

**EFFECTS OF GREEN URBAN BIO-WASTES COMPOST ON SOIL
PRODUCTIVITY FOR ONION AND BLACK NIGHTSHADE PRODUCTION IN
ARUSHA, TANZANIA**

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
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EXTENDED ABSTRACT

In Tanzania most of biowaste produced from vegetable and fruits markets are dumped off which results to loss of nutrients and imposing environmental problems. Composting of wastes is important when used as organic fertilizer and benefits the environment by reducing the emission of greenhouse gases. However, little is known about the nutrient content and rate of application of green urban bio-wastes compost sourced from vegetable and fruit markets due to variations attributed to type and source of bio-wastes used. This study therefore, aimed at assessing the effectiveness of green urban bio-wastes compost in increasing productivity and quality of black nightshade and onion crops. A series of studies were carried out to attain the above objective including laboratory work, pot experiments and field trials.

Laboratory work conducted from August to September 2018 to investigate the physical and chemical properties of soil from Tengeru and biowaste compost prepared by Guavay company made from urban bio-wastes collected from open markets. Investigated parameters included: pH, EC, organic carbon, total nitrogen, phosphorus, potassium and micronutrients. Findings from the present study revealed that the pH were 6.21 and 7.11 for soil in CaCl_2 and water, respectively and that of green urban biowaste compost were 8.74 and 9.5 in CaCl_2 and water, respectively, EC was 0.094 dS/ m for soil and 0.004 dS/ m for green biowaste compost. Total nitrogen was 0.17 % for soil and 1 % for green biowaste compost. Phosphorus and Potassium values were 56.39 mg kg⁻¹ and 2.86 cmol (+)/kg and 0.07 % and 0.85 % - 0.91 % for soil and green urban biowaste compost, respectively. Analytical results indicate that the 'processed bio-wastes' do not qualify to be called fertilizer because they contain less than 5% of the primary macronutrients the threshold value recognized by soil scientists. Thus N,P and K in bio-wastes compost are not sufficient for crop production since it cannot meet the crops demand hence more 'inputs' are required in green bio-wastes to qualify it as a fertilizer.

A pot experiment was conducted to determine the effect of pelletized and non-pelletized urban green biowaste compost on the growth and yield of black nightshade and onion. The treatments tested were: sole application of pelletized and non-pelletized green urban bio waste compost (GUBC) at rates of 0, 200, 400, and 800 mg N kg⁻¹ soil. Also sole application of urea at a rate of 800 mg N kg⁻¹ soil and complementary application of 400 mg N of bio waste and 400 mg N of urea kg of soil were included. The combination of GUBC and urea (400 GUBC + 400 urea) produced the best total number of leaves (58.22) while 800 mg N (urea) kg⁻¹soil and (400 GUBC + 400 urea) mg N kg⁻¹soil produced the best chlorophyll content (60.60 and 58.40 respectively) and 400 (GUBC) mg N kg⁻¹soil produced the tallest plants (33.05 cm) for black night shade. On the other hand onion performed best in terms of both growth and yield parameters under a treatment with a combination of biowaste and urea. For example bulb fresh and dry weight increased from 29.08 g and 24.71 g in control to 130.94 g and 118.69 g in combination of GUBC and urea (400 GUBC + 400 urea) respectively, followed by plants in a treatment with a sole urea whereby the fresh and dry weight of the bulb increased to 95.04 g and 87.71 g respectively. The increase in all cases was highly significant ($P \leq 0.05$). However, there was no significance difference ($P = 0.05$) between pelletized and non-pelletized forms of biowaste. The overall results indicate that bio-waste compost was a good soil amendment material for black nightshade and onion production and that the best results are obtained when used together with urea compared to exclusive application of green biowaste compost.

A field experiment was carried out at TARI-Tengeru farm from December 2018 to May 2019 to evaluate the effects of different rates of biowaste compost on growth, development and yield of black nightshade and onion. The experiment was laid out in a randomized complete block design (RCBD) with four different application rates (regarded as treatments) of biowaste compost (GUBC)/urea viz., 0 kg N ha⁻¹, 400 kg N (GUBC)

ha⁻¹, 400 kg N (UREA) ha⁻¹ and 200 kg N (GUBC) ha⁻¹ + 200 kg N (UREA) ha⁻¹. Each treatment was replicated three times. Plant growth and yield parameters were used to evaluate the effects of the treatments. Parameters measured were; plant height, leaf number, leaf area and leaf fresh weight for black night shade and bulb size, neck size, bulb fresh weight for onion. The application of a combination of 200 kg N (GUBC) ha⁻¹ + 200 kg N (UREA) ha⁻¹ significantly (p=0.05) increased the leaf area and fresh weight for black nightshade, bulb size and bulb weight for onion compared to the rest. Therefore, the use of combination of organic fertilizer and urea is recommended to farmers for improved yield.

DECLARATION

I, Anna Mwalemba Hance, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

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DEDICATION

I wish to dedicate this work to my beloved Parents Mr and Mrs Hance Mwalemba who laid the foundation of my studies.

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LIST OF ABBREVIATIONS AND SYMBOLS

Al	Aluminium
Ca	Calcium
cm	Centimetre
Cmol (+) kg ⁻¹	Cent mole (+) per kilogram
Cu	Copper
CV	Coefficient of variance
DAE	Day after emergence
DAT	Day after transplanting
e.g	for example
EC	Electrical conductivity
<i>et al</i>	and others
FAO	Food and Agriculture Organization of the United Nations
Fe	Iron
GUBC	Green urban biowaste compost
K	Potassium
Mn	Manganese
MSc	Master of Science
N	Nitrogen
Na	Sodium
°C	Degree Celsius
OC	Organic carbon
P	Phosphorous
Pb	Lead
Ph	Potential hydrogen

RCBD	Randomized Complete Block Design
S	Sulphur
Si	Silicon
SUA	Sokoine University of Agriculture
TARI	Tanzania Agricultural Research Institute
Ti	Titanium
USDA	United States Department of Agriculture
viz	such as
XFR	X-ray Fluorescence Spectroscopy
Zn	Zinc

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 Background Information

Bio-wastes are wastes originating from plant and animal sources which may be degraded or broken down by other living organisms to be used as fertilizer (Hartl and Erhart, 2005). Bio-wastes contain waste residues from wood processing industries, households, food and kitchen wastes from markets. Also they include vegetables remains which have high level of organic matter, nutrients and moisture (Hoorweg *et al.*, 2012). Bio-wastes increase pH, nitrogen content, cation exchange capacity, water holding capacity, and microbial biomass in soil. Bio-wastes as organic fraction varies in composition of material, contain 25–65% municipal solid wastes (Lleo *et al.*, 2013; Puig – Ventosa *et al.*, 2013), 30% being the proportion of garden waste (Asase *et al.*, 2009) and plant origin waste account for 66% (Parizeau *et al.*, 2006). Bio-wastes compost improve soil physical properties thus enhancing soil structure and water holding capacity and supply of nutrients for plant growth (Malusa *et al.*, 2012).

Bio-wastes as organic fertilizer lowers soil bulk density thus providing good conditions for enhanced root growth and crop productivity. Bio-wastes fertilizer specifically vegetables and fruits wastes can be used as organic fertilizer by small holder farmers due to their high degradability (Jara-Samaniego *et al.*, 2017). There are also possible problems associated with their use as fertilizers; such as the fact that they have low nutrient contents thus calling for high rates of application which may make their use uneconomical. Vegetable and fruit wastes produced may reduce the environmental impact on climate change, at a rate of about 40% and 70% respectively when used as organic fertilizer (Antón *et al.*, 2005).

Cramer (2000) reported that onion is an important vegetable crop in most areas of the world particularly developing countries. In Tanzania annual production data for cabbage is 42 000 tones and 36 000 tones for onion (Putter *et al.*, 2007; Koenig *et al.*, 2008). It has been estimated that about 180 000 ha are under vegetable production in Tanzania (FAOSTAT, 2005), but much of the suitable land area for horticulture is currently much underutilized. Vegetables are commonly produced in the Morogoro, Tanga, Iringa, Moshi, Arusha, Lushoto and Mbeya regions (Koenig *et al.*, 2008). Tomato, cabbage and onion are the most commonly marketed vegetables, while indigenous vegetables include amaranth, Ethiopian mustard, African nightshade, African eggplant and okra (Pichop, 2007). Ninety percent of production is by smallholders.

Most of the vegetables grown in Tanzania serve as sources of income and for their nutritional value (Humphry *et al.*, 2011). However, under region categorization Onion (*Allium cepa L.*) and black night shade (*Solanum nigrum*) are dominant crops produced in Arusha region ranking first and second respectively. Onion is an important crop as it serves as both a vegetable and commercial crop for farmers. Black nightshade on the other hand, is the preferred and the most dominant vegetable grown in most areas of the region for their nutritional value.

1.2 Problem Statement and Justification

In Tanzania a lot of bio-wastes produced from vegetable and fruits markets are dumped off which results to loss of nutrients and imposing environmental problems. Instead of dumping, vegetable and fruits wastes can be recycled into useful products e.g. organic fertilizer for agriculture (Farrell *et al.*, 2009). Composting of wastes is more economical when used as organic fertilizer and benefits the environment by reducing the emission of greenhouse gases (Lim *et al.*, 2015). However, little is known about their plant nutrient

content and rate of application of green urban bio-wastes sourced from vegetable and fruit markets due to variations attributed to type and source of bio-wastes used. Better understanding of these bio-wastes in terms of their nutrient content and rate of application will enhance soil productivity on crops production.

Therefore, this study investigated the nutrient content and rate of application of bio-wastes fertilizer for enhancing soil productivity, restoring fertility of the soil and boosting production of onion and black nightshade crops to provide a basis for recommending the product as an organic fertilizer.

1.3 Objectives

1.3.1 Overall objective

To assess the effectiveness of green urban bio-waste compost in increasing productivity and quality of black nightshade and onion crops.

1.3.2 Specific objectives

- i. To characterize nutrient contents of green urban bio-waste and soil.
- ii. To determine the optimum application rate of green urban bio-waste for onions and black night shade production under screen house conditions.
- iii. To assess the response of onions and black night shade to application of different levels of green urban bio-waste under field conditions.

1.4 Organisation of the Dissertation

Chapter one is about general introduction. It provides theoretical background information of this study as presented above. Chapter two is on general literature review with respect to green urban biowaste compost, onion and black nightshade. Chapter three covers the

study of characterization of nutrient contents of the soil and green urban biowaste compost. Chapter four covers the screen house study designed to assess the response of black nightshade (*solanum nigrum* L.) and onion (*allium cepa* L.) to application of green urban biowaste compost compared with Urea as positive control. Chapter five covers the field study designed to assess the effects of green urban bio-waste compost on the growth and production of onion (*allium cepa* L) and black nightshade (*solanum nigrum* L.) in Arusha, Tanzania. Chapter six presents general conclusions and recommendations. Key subjects concluded include physical and chemical properties of green urban biowaste compost and soil used during the study, optimum rate recommended for crop production, production cost of black nightshade and onion with respect to use of green urban biowaste compost and urea.

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CHAPTER TWO

2.0 GENERAL LITERATURE REVIEW

2.1 Description of Vegetables Used in this Study

2.1.1 Black nightshade (*Solanum nigrum* L.)

Black nightshade (*Solanum nigrum* L.) is an annual herbaceous plant (and may sometimes be perennial) which can reach up to 100 cm in height. The stem may be smooth or bear small hairs (trichomes). The flowers usually white in colour, have five regular parts and are up to 0.8 cm wide. The leaves are alternate and somewhat ovate with irregularly toothed wavy margin and can reach 10 cm in length and 5 cm in width (Akindahunsi and Salawu, 2005). African nightshade provides increased food base and is the most preferable vegetable in terms of nutrition compared to exotic vegetables, the vegetable is high in calcium, vitamins A and C and iron that are so beneficial to human health (Schippers *et al.*, 2002).

2.1.2 Onion (*Allium cepa*)

Onion (*Allium cepa*) is a vegetable crop belonging to the family of Amaryllidaceae (*Alliaceae*), Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops and is widely grown in almost all over the world (Mishra *et al.*, 2013). Onion is an important vegetable crop whose distinctive flavour is appreciated by people and the bulbs can be harvested and sold either 'green' in salads or used as spice (Lannoy, 2001). Also it is one of the richest sources of flavonoid in the human diet and flavonoid consumption has been associated with a reduced risk of cancer, heart disease and diabetes. In addition it is known for anti-bacterial, antiviral, anti-allergenic and anti-inflammatory potential (Dawar *et al.*, 2007).

2.2 Importance of Bio-waste Compost in Agriculture

Bio-waste compost enhances soil biological activity, which favours root colonisation by mycorrhiza fungi and rhizosphere bacteria. This increases N, P, K and micronutrients in

soil by mobilisation of soluble nutrients (Malusa *et al.*, 2007). It improves the soil physical properties thus enhancing soil structure and water holding capacity and supplying nutrients for plant growth and prolongs the health status by suppressing some soil borne diseases and parasites (Malusa *et al.*, 2010).

2.3 Effects of Bio-waste Compost on Plant Growth

The application of bio-waste increases yield and ascorbic acid, soluble sugar and reduces nitrate contents of crops, increases growth vigour and fruits of crops compared to application of inorganic fertilizer (Dauda *et al.*, 2008). Addition of organic fertilizer has effect on vegetative growth of crops (Arancon *et al.*, 2005). Organic fertilizer increases soil porosity that lower soil bulk density and permit root growth. Good root system enhances above ground growth and development which results in production of higher yield (Baybordi *et al.*, 2000). Moreover, it provides nutrients in soil which activates species of living organisms which release phytohormones and stimulate the plant growth and the absorption of nutrients (Arisha *et al.*, 2003).

