998; Adeniyan and Ojeniyi, 2003; Mbah, 2006; Ayeni *et al.,* 2008; Alabadan *et al.,* 2009; Adeleye *et al.,* 2010; Dikinya and Mufwanzala, 2010; Njoku and Mbah, 2012; Adejuyigbe *et al.,* 2012; Darzi and Haj Seyd Hadi, 2012; Najm *et al.,* 2012). The present paper aims to determine the rate of compost/cow dung application that produces the highest yield of *Corchorus olitorius* compared to the urea rate under North-eastern Benin conditions.

MATERIAL AND METHODS

Material

Site location and climate: Experiments were conducted in the dry season (from December 2012 to February 2013), at the Teaching and Research Farm of Faculty of Agricultural Sciences, University of Parakou in northern Benin with 09°20'16.8'' as latitude North; 002°38'54'' as longitude East and 353 m as altitude (Figure 1). The climate is tropical soudanian, characterized by an average of 800-1100 mm of annual rainfall and 24 – 31 °C monthly temperature. The rainy season extends from May to October. The average relative humidity is 18 – 99%. Initial soil characteristics and chemical properties of compost and cow dung**:** Five fractions of soil texture were determined using the international method modified by the use of Robinson pipette. The organic carbon by Walkey and Black method, the total nitrogen by Kjeldahl method, the pH (1/2.5 ratio soil-water), the phosphorus according to Bray1 method, the exchangeable cations by the acetate of ammonium method. Calcium and magnesium were measured by titration with EDTA and the potassium was determined with a flame photometer.

The soil is tropical ferruginous very much leached and poor. The texture found in the top 20 cm was clay loamy with 35% of clay, 43% of loam and 22% of sand. Organic matter (OM) and total nitrogen contents in the experimental soils were 0.6% and 0.1% respectively. On most plots, organic matter contents were low (OM >2.5%). All sites showed neutral (6.6< pH < 7.3) soils pH. The C/N ratios ranged between 10 and 12, indicating a good mineralization. The potassium was low (< 0.15 cmol.kg^{-1}). The Cation Exchange Capacity (CEC) (<15 cmol.kg^{-1}) was low in the sites. Available phosphorus according to Bray method was low in the top soil (table 1). In summary, soils in location had low soil fertility. Samples of composts and cow dung were air-dried and used for mineral content determination. Samples were digested with nitric-perchloric-sulphuric acid mixture at 120°C during 3 hours in a Teflon digester. Digested samples were thereafter diluted with distilled water. Total K contents were measured by atomic absorption spectrophotometry using an AAS-800 spectrophotometer (Perkin Elmer, Wellesley, MA, USA). Total P content was determined by the colorimetric method using molybdovanadate reagent (Stewart *et al.* 1974) and total N content by the Kjeldahl (block digestion) method (AOAC 981.10) (AOAC, 1990). The nitrogen content ranged from 17.2% in the MSWC to 6.1 in the cow dung. The pH was basic (8.1) in the MSWC and weakly acid (6.0) in cow dung. Organic carbon ranged from 17 in the MSWC to 3.8% in the cow dung. P was 10.3 in the MSWC and 1.4 in the cow dung. The K contents varied from 11.3% in the MSWC to 2.6%, whereas calcium (Ca) ranged between 36.9% in the MSWC and 6.9% in the cow dung, and magnesium (Mg) between 2.9% and 0.9 (table 1).

Table 1: Initial soil characteristics and chemical properties of compost and cow dung (CD)

Soil parameter	MSWC	Cow dung (CD)	Soil
Chemical characteristics			
pH	8.1	6.0	6.7
Organic C (%)	17	3.8	0.6
Total nitrogen (%)	17.2	6.1	0.1
Available phosphorus (%)	10.3	1.4	0.2
Exchangeable Cations (Cmol.kg^{-1})	nd	nd	6.4
Ca (%)	36.9	6.9	0.8
Mg (%)	2.9	0.9	1.2
K (%)	11.3	2.6	2.1
Physical characteristics			
Sand (%)	nd	nd	22
Silt (%)	nd	nd	43
Clay (%)	nd	nd	35

nd: not determined

Crop variety used in the Experiment: Seedlings of *C. olitorius* were hardened and transplanted at three weeks after sowing (WAS). Transplanting was carried out in the evening with seedlings transplanted at a spacing of 0.4 m x 0.1 m to give a total of 250000 plants ha^{-1}. Plants were watered immediately after transplanting and thereafter daily until rainfall was regular.

