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Effect Of Variety And Nutrient Quantity Of Vermicompost On Growth And Yield Parameters Of Tobacco (*Nicotiana Tabacum)*

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DECLARATION

I, **Jinjika Kathy** do hereby declare that this research project herein is my original work and has not been copied from any source without acknowledgement of the source. It has not been submitted before for any degree or examination at any other University.

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I have supervised the research project of the above-mentioned student and I am convinced that the research project:

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Project Supervisor: Mr Mutsengi Signature ___________________________

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I certify that I have checked the Research Project and I am satisfied that it conforms to Department of Crop Science Guidelines for Project Preparation and Presentation. I therefore authorize the student to submit this dissertation for marking.

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DEDICATION

This research project is dedicated to my parents Mr A. Jinjika and Mrs. K. Jinjika

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ABSTRACT

Tobacco is one of the most important cash crops grown in Zimbabwe and it is an important source of foreign currency and livelihoods especially amongst smallholder farmers. The current escalating prices of synthetic fertilizers have led most farmers to shrink their tobacco production posing to lack of foreign currency in the country. Vermicompost has a promising potential and gaining acceptance as an alternative to inorganic fertilizers in Zimbabwe, but farmers are failing to adopt it due to lack of adequate information on it application rates. A field experiment was therefore carried out at Solomio Farm in Madziva. The overall objective was to evaluate the effectiveness of different application rates of vermicompost used solely on tobacco crop specifically to determine the effect of vermicompost levels on growth, yield and quality. A Randomized Complete Block Design (RCBD) with 5 replications was used. The treatments were 3 levels of vermicompost and synthetic fertilizers. Vermicompost rates applied at a rate of 600kgs, 800kgs and 1600kgs/ha and compound C at 400kgs/ha. Data was collected at 2 weeks after transplanting up to week 12. Data collected was subjected to the analysis of variance (ANOVA) to determine the effectiveness of using different application rates of vermicompost on tobacco using SPSS version 22.0. The Turkey's honest significance test at 0.05 probability level was used to separate means. Results shows that 1600kgs/ha of vermicompost have got the highest significance in CGR ($P<0.05$). All treatments on the height they was no significances differences ($p>0.05$) week 2. 1600KGS/ha of vermicompost produced good quality tobacco with grade A mellow and dark mahogany, the lowest being grade C. According to the produced results, farmers are recommended to use 1600kg/ha of vermicompost rate because it produces more yield and quality tobacco. Therefore it is recommended that farmers use this rate since it shows significant difference on all the parameters. Lastly, the students and researchers must do more trials using different types of organic manure, different varieties of tobacco and in different regions.

Key Words: Effect, variety and nutrient quantity, vermicompost, growth and yield, tobacco (*nicotiana tabacum)*

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
CGR	Crop Growth Rate
FAO	Food and Agriculture Organisation
LAI	Leaf Area Index using the formula
LSD	Least significant difference
NAR	Net Assimilation Rate
NPK	Nitrogen Phosphorus Potassium
pH	Potential hydrogen
RCBD	Randomized Complete Block Design
s.e.d	Standard errors of differences of means
TRB	Tobacco Research Board
TIMB	Tobacco Industry Marketing Board
VC	Vermicompost

CHAPTER 1: INTRODUCTION

1.1 Background

Tobacco is one of the most important crops grown in Zimbabwe. It is a cash crop and it is an important source of foreign currency and livelihoods especially amongst smallholder farmers. The tobacco industry is one of the chief supports to agriculture and to the Zimbabwean economy. Tobacco is grown for its 'golden' leaves. About 120 countries in the world grow tobacco on approximately 4 million hectares of the world's arable land under crop production (Kanduza, 1938). It was noted that, tobacco production has doubled globally since 1960 to 1975. Production in developing countries has increased by 300% and in developed countries by 50%. According to world records, tobacco production reached about 7 million metric tonnes in 2006 with low and middle class countries contribution of 85% (FAO, 2OO7).

Africa has been contributing a significant amount of flue cured tobacco with Zimbabwe being the top producer. According to FAO (2017), Zimbabwe is the fourth largest producer on world rankings producing 221 million kg. Flue cured tobacco production has increased in Zimbabwe with A1 farmers and communal farmers contributing significantly to the total yields. Farmers abandoned other cash crops and are now focussing on tobacco production due to its high returns as per dollar invested how much on average how much per dollar invested. The move has been taking place since the fast track land reform program of 2002. The program gave land to the landless Zimbabweans. Also, adoption of the multi-currency system with the $US on top contributed to more production as it mended the tobacco industry. According to TIMB (2017), the number of farmers who registered as tobacco farmers increased from 81,801 to a total of 98,927. These farmers use synthetic fertilisers. However, due to escalating prices and instability of Zimbabwe's economy, some farmers cannot afford to buy the recommended inorganic fertilisers like compound C and Ammonium Nitrate for growing tobacco at U$43 per bag (Scoones *at al.*, 2018).

According to Kutsaga recommendations (2006), flue cured tobacco farmers are recommended to apply Compound C and tobacco blends as basal fertilisers. These fertilisers supply macro and micro elements. Nitrogen, potassium and phosphorous are the major primary macro elements alongside secondary macro elements (Boron and Sulphur). Nutrient composition of Compound

C is represented by 5:15:12 + 6S + 0,1B (max 2% Cl). Tobacco blends constitute almost twice of the nutrient content found in Compound C at a rate of 400kgs/ha at U$43.

Although the use of inorganic fertilizers provides a sufficient content of nutrients into the soil and the influence on yield is evident, on the other hand, it only has a one-time effect. Further, the current agricultural production in Zimbabwe is trying to create sustainable management when it comes to maintaining a balance between the intake and the output of nutrients in the soil. Also, the main concern of some agricultural researchers is decreasing the synthetic chemical content in foods therefore new studies are now being focused on organic farming. To achieve this the use of synthetic inputs should be reduced. The introduction of organic farming and the increase in demands for organically produced crops can play an important role in reducing chemical residues on tobacco crop (Masarirambi, Sibandze, Wahome, & Oseni, 2012)

Cattle manure is a valuable resource as a soil fertilizer because it provides large amounts of macro- and micronutrients for crop growth and is a low-cost, environmentally-friendly alternative to mineral fertilizers (Yadav *et al.*, 2013). Cattle manure contains about 3% N, 2% P, 1% K (Risberg *et al*., 2017). However, the use of animal manure is limited because it is needed in large quantities and also only available to those who have cattle. The quantity of the different nutrients found in the manure depends on many therefore the nutrient worth of the manure cannot be easily predicted. Processing of this waste material through controlled bio-oxidation processes, such as composting, reduces the environmental risk by transforming the material into a safer and more stable product suitable for application to soil (Lazcano *et al.* italics, 2009).Composted materials are therefore gaining acceptance as organic fertilizers in sustainable agriculture. Compost manure contains about 1.2 – 1.5% Nitrogen, 0.7 – 0.9 Phosphorus and 0.6 – 0.7 Potassium (Alvarenga *et al.*, 2015). A field experiment carried out on *Brassica chinensis* and *Zea mays* L indicated that the amount of macro (NPK, calcium , magnesium and sulphur) and micro nutrients (zinc, boron, cupper, and manganese) in the soil increased according to the rate of compost manure application and resulted in dry weight increase in both species (Wong *et al*., 1999). However, the application rates are too high (25-50 t ha^{-1}) and it is difficult to achieve them on large scale (Alvarenga *et al.*, 2015).In alternating several composted manures, vermicompost has the unique features. Vermi-composts are organic materials broken down by interactions between microorganism and earthworms in a mesophilic process (up to 25°C), to produce fully stabilized organic soil amendments with low C:N ratios. They have a high and diverse microbial and enzymatic activity, fine particulate structure, good moisture-holding capacity, and contain nutrients such as N, P, K, Ca and Mg in forms readily taken up by plants (Lavelle and Martin, 1992; Prabha *et al*. italics, 2005; Arancon and Edwards, 2009). Vermicompost is a good substitute for commercial fertilizer and has more N, P and K than the normal heap manure (Srivastava and Beohar, 2004). Besides that earthworms release vitamins such as vitamins A, B1, B2, B3, C and E in the vermicompost (Ramasamy, 2009), B group vitamins (Gavrilov, 1963), some provitamin D (Zrazhevwkii, 1957), vitamin B12 (Atlavinyte and Daciulyte, 1969) and free amino acids (Dubash and Ganti, 1964) in the soil. Vermicompost has nutrient composition of 1.5-2.0% nitrogen (mainly nitrates); 0.5- 1.5% phosphorus; 0.5-1.0% potassium; 0.4-0.8% calcium; 0.3- 0.6% magnesium; 100-500 ppm sulphur; 6.7- 9.3 ppm iron; 2.0- 9.5 ppm copper; and 5.7-11.5 ppm zinc. The great influencing factor of the NPK of vermicompost is, of course, the organic matter injected by the worms. However the nutritional value of worm castings is not only the point. The value of vermicast lies in the plant growth stimulants, the cationic exchange rate and the soil benevolent biota (Arancon and Edwards, 2009).

