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EFFECTS OF THREE DIFFERENT RATES OF APPLICATION OF CATTLE DUNG ON THE GROWTH AND QUALITY OF TWO TRADITIONAL LEAFY VEGETABLES *(AMARANTHUS CRUENTUS AND CORCHORUS OLITORIUS)*

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ABSTRACT

Traditional leafy vegetables have been noted to supply abundant amounts of minerals and to some extent calories and proteins which are vital to the alleviation of problems of malnutrition in developing countries. An experiment was conducted to study the effects of three different rates of application of cattle dung on growth parameters, proximate and mineral composition, weight loss and shelf life of *Amaranthus cruentus* and *Corchorus olitorius.* The treatments were cattle dung manure at rates of 0, 0.5. 0.8 and 1.1 t/ha. Application of 1.1 t/ha in *Amaranthus cruentus* resulted in the highest plant height on the 20th day after transplanting. The 0.8 t/ha rate of application gave the highest number of leaves and shoots of *Amaranthus cruentus.* Higher rates of application produced bigger stem girths which varied significantly from those without manure application. On the effects of the different rates of application on *Corchorus olitorius*, the results showed that, generally, there was no significant difference ($P > 0.05$) from those without manure application. Increased rates of application resulted in a decline in the growth parameters. The results on shelf life for both *Amaranthus cruentus* and *Corchorus olitorius* showed that both wilted and dried on the 24th hour and 48th hour after harvesting respectively. In conclusion, the study showed that increased application of cattle dung produced positive outcomes on the growth parameters of *Amaranthus cruentus.*

Contribution/Originality: This study contributes to the existing literature on the use of cattle dung as a source of fertilizer to improve the growth parameters, nutritional value and shelf life of two traditional leafy vegetables: *Amaranthus cruentus* and *Corchorus olitorius.* Application of cattle dung at 0.8 tonnes and 0.5 of cattle dung resulted in a higher number of leaves in *Amaranthus cruentus* and *Corchorus olitorius* respectively 20 and 30 days after transplanting. Calcium content increased with an increase in the application rate in both *Amaranthus cruentus* and *Corchorus olitorius.* An increase in the application rate reduced the moisture content in both *Amaranthus cruentus* and

Corchorus olitorius. The study concluded that fresh leafy vegetables should be consumed within 24hr after harvesting.

1. INTRODUCTION

Feeding the rapidly growing population in Africa remains a global challenge. As the demand for food increases, climate change, on the other hand, poses more challenges to agricultural productivity, implying that the provision of sufficient quantities and qualities of food is threatened (Dube, Heijman, Ihle, & Ochieng, 2018). Traditional vegetables are plants whose leaves, fruits and roots are acceptable and used as vegetables as part of tradition, custom and habit in urban and rural areas and are widely consumed during famines and natural disasters (Dube et al., 2018). Traditional leafy vegetables (TLVs) in Africa are resilient to adverse weather conditions and are naturally rich in nutrients, including vitamins A & C, iron, protein and other micronutrients (Dube et al., 2018). Diverse indigenous leafy vegetables are rich sources of nutrients that cater for the populace, especially those residing in rural areas. However, inadequate knowledge of their constituents and health benefits has decreased their consumption in recent years as opposed to exotic vegetables. Hence to promote their consumption, information about the nutritional, phytochemical, ethnomedicinal and pharmacological properties of the two most popular and widely used indigenous vegetables: Corchorus olitorius (Jute mallow) and Amaranthus cruentus in several parts of Ghana need to be provided. TLVs are a very inexpensive resource for tackling undernutrition and malnutrition which are prevalent in Ghana. There is, therefore, a need to create awareness that will encourage their consumption in a bid to reduce malnutrition and attain the UN Sustainable Development Goal of achieving food security, improving nutrition, and promoting good health and well-being by 2030 (Osafo, 2021). Recent studies have shown that traditional leafy vegetables contain non-nutrient bioactive phytochemicals that have been linked to protection against cardiovascular and other degenerative diseases (Kwenin, Wolli, & BM, 2011).

Fertilizers are applied to leafy vegetables to ensure a continuous supply of nutrients. Organic and inorganic fertilizers are the major sources of improving soil fertility. The application of inorganic fertilizer, for instance, has been found to increase the performance and chemical properties of soil such as pH, total nutrient content and nutrient availability.

On the other hand, its continuous use could cause nutrient imbalance and soil acidity. Moreover, heavy fertilization in crop production systems could exceed what the plants are able to utilize and can be a major source of excessive nitrate leaching (Usman, Madu, & Alkali, 2015). In addition, they are expensive and may not be readily available. Alternatively, organic fertilizers are used to produce crops free from heavy metal contamination (Asadu & Unagwu, 2012). The addition of organic amendments to manage the current trend of soil physical, chemical and biological degradation has been recommended by Chukwu, Ano, and Asawalam (2012).

In Ghana, most growers of leafy vegetables, particularly in urban areas, have adopted the use of organic fertilizers. Although such fertilizers have been reported to improve yield and soil properties, there is insufficient information on the effects of different levels of application on the postharvest behaviour and quality of traditional leafy vegetables. Animal manure, including cow dung, has been used for centuries as a source of nutrients in agriculture. Among the various types of animal waste, the amount of nutrients in cow manure is 4–9 times that of pig manure (Guo et al., 2013). Hence, investigating effective measures for disposing of animal waste, especially cow manure, has become an important topic. Cattle dung is one of the sources of nitrogen and other nutrients which can decrease the demand for chemical fertilizers, and it has been used for many centuries to increase soil fertility (Rahimabadi, Ansari, & Razavi Nematollahi, 2018).

Many researchers have mentioned the beneficial effects of organic fertilizers, including the increase of hydraulic conductivity, raising the water holding capacity, enhancing soil physical properties, improving soil and landscape quality, reducing runoff, and changing the soil pH, that is, increasing or decreasing the pH, depending on soil type and characteristics of organic fertilizer (Celik, Ortas, & Kilic, 2004; Cogger, 2005; Demir & Doğan Demir, 2019).