2.4 Effect of Application of Bio-waste Compost on Soil Conditions

Yahumri and Yartiwi (2015) reported that the application of organic fertilizer increase plant growth due to the improvement of soil structure as well as increasing water retention capacity in soil. Organic fertilizer is able to lower soil bulk density that results in lighter soil thus providing good conditions for enhanced root growth and crop productivity, increases Cation exchange capacity, water holding capacity, and microbial biomass in soil (Hoornweg *et al.*, 2012).

2.5 Forms and Nutrient Contents of Organic Fertilizers

2.5.1 Nutrient content of organic fertilizers

Nutrient content vary greatly due to variations in the age of organic material and its decomposition rate. For example, leaves 1 % N, 0-0.5% P, 0-0.5% K, cattle manures 2-3%

N, 0.5-1% P, 1-2% K, (Giller and Mapfumo, 2001). Sawdust 0-1% N, 0-0.5% P, 0-1% K, composts 1-3% N, 1-2% P, 1-2% K, sheep/goat dung 0.65% N, 0.5% P, 0.03% K, Chicken manure contains of 2.61% N, 0.80% P, 0.40% K (Widowati *et al.*, 2012).

2.5.2 Forms of nutrients in organic fertilizers

Plants require more nitrogen than any other nutrient but only a small portion of the nitrogen in organic fertilizer is available to plants. Ninety eight percent of the nitrogen in organic fertilizer is in organic forms, most of organic nitrogen cannot be taken up by plants. Plants can readily take up mineral forms of nitrogen, including nitrate and ammonium ions. However, mineral nitrogen in organic fertilizer accounts for only 2 % of the nitrogen. Microorganisms convert organic form of nitrogen to mineral forms when they decompose organic matter and fresh plant residues, this process is called mineralization (Bingham and Cotrufo, 2016). Incubation tests have shown N mineralization rates of 0-30% of total compost N and under field condition not more than 10-15% of total nitrogen applied with compost is plant available in the year of application. This implies that only 10-15% of total N in compost is present in an inorganic form (Poudel *et al.*, 2002). About 85% of total N is present in organic form which is not readily available for plant uptake.

2.5.3 Transformation of organic fertilizer to inorganic fertilizer

Nitrogen is transformed from organic nitrogen to ammonium nitrogen (mineralization); ammonium nitrogen to nitrate nitrogen (nitrification), (Zhu *et al.*, 2005; Barbarick, 2004). Shindo and Nishio (2005) reported that rough estimates are only 10% to 30% of the nitrogen in compost manure will become available in the first season following application. Some of the remaining nitrogen will become available in subsequent years and at much slower rates than in the first year. Repeated annual applications of compost at

high rates above 450 kg N/ha can result in excessive amounts of nitrate in the soil. The few papers published show that Potassium in finished compost is much more available for plant uptake than nitrogen because potassium is not incorporated into organic matter. However, some of the potassium can be leached from the compost because it is water soluble (Martini *et al.*, 2004).

2.6 Influence of Right Quantity of Bio-waste Compost on Crops Production

Lim Ah Hong and Vimala (2012) found that application of 10 000 kg/ha poultry manure gave better yields 0.37 kg/ha of lettuce and 0.32 kg/ha leaf mustard obtained with 30 000 kg/ha. Moreover, other studies articulate that increasing the rates of nitrogen fertilizer in rooting zone raise the availability of minerals in soil solution which favoured the plant growth and hence increase of the total bulb yield in onion (Aisha *et al.*, 2007). The obtained increments at the mentioned rate of nitrogen fertilizer was due to significant increase in leaves number as well as fresh and dry weight of leaves and bulb (Abdel-Moez *et al.*, 2001).

Lakhdar *et al.* (2011) reported that the application of municipal solid waste at 40 tons/ha in growing *Mesembry anthemum edule* enhanced nutrient (N, P, and K) uptake, which resulted to the increase of plant biomass and relative growth rate by 93% on average. Another study done by Rehman *et al.* (2016) indicated that plant height and root length were increased with the addition of farm yard manure. The plant height, root length, and dry weight of shoot were increased by 18, 19.5, and 5.3%, respectively.

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CHAPTER THREE

3.0 CHARACTERIZATION OF NUTRIENT CONTENTS OF THE SOIL FROM TENGERU ARUSHA AND GREEN URBAN BIOWASTE COMPOST FROM DAR ES SALAAM TANZANIA FOR CROP PRODUCTION

ABSTRACT

The reported study was conducted from August to September 2018. The study investigated the physical and chemical properties of soil from Tengeru and compost made from urban bio-waste collected from open markets. Investigated parameters include: pH, EC, organic carbon, total nitrogen, phosphorus, potassium and micronutrients. Findings from the study revealed that pH values were 6.21 and 7.11 for soil in CaCl_2 and water, respectively and for green urban biowaste compost were 8.74 and 9.5 for in CaCl_2 and water, respectively, EC value was 0.094 dS/ m for soil and 0.004 dS/ m for green biowaste compost. Total nitrogen was 0.17 % for soil and 1 % for green biowaste compost. Phosphorus and Potassium values were 56.39 mg/kg and 2.86cmol (+)/kg for soil and 0.07 % and 0.85 % - 0.91 % for green urban bio-waste compost respectively. The results indicated that the 'processed bio-wastes' composts do not qualify to be called fertilizer because they contain less than 5% of the primary macronutrients; the threshold value recognized by soil scientists. Thus N, P and K is not sufficient for crop production since it cannot meet crops demand hence more 'inputs' are required in green biowaste to qualify it as a fertilizer.

Key words: Soil, green urban biowaste compost, chemical and physical properties

3.1 Introduction

Of the soil nutrients required for plant growth and development, nitrogen (N) possesses a unique position (Fageria and Baligar, 2005). However, the phosphorous (P) and potassium (K) also have essential roles for optimum crop production (Bill Griffith, 2010). According to Rani *et al.* (2013), there are numerous organic and inorganic sources of these essential nutrients. Chemical fertilizers are widely used worldwide and have significantly increased the crop quantity and quality. However, the adverse effects of chemical fertilizers on crops, soil, water and climate have been recognized in recent years (Masarirambi *et al.*, 2012). Due to the consequences of chemical fertilizers such as water pollution, chemical burn to crops, increased air pollution, acidification of the soil and mineral depletion of the soil on crop production, farmers are turning towards organic farming by using different organic inputs like bio-waste, poultry manure, and cow dung which are disposed of on open space (Masarirambi *et al.*, 2012). Waste disposal is a serious concern in developing countries, especially in urban areas, where the population density is high and the availability of land for waste processing and disposal is limited (Abu Qdais and Al-Widyan, 2016). Collected waste is often dumped on open land results to severe environmental hazards (Du *et al.*, 2014). Due to the scarcity of land, existing dumping yards are sometimes overfilled. Instead of being dumped on open space the municipal waste can be composted to be used as organic fertilizer for crop production. The conversion of solid waste to organic fertilizer is thus a desirable option. Lal (2015) reported that severe depletion of soil organic matter is a major cause of declining crop productivity. The use of organic fertilizers not only reduces the quantity of the organic fraction that ends up in landfills (Lim *et al.*, 2016), but also reduces the use of inorganic fertilizers (Lim *et al.*, 2015). The objective of the study was intended to characterize the nutrients of green urban bio-waste compost and soil.

3.2 Materials and Methods

3.2.1 Study area description

The study was conducted in the Department of Soil and Geological Sciences laboratory, at Sokoine University of Agriculture (SUA) in Morogoro region, located between latitude of $06^{\circ} 51' S$, longitude $37^{\circ}38'E$ and latitude of $06^{\circ} 50' S$, longitude $37^{\circ}39'E$ at an altitude of 562 m and 533 m above sea level and at Geological Survey of Tanzania (GST) in Dodoma.

3.2.2 Sources of experimental materials

3.2.2.1 Soil sampling and analysis

Soil sample was collected from TARI-Tengeru in Arusha which is located between latitude $3^{\circ} 23' S$, longitude $36^{\circ} 47'E$ and latitude $3^{\circ} 24' S$, longitude $36^{\circ} 49'E$ at an elevation of 1162 m and 1163 m above sea level. The soils of TARI-Tengeru farm were surveyed just to view the variations. However, the soils were found to have no significant observable variation. Therefore five spots were chosen randomly and soil samples were collected to a depth of 20 cm by using a hand hoe and spade. The collected samples were then mixed thoroughly to form a bulk of compost sample. The compost sample was labelled and transported to SUA for laboratory analysis and pot experiment study. Sampled soil was air dried, crushed and sieved through a 2 and 8 mm sieve for physical and chemical properties determination and pot experiment, respectively.

3.2.2.2 Physical properties of the Soil

The particle size distributions were determined by hydrometer method after dispersing soil sample in sodium hexa-metaphosphate solution (Jember, 2011). The textural class of the soil was determined from the USDA textural class triangle (USDA Soil Taxonomy, 1975; FAO, 2006).

3.2.2.3 Chemical properties of the soil

The pH of the soil was determined using a glass electrode pH meter in 1:2.5 (soil: water suspension) and 1:1 Soil: water 0.01CaCl₂ (Watson and Brown, 1998). Electrical conductivity was measured in 1:2.5 (soil: water) by using conductivity meter (Warncke and Brown, 1998). Organic carbon was determined by Walkley and Black method using wet oxidation by potassium dichromate (Charles and Simmons, 1986). Total nitrogen was determined by the micro-Kjedahl digestion procedure followed by distillation (Bremner and Mulvaney, 1982). Extractable P was extracted using Olsen (extraction); Spectrophotometer (quantification) method (Olsen and Sommers, 1982) and determined by the ascorbic acid colorimetric method (Kuo, 1996). Cation exchange capacity (CEC) was determined by using neutral ammonium-acetate saturation method (NH₄OAc, pH 7) followed by Kjeldahl distillation (Jember, 2011). Extractable S was determined by using the turbid metric method as described by Moberg (2000). Exchangeable potassium, calcium, magnesium and sodium were determined from the ammonium-acetate filtrates by Atomic Absorption Spectrophotometer (Thomas, 1982). DTPA extractable micronutrients (Zn, Mn, Fe and Cu) were determined using the procedure described by Lindsay and Norvell (1978).

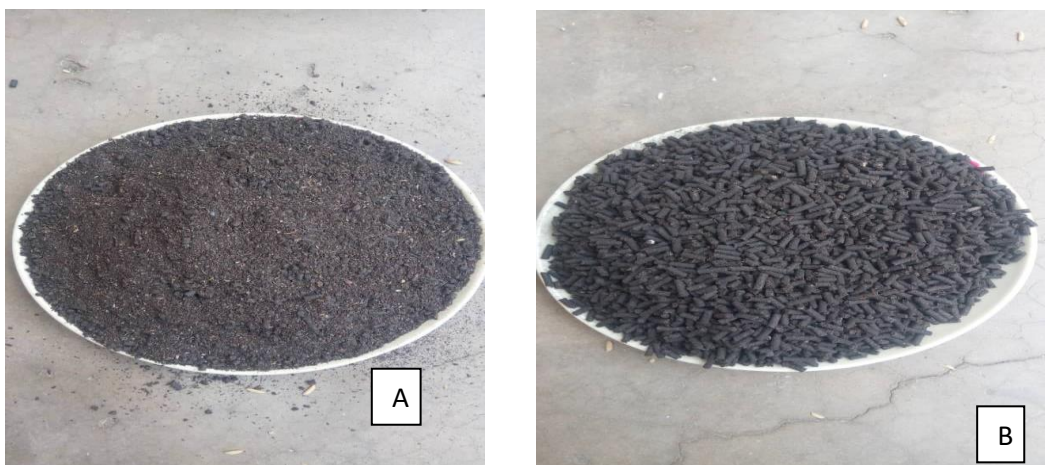


Plate 3.1: Non-Pellet (A) and Pellet (B) Green biowaste Compost

3.2.3 Green urban biowaste compost

Pelleted green urban biowaste compost is a form or shape of a bio-waste made into pellets to improve its consistency, storage, transportation and handling characteristics. Pelletization of green urban bio-waste involves the processes of crushing, mixing with clay soil and solidifying it to produce pellets. Non-pelleted green urban biowaste compost is a biowaste in powder form.

Pelletized and non-pelletized green urban bio-waste composts were collected from Guavay Company Limited in Dar es Salaam. The collected samples were analysed for chemical properties at the Soil and Geological Sciences laboratory at Sokoine University of Agriculture (SUA), Morogoro Tanzania. The same samples were taken to Geological Survey of Tanzania Laboratory (GST) in Dodoma for determination of total elements compositions.

3.2.3.1 Analysis of green urban biowaste compost

The samples were sieved through 2 mm sieve for determination of chemical properties of green urban biowaste; Total N, P K, organic carbon and micronutrients concentrations determination was carried out at Soil Laboratory. Total elements determination was done at Geological Survey of Tanzania (GST) in Dodoma by X-ray Fluorescence Spectroscopy (XRF).

3.3 Results and Discussion

3.3.1 Physical properties of the soil of the studied area

3.3.1.1 Soil texture

According to Brady and Weil (2004) texture is one of the most important physical property of soils as it affects water retention, nutrient availability, pore space, slope stability aeration and erosion susceptibility.