In light of these pieces of evidence, it is clear that vermicompost constitutes a promising alternative to inorganic fertilizers. There has been a considerable increase in researches dedicated to the study of the effect of vermicompost on soil properties and plant growth of vegetable crops. However, literature survey revealed that the study on the effects of vermicompost levels on tobacco growth and yield is scanty. Hence, in the present investigation, an attempt will be made to study the effects of vermicompost levels on growth and yield parameters of tobacco.

1.2 Problem Statement

The current escalating prices of inorganic fertilizers has led most farmers to shrink their tobacco production which seemly posing to lack of foreign currency in the country. Vermicompost has a promising potential and gaining acceptance as an alternative to inorganic fertilizers in Zimbabwe. Unfortunately, farmers are hesitating to go for vermicompost due to lack of adequate information about the use of vermicompost especially application rates. The

Vermicompost Producer Company in Zimbabwe availed the general recommended application rates basing on researches carried outside Zimbabwe. The results may not correlate with soils in Zimbabwe and vary with crop type.

1.3 Justification

Vermicompost promised to be an alternative for expensive inorganic fertilizers which most farmers are not affording to buy. There is need to satisfy farmers with correct information to make use of vermicompost available in the market at cheap prices, effective and eco- friendly. This research aims to evaluate the effectiveness of different application rates of vermicompost used solely on tobacco crop. The results will help farmers to be very sure of benefits of vermicompost and also providing farmers with exact application rate when using vermicompost exclusively on tobacco. In so doing, the researcher will be able to maintain consumer confidence in this type of fertilizer.

1.4 Objectives

1.4.1 Overall objective

- To evaluate the effectiveness of different application rates of vermicompost used solely on tobacco crop.

1.4.2 Specific objectives

- To determine the effect of vermicompost level on growth of tobacco
- To determine the effect of vermicompost level on yield of tobacco
- To determine the effect of vermicompost level on tobacco quality

1.4.3 Hypothesis

- Vermicompost level have no significant difference on growth of tobacco
- Vermicompost level have no significant difference on yield of tobacco
- Vermicompost level have no significant difference on tobacco quality

CHAPTER 2: LITERATURE REVIEW

2.1 Background and the origin of tobacco

Tobacco *(Nicotiana tabacum)* is a plant that was originally grown in South America for a variety of reasons. Around 405 years ago, men crossed the Bering Straight Land Bridge from Asia to the American continents, where they discovered tobacco, as well as other useful plants like potatoes and maize. Tobacco was cultivated for commercial and ceremonial purposes between 5000 and 3000 BC, according to legend.

Tobacco is classified as a member of the Solanaceae family, with the genus Nicotiana and the species tabacum. Tobacco can be categorized by curing method, type, and usage in addition to botanical classification. For example, flue cured Virginia tobacco is used in cigarettes, air cured burley is used in chewing tobacco, and sun cured oriental tobacco is used in pipes and cigarettes (Wennberg, 2014).

2.2 Plant characteristics

In comparison with other field crops, the plant's leaves are quite huge (Trueman, 2020). The plant's genetics, as well as temperature and humidity, influence the size and shape of the leaves. The plant's leaves have trichomes that cover them morphologically (Poethig and Sussex, 1985). These are known to produce gummy compounds, and their quantities are influenced by the plant's genetics, the surrounding environment, and agronomic techniques (Wennberg, 2014). The color of the leaves varies according to the kind and nourishment provided to the crop. There are two sorts of dark green: dark green and light green. The flowers are 5cm in length. They are also usually cream in color at the base, with pink, red, or crimson petals. Seeds are likewise extremely small, with roughly 14000 seeds per gram. The plant has a tap root and fibrous roots in various combinations. Within 5 weeks of transplantation, rapid development is visible. Topping promotes more growth. There are nodes throughout the stem that are capable of developing leaves and at least three buds. The top likewise has a central apex (Poethig and Sussex, 1985).

Tobacco is a commercial crop that is commonly grown in Zimbabwe and other nations. In Zimbabwe, flue-cured Virginia tobacco is generally grown in high-potential locations, whereas air-cured burley is mostly grown on a contract basis. Tobacco is a woody shrub-like perennial that can also be cultivated as an annual from genuine seeds. The plant is not permitted to finish its life cycle in commercial tobacco production. Excess fertilizer is linked to luxury consumption, as seen by increased axillary bud growth.

2.2.1 Important basal fertilizers in tobacco production

The amount of fertilizer applied has a positive link with tobacco growth and yield; the more fertilizer applied, the higher the growth and output of tobacco (David et al., 2011). Although this may affect the quality. Postiglione, 2003, as cited in Joshua Armentrout, 2014, excessive nitrogen fertilizer raises production costs and has the potential to pollute ground and surface water owing to leaching. Nitrate deposition in the leaf as a result of excessive nitrogen can have a detrimental influence on burley tobacco leaf quality. Nitrogen usage efficiency is measured by soil processes, fertilization techniques, and physiology. These factors are influenced by fertilizer as well as varietal indices, such as the fact that early maturing varieties require less nitrogen fertilizer than irrigated, late maturing kinds.

2.2.2 Compound A and Compound B

Before Compound C and tobacco mixes, these basic fertilizers were widely employed in Zimbabwe. Compound A has 2% nitrogen, 17% phosphate, 15% potash, 0.1 percent boron, and 0.1 percent zinc, while Compound B contains 4% nitrogen, 17% phosphate, 15% potash, 0.1 percent boron, and 0.1 percent zinc. According to FAO (2014), these two should be applied at a rate of 600-700 kg/ha. Fertilizers with higher nitrogen content were required since newly produced hybrid types required more feeding, resulting in the production of Compound C and tobacco mixes.

2.2.3 Compound C

After Tobacco fertilizer, compound C is the second most widely used fertilizer in commercial tobacco production. The (5 percent N: 15 percent P: 12 percent K), N percentages range from 5% to 6%, depending on the producer. Boron and chlorine have a concentration of 1% and 2%, respectively. According to Kutsaga (2017), Compound C should be administered at a rate of 600kg-700kg per hectare. Soil tests are recommended before applying any fertilizers. These tests can be performed in private soil laboratories or by government agencies such as the DR&SS. Compound C cost ZWL$3960 per 50kg, according to prices obtained on July 12, 2020.7

2.2.3 Tobacco fert/Extra C/blends

The amount of macro components in these tobacco fertilizers is nearly doubles that of Compound C. The N: P: K ratio in some cases is 10%:28%:23%. Large-scale commercial tobacco growers most commonly utilize these fertilizers. Tobacco mixes should be applied at a rate of 400-500 kg/ha, according to industry standards (FAO, 2005). Because of the exorbitant pricing, most small-scale farmers cannot afford them. As of July 12th, 2020, the price of tobacco blends was ZWL5280 per 50kg.

2.3 Benefits of inorganic fertilizers

Synthetic fertilizers, such as compound C, have a variety of advantages and disadvantages. Unlike organic fertilizers, which are supposed to decompose and mineralize, inorganic fertilizers operate right away, and the nutrients contained in them are quickly available. As a rescue therapy, inorganic fertilizers are mixed into the soil. Synthetic fertilizers include all of the vital nutrients. Because they are synthetic, nutrients are adjusted by using knowledge of how plants use fertilizers (Sabry, 2015). It means that the plant will be able to receive nutrients in a balanced way. Because the nutrients will be delivered in measured amounts, the plant will not experience luxury consumption.

Inorganic fertilizers are more convenient than organic fertilizers in terms of convenience. Creating compost takes some time. Even if creating compost is simple, considerable time must be set up for the work. In a stable economy, inorganic fertilizers are quite inexpensive. When compared to organic fertilizers, which are bulky, inorganic fertilizers are used in fewer quantities.

2.3.1 Disadvantages of using synthetic fertilizers

As a result of using synthetic fertilizers, hazardous waste builds up (Sabry, 2015). Fertilizers are made up of more than just nutrients. Salts in fertilizer formulations, such as potassium chloride, are not absorbed by plants and hence accumulate over time. If they make it to the finish line when present in large concentrations, they can modify soil chemical qualities such as pH, making it unsuitable for crop production (Nduwumuremyi, 2013). Despite the fact that soil amendments can be used to neutralize the soil, some compounds are washed away and deposited in the groundwater table, from which household water is drawn.

The fertilizer rates are based on Compound A, B C, and tobacco blend fertilizers. These general guidelines have been used by commercial tobacco producers. There have been no attempts to investigate if the 2% variation in potash and phosphorous causes a substantial difference in tobacco production when compound L is alternated. Tobacco yields range from 3.5 to 4.5 tonnes per hectare, depending on the variety (TRB, 2011). According to FAO (2014), compound A, B, and C have been demonstrated to be effective in tobacco production. The yield averaged 4 t/ha, with 60 percent of the leaves being of acceptable quality.