The use of animal manure has been reported as a potential factor for better vegetative growth. The positive effects of organic manure on plant height, shoot, leaf area and plant growth have been previously reported (Aziz et al., 2010; Safaei Khorram et al., 2019). The investigation into the effects of organic manure (cattle dung) on growth parameters, nutritional value and shelf life of vegetables is expected to add to the organic manure literature thereby complementing the existing literature on TLVs as well as organic manure.

The purpose of this research was therefore to assess the effects of different levels of cattle dung application on growth parameters and postharvest attributes of selected traditional leafy vegetables in Ghana.

2. MATERIALS AND METHODS

2.1. Experimental Site, Source of Materials, Land Preparation and Soil Amendment

The fieldwork was conducted on the research plots of the Department of Horticulture, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology (KNUST). The site falls within the rainfall pattern of the forest zone of Ghana. The nutritional compositions of the cattle dung, soil and leafy vegetables were also analysed at the soil science laboratory of Kwame Nkrumah University of Science and Technology. The cattle dung was obtained from the Kumasi Abattoir in the Kumasi Metropolis. Seeds of *Corchorus oliterius* and *Amaranthus cruentus* were obtained from the Department of Horticulture, KNUST. The land was ploughed and harrowed. Rubbles, mostly roots of grasses and stumps of shrubs were removed from the soil. The soil was analysed before the commencement of the experiment. The cattle dung was composted for a period of four months, analysed to determine its nutritional composition and applied on plots at the rates of 0, 0.5, 0.8, and 1.1 tonnes.

2.2. Cultural Practices Carried Out

The seeds were nursed using the broadcasting method. Watering was done immediately after sowing. Transplanting was done when seedlings were two weeks old. The plant height, number of leaves, number of shoots and stem girth were measured on the twentieth and thirtieth days after transplanting. Weeding on the experimental plots was done as and when necessary. It was done by hand pulling and hoeing. Watering was also done daily. The plants were harvested on the thirtieth day after transplanting.

2.3. Experimental Design

The experiment was carried out in a two-by-four factorial randomized complete block design (RCBD). The treatment was replicated three times.

2.4. Quality Parameters Studied

2.4.1. Shelf Life

The harvested samples were weighed and kept in the Department of Horticulture, KNUST laboratory (ambient temperature) until the fresh leafy vegetables were observed not to be marketable and consumable.

2.4.2. Weight Loss

The initial weight of the fresh leafy vegetables was taken and compared with the differences in weight after storage. Leafy vegetables weight loss was determined using the formula below:

$$\% \text{ Weight loss} = \frac{W_1 - W_2}{W_1} * 100$$

Where, W_1 = weight of fresh leafy vegetables, W_2 = subsequent sample weight at different storage intervals.

2.4.3. Growth Parameters

2.4.3.1. Plant Height

A metre rule was used to measure plants from the root level to the apex and this was expressed in centimetres.

- Number of leaves: This was done by direct counting (Ufoegbune, Adebiyi, & Adekunle, 2016).
- Number of shoots: This was done by direct counting.
- Stem girth: It was estimated by means of vernier caliper.

2.5. Laboratory Analysis

2.5.1. Proximate Analysis

The methods recommended by the Association of Official Analytical Chemists (AOAC) were used to determine moisture content, ash, carbohydrate, crude fat, crude fibre and crude protein (AOAC, 1990).

2.5.2. Mineral Content

The mineral content of the samples was determined according to AOAC (1990), using atomic absorption spectrophotometry and flame photometer (GBC Scientific Equipment Ltd., Dandenong, Australia)

2.6. Statistical Analysis

Data were subjected to analysis of variance (ANOVA) to determine the treatment effect on the measured parameters. The least significant difference (LSD) at a 5% level of significance was used to compare means. The statistical package used was the Student Edition of Statistix 9.0

3. RESULTS AND DISCUSSION

3.1. Nutritional Composition of Soil and Cattle Dung

The results of the nutritional assessment of soil and cattle dung used for the study are presented in Table 1. The nutritional composition of the soil was: Ca (5.94%), Mg (0.96%), N (0.08%) K (0.75%), Na (0.73%) and total organic content (0.68%). The soil used for this study was observed to be richer in nutrient than that reported by Mhlontlo, Muchaonyerwa, and Mnkeni (2007). On the other hand, the cattle dung was comprised of Ca (0.24%), Mg (0.66%), N (1.25%), K (3. 09%), Na (0.26%), P (0.51%) and total organic carbon (10.37%). The cattle dung manure used in this study was low in N (1.25%), Ca (0.245%), P (0.5%) compared to (1.8%) N, (3.7%) Ca, (1.4%) P, (16 000mg) in Sheep kraal manure (Mhlontlo et al., 2007). The total N and K recorded for the cattle dung manure in this study were quite higher (1.25%) and (3.09%) than the (0.17%) and (0.17%) reported on Poultry manure by Ullah, Islam, Islam, and Haque (2008). The total organic carbon (0.68%) and nitrogen (0.08%) in the soil for this study were found to be lower than (2.85%) and (2.58%) on Obalan campus site on the soil of depth 5cm (Awodun, 2007). However, the K and Ca in this study were also higher than those of the soils from Obalan campus site on soil of depth 5cm. The total organic carbon and N from this study were again lower than 0.34 -0.38 for total nitrogen and 6.20-6.70 for total organic carbon reported on sandy loam soils (Tiamiyu, Ahmed, & Muhammad, 2012).

Table 1 presents the nutritional composition of soil and cattle dung.

Table 1. The nutritional composition of soil and cattle dung.

Sample	%Total Ca	% Total Mg	% Total N	% Total K	% Total Na	% Total P	% Total Organic carbon
Soil	5.94	0.96	0.08	0.75	0.73	16.46	0.68
Cattle dung	0.24	0.66	1.25	3.09	0.26	0.51	10.37

Table 2 shows the effect of cow dung manure application on plant height.

Table 2. The effect of cow dung manure application on plant height.

Treatments	Days After Transplanting		Mean
	Day 20	Day 10	
Amaranth 0	26.000 b	43.00 b	34.50 b
Amaranth 0.5	34.67b	68.00 a	51.33 a
Amaranth 0.8	40.67b	77.67 a	59.17 a
Amaranth 1.1	43.33 b	76.00 a	59.67 a
Mean	36.17b	66.17 a	

Note: Lsd Trts= 12.587, Lsd Treatment Difference (TD)= 8.901, Lsd Interaction= 17.801, CV(%)= 19.87. Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Amaranth 0, 0.5, 0.8 & 1.1 represent Amaranthus cruentus with application levels 0, 0.5, 0.8 and 1.1 tonnes of cattle dung respectively.