The texture of the soil was determined by USDA textural Class triangle. The texture of the study area (TARI-TENGERU) was found to be clay. A clay soil has high water holding and nutrients retention capacity which is suitable for production of vegetables crops (FAO, 2006).

3.3.2 Chemical properties of the soil at the study site area

3.3.2.1 Soil pH

Soil pH is the degree of soil acidity or alkalinity, which is caused by particular chemical, mineralogical and/or biological environment. Soil pH affects nutrient availability and toxicity, microbial activity, and root growth. Soil pH of site as shown in Table 3.1 was 7.11 and 6.21 in water and CaCl₂ respectively. The pH was categorized as slightly alkaline (van Lierop, 1990) and weakly acid (Slattery *et al.*, 1999) respectively. According to Landon (1991), categorized pH values as follows: > 8.5 = very high, 7.0 – 8.5 = high, 5.5 – 7.0 = medium and < 5.5 = low. The pH observed is most suitable for many crops. According to Slattery *et al.* (1999) pH below 6 affects plant growth, primarily as a result of the change in availability of both essential elements, such as P, and most of the micronutrients, Cu, Fe, Mn, Mo, and Zn, as well as nonessential elements such as Al, which can be toxic to plants at elevated concentrations.

3.3.2.2 Electrical Conductivity (EC)

Electrical Conductivity (EC) is an accurate, indirect means of measuring salinity in soils; EC of soils at the study area was 0.094 dS/m which indicate no concentration of salt in the soil as shown in Table 3.1. Gartley (1995) explained the ranges for no saline 0.0–2.0 dS/m, slightly saline 2.2–4.0 dS/m, moderately saline 4.1–8.0 dS/m, strongly saline 8.1–16.0 dS/m very strongly saline >16.1dS/m.

3.3.2.3 Organic carbon

Soil organic carbon as a store of OM is the basis of soil fertility; it releases nutrients for plant growth, promotes the structure, biological and physical health of soil, and is a buffer

against harmful substances (Milne *et al.*, 2015). Result of the study found organic carbon to be 1.59%, which is very low (Table 3.1). Landon (1991) rated organic carbon < 2 % as very low, 2 –4% low, 4 – 10% medium, and 10 – 20% high and > 20% as very high. The amount of organic carbon at the study site was very low. Low organic matter content reduces the availability of the essential nutrients for plant growth. Tisdale *et al.* (1995) reported that some of the functions of OM are: aids in water management as residues or plants protect the soil surface from raindrop impacts, resist wind action, and thus, greatly aid in erosion control. Increases exchange and buffering capacity since well-decomposed OM has a very high CEC that adds to the buffering capacity of the soil, sources of nutrients (N, P, S and most micronutrients).

3.3.2.4 Total nitrogen

Nitrogen (N) is the nutrient taken up by plants in greatest quantity and it is one of the most deficient elements in the tropics for crop production (Mengel *et al.*, 2001). The total N content of a soil is directly associated with its OC content. In the study site soil, Nitrogen was 0.17% (Table 3.1). Following the rating of total N of > 1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and < 0.1% as very low N status as indicated by Landon (1991), the studied soil was low in total N. Low nitrogen in the area was probably contributed by the low level of organic matter of the soil as the total N content of soil is directly associated with its OC content (Tisdale *et al.*, 1995). As OM is the main supplier of soil N, S and P in low input farming systems, a continuous decline in the soil OM content of the soils is likely to affect the soil productivity and sustainability.

3.3.2.5 Extractable P

Phosphorus (P) is considered as a second most frequently limiting macronutrient for plant growth after nitrogen (Schachtman *et al.*, 1998; Cordell *et al.*, 2009). Phosphorus in plants

is involved in major metabolic processes including; photosynthesis, energy transfer, signal transduction, macromolecular biosynthesis and respiration (Khan *et al.*, 2010).

Extractable P of the soils in the study area was high (56.39 mg/kg) shown in Table 3.1. Msanya *et al.* (1996) and Kileo (2000) categorized extractable Phosphorus when determined by the Olsen method as follows <5 mg/kg low, 5-10 mg/kg medium, >10mg/kg high. High level of P was influenced by pH of soil which favoured biological activity which is essential to efficient utilization of P and adequate crop nutrition in sustainable production Oyinlola and Chude (2010).

3.3.2.6 Extractable sulphur

Sulphur is an essential nutrient for plant growth due to its presence in proteins, glutathione, phytochelatins, thioredoxins, chloroplast membrane lipids, and certain coenzymes and vitamins (Khadka *et al.*, 2017).

Sulphur content of soil at study site was 14.47 mg/kg (Table 3.1). Horneck (2011) classified sulphur as follows: 0 - 5 mg/kg low, 5 - 20 mg/kg medium and >20 mg/kg as high. In sight of this, sulphur is not a problem in the studied site as the content is medium.

3.3.2.7 Exchangeable sodium (Na)

The exchangeable Na of the soil was 0.83 cmol (+) kg⁻¹ as shown in Table 3.1 which is high according to Msanya *et al.* (1996) and Kileo (2000). They categorized exchangeable Na as follows: <0.1 cmol (+) kg⁻¹ very low, 0.1-0.3cmol (+) kg⁻¹ low, 0.31-0.70cmol (+) kg⁻¹ medium, 0.71-2.0 cmol (+) kg⁻¹ high, >2 cmol (+) kg⁻¹ very high. ESP of the soil at the study site was non- sodic at 2.8 %. Msanya *et al.* (1996) categorized < 6 % as non-sodic, 6-10% slightly sodic, 11-15% moderately sodic, 16-25% strongly sodic, 26-35% very strongly sodic, >35% extremely sodic.

3.3.2.8 Exchangeable potassium (K)

Potassium (K) is an essential macronutrient for plant growth and it is among the three primary macronutrients (N, P and K). Plants absorb potassium as the potassium ion (K^+). Potassium plays many important regulatory roles in plant growth and development viz; Enzyme Activation, Stomata Activity and plant water use, Photosynthesis Transport of sugars, water and nutrients (Jin *et al.*, 2011).

The exchangeable K of the soil was $2.86 \text{ cmol (+) kg}^{-1}$ as presented in Table 3.1 which is very high. Msanya *et al.* (1996) and Kileo (2000) categorized exchangeable K in clay soil as follows $<0.2 \text{ cmol (+) kg}^{-1}$ very low, $0.2-0.4 \text{ cmol (+) kg}^{-1}$ low, $0.41-1.20 \text{ cmol (+) kg}^{-1}$ medium, $1.21-2.0 \text{ cmol (+) kg}^{-1}$ high, $>2 \text{ cmol (+) kg}^{-1}$ very high. The level of K in the studied area is thus suitable for optimum crop production.

3.3.2.9 Exchangeable magnesium (Mg)

Magnesium ions (Mg^{2+}) are the second most abundant cation in living plant cells, and they are involved in various functions, including photosynthesis, enzyme catalysis, and nucleic acid synthesis (Kobayashi and Tanoi, 2015).

The data for exchangeable magnesium are presented in Table 3.1. The exchangeable Mg was $2.48 \text{ cmol (+) kg}^{-1}$. Metson (1991) rated Mg as follows: 0.3-1 as low, 1-3 as moderate, 3-8 as high and >8 as very high. According to this rating the study site had moderate Mg content.

3.3.2.10 Exchangeable calcium (Ca)

Calcium is a key regulator of plant responses to endogenous stimuli and stress signals of both biotic and abiotic nature (Lecourieux *et al.*, 2002) it is required for structural roles in the cell wall and membranes (Stael *et al.*, 2011).

The calcium content in the soil is shown in Table 3.1. The exchangeable calcium was 8.57 cmol (+) kg⁻¹. Msanya *et al.* (2001) categorized levels of exchangeable calcium in soil as very low <0.2 cmol (+) kg⁻¹, low 2-5 cmol (+) kg⁻¹, medium 5.1-10.0 cmol (+) kg⁻¹, high 10.1-20.0 cmol (+) kg⁻¹, very high >20 cmol (+) kg⁻¹. Following the above rating, the study site has medium calcium content may be due to the neutral pH values.

3.3.2.11 Cation Exchange Capacity (CEC)

Cation exchange capacity (CEC) of soils is explained as the capacity of soils to adsorb and exchange cations (McCauley, 2005). Cation exchange capacity is an important parameter of soil as it gives an indication of the type of clay minerals present in the soil, its capacity to retain nutrients against leaching and assessing their fertility. CEC of a soil is strongly affected by the amount and type of clay, and amount of OM present in the soil (Hepper *et al.*, 2006).

The Cation Exchange Capacity of the soil was 29.40 cmol kg⁻¹ in Table 3.1 generally high according to Msanya *et al.* (2001) rating of <6.0 very low, 6.0-12.0 low, 12.1-25.0 medium, 25.0-40.0 high and > 40 very high. The high CEC of the soils can be attributed to the nature of clay minerals (Opuwaribo and Odu 1978; Juo and Moorman, 1981; Hassan *et al.*, 2011) as well as the organic matter content of soils which tend to influence the amount of CEC (Yakubu *et al.* (2011).

3.4 Micronutrients

The amount of micronutrients in the studied area is tabulated in Table 3.1. According to Landon (1991) and Tisdale *et al.* (1993), all micronutrients are rated as high in studied area.

3.4.1 Available Zinc

According to Alloway (2008) Zinc is essential for several biochemical processes in plants, such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation, and the maintenance of membrane integrity. The available zinc content was 4.65 mg kg⁻¹ (Table 3.1). This indicates high status of available zinc as rated by Tisdale *et al.*, (1993): < 0.5 mg kg⁻¹ very low, 0.5-1.0 mg kg⁻¹ low, 1.0-3.0 mg kg⁻¹ medium and 3.0-6.0 high. Heavier textured soils with high CEC have higher capacities for Zn adsorption than light textured soils; Consequently, Zn deficiency is more likely to occur in sandy than clayey soils. Clay soils adsorb Zn and this adsorption is controlled by CEC and pH (Stahl and James, 1991).

3.4.2 Available copper

Copper is an important micronutrient for plants that is required for lignin synthesis and acts as a constituent of ascorbic acid, oxidase, phenolase and plastocyanin (Havlin *et al.*, 2010). The available copper content was 2.58 mg kg⁻¹ (Table 3.1). This indicates high availability status of copper according to rating by Landon (1991): <0.3 mg kg⁻¹ very low, 0.3-0.8 mg kg⁻¹ low, 0.8-1.0 mg kg⁻¹ medium and > 1.0 mg kg⁻¹ high. There is thus no need for addition of inputs for supplement of copper.

3.4.3 Available manganese

Manganese it is involved in many biochemical functions, primarily acting as an activator of enzymes such as dehydrogenases, transferases, hydroxylases, and decarboxylases involved in respiration, amino acid and lignin synthesis, and hormone concentrations (Graham and Webb, 1991).

Manganese plays an important role in oxidation and reduction processes in plants (Mousavi *et al.*, 2011). The available manganese content was 81.87 mg kg⁻¹ (Table 3.1). This indicates sufficient availability of manganese.

Table 3.1: Physical and chemical properties of the soil collected for pot experiment

Parameter	SI-unit	Value	Rating	Reference
pH (H ₂ O)		7.11	Slightly Alkaline	van Lierop, 1990
pH (CaCl ₂)		6.21	Weakly acid	Slattery <i>et al.</i> 1999
EC	dS/m	0.094	Normal	Msanya <i>et al.</i> 2001
OC	%	1.59	Low	Landon, 1991
Total nitrogen	%	0.17	Low	Landon, 1991
Available phosphorus	mg kg ⁻¹	56.39	High	Kileo, 2000
Calcium	cmol (+) Kg ⁻¹	8.57	Medium	Msanya <i>et al.</i> , 2001
Sodium	cmol (+) Kg ⁻¹	0.83	High	Kileo, 2000
Magnesium	cmol (+) Kg ⁻¹	2.48	Moderate	Metson, 1991
Potassium	cmol (+) Kg ⁻¹	2.86	Very High	Kileo, 2000
Sulphur	mg/kg	14.47	Medium	Horneck (2011)
Cation Exchange Capacity	cmol (+) Kg ⁻¹	29.40	High	Msanya <i>et al.</i> 2001
Copper	mg kg ⁻¹	2.58	Sufficient	Landon 1991
Zinc	mg kg ⁻¹	4.65	High	Tisdale <i>et al.</i> 1993
Iron	mg kg ⁻¹	57.10	Sufficient	Landon 1991
Manganese	mg kg ⁻¹	81.87	Sufficient	Landon 1991
Particle size				
Sand	%	25.74		
Clay	%	46.01		
Silt	%	28.25		
Textural class			Clay	FAO 2006

3.5 Chemical Properties of Green Urban Biowaste Compost Used in the Experiment

Chemical properties of green urban biowaste compost used in the study are presented in Tables 3.2 and 3.3. The pH values range from 9.0 -9.52 for pelletized and 8.74-9.4 for non-pelletized. The compost had very high pH according to Landon (1991), who categorized pH values as follows: > 8.5 = very high, 7.0 – 8.5 = high, 5.5 – 7.0 = medium and < 5.5 =low. This pH range is very high for growing media as mentioned by Bunt AC (1988) who stated that the optimal range a growth media should vary from 5.2 to 7.3. Low-pH composts are in many cases incompletely cured, and may contain elevated concentrations of organic acids. Organic acids are a routine by product of decomposition early in the composting process, but they should no longer be present at later stages. Since organic acids can be phytotoxic, low pH values are undesirable in compost. The pH of a compost to be used in agriculture should fall between 6 and 8.5 as an indication of relative stability (Reddy and Crohn, 2018).