2.4 Effects of fertilizer on curing

Nitrogen control is one of the most important measures for reducing the issues connected with curing. High nitrogen levels may boost yield marginally, but they can also make the curing process more difficult. This is determined by a variety's harvesting indices, which state that the sooner a variety matures, the less nitrogen must be supplied while still meeting crop requirements (Malligenahalli et al., 2013). High nitrogen levels in the barn have been linked to color failure and color fixation issues. Also, the midrib of high-nitrogen leaves does not dry out

2.5 Vermicompost

Vermicomposts are organic materials that have been broken down by reactions between microorganisms and earthworms in a mesophilic (up to 25°C) process to create super stable organic soil remedies with low C:N ratios. The use of the worms for the decomposition of organic matter increases the rate of mineralisation, humification of organic matter and increased microbial diversity that improves the quality of the final compost (Bandyopadhyay, 2014). This (VCs) product is a highly fertile, finely divided peat-like material with high porosity, aeration, water-holding capacity and low C: N ratios (Dominguez and Edwards 2004; Subler et al. 1998). Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect thus supporting better root development, leading to higher crop yields (Sciences, 2015).

According to Rasool Azarmi *et al* (2008) even though vermicompost has many beneficial effects on plant growth, higher metal concentration in this material can result in some problems in plant growth and development. Therefore there is need to know the how much to apply for the benefit of the crops without harming them. According to the research that was conducted in tomatoes the application rate of 15t/ ha resulted in higher yield and better fruit quality than the rate of 10t/ ha and 5t/ ha. The dry matter and leaf area index of tomatoes also increased with the increase in application rate.

Prior studies have identified that vermicompost is rich in organic carbon, which plays a key role in soil fertility, and contains all essential plant nutrients in appropriate proportions. Thus, it is a complete and balanced plant food. It also contains biochemical substances that promote plant growth and fight plant diseases (Saidabad, 2013). The use of vermicompost is an important step in changing your impact on the environment by reducing the amount of household waste that would otherwise find its way into landfills. Composting worms can process up to five pounds of food waste, paper and junk mail per week. Literature shows vermicompost has desirable advantages such as desirable smell, balanced pH, low electrical conductivity, high cation exchange capacity, concentrations of available nutrients and plant growth promoting microorganisms (Zarei, Jahandideh Mahjen Abadi, & Moridi, 2018). Due to its high nutritive value the materials cause useful changes in plant growth.

However, when vermicompost was used in combination with coconut husk and rice hulls ash there was a lower growth of muskmelon seedlings in substrates at higher rate of VC (Manh & Wang, 2014). The researcher suggested that this could be attributed to the higher salt content of excessive nutrient levels in the more concentrated mixture. According Ievinsh (2011) specified that there was inhibition of seed germination of some vegetable species (radish, cabbage, Swedish turnip, beetroot, beans, peas) when replaced with more 50% of VC. According to Arancon *et al*., (2006) as cited in Manh & Wang, (2014) high concentration of plant growth hormones such as auxins and humid acids produced by microorganism in VC slower growth rates of plant at high rate of VC.

In addition, according to the research of Roberts *et al*., (2007) vermicompost was applied at different rates in combination with peat based compost in tomatoes variety money maker and there was no significant increase in total fruit yield, fruit weight, number of fruits and vitamin C concentration with increase in vermicompost rates. On the other hand they noted an increase in germination percentage and marketability of fruits at higher rates of vermicompost. Therefore they concluded that the previous reports about the benefits of vermicompost on horticultural crops were exaggerated.

Despite studies that have been conducted to assess the effectiveness of vermicompost on crop growth, its important in maintaining soil structure and fertility there is lack of information that have objectively targeted its performance in tobacco. Rio et al. observed that integration of vermicompost with mineral fertilizers increased the yield of potato. One of the unique features of vermicompost is its high level of plant available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous and soluble potassium, calcium and magnesium derived from the organic wastes. Nutrients, when applied in adequate quantity, increase fruit quality, fruit size, colour, and fruit taste of tomato. According to Mengistu et al. optimum vermicompost and NP mineral fertilizer application for tomato production has been reported to be 7.5 ton ha-1 and 50% NP mineral fertilizer, respectively.

As a high-quality organic fertilizer, vermicompost contained high levels of different plant growth regulators and soil enzymes (Datta et al., 2018), which promoted the growth and development of plants (Atiyeh et al., 2000). Nurhidayati et al., (2018) found that vermicompost effectively improved soil quality, increased microbial activity and nutrient cycling speed and produced high-quality crops. Replacing about 20% to 40% of the substrate with earthworm droppings promoted plant rooting and growth (Rosa et al., 2013)

CHAPTER 3: MATERIALS AND METHODS

3.0 METHODOLOGY

3.1 Study Site

A field experiment was carried out at Solomio Farm in Madziva. The area is located in Mashonaland Central natural region 2b of Zimbabwe's agro-ecological zones. Madziva receives an average of 800mm rainfall per year. The area experiences a range of temperatures of 24 degrees Celsius to 40 degrees Celsius. The area experiences average maximum temperatures of 28^0C and a minimum of 14^0C. Generally, the area is dominated by sandy loam soil. Solomio farm is located at coordinates are 16.9167^0 South, 31.5333^0 East.

3.2 Experimental Design and Field Layout

A Randomized Complete Block Design (RCBD) was used. The treatments were 3 levels of vermicompost and synthetic fertilizers. The blocking factor was slope. One variety of tobacco was used KRK26. Three different levels of vermicompost rates applied at a rate of 600kgs, 800kgs and 1600kgs/ha. There were four treatments. The control, where no vermicompost was applied and synthetic fertilizer compound c at a rate of 400kgs/ha was used was regarded as positive control.

3.3 Agronomic Practices

3.3.1 Seedling acquisition

Healthy seedlings were acquired from Solomio farm. Seedlings possessing ideal characteristics were selected. These seedlings were about 150mm long, well hardened with a thickness of a pencil, 8-10 leaves below the bud and a vigorous rooting system.

3.4 Tobacco field practices

3.4.1 Land preparation

After irrigating to field capacity, the land was disc ploughed and disc harrowed. Deep ploughing to a depth of 30cm was done (Koga and Chinamo, 2016). Lime was broadcasted 3 months before planting at the rate of 3500kg/ha. The application of lime was based on soil analysis results from Tobacco Research Board (TRB). Flue cured tobacco performs best at a pH ranging from 5.5-6.0. Ridges were marked by the tractor at 1.2m inter-row and planting stations were marked at 0.55m in-row spacing using wholes. The plant spacing translated to a plant population of about 15 000 plants/ha. Ridges improve drainage and increase depth of shallow soils.

3.4.1 Transplanting the seedlings

Each row was 10m long and the inter row spacing was 1.2m. Each row was representing a plot. Three blocks were demarcated with each measuring 33m×1,2m. A 1m pathway between plots and area around each block was left. Water planting was chosen as a planting method. Planting holes were filled with 5L of water. Secondly, Confidor and velum was poured into the holes using cup size number 30. Confidor was used at 58g/100Lof water. The chemical is used to protect plants against aphids. Velum was used at 200ml/100L of water to protect plants against nematodes. Planting was done while water was still in the holes and it was allowed to drain before covering. Small planting hoes were used to dig a hole; plant roots were inserted and pressed into the soil. Seedling leaves were protected with palms to avoid soaking the seedling leaves into the water with Confidor and Velum as it results in scorching and death of seedling leaves.

3.3.5 Basal Fertilizer and top dressing application

Two holes were drilled on both sides of the plant at about 8cm from the stem (this is method known as dolloping). Compound C 400kgs/ha was applied soon after transplanting according to treatment combinations mentioned in the experimental design. Each hole was filled with 22g of Compound C. Covering was done using dry soil to create a soil mulch and also to prevent volatilization of fertilizers. Wet soil was covered with dry soil thereby breaking capillarity. According to the soil tests, a recommendation of 660kg/ha was applied. After, 28 days from transplantation, top dressing (AN) was applied by spot placing at the rate of 8g/plant. Second application of AN (2g/plant) was conducted 8 weeks after transplanting. Soon after topping, calcium nitrate was applied at a rate of 2g/plant to add weight to the top leaves that were receiving synthetic fertilizers.

3.3.5 Vermicompost applications

The 3 levels of vermicompost rates that was used were 600kgs, 800kgs and 1600kgs/ha. At 600kg/ha 80g was applied per plant for first application, second application 40g per plant and third application 40g per plant. At 800kg/ha 106g was applied per plant for first application, second application 53g per plant and third application 53g per plant. Lastly, at 1600kg/ha 212g per plant was applied from first application, second application 106g per plant and third application 106g per plant.

3.3.7 Priming

Priming is the removal of the lower, uneconomical leaves. Priming was conducted when the plants had attained 6 leaves so as to avoid disturbing growth. Early removal of lower leaves reduces photosynthetic area hence slow growth (Rajput, 2017).

3.3.6 Weed management

Mechanical and chemical methods were used to control weeds. Clomazone (1.5 L/200L of water) was mixed with Authority (450ml/200L of water) to target both broad leaf weeds and annual grasses. Herbicides were applied whilst the soil was moist (David et al., 2011). A ridger was used to perfume re-ridging and controlling weeds also.

