INFLUENCE OF TITHONIA AND BIOSLURRY MANURES ON GROWTH, YIELD AND QUALITY OF CARROTS (*Daucus carrota* L. cv. Nantes)

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DEDICATION

To my parents, son and my fiancée, with all my love

ACKNOWLEDGEMENT

My sincere gratitude and appreciation go to my supervisors, Prof. J. N. Aguyoh and Dr. M. Saidi for their guidance, assistance and supervision during the course of the study period. I wish to thank the entire staff of the Department of Crops, Horticulture and Soils and in particular Mr. John Macharia and Mr. George Morara are mostly acknowledged for their remarkable support. I wish to express my heartfelt gratitude to my parents, John and Sarah Rotich who stimulated my interest in education and never ceased their support. I wish to thank my brothers, sisters and cousins for their tireless support in the course of this study. To my son Gerald, thank you for your tolerance and understanding during this long study period. To Felix Ngetich and Christine Ngetich thank you for your technical advice, friendship and moral support during the study period. Special thanks go to my best friend Cecilia for her moral support and encouragement and everyone else who may have assisted me in one way or the other, may God bless you.

Last, but not least, I wish to extend my gratitude to my lovely fiancée Mr. Onesmus Ngetich for his constant encouragement and moral support. Finally, all praises are due to Almighty God, who enabled me to complete this study.

ABSTRACT

Carrot (*Daucus carota* L.) is considered an important vegetable crop because of its increasing importance as human food and its large yield per unit area. Carrot is rich in carotenoids; precursor of vitamin A which is often lacking in the diet of many people. Despite its importance, carrots yield and quality have remained low due to inadequate fertilizer application. Moreover, higher production costs, and increasing awareness of the hazards associated with continuous use of inorganic chemicals, and deterioration of the ecosystems have led to increased need for more sustainable horticultural practices. Increasing, consumer awareness of health and food safety demands a speedy intervention to avert the several health hazards associated with conventionally produced food products. To bridge this gap, this study was undertaken in the Horticulture Research and Teaching Field, Egerton University from October to January (season 1) and February to May (season 2), 2010-2011. The major objective of the study was to enhance carrot yield and quality through use of organic fertilizers. The experiment was set in a Randomized Complete Block design (RCBD), with three replications. Treatments comprised four levels of decomposed bioslurry (0, 2.6, 5.2 and 7.8 t/ha) and four levels of decomposed *Tithonia diversifolia* (0, 1.5, 3.0 and 4.5 t/ha) based on the recommended nitrogen rates for carrots of 75 kg N/ha. Parameters measured included: growth, yield and quality variables. Data was subjected to Analysis of Variance (ANOVA) and significant treatment means separated using the Tukey's Honestly Significant Difference Test at $P \leq 0.05$. Total root yield increased by 33% and 18% in season 1 and 2, respectively when tithonia was applied at 3 t/ha compared to the control. The plants treated with 7.8 t/ha of bioslurry had root yield increase by 23% and 10% in season 1 and 2, respectively compared to control. Combined application of 3 t/ha of tithonia and 7.8 t/ha of bioslurry increased root yield by 69% and 51% in season 1 and 2, respectively compared to control. Plant height increased by 15% in season 1 and 6% in season 2 while number of leaves were more by 18% and 10% in season 1 and 2, respectively for plants treated with tithonia (4.5 t/ha) compared to the control. Plants treated with 7.8 t/ha of bioslurry grew taller by 15% in both seasons while numbers of leaves were more by 15% and 8% in season 1 and 2, respectively compared to control. Total soluble solids at harvest were higher by 14% and 11% in season 1 and 2, respectively in plants applied with 4.5 t/ha of tithonia while 7.8 t/ha of bioslurry increased total soluble solids by 12% and 5% in season 1 and 2, respectively compared to control. At 2 weeks of storage total soluble solids were also higher in plants treated with 4.5 t/ha of tithonia by 11% and 9% in season 1 and 2, respectively compared to control. On the other hand 7.8 t/ha of bioslurry increased total soluble solids by 6.6% and 6.3% in season 1 and 2, respectively compared to the control. The study recommends either 3.0 t/ha (75 kg N/ha) of tithonia or 7.8 t/ha (112.5 Kg N/ha) of bioslurry manure and where both manure are readily available a combined application of tithonia (3.0 t/ha) and bioslurry (7.8 t/ha) be used in order to maximize carrots yield.

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LIST OF ABREVIATIONS AND ACRONYMS

C	Carbon
DAP	Days after Planting
DAS	Days at Storage
FAO	Food and Agriculture Organization
FSSA	Fertilizer Society of South Africa
ICRAF	International Centre for Research in Agro forestry
ISTA	International Seed Testing Association
K	Potassium
Kg N/ha	Kilogram of Nitrogen per Hectare
N	Nitrogen
OMAF	Ontario Ministry of Agriculture and Food
P	Phosphorus
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis System
t/ha	Tonnes per Hectare
USDA	United State Department of Agriculture

CHAPTER ONE
1.0 INTRODUCTION

1.1 Background Information

Carrot (*Daucus carota* L.) is an important vegetable crop widely used in human diet. It is highly valued as food mainly because it is a rich source of carotenoids, a precursor of vitamin A (Handelman, 2001). It contains abundant amounts of nutrients such as protein, carbohydrate, fibre, potassium, and sodium (Ahmad *et al.*, 2004). The fleshy carrot roots are eaten raw in salads, boiled or steamed in vegetable dishes and also used with other vegetables in the preparation of soup (Anjum and Amjad, 2002). Carrots are also processed in large quantities, either alone or in mixtures with other vegetables by canning, freezing or dehydration. Besides being food, it has medicinal value as it increases resistance against blood and eye diseases (Pant and Manandhar, 2007).

Carrot, being a short duration crop with high yields per unit area, is highly profitable, hence a favourite enterprise for most small scale resource poor farmers (Ahmad *et al.*, 2005). Kenya is ranked 6th among the top world carrot producers with an average yield of 13.6 tons/ha (FAO, 2008). Despite this ranking, the production levels are still below optimum due to low technological know how in production methods (Muendo and Tschirley, 2004). Carrot yields depend on the production and translocation of carbohydrates from the leaves to the roots. Thus, to obtain high and quality yields, carrots need good fertility and uninterrupted growth.

Nitrogen, phosphorus, potassium and water availability are considered as the major limiting factors in crop growth, development and final economic yield (Glass, 2003; Parry *et al.*, 2005). Generally, excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield and maximum value of growth (Stewart *et al.*, 2005; Dauda *et al.*, 2008). However, the use of inorganic fertilizers may cause problems to human health and the environment (Arisha and Bardisi, 1999).

Organic manure can serve as an alternative to mineral fertilizers. It supplies the required nutrients, improve soil structure, increase microbial population and at the same time maintain the quality of crop produce (Wong *et al.*, 1999; Nehra *et al.*, 2001; Suresh *et al.*, 2004; Dauda *et al.*, 2008). Although organic manures contain plant nutrients in small quantities as compared to inorganic fertilizers, the presence of growth promoting agents such as enzymes and hormones make them essential for improvement of soil fertility and productivity (Sanwal *et al.*, 2007).

Tithonia diversifolia green biomass is an effective source of nutrients and has been used successfully to improve soil fertility and crop yields in Kenya (Jama *et al.*, 2000). It has the ability to decompose rapidly with a half-life of about one week for the disappearance of dry matter in the rainy season. Tithonia has high water content of green biomass and lignin (6.5%) and extractable polyphenols (1.6%) concentration that are below levels that significantly reduces decomposition (Gachengo *et al.*, 1999). Its abundance and adaptability to various environments coupled with rapid growth rate and very high vegetative matter makes it an important source of nutrients and organic matter for soil rejuvenation (Jama *et al.*, 2000).

Bioslurry, the residual manure generated through anaerobic decomposition of various organic materials such as cow dung, poultry litter and other easily decomposable materials such as kitchen waste, farm wastes and crop residues may be considered to be quality organic fertilizer (Islam, 2006). Multiple advantages accrue from the use of bioslurry. It increases agricultural production because of its high content of plant nutrients and organic matter compared to ordinary farmyard manure (Karki, 2001). In addition it can be used as a bio-chemical pesticide to control potato blight and cauliflower mosaic (Gurung, 1997). Soaking seeds with digested slurry induces faster seed germination. Besides, bioslurry has been used as a supplement in cattle, poultry, hogs and fish feed (Razzak, 2006).

Application of manure which is not fully decomposed promotes forked, coarse and rougher carrots. Composting is therefore the best alternative to ensure complete maturation and stability of manures. The use of decomposed *Tithonia diversifolia* and bioslurry has not been fully exploited in carrot production hence the need to study its potential for enhanced production of carrots.

1.2 Statement of Problem

Carrot is a heavy nutrient feeder and requires continuous fertilization for attainment of high yields and quality. Majority of both commercial and small scale farmers use conventional fertilizers to produce carrots. However there are many constraints associated with the use of the inorganic fertilizers. The rising prices of these fertilizers have made it difficult for most resource poor small scale farmers to purchase sufficient quantities to replenish soil nutrients. In addition, they pose a threat to human health and the environment due to their increased chemical residues. Crop productivity has to be sustained while maintaining soil fertility and microbial life thus rendering the use of organic fertilizers as a potentially viable option. Majority of research has

focused on the application of inorganic fertilizers and complementary application of both inorganic and organic fertilizers but little has been done on the use of decomposed bioslurry and *Tithonia diversifolia* biomass.

1.3 Justification

Continuous cultivation of farms has led to decline in soil fertility due to constant removal of nutrients leading to reduction of crop yields (Okalebo *et al.,* 2006). Intensive use of inorganic fertilizers is hazardous to our environment and human health (Erisman and De Veries, 2000). Alternative production methods to reduce or eradicate the long lasting undesired effects of synthetic fertilizers are necessary. Organic fertilizers offer comparative advantages in enhancing soil fertility besides improving the crops yield (Ashraf *et al.,* 2004). Organically produced crops are healthy and nutritious, and have better shelf life as well as higher market value hence their demand is increasing day by day in the world (Islam and Momin, 2004). Carrot has gained importance because of its increasing demand as a highly nutritious food and its large yield per unit area. Although carrots are assumed to be safe to eat, risks related to chemical and biological hazards have been traced back to its consumption (OMAF, 2001). Carrots require a fertile soil, which allows rapid uninterrupted growth. Therefore, judicious and proper use of organic manures is very essential not only for obtaining higher yields and quality produce but also for sustainable soil health. *Tithonia diversifolia* as a source of organic manure has gained a lot of interest in research because of its relatively high nutrients concentration. Green leaf of tithonia contains 3.5, 0.37 and 4.1% of N, P and K, respectively (Jama *et al.,* 2000) and can therefore supply substantial amounts of N and K to crops . Carrots require nitrogen and phosphorous to increase root growth and dry matter production (Gribinger, 1999). The application of high potassium fertilizer increases sugar content, improves root colour and also enhances better shelf life. Fresh organic matter such as farmyard manure or from a leguminous crop can result in forked, hairy roots with a coarser texture which are difficult to clean and to market (Madge *et al.,* 2003) hence the need to use well decomposed manures. The use of *Tithonia diversifolia* alone might not guarantee substantial crop yields and so integrating it with decomposed bioslurry manure might increase its efficacy.

1.4 Objectives

1.4.1 Broad Objective

The general objective of this study was to enhance carrot yield and quality through use of organic fertilizers.

1.4.2 Specific Objectives

The specific objectives were to:

(1). Determine the effects of decomposed bioslurry manure rates on growth, yield and quality of carrots.

(2). Determine the effects of decomposed *Tithonia diversifolia* manure rates on the growth, yield and quality of carrots.

(3). Determine combined rates of decomposed bioslurry and tithonia manure that enhance growth, yield and quality of carrots.

1.5 Hypotheses

The null hypotheses tested were:

(1). Decomposed bioslurry manure rates have no effects on the growth, yield and quality of carrots.

(2). Decomposed *Tithonia diversifolia* manure rates have no effects on the growth, yield and quality of carrots.

(3). Combined rates of bioslurry and tithonia manures have no effects on growth, yield and quality of carrots.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Taxonomy and Botany

Carrots (*Daucus carota, L.*), originally cultivated in Central Asia and the Near East, were introduced to the American colonies in the seventeenth century and its now cultivated throughout the world. Carrot is a biennial plant and a member of the Apiaceae family. The roots of carrots were not originally yellow-orange, but a range of purple colours. It is thought that the yellow root evolved from a mutant variety which lacked the purple pigment. Ancient Greeks and Romans used both the purple and yellow varieties for medicinal purposes (Kochhar, 1998). Carrots were first used for food by Europeans during the middle Ages. In the nineteenth century, carrots were identified as a rich source of beta-carotene. During World War II, British aviators were fed with a specially developed English carrot, high in beta-carotene, to overcome night blindness. Plant geneticists continued to develop carrots with higher beta-carotene content, as well as strains that are sweeter. The root typically grows deep and ramified; the flowering stem is solid, grooved and hairy, 30-100 cm tall; the leaves are compound and pinnate; the inflorescences are umbels composed of white flowers with a central dark maroon colour. The fruit is an achene coated with brown thorns. The edible portion is a taproot, which grows during the first season of the plant's life. The seeds appear during the second season (Martin *et al.*, 2004). There are four main cultivars of carrot: Imperator, Chantenay, Danvers, Kuroda and Nantes is most preferred cultivar due to its sweet taste (Waterer, 2010).

2.2 Utilization of Carrots

Carrot is cultivated throughout the world for fleshy edible roots which are used for human consumption as well as for animal feed. Carrots are cooked alone or with other vegetables in the preparation of soups, stews, curries and pies (Anjum and Amjad, 2002). Fresh sliced and grated roots are used in salads while tender roots are pickled (Bhupinder and Gurusharan, 2003). Carrot juice is a rich source of carotene and it is used for coloring butter and blending other juices (Stoll *et al.*, 2001). Carrot pomace remains may be used as a source of pectin and carotene precursor of vitamin A (Schieber *et al.*, 2001).

Besides the food value, different parts of carrot can be used for different medicinal purposes. Carrot seeds are used as aromatic, stimulant and carminatives. The fruits have been used in traditional chinese medicine for the treatment of ancylostomiasis, dropsy, chronic kidney

disease and bladder afflictions (Pant and Manandhar, 2007) due to a wide range of reported pharmacological effects, including antibacterial (Rossi *et al.*, 2007), antifungal (Tavares *et al* ., 2008), anthelmintic and hepatoprotective (Bishayee *et al.*, 1995) and cytotoxic (Yang, 2008) activities. An infusion of carrot has long been used as a folk remedy of threadworms. Carrot increases the quantity of urine and large amount in the diet has a favourable effect on the nitrogen balance. Chewing carrot immediately after meals is said to eliminate damaging germs from the mouth, to clean the teeth, to remove food rests and to prevent gum bleeding and tooth decay. One medium carrot provides four times the Daily Value of vitamin A which helps maintain the health of eyes and skin and reduces the risk of certain cancers.

2.3 Nutritional Value

Carrots are an excellent source of beta-carotene and a good source of fibre. Beta-carotene, the plant pigment that gives carrots their vivid orange colour, is converted by the human body to vitamin A (Handelman, 2001). The main carotenoid compounds in carrots are α- and β-carotene (Surles *et al.*, 2004). Raw carrot roots contain an average of 5.7 mg per 100 of β-carotene (Holden *et al.*, 1999; USDA, 2004). Carrots are fat-free and contain abundant amounts of nutrients such as protein (1 g), carbohydrates (5.2-7.3 g), fibre (2.9-3.4 g), potassium (290 mg), sodium (60 mg), thiamine (0.06 g) and riboflavin (0.05 g) (Alonso, 2004; Ahmad *et al,* 2005; Hassan *et al.*, 2005).

2.4 Environmental Requirements

Carrot root quality depends on genetic features of cultivar or hybrid, soil and growth conditions. Different carrot cultivars react differently to changed growth conditions. Carrot is a cold-season crop, growing best in altitude between 1200-2700 m; the seeds germinate best at soil temperature of 16-18°C. Optimal plant growth and best colour and flavour are obtained between temperatures of 15° C to 20°C (Rubatzky *et al.*, 1994; Karkleliene *et al.*, 2007). During intensive root growth, carrots need sufficient humidity. Carrot seeds germinate after 6 to 21 days from sowing (Kirkwiland and Thomas, 2009). The crop grow well in deep, well-drained, well-prepared soil of loose and friable structure (Pant and Manandhar, 2007). Sandy loam or loam soils are most suitable. Heavy, stony, compacted or poorly-drained soils interfere with good root development and are less suitable. In fairly heavy, humus-rich soils, carrots tend to develop excessive leaf growth, and to form forked, hairy roots. They also tend to be rough and coarse on the outside. Very light soils subject to wind erosion should be avoided. However, the lighter-

textured soils, if well fertilized and irrigated, are frequently preferred because roots tend to be smoother, straight and have a better appearance. Roots are also easier to wash clean at harvest.

2.5 Horticultural Production and Practices

Carrot seeds are small and are sown directly in the field therefore soil should be thoroughly prepared, with a level, fine, soil surface (Bluml *et al.*, 1999). Deep ploughing or working to loosen the soil to a depth of at least 30 cm is important to allow good root development (Mbatha, 2008). Carrots are often planted on top of ridges or raised beds. This is especially important on heavier soils, shallow soils or those less well drained, as it gives added soil depth, better drainage and favourable looser soil structure. Seeds should be covered to a uniform depth of 1cm to 2.5 cm, and should be kept moist until the plants are well established. Row planting is generally preferred to a broadcast sowing. Ideal inter row spacing is 20 cm and intra rows spacing of 5cm (Sarkindiya and Yakubu, 2006; Hailu *et al,* 2008a).

Thinning is done 20 days after emergence, at this stage, the plants are already well established (Mbatha, 2008). Early weeding is beneficial for carrots: some common annual weeds have their peak of germination around the same time as crop sowing and affect the crop growth (Turner and Davies, 2005). It has been shown that there is a significant effect of weed removal timing on the yield of carrots: 3-week and 5-week weeded plots had a significantly greater yield than 7-week treatment (Turner and Grundy, 2002). Weed control can be achieved mechanically, by hand, chemically or by a combination of these methods.

Carrots need a constant supply of moisture throughout the growing season to produce uniform and tender quality roots. However, excessive watering discourages good color formation and may encourage disease (Fritz, 2007).

Considerable losses in carrots can be experienced because of attacks by root-knot nematodes (*Meloidogyne* spp). The attacks are generally more severe with carrots grown when soil temperatures are high and favour development of the pest. Various soil fumigants may be used before planting to control nematodes. In organic farming, organic soil amendments may be used. Other pests include aphids, red spider mites and soil pests (Nault, 2010).

Alternaria leaf blight is the most common disease of carrots. It occurs mainly during wet weather, with prolonged heavy dews frequently promoting severe outbreaks. The fungus can be transmitted with the seed, and may cause damping-off of the seedlings. Cultural control methods should be used. Other diseases include bacterial blight and white mould (Dillard, 1988).

Although there are some varietal differences, the crop is usually ready for market within 3 to 4½ months (Northoult, 2004). Carrots planted on ridges or raised beds can be loosened by drawing an implement with a horizontal blade through the soil beneath the roots. Where planted on level ground roots are ploughed up or lifted with forks. Yellowing of leaves may indicate maturity but it is not a sure index. The best and most practical way to determine the size of the roots is to scratch the base of the plants and to see the actual size of the roots or by pulling some samples in the population (Northoult, 2004).

2.6 Role of Nitrogen in Growth of Vegetables

Nitrogen is an essential nutrient in creating the plant dry matter, as well as many energy-rich compounds that regulate photosynthesis and plant production. Nitrogen is the most important constituent of plant proteins and is required throughout crop growth cycle (Madan and Munjal, 2009). It plays a vital role in the growth and development of plants. It is an essential constituent of metabolically active compounds like protein, nucleic acids, chlorophyll, enzymes etc. When nitrogen is deficient in soil, the size, weight and quality of root crops are poor (Abukutsa, 2007).

Carrot is a deep-rooted crop, able to efficiently extract nitrogen from soil to a depth of several feet. Seasonal nitrogen application varies widely among growers and fields, ranging from as low as 75 kg N/ha to over 250 kg/ha (Ali *et al.,* 2003; Amjad *et al.,* 2005). The yield of carrots depends on the production and translocation of carbohydrates from the leaves to the roots and so nitrogen is important. However high rates of nitrogen should be avoided as this stimulates leaf growth at the expense of root development and yield, delays harvesting and may also lead to increased root splitting (Afsar *et al.,* 2003). Carrots show strong tendency to accumulate nitrates in their tissues (Brunsgaard *et al.*, 2006). Restricted nitrogen fertilization, allows keeping of nitrate concentration in the roots to safe levels which is one of the recommended countermeasures.

2.7 Organic Fertilizers

2.7.1 Overview of Organic Fertilizers

Organic fertilizers are all forms of organic soil amendments that originate from both livestock waste and crop residues, with the nutrients in them being mineralized by soil microbes that slowly make them available to plants over a long period of time (Lampkin, 2000; FSSA, 2003). Organic fertilizers supply humus to the soil, making the nutrient and water holding

capacity of the soil more than that of inorganic fertilized soil. This higher capacity as well as low solubility of organic fertilizer leads to slow leaching of nutrients such as nitrogen from the soil (Rembialkowska, 2003). However organic fertilizers contain mineral nutrients in the form of complex organic molecules and the levels of nutrients are much lower than inorganic fertilizers (Palm *et al.,* 1997). Despite their slow release of nutrients they offer good soil management practice in sustainable crop production because soil fertility is enhanced through the modification of soil physical, chemical and biological properties (Haering and Evanylo, 2005). In addition, humus added by organic fertilizers adsorbs large quantities of water and makes it available to plants during drought. This feature as well as the capacity to hold nutrients is important for sandy soils which retain very few nutrients and water (Scholl and Nieuwenhuis, 2004). Similarly application of organic fertilizers assist structuring of clay soil to open and admit air penetration to roots and water drainage, both conditions necessary for satisfactory plant growth (Eimhoit *et al.*, 2005).

2.7.2 Effects of Organic Fertilizers on Crop Development

Conventional agriculture frequently relies on targeted short-term solutions to solve nutritional problems. In contrast; organic systems use a strategically different approach, which relies on long-term solutions at the systems level (Stockdale *et al.,* 2001). Rate of nutrient release among organic fertilizers vary and therefore level of growth is either positively or negatively influenced. This could be attributed to the lower levels of nutrients especially nitrogen and phosphorus in organic fertilizers available for plant growth. Vegetables will grow better at a later growth stage and result in higher yields which can be attributed to high nutrient sustainability of organic fertilizer and improved biological properties of the soil (Levy and Taylor, 2003). Yields of arable crops under organic management vary from as little as 50% to more than 95% of those in conventional agriculture (Lampkin and Measures, 2001). A study done by Ouda and Mahadeen (2008) on broccoli using organic fertilizers (chicken, sheep and cow) at four doses (0, 40, 60 and 80 t/ha) and inorganic fertilizer (NPK) at 0, 30 and 60 kg/ha showed that highest yields were obtained when 60 kg inorganic fertilizer and 60 t/ha were combined. However broccoli plants grown in soil amended with organic fertilizer showed a vigorous vegetative growth as compared to chemical fertilizer. Liu and Li (2003) studied the effect of organic and inorganic nutrient solutions on growth and quality of (*Brassica campestris*) in a soilless culture with an application of 50 t/ha manure. The fresh mass of plants treated with an organic solution

was 25.52% higher than those plants treated with an inorganic solution in winter, but in spring, there was no difference because all climatic factors were favourable. Yields of turmeric increased five times with the application of cow manure in dark red and gray soils compared to the control (Hossain and Ishimine, 2007). In contrast, some reports have shown higher yields in inorganic treated vegetables than the organic. The yield of cucumber treated with inorganic fertilizer was higher than that of the organic fertilized crops (Haraldsen *et al.*, 2000). Combined application of inorganic fertilizer (Nitrogen) and organic fertilizer (Orga) produced yields of carrots that were higher than those treated with organic alone (Hailu *et al.*, 2008a).

2.7.3 Effects of Organic Fertilizers on the Quality of Crops

Organically produced vegetables have shown an increase in the concentration of desirable compounds such as vitamins, β-carotene, soluble protein, carbohydrates, total sugars and mineral such as Ca, K, Mg, S and Na and decrease in the concentration of undesirable compounds such as NO^{-3} and Pb as compared to vegetables produced using inorganic fertilizers (Mozafar, 1994). Forking is caused by anything that impedes root growth. This includes nematodes, stones, or heavy, compacted soil, soil insects and nematodes which feed on the growing tip resulting in branching of the carrot root (Fritz, 2007). In organic production of carrots forking has been associated with the use of fresh manure which releases humic acid during its decomposition thus damaging the growing tip of a young carrot (Fritz, 2007).

According to Premsekhar and Rajashree (2009) application of farmyard manure at 20 t/ha gave better fruits with less fibre content and moisture content of 87.4% as compared to the control 88.9%. This indicates that organic matter favors accumulation more dry matter content in fruit compounds. Organic soils maintain uniform soil moisture and nutrients levels, this allows carrots to expand their roots to deeper layers without any interruption. Poultry manure gave the highest root size of 3.46 cm thickness and 19.93 cm length as compared to the control (Ahmad *et al.*, 2006). A Study by Hailu *et al.*, (2008b) on carrots using inorganic and organic fertilizers recorded that 22.71% more reducing sugar in carrots pre-treated with organic fertilizer application than those from the control treatment. However the combined application of urea with organic fertilizers resulted in slightly better accumulation of reducing sugar in carrot than application of organic fertilizer alone.

2.7.4 Nutrient Content of Organic Fertilizers

Organic fertilizers are derived from different raw materials thus, the variability in their nutrient composition (Lekasi, 2000). The composition of farmyard manure depends very much on the quality of animal feed. The richer the feed in proteins, the richer the manure will be in nitrogen. Similarly, the more phosphorus and potassium there is in the feed, the more of these constituents there will be in the organic fertilizer. Organic fertilizer composition also varies with its age and the extent to which it is exposed to air. When exposed and allowed to dry out, much of the nitrogen in the organic fertilizer may undergo volatilization. Potassium may also be lost from the manure through leaching action of rain water (Okalebo *et al.*, 2006). Application of well decomposed manure or compost will supply nutrients for optimum crop growth (Taiz and Zeiger, 1991). If not well decomposed, nitrogen will be utilized by soil microbes during decomposition process leading to nitrogen losses. Incorporated plant residues can be an important source of nutrients in organic farming. Different quantities of N, P, K and micro nutrients are removed and returned to the soil depending on the crop species (Sylvester-Bradley, 1993).

