KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,
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EFFECT OF THREE DIFFERENT RATES OF APPLICATION OF CATTLE DUNG ON QUALITY OF TWO TRADITIONAL LEAFY VEGETABLES (*AMARANTHUS CRUENTUS* AND *CORCHORUS OLITORIUS*)

BY

SANDRA AMA KABURI

FEBRUARY, 2015

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A THESIS SUBMITTED TO THE DEPARTMENT OF HORTICULTURE, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS OF PHILOSOPHY DEGREE IN POST HARVEST TECHNOLOGY

BY

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FEBRUARY, 2015

DECLARATION

I hereby declare that except for references to other people's work which have been duly acknowledged, this work submitted to the Board of Postgraduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana is the result of my own research work and investigation and has not been presented for any other degree in this University or elsewhere.

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DEDICATION

This thesis is dedicated to the Glory of God

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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. *Amaranthus cruentus* and *Corchorus olitorius* are among such vegetables that could be widely cultivated but information on their fertility requirements is scanty. 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 on *Amaranthus cruentus* and *Corchorus olitorius* on the experimental field of the Department of Horticulture, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology. 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 biggest stem girth which varied significantly from those without manure application. On the effect 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 proximate and mineral composition was not significantly (P > 0.05) affected by the different application rates in both *Amaranthus cruentus* and *Corchorus olitorius.* Increase in the application rates resulted in a decrease in the moisture content in *Amaranthus cruentus* but in *Corchorus olitorius*, there was an increase in the moisture content, even though, this was not statistically significant (P > 0.05). There were no significant differences (P > 0.05) in weight loss after the storage period (48hr) for both *Amaranthus cruentus* and *Corchorus olitorius.* However, *Corchorus olitorius* had higher weight loss than *Amaranthus cruentus*. 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 parameter for *Amaranthus cruentus.* There were no significant ($P > 0.05$) changes in the proximate, mineral composition and shelf life of the two vegetables

ACRONYMS

WHO	World Health Organization
FAO	Food and Agriculture Organization
DM	Dry Matter

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CHAPTER ONE

1.0 INTRODUCTION

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 widely consumed during famines and natural disasters (FAO, 1988). It has been accorded needed recognition for contributing to poverty reduction in Africa. They have been recognized as being the cheapest and most readily available sources of important proteins, vitamins, minerals and essential amino acids (Kwenin *et al.*, 2011; Martin and Meitner, 1998; Nordeide *et al.*, 1996). Traditional leafy vegetables (TLVs) are reported to play a very important role in income generation and subsistence (Schippers, 2000). Leafy vegetables are not only cheaper, they constitute a major component of food of poor households, they provide employment for peri-urban dwellers because of their generally short life cycle, labour intensive production systems, low levels of investment and high yield (Schippers, 2000). A significant proportion of traditional leafy vegetables have also been reported to have health protecting properties and uses (Okeno *et al.*, 2003).

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. They also contribute to the reduction of malnutrition through the supply of abundant amounts of protein, vitamins, calories and minerals needed in diets especially for children (Wehmeyer and Rose, 1983).

According to Ojeniyi (2000), published works on organic manure use in sub-Sahara Africa is rather scanty. The need to use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic fertilizers worldwide. Consequently, scientists have concentrated efforts towards making use of organic materials (both organic manures as well as organic wastes) for improving the physical properties of soils that allow profitable crop production (Somani and Totawat, 1996). Besides, the use of organic fertilizer has attracted significant interest because of its potential in contributing to improving the environmental conditions and public health (Tiamiyu *et al*.., 2012). The use of inorganic fertilizer to compliment soil fertility has not been helpful because it is often associated with soil acidity and nutrients imbalance (Kang and Juo, 1980; Obi and Ebo, 1995; Ojeniyi, 2000) and destruction of soil structure. Furthermore, the extent to which farmers can depend on this input is constrained by unavailability of the right type of inorganic fertilizers at the right time, high cost, lack of technical know-how and lack of access to credit (Chude, 1999). Innovative approaches including the use of organic materials (both organic manures as well as organic waste) for improving the physical properties of soils that allow profitable crop production is being exploited by farmers (Somani and Totawat, 1996).

In Ghana, most growers of leafy vegetables particularly in the 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 effect of different levels of application on the postharvest behaviour and quality of traditional leafy vegetables. It is estimated that 20% of daily food of adult should contain vegetables in order to maintain normal health (WHO, 2003). The World health organization recommends a minimum daily intake of 400g of fruits and vegetables (WHO, 2003). However, it is not clear from the report what proportion of this total daily intake should go to vegetables. Nevertheless, according to the Kobe framework document and an FAO report, the recommended total daily intake is equivalent to five (5) servings of 80g each of fruits and vegetables (FAO/WHO, 2004). In order to fulfill this requirement, there is the need for increased production of vegetables and fruits. Vegetables and fruits production can be increased through the use of fertile soil. Organic and inorganic fertilizers are the major sources of improving the soil fertility.

In recent times people are concerned about their health and prefer products from organic source. Soil organic matter supplies available nutrients through it decomposition. Chemical fertilizers are often used by farmers to improve the soil fertility in order to increase yield. However, prolong application of inorganic fertilizers have some disadvantages to the plant environment. These chemicals may leach down the soil to pollute ground water and rivers.

Cattle dung is one of the sources of nitrogen and other nutrients which can decrease the demand of chemical fertilizer, and it has been used for many centuries to increase soil fertility (Darzi *et al*, 2012; Kolay, 2007; Mathers and Stewart, 1984; Mir and Quadri, 2009; Tagoe *et al.*, 2008; Whalen and Chang, 2001; White *et al.*, 2007). Many researchers have mentioned the beneficial effects of organic fertilizer including the increase of hydraulic conductivity, raising the water holding capacity, changing the soil pH (increase or decrease in the pH, depending on soil type and characteristics of organic fertilizer), elevating the soil aggregation and water infiltration and reducing the frequency of plant diseases (Conn and Lazarovits, 1999; Dong and Shu, 2004; Olson and Papworth, 2006; Tagoe *et al.*, 2008). 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 have been previously reported (Abou-Hussein *et al.*, 2003a; Alam *et al.*, 2007). The investigation into the effect 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 effect of different levels of cattle dung application on growth parameters and postharvest attributes of selected traditional leafy vegetables in Ghana. Specifically, the study sought to achieve the following objectives:

- To determine the effect of different levels of application of cattle dung on some growth parameters of traditional leafy vegetables.
- Assess the influence of different levels of application of cattle dung on nutritional composition of the selected traditional leafy vegetables.
- Assess the influence of different levels of application of cattle dung on the shelf life and weight loss of traditional leafy vegetables.

CHAPTER TWO

2.0 LITERETURE REVIEW

2.1 Vegetables

Vegetables are aromatic, bitter or tasteless herbaceous plants whose parts are eaten as supporting food or main dishes (Edema, 1987). Vegetables are noted to have three important functions when eaten including protection and maintenance of health, and prevention of diseases (Adeniyi *et al*., 2012). This is because, they contain important food ingredients which can be successfully utilized to build up and repair the body (Abukutsa- Onyango, 2007a). Vitamins A, B and C contained in vegetables are essential for healthy body growth and development. Vegetables acts as a buffering agent against acidic substances produce during digestion (Thompson and Kelly, 1990).

Vegetables are categorized into different kinds according to their parts that are eaten. Vegetables may thus be root vegetables, stem vegetables, leafy vegetables, fruit vegetables and seed vegetables (Robinson, 1990). Each of these vegetables group contributes to diet in its own way. Fleshy roots for instance, are high in energy value and good sources of vitamin B. Seeds are relatively high in carbohydrates and proteins while leaves, stems and fruits are excellent sources of minerals, vitamins, water and roughage. Farinaceous vegetables made up of starchy roots such as potatoes, sweet potatoes contain substantial amounts of carbohydrates which provide the body with energy.

2.2 African Indigenous Vegetables

African indigenous vegetables refer to those vegetables whose primary or secondary centre of origin is Africa (Schippers, 2000). Under this definition, two different types of indigenous vegetables can be deduced. Those that have their primary origin in Africa and those that have become part of the culture of the people of Africa, even though, they do not originate from Africa. Vegetables whose secondary centre of origin is Africa may be referred to as 'African traditional vegetables' (Schippers, 2000). The word traditional is used to qualify introduced vegetable species which due to long use have become part of the culture of the people. Generally, traditional leafy vegetables are plant species of which the leafy parts, which may include young, succulent stems, flowers and very young fruit, are used as vegetables (Vorster *et al.*, 2005).

2.2.1 Importance of Africa Indigenous Vegetables

Previous studies have shown that traditional leafy vegetables are richer in vitamins, minerals, proteins and crude fibres than European vegetables (Abukutsa- Onyango, 2007a; Chadha *et al.*, 2000; Mnzava, 1997).Traditional leafy vegetables are also known to contain substantial amounts of chemicals normally classified as anti-oxidants. These chemicals are essential for scavenging for and binding harmful radicals in the body which if left unchecked could cause diseases like cancer and diabetes. On average 100g of fresh vegetable contain levels of calcium, iron and vitamins that would provide 100% of the daily requirement and 40% for the proteins (Abukutsa-Onyango, 2003). African indigenous vegetables are therefore a valuable source of nutrition in rural areas where they contribute substantially to protein, mineral and vitamin intake (Mnzava, 1997).

African traditional leafy vegetables are also compatible to use with starchy staples and represent cheap but quality nutrient source to the poor sector of the population in both urban and rural areas where malnutrition is widespread. Healthy people need a balanced diet consisting not just of starchy foods but also protein and micronutrient rich foods (Abukutsa-Onyango, 2007a). Hunger and malnutrition are mostly experienced in developing countries where they affect growth and development of children (Aphane *et al.*, 2003). African leafy vegetables such as *Amaranthus*, nightshades, spider plants, pumpkin leaves and cassava leaves are easy to grow and can do well with minimal external inputs in these marginal areas with low rainfall and poor soils (Muthoni *et al*, 2009).

African indigenous vegetables have considerable potential as cash income earnings, enabling the poorest people in the rural communities to earn a living (Schippers, 2000, Abukutsa-Onyango, 2003). Socio-economic survey on traditional vegetables conducted in various parts of Africa particularly in Central, Western and Eastern Africa (Abukutsa-Onyango, 2002; Schippers, 2000) revealed that indigenous vegetables are important commodities in household food security. They provide employment opportunities and generate income for the rural population. African Indigenous Vegetables have medicinal properties as they are usually bitter and some have been known to heal stomach-related illnesses (Olembo *et al.*, 1995). Spider plant has, for instance, been reported to aid constipation and facilitate birth while African nightshades have been reported to cure stomach-aches.

2.2.2 Amaranthus

The common names of Amaranthus are Amaranth, Africa Spinach, Bush Greens, Pigweed, Spinach Green etc. In Ghana, it is called "Aleefu". It is found in both the savannah and forest regions of Ghana. It is described as a poor man's vegetable because it is the cheapest leafy vegetable found in tropical markets due to its low cost of production. Amaranthus belongs to the *Amaranthaceae* family. The height of mature plants varies between 0.3m and 2m, depending on the species, growth habit and environment. The leaves are simple, alternate and with a long petiole. Some species have distinct markings on their leaves (Norman, 1992). The inflorescence is a spike of racemes, terminal or axillary. The flowers are small and unisexual occurring in small clusters that sometimes completely cover the spikes. The seeds are tiny, glossy, usually black and biconcave. Grubben and Van Slotten (1978) noted the following as characteristics of Amaranthus; they are easy to cultivate, they are extremely fast growing with high yield potential, they are less susceptible to soil-borne diseases than most other vegetables, they are suitable for crop rotation with any other vegetable crop and it reacts favorably to fertilizers and organic manure.