Table 3 presents the effect of cow dung manure application on the number of leaves.

Table 3. The effect of cow dung manure application on the number of leaves.

Treatments	Days After Transplanting		Mean
	Day 20	Day 30	
Amaranth 0	30.00b	66.33b	48.17b
Amaranth 0.5	52.00b	130.67a	91.33a
Amaranth 0.8	66.33b	141.00a	103.67a
Amaranth 1.1	60.67 b	133.67a	91.33a
Mean	52.25b	117.2a	

Note: Lsd Trts= 27.264, Lsd TD= 19.279, Lsd Interaction= 38.557, CV(%)= 25.88.
Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Amaranth 0, 0.5, 0.8 & 1.1 represent *Amaranthus cruentus* with application levels 0, 0.5, 0.8 and 1.1 tonnes of cattle dung respectively.

Table 4 presents the effect of cow dung manure application on the number of shoots.

Table 4. The effect of cow dung manure application on the number of shoots.

Treatments	Days After Transplanting		Mean
	Day 20	Day 30	
Amaranth 0	6.00c	12.00b	9.00 a
Amaranth 0.5	9.33bc	16.67a	13.00a
Amaranth 0.8	10.00bc	17.33a	13.67a
Amaranth 1.1	10.00bc	16.33a	13.17a
Mean	8.83b	15.58a	

Note: Lsd Trts= 3.016, Lsd TD= 2.133, Lsd Interaction= 4.266, CV(%)= 19.95.
Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Amaranth 0, 0.5, 0.8 & 1.1 represent *Amaranthus cruentus* with application levels 0, 0.5, 0.8 and 1.1 tonnes of cattle dung respectively.

Table 5 presents the effect of cow dung manure application on stem girth.

Table 5. The effect of cow dung manure application on stem girth.

Treatments	Days after transplanting		Mean
	Day 20	Day 30	
Amaranth 0	0.63 b	0.93 b	0.78ab
Amaranth 0.5	0.83b	1.26ab	1.05ab
Amaranth 0.8	1.03b	1.80a	1.42ab
Amaranth 1.1	1.13 b	1.80a	1.22ab
Mean	0.908a	1.325 a	

Note: Lsd Trts= 0.607, Lsd TD= 0.429, Lsd Interaction= 0.858, CV(%)= 43.90.
Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Amaranth 0, 0.5, 0.8 & 1.1 represent *Amaranthus cruentus* with application levels 0, 0.5, 0.8 and 1.1 tonnes per hectare of cattle dung application respectively.

Table 6 presents the effect of cow dung manure application on the plant height of Corchorus.

Table 6. The effect of cow dung manure application on plant height of Corchorus.

Treatments	Days after transplanting		Mean
	Day 20	Day 30	
Amaranth 0	32.33 c	65.33a	48.83a
Amaranth 0.5	25.33cd	59.67a	42.50b
Amaranth 0.8	20.67d	50.33b	35.50c
Amaranth 1.1	19.00d	46.33 b	332.67c
Mean	24.33b	55.42a	

Note: Lsd Trts= 5.417, Lsd TD= 3.830, Lsd Interaction= 7.661, CV(%)= 10.97.
Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Corchorus 0, 0.5, 0.8 & 1.1 represent *Corchorus olitorius* with application levels 0, 0.5, 0.8 and 1.1 tonnes per hectare of cattle dung respectively.

Table 7 presents the effect of cow dung manure application on the number of leaves of Corchorus.

Table 7. The effect of cow dung manure application on the number of leaves of Corchorus.

Treatments	Days after transplanting		Mean
	Day 20	Day 30	
Amaranth 0	58.00 c	195.00a	126.50a
Amaranth 0.5	44.67c	177.33ab	111.00ab
Amaranth 0.8	33.67c	156.00ab	94.83 b
Amaranth 1.1	28.33c	148.33 b	88.33b
Mean	41.17b	169.17 a	

Note: Lsd Trts= 31.586, Lsd TD= 22.335, Lsd Interaction= 44.669, CV(%)= 24.25.
Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Corchorus 0, 0.5, 0.8 & 1.1 represent *Corchorus olitorius* with application levels 0, 0.5, 0.8 and 1.1 tonnes of cattle dung respectively.

Table 8 presents the effect of cow dung manure application on the number of shoots.

Table 8. The effect of cow dung manure application on the number of shoots.

Treatments	Days after transplanting		Mean
	Day 20	Day 30	
Amaranth 0	12.67 b	15.67 a	14.17 a
Amaranth 0.5	10.00bc	16.67 a	13.33 a
Amaranth 0.8	10.00bc	16.00 a	13.00 a
Amaranth 1.1	9.00c	15.67 a	12.33 a
Mean	10.42b	16.00 a	

Note: Lsd Trts= 1.917, Lsd TD= 1.356, Lsd Interaction= 2.712, CV(%)= 11.73.
Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Corchorus 0, 0.5, 0.8 & 1.1 represent *Corchorus olitorius* with application levels 0, 0.5, 0.8 and 1.1 tonnes per hectare of cattle dung respectively.

Table 9 presents the effect of cow dung manure application on stem girth.

Table 10 presents the effect of cow dung manure application on the proximate composition of amaranthus cruentus.

Table 9. The effect of cow dung manure application on stem girth.

Treatments	Days after transplanting		Mean
	Day 20	Day 30	
Amaranth 0	0.23c	0.60a	0.42a
Amaranth 0.5	0.27c	0.47abc	0.37a
Amaranth 0.8	0.23c	0.57a	0.40a
Amaranth 1.1	0.30bc	0.55ab	0.43c
Mean	0.26b	0.546a	

Note: Lsd Trts= 0.189, Lsd TD= 0.133, Lsd Interaction= 0.267, CV(%)= 37.86.
Means within the same row with no superscript in common are significantly different (P < 0.05).
Treatment means were calculated from three replicated values. Treatments Corchorus 0, 0.5, 0.8 & 1.1 represent *Corchorus olitorius* with application levels 0, 0.5, 0.8 and 1.1 tonnes of cattle dung respectively.