Continued application of composts and manures in soil will increase P levels (Sharpley and Moyer, 2001). However in soils already high in P, addition of composts and manures carries with it a risk of P runoff. Baziramakenga *et al.*, (2001) demonstrated that a composted mixture of paper sludge and poultry manure increased the extractable P and K in soils. Potassium remains in water-soluble forms in compost and manures and thus does not need to be mineralized before becoming available to plants. However, it becomes at risk of being leached during the composting process thus often rendering compost a poor source of K (Barker, 1997). Incorporation of low C:N ratio residues of fresh plant material, manures or composts leads to rapid mineralization and a large rise in soil mineral N. Other benefits of organic fertilizers are to provide other non-NPK nutrients. Warman and Cooper (2000) concluded that, the effect of application of composted and non-composted poultry manure on soil nutrient levels was generally similar. However, calcium levels in the topsoil were significantly higher from the composted manure. The low N: P ratio of organic fertilizers is a great challenge in organic farming (Eghball and Power, 2002).

2.7.5 Quality of Organic Fertilizers

Supply of adequate nutrients for optimum crop growth will depend on the quality of the manure. One way of achieving this is through composting process. This process could be defined as a biotechnology where micro-organisms, worms and insects participate to produce an innocuous product, chemically stable and utilizable to improve soil fertility and crop production. (Brito *et al.*, 2009). Composting depends on a number of factors that have both direct and indirect influence on the activities of the micro-organisms. These factors include the type of raw material being composted, its nutrient composition, moisture content, temperature, acidity or alkalinity and aeration. The micro-organisms that do much of the work need high temperatures, plenty of oxygen, and moisture. In the traditional method of composting, the influence of the listed factors had been largely ignored and therefore the final composts obtained from such unimproved method are poor in quality (Paredes *et al.*, 2005).

Compost has been proposed as a means of simultaneously diverting organic materials from landfills while producing a valuable product that improves tilth, organic matter content and nutrient supply of agricultural soils (Levy and Taylor, 2003). However different composting methods have a great influence on the quality of the fertilizer. A study by Taiwo and Oso (2004) showed that, passive aeration composting method using a plastic barrel of 2.5 m diameter and 3 m length produced good quality compost in 5 weeks compared to the conventional pit method which lasted for over 21 weeks. If compost is not well decomposed, it will continue with the decomposition process leading to nutrient immobilization (Lampkin, 2000). The effectiveness of good quality organic fertilizer can be increased by combining it with other important factors such as availability of water, soil characteristics such as; type, depth, pH, slope percentage and temperature and timing of cultural practice (Grubinger, 1999).

2.8 Bioslurry as a Source of Organic Fertilizer

Anaerobic digestion is an important means of organic waste management for several good reasons. It helps to convert a large part of degradable organic carbon to biogas to be used for energy, and it reduces pathogens and minimizes odors while allowing most nutrients to remain in the digested material (Rubaek, 1996). By the end of 1950s many researchers had already reported that manure production by anaerobic digestion was more efficient in nitrogen conservation than aerobic methods (Gurung, 1997).

Biogas is generated through the anaerobic digestion of a cultivar of organic materials. During the anaerobic fermentation process, about 25 to 30% of the organic matter from the faecal matter is converted into biogas while the rest becomes available as a residual manure (bio-slurry) which is generally considered to be rich in major plant nutrients (NPK) as well as in micro nutrients such as zinc, iron, manganese and copper, which are generally in short supply in many soils (Isam, 2006; Thu, 2007). In addition bioslurry is used as fish and pig feed (Razzak, 2006). Application of bioslurry as organic fertilizers and animal feed has plenty of benefits comprising investment reduction, production increase and improvement of sustainable agriculture development for the future (Islam and Momin, 2004). Anaerobic digestion kills more weed seeds than any manure processing system. It is not the methane that kills the seeds; it just inhibits germination but most importantly, the free ammonia kills the seeds (Tripathi, 1993). On the other hand farmyard manure if left as open pool manure loses nutrients, most importantly, nitrogen, and thus possesses relatively lower manurial value. Fresh dung also contains viable weed seeds that compete with the crops and requires farmers to put extra labour and environmental preservation. Even if some of the weed seeds remain viable after anaerobic digestion, subsequent composting of the manure will destroy the viability of these remaining seeds (Karki *et al.*, 1996).

Mineralization rate of nitrogen is higher in bioslurry than in undigested manure; with nitrogen losses during conventional manure processing at 18% or higher, anaerobic processing of manure seems very attractive, because in principle, nitrogen losses during this processing can be zero. Moreover, it may be expected that manure processed in anaerobia conditions contains a large amount of nitrogen that is readily assimilated by plant, though also potentially phytotoxic, for plants as a nitrogen source (Karki, 1997). Similarly, organic acids, which are intermediates of anaerobic degradation, are potentially phytotoxic, and because they are microbial substrates, enhance microbial growth and thereby deplete soil oxygen and cause immobilization of soil nitrogen (Sudradjat, 1990).

Aerobic post-treatment can be used to ensure the maturation of anaerobically digested material and reduce the content of volatile inhibitors such as ammonia and organic acids (Sudradjat, 1990 and Vermeulen *et al.*, 1992). This process, however, can also result in a significant loss of nitrogen through volatilization of ammonia (Salminen, 1999). To minimize emissions of volatile compounds and loss of ammonia during storage and spreading of treated

materials, the storage tank and handling systems should be covered, and emissions should be recovered. Faridpur Muslim Mission (2006) has been using raw bioslurry at about 3000 litres/ha for growing various vegetables in its farm. The yields obtained for Indian spinach, red amaranth, cucumber, cabbage, cauliflower, brinjal, tomato and radish are comparable with those obtained from recommended doses of chemical fertilizers. Salminen *et al.*, (2001) investigated the effectiveness of anaerobically digested poultry slaughterhouse waste as fertilizer in agriculture. The digested material appeared rich in nutrients and minerals and low in heavy metals. The root length (4.9 mm) and the length of aboveground vegetation (9.3 mm) of carrot in digested material statistically equaled those in commercial fertilizer of root length (6.8 mm) and above ground length (10.3 mm). According to Gupta (1991), overall percentage increase in yield from crops treated with bioslurry was 40 percent higher than the control. Application of biogas slurry manure gave best results in vegetable crops such as tomato and brinjal followed by maize and pigeon pea. Karki (2001) studied the effect of bioslurry compost application of 20 t/ha and 10 t/ha on cabbage and maize respectively and the results showed that slurry compost yield was 36.2% and 23% higher respectively over control.

2.9 *Tithonia diversifolia* Hemsl. as a Source of Nutrients to Crops

Tithonia diversifolia Hemsl. commonly known as Mexican sunflower is a shrub belonging to the family Asteraceae. Tithonia originated from Mexico, and it is now widely distributed throughout the world (Sonke, 1997). It commonly grows along fields and farm boundaries as well as along roads, producing large quantities of leaf biomass and tolerates regular pruning (Buresh and Niang, 1997). The reported uses of tithonia are, as an ornamental plant, fodder (Ademiluyi and Omotoso, 2007), insecticide (Akanbi *et al.*, 2007), nematicide and for soil fertility improvement (Jama *et al.*, 2000). Tithonia is not a legume, and it does not biologically fix atmospheric N_2 but obtains its N and other nutrients through effective retrieval of nutrients from the soil. The transfer of tithonia biomass to fields, therefore, constitutes the cycling of nutrients within the farm and landscape rather than a net input of nutrients to the system (Jama *et al.*, 2000).

Green biomass of tithonia as compared to green biomass of other shrubs and trees is relatively high in nutrients and on average contains 3.5% N, 0.37% P and 4.1% K on a dry weight basis (Jama *et al.*, 2000). Tithonia accumulates as much N comparable to those found in nitrogen fixing leguminous shrubs and trees, whereas the P and K concentrations are higher than

those typically found in shrubs and trees (Gachengo, 1996; Jama *et al.*, 2000). Tithonia decomposes and releases its nutrients rapidly with a half-life of about one week for the disappearance of dry matter in the rainy season. Tithonia also has high water content of green biomass, lignin (6.5%) and extractable polyphenols (1.6%) concentration that are below levels that significantly reduces decomposition (Gachengo *et al.*, 1999). The high N concentration and rapid decomposition of green tithonia biomass makes it an effective source of N for crops (Gachengo *et al.*, 1999) leading to a rapid increase in soil inorganic N. Phosphorus release from soil incorporated with green biomass of tithonia is also rapid, and it can supply plant-available P at least as effectively as an equivalent amount of P from soluble fertilizer (Nziguheba and Mutuo, 1998).

A study in western Kenya by ICRAF (1998), compared green biomass of tithonia with mineral fertilizers (urea, triple superphosphate and potassium chloride) at three rates of N, P and K. The ratio of added NPK was 10:1:10 for the three application rates, which corresponded to tithonia dry matter rates of 0.9, 1.8 and 3.6 t/ha. Maize yield tended to be higher with *Tithonia diversifolia* than mineral fertilizer. Akanbi *et al.*, (2007) studied the effects of composted extract of *Tithonia diversifolia* as foliar spray on *Telfairia occidentalis* Hook F. (flutted pumpkin).The vine length and number of primary vines of soil incorporated with NPK and tithonia extract nourished plants were not significantly different. Gachengo (1996) demonstrated increased maize yield following incorporation of fresh tithonia biomass at the equivalent of 5 t/ha dry matter on a site deficient in N, P and K in western Kenya. According to Liasu *et al.* (2008), soils supplemented with fortified tithonia mulch gave the highest number of okra fruits and total fruit weight as compared to those from soils supplemented with inorganic fertilizer and control. Mutuo *et al.* (2000) reported that 5 Mg/ha of tithonia had higher residual effects (50 % yield increase) than other treatments that had yield increases of about 30 % above the control in western Kenya. Application of 5 Mg/ha from tithonia biomass gave significantly higher yield (5.7 Mg/ha) than sole application of fertilizer in maize (4.7 Mg/ha) (Nziguheba and Mutuo, 1998). Aguyoh *et al.*, (2010) reported a significant and positive correlated increase in total yield of watermelon with increasing application rates of *T. diversifolia* manure. In this study, tithonia application enhanced the total yield of watermelon by between 8.5% and 31% compared to the control.

Nziguheba et al. (1998) reported that incorporation of green tithonia biomass equivalent to 5 t/ha to an acid soil in western Kenya increased P in soil microbial biomass and reduced P sorption by soil. In this study, the plots were kept free of weeds and not cropped in order to eliminate plant uptake of P as a factor affecting soil P fractions and processes. Increased P in soil microbial biomass at two weeks after tithonia incorporated into the soil was indicated enhanced biological cycling and turnover of P in labile pools of soil P. The reduction in P sorption following application of tithonia results from production of organic acids during tithonia decomposition, which temporarily bind to the oxides and the hydroxide surfaces of clay particles (Iyamuremye and Dick, 1996).

The major challenge of using tithonia as a source of nutrients is its mechanism on acquisition of nutrients and yet it is a non-nitrogen fixing plant. Research should be done on the process of nutrient acquisition and redistribution of nutrients through tithonia biomass.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at Horticulture Research and Teaching Field, Egerton University, Njoro. The farm lies at a latitude of 0° 23' South, longitudes 35° 35' East in the Lower Highland III Agro Ecological Zone (Jaetzold and Schmidt, 1983) with an altitude of approximately 2,238 meters a.s.l. Average maximum and minimum temperatures range from19 to 22°C and 5 to 8°C, respectively with a total annual rainfall ranging from 1200 to 1400 mm (Egerton Metrological Station, 2010). The soils are predominantly vitric mollic Andosols (Kinyanjui, 1979). The total amount of rainfall and temperature during the experimental period is shown in figure 1.

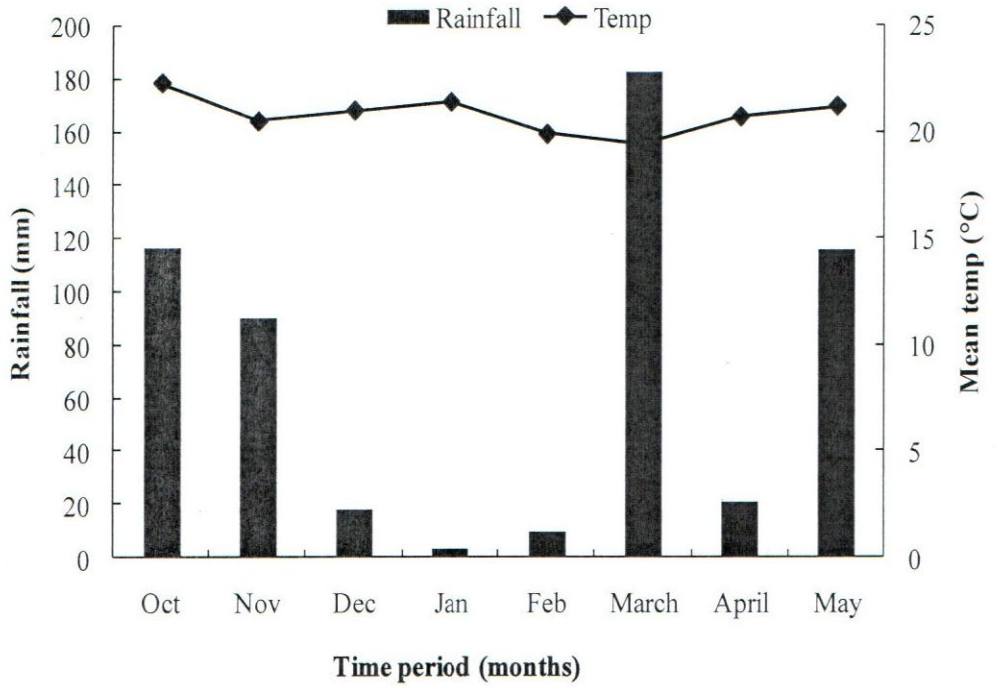


Figure 1. Rainfall and Temperature during the Study period (Source- Egerton University Engineering Meteorological Station, 2010 - 2011).

The total monthly rainfall received at the site for season 1 was 116.7 mm, 90.3 mm, 18.1 mm and 3.3 mm in October, November, December and January 2010 - 2011, respectively and for season 2 was 9.6 mm, 182.3 mm, 20.9 mm, 116 mm in February, March, April and May 2011, respectively giving totals of 228.4 mm in season 1 and 328.5 mm in season 2. The mean

maximum and minimum temperatures for season 1 were 21.4°C (January) and 20.5°C (November) while for season 2 were 21.2°C (May) and 19.4°C March, respectively. Mean temperature for season 1 and 2 were 21.3°C and 19.3°C respectively.

3.2 Design and Treatments Application

The study was a factorial experiment in a Randomized Complete Block Design (RCBD) with three replication. Two factors were studied (application of decomposed bioslurry and decomposed tithonia manure) each at four levels. Basing on the recommended nitrogen fertilizer rates of 75 kg N/ha for carrots as reported by Amjad *et al.*, (2005), decomposed bioslurry manure rates of 0, 2.6, 5.2 and 7.8 t/ha and decomposed tithonia rates of 0, 1.5, 3.0 and 4.5 t/ha were used to determine the treatment combinations. These rates were attained after putting into consideration the initial soil chemical analysis (0.23% N) and chemical composition of decomposed cow bioslurry manure (1.45% N) and decomposed tithonia (2.5% N). Treatment combinations are shown in table 1 below.

Table 1. Treatment combinations of decomposed tithonia and bioslurry manures

Treatments	F_1	F_2	F_3	F_4
T_1	T_1F_1	T_1F_2	T_1F_3	T_1F_4
T_2	T_2F_1	T_2F_2	T_2F_3	T_2F_4
T_3	T_3F_1	T_3F_2	T_3F_3	T_3F_4
T_4	T_4F_1	T_4F_2	T_4F_3	T_4F_4

F_1-Decomposed bioslurry manure rate (0 t/ha), F_2-Decomposed bioslurry manure rate (2.6 t/ha) F_3-Decomposed bioslurry manure rate (5.2 t/ha), F4-Decomposed bioslurry manure rate (7.8 t/ha), T_1-Decomposed tithonia manure rate (0 t/ha), T_2-Decomposed tithonia manure rate (1.5 t/ha), T_3-Decomposed tithonia manure rate (3.0 t/ha) and T_4-Decomposed tithonia manure rate (4.5 t/ha).

The experiment covered an area of 23.5 m by 6.5 m with individual blocks measuring 23.5 m by 1.5 m separated by a 1 m buffer. Individual plots within a block were 1.5 m by 1 m (1.5 m^2) with an inter-plot spacing of 0.5 m. The field layout is shown in figure 2.

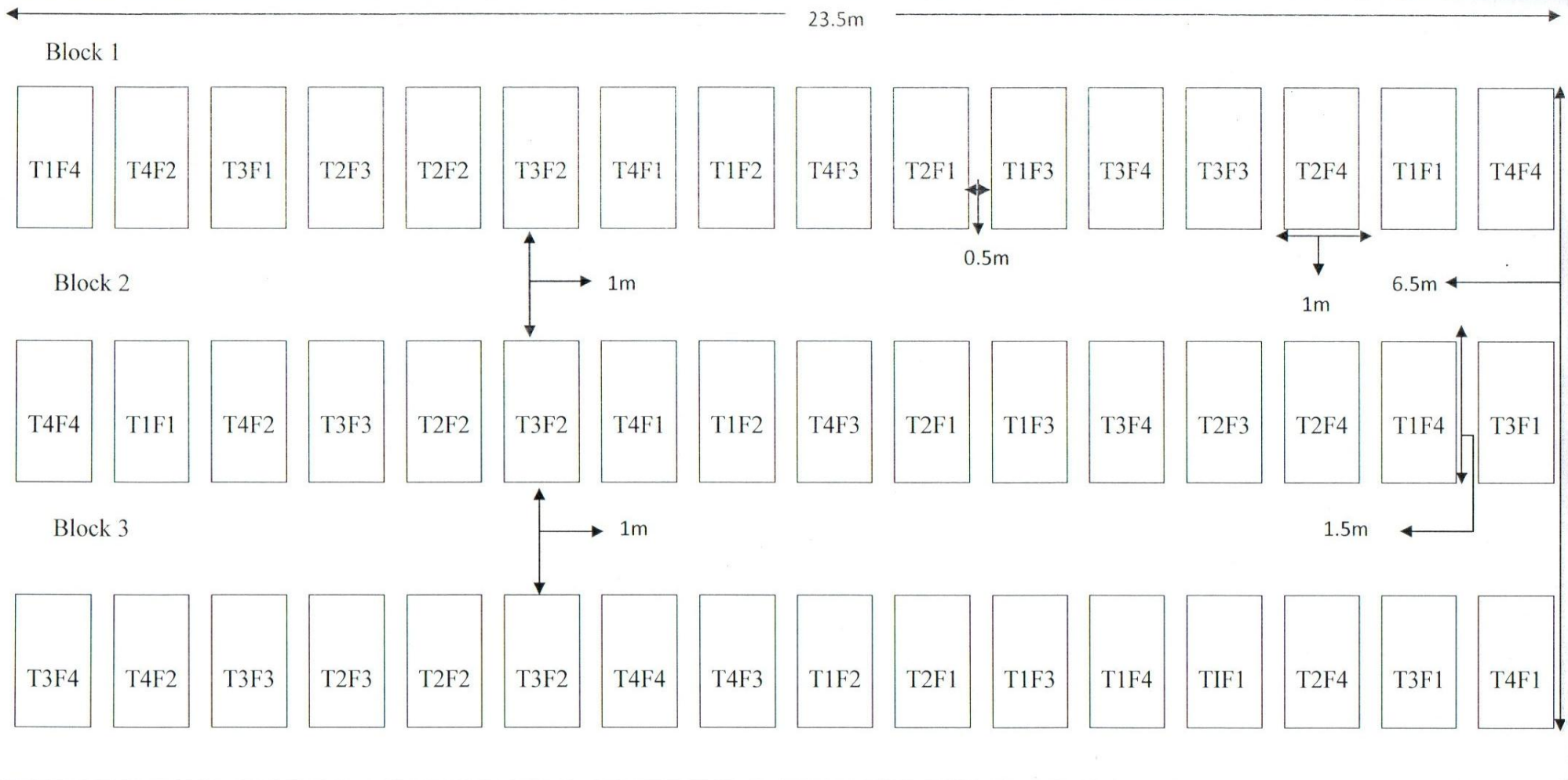


Figure 2. Experimental Layout Showing Randomized Complete Block Design

3.3 Compost Manure Preparation

Manures were decomposed using the passive aeration composting technique as described by Taiwo and Oso (2004). Plastic barrels measuring 2.5 m diameter and 3 m long with 9 holes perforated at intervals of 30 cm apart on the bottom sides was used for composting. Aeration was provided passively through open-ended air intake plastic pipes (5.0 cm in diameter) that were inserted into the holes through which fresh air flowed. Another plastic pipe was inserted vertically, half way into the plastic barrel to enable warm air generated through biological oxidation to escape. *Tithonia diversifolia* fresh biomass and bioslurry manure were moistened and placed into the plastic barrels until complete decomposition was attained.

3.4 Soil and Manure Analysis

For initial soil characterization, the top 0-15 cm of the soil profile was sampled following a zigzag sampling design at various points across the entire experimental field using a soil auger after which a composite sample was derived for chemical analysis. At the end of each trial, other soil samples were taken from each plot from within the top 0-15 cm. The soil and manure samples were air dried, sieved and their nutrient composition analyzed. The soil pH was measured using pH meter (Fisher Accument®). Total nitrogen was determined following Kjeldah method as described by Okalebo *et al.*, (2002). Potassium was determined by use of an Atomic Absorption Spectrophotometer (AAS) as described by Okalebo *et al.* (2002). P was determined calorimetrically using Spectrophotometer (Novaspec® II). Organic carbon was determined using Walkey black method. Soil analysis was conducted at Egerton University Soil Analysis Laboratory. Initial soil analysis and chemical composition of bioslurry and tithonia manure results are shown in Table 2 and 3, respectively.

Table 2. Initial soil analysis from the experimental site

Parameters	Composition
pH (H_2O)	5.86
pH (KCl)	5.42
Total Organic Carbon (%)	1.73
Total N (%)	0.23
Available P (%)	0.16
Exchangeable K (%)	0.10
Exchangeable Ca (%)	0.06
Exchangeable Mg (%)	0.03

Table 3. Chemical composition of bioslurry and tithonia manures

Parameters	Bioslurry	Tithonia
pH (H_2O)	8.42	7.89
pH (KCl)	7.39	6.83
Organic Carbon (%)	33.57	29.44
Total N (%)	1.45	2.50
Total P (%)	1.03	0.32
Total K (%)	1.78	3.20
Total Ca (%)	0.88	0.60
Total Mg (%)	0.45	0.44

3.5 Planting Material

Daucus carota cv. Nantes seeds were sourced from Kenya Seed Company suppliers, Nakuru. This cultivar is the most preferred due to its sweet taste and excellent colour.

3.6 Land Preparation and Planting

Land was manually ploughed to a depth of 30 cm and prepared into a fine tilth. Raised beds of 1.5 m by 1 m and 15 cm high were then prepared. Different combinations of tithonia manure at 0, 0.56, 1.12 and 1.68 kg/plot and bioslurry manure at 0, 1.95, 3.90 and 5.85 kg/plot were spread on individual plots based on treatment before being worked in/incorporated thoroughly into the soil. The soil was then moistened to field capacity. Leveling was done using a rake. Seeds were then drilled to a depth of 1 cm in rows spaced at 20 cm. Thinning was done two weeks after emergence of the crop to attain the recommended spacing of 5 cm between the plants (Sarkindiya and Yakubu, 2006), giving a total of 78 plants per plot.

3.7 Routine Plant Maintenance Practices

The following cultural practices were applied uniformly to all the plots throughout the growing period. Water was continuously applied to field capacity during the growth period on need basis. Continuous weeding by hand pulling was performed to ensure clean fields. Pests and diseases were controlled using the recommended chemicals. Earthing up of carrot shoulders was done frequently to protect them from direct sunlight which causes undesirable green colouration.

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3.8 Data Collection

The different parameters measured were:

3.8.1 Growth Parameters

Height of carrot plants were measured using a ruler from the ground level to the top of the shoot fortnightly and recorded in centimeters. The numbers of fully developed leaves of carrots were counted every two weeks from final thinning.

3.8.2 Physiological Measurement

Forty six days after emergence, fully developed leaves of three tagged plants per plot were used to determine chlorophyll content and stomatal conductance (mmol/m^2s using chlorophyll meter (Minolta SPAD 502® Meter) and Decagon SC-1® Leaf Porometer, respectively, on a fortnightly basis until just before harvesting.

3.8.3 Biomass and Yield Parameters

Total biomass was determined after harvest using five plants which were randomly selected from each plot. The harvested plants shoots were detached from the roots and oven dried separately at 70°C to constant weights. Data obtained were used to compute the total biomass and the harvest index using the formulae;

Total biomass (g/plant) = above Ground Biomass+ below Ground Biomass

Where; above ground biomass is the dry weight of the shoots and below ground biomass is the root dry weight.

Harvest index was computed using the equation shown below;

$$Y = \frac{M}{X} \quad \text{.....Equation (1)}$$

Where; Y is the harvest index, M is the economic yield and X is the total biomass

Twenty carrot plants were randomly taken as a representative sample for determination of total fresh root weight per plot at one hundred and twenty days after planting using a weighing scale balance. Obtained weights were recorded in kg/plot and later converted to ton/hectare. A sample of 5 carrots per treatment was randomly selected for determination of the root volume using water displacement method and volume recorded in cm^3.

3.8.4 Quality Parameters

a. Root Length, Shoulder and Core Diameter

From sixty days after planting, destructive sampling was carried out fortnightly where three carrot roots were picked out of seventy eight roots at random per plot and the carrot root length determined using a ruler starting from the shoulder to the end of the root tip. The shoulder and core diameter of roots were also measured at 0.5 cm from the top of the shoulder using a vernier caliper and a ruler, respectively and measurements recorded in centimeters.

b. Unmarketable Carrots

In this study carrots considered unmarketable were those that were forked, deformed and cracked. Such carrots were counted from a random sample of 15 carrots per treatment and presented as a percentage of the total number.

c. Total Soluble Solids and Firmness Determination

Three carrot root were picked at random per treatment from which total soluble solids were determined fortnightly using a refractometer 0-30 % Brix (RHW Refractometer Optoelectronic Technology Company) so as to establish the changes in total soluble solids at different plant ages. After harvest five roots were used to determine firmness, and thereafter the total soluble solids using penetrometer model FT 327 (3-27Lbs) and refractometer 0-30% Brix (RHW refractometer optoelectronic technology company), respectively. This was done at one week interval from 0 to 14 days after harvesting.

d. Weight Loss

Five carrot roots were used to determine weight loss where periodical weighing of roots at seven days interval for up to the 21st day (0, 7, 14 and 21 days) after harvesting was done adopting the method described by Tefera *et al.*, (2007). The differential weight losses was calculated for each interval and converted into percentage by dividing the change with the initial weight recorded on the preceding week.