Experimental design: The experimental design was a complete randomized block design with thrice replicated. Treatments consisted of three fertilizer types at different levels, i.e. urea (U) 46% N applied at 50, 100 and 200 kg.ha^{-1}; municipal solid waste compost (MSWC) applied at 10, 20 and 30 t.ha^{-1} and cow dung (CD) at 10, 20 and 30 t.ha^{-1} and the control (no fertilizer).

Field management and observations: The experimental area was divided into three blocs each containing 12 plots (to give 36 experimental units). Each plot measured 4 m x 1.2 m with 0.5 m spacing between plots and 1m apart in each block of rows for easy movement during cultural operations. The MSWC was obtained from the Parakou solid waste recycling and composting station, where it was produced under aerobic conditions and placed in windrows for final maturing. Composting took about four months; however, the compost was collected and stored before field application. The municipal waste compost and cow dung were dried and incorporated into the soil three week before seedling transplantation while urea was applied two week after transplanting (WAT). Fertilizers were applied by band placement at 5 cm depth and 7 cm away from the plants, with proper covering up by holes to prevent nutrients leaching by run-off. Weeding was applied manually at two weeks intervals and spraying with neem extract at 20 ml per 10 litres of water at two weeks intervals to control insects. The growth and yield parameters collected to assess the response of *Corchorus* to the fertilizer treatments were: plant height, number of leaves per plant, number of branches per plant, leaf area index (LAI), stem diameter (measured with a digital calliper), limb length, limb width and petiole length. For the plant growth measurements, five plants were selected randomly by leaving the border plants and tagged in each plot for recording various morphological observations at 2, 4, 6 days and week after transplanting (WAT). At Harvest (6 weeks after transplanting), six plants of each treatment were sampled and cut. Then, the plants were separated into leaves, stems and roots and weighed with a sensitive scale and later oven dried at 80°C for 24 h for dry weight and leaves yield per hectare. Other parameters were obtained at harvest. Only the results at 6 weeks after transplanting were presented in this paper.

Statistical analysis: Statistical analysis was performed for different fertilizer sources across growth characters, shoot and root weight, and leaves yield and yield attributing characters. Data were subjected to analysis of variance (ANOVA) using R 2.14.1 software (R Development Core Team, 2011) using a randomized complete block structure with 3 replications. Means were compared using least significant difference (LSD) at $p < 0.05$. Quadratic and linear regression analyses were performed to model crop response to fertilizer levels. The normality (Shapiro and Wilk, 1965), the homogeneity (Snedecor and Cochran, 1956) and the independence of residuals (Durbin and Waston, 1950) were checked for model validation.

RESULTS

Plant growth: *Corchorus olitorius* according to the different treatments showed a significant effect on growth parameters at 8 weeks after transplanting (Table 2). The average plant height, number of leaves, stem diameter, leaf area and number of branches increased as the levels of inorganic and organic fertilizers application increased. However, MSWC at 30 t.ha^{-1}, cow dung (CD) at 30 t.ha^{-1} and urea at 200 kg.ha^{-1} showed low values for few parameters. The tallest plants were obtained from MSWC at 20 t/ha (72.9 cm) which was similar to MSWC at 30 t.ha^{-1} (70.5 cm) and cow dung at 30 t.ha^{-1} (65.1 cm) application. Conversely, control treatment and plants fertilized with urea (200 kg.ha^{-1}) showed significantly lower height (34.6 - 37.2 cm) (Table 1). The plants fertilized with MSWC at 10 t.ha^{-1}, CD at 10 t.ha^{-1}, CD at 20 t.ha^{-1}, urea at 50 kg.ha^{-1} and urea at 100 kg.ha^{-1} showed similar plant height varying from 48.5 to 57.0 cm. The plants fertilized with MSWC at 20 t.ha^{-1} produced the highest number of leaves per plant (118.2). Lower number of leaves per plant was obtained with control and plants fertilized with urea at 200 kg.ha^{-1}. The results showed that stem diameter was significantly influenced by treatments. Significantly higher stem diameter was observed with MSWC at 30 t.ha^{-1} (8.6 mm), followed by MSWC at 20 t.ha^{-1} (8.4 mm) which was similar to MSWC at 10 t.ha^{-1} (7.5 cm) and CD at 30 t.ha^{-1} (7.7 mm). Whereas, lower stem diameter was recorded in control (3.9 to 4.5 mm) and urea at 200 kg.ha^{-1} (4.3 mm). Among the treatments, MSWC at 20 t.ha^{-1} recorded significantly higher (14.6) number of branches over all other treatments, followed by MSWC at 30 t.ha^{-1} (14.1) which was equal to MSWC at 10 t.ha^{-1} (13.3) and CD at 30 t.ha^{-1} (13.6) while, the control had the lower number branches (8.8 to 9.2) (Table 2). Plants fertilized with MSWC at 20 t.ha^{-1}, CD at 30 t/ha and urea at 100 kg.ha^{-1} showed greater height, number of leaves, stem diameter total leaf area and number of branches than other treatment (Table 2).