There are numerous species and varieties of Amaranthus and many hybrids occur between them. The two main kinds of Amaranthus are vegetable and grain Amaranthus. Amaranthus is a C4 plant that grows optimally under warm conditions (day temperatures above 25°C and night temperatures not lower than 15°C, bright light and adequate availability of plant nutrients (Heever and Coertze, 1996a; Maboko, 1999; Schippers, 2000). The various amaranth species are tolerant to adverse climatic conditions

(Grubben, 2004; Maundu and Grubben, 2004) and they are quite drought-tolerant, but prolonged dry spells induce flowering and decrease leaf yield (Schippers, 2000; Palada and Chang, 2003). Amaranth is photoperiod sensitive and starts to flower as soon as the day length shortens. Under cultivated conditions amaranth produces fresh leaf yields up to 40 tonnes per hectare (Heever and Coertze, 1996a; Maboko, 1999; Schippers, 2000; Mhlonthlo *et al.*, 2007).

2.2.3 Uses of Amaranthus

The edible portions of amaranth are the leaves and stem. These parts are rich in proteins. They are good sources of carotene, vitamin C, folic acid, iron, calcium and other micro nutrients. The leaves and stems or young shoots are used as pot herbs in stews and soups (Norman, 1992). The leaves are consumed as vegetable whereas the seeds could be processed into snacks. The young leaves, growth points and whole seedlings of amaranth are harvested and eaten. In the Tzaneen area of South Africa, the leaves and stems of Amaranthus are dried and ground for use as snuff (Hart &Vorster, 2006). In areas where access to salt was limited, such as in parts of the Limpopo Province of South Africa, the whole dried plants of different amaranth species were burnt to produce ash, which was dissolved in water and the precipitate of the filtrate of the ash was used as salt (Fox and Young, 1982). Uzo and Okorie (1983) reported that, the seeds of amaranth are a source of protein. Mensah *et al*. (2008) reported that *Amaranthus cruentus* is used as a dewormer to control tapeworm, as an expellant and a relief of respiratory disease in Nigeria.

2.2.4 Agronomic Requirements and Practices of Amaranthus

Norman (1992) reported that Amaranthus prefers a well-drained soil with a high amount of organic matter. Amaranthus requires high amount of fertilizer and respond well to high soil fertility. According to Schippers (2000), the crop gives good yield when organic matter especially when high levels of nitrogen is applied. Amaranthus is propagated by seeds. It can be done by direct sowing or by nursing. Seeds are sown in drills or are broadcast either in the nursery or on the field. Seeds are mixed with sand to ensure that sowing is more uniform. The seed bed is mulched after sowing to prevent the seeds from being washed away by heavy rains. The mulch is removed soon after the seedlings have appeared. Germination starts from three to five days after sowing. Transplanting is done after four true leaf stages. In direct sowing seedlings are later thinned to avoid overcrowding. The soil should have a fine tilt as the seeds are small.

2.2.5 Corchorus

Corchorus olitorius (jute) is a native plant of tropical Africa and Asia. However, it has spread to Australia, South America and some parts of Europe. (Oboh *et al.*, 2009) The *Corchorus olitorius* plant is known as West Africa sorrel, Jews Mallow, Jute, Long-fruited Jute, Bush Okra and Krin-krin. In Ghana, it is popularly known as 'Ayoyo' or 'Ademe'. *Corchorus olitorius* belongs to the *Tiliaceae* family. (Olaniya *et al.*, 2008) It is an erect annual herb that varies from 20 cm to approximately 150 cm in height unbranched or with only a few side branches. The stems are angular shaped with simple oblong to lanceolate leaves that have serrated margins and distinct hair-like teeth at the base. The leaves are alternate, simple lanceolate with an acuminate tip and a finely serrated or lobed margin. The bright yellow flowers are usually very small (2–3 cm diameter), with five petals and the fruit is a many seeded, straight, angular capsule. It thrives almost anywhere, and can be grown year-round. *Corchorus olitorius* seed shows a high degree of dormancy which can be broken by means of hot water treatment (Schippers *et al.*, 2002a).

2.2.6 Uses and Nutritional importance of Corchorus

The leaves of *Corchorus olitorius* is believed to contain high levels of all essential amino acids except methionine which is at a marginal level (Norman, 1992).The leaves have lower ascorbate but higher dry matter contents than many other vegetables. Its leaves are popularly used in soup preparation and folk medicine for the treatment of fever, chronic cystitis, cold and tumours (Oboh *et al.*, 2009). The mucilaginous leaves and young shoots are used as spinach in stews and soups. Sometimes the leaves and shoots are dried first and used in soups. The presence of mucilage in some vegetables makes their soups more tasty and palatable (Smith, 1985). For example, when fresh leaves and tender shoots of *Corchorus olitorius* are mixed with soda and cooked, a soup of slimy and slippery consistency is produced. The resultant soup is easy to take with thick pastes of locally prepared carbohydrate dishes from rice, cassava, maize or yam. This explains why *Corchorus olitorius* soup is used in traditional medicine to open up the bowels and thus prevent constipation. The immature fruits called bush okra are dried and grounded to powder for the preparation of slimy sauce.

Root scrapings of *Corchorus olitorius* are used to treat toothache in Kenya whereas in Nigeria concoction prepared from seeds is used as purgative (Fondio *et al*., 2004). The young shoot tips can be eaten raw or cooked and it contains high levels of protein and vitamin C (Shittu and Ogunmoyela, 2001). *Corchorus olitorius* is usually recommended for pregnant women and nursing mothers because it is believed to be rich in iron (Oyedele *et al*., 2006). Mensah *et al*. (2008) reported that *Cochorus olitorius* is used as a laxative and blood purifier. Jute from the plant is used as packaging fibre because of its strength and durability (Nirmalya *et al*., 2012).

2.2.7 Agronomic Requirements and Practices of Corchorus

Jansen *et al*. (2007) reported that *Corchorus olitorius* prefers rich, well-drained, medium-textured soils but will also grow in coarse and fine textured soils. Norman (1992) also reported that *Corchorus olitorius* does well in well- drained sandy loam soil with high organic matter. Consequently, *Corchorus olitorius* responds very well to incorporation of organic matter (compost, cattle dung, poultry manure) during the preparation of the soil. *Corchorus olitorius* show a greater response to nitrogen in nitrate form than applied in ammonium form in terms of yield and quality (Fawusi and Fafunso, 1981). Propagation of *Corchorus olitorius* is by seeds. Seeds may be nursed before transplanting onto to the field or planted directly on the field. Two methods are used for nursing the seeds – broad cast method and the drilling method. The seedlings are transplanted 2-3 weeks after sowing.

Corchorus olitorius seeds can be sown and seedlings pricked out 10 days after sowing and for optimum yields the seedlings should be planted out 2-3 weeks after pricking out (Timpo & Boateng, 1982). Harvesting can start from 4-6 weeks after sowing or 3-4 weeks after transplanting. The plants can be harvested either by pulling or topping. Pulling consist of uprooting of the whole plant whiles topping involves the cutting of the terminal shoots. Akorada and Olufolaji (1983) also reported that when topping is used as a method of harvesting, the number of leaves from each harvest increases, accompanied with a reduction in size and weight, and a fall in consumer appeal of recovered leaves.

2.3 Organic Manure

Soil organic matter refers to animal and plant residues in various stages of decomposition. The final form of decomposed organic matter is brown to black, gelatinous substance called humus. Humus provides plants with the necessary nutrient elements for plant growth. The humus makes the soil easier to cultivate and increases its permeability and its retention capacity for water and nutrients. Its black colour helps to absorb excess heat in the soil and helps to regulate soil temperature (Hank, 2003). According to Sharm *et al.* (1991) and Abou *et al.* (2005), organic manures provide a source of all necessary macro- and micro-nutrients in available forms, thereby improving the physical and biological properties of the soil. There are different types of organic manure including compost, green and farm yard manure etc.

2.3.1 Cattle Dung

Cattle manure is a combination of faeces, bedding material, wasted feed, and water. (Hank, 2003) The organic fraction of manure plays an important role in increasing soil organic matter and tilth, improving soil structure and water infiltration. Many of the nutrients in the manure, however, are tied up in the organic fraction and must go through a decomposition process to be converted to the inorganic forms available for plant uptake. In order to get maximum benefit out of cattle manure, proper rates and frequency of application must be ensured. Over application can lead to transport of nutrients into the groundwater through leaching or overland flow, losses of ammonia and nitrous oxide into the atmosphere, contamination of the soil can also occur as excessive loading of nutrients, sodium and other soluble salts can reduce soil quality and productivity Saskatchewan (2000).

2.3.2 Compost

Compost refers to decomposed organic matter which is used as fertilizer to enhance the growth of plants. Compost is obtained through decomposition of a mixture of animal as well as plant waste. Composting is done in pits (in a dry climate) or heaps (in a humid climate). Compost heaps requires less work than pits. Composting has the advantage that plant and human diseases are killed by the high temperatures during the composting (Hank, 2003). Solid cattle manure can be applied either as fresh manure or as compost. Applying the manure as compost is an efficient method for handling cattle manure. Applying composted dung may be preferable to fresh manure for the following reasons: composted manure can be applied more uniformly and efficiently through the reduction of mass and volume, the nutrients are in a more stable form, more similar to that of soil humus, proper composting can eliminate viable weed seeds and pathogens in the manure and odours during application are minimized (Saskatchewan, 2000).

2.4 Shelf Life of Leafy Vegetables

Leafy vegetables have high moisture content and as such highly perishable. According to Abukutsa –Onyango (2002) most Africa leafy vegetables are highly perishable and have a shelf life of less than 24 hours. The shelf life of vegetables depends upon the metabolic processes that go on in the vegetables after harvesting.

2.5 Metabolic Processes in Harvested Leafy Vegetables

Harvesting is the act of detaching plant produce from the parent plant or its production area. Harvesting of leafy vegetables put a lot of stress on the produce resulting in biological and physiological changes to the produce during the post-harvest period. Knowledge of the changes occurring at harvesting period helps in the development of appropriate method(s) for handling the produce to preserve their quality.

Physiologically, harvesting of vegetables causes changes in turgidity which affects the quality of the produce. Turgidity of vegetables keeps them fresh in appearance and guarantees their health. However, because of interruption in the balance of water after harvesting, the turgidity of vegetables is affected. This is because after harvesting the process of evaporation and absorption of water is affected. The effects of the loss of turgidity are; biochemical changes resulting in superficial cells becoming inactive and making the produce vulnerable to pathogenic organisms' attacks (Anorson, 2009)

2.5.1 Factors Affecting Metabolic Processes and Quality of Vegetables after Harvest

Quality refers to a combination of characteristics, attributes or properties that gives a commodity value. In other words, the quality of a produce refers to the attributes of the produce that makes it acceptable to consumers. Quality is judged in terms of its end use. Freshness and free from spots and damages forms 87% of the total quality requirement considered by consumers when buying vegetables.

According to William *et al.* (1991), the following characteristics of harvested vegetables defined their quality: appearance (size, shape, and colour); condition and absence of blemishes; texture (firmness, hardness, softness, succulence, juiciness, etc.); flavour (sweetness, sourness, bitterness, astringency, etc.); and nutritional value (carbohydrates, proteins, vitamins, minerals, lipids).

Condition is a quality attribute which refers to freshness, stage of ripeness or senescence, extent of mechanical damage and disease or pest incidence of a produce. For instance shriveled or wilted vegetable due to moisture loss occurring at the end of shelf life are described as lacking condition. Leafy vegetables that have loss condition are not accepted by consumers. Improved storage condition and shading from direct sunlight can prevent loss of condition. William *et al.* (1991) classified blemishes into biological factors (pathology, entomology and animal), physiological factors (physical disorders, maturity), mechanical damages (bruises, scratches), extraneous matter (chemical residues, growing medium), and genetic factors.

2.5.1.1 Handling

According to William *et al*. (1991), vegetables should be handled with care during harvesting and storage to minimize injuries and postharvest losses. Mechanical injuries usually have minor effect on the nutritional composition of the vegetables but could serve as entry point for bacteria which can lead to rot of the vegetables. It can render the leaves unsalable and also stimulate physiological deterioration. Similarly, failure to remove dirt present in the produce and overheating during temporary field storage can cause rapid deterioration. Inappropriate packaging and transportation of produce over dumpy roads can cause physical damage due to bruising or abrasion. Severe water loss can occur due to overheating especially in open vehicles and lack of cooling or ventilation at high temperatures. Inappropriate storage conditions and poor control of storage condition such as temperature and humidity can lead to rapid deterioration of harvested produce.