3.3.7 Pests management

Initially, some of the pests were controlled at transplanting. Tide was used at 100g/ 200L of water for the control of budworm and dimethoate at 500ml/ha against aphids. Drenching was conducted soon after fertilization. Chlorpyrifos was drenched around the stem of each plant at the rate of 400ml/200L of water against cutworms. A wetting agent was added during foliar sprays at the rate 50ml/200L to break the surface tension of water so that the solution does not come out as droplets and also to stick the chemical onto the leaves.

3.3.7 Diseases management

Routine sprays with fungicides were conducted to avoid plant disease development. Fungicides used included Acibenzolar-s-methyl (Bion) at the rate of 60g/200L of water and Tebuconazole at the rate of 150ml/200L of water. Diseases prevented included wild fire, angular and Alternaria leaf spots (Bright and Board, 2012).

3.4 Data Collection

3.4.1 Plant height (cm)

Plant height was measured at 2 week intervals from 2 weeks after transplanting using a tap measure. The selected plants were tagged for continuous measurements. Plant height was taken 3 times and recorded in centimetres (Bessembinder et al., 2003). All 15 plants were selected from each plot for height measurement. Measurements were taken from where the stem penetrates the ground to the apical bud.

3.4.2 Leaf area (cm2)

Leaf area was measured at 2 week intervals. A leaf area meter (AM350) was used initially to calculate a correction error. For the subsequent measurements, the dimensional method was used. Three plants in each plot were randomly selected and tagged for the measurement of leaf area in cm. A 1m ruler was used together with a string to measure the length and widest part of the leaf. A constant value of 0.781 was used for dimensional leaf area calculation. The area was calculated as: Leaf area = length x width x 0.781. The leaf area was used to determine Leaf Area Index using the formula LAI = * (Rajput, 2017).

Where, GA - ground area covered by the plants

LA1 - leaf area at time 1.

LA2 -leaf area at time 2.

Crop Growth Rate (CGR, g cm-2 day-1)

Destructive sampling was done to come up with dry, green weight. The dry, green weight was taken at 2 week intervals. Three plants were randomly selected from each plot, oven dried at 70 °C to constant weight. The dry, green weight was used to calculate CGR in g cm-2 day-1. The formula used is as follows: CGR= CGR=W2-W1/ P (T2-T1)*1/G (Bessembinder et al., 2003).

Where, W1 and W2 are whole plant dry weight at time t1 – t2 respectively T1 and T2 are time when W1 and W2 were taken. G- Ground area where samples were taken.

Net Assimilation Rate (NAR, g g -1day-1)

Leaf Area Index and Crop Growth Rate were used to deduce Net Assimilation Rate. NAR was calculated two times at 2 week intervals from 2 weeks after transplantation. NAR was calculated as, NAR=CGR/LAI (Rajput, 2017).

$NAR = (W2 - W1)(\log e LA2 - \log e LA1)(t2 - t1)(LA2 - LA1)$

Where,
W1 = dry weight per unit area at t1,
W2 = dry weight per unit area at t2
LA1 = leaf area at t1, LA2 = leaf area at t2
t1= first sampling, t1 =second sampling,
Unit: - g m-2 week-1 or g m-2 day-1

3.4.3 Dry weight (kg)

Dry weight was taken after curing and according to reap numbers. Six leaves per plot where reaped and weighed in kilograms. Dry weight was taken 3 times at weekly intervals using a digital scale.

3.4.4 Leaf quality

Leaves used for dry weight measurements were used to rank colour and texture (Zhang and Zhang, 2011). Ranking was done by assigning the leaves to lots with numbers ranging from 1 to 4. Number one being the A grade leaves and number four being the D grade leaves. High texture and golden leaves were put into lot 1. The number of leaves from each lot was recorded.

3.4.5 Statistical analysis

The data collected was subjected to the analysis of variance (ANOVA) to determine the effectiveness of using different application rates of vermicompost on tobacco using SPSS version 22.0. The Turkey's honest significance test at 0.05 probability level was used to separate means.

CHAPTER 4: RESULTS

4.1 Tobacco growth under different vermicompost treatments

4.1.1 Growth change in height

The results illustrated on Figures 4.1 to 4.6 indicated the growth changes in height of tobacco subjected to different vermicompost treatments from Week 2 to Week 12.

4.1.2 Effect of vermicompost on height of tobacco at week 2

At Week 2, all treatments were almost similar, though the 600 kg/ha (36.6±1.03 cm) treatment had the highest height and the Control (35.8±1.66 cm) the lowest. In addition, all treatments were not significantly different (*p>0.05*) in height at Week 2 (Fig. 4.1). The calculated means showed similar treatment effects among all vermicompost treatments including negative control treatment (Fig 4.1), thus using Turkey's honest significance there was no significant difference in treatment means.

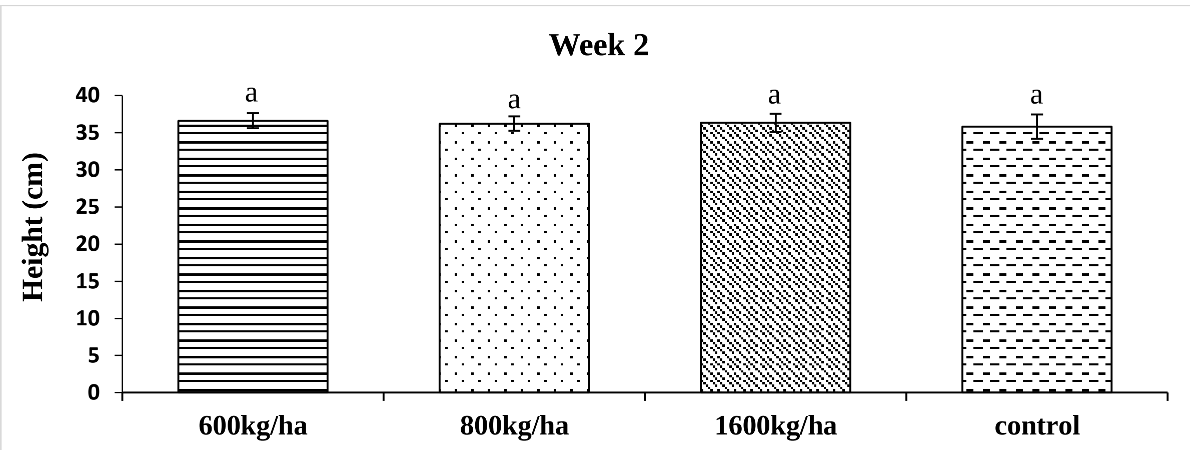

Figure 4.1: Week 2 growth trend in height of tobacco with different vermicompost treatments

4.1.3 Effect of vermicompost on height of tobacco at week 4

There was significant differences in the height of the plants at week 4 (*p<0.05*).The 1600kg/ha treatment gave the tallest plants with an average height of 51.2±1.03 cm. There was no significant difference between all the treatments except the 1600kg/ha treatment.

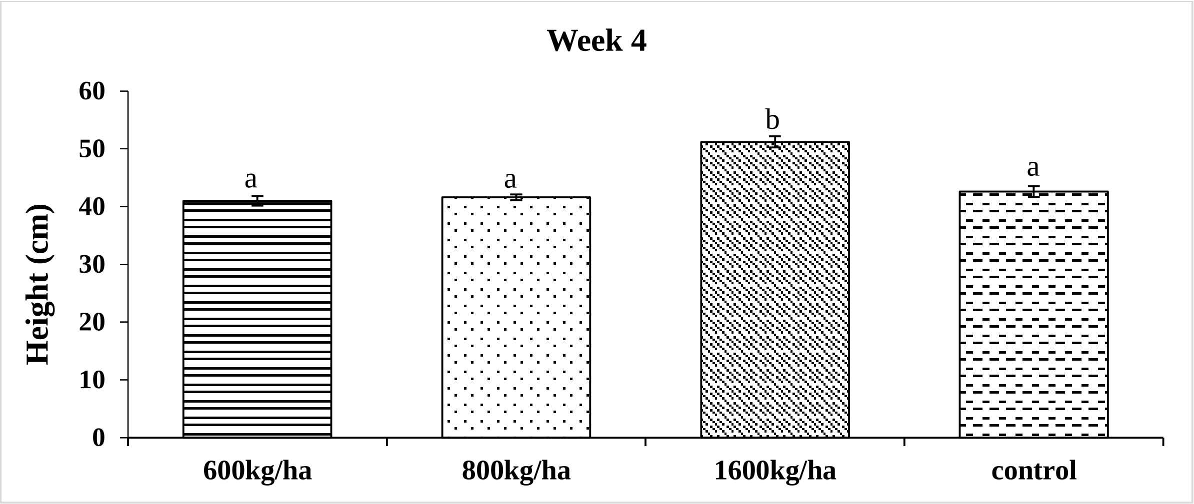

Figure 4.2: Week 4 growth trend in height of tobacco with different vermicompost treatments