Shoot and root weight: The fresh shoot weight of *C. olitorius* plants fertilized with MSWC at 20 t.ha^{-1} (46.5 g per plant) differed significantly ($p < 0.05$) from plants fertilized with other treatment (Table 3). The highest dry shoot weight was obtained from MSWC at 20 t.ha^{-1} (20.6 g per plant) application followed by MSWC at 30 t.ha^{-1} (15.7 g per plant) and MSWC at 10 t.ha^{-1} (11.6 g per plant) (Table 3). The fresh root weight per plant was found non-significant due to treatments. The plants treated with MSWC at 30 t.ha^{-1} showed highest fresh root weight (9.7 g plant^{-1}) whereas the fresh root weight of remaining treatments was considerably similar and ranged from 2.9 to 8.3 g plant^{-1} (Table 3). *C. olitorius* plants fertilized with MSWC at 20 t.ha^{-1}produced significantly higher dry root weight (2.5 g plant^{-1}), whereas values of other treatments were considerably similar and ranged from 21.4 to 2.1 g plant^{-1}. Lower dry root weight was obtained with controls (Table 3).

Table 2: Effect of applying municipal solid waste compost (MSWC), cow dung (CD) or urea on plant growth parameters of *Corchorus olitorius* at 6 week after transplanting.

Levels of fertilizer	Plant Height (cm)	Number of leaves	Stem diameter (mm)	Leaf area (cm²)	Number of branches
MSWC levels ($t.ha^{-1}$)					
0	37.2a	40.1a	4,2a	356.8a	8,9a
10	57.0b	96.9cd	7,5cd	1119.5d	13,3def
20	72.9c	118.2d	8,4d	1157.5d	14,6f
30	70.5c	107.3d	8,6d	810.0bcd	14,1ef
Cow dung levels ($t.ha^{-1}$)					
0	37.2a	40.1a	4,2a	356.8a	8,9a
10	48.5b	55.1ab	6,1b	623.9abc	11,7cd
20	50.9b	61.1ab	6,2b	436.6ab	11,8cd
30	65.1c	91.2cd	7,7cd	905.2cd	13,6def
Urea (46%, $kg.ha^{-1}$)					
0	37.2a	40.1a	4,2a	356.8a	8,9a
50	50.3b	52.7ab	6,8bc	616.0abc	11,1bc
100	53.5b	75.3bc	7.1bc	690.3abc	12,5cde
200	37.1a	43.7a	4,3a	354.9a	9,8ab
Significance	***	***	***	***	***

Means with different letters within columns are significantly different at 5% (*), 1% (**) and 0.1% (***) levels of probability respectively using the Least Significant Difference (LSD), n=15.

Table 3: Effect of applying municipal solid waste compost (MSWC), cow dung (CD) or urea on shoot and root characters of *Corchorus olitorius* at 6 week after transplanting.