Leafy vegetables should not be stored at very low temperatures because this can lead to chilling injuries or physiological disorders. Leafy vegetables should be blanched before storing at low temperatures. Ethylene from ripened fruit can promote rapid senescence of leafy vegetables in mixed storage. Traditional leafy vegetables should be dried in order to prolong the shelf life but leafy vegetables are best consumed fresh (Abukutsa –Onyango, 2002). Open display of produce in the markets exposes produce to bad environmental condition and diseases causing organisms which leads to the reduction of shelf life of the produce.

2.5.1.2 Temperature

Temperature increases induces physiological and biochemical reactions leading to increases in respiration and early spoilage of the produce in accordance with Van't Hoff's Law. Van't Hoff's Law states that the rate of a chemical reaction will approximately double for every 10°C rise in temperature. Cooling of vegetables extends the shelf life by reducing the rate of physiological and biochemical changes and retarding the growth of spoilage fungi and bacteria. Generally, storage temperature of leafy vegetables can be reduced by; harvesting early in the morning to prevent heat build-up in the vegetables, keeping vegetables away from direct sun rays after harvesting, pre cooling of the vegetables after harvesting, use of hydro-cooling, mechanical refrigeration and opening of stores for ventilation.

2.5.1.3 Humidity

Lutz and Hardenburg (1968) reported that most leafy vegetables store best in an atmosphere that has a relative humidity of 90%. This is because high humidity retards wilting and prolongs the useable life of leafy vegetables.

2.5.1.4 Hereditary

The potential storage life of most crops and for that matter leafy vegetable is partially under genetic control and can be manipulated by breeding. Some leafy vegetables such as roselle and corchorus can be processed by sun drying or dehydration to prolong the useable life.

2.6 Proximate Compositions of Leafy Vegetables

2.6.1 Moisture Content

Moisture generally refers to the presence of water in trace amounts. High moisture content in vegetables is indicative of its freshness as well as easy perishability (Adepoju and Oyediran, 2008; Ejoh *et al.*, 2007; Emebu and Anyika, 2011).Microorganisms that promote spoilage in foods thrive well in foods with high moisture contents, resulting in a reduced shelf life (Emebu and Anyika, 2011). Vegetables with high moisture content are indicative of low fat values. For vegetables to be kept for a long time before use, the moisture content has to be reduced to inhibit the autocatalytic enzymes (Ladan *et al.*, 1996).

Amaranthus cruentus and *Corchorus olitorius* have been reported to have 86% and 27% moisture content respectively (Mensah *et al.*, 2008). Anorson (2009) reported on moisture content of Amaranthus blitum and *Corchorus olitorius* as 13.58% and 14.98% respectively on dry matter bases. Florkowski *et al.* (2009) found out that the maximum water content variation between individual vegetables is due to the structural differences and cultivation conditions.

2.6.2 Crude Protein

Crude Proteins are essential organic compounds of high molecular weight found in all living tissues. They are formed from amino acids and may be categorized based on factors such as solubility and shape. Simple proteins consist of only amino acids as building blocks whiles conjugated proteins contain amino acids but in addition, a non-protein or prosthetic group which may be glycoprotein, lipoprotein, chromoprotein (Abugre, 2011). Amaranthus leaves have been noted to have a lower sulphur amino acid protein content but higher in lysine and tryptophane which could complement meals that have high carbohydrate content to provide a more balanced meal (Feine *et al.*, 1979). Mensah *et al. (*2008) reported that the protein content for *Amaranthus cruentus* and *Cochorus olitorus* as 4.6g/100 DM and 27.7g/100 respectively. Ezeala (1985) cited in Norman (1992) also reported the protein content of Amaranthus vividis and Amaranthus blitum as 32.2% and 27.2% respectively on dry matter bases. Anorson (2009) reported on the protein content of *Amaranthus blitum* and *Corchorus olitorius* as 30.73% and 20.97% respectively on dry matter bases.

The World Health organization (WHO) recommends a protein intake of 56g of protein a day for a (75kg) man and 48g for a (64kg) woman. The recommendations of the UK Department of Health and Social Security (DHSS) are slightly higher, at about 68g a day for sedentary or moderately active men, and 54g a day for women.

2.6.3 Dietary Crude Fibre

Dietary fibre consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants. Dietary crude fibre includes polysaccharides, oligosaccharides, lignin among others. Dietary fibre may be classified into three major groups according to structure and properties. The groupings are cellulose, non-cellulose and lignin (Komal and Kaur, 1992). Mensah *et al*. (2008) reported crude fibre content of 1.8 and 8.5g/100g for *Amaranthus cruentus* and *Corchorus olitorius* on dry matter basis. Kwenin *et al*. (2011) also reported crude fibre content of 10.40% for *Amaranthus cruentus*. Dietary fibre has beneficial physiological effects including laxation, blood cholesterol attenuation, and blood glucose attenuation (CFW, 2003). Fibre aids and speeds up the excretion of waste and toxins from the body, preventing them from sitting in the intestine or bowel for too long, which could cause a build-up and lead to several diseases (Hunt *et al.*, 1980). By virtue of its water holding capacity, fibre also helps in the formation of soft stools making them easily evacuatable (Komal and Kaur, 1992). They are also used in diets to prevent and treat obesity and diabetes mellitus.

2.6.4 Crude Fat content

Leafy vegetables are not noted for contributing significantly to the fat supply in foods (Kummerow, 2007). Kwenin *et al.* (2011) reported crude fat contents of 3.0%, 1.33% and 1.50% in Amaranthus *cruentus*, Talinum triangulare and Moringa oleifera respectively. Lipids are essential fats that play a very important role in the human body (Saidu and Jideobi, 2009). Lipids help with brain function, joint mobilization and even energy production. They also help the body to absorb fat-soluble vitamins such as vitamins A and E (Osborne and Voogt, 1978).

2.6.5 Ash Content

Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within a food (McClement, 2003). The ash content indicates the mineral content of foods. Nnamani *et al.* (2009) reported that low ash content suggests that the mineral content is low for any product. Higher ash content predicts the presence of an array of mineral elements as well as high molecular weight elements (Onot *et al.*, 2007). Adeniyi *et al.* (2012) had 0.64% on the ash content of *Corchorus*. Anorson (2009) also reported on the ash content of *Amaranthus blitum* and *Corchorus olitorius* as 19.99 % and 10.30 % respectively. Ezeala (1985) reported the ash content of *Amaranthus vividis* and *Amaranthus caudatus* as 18.7% and 20.1% respectively.

2.6.6 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). Mensah *et al.* (2008) reported carbohydrate content of 7.0 and 26.6g/100g respectively for *Amaranthus cruentus* and *Corchorus olitorius*. Anorson (2009) had carbohydrate content of *Amaranthus blitum* and *Corchorus olitorius* as 17.35% and 28.88% respectively. Carbohydrates are the most important food energy provider among the macronutrients, accounting for between 40 and 80 percent of total energy intake. Carbohydrate also serves as stored forms of energy as glycogen in liver and muscles. It also provides major source of energy and responsible for breaking-down of fatty acids and preventing ketosis (Hassan *et al.*, 2006).

2.7 Mineral Nutrients of Leafy Vegetables

2.7.1 Phosphorus

It has been observed that green leafy vegetables are an important source of phosphorus (Soetan *et al.*, 2010). Mhlontlo *et al*. (2007) reported on the phosphorus content of Amaranthus accession as 0.09-0.14% on the studies of the effect of sheep kraal manure on the growth performance and nutritional composition of Amaranthus accession. The phosphorus content of the plant is influenced markedly by the availability of phosphorus in the soil. Phosphorus is an essential macronutrient for plants and is among the three needed nutrients in the soil because of its vital role of energy transfer in living organisms and in plants.

Phosphorus is very important to the human body. It is involved in many metabolic processes, including those involving the buffers in body fluids (Hays and Swenson, 1985). It functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. Adequate phosphorus availability stimulates early growth and hastens maturity in plants. Deficiency of phosphorus in children causes rickets and osteomalacia in adults.

2.7.2 Potassium

Potassium is the principal cation in intracellular fluid and functions in acid-base balance, regulation of osmotic pressure, conduction of nerve impulse, muscle contraction particularly the cardiac muscle and cell membrane function. Soetan *et al.* (2010) identified vegetables, fruits, nuts as sources of potassium, while Mensah *et al.* (2008) reported potassium content of *Amaranthus cruentus* and *Corchorus olitorius* as 4.82 and 3.83 mg/100 g DM respectively. Mhlontlo *et al.* (2007) reported on the potassium content of *Amaranthus accession* as 3.3-4.7%. A study by Mepba *et al.* (2007) indicated that blanching and cooking significantly ($P \leq 0.05$) decreased levels of potassium in vegetables. It also helps in the transfer of phosphate from ATP to pyruvic acid and probably has a role in many other basic cellular enzymatic reactions. Potassium and magnesium are known to decrease blood pressure. Potassium plays a role in controlling skeletal muscle contraction and nerve impulse transmission. Vegetables with potassium are used to treat patients with soft bone problems. Its metabolism is regulated by aldosterone. Toxicity disease or symptoms include dilatation of the heart, cardiac arrest, small bowel ulcers. Potassium deficiency affects the collecting tubules of the kidney, resulting in the inability to concentrate urine, and also causes alterations of gastric secretions and intestinal motility.

2.7.8 Calcium

Calcium is a major factor sustaining strong bones and plays a part in muscle contraction and relaxation, blood clotting, synaptic transmission and absorption of Vitamins. In plants, calcium is taken up in the ionized form (as $Ca^{2}+$). The leafy vegetables are relatively high in calcium and low in phosphorus, whereas, the reverse is true of the seeds. Legumes, in general, have higher calcium content than grasses (Merck, 1986 cited in Abugre, 2011). Sources of calcium include beans, lentils, nuts, leafy vegetables, dairy products, small fishes, bones, etc. (Soetan *et al.*, 2010).

Mensah *et al.* (2008) reported Calcium content of *Amaranthus cruentus* and *Corchorus olitorius* as 2.05 and 1.26mg/100g DM respectively. Mhlontlo *et al* (2007) reported on the calcium content as 3.7-3.9%. Calcium is an important constituent of bones and teeth and is involved in regulation of nerve and muscle function. In blood coagulation, calcium activates the conversion of prothrombin to thrombin. It plays a vital role in enzyme activation. Calcium activates large number of enzymes such as adenosine triphosphatase (ATPase), succinic dehydrogenase and lipase. It is also required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability (Soetan *et al.*, 2010).

Reduced extracellular blood calcium increases the irritability of nerve tissue, and very low levels may cause spontaneous discharges of nerve impulses leading to tetany and convulsions (Hays and Swenson, 1985). In children, calcium deficiency causes rickets due to insufficient calcification by calcium phosphate of the bones in growing children. The bones therefore remain soft and deformed by the body weight. In adults, it causes osteomalacia, a generalized demineralization of bones. It may also contribute to osteoporosis, a metabolic disorder resulting in decalcification of bone with a high incidence of fracture, that is, a condition where calcium is withdrawn from the bones and the bones become weak and porous and then breaks (Hays and Swenson, 1985; Malhotra, 1998; Murray *et al.*, 2000). Calcium deficiency also affects the dentition of both children and adult. Excess calcium depresses cardiac activity and leads to respiratory and cardiac failure; it may cause the heart to stop in systole, although, normally, calcium ions increase the strength and duration of cardiac muscle contraction.

