KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARMENT OF ENVIRONMENTAL STUDIES

EFFECT OF POULTRY AND INORGANIC MANURE (N.P.K 15:15:15) ON GROWTH, YIELD AND SHELF LIFE OF TOMATO (*LYCOPERSICON ESCULENTUM* MILL)

GIFTY FREMAH APPIAH

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EFFECT OF POULTRY AND INORGANIC MANURE (N.P.K 15:15:15) ON GROWTH, YIELD AND SHELF LIFE OF TOMATO (*LYCOPERSICON ESCULENTUM* MILL)

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DECLARATION

I, Gifty Fremah Appiah, hereby declare that this work is the effort and result from my own research for the award of the degree. However, workdone by others which I used have been correctly cited and acknowledged.

GIFTY FREMAH APPIAH	……………………………	………………….
(STUDENT)	SIGNATURE	DATE
MR. ALFRED K. APETORGBOR	…………………………	………………….
(SUPERVISOR)	SIGNATURE	DATE
DR. I. K. TETTEH	…………………………	………………...
(HEAD OF DEPARTMENT)	SIGNATURE	DATE

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ABSTRACT

The tomato sector in Ghana has failed to reach its potential in terms of attaining yields comparable to other countries. Soil nutrition plays a major role in determining growth, yield and shelf life of tomato. The research was conducted to assess the effect of poultry and inorganic manure (N.P.K.15:15:15) on the growth, yield and shelf life of tomato (Lycopersicon *esculuntum*) at Dormaa Ahenkro in the Brong Ahafo Region of Ghana. The study was conducted on a randomized plot design with three replicates per treatment for poultry manure and N.P.K 15:15:15 fertilizer applied at different rates. Plots without poultry manure or N.P.K 15:15:15 fertilizer served as control. Data were collected on vegetative growth, yield and shelf life to assess the influence of the various treatments on these parameters. Data were taken using five randomly sampled plants per plot. The data were subjected to a one- way Analysis of variance to determine the differences in growth, yield and shelf life for the various treatments. Least Significant Difference was carried out using MS Excel to determine difference from control and between the treatments ($p \leq 0.05$).Higher values were recorded in all parameters measured under poultry manure than N.P.K fertilizer and control treatments, with increase in poultry and N.P.K fertilizer concentrations various parameters also increased. It is recommended that tomato farmers in Ghana apply poultry manure to their farms for them to attain higher yields to promote food security.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Soil is a basic resource for agricultural production systems. Besides it being the core medium for growth, it functions to sustain crop productivity, maintain environmental quality and provide for plant, animal and human health. Soil is a habitat for plants and thus its physical, chemical, and biological properties affect plant growth. The physical properties of a soil largely determine the ways in which it can be used and it includes but not limited to size, shape, and arrangement of the primary materials. Other important physical properties such as the size and shape of the spaces between the particle arrangements (pore space), have a direct effect on the movement of air and water, the ability of the soil to supply nutrients to plants, and the amount of water available to the plant. Chemical properties of soils are important in that, along with their physical and biological properties, they regulate the nutrient supplies to the plant. Without these nutrients supplied by the soil or applied as inorganic fertilizers, organically by manures, and other vegetative materials, plant growth would cease.

Growth and yield of crops is remarkably influenced by organic and inorganic nutrients. However, organic and inorganic fertilizers supply nutrients to soil in different ways. Organic fertilizers create a healthy environment for the soil over a long period of time, while inorganic fertilizers work much more quickly, but fail to create a sustainable environment. Use of inorganic fertilizers for crops is not so good for health because of residual effects but in the case of organic fertilizers such problems do not arise but rather increases the productivity of soil as well as crop quality and yield. The use of organic inputs such as crop residues, manures and compost has great potential for improving soil productivity and crop yield through improvement of the physical, chemical and microbiological properties of the soil as well as nutrient supply (Stone and Elioff, 1998)

Tomato is a herbaceous, usually sprawling plant in the Solanaceae or nightshade family, grown widely for its edible fruits. It has become a major world food crop in less than a century. It is considered a vegetable but actually a fruit and is native to the Americans. It is believed to have been domesticated in Mexico, where a variant of the wild cherry tomato was brought into cultivation as early as 700 AD. Tomatoes grow well in many types of soil but prefer deep, fertile, well-drained soil that is amply supplied with organic matter and is slightly acidic.