Table 10. The effect of cow dung manure application on proximate composition of *amaranthus cruentus.*

Parameters	Treatment means			
	Amaranth 0	Amaranth 0.5	Amaranth 0.8	Amaranth 1.1
Moisture FM (%)	84.83a	83.67a	79.83a	77.83a
Moisture DM (%)	8.53a	6.46a	6.36a	5.93a
Crude protein	17.79a	17.50a	18.37a	19.82a
Crude fat	2.66a	3.33a	3.66a	3.00a
Crude fibre	1.66a	1.76a	1.85a	1.50a
Ash	14.36a	15.40a	16.93a	14.60
carbohydrate	63.51a	62.01a	59.17a	61.07a

Note: Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Amaranth 0, 0.5, 0.8 & 1.1 represent *Amaranthus cruentus* with application levels 0, 0.5, 0.8 and 1.1 tonnes of cattle dung respectively.

Table 11 presents the effect of cow dung manure application on the proximate composition of corchorus oliterius.

Table 11. The effect of cow dung manure application on proximate composition of corchorus *oliterius.*

Parameters	Treatment means			
	Amaranth 0	Amaranth 0.5	Amaranth 0.8	Amaranth 1.1
Moisture FM (%)	74.67a	76.17a	78.50a	83.17a
Moisture DM (%)	12.83a	13.17a	22.50a	11.83a
Crude protein	16.54a	16.33a	19.54a	16.00a
Crude fat	3.15a	2.50a	3.56a	3.11a
Crude fibre	3.167a	2.01a	2.72a	2.22a
Ash	13.00a	14.50a	12.33a	13.33a
Carbohydrate	64.17a	65.15a	61.84a	65.33a

Note: Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments Corchorus 0, 0.5, 0.8 & 1.1 represent *Corchorus olitorius* with application levels 0, 0.5, 0.8 and 1.1 tonnes of cattle dung respectively.

Table 12 presents the effect of three different levels of cattle dung application on the mineral composition of Amaranthus Cruentus and Corchorus olitorius at 30 days after transplanting.

Table 13 shows the weight loss of Amaranthus cruentus.

Table 12. The effects of three different levels of cattle dung application on the mineral composition of Amaranthus Cruentus and Corchorus olitorius at 30 days after transplanting.

Parameters	Treatment Means							
	A0	A0.5	A0.8	A1.1	C0	C0.5	C0.8	C1.1
Calcium	0.79^{a}	0.34bc	0.43bc	0.76ab	0.18^{c}	0.08^{c}	0.10^{c}	0.20c
Magnesium	1.00ab	0.84^{b}	0.96ab	1.13^{a}	0.43^{c}	0.39^{c}	0.37^{c}	0.27^{c}
Phosphorus	0.55^{a}	0.59^{a}	0.62^{a}	0.59^{a}	0.65^{a}	0.65^{a}	0.65^{a}	0.66^{a}
Potassium	4.11^{a}	3.62^{a}	4.47^{a}	4.07^{a}	3.53^{a}	3.68^{a}	4.47^{a}	10.94^{a}
Sodium	0.20^{a}	0.17^{a}	0.22^{a}	0.16^{a}	0.21^{a}	0.23^{a}	0.30^{a}	0.22^{a}

Note: Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments A0, A0.5, A0.8 & A1.1 represent *Amaranthus cruentus* with application levels 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively whereas C0, C0.5, C0.5, and C1.1 stand for *Corchorus olitorius* with application level 0, 0. 5, 0.8, and 1.1 tonnes per hectare of cattle dung respectively.

Table 13. The weight loss of *Amaranthus cruentus.*

Treatments	Hours after harvesting		Mean
	24	48	
Amaranth 0	23.33b	40.00 a	31.67 a
Amaranth 0.5	26.67b	42.00 a	34.33a
Amaranth 0.8	28.00b	38.67 a	33.33 a
Amaranth 1.1	19.33 b	39.00 a	29.17 a
Mean	24.33b	39.92 a	

Note: Lsd Trts= 6.971, Lsd TD= 4.929, Lsd Interaction= 9.858, CV(%)= 17.52.
Means within the same row with no superscript in common are significantly different (P < 0.05). Treatment means were calculated from three replicated values. Treatments A0, A0.5, A0.8 & A1.1 represent *Amaranthus cruentus* with application levels 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively whereas C0, C0.5, C0.5, and C1.1 stand for *Corchorus olitorius* with application level 0, 0. 5, 0.8, and 1.1 tonnes per hectare of cattle dung respectively.

Table 14 presents the weight Loss of Corchorus olitorius.

Table 14. The weight Loss of *Corchorus olitorius.*

Treatments	Hours after harvesting		Mean
	24	**48**	
Amaranth 0	30.33 c	44.33a	37.33a
Amaranth 0.5	33.00c	44.33a	40.67a
Amaranth 0.8	33.67bc	43.00ab	38.33a
Amaranth 1.1	26.67c	43.33a	35.00c
Mean	30.92b	44.75a	

Lsd Trts= 6.786, Lsd TD= 4.798, Lsd Interaction= 9.596, CV (%) = 14.48.
Note: Means within the same row with no superscript in common are significantly different ($P < 0.05$). Treatment means were calculated from three replicated values. Treatments A0, A0.5, A0.8 & A1.1 represent *Amaranthus cruentus* with application levels 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively whereas C0, C0.5, C0.5, and C1.1 stand for *Corchorus olitorius* with application level 0, 0. 5, 0.8, and 1.1 tonnes per hectare of cattle dung respectively.

Figure 1 presents fresh Amaranthus cruentus.

Figure 1. Fresh *Amaranthus cruentus.*

Figure 2 presents Amaranthus cruentus 24 hours after harvesting.

Figure 2. *Amaranthus cruentus* 24 hours after harvesting.

Figure 3 presents Amaranthus cruentus 48 hours after harvesting.