2.7. 9 Magnesium

Magnesium is an active component of several enzyme systems in which thyminepyrophosphate is a cofactor. Oxidative phosphorylation is greatly reduced in the absence of magnesium. It also activates pyruvic acid carboxylase, pyruvic acid oxidase, and the condensing enzyme for the reactions in the citric acid cycle. It is also a constituent of bones, teeth and enzyme cofactor (Murray *et al.*, 2000). Mensah *et al.* (2008) reported magnesium content of *Amaranthus cruentus* and *Corchorus olitorius* as 2.53 and 0.59mg/100 DM respectively. Cleome gynandra has a magnesium content of 86mg/100g (Chweya and Mnzava, 1997). Mhlontlo *et al*. (2007) reported the magnesium content in *Amaranthus accession* as 1.3-1.5%.

High magnesium content in *A. cruentus* (2.53mg/100g), *T. triangulare* (2.22mg/100g), Celosia (1.41mg/100g) and *G. latifolium* (1.32mg/100g) has the ability to lower blood pressure when consumed. Acute magnesium deficiency results in vasodilation, with erythemia and hyperaemia appearing a few days on the deficient diet. Neuromuscular hyperirritability increases with the continuation of the deficiency, and may be followed eventually by cardiac arrhythmia and generalized tremours. The physiological deficiency of magnesium can be prevented by magnesium supplementation of a salt or grain mixture and adequate consumption is also very important (Hays and Swenson, 1985). Toxicity disease or symptoms of magnesium deficiency in humans include depressed deep tendon reflexes and respiration (Murray *et al.*, 2000). The pathological effects of magnesium depletion are the role of this element in regulating potassium fluxes and its involvement in the metabolism of calcium (FAO/WHO, 2004).

2.7.9 Sodium

It is commonly consumed as sodium chloride. It enhances the taste of food and also forms an integral part of human body. Sodium is highly reactive but alkaline in nature. It is malleable and essential for regulation of body fluids and blood. It transmits nerve impulse and controls heart activity. It assists in metabolic formations and in a balanced form is very essential to the smooth running of the human body. Although sodium is not crucial for the survival of plants but they still do contain it and in forms that is easily digestible by human body. (Soetan *et al*, 2010).

Foods that are high in sodium content are beef, greens, milk and milk product like butter milk, cheese, legumes canned foods fruits, bean, meat, green leafy vegetables, spinach ,oysters shrimps etc. Sodium is consumed by the body in small quantities .It maintain blood pressure vessels. A balanced diet is essential as too less or too much of sodium can be harmful to the human body. Lack of sodium causes low pressure.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The field work was conducted on the research plots of the Department of Horticulture of the Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, between November, 2013 and March, 2014.The site falls within the rainfall pattern of the forest zone of Ghana. Nutritional composition on the cattle dung, soil and leafy vegetables were also analyzed at the soil science laboratory of Kwame Nkrumah University of Science and Technology.

3.2 Source of Cattle Dung and Planting Materials

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.

3.3 Land Preparation and Soil Amendment

The land was ploughed and harrowed. Rubbles mostly roots of grasses and stamps of shrubs were removed from the soil. The soil was analyzed before the commencement of the experiment. The cattle dung was composted for a period of four months and on plots at the rates of 0, 0.5, 0.8, 1.1 tonnes. The cattle dung was analyzed to determine the nutritional composition before it was applied to the soil.

3.4 Seed Sowing

The seeds were nursed using the broadcasting method. Watering was done immediately after sowing.

3.5 Cultural Practices Carried Out

3.5.1 Transplanting

Transplanting was done when seedlings were two weeks odd. The plant height, number of leaves, number of shoots and stem girth were measured on twentieth and thirtieth days after transplanting.

3.5.2 Harvesting

The plants were harvested on the thirtieth day after transplanting.

3.5.3 Weeding

Weeding on the experimental plots was done as and when necessary. It was done by hand pulling and hoeing.

3.5.4 Watering

Watering was done daily.

3.6 Experimental Design

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

3.7 Quality Parameters Studied

3.7.1 Shelf life

The leafy vegetables were harvested thirty days after transplanting. The 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.

3.7.2 Weight loss

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

$$\% \text{ Weight loss} = \frac{W1 - W2}{W1} \times 100$$

Where, W1 = weight of fresh leafy vegetables, W2 = subsequent sample weight at different storage intervals.

3.7.3 Growth parameters

Plant height: A metre rule was used to measure plants from the root level to the apex and this was expressed in centimeters.

Number of leaves: This was done by direct counting.

Number of shoots: This was done by direct counting

Stem girth: It was estimated by means of vernier caliper

3.8 Laboratory Analysis

3.8.1 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).

3.8.1.1 Crude Fat Content

The samples were ground and five grams each where weighed into a filter paper. The extraction flask was placed in an oven for about 5 min at 110^{o}Cafter which it was cooled and weighed. A piece of filter paper was folded in such a way that it could hold the sample. The sample was wrapped around a second filter paper which was left open at the top like a thimble. A piece of cotton wool was placed at the top to evenly distribute the solvent as it drops on the sample during extraction. The sample packet was placed in the butt tubes of the Soxhlet extraction apparatus. The extraction was done with petroleum ether for 3 hours without interruption by gentle heating. After 3 hours the extraction flask was dismantled and allowed to cool. The ether was evaporated on a water bath until no odour of ether remained. It was then cooled at room temperature. The extraction flask and its extract were re-weighed and the weight recorded.

Calculations

(A + B) – A = B % ether extract = B/C x 100

where A = flask weight, B = ether extract weight, C = sample weight

3.8.1.2 Crude Fibre Content

Crude fibre was estimated by acid-base digestion with 1.25% H_2SO_4 (prepared by diluting 7.2 ml of 94% conc. acid of specific gravity 1.835g ml-1 per 1000 ml distilled water) and 1.25% NaOH (12.5 g per 1000 ml distilled water) solutions. The residue from ether extract was transferred to a digestion flask and about 200 ml of the boiling H_2SO_4 solution, was added. An anti-foaming agent was also added and immediately connected to a digestion flask with condenser and heated. At the end of 30 minutes, the flask was removed and its content was filtered immediately through a linen cloth and washed with boiling water until washings are no longer acid. The washed residue was put back into flask with 200 ml of the boiling NaOH solution. The flask was connected to reflux condenser and boiled for exactly 30 minutes. At the end of 30 minutes, the flask was removed and the content was immediately filtered through the Gooch crucible. After thorough washing with boiling water, the content was then washed with about 15ml of 95% ethanol. The content and the crucible were dried at 110^{o} C to constant weight. It was then cooled in a desiccator and weighed. The content of crucible was incinerated in muffle furnace at 550^{o}C for 30min until the carbonaceous matter was consumed. It was again cooled in a desiccator and weighed. The loss in weight was recorded as crude fibre.

Calculation

$$\% \text{ crude fibre} = \frac{A - B}{C} \times 100$$

where A = wt. of dry crucible and sample

B = wt. of incinerated crucible and ash, C = sample weight.

3.8.1.3 Crude Protein Content

Two grams (2g) of the sample was weighed and transferred to a 650ml digestion flask and 10ml of distilled water was added. One (1) digestion tablet was added to acts as catalyst as well as 20ml of concentrated H_2SO_4 added to the digestion flask. Boiling chips were added to the sample and digested till the solution became colourless. The cooled digest was diluted with a small quantity of distilled ammonia-free water up to 100ml. The Kjeldahl flask was rinsed with distilled water. Ten millilitres (10ml) out of the 100ml digest was pipette into the distillation flask and 90ml distilled water added to it. Similarly, 20ml of the 40% NaOH was added.

A conical flask containing 10ml of boric acid solution with a few drops of mixed indicator was placed, the sample was distilled and the ammonia collected on boric acid. Hundred millilitres (100ml) to 150ml of distillate was collected. The solution was titrated against the standard 0.1N HCl until the first appearance of pink colour was observed. A reagent blank with equal volume of distilled water was run. The titration volume was then subtracted from that of sample titration volume.

<u>Calculation</u>

The N content of the sample was calculated by the formula:

% Nitrogen

$$= \frac{(\text{ml acid} \times \text{normality of standard acid})}{\text{wt of sample (g)}} \times 0.014 \times 100$$

Therefore

% Crude Protein (CP) = Total Nitrogen (N_T) x 6.25(Protein factor)

3.8.1.4 Moisture Content

Two grams (2g) of granular sample were weighed. The sample was dried overnight in an air oven at 65^{o}C for 24 hours. The crucibles plus sample were allowed to cool and their weight taken.

Calculations

$$M/C = \frac{\text{Fresh weight} - \text{dried weight}}{\text{Fresh weight}} \times 100$$

3.8.1.5 Ash Content

Two grams (2g) of the sample was weighed into porcelain crucible. The sample was put into a furnace for 4 hours at 550^{o}C.The furnace was allowed to cool below 200^{o}C and maintained for 20 minutes. The ash crucible was removed from the furnace and placed in desiccator to cool. The sample was then weighed.

Calculations

$(A + B) – A = B$

$(A + C) - A = C$

% Ash = C/B x 100   where A = crucible weight, B = sample weight, C = ash weight.

3.8.1.6 Carbohydrates Content

The calculation of carbohydrate was made after completing the analysis for ash, crude fibre, ether extract and crude protein. The calculation is made by adding the percentage values on dry matter basis of these analysed contents and subtracting them from 100%.

Calculation

Carbohydrate on DM basis = 100% - (%ash on DM basis + % crude fibre on DM basis + % ether extract on DM basis + % protein on DM basis)

3.8.2 Preparation and Dry Ash Digestion of Plant Tissues for Elemental Analysis

One gram (1.0g) of sample was weighed into a clean ceramic crucible. An empty crucible was included for a blank in each batch of 24 samples. The samples were arranged in a cool muffle furnace and temperature ramped to 500^{o}C over a period of 2 hours. This temperature was allowed to remain for an additional 2 hours. The samples were allowed to cool down in the furnace. Samples were then removed from the furnace ensuring that the environment is free from breeze.

Ashed samples were transferred first into already numbered 50ml centrifuge tubes. Crucibles were rinsed with 10ml of distilled water into the centrifuge tubes. More rinsing of the crucible with 10ml of aqua regia was done. The samples were shaken for 5 minutes for proper mixing on a mechanical reciprocating shaker. Samples were then centrifuged for 10 minutes at 3000 rpm and then transferred into 100ml volumetric flask and again made up to the 100ml mark. The clear supernatant digest were decanted into clean reagent bottles for P, Ca, Mg, K, Na, Zn, Cu, Mn, and Fe determinations.

3.8.2.1Method of Determination of Phosphorus (P)

A vanadomolybdate reagent was prepared by dissolving 22.5g of ammonium molybdate in 400ml of distilled water and 1.25g of ammonium vanadate in 300ml of boiling distilled water. The vandate solution was added to the molybdate solution and cooled to room temperature. Two hundred and fifty millilitres (250ml) of analytical grade HNO_3 was added to the solution mixture and diluted to 1 litre with deionized water. The standard phosphate solution was also prepared by dissolving 0.2195g of analytical grade KH_2PO_4 in 1000ml distilled water. This solution contains 50µg P/ml.

A standard curve was prepared by pipetting 1, 2, 3, 4, 5 and 10 ml of standard solution (50 µg P/ml) in 50 ml volumetric flasks. 10 ml of vanadomolybdate reagent was added to each flask and the volume made up to 50 ml. This gave a P content of the flasks as 1, 2, 3, 4, 5, and 10 µg P/ml. These concentrations were measured on the Jenway 6051 colorimeter to give absorbance measurements at a wavelength of 430 nm. A plot of absorbance against concentration was used to prepare the calibration curve. 5 ml of the sample solution from 3.4.2.2 was put into a 50 ml volumetric flask. 10 ml of vanadomolybdate reagent was added and volume made up to 50 ml. The sample was kept for 30 minutes for colour development. A stable yellow colour developed. The sample was read on the colorimeter at 430 nm. The observed absorbance was used to determine the P content from the standard curve. The % P was calculated as:

P content (g) in 100 g sample (% P) = $\frac{C x df x 100}{1\,000\,000} = \frac{C x 1000 x 100}{1\,000\,000} = \frac{C}{10}$

Where C = concentration of P (µg /ml) as read from the standard curve;

df= dilution factor, which is 100 *10 = 1000, as calculated below:

1 g of sample made to 100 ml (100 times);

5 ml of sample made to 50 ml (10 times)

1 000 000 = factor for converting µg to g

3.8.2.2 Method of Determination of Potassium (K) and Sodium (Na)

A 1.908 g and 2.542 g of analytical grade KCl and NaCl respectively previously dried in an oven for 4 hours at 105^{o}C were each dissolved in 200 ml of deionised water. The two solutions were mixed together and volume made up to 1000 ml. This gave a combined standard of 1000 ppm. For K, a calibration curve (standard curve) of 200, 400, 600 and 800 ppm was prepared. Similarly, a standard curve of 20, 40, 60 and 80 ppm was prepared for sodium. All the absorbance reading was taken using the flame photometer. The sample solution from the $HClO_4$ and HNO_3 was read on the flame photometer. From the standard curve, the concentration of K and Na were calculated using the particular absorbance observed for the sample.