4.1.4 Effect of vermicompost on height of tobacco at week 6

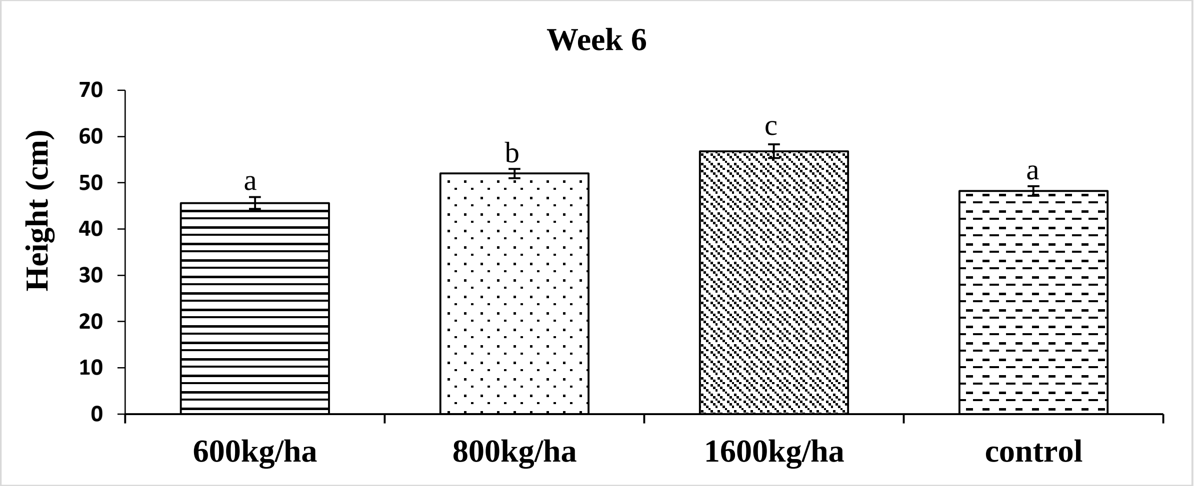

Figure 4.3: Week 6 growth trend in height of tobacco with different vermicompost treatments

There was significant differences in the height of the plants at week 6 ($p<0.05$). The 600 kg/ha (45.6±1.29 cm) and the control treatment (45.6±1.27 cm) had the significantly lowest height whereas the 1600 kg/ha (56.8±1.50 cm) treatment had the average highest plants. However, there was no significant differences in the height for 600 kg/ha and the control treatments.

4.1.5 Effect of vermicompost on height of tobacco at week 8

There was significant differences in the height of the plants at week 8 ($p<0.05$). The 600 kg/ha (50.6±0.75cm) and the control treatment (50.6±0.76 cm) had the significantly lowest height whereas the 1600 kg/ha (65.8±0.73) treatment had the average highest plants. However, there was no significant differences in the height for 600 kg/ha and the control treatments.

4.1.6 Effect of vermicompost on height of tobacco at week 10

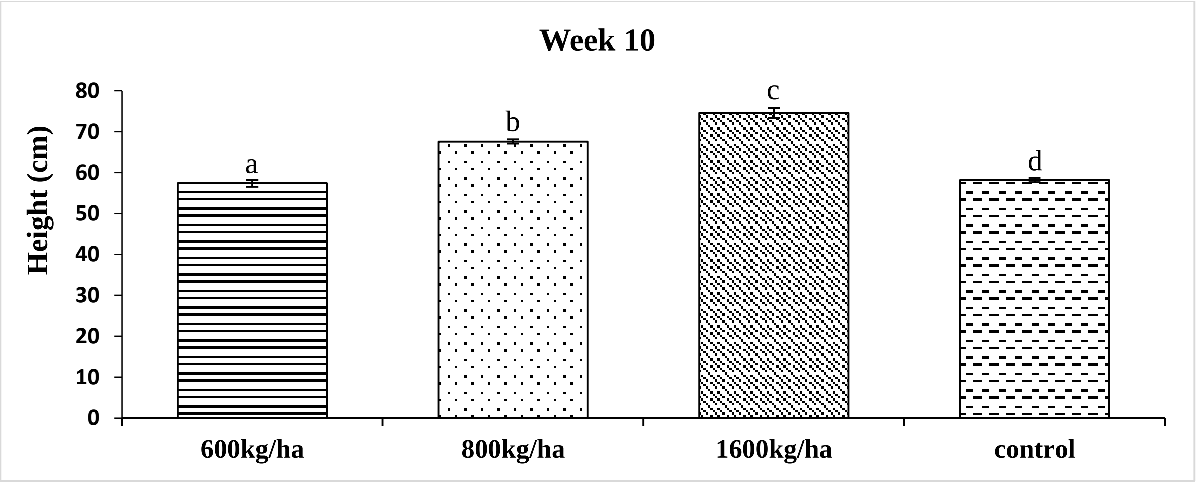

Figure 4.5: Week growth trend in height of tobacco with different vermicompost treatments

At Week 10, all treatments were significantly different ($p<0.05$) and the 1600 kg/ha treatment had the highest height of 74.6±1.21 cm. on the other hand, the 600 kg/ha treatment had the lowest height of 57.4±0.81 cm. In addition, the 600 kg/ha and the Control were almost similar in height (Fig. 4.5).

4.1.7 Effect of vermicompost on height of tobacco at week 12

There was significant differences in the height of the plants at week 12 ($p<0.05$) as shown on Fig. 4.6. The 1600 kg/ha (86.4±0.873 cm) treatment attained the highest height whereas the 600 kg/ha (62±1.18 cm) treatment had the significantly lowest height (Fig. 4.6). In addition, vermicompost treatment effectiveness declined in the order 1600 kg/ha > 800 kg/ha > Control > 600 kg/ha.

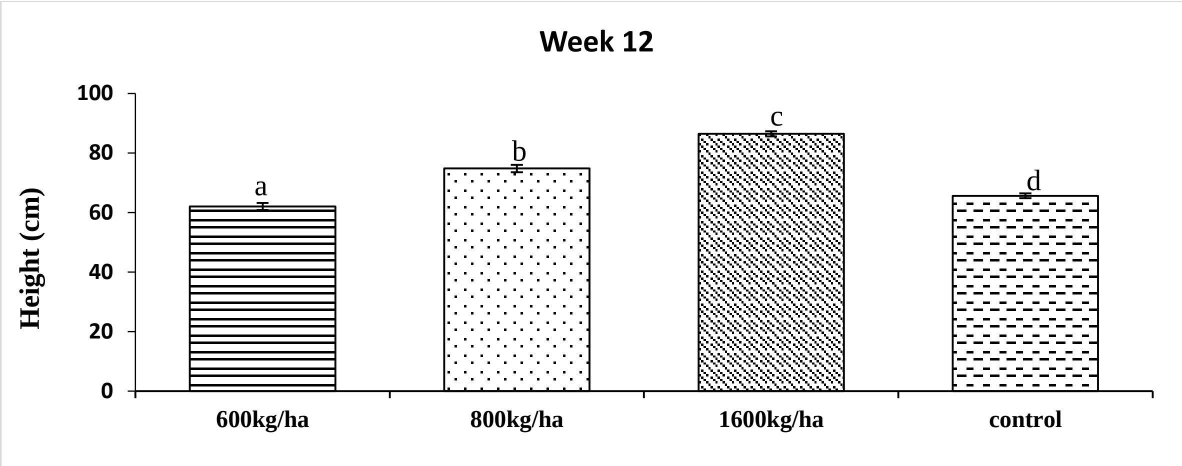

Figure 4.6: Week 12 growth trend in height of tobacco with different vermicompost treatments

4.2 Leaf area index

Table 4.1: Tobacco Leaf Area Index under different vermicompost treatments (mean ± std. dev)

Treatment	Leaf Area Index (cm^2)					
	Week 2	Week 4	Week 6	Week 8	Week 10	Week 12
600 kg/ha	16.2±2.3^a	46.3±6.8	236.5±26.1	856.1±55.3	1174.1±563.3	1699.3±79.7
800 kg/ha	17.4±2.5	60.2±5.1^b	308.5±24.0^b	1148.7±89.8^b	1658.1±110.8^b	2076.6±149.2^b
1600 kg/ha	17.3±2.1	112.9±13.0^c	724.8±44.3^c	1490.9±71.1^c	2394.7±102.8^c	3141.4±65.0^c
Control	17.6±3.1^a	44.8±3.6	243.5±12.0	780.9±49.5	1274.8±62.6	1692.8±35.5

**a, b, c, superscripts down a given column denotes significantly different ($p < 0.05$) .Values followed by different letters, in the same column, are significantly different at $P \leq 0.05$.*

Table 4.1 shows the variation in Leaf Area Index of tobacco grown under different vermicompost treatments. There was no significant differences in Leaf Area Index of tobacco grown under different vermicompost treatments at week 2 (*p>0.05*), the Control (17.6±3.1 cm^2) had the highest LAI, whereas the 600 kg/ha (16.2±2.3cm^2) had the lowest. At Week 4, the 1600 kg/ha had the highest LAI and the Control the lowest LAI attaining values of 112.9±13.0 cm^2 and 6.3±6.8 cm^2 respectively. The 1600 kg/ha treatment had the significantly highest LAI for Week 6 (724.8±44.3 cm^2), Week 8 (1490.9±71.1 cm^2), Week 10 (2394.7±102.8 cm^2) and Week 12 (3141.4±65.0 cm^2). Also, the 600 kg/ha had the lowest LAI for Week 6 (236.5±26.1 cm^2), Week 8 (856.1±55.3 cm^2) and Week 10 (1174.1±563.3 cm^2) respectively. However, at Week 12, the Control (1692.8±35.5 cm^2) had the significantly lowest LAI. Overall, the LAI increased in the order Control < 600 kg/ha < 800 kg/ha < 1600 kg/ha (Table 4.1).