3.9 Data Analysis

Data obtained were subjected to Analysis of Variance (ANOVA) using Proc GLM code of SAS (SAS Institute, 2002) and mean separation carried out using Turkey's Honestly Significant Difference Test at $P \leq 0.05$. Regression and correlation analyses were done using PROC REG and PROC CORR code of SAS, respectively at $P \leq 0.05$ to determine other relationships between response variables and treatments.

The RCBD model fitted for the experiment was:

$Y_{ijkl} = \mu + \rho_i + S_j + \alpha_k + \beta_l + S\alpha_{jk} + S\beta_{jl} + \alpha\beta_{kl} + S\alpha\beta_{jkl} + \varepsilon_{ijkl}$

$i = 1, 2, 3; k = 1, 2, 3, 4; i = 1, 2, 3, 4; j = 1, 2$

Where,

Y_{ijkl} -Crop response

μ -grand mean,

ρ_i -i^{th} blocking effect,

S_j -j^{th} seasonal effect,

α_k -k^{th} effect of decomposed bioslurry manure rates,

β_l -l^{th} effect of decomposed tithonia manure rates,

$S\alpha_{jk}$ -effect of interaction of seasonal variations and decomposed bioslurry manure rates,

$S\beta_{jl}$ -effect of interaction of seasonal variations and decomposed tithonia rates,

$\alpha\beta_{kl}$ -effect of interaction of decomposed bioslurry rates and decomposed tithonia rates,

$S\alpha\beta_{jkl}$ -effect of interaction of seasonal variations, decomposed bioslurry rates and decomposed tithonia manure rates,

ε_{ijkl} -random error component which are normally and independently distributed about zero means with a common variance σ^2.

CHAPTER FOUR

4.0 RESULTS

In this chapter results obtained are presented following the order; growth parameters, physiological parameters, biomass and yield parameters, quality parameters, soil properties and plant tissue nutrient content

4.1 Growth Parameters

4.1.1 Effects of Tithonia and Bioslurry Manure on Carrot Plant Height

Carrot plant height was generally influenced by tithonia and bioslurry manure levels at the different sampling dates in both seasons. The interaction between tithonia and bioslurry levels at the different sampling dates was also significant in both seasons. In response to manure levels, a general trend of increase in plant height with successive increase in bioslurry and tithonia manure application was observed. Main effects of tithonia levels were significant in all data collection days in season 1 except at 45 DAP while in season 2, the effect of tithonia levels was significant only at 55 and 65 DAP (Table 4). In these data collection days, heights were significantly higher for plants treated with 4.5 t/ha of tithonia over the control treatment. Plants treated with 1.5 and 3.0 t/ha of tithonia also tended to be taller than control plants, although the difference was not significant in most data collection days.

On the other hand, bioslurry manure influenced plant height throughout the study period except at 45 and 75 DAP in season 2 (Table 5). In both seasons 1 and 2, plant height was promoted most at the highest level (7.8 t/ha) of bioslurry application with the shortest plants recorded under control treatment. Similar to tithonia effects, plants treated with intermediary levels of bioslurry manure yielded taller plants than the control treatment although the difference was not significant in most data collection days in both seasons.

In most sampling dates, the interaction between tithonia and bioslurry manure on plant height was significant in both seasons (Table 6). During the first sampling date (45 DAP) no differences in height of plants treated with the different manure level combinations were observed in both seasons. Beyond 45 DAP, plant height was significantly influenced by manure level combinations. A general trend could be established at any given bioslurry or tithonia level with changing levels of the other factor. At any given tithonia level, plant height generally increased with increase in bioslurry level with greatest change in height observed when bioslurry level was increased from 0 t/ha to 2.6 t/ha. A similar trend was also established at each given

bioslurry levels with changing levels of tithonia. In both seasons, combined application of 4.5 t/ha of tithonia and 7.8 t/ha of bioslurry resulted in the tallest plants. Across seasons, plants in season 2 grew generally taller (49.34 cm) than those of season 1 (38.28 cm).

Table 4. Effect of tithonia manure on carrot plant height (cm)

		Days after planting					
Tithonia (t/ha)	**Season**	45	55	65	75	85	95
0	S_1**	12.67b*	20.06e	26.13e	30.72d	34.03c	35.70c
1.5	S_1	12.49b	21.13de	29.14d	36.62c	37.68bc	38.23bc
3.0	S_1	13.24b	22.23de	31.82d	37.16c	37.56bc	38.32bc
4.5	S_1	12.80b	22.85cd	35.10c	39.78bc	40.97b	40.88b
0	S_2	21.06a	24.96bc	36.34bc	43.30a	47.41a	47.83a
1.5	S_2	21.70a	26.54ab	38.42ab	44.00a	47.08a	48.25a
3.0	S_2	21.78a	27.15ab	38.34ab	44.89a	49.54a	50.69a
4.5	S_2	21.87a	27.48a	39.51a	46.34a	48.40a	50.59a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

Table 5. Effect of bioslurry manure on carrot plant height (cm)

		Days after planting					
Bioslurry (t/ha)	**Season**	45	55	65	75	85	95
0	S_1**	11.78c*	19.56e	25.89d	32.13e	34.69d	35.86d
2.6	S_1	12.74bc	21.36de	30.01c	35.43de	37.28cd	37.93cd
5.2	S_1	13.56b	21.87de	31.53c	36.97cd	37.75cd	38.14cd
7.8	S_1	13.11bc	23.50cd	34.76b	39.76bc	40.33c	41.19c
0	S_2	20.96a	24.89c	34.70b	42.86ab	45.84b	46.44b
2.6	S_2	21.41a	25.14bc	37.98a	43.40ab	46.22b	47.84b
5.2	S_2	21.66a	27.43ab	39.55a	46.09a	48.28ab	49.83ab
7.8	S_2	22.38a	28.40a	40.39a	46.19a	52.09a	53.26a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

Table 6. Interaction effects of tithonia and bioslurry manure on carrot plant height (cm) at the different sampling dates

			Days after planting					
Tithonia (t/ha)	**Bioslurry (t/ha)**	**Season**	45	55	65	75	85	95
0	0	S_1**	10.90b*	15.85k	20.00h	22.80i	27.62k	31.62j
	2.6	S_1	12.46b	20.83hijk	27.92fg	32.62gh	37.16ghijk	38.55efghij
	5.2	S_1	13.34b	21.35efghijk	27.31g	32.74gh	34.69ijk	34.98ij
	7.8	S_1	14.00b	22.21cdefghij	29.30efg	34.75efgh	36.64hijk	37.64ghij
1.5	0	S_1	11.98b	20.01jk	27.76fg	34.80efgh	36.80hijk	37.17ghij
	2.6	S_1	12.40b	21.31efghijk	29.25efg	36.24defgh	38.19efghij	38.67efghij
	5.2	S_1	13.02b	21.20fghijk	29.31efg	38.49bcdefgh	38.50defghij	39.52defghij
	7.8	S_1	12.59b	22.02cdefghijk	30.22defg	36.95cdefgh	37.22ghijk	37.55ghij
3.0	0	S_1	12.44b	21.45defghijk	29.08efg	36.38defgh	37.73fghijk	38.31fghij
	2.6	S_1	12.40b	20.54ijk	27.83fg	32.19hi	32.37jk	33.22ij
	5.2	S_1	14.30b	22.17cdefghij	31.65cdefg	37.28bcdefgh	38.43defghij	39.34efghij
	7.8	S_1	13.83b	24.78abcdefghij	38.75abc	42.80abcdef	41.70bcdefghij	42.41cdefghi
4.5	0	S_1	11.84b	20.92ghijk	26.72gh	34.55fgh	36.62hijk	36.65hij
	2.6	S_1	13.73b	22.75bcdefghij	35.02bcdef	40.68abcdefgh	41.41cdefghij	41.28cdefghi
	5.2	S_1	13.60b	22.78bcdefghij	37.86abc	39.37abcdefgh	39.37defghij	38.73efghij
	7.8	S_1	12.03b	24.97abcdefghij	40.80ab	44.55abcde	45.77abcdefgh	47.17abcdef
0	0	S_2	19.50a	21.38efghijk	29.95defg	39.07abcdefgh	43.18abcdefghi	41.89cdefghi
	2.6	S_2	20.29a	24.00abcdefghij	38.25abc	44.28abcdef	47.43abcdefgh	47.80abcde
	5.2	S_2	22.26a	27.17abcdefg	38.31abc	45.92abc	47.22abcdefg	49.21abc
	7.8	S_2	22.19a	27.30abcdef	38.84abc	43.94abcdef	51.80ab	52.45ab
1.5	0	S_2	21.66a	26.73abcdefghi	37abcd	42.60abcdef	43.92abcdefghi	45.21bcdefgh
	2.6	S_2	21.20a	24.81abcdefghij	35.33abcde	42.73abcdef	45.06abcdefgh	46.03bcdefg
	5.2	S_2	21.05a	26.94abcdefgh	39.95ab	44.78abcd	47.85abcdef	49.85abc
	7.8	S_2	22.88a	27.68abcd	41.42ab	45.87abcd	51.47abc	51.93ab
3.0	0	S_2	21.13a	26.25abcdefghij	36.19abcde	44.39abcde	47.89abcdef	49.77abc
	2.6	S_2	22.03a	25.35abcdefghij	38.55abc	42.32abcdefg	47.94abcdef	49.65abc
	5.2	S_2	21.13a	28.19abc	39.70ab	46.65abc	49.62abc	50.36abc
	7.8	S_2	21.85a	28.83ab	38.92ab	46.21abc	52.73a	52.99ab
4.5	0	S_2	21.55a	25.20abcdefghij	35.66abcde	45.38abcd	48.37abcde	48.89abcd
	2.6	S_2	22.13a	27.48abcde	39.77ab	44.25abcdef	44.44abcdefghi	47.90abcde
	5.2	S_2	21.20a	27.43abcdef	40.24ab	47.00ab	48.44abcd	49.90abc
	7.8	S_2	22.61a	29.80a	42.37a	48.74a	52.37a	55.70a
		S_1 means	**12.8b**	**21.57b**	**30.55b**	**36.07b**	**37.51b**	**38.28b**
		S_2 means	**21.60a**	**26.53a**	**38.15a**	**44.63a**	**48.11a**	**49.34a**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$. ** S stands for Season

4.1.2 Effects of Tithonia and Bioslurry Manure on Carrot Leaf Numbers

Tithonia and bioslurry manure generally influenced carrot leaf numbers at the different data collection days in both seasons. The interactive effects of tithonia and bioslurry manure levels were also significant in all data collection days in both seasons.

Application of both tithonia and bioslurry manure generally resulted in an increase in leaf numbers. The lowest and highest number of leaves was observed in control and plants subjected to highest level (4.5 t/ha) of tithonia manure, respectively in all days of data collection in season 1 except at 45 DAP. In season 2, effect of tithonia levels was significant only at 55, 85 and 95 DAP (Table 7). Plants treated with 1.5 and 3.0 t/ha had slightly more leaves than control plants. A general increase in leaf number with increasing levels of tithonia manure was observed in both seasons.

Contrary to the effect of tithonia, bioslurry manure significantly affected carrot leaf numbers at 65, 75, 85 and 95 DAP in season 1. However in season 2, bioslurry effect was not significant in all data collection days (Table 8). In most of the data collection days in season 1, plants subjected to 7.8 t/ha of bioslurry had more number of leaves over control. Plants subjected to 2.6 and 5.2 t/ha of bioslurry manure had slightly higher number of leaves than control plants, even though the difference was not significant in most data sampling dates. Similar to the effect of tithonia manure, a general tendency of increase in leaf numbers was observed following an increase in application rate of bioslurry manure (Table 8).

The interaction between tithonia and bioslurry manure was significant in most data collection dates in both seasons except at 45 DAP in season 1 and 55 DAP in season 2 (Table 9). At any given bioslurry level greatest changes in leaf numbers was realized when tithonia manure level was increased from 0 t/ha to 1.5 t/ha. A similar trend was also established at each given tithonia levels with changing levels of bioslurry with greatest increase in leaf numbers observed when bioslurry manure level was increased from 0 t/ha to 2.6 t/ha.

Plants that were treated with the highest combinations (4.5 t/ha of tithonia and 7.8 t/ha of bioslurry) had more leaves in most data collection days with the control generally giving the lowest number of leaves numerically but statistically not different from some treatment combinations (Table 9). On overall, plants in season 1 had more leaves than plants in season 2, from 45 to 75 DAP with no difference in leaf numbers observed at 85 DAP but by 95 DAP plants in season 2 had more leaves.

Table 7. Effect of tithonia manure on carrot leaf numbers

Tithonia (t/ha)	Season	Days after planting					
		45	55	65	75	85	95
0	S_1**	4.77b*	6.72cd	7.79cd	8.12d	8.00d	7.91d
1.5	S_1	5.42ab	7.73ab	8.77ab	9.16bc	8.93bc	8.33cd
3.0	S_1	5.08ab	7.72ab	8.68abc	9.25b	9.12bc	8.75bcd
4.5	S_1	5.37ab	7.93a	9.41a	10.41a	10.27a	9.27ab
0	S_2	5.00ab	6.12d	7.04d	7.87d	8.58cd	8.87bc
1.5	S_2	5.22ab	6.58cd	7.52d	8.18cd	8.91bc	9.12abc
3.0	S_2	5.52a	6.85bcd	7.60d	8.29bcd	9.20bc	9.39ab
4.5	S_2	5.62a	7.27abc	7.85bcd	8.68bcd	9.68ab	9.81a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 8. Effect of bioslurry manure on carrot leaf numbers

Bioslurry (t/ha)	Season	Days after planting					
		45	55	65	75	85	95
0	S_1**	4.75b*	7.14a	7.89bcd	8.31bcd	8.54b	8.14c
2.6	S_1	5.22ab	7.54a	8.54b	9.18b	9.50a	8.58bc
5.2	S_1	5.22ab	7.72a	8.37bc	9.10bc	8.81ab	8.18c
7.8	S_1	5.44ab	7.71a	9.85a	10.35a	9.47a	9.35ab
0	S_2	5.14ab	6.45b	7.04d	8.06d	8.95ab	8.89abc
2.6	S_2	5.29ab	6.27b	7.50bcd	8.18cd	9.02ab	9.33ab
5.2	S_2	5.47a	7.02ab	7.77bcd	8.31bcd	9.10ab	9.37ab
7.8	S_2	5.45a	7.08ab	7.70bcd	8.47bcd	9.31ab	9.60a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 9. Interaction effects of tithonia and bioslurry manure on leaf numbers of carrot at the different sampling dates

			Days after planting					
Tithonia (t/ha)	**Bioslurry (t/ha)**	**Season**	45	55	65	75	85	95
0	0	S_1**	4.16b*	6.16abc	6.75de	7.58f	7.75e	7.58d
	2.6	S_1	4.91ab	6.66abc	8.16bcde	8.50cdef	8.33de	8.00cd
	5.2	S_1	5.00ab	7.58abc	8.50bcd	8.33cdef	8.16de	8.25bcd
	7.8	S_1	5.00ab	6.50abc	7.75de	8.08def	7.75e	7.83d
1.5	0	S_1	5.33ab	7.66abc	8.58bcd	8.75bcdef	9.33bcde	8.75abcd
	2.6	S_1	5.25ab	7.91abc	8.66bcd	9.33bcdef	9.66abcde	8.50bcd
	5.2	S_1	5.25ab	7.33abc	7.50de	8.25cdef	8.41cde	7.58d
	7.8	S_1	5.86ab	8.03ab	10.33ab	10.33abcde	8.33de	8.50bcd
3.0	0	S_1	4.51ab	7.25abc	7.83cde	8.33cdef	8.41cde	8.00cd
	2.6	S_1	5.33ab	7.66abc	8.25bcde	8.25cdef	8.66cde	8.25bcd
	5.2	S_1	5.16ab	7.66abc	8.50bcd	9.33bcdef	9.00cde	8.50bcd
	7.8	S_1	5.33ab	8.33a	10.16abc	11.08ab	10.41abc	10.25abc
4.5	0	S_1	5.00ab	7.50abc	8.41bcd	8.58bcdef	8.66cde	8.25bcd
	2.6	S_1	5.41ab	7.91abc	9.08abcd	10.66abc	11.33ab	9.58abcd
	5.2	S_1	5.50ab	8.33a	9.00abcd	10.50abcd	9.66abcde	8.41bcd
	7.8	S_1	5.58ab	8.00ab	11.16a	11.91a	11.41a	10.83a
0	0	S_2	4.75ab	5.75bc	5.91e	7.66f	8.50cde	8.16bcd
	2.6	S_2	4.91ab	5.58c	7.33de	7.66f	8.41cde	9.00abcd
	5.2	S_2	5.25ab	7.00abc	7.58de	8.25cdef	8.58cde	9.16abcd
	7.8	S_2	5.08ab	6.16abc	7.33de	7.91ef	8.83cde	9.16abcd
1.5	0	S_2	5.00ab	6.41abc	7.25de	8.16cdef	8.91cde	8.83abcd
	2.6	S_2	5.33ab	6.41abc	7.41de	7.91ef	9.00cde	9.16abcd
	5.2	S_2	5.25ab	6.66abc	7.75de	8.33cdef	8.83cde	9.16abcd
	7.8	S_2	5.33ab	6.83abc	7.66de	8.33cdef	8.91cde	9.33abcd
3.0	0	S_2	5.16ab	6.25abc	7.41de	8.50cdef	8.91cde	9.16abcd
	2.6	S_2	5.58ab	6.33abc	7.66de	8.25cdef	9.08cde	9.33abcd
	5.2	S_2	5.91ab	7.25abc	7.83cde	8.08def	9.50abcde	9.50abcd
	7.8	S_2	5.41ab	7.58abc	7.50de	8.33cdef	9.33bcde	9.58abcd
4.5	0	S_2	5.66ab	7.41abc	7.58de	7.91ef	9.50abcde	9.41abcd
	2.6	S_2	5.33ab	6.75abc	7.58de	8.91bcdef	9.58abcde	9.83abcd
	5.2	S_2	5.50ab	7.16abc	7.91cde	8.58bcdef	9.50abcde	9.66abcd
	7.8	S_2	6.00a	7.75abc	8.33bcd	9.33bcdef	10.16abcd	10.33ab
		S_1 means	**5.16a**	**7.53a**	**8.66a**	**9.23a**	**9.08a**	**8.56b**
		S_2 means	**5.34a**	**6.70b**	**7.50b**	**8.26b**	**9.08a**	**9.30a**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$. ** S stands for Season

4.2 Physiological Parameters

4.2.1 Effects of Tithonia and Bioslurry Manure on Carrot Leaf Chlorophyll Content

Leaf chlorophyll content was affected by tithonia and bioslurry manure levels at the different data collection days in both seasons. The interactions between main factors was also significant.

In season 1, application of tithonia at 4.5 t/ha significantly increased leaf chlorophyll content compared to control treatment in all sampling dates. Except at 102 DAP when leaf chlorophyll content for plants treated with 4.5 t/ha of tithonia manure were significantly higher than those of plants treated with 1.5 t/ha, chlorophyll content following application of 1.5 and 3 t/ha were not any different from those of plants treated with 4.5 t/ha in all other sampling dates. Similarly in season 2, highest leaf chlorophyll content was obtained with application of the highest tithonia level (4.5 t/ha). The difference in chlorophyll content of leaves of plants treated with 4.5 t/ha of tithonia and those of control plants was significant at 60, 74 and 88 DAP. Although leaf chlorophyll content for plants treated with 4.5 t/ha were higher than for the plants treated with 1.5 or 3 t/ha, the differences were not significant in most sampling dates (Table 10).

A general trend was established for bioslurry application with highest and lowest leaf chlorophyll content obtained in plants treated with the highest bioslurry manure level (7.8 t/ha) and control plants, respectively in most sampling dates in both seasons (Table 11). In season 1, leaf chlorophyll contents of plants treated with 7.8 t/ha bioslurry were significantly higher than those of plants treated with all other bioslurry levels at 46 and 102 DAP. However , at 60, 74 and 88 DAP, leaf chlorophyll contents of plants treated with 7.8 t/ha bioslurry were only different from control plants. In season 2, leaf chlorophyll contents remained highest following application of 7.8 t/ha bioslurry in all sampling dates except at 88 DAP when 5.2 t/ha yielded insignificantly higher leaf chlorophyll content. At 74 and 88 DAP, significantly higher levels of leaf chlorophyll were obtained following application of the highest bioslurry manure level of 7.8 t/ha in this season. In all other sampling dates, leaf chlorophyll was not significantly influenced by bioslurry level. Overall, in season 1, a general increase in chlorophyll content over time was observed. Maximum chlorophyll content was attained at 74 DAP for both tithonia and bioslurry manure levels in season 2 (Table 12). At the last date (102 DAP) of data collection leaf chlorophyll content of plants subjected to the highest level of tithonia (4.5 t/ha) and bioslurry

(7.8 t/ha) was lower by 24% and 37%, respectively compared to chlorophyll content at 74 DAP for plants treated with maximum rate of tithonia (4.5 t/ha) and bioslurry (7.8 t/ha) in season 2.

The interactions between combined application of tithonia and bioslurry manure levels influenced the leaf chlorophyll content of carrots at all data sampling dates in both seasons (Table 12). However, a general trend could be established at any given bioslurry or tithonia level with changing levels of the other factor. At any given tithonia level, leaf chlorophyll content generally increased with increase in bioslurry level. A similar trend was also established at each given bioslurry levels with changing levels of tithonia. In season 1, the highest treatment combinations of 4.5 t/ha of tithonia and 7.8 t/ha of bioslurry yielded plants with highest leaf chlorophyll content at 46 and 102 DAP while at 60, 74 and 88 DAP, the combination of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry gave the highest chlorophyll content (Table 12). In all sampling dates during this season, control plants had the lowest leaf chlorophyll content. Similarly, during the second season, the highest treatment combinations (4.5 t/ha and 7.8 t/ha) resulted in the highest chlorophyll content in all days of data collection except at 46 DAP with the lowest chlorophyll content obtained in control plants with no manure applied.

Table 10. Effect of tithonia manure on carrot leaf chlorophyll content (SPAD units)

		Days after planting				
Tithonia (t/ha)	**Season**	46	60	74	88	102
0	S_1**	1.87d*	2.27d	2.28e	2.41c	2.30d
1.5	S_1	2.29c	2.48cd	2.45de	2.72bc	2.68bc
3.0	S_1	2.32c	2.73bc	2.75cd	2.91ab	2.95ab
4.5	S_1	2.36bc	2.73bc	2.77cd	2.95ab	3.03a
0	S_2	2.37abc	2.48cd	2.91bc	2.70bc	2.25d
1.5	S_2	2.42abc	2.79bc	3.36b	3.06ab	2.33d
3.0	S_2	2.61ab	3.04b	3.82a	3.23a	2.35d
4.5	S_2	2.57a	3.50a	4.22a	3.33a	2.43cd

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.
** S stands for Season

Table 11. Effect of bioslurry manure on carrot leaf chlorophyll content (SPAD units)

		Days after planting				
Bioslurry (t/ha)	**Season**	46	60	74	88	102
0	S_1**	1.99b*	2.31c	2.26e	2.40d	2.61b
2.6	S_1	2.15b	2.59bc	2.52de	2.70cd	2.63b
5.2	S_1	2.13b	2.49bc	2.64de	2.80bcd	2.58bc
7.8	S_1	2.57a	2.81ab	2.82cd	3.09abc	3.15a
0	S_2	2.41a	2.77ab	3.22bc	2.67cd	2.26d
2.6	S_2	2.50a	2.95a	3.48ab	3.18ab	2.31cd
5.2	S_2	2.55a	2.98a	3.78a	3.27a	2.38bcd
7.8	S_2	2.74a	3.11a	3.83a	3.20ab	2.4bcd

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.
** S stands for Season

Table 12. Interaction effects of tithonia and bioslurry manure on carrot leaf chlorophyll content (SPAD units)

			Days after planting				
Tithonia (t/ha)	**Bioslurry (t/ha)**	**Season**	46	60	74	88	102
0	0	S_1 **	1.69g*	2.01gh	1.90l	2.10f	2.05e
	2.6	S_1	1.91efg	2.12fgh	2.25kl	2.30def	2.68bcde
	5.2	S_1	1.85fg	2.26efgh	2.43jkl	2.47cdef	2.20de
	7.8	S_1	2.04defg	2.70bcdefgh	2.53hijkl	2.76bcdef	2.30bcde
1.5	0	S_1	2.10cdefg	2.20efgh	2.29kl	2.53cdef	3.00b
	2.6	S_1	2.24bcdefg	2.80bcdefgh	2.40jkl	2.71cdef	2.47bcde
	5.2	S_1	2.20bcdefg	2.55cdefgh	2.51hijkl	2.85bcdef	2.65bcde
	7.8	S_1	2.63abcd	2.35defgh	2.63fghijkl	2.80bcdef	2.62bcde
3.0	0	S_1	2.27bcdefg	2.47cdefgh	2.47ijkl	2.40cdef	2.45bcde
	2.6	S_1	2.25bcdefg	2.86bcdefg	2.86efghijkl	2.87bcdef	3.01b
	5.2	S_1	2.03defg	2.44defgh	2.55ghijkl	2.89bcdef	2.60bcde
	7.8	S_1	2.75ab	3.17abcd	3.12cdefghijk	3.49abc	3.75a
4.5	0	S_1	1.90efg	2.57cdefgh	2.40jkl	2.55cdef	2.96bc
	2.6	S_1	2.19bcdefg	2.58cdefgh	2.60fghijkl	2.93bcdef	2.36bcde
	5.2	S_1	2.46abcde	2.72bcdefgh	3.08cdefghijk	2.99abcdef	2.90bcd
	7.8	S_1	2.89a	3.01abcdef	3.01defghijkl	3.33abcd	3.92a
0	0	S_2	2.17bcdefg	1.97h	2.60fghijkl	2.17ef	2.11e
	2.6	S_2	2.33abcdef	2.48cdefgh	3.07cdefghijk	3.13abcdef	2.18de
	5.2	S_2	2.49abcde	2.65bcdefgh	3.07cdefghijk	3.11abcdef	2.39bcde
	7.8	S_2	2.53abcd	2.84bcdefgh	2.92efghijkl	2.40cdef	2.30bcde
1.5	0	S_2	2.33abcdef	2.79bcdefgh	3.07cdefghijk	2.95abcdef	2.42bcde
	2.6	S_2	2.43abcdef	2.88bcdefg	3.05defghijk	2.77bcdef	2.25bcde
	5.2	S_2	2.42abcdef	2.77bcdefgh	3.54bcdefghij	3.22abcde	2.30bcde
	7.8	S_2	2.50abcde	2.71bcdefgh	3.79abcde	3.30abcd	2.37bcde
3.0	0	S_2	2.69abc	2.98abcdef	3.58bcdefghi	2.65cdef	2.17e
	2.6	S_2	2.65abc	3.10abcde	3.68bcdefg	3.85ab	2.50bcde
	5.2	S_2	2.73ab	3.00abcdef	4.30ab	3.37abcd	2.37bcde
	7.8	S_2	2.37abcdef	3.09abcde	3.71bcdef	3.05abcdef	2.36bcde
4.5	0	S_2	2.46abcde	3.35abc	3.65bcdefgh	2.92bcdef	2.34bcde
	2.6	S_2	2.60abcd	3.34abc	4.12abcd	2.98abcdef	2.32bcde
	5.2	S_2	2.55abcd	3.49ab	4.20abc	3.37abcd	2.49bcde
	7.8	S_2	2.65abc	3.82a	4.92a	4.05a	2.56bcde
DAP means S_1			**2.22g**	**2.56e**	**2.57de**	**2.76c**	**2.73cd**
DAP means S_2			**2.50ef**	**2.96b**	**3.58a**	**3.09b**	**2.34fg**
		S_1 means	**2.21b**	**2.55b**	**2.56b**	**2.75b**	**2.74a**
		S_2 means	**2.49a**	**2.95a**	**3.58a**	**3.08a**	**2.34b**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.** S stands for Season

4.2.2 Effects of Tithonia and Bioslurry Manure on Stomatal Conductance of Carrot Leaves

Tithonia and bioslurry manure levels influenced stomatal conductance of carrot leaves at the different data sampling dates. The interaction between tithonia and bioslurry was also significant at the different data collection days in both seasons.