Calculation:

K, Na content (µg) in 1.0 g of plant sample = C x df

K, Na content (g) in 100 g plant sample, (% K, Na) = $\frac{C \times df \times 100}{1000\ 000} = \frac{C \times 100 \times 100}{1000\ 000}$

$\frac{C}{100}$

Where

C = concentration of K (µg / ml) as read from the standard curve

df = dilution factor, which is 100 x1 = 100, calculated as :

- 1.0 g of sample made up to 100 ml (100 times)
- 1000 000 = factor for converting µg to g.

3.8.2.3Method of Determination of Calcium (Ca) and Magnesium (Mg)

Calcium and magnesium determination by EDTA titration involves addition of several reagents. These reagents were prepared as;

Buffer solution – 60 g of ammonium chloride was dissolved in about 200 ml of distilled water. 570 ml of concentrated ammonium hydroxide was added and diluted to 1000 ml in a volumetric flask.

Potassium cyanide: 10 % KCN (W/V) was prepared by dissolving 50 g of KCN in 500 ml of distilled water in a volumetric flask. This solution complex off all cations that react with EDTA.

Potassium hydroxide: 10 % KOH (W/V) was prepared by dissolving 100 g of KOH in a litre of distilled water. Necessary when determining Ca^{2+} since it enables it to react with EDTA.

Calcone – red (cal – red) indicator: This indicator gives red coloration when Ca^{2+} is absent but gives bluish color when Ca^{2+} is present.

Triethanolamine (TEA): 30 % (V/V) was prepared by diluting 300 ml TEA in a litre of distilled water. This is a viscous solution which is included to maintain p H.

Erichrome Black T (EBT): 0.2 g of EBT was weighed and dissolved in a mixture of 50 ml methanol (85 %) and 2 g hydroxylamine hydrochloride. Indicator for determining Ca^{2+} + Mg^{2+}. Gives red coloration in the absence of Ca^{2+} + Mg^{2+} and bluish coloration in the presence of Ca^{2+} + Mg^{2+}.

0.02N EDTA Solution (Versenate): 3.723 g of reagent grade disodium ethylenediamine tetra acetate dehydrate was dissolved in distilled water. It was diluted to 1000 ml and standardized against magnesium solution with EBT indicator (one ml of 0.02 N EDTA =

0.4 mg Ca = 0.24 mg Mg). EDTA complexes with Ca^{2+} and removes it from solution giving a blue end point in the presence of Ca^{2+}.

Calcium standard (0.02 N): 1.0 g of reagent grade calcium carbonate ($CaCO_3$) was dissolved in 1 ml of conc. HCl and diluted to 1000 ml with distilled water.

Magnesium standard (0.02 N): 2.465 g of reagent grade magnesium sulfate heptahydrate was dissolved in 1000 ml distilled water.

Determination of Calcium

5.0 ml of sample solution from 3.4.2.2 was transferred into a 100 ml Erlenmeyer flask. 10 ml of 10 % KOH solution was added followed by 1 ml of 30% TEA. Three drops of 10 % KCN and few drops of EBT indicator solution. The mixture was shaken to ensure homogeneity. The mixture was titrated with 0.02 N EDTA solution from a red to blue end point.

Calcium in mg = Titre value of EDTA x 0.40

$$\% \text{ Calcium} = \frac{\text{mg Calcium}}{\text{Sample wt}} \times 100$$

Determination of Magnesium

5.0 ml sample solution from 3.4.2.2 was emptied into a 100 ml Erlenmeyer flask. 5 ml of ammonium chloride – ammonium hydroxide buffer solution was added followed by 1 ml 30% TEA. Three drops of 10 % KCN and a few drops of EBT indicator solution. The mixture was shaken to ensure homogeneity. The mixture was titrated with 0.02 N EDTA solution from a red to blue endpoint.

Magnesium in mg = Titre value of EDTA x 0.24

$$\% \text{ Mg} = \frac{mgMagnesium}{Samplewt} x\ 100$$

3. 9 Statistical Analysis

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

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CHAPTER FOUR

4.0 RESULTS

4.1 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 4.1. The calcium content of the soil was (5.94%) Mg (0.96%), N (0.08%) K (0.75%) and Na (0.73%). Total organic content was (0.68%). 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 organic carbon (10.37%).

Table 4.1: 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

4.2 Growth Parameters for *Amaranthus cruentus*

Plant height, number of leaves, number of shoots and stem girth were the growth parameters measured. Tables 4.2 to 4.5 show the effect of different rates of cattle dung on the growth parameters of *Amaranthus cruentus* at 20 and 30 days after transplanting.

4.2.1 Plant Height

No significant difference (P > 0.05) was recorded at the end of 20 days after transplanting. Twenty days after transplanting, the highest plant height (43.33cm) was obtained from cattle dung application of 1.1 tonnes per hectare. At the end of 30 days after transplanting, there was significant difference (P > 0.05) between the control and other treatment levels. The highest plant height (77.67) at 30 days after transplanting was recorded by treatment level 0.8 tonnes per hectare.

Table 4.2: Plant Height

Treatments	Days After Transplanting		Mean
	Day 20	Day 30	
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	

Lsd Trts= 12.587, Lsd 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 level 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively.

4.2.2 Number of Leaves

No significant difference (P > 0.05) was observed at day 20 after transplanting. Applicatin of 0.8 tonnes per hectare gave the highest number of leaves (66.33) at day 20 after transplanting. There was significant difference (P > 0.05) between the control and the rest of the treatment levels at the 30th day after transplanting. Although there was no significant difference (P > 0.05) between the different application levels, the application level 0.8 tonnes per hectare gave the highest number of leaves (141.00).

Table 4.3: Number of Leaves

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

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 level 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively.

4.2.3 Number of Shoots

No significant difference (P > 0.05) was recorded on the 20th day after transplanting. There was a significant difference (P > 0.05) between the control and the other treatment levels on the 30th day after transplanting. The highest number of shoots (17.33) was recorded by treatment level 0.8 tonnes per hectare on the 30th day after transplanting.

Table 4.4: 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	

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 level 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively.

4.2.4 Stem girth

No significant difference ($P > 0.05$) was observed on the 20th day after transplanting. Treatment level 1.1tonnes per hectare gave the biggest stem girth (1.13cm) whiles the control gave the smallest stem girth (0.63cm) at the 20th day after transplanting. Significant difference ($P > 0.05$) was observed between the control and the treatments at the 30th day after transplanting. The biggest stem girth (1.80cm) was recorded on the 30th day after transplanting by treatment levels 0.8 and 1.1 tonnes per hectare.

Table 4.5: 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	

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 level 0, 0.5, 0.8 and 1.1tonnes per hectare of cattle dung application respectively.

4.3 Growth Parameters for *Corchorus olitorius*

4.3.1 Plant Height

There was significant difference (P > 0.05) between the control and treatment levels 0.8 and 1.1 tonnes per hectare on the 20th day after transplanting. The highest plant height (32.33cm) was recorded by the control and the least (19.00cm) came from the highest treatment level 1.1 tonnes per hectare.

On the 30th day after transplanting, significant difference (P > 0.05) was recorded between the control and treatment levels 0.8 and 1.1 tonnes per hectare. The increase in the application levels lead to decrease in plant height.

Table 4.6: Plant Height

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

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 level 0, 0.5, 0.8 and 1.1tonnes per hectare of cattle dung respectively.

4.3.2 Number of Leaves

There was no significant difference (P > 0.05) on the 20th day after transplanting. The highest number of leaves (58.00) was recorded by the control and was followed by 0.5 tonnes per hectare whiles the lowest (28.33) was recorded by 1.1tonnes per hectare. There was a significant difference (P > 0.05) between the control and treatment level 1.1 tonnes per hectare. The control recorded the highest number of leaves (195.00).

Table 4.7: Number of Leaves

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

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 level 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively.

4.3.3 Number of Shoots

There was no significant difference (P > 0.05) between the control and the treatment levels on the 20th day and 30th day after transplanting. The control recorded the highest number of shoot (12.67) whiles the highest application level gave the least number of shoots (9.00) on the 20th day after transplanting. On the 30th day after transplanting, the control recorded the highest number of shoot which was followed by the treatment level 0.5 tonnes per hectare.

Table 4.8: Number of Shoots

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

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 level 0, 0.5, 0.8 and 1.1tonnes per hectare of cattle dung respectively.

4.3.4 Stem Girth

No significant difference ($P > 0.05$) was observed on the 20th and the 30th days after transplanting. Treatment level 1.1 tonnes per hectare recorded the biggest stem girth (0.30cm) which was followed by treatment level 0.5 tonnes per hectare (0.27cm). On the 30th day after transplanting, the control recorded the biggest stem girth (0.60cm) which was followed by 0.8 tonnes per hectare (0.5 cm).

Table 4.9: Stem Girth

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

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 level 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively.

4.4 Proximate Composition of *Amaranthus Cruentus*.

Table 4.10 depicts the results on the proximate composition of *Amaranthus cruentus*.

Table 4.10: 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

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 level 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively.

4.4.1 Moisture Content

There was no significant differences (P >0.05) in the moisture content of the *Amaranthus cruentus* at both the fresh and dry states. The moisture content decreased as the level of application increased. The least moisture content (5.93%) at the dry state was recorded by the treatment level 1.1 tonnes per hectare.

4.4.2 Protein Content

There was no significant differences (P >0.05) in the protein content of the *Amaranthus cruentus* (Table 4.10). With the exception of treatment level 0.5 tonnes per hectare, the protein content increased with an increase in the level of application. The highest protein content (19.82) was recorded by treatment level 1.1 tonnes per hectare and was followed by treatment level 0.8 tonnes per hectare.

4.4.3 Fat Content

No significant differences (P >0.05) was recorded in the fat content of *Amaranthus cruentus* (Table 4.10). The highest fat content (3.66%) was obtained from treatment level 0.8 tonnes per hectare which was followed by treatment level 0.5tonnes per hectare. The least fat content value (2.66%) was recorded by the control.

4.4.4 Fibre Content

There was no significant differences (P >0.05) in the fibre content of *Amaranthus cruentus* (Table 4.10). The highest fibre content of (1.85%) was recorded by treatment level 0.8 tonnes per hectare. The least fibre content (1.50%) was obtained by treatment level 1.1 tonnes per hectare.

4.4.5 Ash Content

Ash content of the treatment levels varied between 14.36% and 16.93 % (Table 4.3). *Amaranthus* cruentus at 0.8 tonnes per hectare had the highest (16.93%) and was not significantly different (P >0.05) from the other treatment levels.

4.4.6 Carbohydrates Content

No significant difference (P > 0.05) was observed in the carbohydrate content of *Amaranthus cruentus*. The highest carbohydrate content was obtained by the control whiles the least came from treatment level 0.8 tonnes per hectare.

4.5 Proximate Composition of Corchorus *oliterius*

Table 4.11 depicts the results on the proximate composition of *Corchorus oliterius*

Table 4.11: Proximate Composition of Corchorus *oliterius*

Parameters	Treatment means			
	Corchorus 0	Corchorus 0.5	Corchorus 0.8	Corchorus 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

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 level 0, 0.5, 0.8 and 1.1tonnes of cattle dung respectively.