Effective tomato fertilizer, whether organic or inorganic, provides nutrients tomatoes need at different stages of growth. To get high yields, tomatoes need to be fertilized. There are two groups of crop nutrients: organic manures and chemical fertilizers. Poultry manure is a very valuable kind of manure as plants can easily absorb the nutrients from it. Chemical fertilizer (except for calcium) does not improve the soil structure but enriches the soil by adding nutrients. For sustainable crop production, integrated use of organic and inorganic manure has proven to be highly beneficial to mitigate the deficiency of many secondary and micronutrients in fields that continuously received only N, P and K fertilizers without any micronutrient or organic fertilizer. Various studies (Sutanto *et al.,* 1993; Prasithikhet *et al.*, 1993; Palm, 1995; Quansah *et al*., 1998) have confirmed that combining inorganic and organic fertilizers have proven to be more effective in increasing productivity than being used singly. FAO (1993) reported that soil fertility replenishment for sustaining crop productivity should use all possible sources of plant nutrients in an integrated manner.

1.2 Statement of Research Problem and Justification

Increase in human population has resulted in increased pressure on land and soil resources due to increase in cultivation of crops to meet the ever growing food demand. Increase in pressure on the soil from intensive tillage coupled with unsustainable methods of farming such as continuous cropping results in higher outflow of nutrients which could lead to depletion of soil fertility. Soil-nutrient capital is gradually depleted when farmers are unable to sufficiently compensate losses by returning nutrients to the soil via crop residues, manures and mineral fertilizers. Depletion in soil fertility results in low production of food which could be a threat to the food security of the nation and a drawback to the attainment of the Millennium development goal one; eradicate extreme poverty and hunger by the year 2015.

According to MoFA (1998) soils in Ghana are inherently low in fertility and require external inputs to improve their fertility. The use of mineral fertilizer is the most effective and convenient way to improve soil fertility (MoFA, 1998). Ghanaian soils have consequently shown a negative balance in nutrient budget which poses a great threat to sustainable soil management for increase in growth and crop yield (FAO, 2004).

To achieve sustained soil productivity and subsequent increase in crop growth and yield calls for the exploitation of varied alternative sources of soil fertility improvement and management strategies. Soil fertility replenishing strategies that are conventionally employed are the application of nutrients in the form of either organic or inorganic manure. In Ghana, many farmers resort to the use of inorganic fertilizers than is the case with organic manure.

Over decades since the practice of agriculture, many African farming systems have been employing the application of crop residues as source of nutrients and soil organic matter amendment. These soil management practices have recently changed dramatically including an increased use of synthetic fertilizers and pesticides to help improve crop yields. These plant nutrients can be provided by applying inorganic fertilizer or organic manure or both.

Farmers are now showing interest in organic farming because they are more aware about the residual effect of chemical substances used in the crop field and their degrading impact on the environment. Besides, the excess application of inorganic fertilizer also causes hazard to public health. But the application of both organic and inorganic fertilizer combined, can increase the yield as well as keep the environment sound (MoFA, 1998).

Research has shown that the most deficient nutrients in Ghanaian soils are nitrogen and phosphorus (Ofori and Fianu, 1996) which are usually supplied through natural absorption from organic sources or incorporated artificial chemical preparations.

Available research findings (Sutanto *et al.,* 1993; Prasithikhet *et al*., 1993; Palm 1995; Quansah *et al*., 1998) indicate that integrated plant nutrition, the combined use of organic and mineral fertilizers increases crop yield more than either used alone. Not much research has been conducted on the extent to which organic and inorganic manure affect growth, yield and shelf life of crops. It is against this background that this study was initiated to evaluate how poultry and inorganic manure (N.P.K 15:15:15) affect growth, yield and shelf life of tomato.

1.3 Research Questions

The study sought to find answers to the following questions:

1. What are the effects of poultry and inorganic fertilizer on growth of tomato?
2. What are the effects of poultry and inorganic fertilizer on yield of tomato?
3. What are the effects of poultry and inorganic fertilizer on shelf life of tomato?

1.4 Study Objectives

1.4.1 Main Objective

The main objective of the study was to assess the effect of poultry and inorganic fertilizer on growth, yield and shelf life of tomato.

1.4.2 Specific objectives

1. To assess the performance of different soil treatments (poultry manure and inorganic fertilizer) in the production of tomato.
2. To assess the shelf life of tomato harvested from soils of the different amendments.