Levels of fertilizer	Fresh shoot weight (g $plant^{-1}$)	Dry shoot weight (g $plant^{-1}$)	Fresh root weight (g $plant^{-1}$)	Dry root weight (g $plant^{-1}$)
MSWC ($t.ha^{-1}$)				
0	9,3a	3.7a	3.3	1.1a
10	18.6a	11.6ab	6.9	2.9b
20	46.5c	20.6b	8.3	2.5ab
30	26.6b	15.7ab	9.7	1.9ab
Cow dung ($t.ha^{-1}$)				
0	9,3a	3.7a	3.3	1.1a
10	12.2a	6.4a	4.3	1.4ab
20	21.5b	5.6a	5.0	1.4ab
30	22.8b	10.0ab	6.9	1.7ab
Urea (46%, $kg.ha^{-1}$)				
0	9,3a	3.7a	3.3	1.1a
50	13.2a	7.0a	5.1	1.6ab
100	20.7b	7.9a	5.5	1.1ab
200	9.8a	6.8a	4.6	2.1ab
Significance	*	**	ns	*

n.s: non-significant; Means with different letters within columns are significantly different at 5% (*), 1% (**) and 0.1% (***) levels of probability respectively using the Least Significant Difference (LSD), n=6.

Marketable leaves yield, morphological traits and response to nutrient supply: Fresh Leaves and dry weight were increased by the lower level of applied MSWC and urea significantly and were increased more by the higher levels (Table 4). The fresh leaves yield recorded was highest (33.3 $g.plant^{-1}$) for plants treated with MSWC at 20 $t.ha^{-1}$, followed by MSWC at 30 $t.ha^{-1}$ (26.5 $g.plant^{-1}$), CD 30 at $t.ha^{-1}$ (21.5 $g.plant^{-1}$) and urea at 100 $kg.ha^{-1}$ (21.5 $g.plant^{-1}$). *C. olitorius* leaves yield responded positively to the fertilizers sources and their levels, and the highest marketable leaves yield was obtained with MSWC at 20 $t.ha^{-1}$ (8.1 $t.ha^{-1}$) followed by MSWC at 30 $t.ha^{-1}$ (6.6 $t.ha^{-1}$), CD at 30 $t.ha^{-1}$ (5.4 $t.ha^{-1}$) and urea at 100 $kg.ha^{-1}$ (5.4 $t.ha^{-1}$), whereas the lowest marketable leaves yield were observed with control and 200 $kg.ha^{-1}$ of urea treatments (2.1 to 3.9 $t.ha^{-1}$; Table 3). Treatment effects on leaf length, leaf width and petiole length were highly significant ($p<0.001$). Among the treatments, 20 $t.ha^{-1}$ of MSWC and 50 $kg.ha^{-1}$ of urea recorded significantly higher leaf length (9.8 cm) followed by 30 $t.ha^{-1}$ of MSWC (9.5 cm) and 200 kg of urea per ha (9.5 cm), while the control and 200 kg of urea per ha showed the minimum leaf length ranged from 4.9 to 5.6 cm. The highest leaf width was obtained with 30 $t.ha^{-1}$ of MSWC (7.9 cm) application followed by 100 kg of urea per ha (7.8 cm), 20 $t.ha^{-1}$ of MSWC (7.5 cm) and 20 $t.ha^{-1}$ of CD (7.1 cm). The highest petiole length was observed from plants fertilized with 20 $t.ha^{-1}$ of MSWC (7.9 cm) which was at par with MSWC 30 $t.ha^{-1}$ (7.6 cm) and 100 $Kg.ha^{-1}$ of urea (7.3 cm) but significantly higher than other treatment (Table 4). A significant quadratic response on fresh leaf yield was observed with organic manure leading to a maximum of yield at 23.03 $t.ha^{-1}$. A quadratic response on fresh leaf yield was also observed with urea but the trend was not significant (Figure 1). Linear regression was considered for *C. olitorius* yield response to cow dung levels. The application of organic material (MSWC and cow dung) at level of 20 $t.ha^{-1}$ and urea fertilizer at 100 $kg.ha^{-1}$ to *C. olitorius* plants allows obtaining higher yields.

Table 4: Effect of applying municipal solid waste compost (MSWC), cow dung (CD) or urea on leaves, marketable yield and yield components of *Corchorus olitorius* at 6 week after transplanting.