4.5.1 Moisture Content

There were no significant differences (P >0.05) in the moisture content of the *Corchorus olitorius* at both the fresh and dry states. Although there was no significant difference (P >0.05) in the moisture content, the moisture content at the fresh states increased with an increase in the treatment levels. On the other hand, treatment level 1.1 tonnes per hectare had the least moisture content (11.83) at the dry states.

4.5.2 Protein Content

There was no significant differences (P >0.05) in the protein content of *Corchorus olitorius* (Table 4.4). The highest protein content value of (19.54%) was recorded by treatment level 0.8 tonnes per hectare. The least protein content (16.00%) was found in treatment level 1.1 tonnes per hectare.

4.5.3 Fat Content

There was no significant differences (P >0.05) in the fat content (Table 4.4). The least fat content value (2.50%) was recorded by treatment level 0.5 tonnes per hectare. The highest fat content of (3.15) was recorded by the control.

4.5.4 Fibre Content

No significant difference was recorded in the fibre content of *Corchorus olitorius.* The control recorded the highest fibre content whiles the least was obtained from treatment level 0.5 tonnes per hectare.

4.5.5 Ash Content

Ash content of *Corchorus olitorius* varied between 12.33% and 14.50 % (Table 4.3). Treatment level 0.5 tonnes per hectare had the highest (14.50%) and was not significantly different (P >0.05) from the other treatment levels. Treatment level 0.8 tonnes per hectare had the lowest (12.33%) ash content.

4.5.6 Carbohydrates Content

Treatment level 1.1 tonnes per hectare had the highest carbohydrate content of (65.33%) followed by (65.15%) with level 0.5 tonnes per hectare. No significant difference (P >0.05) was observed.

4.6 Mineral Composition for *Amaranthus cruentus*

Table 4.12 depicts the mineral composition of *Amaranthus cruentus.*

4.6.1 Calcium

The control of *Amaranthus cruentus* had the highest (0.79g/100) calcium content and was significantly different (P <0.05) from treatment level 0.5 and 0.8 tonnes per hectare.

4.6.2 Magnesium

The magnesium content of *Amaranthus cruentus* ranged between 0.84-1.13g/100. There was a significant difference (P <0.05) between treatment level 1.1 tonnes per hectare and treatment level 0.5 tonnes per hectare. The highest magnesium content (1.13g/100) was recorded by treatment level 1.1 tonnes per hectare.

Table 4.12: Effect 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}	0.34^{bc}	0.43^{bc}	0.76^{ab}	0.18^{c}	0.08^{c}	0.10^{c}	0.20c
Magnesium	1.00^{ab}	0.84^{b}	0.96^{ab}	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}

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 level 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.

4.6.3 Phosphorus

There was no significant difference ($P > 0.05$) in the phosphorus content of *Amaranthus cruentus*. The highest (0.63g/100) phosphorus content was obtained by treatment level 0.8 tonnes per hectare. The least (0.55g/100) was recorded by the control sample (Table 4.12).

4.6.4 Potassium

The potassium content ranged from 3.62-4.47g/100. No significant difference ($P > 0.05$) was observed in all the treatment. The highest phosphorus content of (4.47g/100) was recorded by treatment level 0.8 tonnes per hectare and the least (3.62g/100) came from treatment level 0.5 tonnes per hectare.

4.6.5 Sodium

No significant difference (P > 0.05) was observed between the treatments given. Treatment level 0.8 tonnes per hectare recorded the highest (0.22g/100) sodium content whiles treatment level 1.1 tonnes per hectare recorded the lowest (0.16g/100) sodium content.

4.7 Mineral Composition of *Corchorus oliterius*

Table 4.12 above illustrates the results of *Corchorus oliterius.*

4.7.1 Calcium

No significant difference was recorded in the calcium content of *Corchorus oliterius*. The highest calcium content (0.20g/100) was obtained from treatment level 1.1 tonnes per hectare whiles the least (0.08g/100) came from treatment level 0.5 tonnes per hectare.

4.7.2 Magnesium

The control plant had the highest (0.43g/100) magnesium content. There was no significant difference (P <0.05). From the results, it can be observed that, increase in the application rate led to a decrease in the magnesium content.

4.7.3 Phosphorus

No significant difference (P > 0.05) was observed in the phosphorus content for all the treatment. The highest (0.66g/100) phosphorus content was obtained by treatment level 1.1 tonnes per hectare.

4.7.4 Potassium

The potassium content ranged from 3.53-10.94g/100. No significant difference (P > 0.05) was observed in all the treatment levels. The highest phosphorus content of (10.94g/100) was recorded by *Corchorus oliterius* with cattle dung treatment level 1.1 tonnes per hectare and the control of *Corchorus oliterius* recorded the least (3.53) potassium content.

4.7.5 Sodium

No significant differences (P > 0.05) were observed. *Corchorus oliterius* with cattle dung treatment level 0.8 tonnes per hectare had the highest (0.30g/100) sodium content. The least sodium content of (0.21g/100) was recorded for the control.

4.8 Weight Loss of *Amaranthus cruentus*

The weight loss of *Amaranthus cruentus* at different application rate of cattle dung has been presented in Table 4.13. No significant difference (P >0.05) was observed at the end of 24 hours after harvesting. Treatment level 0.8 tonnes per hectare obtained the highest weight loss (28.00%) whiles treatment level 1.1 tonnes per hectare obtained the least weight lost on the 24 hour period. There was no significant difference (P >0.05) at the end of the 48 hours after harvesting. At the end of the 48 hours after harvesting, the least weight loss was obtained by treatment level 0.8 and was not significantly different from the other treatment levels.

Table 4.13: 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	
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 level 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.

4.9 Weight Loss of *Corchorus olitorius*

The weight loss of *Corchorus olitorius* at the different application rate of cattle dung has been presented in Table 4.14. No significant difference ($P > 0.05$) was observed at the end of 24 hours after harvesting. Application rate of 0.8 tonnes per hectare resulted in higher weight loss (33.67%) on the 24 hours after harvesting while the least (26.67%) was recorded by treatment level 1.1 tonnes per hectare. There was no significant difference at the end of the 48 hours after harvesting. Treatment level 0.5 tonnes per hectare had the least weight loss (43.00%).

Table 4.14: Weight Loss of *Corchorus olitorius*

Treatments	Hours after harvesting		Mean
	24	48	
Corchorus 0	30.33 c	44.33a	37.33a
Corchorus 0.5	33.00c	44.33a	40.67a
Corchorus 0.8	33.67bc	43.00ab	38.33a
Corchorus 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

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 level 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.

4.10 Shelf Life of *Amaranthus cruentus*

Plates 4.1, 4.2 and 4.3 respectively show the state of the *Amaranthus cruentus* at harvest, 24 hours and 48 hours after harvesting. It can be observed from plate 4.2 that almost all of leaves had wilted on the 24th hour after harvesting. On the 48th hour after harvesting as depicted in Plate 4.3, *Amaranthus cruentus* had ended its shelf life and therefore no more marketable and consumable. Typical signs of dryness, pale green and brown spot on the leaves were observed at the 48 hours after harvesting.

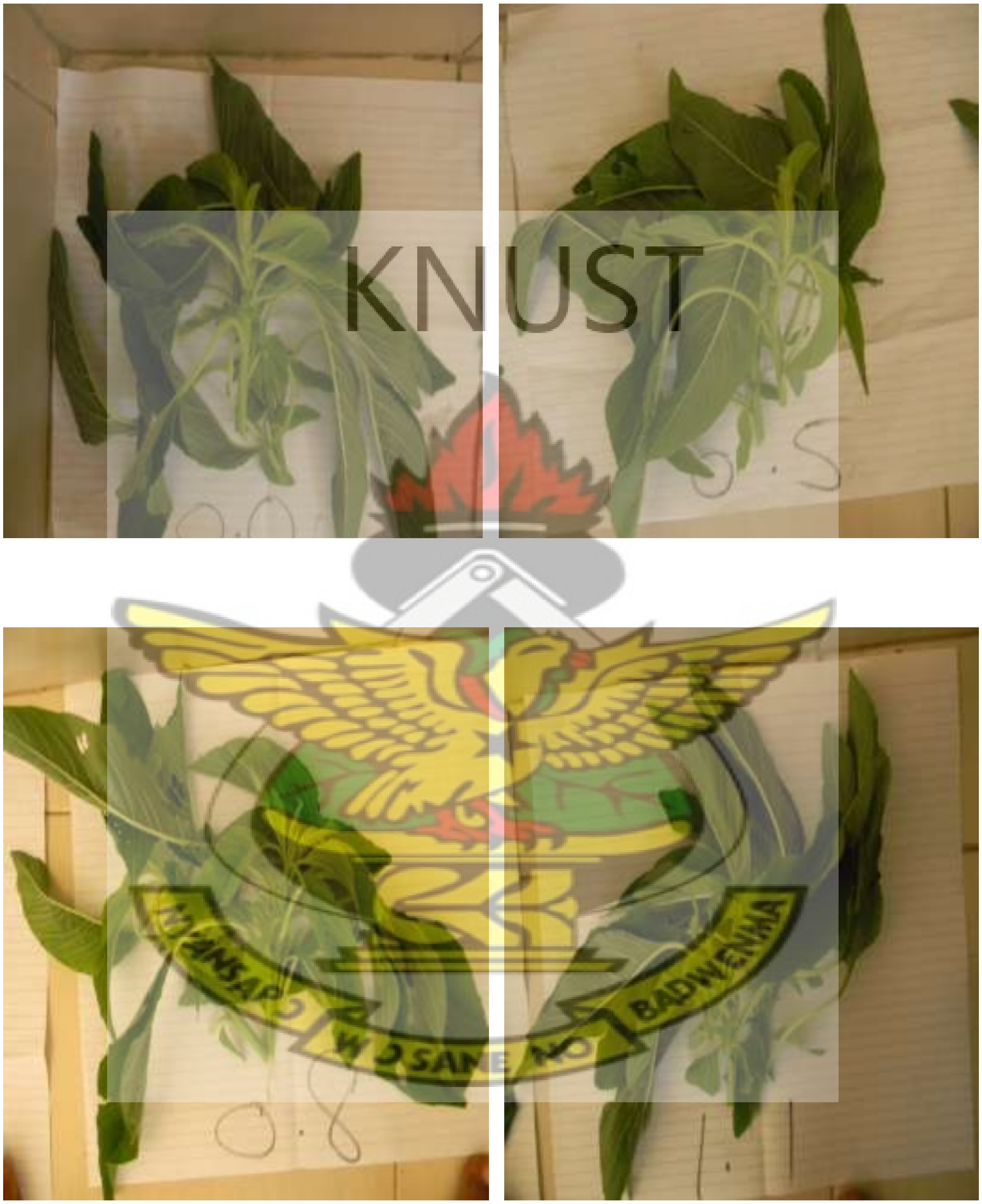

Plate 1: Fresh *Amaranthus cruentus*

Plate 2: *Amaranthus cruentus* 24 hours after harvesting

Plate 3: *Amaranthus cruentus* 48 Hours after Harvesting

4.11 Shelf Life of *Corchorus olitorius*

Plates 4.4, 4.5 and 4.6 respectively show the state of the *Corchorus olitorius* at harvest, 24 hours and 48 hours after harvesting. It can be observed from plate 4.5 that almost all of the *Corchorus olitorius* had wilted on the 24th hour after harvesting. At 48 hours after harvesting as depicted in Plate 4.6, *Corchorus olitorius* was not marketable and consumable. Typical signs of dryness, pale green and brown spot on the leaves were observed at the 48 hours after harvesting.