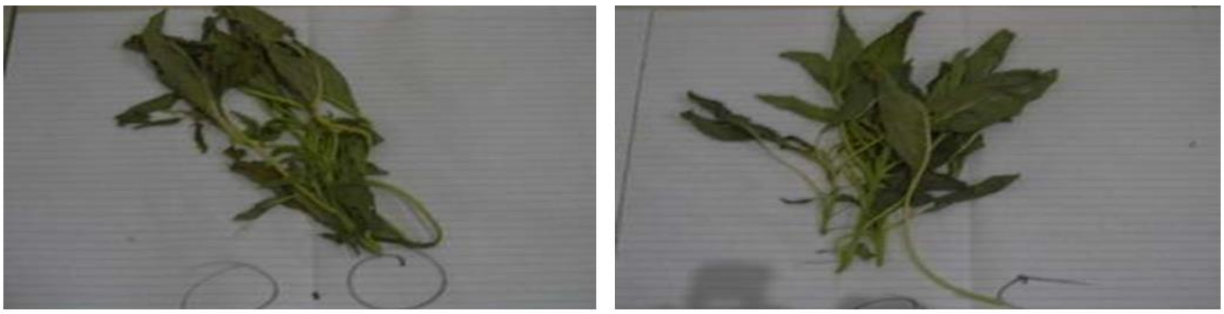

Figure 3. *Amaranthus cruentus* 48 hours after harvesting.

Figure 4 presents fresh Corchorus olitorius.

Figure 4. Fresh *Corchorus olitorius.*

Figure 5 presents Corchorus olitorius after 24 hours of harvesting.

Figure 5. *Corchorus olitorius* after 24 hours of harvesting.

Figure 6 presents Corchorus Oliterius after 48 hours of harvesting.

Figure 6. *Corchorus Oliterius* after 48 hours of harvesting**.**

Table 15 presents the correlation between the minerals in cattle dung and the parameters assessed.

Table 15. The correlation between the minerals in cattle dung and parameters assessed.

Parameters	Magnesium	Calcium	No of branches	Plant height	Carbohydrates
Magnesium	-	0.71 (0.01)		-	-
Number of Branches	-0.21 (0.52)	0.18 (0.57)	-	-	-
Number of leaves	-0.43 (0.16)	-0.10 (0.76)	0.91 (0.00)	-	-0.45 (0.14)
Stem Girth	-0.52 (0.08)	-0.58 (0.05)	0.06 (0.86)	0.23 (0.48)	-0.30 (0.35)
Plant height	-0.35 (0.26)	-0.04 (0.90)	0.84 (0.00)	-	-0.22 (0.49)
Fat	-0.33 (0.29)	0.21 (0.52)	0.42 (0.18)	0.20 (0.52)	-0.85 (0.00)
Fibre	-0.72 (0.01)	-0.78 (0.00)	-0.02 (0.95)	-0.02 (0.95)	0.15 (0.65)
Protein	-0.22 (0.49)	0.03 (0.94)	0.25 (0.44)	0.11 (0.73)	-0.85 (0.00)

3.2. Nutritional Composition of Soil and Cattle Dung

The soil used for this study was observed to be richer in nutrient than that reported by Mhlontlo et al. (2007). The soil for this study had (5.94%) Ca (0.75%), K (0.085%), N (16.46%) P compared to (0.026%), K (0.35%) Ca and 0.02% N of soil as reported by Mhlontlo et al. (2007). The cattle dung manure used in this study was low in N (1.25%), Ca (0.245%), P (0.5%) compared to (1.8%) N, (3.7%) Ca, (1.4%) P, (16 000mg) in Sheep kraal manure (Mhlontlo et al., 2007). The total N and K recorded for the cattle dung manure in this study were quite higher (1.25%) and (3.09%) than the (0.17%) and (0.17%) reported on Poultry manure by Ullah et al. (2008). The total organic carbon (0.68%) and nitrogen (0.08%) in the soil for this study were found to be lower than (2.85%) and (2.58%) on Obalan campus site on the soil of depth 5cm (Awodun, 2007). However, the K and Ca in this study were also higher than those of the soils from Obalan campus site on soil of depth 5cm. The total organic carbon and N from this study were again lower than the 0.34 -0.38 for total nitrogen and 6.20-6.70 for total organic carbon reported on sandy loam soils Tiamiyu et al. (2012). The high nitrogen content and organic carbon in the soil in this study might have resulted in the higher number of leaves produced by both leafy vegetables. Mhlontlo et al. (2007) reported 18 - 48 for the number of leaves in *Amaranthus cruentus*. This was observed to be quite lower than the 28 – 195 obtained in this study for number of leaves. (Table 10 - Table 12).

3.3. Growth Parameters

3.3.1. Plant Height

The highest plant height (43.33cm) which was recorded by *Amaranthus cruentus* after twenty days of transplanting was higher than the 40.50cm reported by Mhlontlo et al. (2007) with 2.5 tonnes rate of application of sheep manure after 30 days of transplanting. Although there was no significant difference ($P < 0.05$) between the control of the *Amaranthus cruentus* with treatment levels 0.8 and 0.5 tonnes per hectare, treatment levels 0.5 and 1.1 tonnes per hectare resulted in higher plant height than the control. This implies that the application of cattle dung contributed positively to the plant height of *Amaranthus cruentus*. Premsekhar and Rajashree (2009) reported that higher yield response of crops as a result of organic manure application could be attributed to improved physical and biological properties of the soil resulting in a better supply of nutrients to the plants. On the contrary, the control of the *Corchorus oliterius* recorded the highest (32.33cm) plant height but was not significantly different ($P < 0.05$) from the rest of the treatment. This can be attributed to the fact that the nutrient in the soil was able to meet the nutritional requirement of the *Corchorus oliterius* or it may be due to the failure of *Corchorus oliterius* to respond well to the cattle dung application. The same trend was observed 30 days after transplanting except that *Amaranthus cruentus* with treatment level 0.8 tonnes per hectare had the highest (77.67cm) plant height and was not significantly different from *Amaranthus cruentus* with treatment level 1.1tonnes per hectare. The results obtained 30 days after transplanting for most of the treatments were still higher than those reported by Mhlontlo et al. (2007) 60 days after transplanting. According to Mhlontlo et al. (2007), Amaranthus gives a good yield when high levels of nitrogen are applied and it responds well to organic matter.