The EC value was 0.004dS/m as shown in Tables 3.2 and 3.3 for both pelletized and non-pelletized green urban biowaste compost. This EC range is below the range (2.0 to 4.0) for growing media as mentioned by Hanlon (2012). EC of mature compost should range from 1 to 3 dS/m (Tognetti *et al.*, 2007).

The total organic carbon result was 17.37% (29.88 % OM) in Tables 3.2 and 3.3 for pelletized green urban biowaste compost, and 17.18 % (29.54% OM) for non-pelletized green urban biowaste compost. These results are in agreement with those by Batjes (1996) who found that the optimum value of total organic matter in compost should be higher than 10%.

In Tables 3.2 and 3.3, the total nitrogen value was 1% for both pelletized and non-pelletized green urban biowaste compost under study. These results are in agreement with those obtained by (Benito *et al.*, 2005) who found that the total nitrogen content in compost ranged from 0.99 to 2.01%. Leonard (1986) reported N ranges for composted materials as 0.75 – 1.5 % N. Well cured compost contains more nitrogen as nitrate than as ammonium, but ammonium-rich composts can be used quite successfully, particularly if they are applied several weeks prior to planting (Näsholm *et al.*, 2009).

Total Phosphorus and Potassium values were 0.07 % and 0.85-0.91 %, respectively Tables 3.2 and 3.3, for pelletized and non-pelletized green urban biowaste compost. Leonard (1986) reported phosphorus and potassium ranges for composted materials as, 0.25 – 0.5 % P₂O₅ (0.11-0.22% P) and 0.5 – 1.0 % K₂O (0.42-0.83 % K).

The C/N ratio was 17.37:1 for pelletized and 17.18:1 for non-pelletized green urban biowaste compost, According to Msanya *et al.* (2001) the biowaste indicate moderate quality of organic matter and also are in agreement with the results obtained by Rosen,

(1993) who found that the C/N ratio ranging from 15:1 to 20:1 is ideal for ready to use compost. The C/N ratio decreases during composting, and can be used as a measure of the stability of the compost (Sánchez-Monedero *et al.*, 2004). Usually, compost can be considered stable when the C/N ratio is approximately 17:1 or less. In the studied the biowaste composts showed C/N ratios 17:1 which was indicative of stable compost. In general, high-C: N-ratio composts supply nitrogen more readily than low-C: N composts, but specific mineralization rates cannot be predicted with any precision. In compost nitrogen does not fully mineralize within a season, and hence will partly become available in later years also plant compost decomposes only for 10% in the first year.

Table 3.2: Chemical properties of the pelletized green biowaste compost used in the experiment

Parameter	SI-unit	Value
pH (H ₂ O)		9.520
pH (CaCl ₂)		9.000
EC	dS/m	0.004
OC	%	17.37
Total nitrogen	%	1.000
Total phosphorus	%	0.070
Total Calcium	%	0.070
Total Magnesium	%	0.070
Total Potassium	%	0.91

Table 3.3: Chemical properties of the non-pelletized green biowaste compost used in the experiment

Parameter	SI-unit	Value
pH (H ₂ O)		9.400
pH (CaCl ₂)		8.740
EC	dS/m	0.004
OC	%	17.18
Total nitrogen	%	1.050
Total phosphorus	%	0.070
Total Calcium	%	0.070
Total Sodium	%	0.010
Total Potassium	%	0.850

3.6 Total Elemental Compositions of Green Urban Biowaste Compost as Determined by XFR

The concentration value obtained for Nickel (Ni) and Lead (Pb) in biowaste (Table 3.4), was 0.001 %, this value fitted WHO (1996) acceptable limits of Ni and Pb in soil which are 0.0035 and 0.0085 % respectively. High levels of Lead (Pb) have been documented to have harmful health effects (Asemave and Anhwange, 2012). The permissible limit of Zinc in soil ranging from 0.0020 - 0.0060 % is recommended by WHO. In biowaste concentration of Zinc was 0.002% which is within permissible limit. Copper (Cu) is considered as a micronutrient for plants however, it may be toxic in excess quantity (Thomas *et al.*, 1998). In bio-waste Cu was 0.19 % which is acceptable according to WHO (1996).

Table 3.4: Total elemental compositions of green urban bio-waste compost (%)

Element	GUBC
Ti	1.500
Mn	0.040
Ni	0.001
Fe	2.890
Zn	0.002
Si	23.230
Pb	0.001
Cu	0.190

3.7 Conclusions and Recommendation

3.7.1 Conclusions

- The results of the study revealed that the soil was slightly alkaline, high in exchangeable cations, low organic carbon and nitrogen content.
- Generally, micronutrient values of soil in the study were above critical levels.
- The green urban biowaste compost had high pH and very high OC.
- The C: N ratio of green urban biowaste compost was ideal for the materials to be used as organic fertilizer.

- The levels of selected micronutrients and heavy metals were below the established standard acceptable limits.

3.7.2 Recommendation

- N from external source and organic materials are required to increase the organic and nitrogen in soil so as to meet the requirements of crops.

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CHAPTER FOUR

4.0 RESPONSE OF BLACK NIGHTSHADE (*Solanum nigrum* L.) AND ONION (*Allium cepa* L) TO APPLICATION OF GREEN URBAN BIOWASTE COMPOST

ABSTRACT

A pot experiment was conducted to determine the effect of pelletized and non-pelletized urban green bio-waste compost on the growth and yield of black nightshade and onion. The experiment was laid out in a split plot design with different levels of the pelletized and non-pelletized green biowaste. Treatments were sole application of pelletized and non-pelletized green bio waste compost (GUBC) at rates of 0, 200, 400 and 800 mg N kg⁻¹ soil. Also included sole application of urea at a recommended rate of 800 mg N kg⁻¹ soil and complementary application of 400 mg N of bio-waste compost and 400 mg N of urea kg of soil. The combination of GUBC and urea (400 GUBC + 400 urea) produced the best total number of leaves (58.22), 800 mg N (urea) kg⁻¹soil and (400 GUBC + 400 urea) mg N kg⁻¹soil produced the best chlorophyll content (60.60 and 58.40 respectively) and 400 (GUBC) mg N kg⁻¹soil produced the tallest plants (33.05 cm) for black night shade. On the other hand onion performed best in terms of both growth and yield parameters under a treatment with a combination of bio-waste compost and urea for example bulb fresh and dry weight increased from 29.08 g and 24.71 g in control to 130.94 g and 118.69 g in combination of GUBC and urea (400 GUBC + 400 urea) respectively, followed by plants in a treatment with a sole urea whereby the fresh and dry weight of the bulb increased to 95.04 g and 87.71 g respectively. The increase in all cases was highly significant ($P \leq 0.05$). However, there was no significance difference ($P = 0.05$) between pelletized and non-pelletized forms of biowaste. The overall results indicate that bio waste compost was good soil amendment material for black nightshade and onion production and that the best

results are obtained when used together with urea compared to exclusive application of either biowaste compost or urea. These findings need to be verified under field conditions.

Key words: Green urban bio waste compost, *Solanum nigrum*, *Allium cepa*, soil

4.1 Introduction

Black nightshade (*Solanum nigrum* L.) and onion (*Allium cepa* L.) vegetables are valuable for their contribution to food security, nutritional values and as a source of household income in many regions of Tanzania. Black nightshade (*Solanum nigrum* L.) is a leafy vegetable belonging to family Solanaceae found in many wooded areas as well as disturbed habitats (Okunlola and Adeona, 2016). *Solanum nigrum* is an important weed in many crops (Defelice, 2003) in African countries the plant is an important wild vegetable containing high nutritional value, providing an important source of Ca, Fe, proteins, Vitamin A and fiber among other nutrients (Husselman and Sizane, 2006). Manoko (2007) reported that in Tanzania *Solanum nigrum* is a common leafy vegetable in many regions where it is known by local names like *Mwaha-ka* (Kihehe), *Mnavu* (Swahili, Pogoro, Bondei and Sambaa), *Mhaki* (Bena) *Kisuhumensoka* (Sukuma), *Mnafu* (Chaga) and *Shwiga* (Haya). Onion (*Allium cepa* L.) is one of the most important vegetable crops and is widely grown in almost all over the world and has great economic importance (El Balla *et al.*, 2013). In Tanzania, onion is the most important spice vegetable. The country ranked tenth amongst onion producing countries in Africa with production of about 56 000 tons of onion annually (FAO, 2000). The crop is produced almost all over the country from the Southern Highlands through the Central Plateau to the Northern Highlands (FAO, 2000). Most of vegetables farmers produce crops by using different organic fertilizer which contains different nutrients, some meet all requirements needed by plants but not all organic fertilizer nutrients contained are known. Green urban bio wastes compost are added on soil to supply essential nutrients for plant growth as well as improving the soil

physical properties in areas exposed to loss of soil nutrients as a result of continuous cropping. It is also important on leaf vegetable production because any nutrients deficient in the soil are easily noticed on the leaves of the vegetables (Aluko *et al.*, 2014). This research was carried out to evaluate the effects of Green urban biowaste compost on the growth and yield of *Solanum nigrum* and *Allium cepa* under pot experiment conditions.

4.2 Materials and Methods

4.2.1 Study area description

This study was conducted from October to November 2018 for *Solanum nigrum* and October to late January 2019 for *Allium cepa* in a screen house of Department of Soil and Geological Sciences at Sokoine University of Agriculture located at latitude of 06 ° 51 'S, longitude 37°38'E and latitude of 06 ° 50 'S, longitude 37°39'E. Average temperatures were 30, 29 and 32⁰C for October, November and December 2018 respectively and 34 ⁰C for January 2019.

4.2.2 Source of experimental materials and characterization for pot experiment

4.2.2.1 Green urban biowaste compost

Pelletized and non-pelletized compost made from green urban bio-wastes compost were collected from Guavay Company Limited in Dar es Salaam. The collected samples were transported to Soil and Geological Sciences laboratory at Sokoine University of Agriculture (SUA), Morogoro Tanzania for determination of chemical properties. The same samples were also taken to Geological Survey of Tanzania Laboratory (GST) in Dodoma for determination of total elements compositions.

4.2.2.2 Analysis of Green urban bio-waste compost

The fertilizer samples were passed through a 2 mm sieve before analysing them for chemical properties. Total N, P K, organic carbon and micronutrients concentrations were carried out at Soil Science Laboratory by wet chemistry method. Total elements

determination was done at Geological Survey of Tanzania (GST) in Dodoma by X-ray Fluorescence Spectroscopy (XRF).

4.2.3 Soil sampling and analysis

The soil used in this study was collected at 0-20 cm depth from TARI-Tengeru in Arusha located between latitude 3° 23' S, longitude 36° 47'E and latitude 3° 24' S, longitude 36° 49'E at an elevation of 1162 m and 1163 m above sea level. The soil was dried, crushed and sieved through a 8 mm sieve for pot experiment and 2 mm mesh sieve for physical and chemical properties determination. The textural class of the soil was determined by USDA textural Class triangle (USDA Soil Taxonomy, 1975; FAO, 2006). The particle size distributions were determined by hydrometer method after dispersing soil sample in sodium hexametaphosphate solution (Jember, 2011). Soil pH was determined using a glass electrode pH meter in 1:2.5 (soil: water suspension) and 1:1 Soil: water 0.01CaCl₂ (Watson and Brown, 1998). Electrical conductivity was measured in 1:2.5 (soil: water) by using a conductivity meter (Warncke and Brown, 1998). Organic carbon was determined by Walkley and Black method using wet oxidation by potassium dichromate (Charles and Simmons, 1986). Total nitrogen was determined by the micro-Kjeldahl digestion procedure followed by distillation (Bremner and Mulvaney, 1982). Extractable P was extracted using Olsen (Olsen and Sommers, 1982) extraction procedure and determined by ascorbic acid-colorimetric method using a spectrophotometer (Zhang and Kovar, 2009). Cation exchange capacity (CEC) was determined by using neutral ammonium-acetate saturation method (NH₄OAc, pH 7) followed by Kjeldahl distillation (Jember, 2011). Extractable S was determined in the filtrates by spectrophotometry and analysed by using the turbid metric method as described by Moberg (2000). Exchangeable potassium, calcium, magnesium and sodium were determined from the ammonium-acetate filtrates by Atomic Absorption Spectrophotometer (Thomas, 1982). DTPA extractable micronutrients (Zn, Mn, Fe and Cu) were determined using the procedure described by Lindsay and Norvell (1978).