Plate 4: Fresh *Corchorus olitorius*

Plate 5: *Corchorus olitorius* after 24 Hours of Harvesting

Plate 6: *Corchorus Oliterius* after 48 hours of harvesting

4.12 Correlation Analysis

Table 4.15 shows the correlation between the minerals in the manure applied and the parameters assessed. There was a positive correlation between number of branches and number of leaves. It was observed that as the number of branches increased the number of leaves also increased. There was also negative correlation between calcium and stem girth. As the level of calcium increased with increasing levels of cattle dung, stem girth reduced. A negative correlation was observed between carbohydrate (NFE) and fat content. An increase in NFE content was associated with a decrease in the fat content of the plant leaves. An increase in magnesium and calcium level in the soil again was associated with a decrease in the fat content of the plant leaves. The carbohydrate content of the plant leaves also decreased with an increase in the protein level of the plant.

Table 4.15 Correlation between the minerals in Cattle Dung and Parameters Assessed

	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)

CHAPTER FIVE

5.0 DISCUSSION

5.1 Nutritional Composition of Soil and Cattle Dung

The soil used for this study was observed to be rich 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 were 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 a soil of depth 5cm (Awodun, 2007). However, the K and Ca in this study were also higher than the soils from Obalan campus site on a 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 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 4.3- Table 4.7)

5.2 Growth Parameters

5.2.1 Plant height

The highest plant height (43.33cm) which was recorded by *Amaranthus cruentus* after twenty days of transplanting was higher than (40.50cm) that 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 level 0.8 and 0.5 tonnes per hectare, treatment level 0.5 and 1.1 tonnes per hectare resulted in higher plant height than the control. This implies that 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 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 possibly it may due to the failure of *Corchorus oliterius* not responding well to the cattle dung application. The same trend was observed at 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 at 30 days after transplanting for most of the treatment was still higher than that reported by Mhlontlo *et al* (2007) at 60 days after transplanting. According to Schippers (2000) Amaranthus gives good yield when high levels of nitrogen are applied and it responds well to organic matter.

5.2.2 Number of Leaves

Amaranthus cruentus at 0.8 and 1.1 tonnes per hectare application rate had the highest (66.33) and (60.67) number of leaves with no significant difference (P > 0.05) occurring between them at 20 days after transplanting. The same pattern occurred at 30 days after transplanting. Xu *et al*. (2005) reported that vegetables grown with high levels of organic manure grows better and result in higher yield than those grown on lower amount of organic manure. According to Myers (1998) increase in the rate of organic matter leads to the availability and uptake of nitrogen which promoted vegetative growth of the plants. The control from *Corchorus oliterius* recorded the highest (58.00) number of leaves for all the treatment in *Corchorus oliterius*. The result obtained from the *Corchorus oliterius* is not in conformity with that reported by (Xu *el al*., 2005).This could be that the plants' nutritional needs were satisfied by nutrients already present in the soil.

5.2.3 Number of Shoots

There was a significant difference between the control and the other treatment levels on the 30th day after 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), higher rate of manure (sheep kraal manure) produced higher fresh yields (shoot, leaf and stem.).This assertion is in conformity to the findings of this study. Abou- Hussein *et al*. (2003a), 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 temperature, humidity, moisture etc. was not favorable at the time of planting. According to Jayramaiah *et al* (2005), the increased in plant height, shoot, leaf area and total dry matter accumulation can be obtained by the application of 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*.

5.2.4 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 the stem girth could be attributed to the amount of nitrogen in the soil. Rao (1991) showed that the soil could be enriched by application of higher amount of organic materials which tends to decompose 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

5.3 Proximate Composition of *Amaranthus cruentus* and *Corchorus oliterius*

5.3.1 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 mater 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 Florkowski *et al.* (2009), maximum water content of vegetables varies among vegetable types and is influenced by cultivation condition and structural differences. *Corchorus oliterius* with cattle dung treatment level 0.5 tonnes per hectare gave the highest (13.13%) moisture content whiles *Amaranthus cruentus* with treatment level 1.1 tonnes per hectare had the least (5.93%) moisture content. High moisture content in vegetables is indicative of its freshness as well as easy perishability (Adepoju and Oyewole, 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-organism during storage. The results obtained in the study is slightly lower than 13.58% and 14.98% reported on *Amaranthus blitum* and *Corchorus olitorius* respectively on dry matter bases by Anorson (2009). This could be due to the different environmental conditions for growing the vegetable, time of harvesting and varietal differences.

5.3.2 Crude Protein

There were no significant differences (p>0.05) in crude protein content of *Amaranthus cruentus* and *Corchorus olitorius* at the various cattle dung application levels (Tables 4.10 and 4.11). *Corchorus olitorius* with 0.8 tonnes of the 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 *et al.* (2008) reported protein content for *Amaranthus cruentus* and *Cochorus 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* was higher than that reported by Mensah *et al.* (2008) whiles the protein levels of the *Corchorus olitorius* was 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 Chweya and Mnzava (1997), 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 (Jonhson, 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.

5.3.3 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, lignin among others. The control of the *Corchorus olitorius* had the highest (3.33%) fibre content whiles *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 rate.

Mensah *et al*. (2008) reported crude fibre content of *Amaranthus cruentus* and *Cochorus olitorius* as 1.8g/100g and 8.5g/100g dry matter respectively. Kwenin *et al.* (2011) also reported 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-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/100g1-3.33g/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. Chweya and Mnzava (1997) and Morris *et al.*(2004) reported that several factors, including genetic make-up of a plant, soil in which it is grown, 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 a good source of dietary fibre.

5.3.4 Crude Fat

Leafy vegetables are not noted for contributing significantly to the fat supply in foods (Kummerow, 2007). No significant difference (p>0.05) was obtained from all the treatment. 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 slight influence on the fat content. The high (3.66%) fat content in *Amaranthus cruentus* at 0.08 tonnes per hectare suggests that its can contribute significantly to the energy requirement for humans. Its high fat content would make it a better source of fat than the others. High fat of *Amaranthus cruentus* will make it useful in improving palability of foods in which it is incorporated (Aiyesanmi and Oguntokun, 1996).

5.3.5 Ash Content

McClement (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 (Onot *et al.*, 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 cattle dung level 0.8tonnes per hectare and the least (12.33%) from *Corchorus olitorius* cattle dung level 0.8 tonnes per hectare. The study showed that the ash content ranged from 12.33-16.93g/100g with *Amaranthus cruentus* having the highest ash content than *Corchorus olitorius*. Adeniyi *et al.* (2012) reported ash content of *Corchorus olitorius* as 0.64g/100g. Anorson (2009) also reported ash content of *Corchorus olitorius* as 10.30g/100g. The ash content values obtained in this study were found to be higher than that reported by Adeniyi *et al.* (2012) and Anorson (2009). Ash content is important because it provides the mineral requirements for daily intake.

5.3.6 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). Mensah *et al.* (2008) reported carbohydrate content of *Amaranthus cruentus* and *Corchorus olitorius* as 7.0 and 26.6g/100g dry matter respectively. Anorson (2009) gave carbohydrate content of *Amaranthus blitum* and *Corchorus olitorius* as 17.35g/100g and 28.88g/100g respectively.

No significant differences ($p>0.05$) were obtained in the carbohydrate content of all the treatment. In general, the levels of carbohydrate in the *Corchorus olitorius* were higher than that of the *Amaranthus cruentus*. *Corchorus olitorius* with cattle dung application 1.1tonnes per hectare recorded the highest carbohydrate level of 65.33g/100g followed by

Corchorus olitorius with treatment level 0.5tonnes per hectare (65.15g/100g). Comparing the results with 28.88g/100g in *Corchorus olitorius* by Anorson (2009), it is clear that the results from the study recorded higher carbohydrate content implying that the addition of cattle dung could result in high carbohydrate content in vegetables.

The differences in the carbohydrate content could also be attributed to differences in environment, genetic factors and methods employed in analysis as indicated by Hassan *et al.* (2007). 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. DGA (2005) reported that carbohydrate is the most important food energy provider among the macronutrients, accounting for between 40 and 80 percent of total energy intake.

5.4 Mineral Composition of *Amaranthus cruentus* and *Corchorus oliterius*

5.4.1 Phosphorus

There were no significant differences (p>0.05) among the treatment. 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 treatment level 1.1tonnes 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 deduce that increasing the level of the cattle dung can lead to increases in the phosphorus content of the two leafy vegetables. Base on the findings from 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 promote strong bones of consumers.

5.4.2 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 *Amarnthus 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 high potassium content than *Corchorus olitorius*. Mensah *et al.* (2008) reported potassium content of *Amaranthus cruentus* and *Corchorus olitorius* as 4.82mg/100g and 3.83mg/100g DM respectively. Mhlontlo *et al* (2007) reported 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 (Soetan *et al.*, 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).

5.4.3 Calcium

Amaranthus cruentus had higher calcium content than *Corchorus olitorius*. Mensah *et al.* (2008) reported Calcium content of *Amaranthus cruentus* and *Corchorus olitorius* as 2.05 and 1.26mg/100g DM respectively. Mhlontlo *et al*. (2007) reported 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 Chweya and Mnzava (1997) 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 strengthening of the bones and teeth of consumers.

5.4.4 Magnesium

The highest (1.13) magnesium content was recorded in *Amaranthus cruentus* with treatment level 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 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 1.3-1.5g/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. The values obtained from the study are lower compare to other studies, even though, it is above the daily requirement of 0.42g/day for adult (National Academy of Sciences, 2004). *Amaranthus cruentus* and *Corchorus olitorius* will be a good source of magnesium. Magnesium is essential in enzyme systems and helps maintain electrical potential in nerves (Ferrao *et al.*, 1987). Nutritionally, *Amaranthus cruentus* at 1.1 tonnes per hectare can be considered as a superior source of magnesium followed by control of *Corchorus olitorius* than the others and as such they could be used as supplement in providing the daily requirement of magnesium for adults (265-350 mg) as reported by Food and Nutrition Board (1997).

5.4.5 Sodium

The sodium content ranged between 0.16g/100-0.30g/100. No significance differences (P > 0.05) were observed in all the treatment. Reema (2011) reported the sodium content of *A. viridis* (54mg), *A. blitum* (39.38mg) and *A. tricolor* (30mg). From the Fable 4.12, 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*.

5.5 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 weight during 24 hours of storage except *Amaranthus cruentus* with treatment level 1.1 tonnes per hectare (Table 4.13). 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 evaporation of moisture from the surface of the leaves and led to loss of moisture. Prolong loss of moisture resulted in changes in weight and texture of the leaves and these affected quality. Application rate of 1.1 tonnes per hectare of cattle dung in *Amaranthus cruentus and Corchorus oliterius* at 24 hours after harvesting had the lowest weight loss of (19.33%) and (26.67%) respectively. This implies that increased in the cattle dung application rate lead to lesser weight loss. *Corchorus oliterius* lost more weight than *Amaranthus cruentus* and this is not in conformity to the findings by Anorson (2009), who reported that *Amaranthus cruentus* lost more weight than *Corchorus olitorius* when he used different packaging materials. This could be attributed to the different packaging materials used and other environmental factors.

5.6 Shelf Life

It can be observed from plate 4.1 that most (98%) of the vegetables wilted on the 24th hour after harvesting, however fewer leaves from *Amaranthus cruentus* and *Corchorus olitorius* at application rate of 1.1 tonnes per hectare were partly fresh. According to Abukutsa –Onyango (2002) most Africa 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. The wilting occurred as a result of water stress or other stresses in the plant (Anorson, 2009).

There were no significant changes in the green colour of the leaves and this corresponds with the work done by Anorson (2009). This may be as a result of the absence of ethylene in the storage room. Ethylene accelerates senescence and loss of green colour in leafy vegetables. It decreases storage life and quality of vegetables. All the samples finally dried up on the 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 on the 24 hours of storage and total dryness on the 48 hours.

5.7 Correlation Analysis

From the results (Table 4.15), 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 numbers of leaves are also expected to increase. It was also observed that increased levels of calcium resulted in reduced stem girth. Although bigger stem girth 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 amount of carbohydrate (starch) and minerals could not possibly contain high amount of fat. Moreover, leafy vegetables are not noted for contributing significantly to fat supply in foods (Kummerow, 2007). Therefore, the results from the correlation were in line with facts well noted in research.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 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 of cattle dung resulted in higher number of leaves in *Amaranthus cruentus* and *Corchorus olitorius* respectively at both 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 increase in the application rate in both *Amaranthus cruentus* and *Corchorus olitorius*. 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.