3.3.2. Number of Leaves

Amaranthus cruentus at 0.8 and 1.1 tonnes per hectare application rates had the highest (66.33) and (60.67) number of leaves with no significant difference ($P > 0.05$) occurring between them 20 days after transplanting. The same pattern occurred 30 days after transplanting. Xu, Wang, Xu, Mridha, and Goyal (2002) reported that vegetables grown with high levels of organic manure grow better and result in higher yields than those grown with lower amounts of organic manure. According to Myers (1998), an increase in the rate of organic matter leads to the availability and uptake of nitrogen which promotes the vegetative growth of the plants. The control from *Corchorus oliterius* recorded the highest (58.00) number of leaves for all the treatments in *Corchorus oliterius.* The result obtained from the *Corchorus oliterius* is not in conformity with that reported by Xu et al. (2002). This could be because the plants' nutritional needs were satisfied by nutrients already present in the soil.

3.3.3. Number of Shoots

There was a significant difference between the control and the other treatment levels on the 30th day after the transplanting of *Amaranthus cruentus.* The highest number of shoots (17.33) was recorded by treatment level 0.8 tonnes per hectare on the 30th day after transplanting. According to Mhlontlo et al. (2007) and Makus (1984), a higher rate of manure (sheep kraal manure) produced higher fresh yields (shoot, leaf and stem.).This assertion is in conformity with the findings of this study. Abou-Hussein, Abou-Hadid, and El-Shorbagy (2002) reported that the increase in soil nutrients and other factors can encourage shoot growth and elevate the metabolism of photosynthesis. The increase in the soil nutrients did not positively affect *Corchorus oliterius.* It may be due to other factors such as unfavorable temperature, humidity, moisture, etc. at the time of planting. According to Jayramaiah et al. (2010), the increase in plant height, shoot, leaf area and total dry matter accumulation can be obtained by the application of an appropriate amount of farm yard manure. It is also possible that the quantity of the manure was not adequate to support shoot growth in *Corchorus oliterius.*

3.3.4. Stem Girth

There was no significant difference ($P > 0.05$) between the control and all the treatments in *Amaranthus cruentus*, although 1.1 tonnes per hectare had the biggest (1.13) stem girth. It can be observed that there was an increase in the stem girth of the *Amaranthus cruentus* with an increase in the level of the cattle dung application. The increase in stem girth could be attributed to the amount of nitrogen in the soil. Gonzales, Caralde, and Aban (2015) showed that the soil could be enriched by the application of a higher amount of organic materials which tends to decompose a large amount of nitrogen into the soil before planting fresh crops. *Corchorus olitorius* with treatment level 1.1 recorded the highest stem girth and confirms that the cattle dung used in the experiment had some relevant nutrient content which could promote growth.

3.4. Proximate Composition of Amaranthus cruentus and Corchorus Oliterius

3.4.1. Moisture Content

There were no significant differences ($p>0.05$) in moisture content between the various treatment levels at both fresh and dry matter states. The moisture content of *Amaranthus cruentus* and *Corchorus olitorius* varied between (74.67%-84.83%) and (5.95% -13.13%) for fresh and dry matter states respectively. The differences in moisture content of *Amaranthus cruentus* and *Corchorus olitorius* under the different cattle dung application rates may be due to the fact that they are different plants with different structures. According to Das, Baruah, Khatoniar, Baruah, and Chatterjee (2016), the maximum water content of vegetables varies among vegetable types and is influenced by cultivation conditions and structural differences. *Corchorus oliterius* with a cattle dung treatment level of 0.5 tonnes per hectare gave the highest (13.13%) moisture content whiles *Amaranthus cruentus* with a treatment level of 1.1 tonnes per hectare had the least (5.93%) moisture content. High moisture content in vegetables is indicative of their freshness as well as easy perishability (Thomas & Oyediran, 2008).

Similarly, George (2003) stated that moisture content contributes to the texture of the leaves and helps in maintaining the protoplasmic content of the cells; it also makes them perishable and susceptible to spoilage by micro-organisms during storage.

3.4.2. Crude Protein

There were no significant differences ($p>0.05$) in the crude protein content of *Amaranthus cruentus* and *Corchorus olitorius* at the various cattle dung application levels (Tables 10 and 11). *Corchorus olitorius* with 0.8 tonnes of dung gave the highest (19.83%) protein content and the least (16.00%) was also from *Corchorus olitorius* at 1.1 tonnes per hectare. Mensah, Okoli, Ohaju-Obodo, and Eifediyi (2008) reported the protein content of *Amaranthus cruentus* and *Corchorus olitorus* as 4.6g/100 DM and 27.7g/100, respectively. From the study, it can be observed that the protein levels of *Amaranthus cruentus* were higher than those reported by Mensah et al. (2008) while the protein levels of the *Corchorus olitorius* were lower than what Mensah et al. (2008) reported. Differences in the protein content of *Amaranthus cruentus* and *Corchorus olitorius* can be attributed to levels of the cattle dung applied as well as differences in species.

According to Mensah et al. (2008), the nutritional composition of plants may vary with soil fertility, environment, plant type, plant age, production techniques used and level of processing. Protein helps in building and maintaining all tissues in the body, forms an important part of enzymes, fluids and hormones of the body and also helps form antibodies to fight infection and supplies energy (Johnson, 1996). Thus, the high level of protein in *Amaranthus cruentus* (17.50%-19.82%) recorded in this study suggests that the cattle dung could be used to improve upon the protein content of the vegetable which in turn could be used as protein supplements.

3.4.3. Crude Fibre

There were no significant differences ($p>0.05$) in the fibre content of the *Amaranthus cruentus* and *Corchorus olitorius* at the various cattle dung application rates. Dietary fibre consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants. Dietary crude fibre includes polysaccharides, oligosaccharides, and lignin, among others. The control of the *Corchorus olitorius* had the highest (3.33%) fibre content while *Amaranthus cruentus* with the highest treatment level had the lowest (1.50%) fibre content. The difference can be attributed to the fact that they are from different plant sources and will respond differently to different application rates.