Table 4.1: Physical and chemical properties of the soil used in the experiment

Parameter	SI-unit	Value	Rating	Reference
pH (H ₂ O)		7.11	Slightly Alkaline	van Lierop, 1990
pH (CaCl ₂)		6.21	Weakly acid	Slattery <i>et al.</i> 1999
EC	dS/m	0.094	Normal	Msanya <i>et al.</i> 2001
OC	%	1.59	Low	Landon, 1991
Total nitrogen	%	0.17	Low	Landon, 1991
Available phosphorus	mg kg ⁻¹	56.39	High	Kileo, 2000
Calcium	cmol (+) Kg ⁻¹	8.57	Medium	Msanya <i>et al.</i> , 2001
Sodium	cmol (+) Kg ⁻¹	0.83	High	Kileo, 2000
Magnesium	cmol (+) Kg ⁻¹	2.48	Moderate	Metson, 1991
Potassium	cmol (+) Kg ⁻¹	2.86	Very High	Kileo, 2000
Sulphur	mg/kg	14.47	Medium	Horneck (2011)
Cation Exchange Capacity	cmol (+) Kg ⁻¹	29.40	High	Msanya <i>et al.</i> 2001
Copper	mg kg ⁻¹	2.58	Sufficient	Landon 1991
Zinc	mg kg ⁻¹	4.65	High	Tisdale <i>et al.</i> 1993
Iron	mg kg ⁻¹	57.10	Sufficient	Landon 1991
Manganese	mg kg ⁻¹	81.87	Sufficient	Landon 1991
Particle size				
Sand	%	25.74		
Clay	%	46.01		
Silt	%	28.25		
Textural class			Clay	FAO 2006

4.2.4 Design of the pot experiment

The experiment was laid out in a Split plot design to different levels of the pelletized and non-pelletized fertilizer from green urban bio waste compost. The main plots were pelletized and non-pelletized forms of the bio waste compost. Levels/treatments of each main plot were sub-plots with six treatments in each main plot were randomized in 4 kg potted soils and replicated 3 times.

Table 4.2: Pot Experiment Treatments for Pelletized green biowaste

S/N	Treatments	Description	Fertilizer Application Rates
1	T1	Control (soil only)	0 mg N kg ⁻¹ soil
2	T2	P green urban biowastes	200 mg N kg ⁻¹ soil
3	T3	P green urban biowastes	400 mg N kg ⁻¹ soil
4	T4	P green urban biowastes	800 mg N kg ⁻¹ soil
5	T5	Inorganic fertilizer(+ control)	800 mg N kg ⁻¹ soil
6	T6	P green urban biowastes +inorganic fertilizer	400 mg N kg ⁻¹ soil + 400 mg N kg ⁻¹ soil

Note; P = Pelletized T; Treatment for pelletized green bio-waste

Table 4.3: Pot Experiment Treatments for non-pelletized green biowaste

S/N	Treatments	Description	Fertilizer Application Rates
1	T1	Control (soil only)	0 mg N kg ⁻¹ soil
2	T2	NP green urban biowastes	200 mg N kg ⁻¹ soil
3	T3	NP green urban biowastes	400 mg N kg ⁻¹ soil
4	T4	NP green urban biowastes	800 mg N kg ⁻¹ soil
5	T5	Inorganic fertilizer	800 mg N kg ⁻¹ soil
6	T6	NP green urban biowastes+inorganic fertilizer	400 mg N kg ⁻¹ soil + 400 mg N kg ⁻¹ soil

Note; T = Treatment for non-pelletized; NP = non- pelletized

4.2.5 Setting of the pot experiment

A bulk of soil sample sieved through 8 mm sieve was mixed and used for the pot experiment. Four kilograms of the soil was weighed into each pot before application of green urban bio waste compost. The pots were labelled according to treatment to be applied. There after the respective amount of green urban bio waste compost required for each pot was weighed (Table 4.2 and 4.3) using a chemical balance and thoroughly mixed with the soil on a respective pot to avoid cross contamination of treatments. Nitrogen was consistently applied in the form of Urea at a rate of 400 and 800 mg N Kg⁻¹ in two splits to pots of combination of urea and green urban bio waste and positive control (urea).

After mixing with green urban bio-waste compost the soil was re-filled in the pots and equilibrated to 90% of field capacity by using tap water. After twenty four hours of equilibration six *Solanum nigrum* and ten *Allium cepa* seeds were planted and irrigation was done to maintain soil moisture around field capacity for the first seven days for *Solanum nigrum* and fourteen days for *Allium cepa*. On the seven day and fourteen day after germination, the plants were thinned to two plants for *Solanum nigrum* and four plants for *Allium cepa* per pot respectively. Weeding was done by uprooting all emerging weeds to keep the crop free from weed competition and the second split of N was applied two weeks for *Solanum nigrum* and four weeks for *Allium cepa* after germination.

4.2.6 Data collection

Black night shade and onion growth attributes specifically the number of leaves; chlorophyll content, plant height, and leaf area were recorded on weekly basis starting at 14 and 21 days respectively after germination. According to Saxena and Singh, 1965, leaf area was determined by non-destructive method using formula: $LA=0.75$ (length x width), where 0.75 is a constant. Chlorophyll content to measure the relative chlorophyll concentration in the leaves, the LEAF chlorophyll meter was used. Yield data:, bulb size and bulb diameter measured by Vernier caliper, dry biomass and fresh yield (kg/ha) measured by electric weighing balance, were recorded at harvesting after 46 days for black nightshade and 120 days for onion. Soil sample from pot was sampled a week after harvesting for chemical properties determination.

4.2.7 Statistical analysis

Collected data were subjected to analysis of variance using GenStat Software 15.2 version. Treatment mean separation was done by using Duncan Multiple Range Test at the 5% probability level.

4.3 Results and Discussion

4.3.1 Effects of green urban bio-waste compost on soil chemical properties

4.3.1.1 Effects on primary nutrients

Forms of green biowaste compost applied indicated no significance difference on primary nutrients however different rate of pelletized and non-pelletized revealed significance differences among them. Application of biowaste had remarkable influence on chemical properties as indicated in Table 4.4 as compared to the data analysed before the experiment. From the soil on study site that received different rates of green urban bio wastes compost and urea tended to increase in total N compared to control. The rate 200 and 400 mg N kg⁻¹ soil had low nitrogen compared to 800 mg N kg⁻¹ soil, the higher the

rate of biowaste the more nitrogen content. On other hand urea had high level of nitrogen in soil after harvest probably due to residual effect, also total N increased in soil treated with biowaste compost due to increase in organic matter of that soil. This is collaborated by Tisdale *et al.* (1995) who reported that high level of organic matter of the soil increase the nitrogen as the total N content of a soil is directly associated with its OC content.

Potassium in finished compost is much more available for plant uptake than nitrogen because potassium is not incorporated into organic matter; such findings explained the difference in mineralization and enhancement of the two for plant uptake.

Table 4.4: Effects of green urban biowaste compost on soil primary nutrients

Forms (GUBC)	RATE (mg N kg ⁻¹ soil)	Total N (%)	Total P (mg/kg)	Total Kcmol (+) kg ⁻¹
P-C	0	0.08ab	63.03a	3.09a
NP-C	0	0.08a	54.17a	2.62a
P-C	800 Urea	0.23 f	60.53a	5.42a
NP-C	800 urea	0.20cde	52.30a	2.60a
P	200 GUBC	0.19abcd	63.98a	3.99a
NP	200 GUBC	0.19abc	68.95ab	3.50a
P	400 GUBC	0.19abcd	65.40 a	4.69a
NP	400 GUBC	0.21def	67.93ab	4.13a
P	800 GUBC	0.21ef	89.09bc	5.30a
NP	800 GUBC	0.21ef	96.75c	11.43b
P	400 GUBC + 400 urea	0.23 f	68.83ab	5.45 a
NP	400 GUBC + 400 urea	0.20cde	70.76ab	3.65a
P-values		<.001	0.010	0.17
CV		4.8	17.8	19.10

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test (P=0.05).

Note: GUBC=Green urban biowaste, P-C=Pellet control, NP-C= Non pellet control, P= Pellet, NP= Non-pellet, P-value=Probability value, CV=Coefficient of variance

4.3.1.2 Effects of green biowaste compost on OC and pH

From the experiment there is no significance difference between different rates of green biowaste compost on soil chemical properties (Table 4.5). The highest level 2.97% of OC was observed in the 800 mg N kg⁻¹ soil compared to other treatments; this is due to high

organic matter content on the soil. Also for treatments that received urea the lowest level of OC (2.07 %) observed is due to low inherent organic matter possessed by soil. According to Msanya *et al.* (2001), soil carbon may be rated as <0.6 % very low, 0.6 – 1.25% low, 1.26 – 2.5% medium, 2.51 – 3.5% high and >3.5% very high. According to aforementioned rates, application of biowaste at 800 mg N kg⁻¹ soil improved OC from medium (1.59%) to high (2.9 %) compared to other treatments. These results indicate that bio-waste compost have a potential to be used as soil amendment since OM is one of the most important soil fertility determining parameters. Application of green biowaste compost maintained the neutrality of the soil this was observed on treatment that received 800 mg N kg⁻¹ soil where pH was 7.36 compared to other treatments. On the other hand, pH decreased to 5.7 on sole application of urea this is due to acidification of the soil. According to Slattery *et al.* (1999) the pH below 6 affects plant growth, primarily as a result of the change in availability of both the essential elements, such as P.

Table 4.5: Effects of application of green urban bio-waste compost on OC and pH

Forms (GUBC)	RATE (mg N kg ⁻¹ soil)	OC (%)	Soil pH	EC us/cm
P-C	0	2.54 a	6.77b	232.1a
NP-C	0	2.87 a	6.64b	258.3a
P-C	800 urea	2.07 a	6.02a	856.0bcd
NP-C	800urea	2.15 a	5.79a	1153.0d
P	200 GUBC	2.73 a	6.76b	231.7a
NP	200 GUBC	2.46 a	6.69b	325.6a
P	400 GUBC	2.54 a	7.02bc	466.7abc
NP	400 GUBC	2.79 a	7.02bc	294.0a
P	800 GUBC	2.98 a	7.22bc	457.4abc
NP	800 GUBC	2.93 a	7.37c	407.3ab
P	400 GUBC + 400 urea	2.67 a	6.67b	932.4 cd
NP	400 GUBC + 400 urea	2.32 a	6.96bc	738.0abcd
P-values		0.73	<.001	0.003
CV		28.0	4.5	29.7

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P=0.05$).

Note: GUBC=Green urban biowaste compost, P-C=Pellet control, NP-C= Non pellet control, P= Pellet, NP= Non-pellet, P-value=Probability value, CV=Coefficient of variance

4.4 Effects of Application of Different Rates of GUBC on Plant Growth

Parameters of Black Nightshade

4.4.1 Plant height and number of leaves

The response of Black nightshade to different rates of GUBC is shown in Table 4.6 whereby different parameters have been measured and recorded. The effect of application of different rates of GUBC on plant height and number of leaves of the Black nightshade is indicated in Table 4.6. The tallest plant (33.05 cm) was observed in 400 Non-pelletized GUBC treatments, and shortest plant (18.41 cm) was recorded in the absolute (zero) control. However, the tallest plant observed was not significantly different ($P=0.05$) from that observed in the 'positive' control (800 urea). The greatest number of leaves (58.22) was observed in a treatment with a combination of GUBC and urea (400 GUBC + 400 urea) this was significantly different from the leaves in the positive control (800 urea). The lowest number of leaves (18.39) was recorded in the absolute (zero) control. This is similar to the results observed by Ogunlade *et al.* (2011) who reported that the use of organomineral fertilizer enhanced pumpkin fruit weight. Zhang *et al.* (2010) confirmed that Nitrogen generally stimulates vegetative growth thereby increasing the number of leaves also plant height and leaf numbers increased with plant maturity. From this study, it is likely that the height increased due the uptake of N, which in turn improved the vegetative growth.

4.4.2 Leaf area

The effect of different rates of GUBC on leaf area of the Black nightshade is indicated in Table 4.6. The largest leaf area (36.21 cm²) was observed in a treatment with a combination of GUBC and urea (400 GUBC + 400urea) and smallest leaf area (11.06 cm²) was recorded in the absolute (zero) control. The largest leaf area recorded was not significantly different ($P=0.05$) from that of the positive control (800 IF). Bharadwaj

(2003) reported that application of organic fertilizer increased the leaf area of the wheat plant. Plant growth and yield are affected by Nitrogen (N) and leaf area increase with increase in N level during vegetative development (Hartl and Erhart, 2003).

Table 4.6: Effect of application of different rates of GUBC on plant height, number of leaves and leaf area of the Black nightshade

Forms (GUBC)	Rate (mg N kg ⁻¹ soil)	Plant height (cm)	Number of leaves	Leaf area (cm ²)
P-C	0	18.41 a	18.39 a	13.82 ab
NP-C	0	18.95 ab	18.50 a	11.06 a
P-C	800 urea	27.52 de	52.39 d	33.33 d
NP-C	800 urea	27.67 de	52.61 d	34.81 d
P	200 GUBC	19.44 abc	23.89 b	16.01 abc
NP	200 GUBC	19.13 ab	24.44 b	17.37 abc
P	400 GUBC	25.23 cd	24.33 b	16.86 abc
NP	400 GUBC	33.05 e	21.78 b	13.17 ab
P	800 GUBC	24.76 bcd	27.78 c	18.97 bc
NP	800 GUBC	20.06 abc	24.11 b	22.58 c
P	400 GUBC + 400 urea	21.84 abcd	58.22 e	36.20 d
NP	400 GUBC + 400 urea	18.32 a	63.56 f	36.21 d
P-values		<.001	<.001	<.001
CV (%)		13.8	4.5	16.8

Means in the column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

Note: GUBC =Green urban biowaste compost, P-C=Pellet control, NP-C= Non pellet control, P= Pellet, NP= Non-pellet, P-value=Probability value, CV=Coefficient of variance

4.5 Effect of Application of Different Rates of GUBC on Chlorophyll Content, Fresh Biomass and Dry Biomass of the Black Nightshade

4.5.1 Chlorophyll content

The effect of different rates of GUBC on chlorophyll content of the black nightshade is indicated in Table 4.7. The highest chlorophyll content (60.60) was observed in the

positive control (800 urea), followed by 400 GUBC non-pelletized (58.40) and the lowest chlorophyll content (40.53) was recorded in a treatment with a combination of GUBC and urea (400 GUBC + 400 urea) non-pelletized. This was not significantly different ($P=0.05$) from the absolute (zero) control. Netto *et al.* (2005) reported that majority of N is contained in chlorophyll molecules which mean high chlorophyll content in plant cells are an indication of high N and therefore a good nutrient status of the plant. Different fertiliser dosages had different effects on the growth of *Solanum nigrum*.