The main effect of tithonia manure on leaf stomatal conductance at the different data collection days varied in the two seasons. In season 1, leaf stomatal conductance were higher for all plants treated with tithonia manure at any given level compared to control plants as from 46 to 74 DAP. At the late sampling dates (88 and 102 DAP), there were no significant differences in stomatal conductance of leaves from all the tithonia level treatments and control plants. In season 2, apart from 46 DAP when stomatal conductance from the different tithonia levels were not significant, stomatal conductance was significantly affected by the varying rates of tithonia manure at 60, 74, 88 and 102 DAP, with highest stomatal conductance recorded following application of the highest level (4.5 t/ha) of tithonia manure (Table 13). In general, higher leaf stomatal conductance was realized in the plants subjected to the highest level (4.5 t/ha) of tithonia manure in both seasons with lowest stomatal conductance observed in plants subjected to the control treatment. A general increase in leaf stomatal conductance with increase in tithonia manure levels was also observed.

Bioslurry manure on the other hand, significantly affected the leaf stomatal conductance at all days of data collection in season 1 except at 88 DAP. In season 2, apart from 46 and 60 DAP, bioslurry manure levels influenced the leaf stomatal conductance at all other sampling dates (Table 14). At 74, 88 and 102 data sampling dates, bioslurry manure at all levels increased the leaf stomatal conductance over the control. In season 1, a general decrease in stomatal conductance over time for both tithonia and bioslurry manure levels was observed while in season 2, the maximum stomatal conductance was attained at 74 DAP (Table 15).

Interactions between tithonia and bioslurry manure levels influenced the leaf stomatal conductance of carrots in both seasons (Table 15). Plants that were subjected to the highest treatment combination (4.5 t/ha of tithonia and 7.8 t/ha of bioslurry manure) tended to have higher leaf stomatal conductance in all days of data collection except at 88 and 102 DAP in season 1 and 88 DAP in season 2 when higher stomatal conductance were observed in plants treated with a combination of 4.5 t/ha tithonia and 0 t/ha bioslurry and 4.5 t/ha tithonia and 2.6

t/ha bioslurry, respectively. In general, stomatal conductance was lowest in plants from plots with no manure applied. Overall, plants in season 2 had higher leaf stomatal conductance (100.25 mmol/m^2s) than those of season 1 (47.70 mmol/m^2s) (Table 15).

Table 13. Effect of tithonia manure on stomatal conductance (mmol/m^2s) of carrot leaves

		Days after planting				
Tithonia (t/ha)	**Season**	46	60	74	88	102
0	S_1**	93.39d*	70.4f	58.38e	43.53d	44.76d
1.5	S_1	121.25bc	90.85e	69.95d	44.85d	52.06d
3.0	S_1	139.25b	104.80cd	77.46d	48.89d	48.00d
4.5	S_1	173.06a	103.63de	70.47d	45.42d	45.80d
0	S_2	109.38cd	115.05bcd	128.66c	90.10c	84.27c
1.5	S_2	109.45cd	117.36bc	136.05c	97.90bc	96.89b
3.0	S_2	108.56cd	123.75ab	150.94b	103.53b	103.68b
4.5	S_2	113.79cd	131.68a	175.13a	116.14a	116.14a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.
** S stands for Season

Table 14. Effect of bioslurry manure on stomatal conductance (mmol/m^2s) of carrot leaves

		Days after planting				
Bioslurry (t/ha)	**Season**	46	60	74	88	102
0	S_1**	132.63b*	79.45d	60.68d	41.34c	42.66d
2.6	S_1	118.15bc	89.87cd	63.94d	48.44c	48.03cd
5.2	S_1	118.45bc	95.05bc	68.94d	42.99c	54.84c
7.8	S_1	157.72a	105.31b	83.18c	49.92c	45.30cd
0	S_2	105.15c	119.13a	137.74b	90.24b	90.29b
2.6	S_2	108.36c	120.65a	146.29a	104.15a	101.16a
5.2	S_2	114.97bc	125.87a	152.59a	106.09a	102.95a
7.8	S_2	112.71bc	122.20a	154.17a	107.20a	106.58a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.
** S stands for Season

Table 15. Interaction effects of tithonia and bioslurry manure on stomatal conductance (mmol/m^{2}s) of carrot leaves

Tithonia (t/ha)	Bioslurry (t/ha)	Season	Days after planting				
			46	60	74	88	102
0	0	S_1**	84.08 f*	56.43g	47.08l	34.53j	28.29i
	2.6	S_1	101.80 def	83.36cdefg	70.59hijkl	58.80ghij	45.31ghi
	5.2	S_1	91.85ef	68.10fg	49.87kl	40.96j	54.15efghi
	7.8	S_1	95.84ef	73.71defg	65.97ijkl	45.12ij	51.30fghi
1.5	0	S_1	121.59cdef	71.87efg	71.94hijkl	49.55hij	50.38ghi
	2.6	S_1	82.24f	72.65defg	67.10hijkl	42.60j	51.18fghi
	5.2	S_1	154.61bcd	113.89abc	61.86kl	43.45ij	67.67defgh
	7.8	S_1	126.55bcdef	104.98abcde	78.92ghijk	38.51j	39.03i
3.0	0	S_1	142.65bcd	106.86abcd	63.74ijkl	38.24j	43.56hi
	2.6	S_1	139.45bcdef	100.84bcdef	62.68jkl	50.96hij	50.83ghi
	5.2	S_1	106.04def	99.70bcdef	91.06ghij	42.85j	50.60ghi
	7.8	S_1	168.86bc	111.80abc	92.35ghi	63.50fghij	47.80ghi
4.5	0	S_1	182.19ab	82.65cdefg	59.96kl	43.03ij	48.40ghi
	2.6	S_1	149.10bcde	102.61bcde	53.47kl	41.42j	44.80hi
	5.2	S_1	121.31cdef	98.50bcdef	72.95hijk	44.70ij	46.93ghi
	7.8	S_1	239.65a	130.75ab	95.48gh	52.53hij	43.07hi
0	0	S_2	102.46def	114.86abc	107.09fg	73.84efghi	72.25defg
	2.6	S_2	107.86def	116.03abc	128.77ef	85.87cdefg	78.40cdef
	5.2	S_2	113.45cdef	123.27ab	142.05cde	101.88abcde	94.32bcd
	7.8	S_2	113.76cdef	106.05abcde	136.72e	98.81abcde	92.10bcd
1.5	0	S_2	104.23def	108.70abc	132.88ef	79.74defgh	79.20cde
	2.6	S_2	107.79def	115.10abc	132.71ef	107.85abcd	100.12bcd
	5.2	S_2	114.43cdef	121.99ab	139.48de	110.17abcd	106.75ab
	7.8	S_2	107.81def	123.68ab	139.14de	93.83bcdef	101.49abc
3.0	0	S_2	104.35def	124.54ab	143.83cde	101.47abcde	102.74abc
	2.6	S_2	109.82def	124.30ab	152.77bcde	96.91abcde	104.07abc
	5.2	S_2	114.18cdef	126.40ab	152.20bcde	103.79abcde	100.86abc
	7.8	S_2	109.46def	119.77ab	154.98bcde	111.97abc	107.06ab
4.5	0	S_2	109.55def	128.42ab	167.17abc	105.91abcd	106.98ab
	2.6	S_2	107.99def	127.19ab	170.90abc	125.96a	122.03a
	5.2	S_2	117.83cdef	131.80ab	176.63ab	108.52abcd	109.87ab
	7.8	S_2	119.80cdef	139.30a	185.85a	124.18ab	125.68a
DAP means S_1			**131.20b**	**92.00f**	**69.06g**	**47.70h**	**45.67h**
DAP means S_2			**110.30d**	**121.96c**	**147.70a**	**101.00e**	**100.25e**
		S_1 means	**131.74a**	**92.42b**	**69.06b**	**45.67b**	**47.70b**
		S_2 means	**110.30b**	**121.00a**	**147.70a**	**101.92b**	**100.25a**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.** S stands for Season

4.3 Biomass and Yield Parameters

4.3.1 Effects of Tithonia and Bioslurry Manure on Fresh and Dry Shoot Biomass of Carrot

In season 1, tithonia and bioslurry manure levels did not affect fresh leaf biomass of carrots. In season 2, however, both tithonia and bioslurry manure levels had a significant influence on carrot fresh shoot biomass (Table 16). The interaction between tithonia and bioslurry manure levels was also significant in both seasons (Table 16).

Application of tithonia at the highest level (4.5 t/ha) resulted in higher fresh leaf biomass over 1.5 t/ha and control treatment in season 2. Fresh shoot biomass of plants supplied with 3.0 t/ha was, however, not any different from that of plants treated with 4.5 t/ha. In both seasons, a general trend could be established where by fresh shoot biomass of carrot plants tended to increase with increase in amount of tithonia manure applied with the application of tithonia at the highest level of 4.5 t/ha increasing fresh shoot biomass by 22.9 % and 20.8% in season 1 and 2, respectively compared to the control treatment.

Similar to the effect of tithonia, plants treated with 7.8 t/ha of bioslurry had higher fresh shoot biomass compared to the two lower levels (2.6 and 0 t/ha). The difference in fresh biomass of plants treated with 5.2 t/ha and 7.8 t/ha was not significant. Application of 7.8 t/ha increased fresh shoot biomass by 33.7% and 20% in season 1 and 2, respectively compared to control.

The interaction of combined application of tithonia and bioslurry manure levels was significant in both seasons (Table 16). An analysis of the interaction showed it in magnitude whereby at any given level of tithonia, fresh shoot biomass tended to increase with increase in bioslurry level with the magnitude of increase varying for the different tithonia x bioslurry level combinations . Plots treated with the highest treatment combinations of 4.5 t/ha of tithonia and 7.8 t/ha of bioslurry resulted in an increase in fresh shoot biomass of 103% and 56% in season 1 and 2, respectively compared to the control.

Dry shoot biomass followed a trend similar to that of fresh leaf biomass following application of tithonia and bioslurry manures at the different levels in both seasons. The main factors did not affect dry shoot biomass in season 1, but in season 2, the effect was significant (Table 17). The interactions between tithonia and bioslurry manure was significant in both seasons (Table 17). Dry shoot biomass increased by 27.4% and 22.1% in season 1 and 2, respectively compared to control treatment following application of the highest level of tithonia

(4.5 t/ha). On the other hand application of 7.8 t/ha of bioslurry increased dry leaf biomass by 21.2% and 18.7% in season 1 and 2, respectively compared to control. Significant interactions were observed following combined application of tithonia and bioslurry manure at the different levels in both seasons with plots treated with the highest treatment combinations of 4.5 t/ha tithonia and 7.8 t/ha of bioslurry recording an 81% and 56% increase in dry shoot biomass in season 1 and 2, respectively compared to the control (Table 17). Across seasons, plants in season 2 had higher fresh (16.14 t/ha) and dry shoot biomass (3.29 t/ha) compared to those of season 1 which had 5.87 t/ha and 1.69 t/ha of fresh and dry shoot biomass respectively (Tables 16 and 17).

4.3.2 Effects of Tithonia and Bioslurry Manure on Dry Root Biomass of Carrots

Tithonia and bioslurry manure application on carrot root dry biomass was significant in both seasons (Table 18). Tithonia by bioslurry interactions was also found to be significant (Table 18).

Plants treated with 3.0 t/ha and 4.5 t/ha had higher root dry biomass compared to control plants in season 1. In this season, a 16.5 and 14.7% increase in dry root biomass was recorded for plants treated with 3.0 and 4.5 t/ha of tithonia, respectively compared to the control plants. In season 2, 4.5 t/ha of tithonia produced highest dry root biomass, registering a 16.3% increase compared to control plants.

The highest level (7.8 t/ha) of bioslurry manure yielded the highest dry root biomass in both seasons increasing dry root biomass by 18.2% and 19.7% in season 1 and 2, respectively compared to control. In both seasons, plants treated with the intermediary levels of bioslurry yielded higher dry root biomass than control plants, although the differences were not significant.

Interaction between combined application of tithonia and bioslurry manure levels was also significant in both seasons. At any given bioslurry level, dry root biomass generally increased with increase in tithonia level with the magnitude of increase varying for the different combinations of tithonia and bioslurry levels. Combined application of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry gave highest dry root biomass of 6.5 t/ha and 7.1 t/ha in season 1 and 2, respectively. Overall, plants in season 2 yielded higher root dry biomass (5.85 t/ha) than those of season 1 (5.39 t/ha) although the difference was not significant.

Table 16. Effects of tithonia and bioslurry manure on fresh shoot biomass (t/ha) of carrots

	Season 1					Season 2				
	Bioslurry (t/ha)					Bioslurry (t/ha)				
Tithonia (t/ha)	0	2.6	5.2	7.8	**Tithonia means**	0	2.6	5.2	7.8	**Tithonia means**
0	4.22e*	5.72e	5.99e	4.94e	**5.23C**	12.92bcd	14.49abc	17.37ab	15.59ab	**15.09B**
1.5	4.64e	6.02e	5.86e	5.78e	**5.58C**	13.14bc	14.75ab	15.01ab	17.54ab	**15.11B**
3.0	5.45e	6.28e	6.29e	6.87de	**6.22C**	15.58ab	14.82ab	16.27ab	17.85ab	**16.13AB**
4.5	5.28e	6.50e	5.39e	8.57cd	**6.43C**	17.51ab	16.57ab	18.83ab	20.05a	**18.23A**
Bioslurry means	**4.89c**	**6.14c**	**5.88c**	**6.54c**		**14.79b**	**15.5b**	**16.87ab**	**17.75a**	
Seasons means			**5.87b**					**16.14a**		

*Means followed by the same letters in a letter series within a column with upper case series or row with lower case series are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

Table 17. Effects of tithonia and bioslurry manure on dry shoot biomass (t/ha) of carrots

	Season 1					Season 2				
	Bioslurry (t/ha)					Bioslurry (t/ha)				
Tithonia (t/ha)	0	2.6	5.2	7.8	**Tithonia means**	0	2.6	5.2	7.8	**Tithonia means**
0	1.26j*	1.53hij	1.59hij	1.45ij	**1.46C**	2.64bcdefghi	2.65bcdefghi	3.33abcd	3.48abc	**3.03B**
1.5	1.51ij	1.89efghij	1.77fghij	1.63hij	**1.70C**	2.81abcdefgh	3.07abcde	2.92abcdefg	3.32abcd	**3.03B**
3.0	1.84fghij	1.39ij	1.68ghij	1.96efghij	**1.71C**	3.37abc	2.97abcdef	3.29abcd	3.61ab	**3.31AB**
4.5	1.45ij	2.08defghij	1.66ghij	2.28cdefghi	**1.86C**	3.39abc	3.63ab	3.98a	4.07a	**3.76A**
Bioslurry means	**1.51c**	**1.67c**	**1.72c**	**1.83c**		**3.05b**	**3.08b**	**3.38ab**	**3.62a**	
Season means			**1.69b**					**3.29a**		

*Means followed by the same letters in a letter series within a column with upper case series or row with lower case series are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

Table 18. Effects of tithonia and bioslurry manure on dry root biomass (t/ha) of carrots

	Season 1					Season 2				
	Bioslurry (t/ha)					Bioslurry (t/ha)				
Tithonia (t/ha)	0	2.6	5.2	7.8	**Tithonia means**	0	2.6	5.2	7.8	**Tithonia means**
0	3.38c*	5.63ab	5.07abc	5.52abc	**4.90C**	4.10bc	5.78ab	6.37a	5.62ab	**5.47BC**
1.5	5.31abc	5.58ab	5.42abc	5.00abc	**5.33BC**	5.64ab	5.26abc	5.11abc	6.30a	**5.58ABC**
3.0	4.93abc	5.45abc	6.01ab	6.45a	**5.71AB**	5.98ab	5.18abc	5.69ab	7.08a	**5.98AB**
4.5	4.93abc	5.82ab	6.00ab	5.72ab	**5.62AB**	6.04ab	6.19ab	6.17ab	7.04a	**6.36A**
Bioslurry means	**4.64c**	**5.62b**	**5.63b**	**5.67ab**		**5.44bc**	**5.60b**	**5.83ab**	**6.51a**	
Seasons means	**5.39b**					**5.85b**				

*Means followed by the same letters in a letter series within a column with upper case series or row with lower case series are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

4.3.3 Effects of Tithonia and Bioslurry Manure on Total Dry Biomass of Carrots

Total dry biomass of carrot was significantly influenced by both tithonia and bioslurry manure in both seasons (Table 19). Interactions between main factors were also significant (Table 19).

Application of the highest level of tithonia manure (4.5 t/ha) resulted in the highest total dry biomass in both seasons. Subjecting plants to this treatment resulted in 17.7% and 19.2% increase in dry biomass in season 1 and 2, respectively compared to control. Dry biomass of plants subjected to 3.0 and 1.5 t/ha also tended to be higher than for control plants, although the difference was not significant.

Similarly, the highest level of bioslurry manure (7.8 t/ha) gave the highest dry biomass in both seasons 1 and 2 (Table 19). Application of bioslurry at 7.8 t/ha increased total dry biomass of plants by 22.1% and 19.2% in season 1 and 2, respectively compared to the control. Similar to tithonia effects, plants treated with the intermediate levels of bioslurry manure (2.6 and 5.2 t/ha) had more total dry biomass than control, although the difference was not significant. There was a general increase in total dry biomass of carrots with increasing levels of bioslurry and tithonia manure.

Combined application of tithonia and bioslurry manure also influenced total dry biomass with the highest total dry mass obtained with application of 3.0 t/ha of tithonia in combination with 7.8 t/ha of bioslurry in season 1 and 4.5 t/ha of tithonia in combination with 7.8 t/ha of bioslurry in season 2 (Table 19). Overall, total dry biomass were higher in season 2 (9.13 t/ha) than in season 1 (7.08 t/ha).

4.3.4 Effects of Tithonia and Bioslurry Manure on Shoot: Root Ratio of Carrots

Shoot: root ratio was not influenced by tithonia and bioslurry manure levels in both seasons (Table 20). The interactions between tithonia and bioslurry manure levels were also not significant (Table 20). However, in both seasons, the highest treatment combination of 4.5 t/ha of tithonia and 7.8 t/ha of bioslurry had the highest shoot: ratio of 0.20 and 0.30 in season 1 and 2, respectively. At any given tithonia level, shoot: root ratios generally increased with increase in bioslurry level with the changes in increase varying for the different tithonia x bioslurry level combinations. Shoot: root ratio was higher by 88% in season 2 (0.27) compared to season1 (0.16) (Table 20).

Table 19. Effects of tithonia and bioslurry manure on total dry biomass (t/ha) of carrots

	Season 1					Season 2				
	Bioslurry (t/ha)					Bioslurry (t/ha)				
Tithonia (t/ha)	0	2.6	5.2	7.8	**Tithonia means**	0	2.6	5.2	7.8	**Tithonia means**
0	4.64i*	7.17defghi	6.67fghi	6.98efghi	**6.36E**	6.75fghi	8.44abcdefgh	9.71abcde	9.10abcdefgh	**8.50BC**
1.5	6.83fghi	7.48cdefgh	7.20defghi	6.63ghi	**7.03DE**	8.45abcdefgh	8.34bcdefgh	8.04bcdefgh	9.63abcde	**8.61B**
3.0	6.77fghi	6.84fghi	7.69cdefgh	8.41abcdefgh	**7.43CDE**	9.36abcdefg	8.15bcdegfgh	8.95abcdefgh	10.70ab	**9.29AB**
4.5	6.38hi	7.89cdefgh	7.65cdefgh	8.01bcdefgh	**7.48CD**	9.44abcdef	9.82abcd	10.15abc	11.11a	**10.13A**
Bioslurry means	**6.15e**	**7.34d**	**7.30d**	**7.51cd**		**8.50bc**	**8.68b**	**9.22ab**	**10.13a**	
Seasons means			**7.08b**					**9.13a**		

*Means followed by the same letters in a letter series within a column with upper case series or row with lower case series are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

Table 20. Effect of tithonia and bioslurry manure on shoot: root ratio of carrots

	Season 1					Season 2				
	Bioslurry (t/ha)					Bioslurry (t/ha)				
Tithonia (t/ha)	0	2.6	5.2	7.8	**Tithonia means**	0	2.6	5.2	7.8	**Tithonia means**
0	0.15hij*	0.18cdefghij	0.17defghij	0.14hij	**0.16B**	0.26abcdef	0.24abcdefgh	0.28ab	0.29ab	**0.27A**
1.5	0.13ij	0.16efghij	0.15hij	0.15hij	**0.15B**	0.25abcdefg	0.26abcdef	0.28ab	0.29ab	**0.27A**
3.0	0.13ij	0.18cdefghij	0.15hij	0.16efghij	**0.15B**	0.24abcdefghi	0.27abcd	0.25abcdefg	0.28ab	**0.26A**
4.5	0.17defghij	0.14hij	0.13ij	0.20bcdefghij	**0.16B**	0.27abcd	0.26abcdef	0.30ab	0.31a	**0.28A**
Bioslurry means	**0.14b**	**0.16b**	**0.15b**	**0.16b**		**0.25a**	**0.26a**	**0.28a**	**0.29a**	
Season means			**0.16b**					**0.27a**		

*Means followed by the same letters in a letter series within a column with upper case series or row with lower case series are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

4.3.5 Effects of Tithonia and Bioslurry Manure on Carrot Root Volume

Carrot root volume was generally influenced by tithonia and bioslurry manure in both seasons (Table 21). Significant interactions between tithonia and bioslurry manure levels were also observed in both seasons (Table 21).

Plants subjected to 3.0 t/ha of tithonia produced the highest root volume than control plants in season 1. Subjecting plants to this treatment resulted in 14.6% increase in root volume in season1. In season 2, plants that received higher levels (3.0 t/ha and 4.5 t/ha) of tithonia manure had higher root volume than control plants. Application of 3.0 t/ha and 4.5 t/ha of tithonia resulted into 10.8% and 11.9% more root volume, respectively compared to control in season 2. In both seasons root volume of plants treated with 1.5 t/ha of tithonia tended to be higher than for control plants, although the difference was not significant.

On the other hand, the bioslurry manure of 7.8 t/ha gave the highest root volume in both seasons. Application of bioslurry at 7.8 t/ha increased root volume by 29.3% and 21% in season 1 and 2, respectively compared to control. Root volume of plants treated with 2.6 t/ha of bioslurry tended to be higher than for control plants, although the difference was not significant. A general trend of increase in root volume with successive increase in bioslurry application was observed.

There were significant interactions between tithonia and bioslurry on the carrot root volume (Table 21). A general increase in root volume with changing levels of bioslurry at any given tithonia level could be established. Lowest root volume was observed in the control treatments and the highest carrot roots treated with combination of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry in both seasons. Application of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry increased root volume by 59.3% and 43% compared to the control in season 1 and 2, respectively. Overall, carrots in season 2 had more volume (75.16 cm^3) than those of season 1 (68.17 cm^3) ((Table 21).

Table 21. Effects of tithonia and bioslurry manure on carrot root volume (cm^3)

	Season 1					Season 2				
	Bioslurry (t/ha)					Bioslurry (t/ha)				
Tithonia (t/ha)	0	2.6	5.2	7.8	**Tithonia means**	0	2.6	5.2	7.8	**Tithonia means**
0	53.33g*	65.83cdefg	68.83bcdefg	64.16defg	**63.04C**	61.40efg	73.3abcde	77.10abcde	70.63abcdefg	**70.62B**
1.5	54.16fg	64.83defg	72.83abcdef	83.26abcd	**68.77BC**	61.46efg	67.16cdefg	75.56abcde	86.70ab	**72.70AB**
3.0	69.16abcdefg	69.16abcdefg	65.83cdefg	84.93abc	**72.27AB**	73.73abcde	76.66abcde	74.53abcde	88.06a	**78.25A**
4.5	64.16defg	67.50cdefg	63.66efg	79.16abcde	**68.62BC**	76.23abcde	74.96abcde	80.13abcde	84.90abc	**79.05A**
Bioslurry means	**60.20d**	**66.83cd**	**67.79c**	**77.88ab**		**68.20c**	**73.02bc**	**76.83ab**	**82.57a**	
Season means			**68.17b**					**75.16a**		

*Means followed by the same letter in a letter series within a column with upper case series or row with lower case series are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

4.3.6 Effects of Tithonia and Bioslurry Manure on Carrot Total Root Yield

Total root yield was influenced by tithonia and bioslurry manure levels in both seasons (Table 22). The interaction between main effects of tithonia and bioslurry was also significant in both seasons (Table 22).