Levels of fertilizer	Fresh wt. ($g.plant^{-1}$)	Dry wt. ($g.plant^{-1}$)	Yield ($t.ha^{-1}$)	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)
MSWC ($t.ha^{-1}$)						
0	11.9a	3.5a	3.1a	5.6a	4.5a	4.0a
10	18.1ab	7.5bc	6.8b	8.3bcd	6.8bc	6.9cd
20	33.3c	8.6c	8.0c	9.8d	7.5c	7.9d
30	26.5bc	5.4ab	7.6bc	9.5cd	7.9c	7.6d
Cow dung ($t.ha^{-1}$)						
0	11.9a	3.5a	3.1a	5.6a	4.5a	4.0a
10	13.8ab	4.4a	3.5ab	7.8b	5.8bc	5.6bc
20	16.5ab	4.7a	4.1ab	8.5bcd	7.1bc	6.2bc
30	21.5abc	5.1a	5.4abc	8.1bc	6.9bc	6.2bc
Urea (46%, $kg.ha^{-1}$)						
0	11.9a	3.5a	3.1a	5.6a	4.5a	4.0a
50	13.4ab	4.3a	3.4ab	9.8d	6.9bc	6.2bc
100	21.5abc	5.5ab	5.4abc	9.5cd	7.8c	7.3cd
200	10.6a	4.2a	3.7a	5.4a	4.6a	4.7ab
Significance	***	***	***	***	***	***

n.s: non-significant; Means with different letters within columns are significantly different at 5% (*), 1% (**) and 0.1% (***) levels of probability respectively using the Least Significant Difference (LSD).

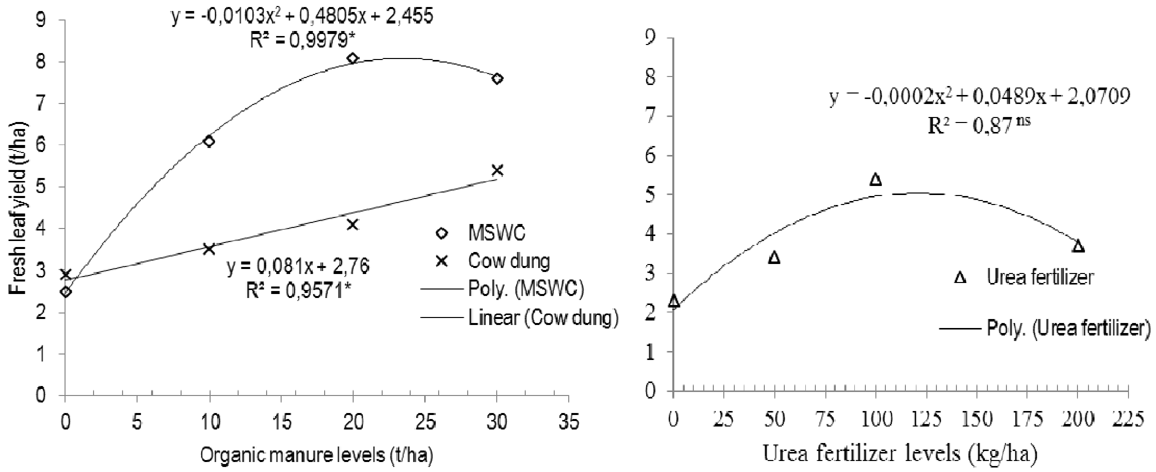

Figure1: Jute mallow yield response to organic manures and urea fertilizer levels. Measured yields (dots) are treatment average modelled by parabolic curves or linear trendlines (equation and R^2). ns or * mean that model is not or significant at $p < 0.05$ respectively.