Mensah et al. (2008) reported the crude fibre content of *Amaranthus cruentus* and *Corchorus olitorius* as 1.8g/100g and 8.5g/100g dry matter respectively. Kwenin et al. (2011) also reported the crude fibre content of *Amaranthus cruentus* as 10.40g/100g. The fibre content of *Amaranthus cruentus* obtained in this study ranges between 1.50g/100g and 1.85g/100g which conforms to the results from Mensah et al. (2008) but contrary to 10.40g/100g in *Amaranthus cruentus* as reported by Kwenin et al. (2011). The fibre content of the *Corchorus olitorius* ranged from 2.01g/100g1 to 3.33g/100 which is far below that reported by Mensah et al. (2008). The differences in the fibre content may be due to the soil fertility, plant age at harvest, environment and production techniques. Hammer and Heller (1998) and Morris, Barnett, and Burrows (2004) reported that several factors, including the genetic makeup of a plant, the soil in which it is grown, the use of fertilizer, prevailing weather condition and maturity at harvest influence the nutritional content of a plant. Intake of dietary fibre is useful for the treatment of both obesity and diabetes mellitus Komal and Kaur (1992). The study showed that *Amaranthus cruentus* and *Corchorus olitorius* are good sources of dietary fibre.

3.4.4. Crude Fat

Leafy vegetables are not noted for contributing significantly to the fat supply in food. No significant difference ($p>0.05$) was obtained from all the treatments. The fat content of the study ranged between 2.6-3.66g/100g which is slightly higher than 3.19g/100g, 3.0g/100g, 1.33g/100g and 1.50g/100g in *Xanthosoma sagittifolia*, *Amaranthus cruentus*, *Talinum triangulare* and *Moringa oleifera* respectively as reported by Kwenin et al. (2011). This is an indication that the treatment had a slight influence on the fat content. The high (3.66%) fat content in *Amaranthus cruentus* at 0.08 tonnes per hectare suggests that it can contribute significantly to the energy requirement of humans. Its high-fat content would make it a better source of fat than the others. The high fat of *Amaranthus cruentus* will make it useful in improving the palatability of foods in which it is incorporated (Aiyesanmi & Oguntokun, 1996).

3.4.5. Ash Content

McClements (2003) reported that the ash content of a vegetable provides a measure of the total amount of minerals within it. Higher ash content predicts the presence of an array of mineral elements as well as high molecular weight elements (Ekpe, Umoh, & Eka, 2007). No significant difference ($p>0.05$) was recorded in the ash content of the two vegetables under study. The high (16.93%) ash content was recorded by *Amaranthus cruentus* with a cattle dung level of 0.8tonnes per hectare and the least (12.33%) from *Corchorus olitorius* cattle dung level of 0.8 tonnes per hectare. The study showed that the ash content ranged from 12.33-16.93g/100g with *Amaranthus cruentus* having a higher ash content than *Corchorus olitorius.* Adeniyi, Ehiagbonare, and Nwangwu (2012) reported the ash content of *Corchorus olitorius* as 0.64g/100g. The ash content values obtained in this study were found to be higher than that reported by Adeniyi et al. (2012). Ash content is important because it provides the mineral requirements for daily intake.

3.4.6. Carbohydrates

Carbohydrates refer to polyhydroxy aldehydes or ketones and their derivatives and other compounds that yield them on hydrolysis (Abugre, 2011). They form 50-80% of vegetable dry matter in the form of non-starch polysaccharides, including cellulose, hemicelluloses and lignin (Abugre, 2011). Abugre (2011) reported the carbohydrate content of *Amaranthus cruentus* and *Corchorus olitorius* as 7.0 and 26.6g/100g dry matter respectively. No significant differences ($p>0.05$) were obtained in the carbohydrate content of all the treatments. In general, the levels of carbohydrates in the *Corchorus olitorius* were higher than those of the *Amaranthus cruentus. Corchorus olitorius* with cattle dung application of 1.1tonnes per hectare recorded the highest carbohydrate level of 65.33g/100g followed by *Corchorus olitorius* with treatment level of 0.5tonnes per hectare (65.15g/100g). The high carbohydrate content recorded in samples under study could mean that the vegetables can provide high energy in diets and this will be beneficial to consumers.

3.5. Mineral Composition of Amaranthus cruentus and Corchorus oliterius

3.5.1. Phosphorus

There were no significant differences ($p>0.05$) among the treatments. The phosphorus content ranged between 0.55g/100g-0.62g/100g and 0.65g/100g-0.66g/100g for the *Amaranthus cruentus* and the *Corchorus olitorius* respectively. The highest (0.66%) phosphorus value was recorded in *Corchorus olitorius* with a treatment level of 1.1 tonnes per hectare. In general, *Corchorus olitorius* recorded higher values in the phosphorus content than the

Amaranthus cruentus. Mhlontlo et al. (2007) reported phosphorus content of 0.09-0.14% on the effect of sheep kraal manure on the growth performance and nutritional composition of *Amaranthus* accession. The differences in the phosphorus content obtained from the study and that of Mhlontlo et al. (2007) can be attributed to the variety, the environment, and the treatment levels. It can be deduced that increasing the level of cattle dung can lead to increases in the phosphorus content of the two leafy vegetables. Based on the findings of this study, it can be stated that *Amaranthus cruentus* and *Corchorus olitorius* are good sources of phosphorus and would be useful in providing the phosphorus needs of consumers. Since phosphorus is required for many metabolic processes in the body, including bone mineralization, consumption of *Amaranthus cruentus* and *Corchorus olitorius* will strengthen the bones of consumers.

3.5.2. Potassium

There were no significant differences (p>0.05) between the means of three levels of the cattle dung of *Amaranthus cruentus* and the *Corchorus olitorius*. The potassium content of the *Amaranthus cruentus* and the *Corchorus olitorius* ranged between 3.62-4.47g/100g and 3.52-3.69g/100g respectively. The results show that *Amaranthus cruentus* had higher potassium content than *Corchorus olitorius*. Mensah et al. (2008) reported the potassium content of *Amaranthus cruentus* and *Corchorus olitorius* as 4.82mg/100g and 3.83mg/100g Dry matter (DM) respectively. Mhlontlo et al. (2007) reported the potassium content of Amaranthus as 3.3-4g/100g. Potassium is known to promote good muscle contraction and also functions in acid-base balance in the body (KO, CO, & EO, 2010). Consumption of *Amaranthus cruentus* and *Corchorus olitorius* will promote good muscle, heart and kidney functioning. Consumption of *Amaranthus cruentus* and *Corchorus olitorius* at 0.8 tonnes per hectare of application will serve as an important mineral which will help maintain electrolyte balance in humans and is important in amelioration of hypertension (Whelton et al., 1997).