A general trend of increase in total root yield with successive increase in tithonia application was also observed. In both seasons, the highest yield of carrot was obtained from plants treated with 3.0 t/ha and 4.5 t/ha of tithonia while the lowest yields were recorded in control treatments. Subjecting plants to 3.0 t/ha and 4.5 t/ha of tithonia increased carrot yields by 32.6% and 31.7% in season 1 and by 18.1% and 19.9% in season 2, respectively compared to control plants. Plants treated with 1.5 t/ha of tithonia yielded more than control, although the difference was not significant.

Contrary to the effect of tithonia, plants subjected to bioslurry manure (7.8 t/ha) had higher yields than control plants in season 1. Application of 7.8 t/ha increased total yield by 23% compared to control plants in season 1. In season 2, 5.2 t/ha and 7.8 t/ha had higher yields compared to control plants. Treating plants with 5.2 t/ha and 7.8 t/ha increased yields by 8.8 % and 9.5% compared to control in season 2. Plants treated with 2.6 t/ha and 5.2 t/ha of bioslurry also yielded more than control plants in season 1, however in season 2, the difference in yields of 2.6 t/ha and control plants was not significant.

Effect of combined application of tithonia and bioslurry manure on total root yield was significant in both seasons. In seasons 1 and 2, highest yields of 52.81 t/ha and 68.86 t/ha, respectively, was realized in the combination of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry manure with control generally having the lowest yields. Root yields from plants that were subjected to 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry were higher by 69.2% and 51% in season 1 and 2 respectively, compared to the control. A general trend could however, be established at any given bioslurry or tithonia level with changing levels of the other factor. At any given bioslurry level, yield generally increased with increase in tithonia level with greatest change in yield observed when tithonia level was increased from 0 t/ha to 1.5 t/ha. A similar trend was also established at each given tithonia levels with changing levels of bioslurry. Total root yield was lower (40.86 t/ha) in season 1 by 30.8% than in season 2 (59.07 t/ha) (Table 22).

Table 22. Effects of tithonia and bioslurry manure on carrot total root yield (t/ha)

	Season 1					Season 2				
	Bioslurry (t/ha)					Bioslurry (t/ha)				
Tithonia (t/ha)	0	2.6	5.2	7.8	**Tithonia means**	0	2.6	5.2	7.8	**Tithonia means**
0	31.22j*	32.89ij	36.32ghij	33.24hij	**33.42D**	42.28efgh	49.82cde	59.82ab	57.45abc	**52.34B**
1.5	37.72fghij	42.02efghi	43.33efg	43.51efg	**41.64CD**	59.30ab	58.31abc	59.91ab	60.16ab	**59.42AB**
3.0	38.07fghij	42.72efg	43.68efg	52.81bcd	**44.32C**	59.89ab	60.69ab	61.63ab	63.86a	**61.77A**
4.5	38.07fghij	42.98efg	45.70def	49.56cde	**44.07C**	60.72ab	62.37a	63.35a	62.54a	**62.75A**
Bioslurry means	**36.27e**	**40.15d**	**42.26cd**	**44.78c**		**56.05b**	**57.79ab**	**61.43a**	**61.01a**	
Season means			**40.86b**					**59.07a**		

*Means followed by the same letters in a letter series within a column with upper case series or row with lower case series are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

4.3.7 Effects of Tithonia and Bioslurry Manure on Harvest Index of Carrots

Tithonia and bioslurry manure levels did not influence harvest index in both seasons (Table 23). Effects of combined application of tithonia and bioslurry manure levels was also not significant (Table 23). However, in season 1, combined application of 3.0 t/ha of tithonia and 2.6 t/ha of bioslurry manure resulted in the highest harvest index of 0.80 with the lowest harvest index of 0.71 obtained from the highest treatment combination of 4.5 t/ha tithonia and 7.8 t/ha bioslurry. In season 2, the highest harvest index of 0.68 was obtained following the application of 2.6 t/ha of bioslurry with no tithonia while the lowest harvest index (0.60) with application of 4.5 t/ha of tithonia and 5.2 t/ha of bioslurry. Harvest index was on overall higher (0.76) by 18% in season 1 compared to season 2 (0.64).

Table 23. Effects of tithonia and bioslurry manure on harvest index of carrots

	Season 1					Season 2				
	Bioslurry (t/ha)					Bioslurry (t/ha)				
Tithonia (t/ha)	0	2.6	5.2	7.8	**Tithonia means**	0	2.6	5.2	7.8	**Tithonia means**
0	0.73abcdefghi	0.78ab	0.76abcde	0.79ab	**0.76A**	0.61jk	0.68bcdefghijk	0.65defghijk	0.61jk	**0.64B**
1.5	0.78ab	0.74abcdefg	0.75abcdef	0.75abcdef	**0.75A**	0.66cdefghijk	0.63ghijk	0.64fghijk	0.65defghijk	**0.65B**
3.0	0.73abcdefghi	0.80a	0.78ab	0.76abcd	**0.76A**	0.64fghijk	0.64fghijk	0.63ghijk	0.66cdefghijk	**0.64B**
4.5	0.77abc	0.73abcdefgh	0.78ab	0.71abcdefghij	**0.75A**	0.64fghijk	0.63ghijk	0.60k	0.64ghijk	**0.62B**
Bioslurry means	**0.75a**	**0.77a**	**0.77a**	**0.76a**		**0.63b**	**0.65b**	**0.63b**	**0.64b**	
Seasons means			**0.76a**					**0.64b**		

*Means followed by the same letters in a letter series within a column with upper case series or row with lower case series are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

4.4 Quality Parameters

4.4.1 Effects of Tithonia and Bioslurry Manure on Carrot Shoulder Diameter

Carrots shoulder diameter at the different data collection days was influenced by tithonia and bioslurry manure levels in both seasons. Significant interactions between tithonia and bioslurry manure levels were also observed at the different sampling dates.

Carrot shoulder diameter was greatly affected by tithonia manure levels at most sessions of data collection except at 88 and 102 DAP in season 1 and 74 and 102 DAP in season 2 (Table 24). The highest shoulder diameter of carrot was recorded from plants subjected to highest level (4.5 t/ha) of tithonia, although not significantly different from the intermediary levels on some data collection dates, with the lowest shoulder diameter recorded in plots not treated with manure in most data collection days. Over the study period, the greatest shoulder diameter of 2.99 cm was observed from plants subjected to 4.5 t/ha of tithonia at 102 DAP in season 2.

Main effects of bioslurry manure levels also significantly influenced carrot shoulder diameter at 60 and 102 DAP in season 1 and 74 and 88 DAP in season 2 (Table 25). Plants supplied with 7.8 t/ha of bioslurry level recorded the highest shoulder diameter, although not significantly different from 1.5 t/ha and 3.0 t/ha in some data collection days. At 102 DAP in season 2, plants treated with 7.8 t/ha of bioslurry had greatest shoulder diameter of 2.93.

Significant interactions between tithonia and bioslurry manure levels on carrots shoulder diameter were also recorded at the different data collection dates in both seasons. Combined application of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry manure levels gave the highest shoulder diameter at the different data collection days in season 1 while in season 2, the greatest shoulder diameter was observed from plants treated with combined application of 4.5 t/ha of tithonia and 2.6 t/ha of bioslurry in most data sampling dates (Table 26). Mean shoulder diameter of carrots in season 1 (2.33 cm) was not statistically different from that of season 2 (2.87 cm).

Table 24. Effect of tithonia manure on carrot shoulder diameter (cm)

		Days after planting			
Tithonia (t/ha)	**Season**	60	74	88	102
0	S_1**	1.04c*	1.82c	2.25bc	2.30b
1.5	S_1	1.14bc	2.01abc	2.45ab	2.35b
3.0	S_1	1.27ab	2.07a	2.43ab	2.34b
4.5	S_1	1.32a	1.98abc	2.44ab	2.34b
0	S_2	1.11bc	1.86bc	2.14c	2.73a
1.5	S_2	1.13bc	2.00abc	2.20bc	2.80a
3.0	S_2	1.34a	2.00abc	2.39abc	2.95a
4.5	S_2	1.32a	2.03ab	2.58a	2.99a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 25. Effect of bioslurry manure on carrot shoulder diameter (cm)

		Days after planting			
Bioslurry (t/ha)	**Season**	60	74	88	102
0	S_1**	1.04c*	1.88ab	2.31ab	2.13c
2.6	S_1	1.16abc	1.89ab	2.41a	2.42b
5.2	S_1	1.30a	2.04a	2.37ab	2.34bc
7.8	S_1	1.26ab	2.07a	2.47a	2.45b
0	S_2	1.12bc	1.83b	2.13b	2.77a
2.6	S_2	1.29ab	1.88ab	2.28ab	2.90a
5.2	S_2	1.25ab	2.06a	2.46a	2.88a
7.8	S_2	1.24ab	2.07a	2.43a	2.93a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 26. Interaction effects of tithonia and bioslurry manure on carrot shoulder diameter (cm)

			Days after planting			
Tithonia (t/ha)	**Bioslurry (t/ha)**	**Season**	60	74	88	102
0	0	S_1**	0.83g*	1.60d	2.10ab	2.16fg
	2.6	S_1	0.98fg	1.70bcd	2.36ab	2.58abcdefg
	5.2	S_1	1.30abcdef	2.06abcd	2.23ab	2.21defg
	7.8	S_1	1.06defg	1.93abcd	2.31ab	2.26defg
1.5	0	S_1	1.13cdefg	1.88abcd	2.46ab	2.16fg
	2.6	S_1	1.01efg	2.05abcd	2.38ab	2.40bcdefg
	5.2	S_1	1.25bcdef	2.16ab	2.53ab	2.43bcdefg
	7.8	S_1	1.16bcdefg	1.95abcd	2.4a	2.43bcdefg
3.0	0	S_1	1.06defg	2.06abcd	2.30ab	2.01g
	2.6	S_1	1.18bcdefg	1.93abcd	2.26ab	2.30cdefg
	5.2	S_1	1.28bcdef	2.05abcd	2.45a	2.45bcdefg
	7.8	S_1	1.55ab	2.25a	2.73a	2.61abcdefg
4.5	0	S_1	1.15bcdefg	2.00abcd	2.4ab	2.18efg
	2.6	S_1	1.46abcd	1.88abcd	2.60a	2.41bcdefg
	5.2	S_1	1.40abcde	1.88abcd	2.28ab	2.26defg
	7.8	S_1	1.28bcdef	2.16ab	2.43ab	2.52abcdefg
0	0	S_2	1.01efg	1.64cd	1.93b	2.57abcdefg
	2.6	S_2	1.11cdefg	1.91abcd	2.17ab	2.80abcdef
	5.2	S_2	1.20bcdefg	1.94abcd	2.35ab	2.75abcdef
	7.8	S_2	1.12cdefg	1.96abcd	2.12ab	2.82abcdef
1.5	0	S_2	1.06defg	1.97abcd	2.11ab	2.82abcdef
	2.6	S_2	1.20bcdefg	1.82abcd	2.21ab	2.73abcdef
	5.2	S_2	1.14bcdefg	2.12abc	2.22ab	2.74abcdef
	7.8	S_2	1.13cdefg	2.11abc	2.2ab	2.94abc
3.0	0	S_2	1.26bcdef	1.90abcd	2.13ab	2.87abcd
	2.6	S_2	1.15bcdefg	1.93abcd	2.15ab	2.95abc
	5.2	S_2	1.52abc	2.04abcd	2.65a	3.00ab
	7.8	S_2	1.44abcd	2.12abc	2.62a	3.00ab
4.5	0	S_2	1.17bcdefg	1.83abcd	2.36ab	2.83abcde
	2.6	S_2	1.7a	2.07abcd	2.65a	3.12a
	5.2	S_2	1.15bcdefg	2.13abc	2.63a	3.04ab
	7.8	S_2	1.26bcdef	2.11abc	2.72a	2.98ab
		S_1 means	**1.19a**	**1.97a**	**2.39a**	**2.33a**
		S_2 means	**1.22a**	**1.97a**	**2.32a**	**2.87a**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

4.4.2 Effects of Tithonia and Bioslurry Manure on Carrot Core Diameter

Carrot core diameter was generally affected by tithonia manure levels at the different data collection days in both seasons. The effect of bioslurry manure levels was, however, not significant through out the study period. Tithonia by bioslurry levels interaction was also significant.

The effect of tithonia manure levels on carrot core diameter of carrots varied in the two seasons. In season 1, the largest core diameter was observed at 60 and 102 DAP in plants treated with highest level (4.5 t/ha) of tithonia, although the difference was not significant with other levels. However in season 2, the highest level of tithonia (4.5 t/ha) gave the largest core diameter in most days of data collection compared to the lower levels (1.5 t/ha and 0 t/ha) (Table 27).

Core diameter was not affected by bioslurry manure levels at all days of data collection in both seasons (Table 28). The interactions between combined application of tithonia and bioslurry manure levels did not affect core diameter of carrots at most data collection days in season 1, however in season 2 the largest core diameter of 1.93cm was recorded with combined application of 4.5 t/ha of tithonia and 2.6 t/ha of bioslurry while the smallest core diameter (1.22cm) was recorded with 1.5 t/ha of tithonia and 2.6 t/ha of bioslurry at maturity, although the difference was not significant with some other treatment combinations (Table 29). Generally, season 2 carrots had larger core diameters on average although the difference with that of season 1 was not statistically different in most days of data collection (Table 29).

Table 27. Effect of tithonia manure on carrot core diameter (cm)

		Days after planting			
Tithonia (t/ha)	**Season**	60	74	88	102
0	S_1**	0.80abc*	1.00	1.12ab	1.13d
1.5	S_1	0.75abc	0.93	1.25a	1.09d
3.0	S_1	0.73bc	0.91	1.08ab	1.09d
4.5	S_1	0.82ab	0.87	1.11ab	1.17cd
0	S_2	0.68c	0.86	0.96b	1.42b
1.5	S_2	0.68c	0.90	1.03b	1.36bc
3.0	S_2	0.79abc	0.94	1.12ab	1.49ab
4.5	S_2	0.85a	0.95	1.23a	1.66a

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.
** S stands for Season

Table 28. Effect of bioslurry manure on carrot core diameter (cm)

		Days after planting			
Bioslurry (t/ha)	**Season**	60	74	88	102
0	S_1**	0.77*	0.94	1.15	1.08b
2.6	S_1	0.79	0.90	1.12	1.13b
5.2	S_1	0.77	0.95	1.13	1.15b
7.8	S_1	0.77	0.93	1.15	1.12b
0	S_2	0.72	0.91	1.11	1.38a
2.6	S_2	0.81	0.92	1.12	1.54a
5.2	S_2	0.79	0.96	1.05	1.45a
7.8	S_2	0.68	0.86	1.05	1.55a

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.
** S stands for Season

Table 29. Interaction effects of tithonia and bioslurry manure on carrot core diameter (cm)

			Days after planting			
Tithonia (t/ha)	**Bioslurry (t/ha)**	**Season**	60	74	88	102
0	0	S_1**	0.86abc*	1.03	1.13abc	1.15cdef
	2.6	S_1	0.65c	0.96	1.11abc	1.11def
	5.2	S_1	0.81abc	1.03	0.80c	1.06f
	7.8	S_1	0.86abc	1.00	1.23abc	1.20bcdef
1.5	0	S_1	0.75abc	0.86	1.30ab	1.01f
	2.6	S_1	0.81abc	0.88	1.20abc	1.13def
	5.2	S_1	0.70bc	1.05	1.20abc	1.18bcdef
	7.8	S_1	0.76abc	0.95	1.31ab	1.05f
3.0	0	S_1	0.68c	0.93	1.08abc	1.05f
	2.6	S_1	0.80abc	0.88	1.03abc	1.06f
	5.2	S_1	0.76abc	0.96	1.20abc	1.16bcdef
	7.8	S_1	0.68c	0.86	1.03abc	1.08ef
4.5	0	S_1	0.80abc	0.93	1.10abc	1.11def
	2.6	S_1	0.91abc	0.88	1.15abc	1.21bcdef
	5.2	S_1	0.81abc	0.75	1.15abc	1.20bcdef
	7.8	S_1	0.76abc	0.93	1.05abc	1.15cdef
0	0	S_2	0.70bc	0.88	1.08abc	1.44abcdef
	2.6	S_2	0.72abc	0.91	0.95bc	1.38bcdef
	5.2	S_2	0.64c	0.82	1.00abc	1.27bcdef
	7.8	S_2	0.67c	0.84	1.02abc	1.60abcde
1.5	0	S_2	0.67c	0.87	1.03abc	1.36bcdef
	2.6	S_2	0.71bc	0.88	1.01abc	1.22bcdef
	5.2	S_2	0.72abc	0.95	0.97abc	1.25bcdef
	7.8	S_2	0.63c	0.90	1.11abc	1.60abcde
3.0	0	S_2	0.73abc	0.95	1.13abc	1.33bcdef
	2.6	S_2	0.81abc	0.94	1.12abc	1.64abcd
	5.2	S_2	0.98ab	1.07	1.28ab	1.66abc
	7.8	S_2	0.64c	0.80	0.95bc	1.34bcdef
4.5	0	S_2	0.78abc	0.94	1.20abc	1.41abcdef
	2.6	S_2	1.02a	0.96	1.41a	1.93a
	5.2	S_2	0.81abc	1.00	1.16abc	1.63abcd
	7.8	S_2	0.80abc	0.92	1.14abc	1.68ab
		S_1 means	**0.77a**	**0.93a**	**1.11a**	**1.12b**
		S_2 means	**0.75a**	**0.91a**	**1.08a**	**1.48a**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.** S stands for Season

4.4.3 Effects of Tithonia and Bioslurry Manure on Carrot Root Length

Tithonia and bioslurry manure levels affected carrot root lengths at the different sampling dates in both seasons. The interactions between tithonia and bioslurry levels were also found significant.

Tithonia manure levels influenced root length of carrots only at 102 DAP in season 1 and at 88 and 102 DAP in season 2 (Table 30). The longest roots were observed from plants treated with 3.0 t/ha of tithonia compared to control at 102 DAP in season 1. However in season 2, the highest level (4.5 t/ha) had longest roots compared to control at 88 and 102 DAP with the control generally having the shortest roots in most days of data collection. Application of tithonia manure at 3.0 t/ha and 4.5 t/ha resulted in 19.5% and 11.5 % increase in root length at 102 DAP compared to the control in season 1 and 2, respectively.

On the other hand, bioslurry manure influenced root length only at 88 and 102 DAP in season 1, but its effect was not significant in season 2 (Table 31). The interaction effects between tithonia and bioslurry were significant although the effect of treatment combinations on root length differed in all days of data collection in both seasons (Table 32). Generally plants in season 2, had longer roots (20.4 cm) than those of season 1 (18.0 cm).

Table 30. Effect of tithonia manure on carrot root length (cm)

		Days after planting			
Tithonia (t/ha)	**Season**	60	74	88	102
0	S_1**	15.88b*	17.42bc	18.10d	16.49d
1.5	S_1	17.25ab	17.30bc	19.28bcd	17.86cd
3.0	S_1	16.55ab	16.73c	19.72abcd	19.70abc
4.5	S_1	16.26b	17.82abc	18.80cd	18.11cd
0	S_2	16.48ab	18.49ab	18.72cd	19.02bc
1.5	S_2	16.88ab	18.68ab	19.86abc	20.41abc
3.0	S_2	17.26ab	19.17a	20.50ab	20.75ab
4.5	S_2	17.46a	18.88ab	21.16a	21.22a

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.
** S stands for Season

Table 31. Effect of bioslurry manure on carrot root length (cm)

		Days after planting			
Bioslurry (t/ha)	**Season**	60	74	88	102
0	S_1**	17.01ab*	16.72d	18.04bc	15.47c
2.6	S_1	15.67b	17.70bcd	17.81c	18.80b
5.2	S_1	16.20ab	17.35cd	19.95a	18.80b
7.8	S_1	16.96ab	17.50cd	20.20a	19.08ab
0	S_2	16.93ab	17.86abcd	19.69ab	20.27ab
2.6	S_2	16.92ab	18.67abc	20.01a	19.76ab
5.2	S_2	17.14a	19.44a	20.54a	20.85a
7.8	S_2	17.10ab	19.25ab	20.00a	20.51ab

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.
** S stands for Season

Table 32. Interaction effects of tithonia and bioslurry manure on carrot root length (cm)

Tithonia (t/ha)	Bioslurry (t/ha)	Season	Days after planting			
			60	74	88	102
0	0	S_1	15.23bcd*	16.20abc	15.53c	14.20g
	2.6	S_1	14.93cd	17.35abc	18.98abc	19.20abcdef
	5.2	S_1	17.03abcd	18.40abc	19.50abc	17.565abcdefg
	7.8	S_1	16.33abcd	17.73abc	18.41abc	14.91fg
1.5	0	S_1	18.48abc	17.91abc	17.80abc	15.35efg
	2.6	S_1	16.96abcd	16.48abc	17.81abc	20.20abcde
	5.2	S_1	16.05bcd	17.88abc	20.80a	16.73cdefg
	7.8	S_1	19.90a	16.93abc	20.71a	19.16abcdefg
3.0	0	S_1	18.61ab	15.75bc	20.53a	15.31efg
	2.6	S_1	16.15bcd	17.85abc	18.53abc	19.55abcdef
	5.2	S_1	15.35bcd	15.65c	19.05abc	22.16a
	7.8	S_1	16.11bcd	17.68abc	20.80a	21.78ab
4.5	0	S_1	16.10bcd	17.01abc	18.31abc	17.05bcdefg
	2.6	S_1	17.03abcd	19.11abc	15.93bc	16.25defg
	5.2	S_1	16.40abcd	17.50abc	20.06ab	18.66abcdefg
	7.8	S_1	15.51bcd	17.65abc	20.90a	20.48abcd
0	0	S_2	16.45abcd	17.76abc	17.44abc	18.05abcdefg
	2.6	S_2	16.02bcd	17.91abc	18.73abc	18.38abcdefg
	5.2	S_2	16.64abcd	18.90abc	20.64a	20.50abcd
	7.8	S_2	16.82abcd	19.40abc	18.07abc	19.14abcdefg
1.5	0	S_2	16.57abcd	17.97abc	19.54abc	20.77abcd
	2.6	S_2	14.56d	18.44abc	20.05ab	19.01abcdefg
	5.2	S_2	17.05abcd	19.63abc	20.41a	20.40abcd
	7.8	S_2	16.94abcd	18.67abc	19.46abc	21.47abc
3.0	0	S_2	17.25abcd	18.60abc	20.56a	20.87abcd
	2.6	S_2	17.23abcd	18.95abc	20.27a	20.63abcd
	5.2	S_2	17.48abcd	19.92a	19.80a	20.97abcd
	7.8	S_2	17.10abcd	19.21abc	21.35a	20.52abcd
4.5	0	S_2	17.44abcd	17.11abc	21.23a	21.37abc
	2.6	S_2	17.48abcd	19.38abc	21.00a	21.03abcd
	5.2	S_2	17.40abcd	19.32abc	21.31a	21.54abc
	7.8	S_2	17.54abcd	19.73ab	21.10a	20.93abcd
		S_1 means	**16.48b**	**17.31b**	**18.98b**	**18.04b**
		S_2 means	**17.02a**	**18.80a**	**20.06a**	**20.35a**

*Means followed by the same letters or no letters within a column or row are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$

4.4.4 Effects of Tithonia and Bioslurry Manure on Total Soluble Solids at Different Ages

The percentage total soluble solids of carrot roots were generally affected by tithonia and bioslurry manure and the interaction of tithonia and bioslurry levels in both seasons. A general trend of increase in total soluble solids with successive increase in bioslurry and tithonia manure application was observed.

Main effects of tithonia levels were significant at 60 and 102 DAP in season 1 and at 88 and 102 DAP in season 2 (Table 33). In all other sampling dates, total soluble solids were not significantly influenced by tithonia. Generally the lowest total soluble solids were recorded in carrots that received no manure while the highest total soluble solids were obtained in carrots that received the highest level (4.5 t/ha) of tithonia in both seasons. Total soluble solids following application of 3.0 t/ha were also not any different from 4.5 t/ha of tithonia in most sampling dates.

Bioslurry manure on the other hand had significant effects on total soluble solids at 88 and 102 DAP in season 1 and at 60 and 88 DAP in season 2 (Table 34). In most of these sampling dates, the highest level (7.8 t/ha) of bioslurry manure yielded higher total soluble solids than the lower levels (0 t/ha and 2.6 t/ha). Although total soluble solids for plants treated with 7.8 t/ha were higher than those of plants treated with 5.2 t/ha, the differences were not significant in most sampling dates.

The application of different combinations of tithonia and bioslurry significantly influenced the percentage total soluble solids of carrots in both seasons except at 74 DAP (Table 35). Generally, the highest total soluble solids were recorded from plants subjected to the highest treatment combinations (4.5 t/ha of tithonia and 7.8 t/ha of bioslurry) in most days of data collection while the lowest total soluble solids varied in the different sampling dates, obtained with a combination of 1.5 t/ha of tithonia and 7.8 t/ha of bioslurry at 60 DAP and 0 t/ha of tithonia and 2.6 t/ha of bioslurry at 88 and 102 DAP in season 1. In season 2, the lowest total soluble solids was observed with combined application of 4.5 t/ha of tithonia and 0 t/ha of bioslurry, 2.6 t/ha of tithonia and 0 t/ha bioslurry and 0 t/ha of tithonia and 2.6 t/ha of bioslurry at 60, 88 and 102 DAP, respectively. Overall, plants in season 1 had higher total soluble solids (12.2%) than those of season 2 (10.9%).