4.5.2 Fresh biomass and dry biomass

The effect of different rates of GUBC on fresh biomass and dry biomass of the Black nightshade is as shown in Table 4.7. The highest fresh biomass weight (87.08 g pot⁻¹) was observed in a treatment with a combination of GUBC and urea (400 GUBC + 400urea) non-pellets. This was significantly different from the positive control (800 urea). In combination of pellets and urea the fresh biomass was 70.92 g pot⁻¹ lower than urea, this is due to slow mineralization which lead to low release of nitrogen, thus treatment 800 N-GUBC had significantly lower fresh biomass than 800 N-Urea meaning that inorganic N had a bigger impact on fresh biomass than organic N in the mixed treatment. The lowest fresh biomass (12.01 g pot⁻¹) was recorded in the absolute (zero) control. Similar results were reported by Ondieko *et al.* (2004) who observed that the average fresh weight of the African nightshades was highest when 8 ton/ha of manure was applied compared to the control. In addition, Kipkosgei *et al.* (2003) working on African nightshade reported that synergetic effect of inorganic and organic fertilizer increases African nightshade leaf yields.

The highest dry biomass weight (8.859 g pot⁻¹) was observed in a treatment with a combination of N-GUBC and urea (400 GUBC + 400urea). This was significantly different from the positive control (800urea). The lowest dry weight (1.083 g pot⁻¹) was recorded in the absolute (zero) control. This result was also confirmed by the findings of

Kashem *et al.* (2015) on using vermicompost in tomato production. The increase may be due to the availability of macro and micro nutrients through the mechanism of reduction, chelation and favorable changes in soil.

Table 4.7: Effects of application of different rates of GUBC on chlorophyll content, fresh biomass weight and dry biomass weight of the black nightshade

Forms (GUBC)	Rate (mg N kg ⁻¹ soil)	Chlorophyll content	Fresh Biomass (g pot ⁻¹)	Dry Biomass (g pot ⁻¹)
P-C	0	42.62 a	15.09 ab	1.51 a
NP-C	0	43.24 a	12.01 a	1.08 a
P-C	800 urea	58.25 c	65.95 de	6.88 b
NP-C	800 urea	60.60 c	65.11 d	7.38 b
P	200 GUBC	41.43 a	16.57 ab	1.87 a
NP	200 GUBC	45.11 ab	15.08 ab	1.36 a
P	400 GUBC	49.53 ab	17.83 ab	1.88 a
NP	400 GUBC	58.40 c	12.83 a	1.35 a
P	800 GUBC	52.83 bc	25.46 c	2.07 a
NP	800 GUBC	43.52 a	19.72 b	1.68 a
P	400 GUBC + 400 urea	46.73 ab	70.92 e	7.49b
NP	400 GUBC + 400 urea	40.53 a	87.08 f	8.86 c
P-values		<.001	<.001	<.001
CV (%)		9.9	9.1	14.3

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$).

Note: GUBC=Green urban biowaste, P-C=Pellet control, NP-C= Non pellet control, P= Pellet, NP= Non-pellet, P-value=Probability value, CV=Coefficient of variance

4.6 Effects of Application of Different Rates GUBC on Plant Height, Number of Leaves, Neck Size and Bulb Size of Onion

Effect of different rates of GUBC on plant height, number of leaves, Neck size and bulb size of the onion is presented on Table 4.8. Pelletized GUBC significantly ($P=0.05$) increased plant height, number of leaves, neck size and bulb size of the onion, although there was inconsistency with treatment rate ranking. The tallest onion plant (50.49 cm),

greatest number of leaves (8.278) and largest bulb size (4.069 cm) were recorded in a combination of GUBC and urea (400 GUBC + 400 urea). El-Naggar (2010) reported that increment in number of leaves/plant of narcissus was recorded resulting from the interaction between bio fertilizers treatment and the highest rate of mineral fertilizer in both seasons. Comparable plant heights (49.56 cm and 46.12 cm) were observed in the sole application of 800 mg N (GUBC) and 800 mg N (Urea) kg-1soil respectively. All these parameters were statistically significant different ($P=0.05$) from the same parameters observed in control treatment.

Smallest neck size was recorded in an 800 mg N (Urea) kg-1soil implying the big bulbs were obtained as a result of the treatment, since neck size is inversely proportion to the bulb size. This parameter was also significant different ($P=0.05$) from that one in control treatment. A study by Brotodjojo and Arbiwati (2017) showed that the neck size of red onion treated with granular organic fertilizer was significantly higher than those treated with inorganic fertilizer.

Non-pelletized GUBC significantly ($P=0.05$) increased plant height, number of leaves, neck size and bulb size of the Onion, although there was inconsistency with treatment rate ranking. The tallest onion plant (51.91cm) and greatest number of leaves (8.278) were recorded in the sole application of 800 mg N (GUBC). According to Abdissa *et al.* (2011) the proper application of N fertilizer can increase plant height and leaves number approximately 11.5% and 8%.

Largest bulb size (3.824 cm) was recorded in a combination of GUBC and urea (400 GUBC + 400urea) this result confirmed by Jongtae *et al.* (2015) that higher bulb diameter in conventional onion bulb might result from an increase of all components of scale characteristics, but not from each characteristic. Comparable plant heights (46.88 cm and

49.76 cm) and number of leaves (6.722 and 7.389) were observed in the sole application of 800 mg N (GUBC) and in a combination of GUBC and urea (400 GUBC + 400 urea) respectively. All these parameters were statistically significant different ($P=0.05$) from the same parameters observed in control treatment.

Smallest neck size was recorded in a combination of GUBC and urea (400 GUBC + 400 urea) implying the big bulbs were obtained as a result of the treatment, since neck size is inversely proportion to the bulb size. This parameter was also significantly different ($P=0.05$) from that one in control treatment. The results of Akoun (2005) and Jayathilake *et al.* (2003) showed that the interaction of organic and inorganic fertilizers can increase the diameter of the shallot bulbs.

Table 4.8: Effects of application of different rates of GUB compost on plant height, number of leaves, neck size and bulb size of onion

Forms (GUBC)	Rate (mg N kg ⁻¹ soil)	Plant height (cm)	Number of leaves	Neck size (cm)	Bulb size (cm)
P-C	0	38.19 a	5.94 a	0.91 cd	2.22 a
NP-C	0	37.54a	5.72 a	0.89bcd	2.14a
P-C	800 urea	46.12bcd	6.61abcd	0.66ab	3.33 cd
NP-C	800 urea	46.88bcd	6.72abcde	0.67abc	3.24 cd
P	200 GUBC	45.85bcd	6.61abc	0.96 d	2.13a
NP	200 GUBC	42.44ab	6.06 ab	0.97 d	2.42 a
P	400 GUBC	43.91abc	6.61abc	0.85abcd	2.56ab
NP	400 GUBC	45.55bcd	7.39 abcde	0.93 d	2.68abc
P	800 GUBC	49.52bcd	6.94abcde	0.94 d	3.09bc
NP	800 GUBC	51.91d	7.72 bcde	1.04 d	3.09bc
P	400 GUBC + 400 urea	50.49cd	8.28 ce	0.79abcd	4.07 e
NP	400 GUBC + 400 urea	49.76bcd	7.39abcde	0.61 a	3.82de
P-values		0.004	0.052	0.01	<.001
CV (%)		8.7	12.6	15.6	12.1

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P=0.05$).

Note: GUBC=Green urban biowaste compost, P-C=Pellet control, NP-C= Non pellet control, P= Pellet, NP= Non-pellet, P-value=Probability value, CV=Coefficient of variance

4.7 Effect of Application of Different Rates of Pelletized and Non-pelletized GUBC on Dry Weight of Bulbs and Leaves, Fresh Weight of Bulbs and Leaves of the Onion

Effect of different rates of GUBC on dry weight bulb, dry weight of leaves, fresh weight bulb and fresh weight leaves of the onion is presented on Table 4.9. Pelletized GUBC significantly ($P=0.05$) increased bulb dry weight, dry weight of leaves, bulb fresh weight and fresh weight of leaves of the onion, although the increase was inconsistent with treatment rate ranking. The greatest bulb dry weight (108.56 g), bulb fresh weight (120.20 g) and dry weight of leaves (4.923 g) were observed in a combination of GUBC and urea (400 GUBC + 400urea). The greatest fresh weight of leaves (32.89 g) was observed in the sole application of 800 mg N (GUBC). All these parameters were statistically significant different ($P=0.05$) from the same parameters observed in control treatment. Application of sole 800 GUBC significantly ($P=0.05$) increased all named yield parameters above as compared to the control treatment.

Non-pelletized GUBC significantly ($P=0.05$) increased dry weight of bulb, dry weight of leaves, fresh weight of bulb and fresh weight of leaves of onion, although the increase was inconsistent with treatment rate ranking. The greatest dry bulb weight (118.69g), fresh bulb weight (130.94g) and dry leaves weight (4.923 g) were recorded in a combination of GUBC and urea (400 GUBC + 400urea). The greatest dry weight leaves (5.361 g) and fresh weight leaves (37.35 g) were recorded in the sole application of 800 mg N (GUBC). All these parameters were statistically significant different ($P=0.05$) from the same parameters observed in control treatment. Application of sole 800 GUBC significantly ($P=0.05$) increased dry weight leaves, fresh weight bulb and fresh weight leaves of the onion compared to the control treatment.

Increasing biowaste resulted in progressive increase in bulb yield of onion. Similar result was also reported by Anwar *et al.* (2001) for onion. The interaction between organic

manure and mineral fertilizer revealed the superiority of applying the highest levels of organic and mineral fertilizer on enhancing bulb. The significant increases in bulb as affected by biofertilizers and organic manure or mineral fertilizer may be related to increasing the availability of minerals especially N fixation that may led to an increase in photosynthesing surface (El-Naggar, 2010).

Table 4.9: Effects of application of different rates of GUBC compost on dry and fresh weight (g) of bulbs and leaves of onion

Forms (GUBC)	Rate (mg N kg ⁻¹ soil)	Dry weight bulb (g)	Dry weight leaves (g)	Fresh weight bulb (g)	Fresh weight leaves(g)
P-C	0	24.71 a	2.952 a	29.08 a	18.73 a
NP-C	0	23.01 a	2.912 a	29.26 a	19.12 a
P-C	800 urea	87.71 de	3.866 ab	95.04 ef	22.40 ab
NP-C	800 urea	74.99 cd	4.038 abc	81.91 de	20.14 a
P	200 GUBC	33.35 a	3.687 ab	38.67 ab	26.61 abc
NP	200 GUBC	46.35 ab	4.234 abc	52.20 abc	29.13 abc
P	400 GUBC	38.22 a	3.600 ab	47.50 abc	27.81 abc
NP	400 GUBC	47.78 ab	4.143 abc	51.47 abc	32.64 bc
P	800 GUBC	69.14 bcd	4.764 bc	77.07 cde	32.89 bc
NP	800 GUBC	50.88 abc	5.361 c	61.80 bcd	37.35 c
P	400 GUBC + 400 urea	108.56 ef	4.923 bc	120.20 fg	29.90 abc
NP	400 GUBC + 400 urea	118.69 f	3.105 a	130.94 g	19.96 a
P-values		<.001	0.005	<.001	0.007
CV (%)		24.1	17.5	23.2	21.7

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test ($P=0.05$).

Note: GB=Green urban biowaste, P-C=Pellet control, NP-C= Non pellet control, P= Pellet, NP= Non-pellet, P-value=Probability value, CV=Coefficient of variance



Plate 4.1: Performance of nightshade 42 DAE as affected by bio-waste compost



Plate 4.2: Appearance of the best performing nightshade 42 DAE and the corresponding application rate of inorganic fertilizer



Plate 4.3: Appearance of onions 42 DAE on application of GUBC

4.8 Conclusions and Recommendations

4.8.1 Conclusions

- Optimum treatment for high yields of black nightshade and onion was a combination of 200 kg N (GUBC)/ha + 200 kg N (urea)/ha.
- Rate of 800 kg N (urea)/ha significantly increased the yield of black nightshade and onion

4.8.2 Recommendations

- The recommended optimum rate for black nightshade and onion production is 200 kg N (GUB)/ha + 200 kg N (urea)/ha
- Field trials are recommended to validate results from pot experiment study

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CHAPTER FIVE

5.0 EFFECTS OF GREEN URBAN BIO-WASTE COMPOST ON GROWTH AND PRODUCTION OF ONION (*Allium Cepa* L) AND BLACK NIGHTSHADE (*Solanum nigrum* L.) IN ARUSHA, TANZANIA.

ABSTRACT

A field experiment was carried out at TARI-Tengeru farm from December 2018 to May 2019 to evaluate the effects of different rates of biowaste compost on growth, development and yield of black nightshade and onion. The experiment was laid out in a randomized complete block design (RCBD) with four different application rates (regarded as treatments) of bio-waste compost (GUBC)/urea viz., 0 kg N ha⁻¹, 400 kg N (GUBC) ha⁻¹, 400 kg N (UREA) ha⁻¹ and 200 kg N (GUBC) ha⁻¹+ 200 kg N (UREA) ha⁻¹. Each treatment was replicated three times. Plant growth and yield parameters were used to evaluate the effects of the treatments. Parameters measured were: plant height, leaf number, leaf area and leaf fresh weight for black night shade and bulb size, neck size, bulb fresh weight for onion. The application of a combination of 200 kg N (GUBC) ha⁻¹ + 200 kg N (UREA) ha⁻¹ significantly (p=0.05) increased the leaf area and fresh weight for black nightshade, bulb size and bulb weight for onion compared to the rest. Therefore, the use of combination of organic fertilizer and urea is recommended to farmers for improved yield.