4.3 Crop growth rate

The crop growth rate of tobacco under different vermicompost treatments are shown in Figures 4.7 to 4.11. There was significant differences in crop growth rate (CGR) of tobacco (*$p<0.05$*) as shown on Fig. 4.7 at week 2. The CGR for all treatments increased gradually from Week 2 to Week 8, but declined at Week 10. The 1600 kg/ha (6.97±0.47 $gcm^{-2}day^{-1}$) vermicompost treatment had the significantly highest CGR for Week 2 whereas the 600 kg/ha (4.31±0.10 $gcm^{-2}day^{-1}$) had the lowest (Fig. 4.7).

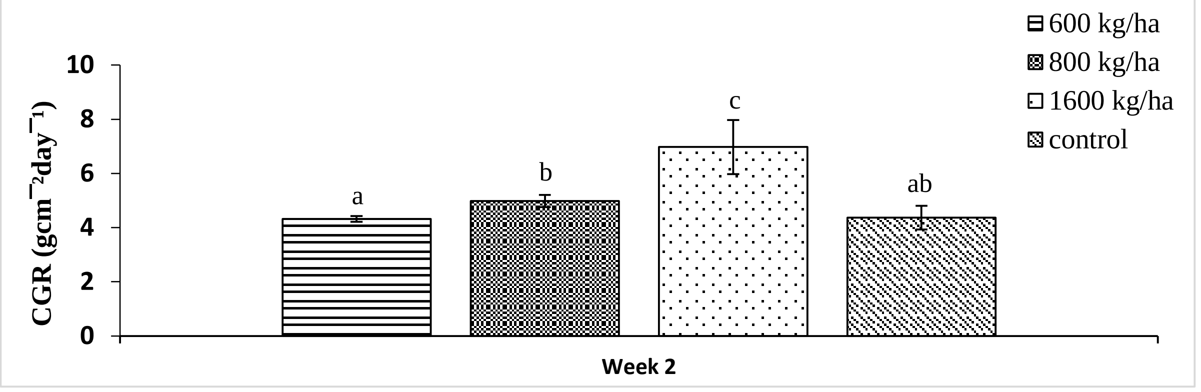

Figure 4.7: Crop Growth Rate of tobacco with different vermicompost treatments at Week 2

There was significant differences in crop growth rate (CGR) of tobacco (*$p<0.05$*) as shown on Fig. 4.8 at week 4. At Week 4 the 600 kg/ha treatment had the significantly lowest CGR (8.35±0.21 $gcm^{-2}day^{-1}$), and the 1600 kg/ha had the significantly highest CGR Week 4 (12.93±0.30 $gcm^{-2}day^{-1}$). However, the 800 kg/ha treatment was not significantly different with the Control in CGR at Week 4 (Fig. 4.8).

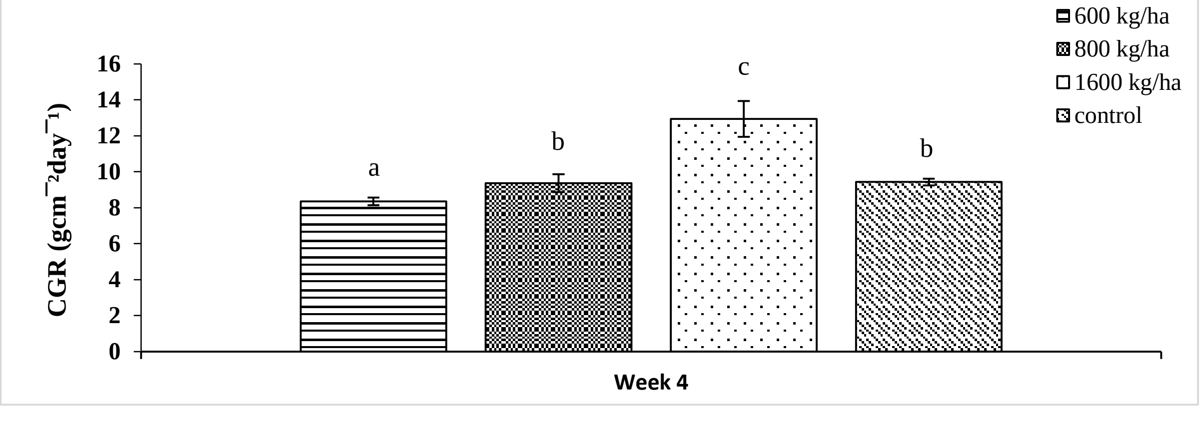

Figure 4.8: Crop Growth Rate of tobacco with different vermicompost treatments at Week 4

There was significant differences in crop growth rate (CGR) of tobacco (*p<0.05*) as shown on Fig. 4.9 at week 6. At Week 6, the 1600 kg/ha (15.51±0.49 $gcm^{-2}day^{-1}$) vermicompost treatment had the highest CGR whereas the 600 kg/ha (8.76±1.28 $gcm^{-2}day^{-1}$) treatment had the lowest CGR. Also, the 600 kg/ha treatment was not significantly different from the Control (Fig. 4.9).

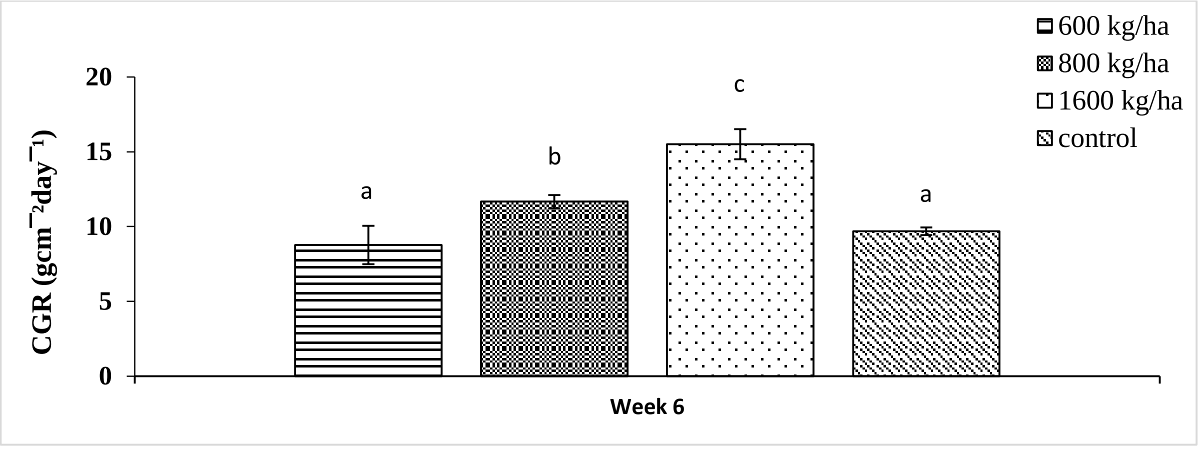

Figure 4.9: Crop Growth Rate of tobacco with different vermicompost treatments at Week 6

There was significant differences in crop growth rate (CGR) of tobacco (*p<0.05*) as shown on Fig. 4.10 at week 8. At Week 8, the 800 kg/ha treatment had the highest CGR (15.7±2.4 $gcm^{-2}day^{-1}$), whereas the Control had the lowest (12.3±0.6 $gcm^{-2}day^{-1}$). There was no significant difference between all the treatments except the control treatment.