Table 33. Effect of tithonia manure on total soluble solids (%) of carrots at different ages

Tithonia (t/ha)	Season	Days after planting			
		60	74	88	102
0	S_1**	6.90b*	7.74abc	9.02a	11.23bcd
1.5	S_1	6.82b	7.678abc	9.21a	12.00ab
3.0	S_1	7.05ab	8.05ab	9.25a	12.70a
4.5	S_1	7.37a	8.24a	9.54a	12.73a
0	S_2	7.10ab	6.98d	7.55bc	10.37d
1.5	S_2	7.11ab	7.10d	7.41c	10.78cd
3.0	S_2	7.33a	7.42cd	7.77bc	10.96cd
4.5	S_2	7.31a	7.53bcd	8.15b	11.56bc

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 34. Effect of bioslurry manure on total soluble solids (%) of carrots at different ages

Bioslurry (t/ha)	Season	Days after planting			
		60	74	88	102
0	S_1**	6.86cd*	7.83abc	8.89b	11.40bc
2.6	S_1	7.15bc	7.99a	8.95b	12.00ab
5.2	S_1	6.95cd	8.07a	9.39ab	12.35a
7.8	S_1	7.20bc	7.92a	9.79a	12.90a
0	S_2	6.75d	6.97d	7.28d	10.63c
2.6	S_2	7.07bcd	7.23cd	7.67cd	10.69c
5.2	S_2	7.40ab	7.50abcd	7.85cd	11.25bc
7.8	S_2	7.63a	7.33bcd	8.08c	11.11bc

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 35. Interaction effects of tithonia and bioslurry manure on total soluble solids (%) at different ages

Tithonia (t/ha)	Bioslurry (t/ha)	Season	Days after planting			
			60	74	88	102
0	0	S_1**	6.35gh*	7.43ab	8.43cdefghij	10.73cdef
	2.6	S_1	7.43abcdef	7.56ab	8.33cdefghij	10.06f
	5.2	S_1	6.96bcdefgh	7.86ab	9.10abcdef	11.80abcdef
	7.8	S_1	6.88cdefgh	8.10ab	10.21ab	11.90abcdef
1.5	0	S_1	7.13abcdefgh	8.10ab	8.90abcdefgh	11.63bcdef
	2.6	S_1	6.75defgh	7.93ab	9.33abcde	12.06abcdef
	5.2	S_1	6.34gh	7.73ab	9.23abcdef	12.33abcdef
	7.8	S_1	7.10abcdefgh	7.38ab	9.40abcd	11.96abcdef
3.0	0	S_1	6.53fgh	7.63ab	9.20abcdef	11.96abcdef
	2.6	S_1	7.43abcdef	8.10ab	8.80bcdefghi	12.70abcd
	5.2	S_1	7.26abcdefg	8.2ab	9.83abc	12.50abcde
	7.8	S_1	7.00bcdefgh	8.2ab	9.16abcdef	13.63ab
4.5	0	S_1	7.43abcdef	8.16ab	9.03abcdefg	11.26bcdef
	2.6	S_1	7.00bcdefgh	8.36a	9.33abcde	12.76abcd
	5.2	S_1	7.23abcdefgh	8.43a	9.40abcd	12.80abc
	7.8	S_1	7.83ab	8.00ab	10.40a	14.10a
0	0	S_2	6.66efgh	6.82b	7.35hij	10.02f
	2.6	S_2	6.93bcdefgh	6.97ab	7.35hij	10.50cdef
	5.2	S_2	7.66abcd	7.2ab	7.77efghij	11.26bcdef
	7.8	S_2	7.15abcdefgh	6.95ab	7.73fghij	10.15ef
1.5	0	S_2	6.68efgh	6.77b	7.04j	10.41def
	2.6	S_2	7.04bcdefgh	7.08ab	7.48ghij	10.86cdef
	5.2	S_2	7.06abcdefgh	7.46ab	7.46ghij	10.84cdef
	7.8	S_2	7.66abcd	7.06ab	7.66fghij	11.02cdef
3.0	0	S_2	7.11abcdefgh	7.24ab	7.48ghij	11.22cdef
	2.6	S_2	7.15abcdefgh	7.13ab	7.86defghij	10.51cdef
	5.2	S_2	7.31abcdef	7.51ab	7.75efghij	10.91cdef
	7.8	S_2	7.75abc	7.80ab	8.00defghij	11.23cdef
4.5	0	S_2	6.55fgh	7.04ab	7.26ij	10.86cdef
	2.6	S_2	7.17abcdefgh	7.73ab	8.00defghij	11.33bcdef
	5.2	S_2	7.55abcde	7.82ab	8.40cdefghij	11.97abcdef
	7.8	S_2	7.97a	7.53ab	8.95abcdefg	12.06abcdef
		S_1 means	**7.04b**	**7.95a**	**9.25a**	**12.16a**
		S_2 means	**7.21a**	**7.26b**	**7.72b**	**10.92b**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

4.4.5 Changes in Total Soluble Solids of Carrots During Storage as Influenced by Tithonia and Bioslurry Manure

Total soluble solids of carrots were influenced by tithonia and bioslurry manure during the 14 days of storage in both seasons. The interactive effects of tithonia and bioslurry manure levels was also significant.

In season 1, total soluble solids were higher in plants treated with 3.0 t/ha and 4.5 t/ha than control plants at 0 and 7 DAS while at 14 DAS, total soluble solids were higher in plants treated with all tithonia levels than control c. In the second season, total soluble solids remained higher in carrots treated with 4.5 t/ha compared to control carrots at 0 and 14 DAS while at 7 DAS both the higher levels of tithonia (3.0 t/ha and 4.5 t/ha) had more total soluble solids than the lower levels (1.5 t/ha and 0 t/ha) (Table 36).

Contrary to the effects of tithonia, bioslurry effect was observed at all sampling dates in season 1, except at 14 DAS while in season 2, the effect was significant only at 7 DAS (Table 36). In the sampling dates when the effect of bioslurry on total soluble solids during storage was significant, carrots grown under the higher levels (5.2 t/ha and 7.8 t/ha) of bioslurry maintained more total soluble solids than control plants during storage. Although total soluble solids of plants subjected to 5.2 t/ha of bioslurry were higher than for plants treated with 2.6 t/ha, the difference were not significant in most sampling dates.

The combined application of tithonia and bioslurry manure levels affected total soluble solids of carrots at all data collection days (Table 37). A general trend could however be established at any given bioslurry or tithonia level with changing levels of the other factor. At any given tithonia level, total soluble solids of carrots generally increased with increase in bioslurry level although the change in total soluble solids as bioslurry level was increased from one level to the other varied. A similar trend was also established at each given bioslurry levels with changing levels of tithonia. In both seasons, highest total soluble solids were obtained in carrots subjected to the highest treatment combinations (4.5 t/ha of tithonia and 7.8 t/ha of bioslurry) at all sampling dates with the lowest amounts recorded in control plants. Subjecting plants to the highest treatment combination increased total soluble solids by 24% and 21% in season 1 and 2, respectively compared to control plants. A general increase was observed in the total soluble solids of carrots during the storage period of 14 days (Table 37). Overall, carrots of season 1 had more total soluble solids than season 2.

Table 36. Effects of tithonia and bioslurry manure on total soluble solids (%) of carrots during storage

		Days at storage				Days at storage		
Tithonia (t/ha)	**Season**	0	7	14	**Bioslurry (t/ha)**	0	7	14
0	S_1**	11.22bcd*	17.01cd	19.27cd	0	11.41bcd	16.90c	19.84abc
1.5	S_1	12.03ab	17.39bc	20.87ab	2.6	12.06abc	17.56b	20.70ab
3.0	S_1	12.74a	17.66b	21.22ab	5.2	12.36ab	18.11a	21.05a
4.5	S_1	12.75a	18.56a	21.48a	7.8	12.90a	18.05ab	21.15a
0	S_2	10.37d	14.92e	18.74d	0	10.63d	14.94e	18.82c
1.5	S_2	10.78cd	15.32e	19.36cd	2.6	10.69d	16.12d	19.62bc
3.0	S_2	10.96bcd	16.49d	19.83bcd	5.2	11.25cd	15.84d	19.91abc
4.5	S_2	11.56bc	16.80d	20.42abc	7.8	11.11cd	16.67c	20.01abc

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

Table 37. Interaction effects of tithonia and bioslurry manure on total soluble solids (%) of carrots during storage

			Days at storage		
Tithonia (t/ha)	**Bioslurry (t/ha)**	**Season**	**0 DAS**	**7 DAS**	**14DAS**
0	0	S_1 **	10.73c*	16.08hijkl	18.21cde
	2.6	S_1	10.53c	14.44mn	19.55abcde
	5.2	S_1	11.75abc	15.71jklm	20.84abcde
	7.8	S_1	11.86abc	15.73jklm	18.47cde
1.5	0	S_1	11.67abc	17.35defgh	20.48abcde
	2.6	S_1	12.13abc	16.66fghijk	21.68abc
	5.2	S_1	12.35abc	14.46mn	20.15abcde
	7.8	S_1	11.97abc	15.13lmn	21.15abcde
3.0	0	S_1	12.00abc	15.67klm	20.77abcde
	2.6	S_1	12.77abc	16.35ghijkl	21.02abcde
	5.2	S_1	12.53abc	18.28abc	21.62abcd
	7.8	S_1	13.68ab	17.93bcde	22.04ab
4.5	0	S_1	11.26bc	15.08lmn	19.40abcde
	2.6	S_1	12.80abc	18.73ab	20.55abcde
	5.2	S_1	12.82abc	18.86ab	22.00ab
	7.8	S_1	14.08a	19.40a	22.53ab
0	0	S_2	10.02c	14.00n	17.82e
	2.6	S_2	10.06c	16.86efghijk	18.95bcde
	5.2	S_2	11.26bc	17.64bcdefg	20.05abcde
	7.8	S_2	10.15c	17.44cdefg	18.14de
1.5	0	S_2	10.41c	15.02lmn	19.04abcde
	2.6	S_2	10.86c	17.23defghi	19.77abcde
	5.2	S_2	10.84c	17.61bcdefg	19.02bcde
	7.8	S_2	11.02bc	17.33defghi	19.61abcde
3.0	0	S_2	11.22bc	16.91efghijk	19.44abcde
	2.6	S_2	10.51c	17.44cdefg	19.40abcde
	5.2	S_2	10.91bc	16.00ijkl	20.22abcde
	7.8	S_2	11.23bc	17.88bcdef	20.33abcde
4.5	0	S_2	10.86c	17.25defghi	19.88abcde
	2.6	S_2	11.33abc	17.04defghij	20.35abcde
	5.2	S_2	11.97abc	17.21defghi	20.75abcde
	7.8	S_2	12.06abc	17.65bcdef	21.55abcd
		S_1 means	**12.18a**	**17.65a**	**20.68a**
		S_2 means	**10.92b**	**15.89b**	**19.59b**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

4.4.6 Effects of Tithonia and Bioslurry Manure on Firmness of Carrots During Storage

The main effects of tithonia and bioslurry manure levels did not influence carrots firmness in both seasons (Tables 38). However, combined application of tithonia and bioslurry manure at different levels influenced the firmness of carrots at harvest in both seasons (Table 39). In the significant data sampling date (0 DAS), the effect of combined application of tithonia and bioslurry manure on firmness varied in both seasons. In season 1, more firmer carrots were obtained in plants treated with 4.5 t/ha of tithonia and 2.6 t/ha of bioslurry with less firmer carrots observed in plants subjected to 0 t/ha of tithonia and 2.6 t/ha of bioslurry. On the other hand in season 2, 0 t/ha of tithonia and 2.6 t/ha of bioslurry produced more firmer carrots with less firmer carrots recorded from plants treated with 4.5 t/ha of tithonia and 0 t/ha of bioslurry. The general trend was a decrease in firmness during the 14 days of storage in both seasons (Table 39).

Table 38. Effects of tithonia and bioslurry manure on the firmness (Kgf) of carrots during storage

		Days at storage				Days at storage		
Tithonia (t/ha)	**Season**	0	7	14	**Bioslurry (t/ha)**	0	7	14
0	S_1**	12.43c*	12.70a	9.21a	0	12.59c*	12.43a	8.97a
1.5	S_1	12.40c	12.59a	9.31a	2.6	12.33c	13.07a	9.35a
3.0	S_1	12.47c	13.33a	9.56a	5.2	12.36c	12.93a	8.93a
4.5	S_1	12.85bc	13.13a	9.73a	7.8	12.77bc	13.32a	9.85a
0	S_2	13.31ab	13.48a	9.71a	0	13.42a	13.21a	9.60a
1.5	S_2	13.98a	13.03a	9.36a	2.6	13.53a	12.75a	9.68a
3.0	S_2	13.38ab	13.31a	9.87a	5.2	13.56a	13.45a	9.58a
4.5	S_2	13.39ab	12.57a	9.85a	7.8	13.37ab	12.98a	9.94a

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

Table 39. Interaction effects of tithonia and bioslurry manure on firmness (Kgf) of carrots during storage

Tithonia (t/ha)	Bioslurry (t/ha)	Season	Days at storage		
			0	7	14
0	0	S_1 **	13.05bcde*	12.37	8.72
	2.6	S_1	11.37f	12.77	9.42
	5.2	S_1	12.47bcdef	12.44	8.40
	7.8	S_1	12.78bcdef	13.52	10.32
1.5	0	S_1	11.94def	13.81	8.26
	2.6	S_1	12.85bcdef	12.27	8.32
	5.2	S_1	12.10def	12.56	8.84
	7.8	S_1	12.88bcdef	13.24	8.98
3.0	0	S_1	12.81bcdef	13.21	9.17
	2.6	S_1	11.57ef	13.42	9.75
	5.2	S_1	12.50bcdef	13.37	9.23
	7.8	S_1	13.00bcdef	13.05	10.38
4.5	0	S_1	12.56bcdef	13.81	9.33
	2.6	S_1	13.53abcd	11.80	10.22
	5.2	S_1	12.40bcdef	13.63	9.26
	7.8	S_1	12.62bcdef	13.21	9.73
0	0	S_2	13.77abc	13.35	9.61
	2.6	S_2	15.07a	13.67	9.73
	5.2	S_2	13.75abc	13.81	9.18
	7.8	S_2	14.01ab	13.08	10.34
1.5	0	S_2	13.93ab	12.28	9.32
	2.6	S_2	12.71bcdef	13.67	8.98
	5.2	S_2	13.50abcd	13.42	9.56
	7.8	S_2	12.70bcdef	12.55	9.56
3.0	0	S_2	13.82ab	13.71	9.68
	2.6	S_2	13.27bcd	13.05	9.45
	5.2	S_2	13.73abc	13.45	9.74
	7.8	S_2	13.28bcd	13.33	10.30
4.5	0	S_2	12.15cdef	12.11	9.80
	2.6	S_2	13.08bcde	11.80	10.24
	5.2	S_2	13.26bcd	13.14	9.82
	7.8	S_2	13.31bcd	13.24	9.56
		S_1 means	**12.51b**	**12.94a**	**9.28b**
		S_2 means	**13.47a**	**13.10a**	**9.70a**

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

4.4.7 Effects of Tithonia and Bioslurry Manure on Carrots Weight Loss During Storage

Main effects of tithonia and bioslurry manure level did not influence the weight loss of carrots in the 21 days of storage (Table 40). However, when applied together, significant differences in carrot weight loss are observed at 7 DAS and 14 DAS in season 1 and 2, respectively (Table 41). In these sampling dates, carrots from plants treated with the highest manure level combination of 4.5 t/ha of tithonia and 7.8 t/ha of bioslurry registered higher weight loss of 16.43% at 7 DAS in season 1 and 20.1% at 14 DAS in season 2. The lowest weight loss of 6.52% and 9.99% was recorded at 7 DAS in season 1 and at 14 DAS in season 2 in control treatment (Table 41). In both seasons, magnitude of weight loss tended to increase with the advancement of storage period (Table 41).

Table 40. Effects of tithonia and bioslurry manure on carrots weight loss (%)

		Days at storage				Days at storage		
Tithonia (t/ha)	**Season**	7	14	21	**Bioslurry (t/ha)**	0	14	21
0	S_1**	9.67*	10.15	26.96	0	9.43*	10.80	24.28
1.5	S_1	9.77	10.63	26.07	2.6	10.21	12.11	26.43
3.0	S_1	10.26	11.65	27.07	5.2	10.70	10.18	27.28
4.5	S_1	12.38	12.93	27.72	7.8	11.74	12.26	29.14
0	S_2	9.07	11.32	23.58	0	9.95	15.10	24.98
1.5	S_2	11.69	11.87	22.99	2.6	12.12	12.96	24.90
3.0	S_2	11.50	12.16	24.56	5.2	12.08	13.05	25.10
4.5	S_2	12.57	13.25	27.23	7.8	10.68	13.50	24.08

*Means not followed by letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

Table 41. Interaction effects of tithonia and bioslurry manure on carrots weight loss (%)

Tithonia (t/ha)	Bioslurry (t/ha)	Season	Days at storage		
			7	14	21
0	0	S_1**	6.52b*	8.04b	25.92
	2.6	S_1	10.52ab	11.35b	26.19
	5.2	S_1	9.76ab	9.62b	29.25
	7.8	S_1	11.89ab	11.05b	26.47
1.5	0	S_1	10.97ab	11.79ab	18.57
	2.6	S_1	10.81ab	12.52ab	24.87
	5.2	S_1	9.35ab	8.56b	28.37
	7.8	S_1	7.95ab	10.17b	32.47
3.0	0	S_1	9.92ab	10.53b	27.61
	2.6	S_1	9.07ab	12.98ab	26.25
	5.2	S_1	11.32ab	11.64ab	26.32
	7.8	S_1	10.73ab	11.43ab	28.09
4.5	0	S_1	10.29ab	12.30ab	27.80
	2.6	S_1	10.43ab	11.60ab	29.00
	5.2	S_1	12.38ab	11.43ab	25.18
	7.8	S_1	16.43a	16.41ab	29.52
0	0	S_2	8.08ab	9.99b	22.88
	2.6	S_2	11.25ab	12.46ab	22.11
	5.2	S_2	9.96ab	9.96b	23.66
	7.8	S_2	7.92ab	12.87ab	25.66
1.5	0	S_2	9.44ab	10.02b	21.71
	2.6	S_2	11.30ab	12.68ab	22.16
	5.2	S_2	7.52ab	13.02ab	25.32
	7.8	S_2	12.91ab	11.79ab	22.79
3.0	0	S_2	10.97ab	15.93ab	24.55
	2.6	S_2	11.34ab	12.18ab	26.35
	5.2	S_2	12.91ab	12.89ab	24.47
	7.8	S_2	10.79ab	13.42ab	22.86
4.5	0	S_2	11.32ab	14.24ab	27.97
	2.6	S_2	14.61ab	14.50ab	24.99
	5.2	S_2	12.30ab	16.33ab	26.95
	7.8	S_2	12.03ab	20.1a	28.39
		S_1 means	**10.52a**	**11.34b**	**26.95a**
		S_2 means	**11.21a**	**13.65a**	**24.59b**

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

4.4.8 Effects of Tithonia and Bioslurry Manure on Unmarketable carrots

In this study carrots considered unmarketable were those that were forked, cracked and deformed. The percentage of forked, cracked and deformed carrots was neither influenced by tithonia, bioslurry nor combined application of both during the study period (Tables 42 and 43). A general trend of increase in percent forked carrots with increasing levels of tithonia manure levels was, however, observed.

Table 42. Effects of tithonia and bioslurry manure on unmarketable (%) carrots

Tithonia (t/ha)	**Season**	Forked	Cracked	Deformed	**Bioslurry (t/ha)**	Forked	Cracked	Deformed
0	S_1**	7.46*	7.98	8.89	0	7.57	7.69	8.97
1.5	S_1	7.76	7.46	8.34	2.6	7.83	6.98	8.77
3.0	S_1	8.04	7.53	8.66	5.2	8.16	7.37	8.63
4.5	S_1	8.27	8.53	8.85	7.8	7.98	8.99	8.39
0	S_2	7.69	7.30	7.83	0	7.93	6.98	8.77
1.5	S_2	7.85	7.85	7.13	2.6	8.40	6.98	7.70
3.0	S_2	8.56	7.21	7.41	5.2	8.06	7.46	7.16
4.5	S_2	8.94	8.23	7.54	7.8	8.65	8.46	7.79

*Means not followed by letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

Table 43. Interaction effects of tithonia and bioslurry manure on unmarketable (%) carrots

Tithonia (t/ha)	Bioslurry (t/ha)	Season	Forked	Cracked	Deformed
0	0	S_1**	7.35*	6.66	8.79
	2.6	S_1	7.41	6.66	8.29
	5.2	S_1	7.35	6.66	8.15
	7.8	S_1	7.71	9.92	9.51
1.5	0	S_1	7.00	6.66	8.15
	2.6	S_1	7.00	6.66	7.65
	5.2	S_1	8.89	7.30	8.79
	7.8	S_1	8.16	8.58	8.79
3.0	0	S_1	8.89	8.84	8.29
	2.6	S_1	8.63	6.66	8.79
	5.2	S_1	7.75	6.66	8.79
	7.8	S_1	7.00	8.84	8.79
4.5	0	S_1	7.35	8.48	8.15
	2.6	S_1	7.75	7.30	9.33
	5.2	S_1	9.15	8.84	8.79
	7.8	S_1	9.00	8.38	8.15
0	0	S_2	7.75	6.66	7.65
	2.6	S_2	8.16	7.30	7.80
	5.2	S_2	7.35	7.94	7.16
	7.8	S_2	7.91	7.30	8.70
1.5	0	S_2	7.00	7.30	7.16
	2.6	S_2	7.75	7.30	6.66
	5.2	S_2	8.89	7.30	6.66
	7.8	S_2	7.75	9.48	7.65
3.0	0	S_2	9.63	7.94	6.66
	2.6	S_2	9.79	6.66	7.65
	5.2	S_2	7.41	6.66	7.65
	7.8	S_2	7.41	6.66	7.65
4.5	0	S_2	7.41	7.94	7.16
	2.6	S_2	8.59	6.66	8.70
	5.2	S_2	8.59	7.94	7.16
	7.8	S_2	9.07	9.38	7.16
		S_1 means	**7.88**	**8.05**	**8.82**
		S_2 means	**8.26**	**7.65**	**7.45**

*Means not followed by letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

4.5 Effects of Tithonia and Bioslurry Manure on Residual Soil Properties and Tissue Nutrient Content

4.5.1 Effects of Tithonia and Bioslurry Manure on Residual Soil Properties

(a) Soil pH

Tithonia and bioslurry manure levels did not influence soil pH in both seasons (Table 44). Similarly, the interactive effects of tithonia and bioslurry manure were not found significant (Table 45).

(b) Soil Organic Carbon

The effects of tithonia and bioslurry manure levels on soil organic carbon were significant in season 1 but not in season 2 (Tables 44). The interaction between tithonia and bioslurry manure levels was on the other hand not significant in both seasons (Table 45). Application of tithonia at the highest level (4.5 t/ha) resulted in highest soil organic carbon in season 1. Plots treated with intermediary levels of tithonia in this season also had higher organic carbon than the control treatment although the difference was not significant. In both seasons, a general trend could be established where by soil organic carbon tended to increase with increase in amount of tithonia manure applied with the application of tithonia at the highest level of 4.5 t/ha increasing soil organic carbon by 27.5% and 10.3% in season 1 and 2, respectively compared to the control treatment.

Similar to the effect of tithonia, plots treated with 7.8 t/ha of bioslurry had higher soil organic carbon than control plots. Although plots subjected to 2.6 t/ha and 5.2 t/ha of bioslurry tended to have higher soil organic carbon than control plots, the difference was not significant. Application of 7.8 t/ha of bioslurry increased soil organic carbon by 26.3% and 12.5% compared to the control in season 1 and 2, respectively.

Table 44. Effects of tithonia and bioslurry manure on Soil pH and organic carbon (%)

Tithonia (t/ha)	**Season**	Soil pH	Soil organic carbon	**Bioslurry (t/ha)**	**Season**	Soil pH	Soil organic carbon
0	S_1**	6.11*	1.67d	0	S_1**	6.05	1.69c
1.5	S_1	6.12	1.84cd	2.6	S_1	6.20	1.72bc
3.0	S_1	6.18	1.99cd	5.2	S_1	6.20	2.09bc
4.5	S_1	6.19	2.13ab	7.8	S_1	6.26	2.13b
0	S_2	6.41	2.53ab	0	S_2	6.32	2.57a
1.5	S_2	6.39	2.61a	2.6	S_2	6.43	2.70a
3.0	S_2	6.43	2.93a	5.2	S_2	6.37	2.69a
4.5	S_2	6.35	2.79a	7.8	S_2	6.47	2.89a

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

Table 45. Interaction effects of tithonia and bioslurry manure on soil pH and organic carbon (%)

Tithonia (t/ha)	Bioslurry (t/ha)	Season	Soil pH	Soil organic carbon
0	0	S_1 **	5.89*	1.36g
	2.6	S_1	6.17	1.39g
	5.2	S_1	6.07	1.88bcdefg
	7.8	S_1	6.32	2.07abcdefg
1.5	0	S_1	6.17	1.52fg
	2.6	S_1	5.94	1.59efg
	5.2	S_1	6.23	2.21abcdefg
	7.8	S_1	6.14	2.01abcdefg
3.0	0	S_1	6.23	2.09abcdefg
	2.6	S_1	5.97	1.77defg
	5.2	S_1	6.31	1.97abcdefg
	7.8	S_1	6.22	2.12abcdefg
4.5	0	S_1	5.93	1.78cdefg
	2.6	S_1	6.29	2.13abcdefg
	5.2	S_1	6.19	2.32abcdefg
	7.8	S_1	6.39	2.29abcdefg
0	0	S_2	6.32	2.09abcdefg
	2.6	S_2	6.36	2.49abcdef
	5.2	S_2	6.32	2.76abcd
	7.8	S_2	6.67	2.81abcd
1.5	0	S_2	6.28	2.59abcdef
	2.6	S_2	6.47	2.49abcdef
	5.2	S_2	6.48	2.53abcdef
	7.8	S_2	6.35	2.82abc
3.0	0	S_2	6.38	2.86abc
	2.6	S_2	6.56	2.98a
	5.2	S_2	6.33	2.87ab
	7.8	S_2	6.45	2.82abc
4.5	0	S_2	6.29	2.76abcd
	2.6	S_2	6.32	2.87ab
	5.2	S_2	6.34	2.61abcde
	7.8	S_2	6.43	2.93ab

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

(c) Nutrients

Tithonia and bioslurry manure generally influenced most minerals tested in both seasons. The interactive effects of tithonia and bioslurry manure levels were also significant for most mineral nutrients. Residual nitrogen, potassium, magnesium and calcium were significantly ($P \leq 0.05$) influenced by tithonia manure levels in both seasons (Table 46). On the other hand, soil phosphorous levels were not influenced by tithonia application in both seasons. The highest level (4.5 t/ha) of tithonia manure led to better retention of nitrogen, potassium, magnesium and calcium. Although plots subjected to 1.5 t/ha of tithonia retained more nutrients than control plots, the difference was not significant with most of the nutrients tested in both seasons (Table 46).