Keywords: Green urban biowaste compost, black night shade, onion and green bio-waste application rate.

5.1 Introduction

Consumption of traditional leafy vegetables and onion in most of the developing countries including Tanzania is increasing due to their good adaptability to harsh climatic conditions and tolerance to pests and diseases; and also their nutritional and medicinal values (Weinberger and Msuya, 2004). One of the most commonly consumed traditional leafy vegetables in Arusha region of Tanzania is the African Nightshade (Lotter *et al.*, 2014). Black nightshade common in Arusha as used as leaf vegetables for nutrition and medicinal purpose. Arusha also is reported to be a good producer of onion. Onion is largely produced and consumed all over the country due to its significant contribution in human diet, economic earnings as well as its medicinal properties (Gessesew *et al.*, 2015). Onion is consumed primarily for unique flavor or ability to enhance flavor in food (Raddle, 2000; Yohannes *et al.*, 2013). Onion (*Allium cepa* L.) is also one of the most important commercial vegetable crops grown intensively in the Tanzania. African Nightshade and onion grow in various soil types, but are best adapted to soils of high fertility; especially those rich in nitrogen, phosphorus and organic matter. According to FAOSTAT (2010), there are 7 million acres under onion cultivation with yield of 37 million tons each year worldwide. The total area covered by onion crop in Tanzania is more than 8,781 ha of land as reported by Agricultural Census 2008, with total production of 56,000 tons of onion annually (FAO, 2000). In Tanzania onion has average productivity of 4.02 tons/ha, this is very low yield compared to the world average of 19.7 tons/ha (Haq *et al.*, 2016).

Low yield is attributed to factors, such as low soil fertility, pests and diseases, price fluctuation and poor storage facilities (Zziwa and Kabirizi, 2015). Moreover, lack of improved varieties and seed, and absence of recommended organic fertilizer rates are the pertinent problems in any given area (Gessesew *et al.*, 2015). Therefore, to improve black

nightshade and onion production, a number of inputs are required, including adequate soil fertility management (Yohannes *et al.*, 2013).

Accordingly, integrated nutrient management, especially the use of different soil organic amendments, has gained tremendous importance in many countries (Mohd *et al.*, 2002). In fact, soil organic amendments remain the only feasible option for the small holder farmers, because it is cheap, affordable and capable of improving the physical, chemical and biological properties of the soil (Ahmed *et al.*, 2013). Organic materials, such as farmyard manure, not only improve soil physical and chemical properties but also have positive effect on root growth, such as improving the root rhizosphere conditions (structure, humidity), as well as encouraging increasing population of microorganisms (Funda *et al.*, 2011). Also, organic fertilizers support and sustain healthy ecosystems, food production and overall economy in terms of human health (Islam *et al.*, 2017). However, the information on the response of black nightshade and onion to green urban bio-waste compost in Tanzania is scanty and limited. Therefore, the objective of this study was to assess the response of the onion and black nightshade to green urban bio-waste compost from Guavay Company, Dar es Salaam in Tanzania under field conditions.

5.2 Materials and Methods

5.2.1 Study area description

A field experiment was conducted in Arusha at TARI-Tengeru from December 2018 to May, 2019. TARI-Tengeru is located at latitude 3^o 24' S and longitude 36^o 47'E at an elevation of some 1250 m above sea level in the Arumeru district about 14 km from Arusha town. The mean annual rainfall ranges from 720 to 1 000 mm, the mean monthly temperature ranges from 15 to 25^o C (Maliwa, 1985). The climate of the study area is mild, and generally warm and temperate. The precipitation is lowest in August, with an average

of 13 mm. The greatest amount of precipitation occurs in April, with an average of 339 mm. At an average temperature of 23 °C, March is the hottest month of the year. The lowest average temperatures in the year occur in July, when it is around 18 °C.

5.2.2 Experimental design, treatments and crop establishment

The experiment followed a randomized complete block design (RCBD) with four treatments, each replicated three times. The four treatments were 0 kg N ha⁻¹, 400 kg N (GUBC) ha⁻¹, 400 kg N (UREA) ha⁻¹ and 200 kg N (GUBC) ha⁻¹ + 200 kg N (UREA) ha⁻¹ designated as T1, T2, T3 and T4 respectively, where T1 and T3 are control. The site was cleared mechanically ploughed and harrowed to provide a medium fine tilth for the good growth of the crops; later plots were marked and demarcated. Twelve plots of 4 × 4 m size for black night shade and 3 × 3 m for onion separated by 1 m. were established. The plots were levelled using hand hoe and the GUBC was then applied to plots and mixed with soil per treatment requirement. Local variety for black night shade called Mnavu Mpana (local name) and red bombay variety for onion, most commonly grown varieties by farmers were used in this study. Seeds were sown on a nursery on the December 8th, 2018 for onion and January 13th 2019 for black nightshade and kept for eight weeks for onion and four weeks for black nightshade. On February 11th 2019 vigorous seedlings were transplanted into their well-prepared plots. The inter row spacing of 30 cm and intra row spacing of 20 cm for onion and inter row spacing of 30 cm and intra row spacing of 25 cm for black nightshade were used.

5.2.3 Fertilization

Green urban bio-waste compost was applied to the plots during the time of transplanting at different treatment rates of 0 kg N ha⁻¹, 200 kg N (GUBC) ha⁻¹ and 400 kg N (GUBC) ha⁻¹ using band method. Urea was applied as top dressing at a rate of 200 and 400 kg N ha⁻¹ in three splits to plots of combination of urea and green urban bio waste and Urea alone respectively.

5.2.4 Management practices and harvesting

Weeding was done as necessary by hoeing and hand removal. Earthing up was done to prevent exposure of bulbs for onion crop. Pesticide (profenofos) was applied 30mls per 20L sprayer to the field to avoid pest and diseases to the plant. Irrigation was done as necessary to avoid water stress. Harvesting was done by cutting with knife for nightshade at 62 days after transplanting (DAT) and by digging out the bulbs for onion crop using the hand hoe at 94 DAT.

5.3 Data Collection

Growth and Yield Parameters

Plant growth and yield parameters were recorded. Five plants were randomly chosen for measurement of plant height (cm), number of leaves, leaf area and chlorophyll content for both black nightshade and onion crops. The parameters were measured at 62 and 94 DAT for black nightshade and onion. Plant height was measured using a tape measure; numbers of leaves were counted while leaf chlorophyll content was measured using a LEAF Digital chlorophyll meter device. Areas of 4 m² and 1.5 m² were marked at the centers (avoiding border effect) of black nightshade and onion plots, respectively and harvested for determination of yields. Fresh and dry biomasses were measured using electronic weighing balance. Other parameters recorded were fresh and dry leaf weight, fresh bulb weight measured by electronic weighing balance, bulb size and neck size measured by Vernier caliper.

5.4 Statistical Analysis

Collected data were subjected to analysis of variance using GenStat Software version 15.2. Treatment mean separation was done by using Duncan Multiple Range Test at the 5% probability level.

5.5 Results and Discussion

5.5.1 Black nightshade

5.5.1.1 Effects of different rates of GUBC on plant height, number of leaves and leaf area of the Black nightshade under field conditions

The effects of GUBC on plant height, number of leaves and leaf area are shown in Table 5.1. GUBC affected significantly ($P=0.05$) the plant height, number of leaves and leaf area.

5.5.1.1.1 Plant height

The Plant height increased with maturity, with maximum plant height of (155.7 cm) recorded in 400 kg N (UREA)/ha. The plot treated with 200 GUBC + 200 urea produced statistical similar ($P = 0.05$) plant height to that applied with 400 kg N (UREA)/ha. The shortest plant height (117.4 cm) which was significantly different from other treatments was recorded in the control. Bvenura and Afolayan (2013) recorded a maximum height of 90.33 cm in black nightshade. This value is however lower than the value obtained in the present study.

5.5.1.1.2 Number of leaves

Maximum number of leaves was observed in a plot treated with 200 kg N (GUBC)/ha + 200 kg N (urea)/ha. Plots treated with 400 kg N (UREA)/ha and 400 kg N (GUBC)/ha produced statistical comparable number of leaves which were 292.7 and 314.7 respectively. This is in agreement with Ojetayo *et al.* (2011) who observed increased in growth parameters with applied fertilizer types, which might be due to the effective use of applied fertilizer by the plants. The lowest number of leaves (209.7) was observed in the control treatment.

5.5.1.1.3 Leaf area

Statistical comparable leaf areas were noted in 400 kg N (UREA)/ha and 200 kg N (GUBC)/ha + 200 kg N (urea)/ha with values 311.6 cm² and 308.6 cm² respectively. The smallest leaf area (170.9 cm²) was observed in the control. All of the four treatments exhibited significant difference (P = 0.05) in leaf area from each other. Work conducted by Ng'etich *et al.* (2012) reported a high (62 cm²) leaf area in *Cleome gynandra* at 100 Kg N/ha after 100 days of planting. In the current study, about 62 days after transplanting, the highest values (311.6 cm²) and 308.6 cm² respectively higher than previous finding were obtained in the treatment with a sole application of urea and combination of 200 kg N/ha urea and 200 kg N/ha GUB. In agronomy context, leaf area measurement is critical in understanding the water and nutrient use of the crop as well as its growth and yield potential (Pandey and Singh, 2011).

Table 5.1: Effect of different rates of GUBC on plant height, number of leaves and leaf area of the Black nightshade

GUBC	Rate (kg N /ha)	Plant height (cm)	Number of leaves	Leaf area (cm ²)
T1- A control	0	117.4 a	209.7 a	170.9 a
T2-P control	400 urea	155.7 c	292.7 b	311.6 c
T3	400 GUBC	136.0 b	314.7b	219.6b
T4	200 GUBC + 200 urea	155.5 c	452.0 c	308.6 c
P-values		0.002	<.001	<.001
CV (%)		5.1	11.2	9.5

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test (P=0.05).

Note: GUB=Green urban biowaste compost, A =Absolute control, P= Positive control, P-value=Probability value, CV=Coefficient of variance

5.5.1.2 Effect of different rates of GUBC on chlorophyll content, fresh biomass

weight and dry biomass weight of the Black nightshade under field condition

The effects of GUBC on chlorophyll content, fresh biomass weight and dry biomass weight are shown in Table 5.2. There was significant difference (P=0.05) between the treatments in chlorophyll content, fresh biomass weight and dry biomass weight.

5.5.1.2.1 Chlorophyll content

Statistical comparable leaf chlorophyll content were noted in 400 kg N (GUBC)/ha and 200 kg N (GUBC)/ha + 200 kg N (urea)/ha with values 40.67 and 42.33 respectively. The highest leaf chlorophyll content (45.63) which was significant different ($P = 0.05$) from other treatments was recorded in the 400 kg N (UREA)/ha. Bvenura and Afolayan (2013) reported higher values between 23.11 and 60.34 in *Solanum nigrum* on application of organic and inorganic source. The significant lowest leaf chlorophyll content (38.57) was observed in the control, this is an indication of low N and therefore a low nutrient status of the plant.

5.5.1.2.2 Fresh weight

Maximum fresh weight (80,042 kg ha⁻¹) was noted in a plot treated with 400 kg N (UREA)/ha followed by 200 kg N (GUBC)/ha + 200 kg N (urea)/ha which produced statistical similar fresh weight (75 283 kg) to that of 400 kg N (UREA)/ha. The significant lowest fresh weight (24 967 kg ha⁻¹) was observed in the control treatment. Compost manure fertilizer being an excellent source of macro- and micro-nutrients, could have contributed to enhanced biomass production. Similar findings were observed by Van Averbeké *et al.* (2007) who reported increased total fresh and oven dry above ground biomass of *Solanum retroflexum* with increased nitrogen application rates. Further, Mahadeem *et al.* (2008) working on broccoli, reported that inorganic fertilizer produces the highest yields compared to the corresponding amounts of organic manure, however combined fertilizer application produces comparable yields to pure inorganic fertilizer.

5.5.1.3 Dry weight

Highest dry weight (26,542 kg ha⁻¹) was noted in a plot treated with 200 kg N (GUBC)/ha + 200 kg N (urea)/ha followed by 400 kg N (UREA)/ha (18,637 kg ha⁻¹), however, the two treatments were not significantly different ($P = 0.05$). The significant lowest dry weight (9398 kg ha⁻¹) was observed in the control treatment. This result was also confirmed by the

findings of Kashem *et al.* (2015) in tomato. The increase number of leaves may be due to the availability of macro and micro nutrients through the mechanism of reduction, chelation and favourable changes in soil.

Table 5.2: Effect of different rates of GUBC on chlorophyll content, fresh biomass weight and dry biomass weight of the Black nightshade

GUBC	Rate (kg N /ha)	Chlorophyll content	Fresh Biomass (kg/ha)	Dry Biomass (kg/ha)
T1- A control	0	38.57 a	24967 a	9398 a
T2-P control	400 urea	45.63 c	80042 c	18637 bc
T3	400 GUBC	40.67 ab	40758b	14717 ab
T4	200 GUBC + 200 urea	42.33 b	75283 c	26542 c
P-values		0.008	<.001	0.003
CV (%)		3.8	9.7	18.3

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test (P=0.05).