3.5.3. Calcium

Amaranthus cruentus had higher calcium content than *Corchorus olitorius*. Mensah et al. (2008) reported the Calcium content of *Amaranthus cruentus* and *Corchorus olitorius* as 2.05 and 1.26mg/100g DM respectively. Mhlontlo et al. (2007) reported the calcium content of Amaranthus accession as 3.7-3.9g/100g. This shows that the values obtained from this study were very low. According to Hammer and Heller (1998), the nutritional composition of plants may vary with soil fertility, environment, plant type, plant age, production techniques used and level of processing. Since calcium is known to promote bone and teeth formation, consumption of *Amaranthus cruentus* and *Corchorus olitorius* may result in the strengthening of the bones and teeth of consumers.

3.5.4. Magnesium

The highest (1.13) magnesium content was recorded in *Amaranthus cruentus* with a treatment level of 1.1tonnes per hectare. *Corchorus olitorius* recorded lower values in the magnesium content with the control of *Corchorus olitorius* recording the highest value (0.43g/100g). Mensah et al. (2008) reported the magnesium content of *Amaranthus cruentus*, *Corchorus olitorius* and *Basella rubra* as 2.53, 0.59 and 0.06mg/100g DM respectively. Mhlontlo et al. (2007) reported magnesium content in Amaranthus accession as 1.31.5g/100g. The magnesium content in this study ranged between 0.84-1.13g/100g and 0.37-0.43g/100g of the *Amaranthus cruentus* and *Corchorus olitorius*, respectively. *Amaranthus cruentus* and *Corchorus olitorius* will be good sources of magnesium. Magnesium is essential in enzyme systems and helps maintain electrical potential in nerves (Ferrao, Ferrao, & Anatures, 1987).

3.5.5. Sodium

The sodium content ranged between 0.16g/100-0.30g/100. No significant differences (P > 0.05) were observed in all the treatments. (Srivastava, 2011) reported the sodium content of *A. viridis* (54mg), *A. blitum* (39.38mg) and *A.*

tricolor (30mg). From Table 12, it can be observed that *Corchorus olitorius* with treatment level 1.1 tonnes per hectare recorded the same value (0.30g/100g) as *A. tricolor.* It can be observed that *A. viridis and A. blitum* had higher values than *Corchorus olitorius* and *Amaranthus cruentus.*

3.6. Weight Loss

No significant difference (P > 0.05) was observed at the end of 24 hours after harvesting.

Almost all the vegetables lost more than 20% of their weight during 24 hours of storage except *Amaranthus cruentus* with a treatment level of 1.1 tonnes per hectare (Table 13). The loss in weight in almost all the samples could be attributed to the fact that they were exposed to room conditions of temperature and air current. Air circulating in the storage room must have enhanced the evaporation of moisture from the surface of the leaves and led to a loss of moisture. Prolong loss of moisture resulted in changes in the weight and texture of the leaves and these affected quality. An application rate of 1.1 tonnes per hectare of cattle dung in *Amaranthus cruentus and Corchorus oliterius* 24 hours after harvesting had the lowest weight loss of (19.33%) and (26.67%) respectively. This implies that an increase in the cattle dung application rate leads to lesser weight loss. This could be attributed to the different packaging materials used and other environmental factors.

3.7. Shelf Life

It can be observed from Figure 2 that most (98%) of the vegetables wilted on the 24th hour after harvesting, however, fewer leaves from *Amaranthus cruentus* and *Corchorus olitorius* at an application rate of 1.1 tonnes per hectare were partly fresh. According to Abukutsa-Onyango (2002), most African leafy vegetables are highly perishable and have a shelf life of less than 24 hours. After 24 hours of storage, most of the vegetables had wilted. Wilting is a result of a reduction in cell turgor that reduces the turgidity of the plant. There were no significant changes in the green colour of the leaves. This may be a result of the absence of ethylene in the storage room. Ethylene accelerates senescence and loss of green colour in leafy vegetables. It decreases the storage life and quality of vegetables. All the samples finally dried up 48 hours after harvesting. The high moisture content in the two leafy vegetables resulted in the short shelf life of the vegetables leading to (98%) wilt within 24 hours of storage and total dryness within 48 hours of storage.

3.8. Correlation Analysis

From the results (Table 15), it was not surprising when an increase in the number of leaves was associated with an increase in the number of branches. Leaves are found on branches of plants; therefore, with an increase in the number of branches, the number of leaves is also expected to increase. It was also observed that increased levels of calcium resulted in reduced stem girth. Although bigger stem girths are required by plants to hold the branches and leaves, more calcium absorbed would help the plant to maintain a strong stem girth to hold the plant. However, if maximum absorption of calcium is made by the plant, there would be no need for the plant to form a bigger stem girth. This could, therefore, be the reason why increased levels of calcium resulted in reduced size of stem girth. A decrease in fat content was associated with an increase in carbohydrate content as well as magnesium and calcium. This was expected as leaves with high amounts of carbohydrates (starch) and minerals could not possibly contain a high amount of fat. Moreover, leafy vegetables are not noted for contributing significantly to the fat supply in foods. Therefore, the results from the correlation were in line with facts well noted in the research.

4. CONCLUSIONS

The rates of application above 0.5 tonnes per hectare did not make any significant difference (P > 0.05) in the growth parameters. Application of cattle dung at 0.8 tonnes and 0.5 tonnes resulted in a higher number of leaves in *Amaranthus cruentus* and *Corchorus olitorius* respectively 20 and 30 days after transplanting. The different application rates did not significantly affect stem girth. The proximate and mineral composition was not significantly affected by the different application rates. Calcium content increased with an increase in the application rate in both *Amaranthus cruentus* and *Corchorus olitorius*. An increase in the application rate reduced the moisture content in both *Amaranthus cruentus* and *Corchorus olitorius*. The moisture content in the leafy vegetables positively affected the weight loss and shelf life after the storage period (48hr). Although there were no significant differences in the weight loss after the storage period (48hr), the *Corchorus olitorius* recorded higher weight loss than *Amaranthus cruentus*. It can be concluded that fresh leafy vegetables should be consumed within 24hr of harvesting.

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