Application of bioslurry manure at the different levels, on the other hand, significantly affected residual soil nitrogen and magnesium but had no effect on soil phosphorous, potassium and calcium levels in both seasons (Table 47). Application of bioslurry manure at the highest level (7.8 t/ha) increased residual N and Mg by 13.6% and 13.1% in season 1 and by 25% and 8% and in season 2, respectively compared to control plots.

Except for phosphorous, the interaction of tithonia and bioslurry manure levels significantly influenced all other tested nutrients in both seasons (Table 48). Although the interaction was significant, a general trend could be established at any given bioslurry or tithonia level with changing levels of the other factor. At any given tithonia level, residual minerals tested generally increased with increase in bioslurry level although the magnitude of increase varied. A similar trend was also established at each given bioslurry levels with changing levels of tithonia. The effect of combined application of tithonia and bioslurry levels on residual nitrogen varied in the two seasons. In season 1, the highest treatment combination of tithonia (4.5 t/ha) and bioslurry (7.8 t/ha) resulted in highest soil nitrogen levels at the end of the season while in season 2, highest soil nitrogen levels at the end of the season were obtained following combined application of tithonia (1.5 t/ha) and bioslurry (7.8 t/ha). Highest soils potassium, magnesium and calcium levels on the other hand were recorded in plots treatment with the highest tithonia (4.5 t/ha) and bioslurry (7.8 t/ha) level combination in both seasons.

Table 46. Effect of tithonia manure on residual soil nutrients

Tithonia (t/ha)	Season	%				
		N	P	K	Mg	Ca
0	S_1**	0.31ef*	0.0031	0.0131d	0.0019e	0.0538c
1.5	S_1	0.34de	0.0034	0.0137bc	0.0021e	0.0818bc
3.0	S_1	0.36cd	0.0045	0.0138b	0.0021e	0.1046ab
4.5	S_1	0.39bc	0.0042	0.0144a	0.0028d	0.1107ab
0	S_2	0.26f	0.0033	0.0133cd	0.0037c	0.0813bc
1.5	S_2	0.43b	0.0041	0.0136bcd	0.0036c	0.0969ab
3.0	S_2	0.41b	0.0034	0.0139ab	0.0042b	0.1162ab
4.5	S_2	0.56a	0.0043	0.0139ab	0.0044a	0.1206a

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 47. Effect of bioslurry manure on residual soil nutrients

Bioslurry (t/ha)	Season	%				
		N	P	K	Mg	Ca
0	S_1**	0.32d*	0.0032	0.0137	0.0021ef	0.0687b
2.6	S_1	0.34cd	0.0034	0.0137	0.0019f	0.0877ab
5.2	S_1	0.35cd	0.0038	0.0138	0.0023de	0.0885ab
7.8	S_1	0.37bc	0.0048	0.0139	0.0025d	0.1060ab
0	S_2	0.39b	0.0027	0.0135	0.0037c	0.0857ab
2.6	S_2	0.41b	0.0047	0.0137	0.0039bc	0.1048ab
5.2	S_2	0.38bc	0.0038	0.0137	0.0041ab	0.1111a
7.8	S_2	0.52a	0.0037	0.0139	0.0042a	0.1113a

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 48. Interaction effects of tithonia and bioslurry manure on residual soil nutrients

			%				
Tithonia (t/ha)	**Bioslurry (t/ha)**	**Season**	N	P	K	Mg	Ca
0	0	S_1**	0.24efg*	0.0019	0.0130b	0.0018i	0.0333c
	2.6	S_1	0.31def	0.0024	0.0131ab	0.0017i	0.0772abc
	5.2	S_1	0.33bcdef	0.0030	0.0130b	0.0021hi	0.0559abc
	7.8	S_1	0.35bcde	0.0047	0.0133ab	0.0021hi	0.0481abc
1.5	0	S_1	0.32def	0.0032	0.0139ab	0.0020i	0.0706abc
	2.6	S_1	0.34bcde	0.0028	0.0138ab	0.0019i	0.0789abc
	5.2	S_1	0.32def	0.0035	0.0134ab	0.0021hi	0.0726abc
	7.8	S_1	0.37bcd	0.0039	0.0135ab	0.0023gh	0.1050abc
3.0	0	S_1	0.39bcd	0.0038	0.0132ab	0.0020i	0.0837abc
	2.6	S_1	0.34bcde	0.0047	0.0140ab	0.0021hi	0.0935abc
	5.2	S_1	0.34bcde	0.0028	0.0139ab	0.0019i	0.1179abc
	7.8	S_1	0.35bcd	0.0066	0.0143ab	0.0022hi	0.1231abc
4.5	0	S_1	0.34bcde	0.0036	0.0145a	0.0027fg	0.0869bc
	2.6	S_1	0.38bcd	0.0035	0.0141ab	0.0021hi	0.1011abc
	5.2	S_1	0.40bcd	0.0057	0.0145a	0.0031efg	0.1076abc
	7.8	S_1	0.41bcd	0.0041	0.0145a	0.0032efg	0.1478a
0	0	S_2	0.16g	0.0014	0.0130b	0.0033efg	0.0583abc
	2.6	S_2	0.22fg	0.0048	0.0130b	0.0038bcd	0.0969abc
	5.2	S_2	0.33bcdef	0.0033	0.0134ab	0.0045ab	0.0852abc
	7.8	S_2	0.35bcde	0.0036	0.0137ab	0.0035def	0.0846abc
1.5	0	S_2	0.37bcd	0.0041	0.0139ab	0.0042bc	0.0729abc
	2.6	S_2	0.32bcdef	0.0046	0.0134ab	0.0034def	0.0967abc
	5.2	S_2	0.32cdef	0.0053	0.0134ab	0.0035def	0.1094abc
	7.8	S_2	0.70a	0.0023	0.0136ab	0.0034ef	0.1087abc
3.0	0	S_2	0.39bcd	0.0023	0.0132ab	0.0034def	0.1044abc
	2.6	S_2	0.43b	0.0034	0.0143ab	0.0044ab	0.1198abc
	5.2	S_2	0.43bc	0.0041	0.0141ab	0.0045ab	0.1283abc
	7.8	S_2	0.39bcd	0.0037	0.0143ab	0.0045ab	0.1296ab
4.5	0	S_2	0.67a	0.0033	0.0138ab	0.0040bcd	0.1072abc
	2.6	S_2	0.67a	0.0058	0.0139ab	0.0043bc	0.1056abc
	5.2	S_2	0.43bc	0.0028	0.0139ab	0.0046ab	0.1224abc
	7.8	S_2	0.66a	0.0053	0.0142ab	0.0049a	0.1296ab
		S_1means	**0.35b**	**3.79a**	**13.76a**	**3.99a**	**87.73b**
		S_2means	**0.43a**	**3.74a**	**13.70a**	**2.22b**	**103.74b**

*Means followed by the same letters or no letters within a column or row are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

4.5.2 Effects of Tithonia and Bioslurry Manure on Selected Tissue Nutrients

(a) Leaf Nutrients

In general, all leaf nutrients except Ca were influenced by main effects of tithonia and bioslurry manure in both seasons. Significant interactions between tithonia and bioslurry manure was also observed for all nutrients except Ca. Application of tithonia manure led to higher N, P, K and Mg levels in leaf tissue, in both seasons with the highest levels obtained in plants from plots treated with the highest level (4.5 t/ha) of tithonia manure (Table 49). Leaf nutrients of plants from this treatment were, however, not any different from those of plants treated with 3 t/ha in both seasons.

Similar to the effects of tithonia, addition of bioslurry manure levels also influenced leaf tissue N, P, K and Mg (Table 50). Plants that received the higher levels (5.2 t/ha and 7.8 t/ha) of bioslurry manure accumulated more of N, P, K and Mg than control plants in both seasons. Plants treated with 2.6 t/ha of bioslurry tended to have more nutrients than control, although the difference was not significant for most nutrients.

Combined application of tithonia and bioslurry manure levels varied in influencing the accumulation of leaf nutrients in both seasons (Table 51).

Table 49. Effect of tithonia manure on selected leaf nutrients

		%				
Tithonia (t/ha)	**Season**	N	P	K	Mg	Ca
0	S_1**	1.15b*	0.12d	1.35c	0.97bc	0.67
1.5	S_1	1.18b	0.27c	1.41ab	1.04b	0.67
3.0	S_1	1.36a	0.40abc	1.42a	1.02b	0.72
4.5	S_1	1.38a	0.40abc	1.44a	1.40a	0.71
0	S_2	0.86c	0.30bc	1.37bc	0.93c	0.67
1.5	S_2	1.16b	0.36abc	1.41ab	0.90c	0.66
3.0	S_2	1.37a	0.42ab	1.41ab	1.04b	0.66
4.5	S_2	1.35a	0.46a	1.42a	1.05b	0.68

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 50. Effect of bioslurry manure on selected leaf nutrients

		%				
Bioslurry (t/ha)	**Season**	N	P	K	Mg	Ca
0	S_1**	1.14b*	0.21d	1.35d	0.99c	0.66ab
2.6	S_1	1.24ab	0.30cd	1.41abc	1.07bc	0.65ab
5.2	S_1	1.34a	0.32bcd	1.40bc	1.15ab	0.72ab
7.8	S_1	1.35a	0.36bc	1.45a	1.22a	0.74a
0	S_2	0.96c	0.30cd	1.38cd	0.87d	0.60b
2.6	S_2	1.14b	0.32bcd	1.39bcd	0.98c	0.67ab
5.2	S_2	1.31a	0.43ab	1.41ab	1.06c	0.68ab
7.8	S_2	1.34a	0.50a	1.42ab	1.01c	0.71ab

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 51. Interaction effects of tithonia and bioslurry manure on selected leaf nutrients

			%				
Tithonia (t/ha)	**Bioslurry (t/ha)**	**Season**	N	P	K	Mg	Ca
0	0	S_1**	0.89efg*	0.13def	1.28e	0.84fghi	0.56
	2.6	S_1	1.08cdef	0.11f	1.41abcd	0.92defghi	0.74
	5.2	S_1	1.28abcd	0.13def	1.37cde	1.05cdefg	0.69
	7.8	S_1	1.37abc	0.13def	1.36cde	1.06cdefg	0.70
1.5	0	S_1	0.96defg	0.21bcdef	1.42abcd	1.01cdefghi	0.74
	2.6	S_1	1.13bcde	0.24abcdef	1.38bcde	0.98defghi	0.50
	5.2	S_1	1.35abc	0.26abcdef	1.41abcd	1.04cdefgh	0.69
	7.8	S_1	1.29abcd	0.38abcdef	1.43abcd	1.13bcd	0.75
3.0	0	S_1	1.42abc	0.26abcdef	1.36cde	1.00cdefghi	0.67
	2.6	S_1	1.38abc	0.39abcdef	1.42abcd	1.06cdefg	0.73
	5.2	S_1	1.38abc	0.45abcd	1.41abcd	0.95defghi	0.73
	7.8	S_1	1.37abc	0.48ab	1.49a	1.09bcde	0.77
4.5	0	S_1	1.29abcd	0.25abcdef	1.38cde	1.32b	0.65
	2.6	S_1	1.40abc	0.47abc	1.44abcd	1.09cde	0.65
	5.2	S_1	1.36abc	0.43abcde	1.41abcd	1.56a	0.77
	7.8	S_1	1.39abc	0.45abcd	1.53a	1.61a	0.75
0	0	S_2	0.66g	0.25abcdef	1.37cde	0.81hi	0.69
	2.6	S_2	0.66g	0.15cdef	1.41abcd	0.94defghi	0.61
	5.2	S_2	1.08cdef	0.33abcdef	1.33de	1.11bcd	0.71
	7.8	S_2	1.07cdef	0.50ab	1.37cde	0.87efghi	0.66
1.5	0	S_2	0.77fg	0.14def	1.38bcde	1.05cdefg	0.69
	2.6	S_2	1.15bcde	0.29abcdef	1.39bcd	0.84fghi	0.51
	5.2	S_2	1.25abcde	0.48ab	1.42abcd	0.86efghi	0.64
	7.8	S_2	1.48ab	0.55a	1.42abcd	0.83fghi	0.80
3.0	0	S_2	1.36abc	0.43abcdef	1.37cde	0.85fghi	0.69
	2.6	S_2	1.37abc	0.44abcde	1.45abc	1.09bcde	0.63
	5.2	S_2	1.45ab	0.37abcdef	1.39bcd	1.12bcd	0.68
	7.8	S_2	1.25abcde	0.44abcde	1.43abcd	1.13bcd	0.65
4.5	0	S_2	1.06cdef	0.39abcdef	1.39bcd	0.80hi	0.61
	2.6	S_2	1.39abc	0.39abcdef	1.45abc	1.07cdef	0.67
	5.2	S_2	1.49ab	0.55a	1.42abcd	1.14bcd	0.70
	7.8	S_2	1.56a	0.51ab	1.44abcd	1.22bc	0.75
		S_1 means	**1.27a**	**0.30b**	**1.40a**	**1.11a**	**0.69a**
		S_2 means	**1.19b**	**0.39a**	**1.40a**	**0.98b**	**0.67a**

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

(b) Root Nutrients

Carrot root nutrients were affected by tithonia and bioslurry manure levels in both seasons. The interactions between main factors were also significant with an exception of Ca in season 2. A general increase in root nutrients with increasing amounts of tithonia manure levels was observed in both seasons. The highest level (4.5 t/ha) of tithonia manure increased N, P, K, Mg by 15.8%, 42.9%, 11% and 4% in season 1 and by 47.2%, 43.6%, 8% and 22.7% in season 2, respectively compared to the control (Table 52). The effect of tithonia levels on root tissue Ca varied in the two seasons. In season 1, all tithonia levels increased Ca in the root tissue over control treatment, but in season 2, the influence was not significant.

Apart from Ca and Mg which were not affected by bioslurry, N, P and K were significantly influenced by bioslurry levels in both seasons. N, P and K in carrot root tissue increased by 8.6%, 11% and 6.5% and by 18.3%, 41.7%, and 3.5% in season 1 and 2, respectively following application of the highest level (7.8 t/ha) of bioslurry compared to the control (Table 53). Plants treated with 5.2 t/ha of bioslurry tended to have more nutrients than plants subjected to 2.6 t/ha of bioslurry, although the difference was not significant in most selected root nutrients.

Significant interactions were observed between tithonia and bioslurry manure levels on root nutrient content (Table 54). In season 1, the amounts of P and K were influenced by combined application of tithonia and bioslurry manure levels while N, Ca and Mg were not affected. In season 2, however all selected root nutrients were influenced by combined application of tithonia and bioslurry manure. The interactive effects of tithonia (4.5 t/ha) and bioslurry (7.8 t/ha) led to highest accumulation of N, P and Mg in carrot, with roots of control plants accumulating least nutrients in both seasons. The effect of combined application of tithonia and bioslurry manure levels on K and Ca varied in the two seasons (Table 54). In season 1, higher root K was recorded in plants treated with 4.5 t/ha of tithonia and 2.6 t/ha of bioslurry while in season 2, 3.0 t/ha of tithonia and 2.6 t/ha of bioslurry accumulated more K. On the other hand, Ca in the root tissue was not influenced by combined application of tithonia and bioslurry manure in season 1, while in season 2, higher root Ca was recorded in plants treated with 3.0 t/ha of tithonia and 2.6 t/ha of bioslurry.

Table 52. Effect of tithonia manure on selected root nutrients

Tithonia (t/ha)	Season	%				
		N	P	K	Mg	Ca
0	S_1**	0.57de	0.28c	1.36e	0.15e	0.44b
1.5	S_1	0.58cde	0.33b	1.42cd	0.18de	0.62a
3.0	S_1	0.63bcd	0.38a	1.50a	0.20cde	0.59a
4.5	S_1	0.66bc	0.40a	1.51a	0.21cd	0.63a
0	S_2	0.53e	0.22d	1.37e	0.22bcd	0.55ab
1.5	S_2	0.63bcd	0.32bc	1.40de	0.24abc	0.51ab
3.0	S_2	0.70ab	0.29bc	1.45bc	0.25ab	0.65a
4.5	S_2	0.78a	0.39a	1.48ab	0.27a	0.52ab

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 53. Effect of bioslurry manure on selected root nutrients

Bioslurry (t/ha)	Season	%				
		N	P	K	Mg	Ca
0	S_1**	0.58c	0.28d	1.39c	0.17d	0.53
2.6	S_1	0.61bc	0.37ab	1.45ab	0.17d	0.63
5.2	S_1	0.62bc	0.35ab	1.45ab	0.19cd	0.56
7.8	S_1	0.68ab	0.39a	1.48a	0.20bcd	0.56
0	S_2	0.60bc	0.24d	1.39c	0.23abc	0.54
2.6	S_2	0.67ab	0.29cd	1.43bc	0.24ab	0.61
5.2	S_2	0.66abc	0.36ab	1.43bc	0.24ab	0.52
7.8	S_2	0.71a	0.34bc	1.44b	0.27a	0.56

*Means followed by the same or no letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

Table 54. Interaction effects of tithonia and bioslurry manure on selected root nutrients

Tithonia (t/ha)	Bioslurry (t/ha)	Season	% N	P	K	Mg	Ca
0	0	S_1**	0.54defg	0.28defg	1.28k	0.13d	0.59abcd
	2.6	S_1	0.56defg	0.25defg	1.37hijk	0.15cd	0.69abcd
	5.2	S_1	0.60defg	0.27defg	1.39fghij	0.16cd	0.56abcd
	7.8	S_1	0.56defg	0.30cdef	1.40efghij	0.16cd	0.51bcd
1.5	0	S_1	0.57defg	0.26defg	1.42defghi	0.18bcd	0.39bcd
	2.6	S_1	0.60defg	0.37abcd	1.39fghij	0.16cd	0.49bcd
	5.2	S_1	0.57defg	0.32bcd	1.41efghij	0.16cd	0.65abcd
	7.8	S_1	0.60defg	0.36abcd	1.46bcdefgh	0.21abcd	0.73abc
3.0	0	S_1	0.61cdefg	0.27defg	1.45bcdefghi	0.19bcd	0.44bcd
	2.6	S_1	0.61cdefg	0.42abc	1.45bcdefghi	0.22abcd	0.48bcd
	5.2	S_1	0.61cdefg	0.42abc	1.54ab	0.19bcd	0.45bcd
	7.8	S_1	0.67bcdefg	0.41abc	1.54ab	0.19bcd	0.46bcd
4.5	0	S_1	0.59defg	0.32bcd	1.43cdefghi	0.19bcd	0.72abc
	2.6	S_1	0.69bcde	0.43abc	1.61a	0.21abcd	0.60abcd
	5.2	S_1	0.68bcdef	0.37abcd	1.46bcdefghi	0.18bcd	0.60abcd
	7.8	S_1	0.68bcdef	0.48a	1.53abc	0.22abcd	0.61abcd
0	0	S_2	0.44g	0.17g	1.33jk	0.20bcd	0.50bcd
	2.6	S_2	0.47fg	0.19fg	1.36ijk	0.21bcd	0.52abcd
	5.2	S_2	0.64cdefg	0.27defg	1.38fghij	0.24abcd	0.63abcd
	7.8	S_2	0.56defg	0.28defg	1.41efghij	0.22abcd	0.54abcd
1.5	0	S_2	0.75abcd	0.19efg	1.41efghij	0.23abcd	0.58abcd
	2.6	S_2	0.65cdefg	0.36abcd	1.40efghij	0.22abcd	0.57abcd
	5.2	S_2	0.52efg	0.41abc	1.41efghij	0.22abcd	0.54abcd
	7.8	S_2	0.61cdefg	0.33bcd	1.38hijk	0.29ab	0.55abcd
3.0	0	S_2	0.58defg	0.30cdef	1.43cdefghij	0.26abc	0.55abcd
	2.6	S_2	0.65cdefg	0.28defg	1.46bcdefgh	0.23abcd	0.88a
	5.2	S_2	0.83abc	0.27defg	1.53abcd	0.26abc	0.55abcd
	7.8	S_2	0.74abcde	0.30cdef	1.48bcdefg	0.25abc	0.62abcd
4.5	0	S_2	0.64cdefg	0.30cdef	1.40efghij	0.24abcd	0.55abcd
	2.6	S_2	0.89ab	0.33bcd	1.50bcde	0.29ab	0.56abcd
	5.2	S_2	0.65cdefg	0.44ab	1.39fghij	0.25abcd	0.56abcd
	7.8	S_2	0.92a	0.47a	1.50bcdef	0.33a	0.53abcd
		S_1 means	**0.61b**	**0.35a**	**1.45a**	**0.18b**	**0.57a**
		S_2 means	**0.66b**	**0.31b**	**1.42b**	**0.24a**	**0.56a**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at $P \leq 0.05$.

** S stands for Season

Table 54. Interaction effects of tithonia and bioslurry manure on selected root nutrients

Tithonia (t/ha)	Bioslurry (t/ha)	Season	%				
			N	P	K	Mg	Ca
0	0	S_1**	0.54defg	0.28defg	1.28k	0.13d	0.59abcd
	2.6	S_1	0.56defg	0.25defg	1.37hijk	0.15cd	0.69abcd
	5.2	S_1	0.60defg	0.27defg	1.39fghij	0.16cd	0.56abcd
	7.8	S_1	0.56defg	0.30cdef	1.40efghij	0.16cd	0.51bcd
1.5	0	S_1	0.57defg	0.26defg	1.42defghi	0.18bcd	0.39bcd
	2.6	S_1	0.60defg	0.37abcd	1.39fghij	0.16cd	0.49bcd
	5.2	S_1	0.57defg	0.32bcd	1.41efghij	0.16cd	0.65abcd
	7.8	S_1	0.60defg	0.36abcd	1.46bcdefgh	0.21abcd	0.73abc
3.0	0	S_1	0.61cdefg	0.27defg	1.45bcdefghi	0.19bcd	0.44bcd
	2.6	S_1	0.61cdefg	0.42abc	1.45bcdefghi	0.22abcd	0.48bcd
	5.2	S_1	0.61cdefg	0.42abc	1.54ab	0.19bcd	0.45bcd
	7.8	S_1	0.67bcdefg	0.41abc	1.54ab	0.19bcd	0.46bcd
4.5	0	S_1	0.59defg	0.32bcd	1.43cdefghi	0.19bcd	0.72abc
	2.6	S_1	0.69bcde	0.43abc	1.61a	0.21abcd	0.60abcd
	5.2	S_1	0.68bcdef	0.37abcd	1.46bcdefghi	0.18bcd	0.60abcd
	7.8	S_1	0.68bcdef	0.48a	1.53abc	0.22abcd	0.61abcd
0	0	S_2	0.44g	0.17g	1.33jk	0.20bcd	0.50bcd
	2.6	S_2	0.47fg	0.19fg	1.36ijk	0.21bcd	0.52abcd
	5.2	S_2	0.64cdefg	0.27defg	1.38fghij	0.24abcd	0.63abcd
	7.8	S_2	0.56defg	0.28defg	1.41efghij	0.22abcd	0.54abcd
1.5	0	S_2	0.75abcd	0.19efg	1.41efghij	0.23abcd	0.58abcd
	2.6	S_2	0.65cdefg	0.36abcd	1.40efghij	0.22abcd	0.57abcd
	5.2	S_2	0.52efg	0.41abc	1.41efghij	0.22abcd	0.54abcd
	7.8	S_2	0.61cdefg	0.33bcd	1.38hijk	0.29ab	0.55abcd
3.0	0	S_2	0.58defg	0.30cdef	1.43cdefghij	0.26abc	0.55abcd
	2.6	S_2	0.65cdefg	0.28defg	1.46bcdefgh	0.23abcd	0.88a
	5.2	S_2	0.83abc	0.27defg	1.53abcd	0.26abc	0.55abcd
	7.8	S_2	0.74abcde	0.30cdef	1.48bcdefg	0.25abc	0.62abcd
4.5	0	S_2	0.64cdefg	0.30cdef	1.40efghij	0.24abcd	0.55abcd
	2.6	S_2	0.89ab	0.33bcd	1.50bcde	0.29ab	0.56abcd
	5.2	S_2	0.65cdefg	0.44ab	1.39fghij	0.25abcd	0.56abcd
	7.8	S_2	0.92a	0.47a	1.50bcdef	0.33a	0.53abcd
		S_1 means	**0.61b**	**0.35a**	**1.45a**	**0.18b**	**0.57a**
		S_2 means	**0.66b**	**0.31b**	**1.42b**	**0.24a**	**0.56a**

*Means followed by the same letters within a column are not significantly different according to Tukey Honestly Significantly Test at P≤0.05.

** S stands for Season

4.6 Relationship between Shoulder and Core Diameter

Relationship between shoulder and core diameter was studied using correlation analysis. These parameters were found to be significantly and positively correlated with a correlation coefficient of 0.62 ($P < 0.0001$).

4.7 Relationship between Leaf N and Chlorophyll Content

The relationship between leaf N and chlorophyll content was studied using linear regression analysis. The regression model was highly significant ($P < 0.0001$) with R^2 value of 0.29 (Fig.3).

4.8 Relationship between Root Yield and Above Ground Biomass

The relationship between root yield and above ground biomass is shown in figure 4. Using R^2 as the basis of selecting the best model, the relationship between root yield and above ground biomass could best be described using second order polynomial equation. The regression model was highly significant ($P<0.0001$) with R^2 value of 0.82.