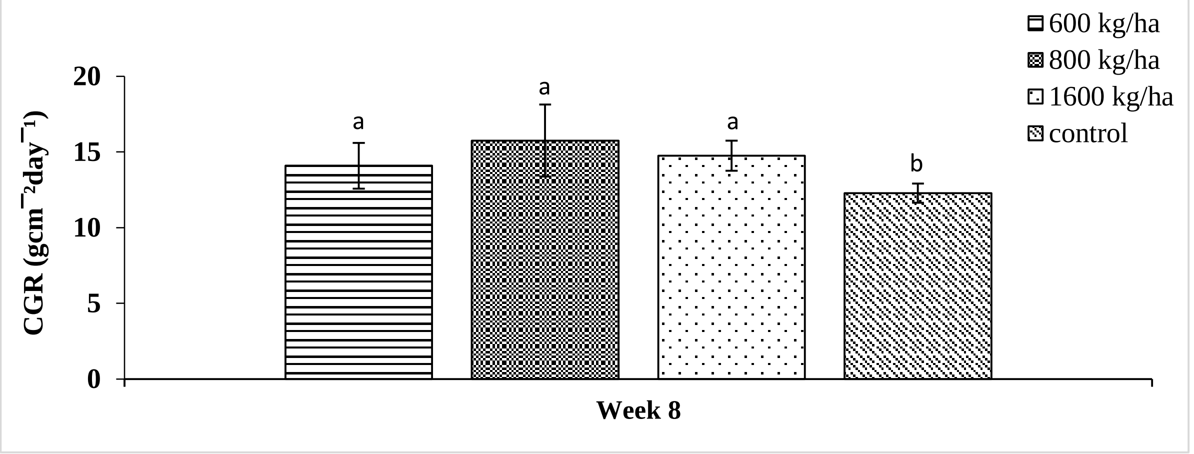

Figure 4.10: Crop Growth Rate of tobacco with different vermicompost treatments at Week 8

There was significant differences in crop growth rate (CGR) of tobacco (*p<0.05*) as shown on Fig. 4.11 at week 10. At Week 10, the CGR had declined in all treatments, though the 1 600 kg/ha vermicompost treatment had the significantly highest CGR attaining a value of 9.39±0.38 $gcm^{-2}day^{-1}$ whereas the 600 kg/ha treatment had the lowest attaining a value of 3.8±0.5 $gcm^{-2}day^{-1}$. In addition, the 800 kg/ha and 1 600 kg/ha treatments were significantly not different at Week 10 (Fig. 4.11).

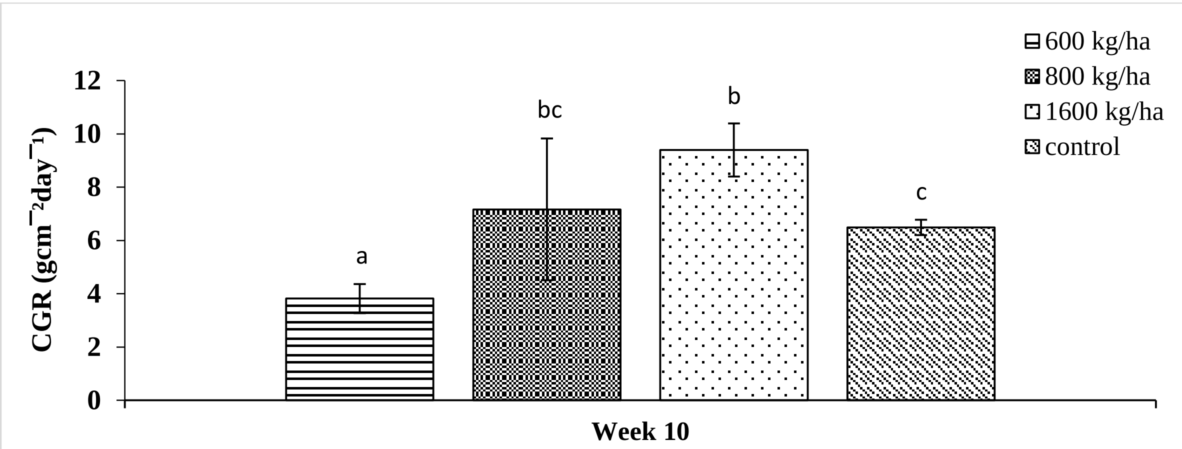

Figure 4.11: Crop Growth Rate of tobacco with different vermicompost treatments at Week 10

4.4 Tobacco yield under different vermicompost treatments

4.4.1 Tobacco leaf weight

Table 4.2 shows the changes in tobacco leaf weight overtime with respect to different vermicompost treatments. The 1600 kg/ha treatment maintained the significantly highest leaf weight from Week 4 (155.5±3.6 g) to Week 12 (888.9±11.2 g), whereas the 600 kg/ha treatment had the lowest leaf weight from Week 4 (118.6±0.8 g) to Week 12 (608.3±1.8 g) respectively. The leaf weights were significantly different for all treatments at Week 6, Week 8 and Week 12. However, at Week 4 and Week 10, the 600 kg/ha treatment and the Control treatments were not significantly different. Overall, with respect to treatment, tobacco leaf weight decreased in the order 1600 kg/ha > 800 kg/ha > Control > 600 kg/ha.

Table 4.2: Tobacco leaf weight changes in different vermicompost treatments

Treatment	Leaf weight (g)				
	Week 4	Week 6	Week 8	Week 10	Week 12
600 kg/ha	118.6±0.8	235.4±2.9[a]	358.6±11.4[a]	555.8±5.3[a]	608.3±1.8[a]
800 kg/ha	129.5±1.6[b]	259.6±4.5[b]	422.6±8.9[b]	632.5±7.3[b]	741.7±15.1[b]
1600 kg/ha	155.5±3.6[c]	335.7±4.7[c]	551.2±9.3[c]	758.2±7.2[c]	888.9±11.2[c]

Control	118.7±1.2	249.5±2.5[d]	385.7±3.0[d]	558.5±5.1[a]	645.7±4.1[d]

*[a, b, c, d] *superscripts down a given column denotes significantly different (*$p < 0.05$). *Values followed by different letters, in the same column, are significantly different at $P \leq 0.05$.*

4.4.2 Net assimilation rate

The Net Assimilation Ratios (NAR) for tobacco grown under different vermicompost treatments is depicted in Fig. 4.12. The NAR was significantly highest in the 1 600 kg/ha treatment at Week 2 (0.4±0.04 $gday^{-1}$). However, at Week 4 and Week 6 the Control treatment had the significantly highest NAR values of 0.21±0.02 $gday^{-1}$ and 0.04±0.02 $gday^{-1}$ respectively. At Week 8 and Week 10, all treatments were almost similar in NAR. Overall, all treatments declined in NAR with respect to time.

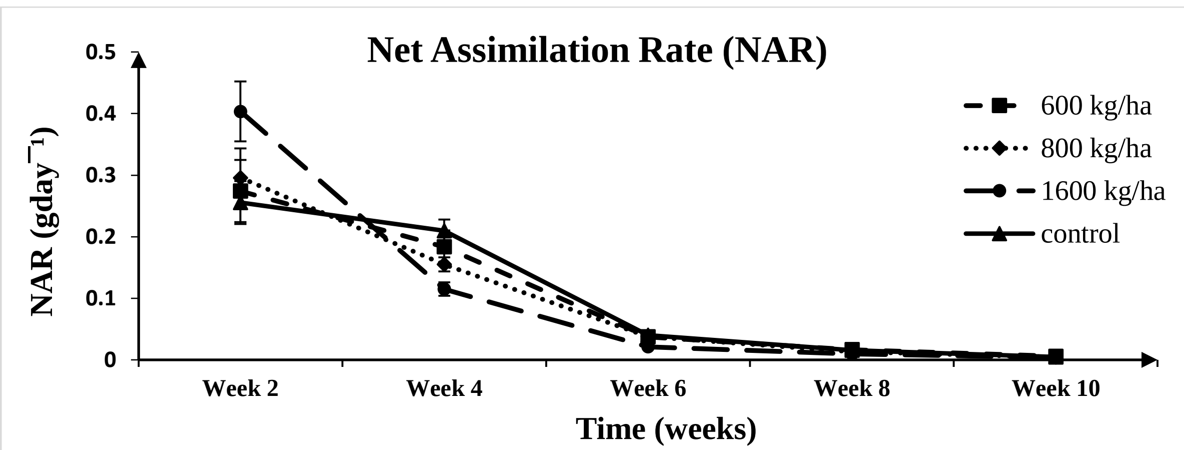

Figure 4.12: Changes in Net Assimilation Rate of tobacco with different vermicompost treatments

4.5 Tobacco leaf quality under different vermicompost treatments

Table 4.3 shows the quality of tobacco leaves harvested from blocks treated with different vermicompost treatments. The 1600 kg/ha was mainly made up of leaves grown at or above mid-portion of stalk, which were very mellow and dark mahogany in colour. As such, this was classified as the best grade (A). On the other hand, the least quality was the grade C which was composed of several orange-coloured leaves and consisted the 600 kg/ha and the Control. Tobacco from these treatments was mainly ripe, soft natured leaves that were orange in colour.

Table 4.3: Quality of tobacco leaves grown in different vermicompost treatments

Treatment	**Quality parameter**		**Grade/Quality**
	Colour	**Texture**	
600 kg/ha	Orange (O)	Full coloured, open-grained, ripe and soft natured leaves. Grade (FA)	**C**
800 kg/ha	Mahogany light (R)	Full coloured, open-grained, ripe and soft natured leaves. Grade (F)	**B**
1600 kg/ha	Mahogany dark (S)	Very ripe to mellow, associated with advanced maturity. Grade (H)	**A**
Control	Orange (O)	Full coloured, open-grained, ripe and soft natured leaves. Grade (FA)	**C**

CHAPTER 5: DISCUSSION

5.1 Tobacco growth rate

5.1.1 Plant height

In the first two weeks of different fertilizer application rates, there were no significant differences in height in all treatments (that is 600kg/ha, 800kg/ha, 1600kg/ha and the control). This might be as a result of the fact that this it soon after transplanting and the different fertilizers had not yet started being absorbed by the soil. The height across all the treatments during this period was generally 36cm. However, as the period progressed to the fourth week there were some notable changes in height especially for the 1600 kg/ha treatment which had the highest height recordings whereas the 600 kg/ha had the lowest height, attaining values. The absorption of the fertilizer had now started thus the 1600 kg/ha treatment showed some significant different from other treatments during the period in question. The other three treatments remained at par.