6.2 Recommendations

Based on the findings, the following recommendations have been made;

- Farmers must be encouraged to process leafy vegetables into other forms that will extend its shelf life.
- Farmers must be encouraged not to expose their harvested leafy vegetables to ambient weather conditions in order to extent the shelf life.
- Organic manure should be applied to improve the nutritional content of vegetables but in cases where there are high cost of purchases and non-availability of manures, it should not be an option since the differences in the nutritional content observed in this study was not significantly different from the control.
- Application of 0.8 tonnes per hectare in *Amaranthus cruentus* is recommended for farmers for better growth parameters.
- The research should be replicated in a different geographical zone to ascertain the effect of the cattle dung application on *Amaranthus cruentus* and *Corchorus olitorius*.
- The cattle dung should be composted for more than a four month period and applied to the soil to ascertain its effect on *Amaranthus cruentus* and *Corchorus olitorius*.
- The application rate of the cattle dung should be widened to ascertain its effect on the growth performance, shelf, nutritional and mineral composition of *Amaranthus cruentus* and *Corchorus olitorius*.

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Appendix 1: Results

Analysis of Variance Table for Number of branches

Source	DF	SS	MS	F	P
Rep	2	5.583	2.792		
Days	1	273.375	273.375	46.07	0.0000
Trt	3	83.792	27.931	4.71	0.0179
Days*Trt	3	2.125	0.708	0.12	0.9472
Error	14	83.083	5.935		
Total	23	447.958			

Grand Mean 12.208   CV 19.95

Analysis of Variance Table for Number of leaves

Source	DF	SS	MS	F	P
Rep	2	1408.6	704.3		
Days	1	25872.7	25872.7	53.37	0.0000
Trt	3	11359.5	3786.5	7.81	0.0026
Days*Trt	3	1746.3	582.1	1.20	0.3456
Error	14	6786.8	484.8		
Total	23	47173.8			

Grand Mean 85.083   CV 25.88

Analysis of Variance Table for Plant height

Source	DF	SS	MS	F	P
Rep	2	240.08	120.04		
Days	1	5400.00	5400.00	52.26	0.0000
Trt	3	2484.33	828.11	8.01	0.0024
Days*Trt	3	354.33	118.11	1.14	0.3659
Error	14	1446.58	103.33		
Total	23	9925.33			

Grand Mean 51.167   CV 19.87

Analysis of Variance Table for Stem girth

Source	DF	SS	MS	F	P
Rep	2	0.93583	0.46792		
Days	1	1.04167	1.04167	4.33	0.0562
Trt	3	1.29333	0.43111	1.79	0.1945
Days*Trt	3	0.29833	0.09944	0.41	0.7457
Error	14	3.36417	0.24030		
Total	23	6.93333			

Grand Mean 1.1167   CV 43.90

Analysis of Variance Table for Weight loss

Source	DF	SS	MS	F	P
Rep	2	19.00	9.50		
Days	1	1457.04	1457.04	45.98	0.0000
Trt	3	91.79	30.60	0.97	0.4364
Days*Trt	3	63.13	21.04	0.66	0.5879
Error	14	443.67	31.69		
Total	23	2074.63			

Grand Mean 32.125   CV 17.52

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Analysis of Variance Table for Number of branches

Source	DF	SS	MS	F	P
Rep	2	11.083	5.542		
Days	1	187.042	187.042	77.97	0.0000
Trt	3	10.458	3.486	1.45	0.2698
Days*Trt	3	13.792	4.597	1.92	0.1733
Error	14	33.583	2.399		
Total	23	255.958			

Grand Mean 13.208   CV 11.73

Analysis of Variance Table for Number of leaves

Source	DF	SS	MS	F	P
Rep	2	632	316.2		
Days	1	98304	98304.0	151.09	0.0000
Trt	3	5276	1758.6	2.70	0.0854
Days*Trt	3	298	99.4	0.15	0.9261
Error	14	9109	650.6		
Total	23	113619			

Grand Mean 105.17   CV 24.25

Analysis of Variance Table for Plant height

Source	DF	SS	MS	F	P
Rep	2	36.75	18.38		
Days	1	5797.04	5797.04	302.92	0.0000
Trt	3	949.46	316.49	16.54	0.0001
Days*Trt	3	45.46	15.15	0.79	0.5184
Error	14	267.92	19.14		
Total	23	7096.62			

Grand Mean 39.875   CV 10.97

Analysis of Variance Table for Stem girth

Source	DF	SS	MS	F	P
Rep	2	0.14396	0.07198		
Days	1	0.49594	0.49594	21.40	0.0004
Trt	3	0.01198	0.00399	0.17	0.9133
Days*Trt	3	0.02615	0.00872	0.38	0.7716
Error	14	0.32437	0.02317		
Total	23	1.00240			

Grand Mean 0.4021   CV 37.86

Analysis of Variance Table for Weight loss

Source	DF	SS	MS	F	P
Rep	2	13.58	6.79		
Days	1	1148.17	1148.17	38.23	0.0000
Trt	3	99.33	33.11	1.10	0.3809
Days*Trt	3	45.83	15.28	0.51	0.6826
Error	14	420.42	30.03		
Total	23	1727.33			

Grand Mean 37.833   CV 14.48

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Completely Randomized AOV for Calcium

Source	DF	SS	MS	F	P
TRT	7	1.66067	0.23724	16.42	0.0000
Error	16	0.23113	0.01445		
Total	23	1.89180			

Grand Mean 0.3600   CV 33.39

Homogeneity of Variances	**F**	**P**
Levene's Test	3.28	0.0232
O'Brien's Test	1.46	0.2502
Brown and Forsythe Test	0.76	0.6298

Welch's Test for Mean Differences

Source	DF	F	P
TRT	7.0	120.76	0.0000
Error	6.7		

Component of variance for between groups	0.07426
Effective cell size	3.0

Student Edition of Statistix 9.0 10/5/2014, 10:35:23 PM

Randomized Complete Block AOV Table for Phosphorus

Source	DF	SS	MS	F	P
Rep	2	0.00347	0.00173		
Trt	3	0.00747	0.00249	2.43	0.1629
Error	6	0.00613	0.00102		
Total	11	0.01707			

Grand Mean 0.5933 CV 5.39

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	0.00123	0.00123	1.26	0.3131
Remainder	5	0.00490	0.00098		

Relative Efficiency, RCB 1.07

Student Edition of Statistix 9.0 8/3/2014, 2:49:58 PM

Completely Randomized AOV for Magnesium

Source	DF	SS	MS	F	P
TRT	7	2.25156	0.32165	108.27	0.0000
Error	16	0.04753	0.00297		
Total	23	2.29910			

Grand Mean 0.6871 CV 7.93

Homogeneity of Variances	**F**	**P**
Levene's Test	1.08	0.4178
O'Brien's Test	0.48	0.8342
Brown and Forsythe Test	0.18	0.9847

Welch's Test for Mean Differences

Source	DF	F	P
TRT	7.0	113.92	0.0000
Error	6.7		

Component of variance for between groups 0.10623
Effective cell size 3.0

Student Edition of Statistix 9.0 8/3/2014, 2:52:51 PM

Completely Randomized AOV for Potassium

Source	DF	SS	MS	F	P
TRT	7	133.465	19.0664	1.03	0.4505
Error	16	297.206	18.5754		
Total	23	430.670			

Grand Mean 4.7558 CV 90.62

Homogeneity of Variances	F	P
Levene's Test	4.00	0.0103
O'Brien's Test	1.78	0.1614
Brown and Forsythe Test	0.97	0.4837

Welch's Test for Mean Differences

Source	DF	F	P
TRT	7.0	59.36	0.0000
Error	6.7		

Component of variance for between groups 0.16367
Effective cell size 3.0

Student Edition of Statistix 9.0 8/3/2014, 2:58:30 PM

Completely Randomized AOV for Sodium

Source	DF	SS	MS	F	P
TRT	7	138.322	19.7604	1.00	0.4670
Error	16	316.540	19.7837		
Total	23	454.862			

Grand Mean 1.1225 CV 396.25

Homogeneity of Variances	F	P
Levene's Test	4.00	0.0103
O'Brien's Test	1.78	0.1611
Brown and Forsythe Test	1.00	0.4676

Welch's Test for Mean Differences

Source	DF	F	P
TRT	7.0	M	0.0000
Error	M		

Component of variance for between groups -0.00780
Effective cell size 3.0

Student Edition of Statistix 9.0 11/7/2014, 11:17:23 AM

Randomized Complete Block AOV Table for MCB

Source	DF	SS	MS	F	P
Rep	2	10.292	5.1458		
Trt	3	96.063	32.0208	3.08	0.1119
Error	6	62.375	10.3958		
Total	11	168.729			

Grand Mean 81.542 CV 3.95

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	0.0185	0.0185	0.00	0.9708
Remainder	5	62.3565	12.4713		

Relative Efficiency, RCB 0.86

Student Edition of Statistix 9.0 11/7/2014, 11:07:02 AM

Randomized Complete Block AOV Table for Ash

Source	DF	SS	MS	F	P
Rep	2	9.0650	4.53250		
Trt	3	12.1092	4.03639	1.04	0.4401
Error	6	23.2883	3.88139		
Total	11	44.4625			

Grand Mean 15.325 CV 12.86

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	1.9766	1.97657	0.46	0.5261
Remainder	5	21.3118	4.26235		

Relative Efficiency, RCB 0.98

Randomized Complete Block AOV Table for Fat

Source	DF	SS	MS	F	P
Rep	2	9.0417	4.52083		
Trt	3	1.6667	0.55556	2.29	0.1788
Error	6	1.4583	0.24306		
Total	11	12.1667			

Grand Mean 3.1667 CV 15.57

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	0.07101	0.07101	0.26	0.6345
Remainder	5	1.38733	0.27747		

Relative Efficiency, RCB 3.99

Randomized Complete Block AOV Table for Fibre

Source	DF	SS	MS	F	P
Rep	2	0.02660	0.01330		
Trt	3	0.19869	0.06623	0.13	0.9356
Error	6	2.94513	0.49086		
Total	11	3.17042			

Grand Mean 1.6925   CV 41.40

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	0.11507	0.11507	0.20	0.6710
Remainder	5	2.83006	0.56601		

Relative Efficiency, RCB 0.78

Randomized Complete Block AOV Table for Moisture

Source	DF	SS	MS	F	P
Rep	2	5.5800	2.79000		
Trt	3	12.1558	4.05194	1.69	0.2669
Error	6	14.3667	2.39444		
Total	11	32.1025			

Grand Mean 6.8250   CV 22.67

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	4.91342	4.91342	2.60	0.1679
Remainder	5	9.45325	1.89065		

Relative Efficiency, RCB 0.98

Randomized Complete Block AOV Table for NFE

Source	DF	SS	MS	F	P
Rep	2	91.797	45.8983		
Trt	3	29.657	9.8858	0.71	0.5797
Error	6	83.365	13.8942		
Total	11	204.819			

Grand Mean 61.443   CV 6.07

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	5.4002	5.4002	0.35	0.5818
Remainder	5	77.9652	15.5930		

Relative Efficiency, RCB 1.35

Randomized Complete Block AOV Table for Protein

Source	DF	SS	MS	F	P
Rep	2	23.5873	11.7937		
Trt	3	9.6455	3.2152	0.77	0.5525
Error	6	25.1234	4.1872		
Total	11	58.3563			

Grand Mean 18.373   CV 11.14

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	22.1006	22.1006	36.56	0.0018
Remainder	5	3.0228	0.6046		

Relative Efficiency, RCB 1.26

Appendix 2: Fieldwork

Amaranthus cruentus seedlings ready for transplanting

Corchorus olitorius seedlings ready for transplanting

Field ready for transplanting

Corchorus olitorius growing on the field

Amaranthus cruentus growing on the field