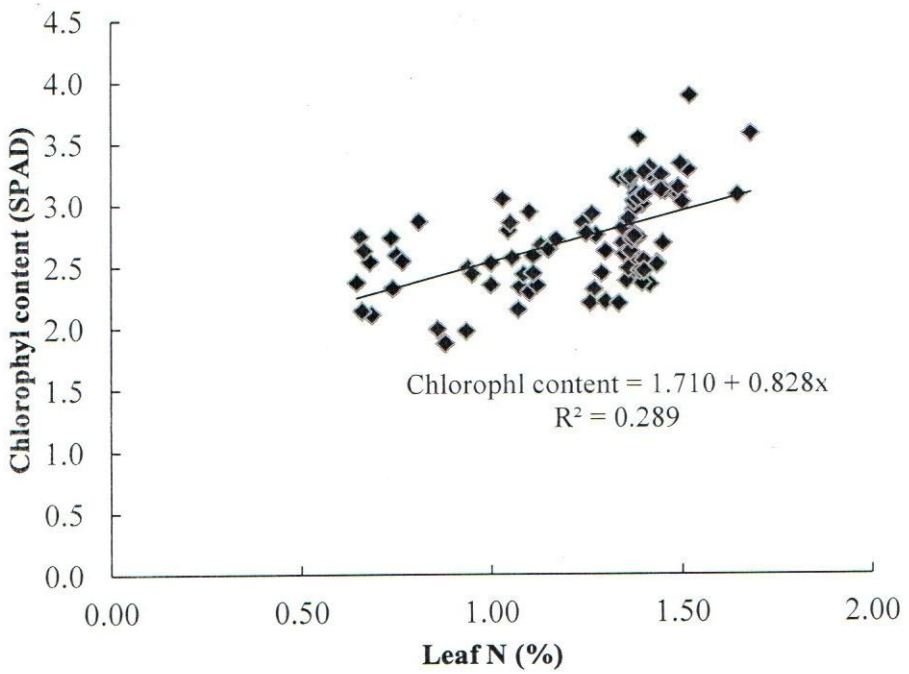


Figure 3. Relationship between leaf N (%) and chlorophyll content

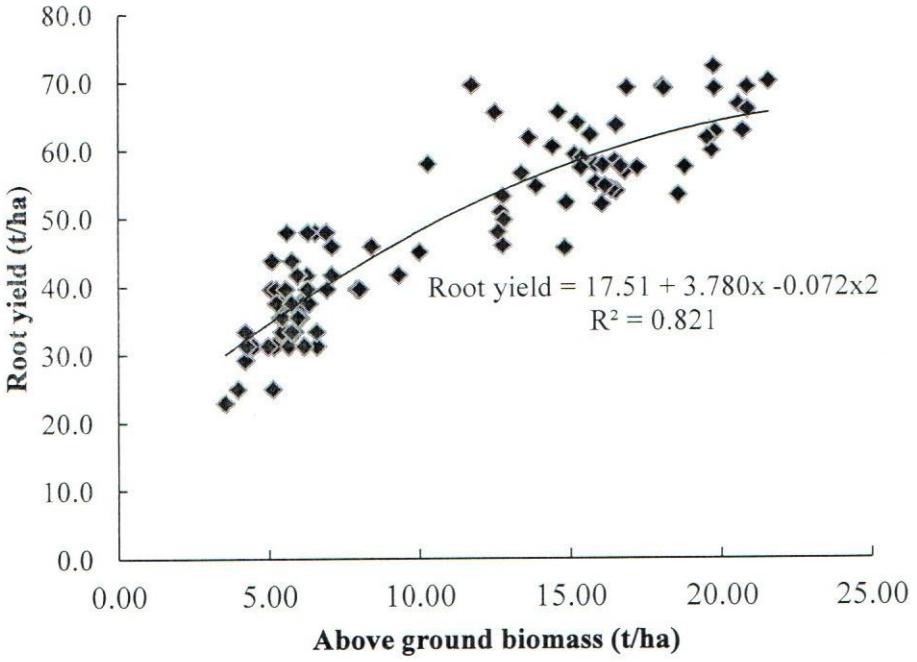


Figure 4. Relationship between above ground biomass (t/ha) and root Yield (t/ha)

CHAPTER FIVE

5.0 DISCUSSION

In this chapter, the results presented in chapter four have been discussed. The same order of presentation of results has been followed in the discussion.

5.1 Effects of Tithonia and Bioslurry Manure on Carrot Growth

The role of organic manures in plant growth cannot be underscored. Organic manures have been shown to supply the required plant nutrients, improve soil structure and water holding capacity, increase microbial population and at the same time promote plant growth (Dauda *et al.*, 2008). Findings of the current study support these arguments. An increase in all measured growth parameters was observed with successive increase in tithonia and bioslurry manure levels. Carrot plants treated with highest level (4.5 t/ha) of tithonia manure or 7.8 t/ha of bioslurry manure grew taller and had more number of leaves than control plants. A similar trend was observed when the same treatments were combined. Similar to the findings of this study, Mbatha (2008) observed increased plant height and leaf number of carrots subjected to higher rates of different organic fertilizers (chicken, kraal and compost) which she attributed to enhanced nutrients availability, moisture retention and uptake as a result of manure application. Liasu *et al.*, (2008) similarly observed increased okra plant height in soils supplemented with fortified tithonia mulch which they attributed to improved soil conditions through replenishment of soil nutrients. Nitrogen, phosphorous and potassium are essential for good growth of plants. In the current study, higher plant heights and leaf numbers obtained could be attributed to better levels of major nutrients (NPK) in both bioslurry and tithonia manure which was later reflected in the growing medium at the end of each growing season. Phosphorous has been shown to favour early crop establishment and better growth while nitrogen on the other hand is essential for vegetative growth. Similar to the current findings, Hailu *et al.*, (2008) observed higher plant height of carrots treated with organic P fertilizer (Orga) compared to control plants which he attributed to the ability of phosphorus to enhance early plant growth.

5.2 Effects of Tithonia and Bioslurry Manure on Physiological Parameters

Nitrogen is important for plant growth due to being part of amino acid, protein and chlorophyll molecule synthesis (Madan and Munjal, 2009). Higher leaf chlorophyll content has been associated with higher leaf N which also depends on soil nitrogen status (Ghosh *et al.*, 2000). In this study, leaf chlorophyll content increased with increasing levels of tithonia and bioslurry manure. Similar to the observations of the current study, Karanastidis and Berova (2009) reported an increased leaf chlorophyll content on pepper plants treated with higher levels of Emason (organic N fertilizer) over control treatment, which they attributed to increased nitrogen mineralization and uptake by plants. In line with these arguments, higher leaf chlorophyll contents following tithonia and bioslurry application in the present study could be attributed to higher nitrogen content in the manures that enhanced the soil nitrogen status as reflected by the differences in soil nitrogen at the beginning and at the end of each growing seasons, could have led to better nitrogen accumulation in the leaf tissues. This argument is further supported by the linear relationship established between leaf nitrogen and chlorophyll content. Abuselvi (2010) also observed a linear relationship between different nitrogen levels supplied through manure (coir waste and cow dung) and leaf chlorophyll content on black gram which he attributed to enhanced nutrients release and uptake by plants.

In addition, magnesium has been shown to be an essential component of the enzyme that catalyzes chlorophyll synthesis and functions as a bridging element between ribosome subunits in protein synthesis (Rissler *et al.*, 2002). In this study, the appreciable quantities of magnesium in tithonia and bioslurry manure which also resulted in higher magnesium levels in plant tissues might have helped in the chlorophyll synthesis and thus enhanced leaf chlorophyll content in manure treated plants.

The control of leaf stomatal conductance is a crucial mechanism for plants, since it is essential for both carbon dioxide acquisition and utilization in the process of photosynthesis and subsequently increasing plant biomass and yield (Dodd, 2003). In the current study, leaf stomatal conductance displayed similar trends to those of leaf chlorophyll content with a tendency of increasing with increasing manure levels. The higher stomatal conductance could be attributed to the better levels of nitrogen, potassium and magnesium which were reflected by higher tissue nutrient content. These observations may allude to the fact that along with leaf chlorophyll content, plants treated with manure may have had higher photosynthetic rates compared to their

control counterparts. Similar results have been reported by Ghosh *et al.*, (2000) who noted an increase in stomatal conductance with increasing levels of nitrogen in potato plants and Karantsidis and Berova (2009) who observed increased stomatal conductance in pepper plants treated with Emason (organic N fertilizer). Increased stomatal conductance observed with increasing levels of manures could also be attributed to the role of potassium contained in manures in regulating water status in plants. These findings are consistent with those of Fanaei *et al.*, (2009) who observed greater water use efficiency, greater leaf water content and greater leaf stomatal conductance in *Brassica napus* and *Brassica juncea* treated with potassium compared to control. Magnesium has also been shown to influence various physiological aspects related to leaf water. Foliar feeding spinach with magnesium salts has been shown to increase gas exchange rates, leaf protein and chlorophyll content (Borowski and Michalek 2010).

5.3 Effects of Tithonia and Bioslurry Manure on Biomass and Yield Parameters

Organic manures are known to have the ability to supply both macro and micro nutrients required for crop growth, development and final economic yield (Parry *et al.*, 2005). In current study, an increase in all measured biomass parameters was observed with successive increase in tithonia and bioslurry manure levels. Higher fresh and dry shoot biomass was obtained following application of 4.5 t/ha of tithonia or 7.8 t/ha of bioslurry or combined application of both. Similar results were reported by Hossain and Ishimine (2007) on turmeric plants subjected to chicken, goat and cow manure, which they attributed to enhanced aeration in the soil and improved microbial activities which could have led to better release of nutrients from organic manures and Ouda and Mahadeen (2008) who recorded increased vegetative growth in broccoli plants treated with increasing doses of organic manures. In the current study, higher fresh and dry shoot biomass obtained could be attributed to the supply of macronutrients and enhanced soil physical properties by tithonia and bioslurry manure. Organic manures are also known to have the ability to activate many species of living organisms, which release phytohormones that may stimulate growth and absorption of nutrients (Arisha *et al.*, 2005).

Organic manure provides more conducive conditions in the soil, which enhance root expansion and development (Mandal *et al.*, 2003). Tithonia green manure has been shown to increase root growth, root density, fresh root weight and dry root weight in maize (Sangakkara *et al.*, 2004). Findings of the current study concur with these observations where higher dry root weight and root volume was observed for carrots treated with higher levels of tithonia and

bioslurry manure than control plants. The observed increase in dry root weight and root volume in this study could be attributed to increased nutrients following the application of manures. Maximum and lowest root volume was recorded in plants treated with combined application of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry manure levels and control treatment, respectively with application of the highest levels of treatment combinations causing a reduction in the dry root biomass and root volume. This reduction could probably have been as a result of excessive vegetative growth at higher N levels thus affecting the partitioning of photosynthates into the roots. Similar results have been recorded on turmeric plants subjected to chicken, goat and cow manure (Hossain and Ishimine, 2007).

A general increase in total root yield with successive increase in tithonia and bioslurry manure was observed in this study. Carrot yields increased by between 8.8% and 32.6% in plants treated with the higher levels of tithonia and bioslurry manure. Combined application of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry also increased yields by between 51% and 69%. The findings are in agreement with those of Aguyoh *et al.,* (2010) who reported a significant and positively correlated increase in total yield of watermelon with increasing application rates of *Tithonia diversifolia* manure with yields enhanced by between 8.5% and 31% in plants subjected to the highest level (5.4 t/ha) of tithonia compared to the control. Similar trends of yield increase with increase in manure application have been reported with amaranthus (Maerere *et al.*, 2001) and carrots (Mbatha, 2008). The observed increase in yields in the current study could be attributed to the advantage of organic manures being able to supply the required nutrients, improve soil structure, increase microbial biomass and increase water holding capacity which might have influenced nutrient availability and uptake leading to enhanced root development and increased growth rate and yields. The enhanced root yield observed in this study could also be attributed to the increased vegetative growth as a result of nutrients supplied through application of manures and hence increased photosynthesis, assimilation and translocation of photosynthates into the roots. This argument is supported by the strong relationship ($R^2 = 0.82$) established between the above ground and root yield.

Root yield of carrots were greatly influenced by seasons. In season 1, root yields were lower by 30.8% compared to season 2. This could mainly be attributed to variation in weather, particularly temperature. Temperatures recorded during the study period ranged between 20.5 °C to 21.4 °C and 19.4°C to 21.2 °C in season 1 and 2, respectively. Carrot is a cool season crop with

optimum plant growth obtained at between temperatures of 15°C - 20°C (Karkleliene *et al.*, 2007). The slightly higher temperatures recorded in season 1 could therefore, partly explain the lower root yields in season 1.

Harvest index was not influenced by manure levels through out the study. Zelalem *et al.*, (2009) similarly observed non-significant harvest index with increasing N rates on potato which he attributed to increased haulm growth. In the current study, the non-significant difference in harvest index could be attributed to increased shoot growth.

5.4 Effects of Tithonia and Bioslurry Manure on Quality Parameters

Quality improvement of vegetables and fruits has been observed as one of the beneficial effects of organic manures (Islam and Momin 2004). In the current study, longest roots recorded following application of higher levels of tithonia and bioslurry manure than of control plants attribute to the effect of manures in the reduction of soil bulk density, hence, better root growth, expansion and proliferation. These observations support those by Maerere *et al.* (2001) who recorded increased root length of amaranthus with increasing rates of poultry manure and Mbatha (2008) who observed an increase in root length of carrots with successive increase in different organic fertilizers (kraal, chicken and compost).

Largest shoulder diameter was recorded when carrot plants were subjected to the higher levels of tithonia and bioslurry manure in the present study. Consistent with these observations are the results of Hailu et al., (2008) who recorded a 17.5% increase in shoulder diameter of carrots treated with organic P fertilizer and attributed it to the ability of phosphorous to enhance root growth and development. In the current study, the better levels of phosphorous in both tithonia and bioslurry manure could have contributed to the improved shoulder diameter. Core diameter also displayed similar trends to those of shoulder diameter when treated with tithonia manure, however no differences were observed in plants treated with bioslurry manure. Finding of this study in part support those of Hailu *et al.*, (2008) who also observed non-significant differences in carrots core diameter treated with organic P fertilizer. Organic manures increase water holding capacity and reduces bulk density in the soil (Adeleye *et al.*, (2010). Loose soil following application of manures may have probably favored root growth and expansion leading to increased shoulder diameter of carrots. With increasing shoulder diameter, core diameter also tended to increase as revealed by the positive significant correlation ($R^2 = 0.62$; $P < 0.0001$) between shoulder and core diameter observed in the current study.

Total soluble solids is the Brix, which is the total amount of soluble solids of the juice which are mainly sugars, with smaller amounts of organic acids, vitamins, protein, free amino acids, essential oils and glucosides (Hardy and Sanderson, 2010). Tithonia, bioslurry manure and their interactions influenced total soluble solids of carrots with control generally having the lowest total soluble solids. Results of the present study are in agreement with the findings of Ahmad *et al.*, (2005) who reported positive effect of farmyard manure on total soluble solids content of carrots compared to the control and Aguyoh *et al.*, (2010) who noted increased total soluble solids content of watermelon supplied with higher levels of tithonia manure. The enhanced total soluble solids observed following application of higher levels of tithonia and bioslurry manure in this study could be attributed to the better levels of macronutrients and micronutrients in manures required for growth and quality. Potassium is the key element in influencing quality of fruits and vegetables (Madge *et al.*, 2003). Higher total soluble solids values recorded for manure treated carrots in the current study could probably be due to more potassium contained in the manures. The general trend of increased total soluble solids observed during the 14 days of storage could be associated with moisture loss and hydrolysis of carbohydrates to soluble sugars. Hailu *et al.*, (2008) also reported increased total soluble solids after 28 days of storage of carrots under ambient conditions.

Weight loss and firmness were not influenced by application of either tithonia or bioslurry manure. Similar findings were reported by Kodithuwakku and Kirthisighe (2009) on cauliflower using different rates of nitrogen.

Forked carrots were neither significantly influenced by main factors of tithonia and bioslurry nor the combined application of tithonia and bioslurry. Forked carrots tend to form in heavy soils and those applied with fresh organic manure. In the current study, well decomposed manure was used and this could be the possible reason for the non-significant difference observed among treatment levels. Similar effect was observed with percentage cracked roots, which could be attributed to the fact that water was supplied evenly hence prevented cracking.

5.5 Effects of Tithonia and Bioslurry Manure on Residual Soil Properties

Organic manures has been shown to enhance soil fertility through the modification of soil physical, chemical and biological properties (Haering and Evanylo, 2005). Soil pH in this study was not influenced by tithonia and bioslurry manure levels. This is similar to the findings of Tolanar and badanar (2003) and Rajashree *et al.*, (2005). However, Soil pH at the end of the

experiment was higher and ranged between 6.05 to 6.47 than at the beginning (5.86). It is possible that well decomposed manure acted as a buffering agent (Wong *et al.*, 1999). Soil organic carbon increased with increasing levels of tithonia and bioslurry with the highest level 4.5 t/ha of tithonia and 7.8 t/ha of bioslurry increasing soil organic carbon by between 10.3% and 26.3% in both seasons compared to control plots. These findings support results by Akanbi *et al.*, (2007) who found that the use of composted tithonia manure increased soil organic matter. Similarly, Ghuman and Sur (2006), reported higher organic matter following application of farmyard manure at 18 t/ha over 6 t/ha. The increase in organic carbon in the current study is ascribed to the addition of organic matter into the soil which was later mineralized by micro-organisms to carbon.

Increased amounts of N, K, Mg and Ca was observed at higher levels of tithonia and bioslurry manure applied either singly or in combination. In line with these findings, Olubukola *et al.*, (2010) reported that use of tithonia as soil amendment for growth of *Celosia argentea* led to the retention of more N, P, K, Mg and Ca compared to the control. Similar results were also reported by Adeleye *et al.*, (2010) on soils treated with poultry manure. The better retention of macronutrients could be attributed to the ability of tithonia and bioslurry manure to supply humus to the soil thereby enhancing the water holding capacity and nutrient retention in the soil. The significant increase in available nutrients content due to addition of both tithonia and bioslurry manure levels could be due to increased multiplication of microbes which might have mineralized the nutrients contained in them. Organic manure has also been mentioned to contain various acids, which might help in the release of the non-exchangeable K to the water soluble forms (Chitra and Janaki, 1999).

5.6 Effects of Tithonia and Bioslurry Manure on Root and Leaf Tissue Nutrients

There were significant responses of leaf and root N, P, K, Ca and Mg concentrations to the application of main factors of tithonia and bioslurry manure or combined application of both with manure treated plants generally having higher nutrient accumulation in their tissues compared to controls. Similarly, Adeleye *et al.*, (2010) reported enhanced leaf nutrients content of Yam following poultry manure application; Olubukola *et al.*, (2010) observed better nutrient accumulation in *Celosia argentea* using tithonia and compost and Ojeniyi and Adeyobi (2002) reported increased leaf nutrients of amaranthus following combined application of ash and goat manure which they attributed to the release of nutrients from plants and animal wastes. In the

current study, it is possible that added tithonia and bioslurry manure decomposed releasing nutrients, thereafter leading to increased absorption and accumulation of mineral nutrients by plants. Generally, greater amounts of nutrients were accumulated in the shoots than roots. A higher accumulation of nutrients in the shoots than in the roots has been possibly attributed to osmoregulation of plant cells (Fontes *et al.*, 2000).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the findings of this study, the following conclusions can be made:

1. Application of tithonia and bioslurry manure and their combinations influence carrot plant growth.
2. Tithonia manure applied at rates of 3.0 t/ha and 4.5 t/ha and bioslurry manure applied at 7.8t/ha or combined application of 3.0 t/ha of tithonia and 7.8 t/ha of bioslurry enhances yields of carrots.
3. Application of tithonia and bioslurry manure at rates above 3.0 t/ha and 5.2 t/ha, respectively, enhances carrot total soluble solids while combined application of 4.5 t/ha and 7.8 t/ha of tithonia and bioslurry manure respectively, resulted in highest total soluble solids.

6.2 Recommendations

From the above conclusions, the following recommendations can be made:

1. Farmers are advised to use either 3.0 t/ha of tithonia manure or 7.8 t/ha of bioslurry manure in production of carrots.
2. Combined application of 3.0 t/ha and 7.8 t/ha of bioslurry to be used for maximum production of carrots.
3. Further research to be done on the comparison between the manures (tithonia and bioslurry) and inorganic fertilizers.
4. Cost-effective studies to be done between the two manures and inorganic fertilizers.

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APPENDICES

These are some of the ANOVA tables;

Appendix 1. ANOVA table for effects of tithonia and bioslurry manure on plant height

45 DAYS AFTER PLANTING

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	1.31	0.65	0.52	0.59
Season	1	1860.32	1860.32	1500.25	<.0001
Tithonia	3	5.75	1.91	1.54	0.21
Season x tithonia	3	2.80	0.93	0.75	0.52
Bioslurry	3	28.00	9.33	7.52	0.002
Season x bioslurry	3	5.46	1.82	1.47	0.23
Tithonia x bioslurry	9	19.36	2.15	1.73	0.10
Season x tithonia x bioslurry	9	11.02	1.22	0.98	0.45
Error	62	76.94	1.24		
Coefficient of variation = 6.47%					

75 DAYS AFTER PLANTING

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	63.43	31.71	3.45	0.038
Season	1	1758.95	1758.95	191.84	<.0001
Tithonia	3	455.10	151.7	16.54	0.015
Season x tithonia	3	133.37	44.46	4.85	0.004
Bioslurry	3	415.57	138.52	15.10	0.010
Season x bioslurry	3	59.59	19.87	2.17	0.100
Tithonia x bioslurry	9	223.42	24.82	2.71	0.010
Season x tithonia x bioslurry	9	78.46	8.72	0.95	0.049
Error	62	569.16	9.17		
Coefficient of variation = 7.50%					

95 DAYS AFTER PLANTING

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	17.08	8.54	1.001	0.37
Season	1	2936.54	2936.54	343.85	<.0001
Tithonia	3	208.76	69.59	8.14	0.085
Season x tithonia	3	34.59	11.53	1.35	0.27
Bioslurry	3	471.47	157.16	18.40	0.01
Season x bioslurry	3	17.82	5.94	0.69	0.56
Tithonia x bioslurry	9	205.22	22.80	2.67	0.01
Season x tithonia x bioslurry	9	127.51	14.17	1.66	0.11
Error	62	529.94	8.54		
Coefficient of variation = 6.67%					

Appendix 2. ANOVA table for effects of tithonia and bioslurry manure on leaf numbers

45 DAYS AFTER PLANTING

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	2.35	1.18	4.06	0.02
Season	1	0.77	0.77	2.65	0.11
Tithonia	3	4.90	1.63	5.62	0.003
Season x tithonia	3	1.28	0.43	1.48	0.24
Bioslurry	3	3.40	1.13	3.89	0.008
Season x bioslurry	3	0.55	0.18	0.62	0.61
Tithonia x bioslurry	9	1.39	0.16	0.55	0.85
Season x tithonia x bioslurry	9	1.14	0.13	0.45	0.92
Error	62	18.22	0.29		
Coefficient of variation = 10.14%					

75 DAYS AFTER PLANTING

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	1.22	0.61	1.02	0.37
Season	1	23.01	23.01	38.35	<.0001
Tithonia	3	29.08	9.69	16.15	0.009
Season x tithonia	3	6.57	2.19	3.65	0.017
Bioslurry	3	18.39	6.13	10.21	0.032
Season x bioslurry	3	8.22	2.74	4.54	0.006
Tithonia x bioslurry	9	11.88	1.32	2.19	0.04
Season x tithonia x bioslurry	9	7.35	0.82	1.35	0.23
Error	62	42.06	0.60		
Coefficient of variation = 9.26%					

95 DAYS AFTER PLANTING

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	1.63	0.82	1.58	0.22
Season	1	12.94	12.94	24.88	<.0001
Tithonia	3	17.28	5.76	11.07	0.02
Season x tithonia	3	0.59	0.19	0.37	0.77
Bioslurry	3	11.80	3.93	7.56	0.05
Season x bioslurry	3	2.64	0.88	1.71	0.17
Tithonia x bioslurry	9	8.99	0.99	1.94	0.06
Season x tithonia x bioslurry	9	6.06	0.67	1.29	0.25
Error	62	31.75	0.52		
Coefficient of variation = 7.85%					

Appendix 3. ANOVA table for effects of tithonia and bioslurry manure on yield

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	69.43	34.72	4.25	0.0187
Season	1	7953.40	7953.40	973.48	<.0001
Tithonia	3	1727.00	575.67	70.46	<.0001
Season x tithonia	3	8.85	2.95	0.36	0.0078
Bioslurry	3	662.91	220.97	27.05	<.0001
Season x bioslurry	3	45.55	15.18	1.86	0.0145
Tithonia x bioslurry	9	203.55	22.61	2.77	0.0087
Season x tithonia x bioslurry	9	355.11	39.46	4.83	<.0001
Error	62	506.65	8.17		
Coefficient of variation = 5.72%					

Appendix 4. ANOVA table for effects of tithonia and bioslurry manure on total soluble solids at different ages

60 DAYS AFTER PLANTING

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	0.35	0.18	2.25	0.13
Season	1	0.74	0.74	9.25	0.004
Tithonia	3	2.18	0.71	8.88	0.19
Season x tithonia	3	0.47	0.16	1.96	0.13
Bioslurry	3	4.57	1.52	19.0	0.04
Season x bioslurry	3	1.71	0.57	7.13	0.0004
Tithonia x bioslurry	9	3.38	0.38	4.75	0.0001
Season x tithonia x bioslurry	9	3.03	0.34	4.25	0.0003
Error	62	5.08	0.08		
Coefficient of variation = 4.56%					

102 DAYS AFTER PLANTING

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	1.19	0.59	1.10	0.34
Season	1	37.08	37.08	68.67	<.0001
Tithonia	3	24.39	8.13	15.05	0.005
Season x tithonia	3	2.36	0.79	1.47	0.023
Bioslurry	3	14.43	4.81	8.91	0.02
Season x bioslurry	3	3.22	1.07	1.99	0.12
Tithonia x bioslurry	9	8.51	0.95	1.76	0.09
Season x tithonia x bioslurry	9	3.41	0.38	0.71	0.70
Error	62	33.57	0.54		
Coefficient of variation = 6.37%					

Appendix 5. ANOVA table for effects of tithonia and bioslurry manure on total soluble solids during storage

0 DAY AT STORAGE

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	2.82	1.41	1.87	0.16
Season	1	38.38	38.38	50.87	<.0001
Tithonia	3	24.98	8.33	8.84	0.005
Season x tithonia	3	2.69	0.89	1.19	0.032
Bioslurry	3	14.05	4.69	4.97	0.03
Season x bioslurry	3	3.18	1.06	1.41	0.02
Tithonia x bioslurry	9	8.48	0.94	1.25	0.28
Season x tithonia x bioslurry	9	3.46	0.38	0.51	0.04
Error	62				
Coefficient of variation = 5.72%					

14 DAYS AT STORAGE

Source of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F value	Probability>F
Block	2	0.29	0.15	0.88	0.43
Season	1	74.38	74.38	437.52	<.0001
Tithonia	3	41.04	13.68	80.47	0.008
Season x tithonia	3	3.11	1.04	6.11	0.001
Bioslurry	3	26.73	8.91	52.41	0.03
Season x bioslurry	3	3.25	1.08	6.35	0.0008
Tithonia x bioslurry	9	16.21	1.80	10.59	<.0001
Season x tithonia x bioslurry	9	6.56	0.73	4.29	0.0002
Error	62	10.73	0.17		
Coefficient of variation = 2.48%					

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