DISCUSSION

Effect of different fertilizer types on growth parameters: The application of organic manures enhanced significantly the growth parameters (plant height, number of leaves, stem diameter, total leaf area and number of branches) in *C. olitorius*. The application of 20 tons of MSWC per ha favourably influenced the different growth parameters at 6 WAT followed by 30 tons of cow dung per ha and 100 kg of urea per ha. Several authors mentioned similar results on different plants such as Emuh (2013) on jute mallow, Khalil and El-Sherbeny (2003) on three Mentha species plants, Khalil *et al.* (2002) on *Tagetes erecta*, El-Desuki *et al.* (2001) on sweet fennel, Rekha and Gopal Krishna (2001) in bitter gourd, Aliyu (2000) on pepper, Dauda *et al.* (2005) on eggplant, Sutagundi (2000) in chilli, Herrera *et al.* (1997) on horehound, thyme and angelica plants and O'Brien and Barker (1996) on peppermint, who observed that increasing organic manures levels in soil improved significantly growth characters. This has been the consequence because of higher nutrient availability and increased nitrogen from organic manures (MSWC and cow dung) which had profoundly influenced in mobilizing the nutrients from the unavailable form of nutrients mainly due to improved physical, chemical and biological properties of the soil. This increasing reconfirmed the role of nitrogen in promoting vigorous vegetative growth in leafy vegetables (Tisdale and Nelson, 1990). This showed also that nitrogen stimulates formation of new leaves and increases the size and height of plant. As well established previously in the literature, manures increase organic matter and plant nutrient availability, and improve some soil physical properties (Aliyu, 2000; Adeniyan and Ojeniyi, 2005; Adenawoola and Adejoro, 2005; Agbede *et al.,* 2008; Okonwu and Mensah, 2012; Emuh, 2013). The application of different rates of urea influenced plant height, stem diameter and number of leaves variably at 6 weeks after transplanting. This improvement of vegetative characteristics with the increasing of different rates of urea could be attributed to increased uptake of nitrogen and its associated role in chlorophyll synthesis and hence the process of photosynthesis and carbon dioxide assimilation (Jasso-chaverria *et al.,* 2005) leading to enhanced growth. It was observed that, the control was not statistically different with plots that received 200 $Kg.ha^{-1}$ of urea and for this reason, it can be deduced that the application of over 100 $Kg.ha^{-1}$ of urea fertilizer (46% N) does not enhance the growth of *C. olitorius*. The reduced plant height, number of leaves and stem diameter on plots subjected to no fertilizer can be attributed to deficiency of nitrogen in the soil and hence stunted plants.

Effect of different types of fertilizer on leaves yield and yield parameters: Yield is the manifestation of morphological, physiological, biochemical and growth parameters and is considered as a result from the trapping and conversion of solar energy efficiency. Yield is polygenic in nature and is influenced by several factors (internal and external) throughout the crop growth period. The treatment with 20 tons per ha of MSWC recorded significantly higher yield followed by 30 tons per ha of cow dung. The reasons for increased leaves yield was due to the increased solubilization effect and availability of nutrients by the addition of organic manures (OM) that increased physiological activity leading to the build-up of sufficient food reserves for the developing sinks and better portioning towards the developing leaves. Similar results were also reported by Emuh (2013), Okonwu and Mensahin (2012) and Arancon *et al.* (2006). As this study showed, plants seem to perform better in treatments receiving compost due to the presence of growth promoting substances (Sridevi and Srinivasamurthy, 2010), micro-nutrients, and a variety of inorganic and organic compounds. At the same time, addition of organic amendments improves soil structure, aggregate stability and moisture retention capacity (Bhattacharyya *et al.,* 2008). Moreover, in this study, higher fresh shoot weight was observed with plants fertilized with 20 tons per ha of MSWC compared to plants fertilized with various levels of cow dung or urea. In contrast, there is no significant difference between different treatments for fresh root weight. Plants adjust themselves to nutrient uptake and absorption via profuse growth of roots. Similarly, the results may in part be explained by the increased microbial activities and release of phytohormones and enzymes with compost application. The results of this study revealed that the application of urea (46% N) increases fresh and dry leaves yield of jute mallow to a point where further increase in fertilizer results into a decline in productivity. The results are in agreement to those reported by Najm *et al.* (2013), Ng'etich *et al.* (2013), Olaniyi and Ajibola (2008), Sincik *et al.* (2008), Honeycutt *et al.* (1996) and Greef (1994) that in average fresh and dry leaf yield of vegetables increases with increase in nitrogen fertilizer applied up to a point of stagnation and a decrease in dry matter production for nitrogen deficient soils. Lower growth and yield of plants fertilized with high urea rates may be associated with larger gaseous nitrogen losses (Kirchmann and Pettersson, 1995) or could be explained by the fact that a high concentration of soluble N increases the osmotic potential of the soil solution, causing reduction in water uptake by the plant roots.

CONCLUSION

Under Northern Benin environmental conditions, the different types and dose of fertilizer positively affects growth parameters and yield of *C. olitorious*. The municipal solids waste compost (MSWC) performs better when used at the optimal rate (23.03 t.ha^{-1}), and can be used as a promising fertilizer source in *Corchorus olitorius* production in Benin. The findings opened a way for organic production of *Corchorus olitorius.*

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