All vermicompost treatments were significantly different with the 600kg/ha treatment recording a significantly lowest height at week 6, whereas the 1600 kg/ha treatment had the significantly highest recording which might be as a result of the fact that they was removal of suckers and topping which reduces competition for the nutrients. The nutrients were being used by the remaining plants after. The 800kg/ha treatment had slightly higher recording than the 600kg/ha treatment. The control and the 600kg/ha treatments had almost the same recordings 45.6±1.29 cm. This is in line with the findings of David et al., (2011) which asserts that the amount of fertilizer applied has a positive link with tobacco growth and yield; the more fertilizer applied, the higher the growth and output of tobacco. At week 8, generally all the vermicompost treatments were significantly different, with the 1600 kg/ha treatment attaining the highest height value of 65.8±0.73 cm whereas the 600 kg/ha treatment had the significantly lowest height.

At week, all treatments were significantly different and the 1600 kg/ha treatment had the highest height. There was competition and no significant differences between the 800kg/ha and the 1600kg/ha treatments. On the other hand, the 600 kg/ha treatment had the lowest and almost the same with the height recordings. The last recording at week 12 revealed that the 1600 kg/ha treatment still had the highest recorded height whereas the 600 kg/ha treatment had the lowest.

In addition, vermicompost treatment effectiveness declined in the order 1600 kg/ha > 800 kg/ha > Control > 600 kg/ha.

5.1.2 Crop growth rate

In terms of the tobacco crop growth rate (CGR) under different vermicompost treatments, results showed that there was a gradual increase from week 2 to week 8 even though it declined in week 10. The 1600kg/ha treatment dominated with the highest recordings whilst the 600kg/ha treatment remained the lowest of them all but almost the same with the control. Why there is no discussion here. Higher plant height and thicker stem diameter were found after the treatments with vermicompost, which is consistent with previous research showing that crop plants had increased height after vermicompost was applied (Hossain, Uddin and Sugimoto, 2012). This result could be due to the higher nitrogen content in soil caused by applying vermicompost in this experiment. Manh and Wang (2014) found that soil NH+4-N and NO−3-N were immediately improved after applying vermicompost. The current study findings are in sync with studies by Hanc and Vasak (2015) that concluded that vermicompost contains nutrients in the forms that are readily taken up by the plants that increasing crop growth rate at high application quantities. The current study results also collaborated with Hossain *et al*. (2012), who stated that vermicomposts are characterized by high porosity, aeration, drainage, water-holding capacity and microbial activity that lead to increased growh rate of tobacco plants were sufficient rates are applied. Many studies have demonstrated positive effects of vermicompost on a wide range of crops, including cereals and legumes, ornamental, and flowering plants (Zaman *et al*, 2018), and field crops (Sharif, Ali and Rahman, 2020). Application of compost and vermicompost can also increase soil organic carbon, nitrates, phosphates, exchangeable calcium and some other nutrients for plants (Scaglia *et al*, 2016). Thus it can be confirmed that that vermicompost usually has significant beneficial effects on plant growth.

5.2 Tobacco yield under different vermicompost treatments

5.2.1 Tobacco leaf weight

Throughout the period of the field trial, the 1600 kg/ha treatment maintained the significantly highest leaf weight from week 4 to week 12, whilst the 600 kg/ha treatment had the lowest leaf weight during the same period. The leaf weights were significantly different for all treatments at week 6, week 8 and week 12. However, at week 4 and week 10, the 600 kg/ha treatment and the control treatments were not significantly different. There was a general decrease in tobacco leaf weight in the order 1600 kg/ha > 800 kg/ha > Control > 600 kg/ha. This might be as a result of the absorption rate and quantities of the different fertilisers. The current study results are in line with the studies of Yang *et al* (2015), the application of vermicompost in combination with chemical fertilizer can result in high leaf area index. The current study result is in agreement with Atiyeh *et al* (2000), who reported that ermicompost can lead to a higher leaf area index, plants become photosynthetically more active, which would contribute to the improvement in yield attributes. Vermicompost contained numerous humic acids, which enhances the number of leaf, leaf area index, plant height and increased the growth rate (Hossain *et al*, 2012). Vermicompost to the soil is very beneficial, in increasing nutrient availability (Roy *et al*. 2006) and improve the growth and fruit yield (Theunissen *et al*. 2010). The increase in leaf weight as the application quantity of vermicompost increases in this study can be explained on the basis that vermicompost can also enhance the growth of nitrogen-fixing microorganisms in the rhizosphere, which enhances N availability by making biologically fixed N available through the intimate mixing of ingested particles with soil (Hossain *et al*, 2012). As noted by Yang *et al* (2015), who indicated the improvements in crop growth and increase in fruit yields could also be due to partially to large increase in soil microbial biomass after application of vermicompost, leading to the more hormones or humate content in the vermicompost treatment.

5.3 Tobacco leaf quality under different vermicompost treatments

Results of the quality of tobacco leaves harvested from blocks treated with different vermicompost treatments revealed that the 1600 kg/ha was mainly made up of leaves grown at or above mid-portion of stalk, which were very mellow and dark mahogany in colour. As such, this was classified as the best grade (A). On the other hand, the least quality was the grade C which was composed of several orange-coloured leaves and consisted the 600 kg/ha and the control. Tobacco from these treatments was mainly ripe, soft natured leaves that were orange in colour. Results are in agreement with Hanc and Vasak (2015) who found that the integrated application of vermicompost significantly increased vegetative growth. Zaman *et al (*2018) also observed that combined application of different vermicompost increased both vegetative and leaf number and quality in plants. Thus in this current study Thus, a high nutrient or hormones status of soil with vermicompost may improve the tobacco leaf quality as obtained on the higher treatment of 1600 kg/ha. The current study findings collaborated with Manh and Wang (2014), who applied the vermicompost to the flue cured tobacco and finding that the vermicompost promoted the quality of leaves, germination of seeds, the height of the plant, the number of leaves of each plant, length of leaves and width of leaves of each plant and the yield. Thus, applying organic fertilizer produced an improvement in plants even at the beginning of the growth cycle. Sharif, Ali and Rahman (2020) showed that vermicompost had beneficial effects on growth and yield of rice, especially caused significant increase of many growth parameters, seeds germination, chlorophyll concentration and yield. Similar results were noted by Scaglia et al (2016), who reported that tomato yields in field soils amended with vemicompost were significantly greater than those in the untreated plots.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the results of this study, vermicompost application levels has significant differences on growth, yield and quality of tobacco using rate of 1600kg/ha of vermicompost). Vermicompost was noted to have effects on growth, yield and nutrient quantity (i.e. LAI, NAR, leaf quality and CGR). Using the rates 600, 800 and 1600 kg/ha and control which is compound C the vegetation growth stages of the crop could not be differentiate on the basis of visual analysis. At 1600kgs/ha yield have got the highest leaf weight from week 4 to week 12. Where 600kgs/ha has the lowest from week 4 to 12. Leaf weights were significantly different for all the treatments at week 6, 8 and 12 ($p<0.05$). At 1600kgs/ha tobacco produced leaves with mellow and dark mahogany in color and was classified as grade A and C as the lowest grade. In week 2 they was significant differences in CGR ($p<0.05$) of tobacco and a gradual increase from week 2 to 8 but later decline in week 10. At rate of 1600kgs/ha vermicompost treatments had the significant highest CGR ($p<0.05$) for week 2 while 600kgs/ha had the lowest.

6.2 Recommendations

6.2.1 Recommendation to the farmer

The study recommends the farmers the use of 1600 kg of vermicompost as it produced quality high yielding tobacco.

6.2.2 Recommendation to students and researchers

For further research, students and researchers are recommended to do more trials in different regions that grow tobacco, using different tobacco varieties and combining all types of organic fertilizers e.g vermicompost, manure and murakwani.

6.2.3 Recommendation to the companies and researchers

For further studies should include soil analysis.

to determine the presence of pesticide residues in the final yield, the effects of maize variety, soil type (pH) and methods of seed dressing should be carried out.

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Zaman *et al.* (2018) reported that vermicompost along with different rates of chemical fertilzers exerted significant influence on the growth, leaf biomass yield and stevioside content of stevia.

APPENDIX 1: BLOCK DESIGN

BLOCK	REPLICATION			
	R1	**R2**	**R3**	**R4**
B1	Control	600 kg/ha	800 kg/ha	1600 kg/ha
B2	600kg/ha	Control	1600 kg/ha	800 kg/ha
B3	800 kg/ha	1600 kg/ha	Control	600 kg/ha
B4	1600 kg/ha	800 kg/ha	600 kg/ha	Control