Note: GUBC=Green urban biowaste compost, A =Absolute control, P= Positive control, P-value=Probability value, CV=Coefficient of variance

5.6 Onion

5.6.1 Effects of different rates of GUBC on plant height, number of leaves, neck size and bulb size of the onion under field

The effects of GUBC on plant height, number of leaves, neck size and bulb size are shown in Table 5.3. GUBC affected significantly ($P=0.05$) the plant height, number of leaves, neck size and bulb size.

5.6.1.1 Plant height

The significant shortest plant height (38.33 cm) was recorded in control treatment. 400 kg N (UREA)/ha, 400 kg N (GUBC)/ha and 200 kg N (GUBC)/ha + 200 kg N (urea)/ha treatments produced statistical similar ($P = 0.05$) plant height with values 44.00 cm, 44.33 cm and 45.33 cm respectively. Farooq *et al.* (2015) reported that increase in application of organic fertilizers increases height of plant. However, the longest plant was noted in plot a treated with 200 kg N (GUBC)/ha + 200 kg N (urea)/ha.

5.6.1.2 Number of leaves

The present study revealed no significant difference between the control treatments over other treatments on number of leaves. The greatest number of leaves (8.0) was recorded in plots treated with 200 kg N (GUBC)/ha + 200 kg N (urea)/ha and 400 kg N (GUBC)/ha, as number of leaves increase the bulb size also increases (Seran *et al.*, 2010) whereas the lowest number of leaves (6.0) was recorded the control. Reddy and Reddy (2005) observed that highest number of leaves per plant in onion was recorded with 30 t/ha vermicompost with 200 kg N/ha.

5.6.1.3 Neck size

The smallest neck size (1.2 cm) was recorded in the 200 kg N (GUBC)/ha + 200 kg N (urea)/ha treatment which was statistically similar ($P = 0.05$) to 400 kg N (GUBC)/ha (1.467 cm) and 400 kg N (UREA)/ha (1.300 cm). The significant largest neck size (1.700 cm) was observed in the control. This could be due to the fact that bulb size is inversely proportion to neck size, large neck size result to small bulb.

5.6.1.4 Bulb size

The greatest bulb size (5.167 cm) was noted in a plot applied with 200 kg N (GUBC)/ha + 200 kg N (urea)/ha followed by bulb (4.567 cm) produced in plot treated with 400 kg N (UREA)/ha. These two treatments were not statistically significantly different ($P = 0.05$). Smallest bulb (3.200 cm) was noted in the control. Similar results were reported by Mandal *et al.* (2013) and Brinjh *et al.* (2014) they reported bulb diameter increase due to increased use of combined application of organic manure and inorganic fertilizer.

Table 5.3: Effect of different rates of GUBC on plant height, number of leaves, neck size and bulb size of the onion

GUBC	Rate (kg N /ha)	Plant height (cm)	Number of leaves	Neck size (cm)	Bulb size (cm)
T1- A control	0	38.33 a	6.000a	1.700 b	3.200 a
T2-P control	400 urea	44.00 b	7.667 a	1.300 a	4.567 bc
T3	400 GUBC	44.33 b	8.000 a	1.467 ab	4.267 b
T4	200 GUBC + 200 urea	45.33 b	8.000 a	1.200 a	5.167 c
P-values		0.039	0.189	0.019	0.004
CV (%)		5.5	15.1	9.8	8.9

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test (P=0.05).

Note: GUBC=Green urban biowaste compost, A =Absolute control, P= Positive control, P-value=Probability value, CV=Coefficient of variance

5.6.2 Effect of different rates of GUBC on fresh bulb weight and fresh leaves weight of onion

The effects of GUBC on bulb fresh weight and leaf fresh weight are shown in Table 5.4. There were significant difference (P=0.05) between the treatments in fresh weight bulb and fresh weight of leaves.

5.6.2.1 Bulb fresh weight

The highest fresh weight of bulb (10,667 kg ha⁻¹) was noted in a plot treated with 200 kg N (GUBC)/ha + 200 kg N (urea)/ha followed by 400 kg N (UREA)/ha (10,422 kg ha⁻¹), however, the two treatments were not significantly different (P = 0.05). The increased N fertilizer which increased the weight of bulbs might be due to that N supply in plants increases the rate of metabolism and synthesis of more carbohydrate thus increased bulb weight.

The significant lowest fresh weight of bulb (6267 kg ha⁻¹) was observed in the control treatment. However, combination of organic and inorganic fertilizers produced better

yields than biowaste compost alone. The present result agreed with previous findings obtained on onion (Gambo *et al.*, 2008); also application of inorganic fertilizers gave higher yield than application of organic manure alone. Inorganic fertilizers release the nutrients quickly and fulfill the plants need therefore, plants would not face any limitation during the yield forming period and it could produce better yield (Seran *et al.*, 2010).

5.6.2.2 Leaf fresh weight

The minimum fresh weight of leaves (1311 kg) was recorded in the 400 kg N (UREA)/ha treatment which was statistically similar ($P = 0.05$) to 200 kg N (GUBC)/ha + 200 kg N (urea)/ha with a value of 1578 kg ha⁻¹. The maximum fresh weight of leaves (2978 kg) was recorded in the control treatment which was statistically similar ($P = 0.05$) to 400 kg N (GUBC)/ha.

Highest number of tops-down and yellowing in inorganic onion result to lowest leaf fresh weight as compared with organic onion; must result from early bulb growth and possibly early nitrogen mineralization from inorganic fertilizer (Jongtae *et al.*, 2015).

Table 5.4: Effect of different rates of GUB compost on fresh weight bulb and leaves of onion

GUBC	Rate (kg N /ha)	Bulb fresh weight (kg/ha)	Leaf fresh weight (kg/ha)
T1- A control	0	6267 a	2978 b
T2-P control	400 urea	10422 bc	1311 a
T3	400 GUBC	8133 ab	2800 b
T4	200 N -GUBC + 200 urea	10667 c	1578 a
P-values		0.012	0.004
CV (%)		13.4	17.9

Means in a column followed by the same letter are not significantly different according to Duncan's multiple range test (P=0.05).

Note: GUBC=Green urban biowaste compost, A =Absolute control, P= Positive control, P-value=Probability value, CV=Coefficient of variance

5.7 Benefit-cost Analysis of Using Green Urban Biowaste Compost as a Fertilizer

Material for Black Nightshade and Onion Production

The findings from the present study indicated that combined application of GUBC and inorganic fertilizer (urea) at a rate of 200 kg N ha⁻¹ each and sole application of 400 kg N (UREA) ha⁻¹ were the best in terms of growth and yield performance of black nightshade and onion. These rates can be expressed in the actual amount of GUBC and urea based on the percentage of nitrogen contained by GUBC and urea. From the laboratory analysis of GUBC, it was found to contain 1 % N, and the urea used in this study contained 46 % N. Computing the amount of GUBC and urea which is equivalent to 200 kg N (GUBC) ha⁻¹ reveals 20,000 kg of GUBC (20 tons of GUBC) and 435 kg of urea respectively while 400 kg N (UREA) ha⁻¹ reveals 870 kg of urea (Appendices 1 and 2).

Table 5.5: Cost analysis for production of onion and black nightshade per hectar

S.No	Costs	Onion	Black nightshade
1	Urea fertilizer	990 000	990 000
2	GUBC and Urea fertilizer	14 495 000	14 495 000
3	Seeds	330 150	120 000
4	Land preparation	437 000	300 000
5	Ploughing and harrowing	710 000	612 000
6	Planting	720 000	540 000
7	Weeding	3 100 000	200 000
8	Irrigation	430 000	340 000
9	Pesticides	130 000	90 000
10	Harvesting	380 000	312 000
Total Costs			
	Urea	7 227 150	3 504 000
	GUBC + Urea	20 732 150	17 009 000
Revenue			
	Yield for Urea	10 422 kg@ 1 500 =15 633 000	80 042 kg @ 500 =40 021 000
	Yield for GUBC and Urea	10 667 kg @1500 =16 000 500	75 283 kg@500 =37 641 500
Profit Margin			
	When Urea used	8 405 850	36 517 000
	When GUBC and Urea used	-4 731 650	20 632 500

The greatest profit margin (3 651 700 Tanzania shillings) was obtained when urea only used in black nightshade, followed by a combination of urea and biowaste compost which gave the profit

margin of 20 632 500 Tanzania shillings. In onion crop the greatest profit margin (8 405 850 Tanzania shillings) obtained when urea only used while there a loss of 4 731 650 Tanzania shillings per hectare when a combination of urea and biowaste compost applied in onion.

5.8 Conclusions and Recommendations

5.8.1 Conclusions

- Combination of green urban biowaste compost and urea at the rate of 200 kg N (GUB)/ha + 200 kg N (urea)/ha gave optimum yields of black nightshade and onion.
- The cost of producing black nightshade and onion using combination of 200 kg N (GUB)/ha + 200 kg N (urea)/ha is very high about 15 times that of using urea alone.
- Sole application of 400kg N (UREA)/ha produced comparable yields to those obtained in the optimum rate of 200 kg N (GUB)/ha + 200 kg N (urea)/ha.

5.8.2 Recommendations

- Use GUBC and Urea in combination for high yields of onion and black nightshade.
- Price of green urban biowaste compost must be reduced to become competitive with urea.

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CHAPTER SIX

6.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- The results of the study revealed that the soil was slightly alkaline, high in exchangeable cations, low organic carbon and nitrogen content.
- Generally, micronutrient values of soil recorded in the study were above critical levels.
- Combination of green urban biowaste compost and urea at the rate of 200 kg N (GUB)/ha + 200 kg N (urea)/ha gave optimum yields of black nightshade and onion.
- The cost of producing black nightshade and onion using combination of 200 kg N (GUB)/ha + 200 kg N (urea)/ha is very high about 15 times that of using urea alone.
- Sole application of 400 kg N (UREA)/ha produced comparable yields to those obtained in the optimum rate of 200 kg N (GUB)/ha + 200 kg N (urea)/ha.
- The green urban biowaste compost had high pH and very high OC.
- The C: N ratio of green urban biowaste compost was ideal for the materials to be used as organic fertilizer.
- The levels of selected micronutrients and heavy metals were in the established standard acceptable limits.

6.2 Recommendations

- N from external source and organic materials are required to increase the organic and nitrogen in soil so as to meet the requirements of crops.
- Green urban biowaste compost should be fortified to increase the amount of Nutrients needed to meet the requirements of crops.
- The recommended optimum rate for black nightshade and onion production is 200 kg N (GUB)/ha + 200 kg N (urea)/ha.
- Field trials are recommended to validate results from pot experiment study.

- Use of GUBC and Urea in combination for high yield of onion and black nightshade is recommended.
- Price of green urban biowaste compost must be reduced to become competitive with urea.

APPENDICES

Appendix 1: Soil fertilization cost for black nightshade and onion production

Soil fertilization cost for black nightshade and onion production can be computed as follows: 50 kg of GUBC and urea are sold at TZS 35 000/= and TZS 55 000/= respectively. Twenty thousand kilogram of GUBC contains 400 bags of 50 kg and 435 kg of urea contains 9 bags of 50 kg of urea. Then $400 \times 35\,000 = 14\,000\,000$ /= for GUBC and $9 \times 55\,000 = 495\,000$ /. Therefore total soil fertilization cost is obtained by summation of cost of GUBC and urea (i.e. $TZS\ 14\,000\,000 + 495\,000 = TZS\ 14\,495\,000$ /=). Therefore production cost in respect to soil fertilization under the combined fertilization of $200\ \text{kg N (GUBC)}\ \text{ha}^{-1} + 200\ \text{kg N (UREA)}\ \text{ha}^{-1}$ was TZS 14 495 000/=

For $400\ \text{kg N (UREA)}\ \text{ha}^{-1}$ which is equivalent to 870 kg urea per ha. Eighteen bags of 50 kg are contained in 870 kg of urea. Then soil fertilization cost under $400\ \text{kg N (UREA)}\ \text{ha}^{-1}$ is given by $18 \times 55\,000 = TZS\ 990\,000$ /=

Appendix 2: Revenue

According to the present study yields of black nightshade and onion were 75 283 kg ha⁻¹ and 10 667 kg ha⁻¹ under the combined fertilization of 200 kg N (GUBC) ha⁻¹ + 200 kg N (UREA) ha⁻¹. While yields under 400 kg N (UREA) ha⁻¹ were 80,042 kg and 10 422 kg for black nightshade and onion respectively.

Market prices for 1 kg black nightshade and onion are TZS 500/= and TZS 1500/= respectively. Therefore revenue is given by multiplying yield and price. Revenue for:

Black nightshade under combined fertilization of 200 kg N (GUBC) ha⁻¹ + 200 kg N (UREA) ha⁻¹ is $75,283 \times 500 = \text{TZS } 37\,641\,500/=$

Onion under combined fertilization of 200 kg N (GUBC) ha⁻¹ + 200 kg N (UREA) ha⁻¹ is $10\,667 \times 1\,500 = \text{TZS } 16\,000\,500/=$

Black nightshade under 400 kg N (UREA) ha⁻¹ is $80\,042 \times 500 = \text{TZS } 40\,021\,000/=$

Onion under 400 kg N (UREA) ha⁻¹ is $10\,422 \times 1\,500 = \text{TZS } 15\,633\,000/=$