1.5 Significance of Study

Statistical figures (SRID MoFA, 2008) indicate a decline in the production of food, especially fruits and vegetables in Ghana. This is evident in the volume of fresh tomatoes that is imported into the country from neighbouring countries like Burkina Faso (over 40% of fresh tomato demand) and tinned tomato puree from Europe (Anum, 2009). Findings obtained from this study would provide information to farmers, agriculture extension officers and other stakeholders on the effects of organic and inorganic fertilizer on the growth, yield and shelf life of tomatoes. Also the level at which organic and inorganic fertilizer should be applied to tomato plant so as to reduce the level of pollution these fertilisers leached to water bodies creating environmental imbalance This would equip them with the requisite knowledge to help increase their production levels to meet the food demand of the nation hence ensuring food security to meet the Millennium Development Goal 1(i.e. to eradicate extreme poverty and hunger).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Among the factors that contribute to low tomato yield in Ghana is low soil fertility and unfavourable soil physical properties. Over several decades, nutrient depletion as a result of unsustainable farming practices such as slash and burn, continuous cropping among others have transformed originally fertile lands into infertile ones. Conventional soil fertility maintenance strategies such as fallowing, intercropping cereals with legume crops, mixed farming and opening new lands have been adopted by farmers in times past. These traditional strategies have been unsustainable in the production of crops due to the limited areas of land from population explosion and its associated pressures. Tomatoes are quality nutrient demanding crops which are to be supplied by the soil as the basic habitat and supplier of the nutrients.

2.2 The Tomato Plant

Tomato is botanically a fruit but classified as vegetable in trade. Naika *et al.* (2005) placed tomato under the Solanaceae family. This family also includes other well-known species, such as potato, tobacco, peppers and eggplant (aubergine). Tomato has its origin in the South American Andes. Cultivated tomato was brought to Europe by the Spanish in the sixteenth century and later introduced from Europe to southern and eastern Asia, Africa and the Middle East. Tomatoes are rich in minerals, vitamins, essential amino acids, sugars and dietary fibres. Tomato contains much vitamin B and C, iron and phosphorus. Tomato is an annual plant, which can reach a height of over two metres. The shape of the fruit differs per cultivar. The colour ranges from yellow to red.

2.3 Variety of tomatoes cultivated in Ghana

The recommended varieties of tomato cultivated by farmers in Ghana include Roma VF, Pectomech, Tropimech, Rio Grande, Cac J, Wosowoso and Laurano 70. Certified seed producers, certified agricultural input dealers and input shops of the Ministry of Food and Agriculture are the source of seeds available to producers (MoFAIR Centre, 2008).

2.4 Soil requirements for Tomato

Tomatoes can be grown on many different soil types, but a deep, loamy, well-drained soil supplied with organic matter and nutrients is most suitable. As with most vegetables, tomatoes grow best in a slightly acid soil with a pH of 6.2 to 6.8 (Riofrio, 2000). Tomatoes prefer well drained soil because they are sensitive to waterlogging (Hanson *et al.*, 2000).

2.5 Nutrient requirements for Tomato

Plant nutrition is concerned with the processes affecting the acquisition of nutrient elements by plants, the health of the plant with respect to its supply or content of essential elements, and the functions of those elements in the life of the plant (Morgan, 2006).

Four major elements: Nitrogen (N), Calcium (Ca), Potassium (K), and Phosphorus (P) are particularly critical in the production of tomatoes in soil-field systems. Some micronutrients have been specifically studied to be critical for tomato. These are Boron (B), Iron (Fe) and Zinc (Zn). Micronutrient deficiencies are not common except on very sandy soils, on high pH soils, or in instances when imbalances occur due to major element excesses, such as Phosphorus. The micronutrients, when not in their proper concentration range in the growing media or plant, can result in a deficiency or toxicity. Additions of a micronutrient to the soil should be made based on a soil test and/or plant analysis-based recommendation (Jones, 2013). Monitoring the micronutrient concentration in a nutrient solution is important in order to avoid their excess accumulation or deficiency. Sulfur (S), chlorine (Cl), copper (Cu), manganese (Mn), and molybdenum (Mo) are the other essential mineral elements. Their insufficiency in soils, soilless media, or hydroponic nutrient solutions is not likely to occur under normal growing and cultural conditions. There is a body of literature that suggests that there are elements Silicon (Si), Sodium (Na), Vanadium (V), Nickel (Ni)] that can be beneficial to the plant, and therefore should be readily available to the plant or added, particularly to a nutrient solution. For soil growing, these elements are naturally present in sufficient concentration, but in hydroponic nutrient solutions, they may or should be included in the formulations (Jones, 2013).

Tomato crop requires certain nutrients that are essential for fruit growth and quality. The fruit requires good amounts of nitrogen, phosphorus, high amounts of calcium and often extremely high levels of potassium if fruit quality is to be maximized (Morgan, 2006).

2.5.1 Phosphorus

Large amounts of phosphorus (P) are required for seed formation within the fruit. A fruiting tomato plant absorbs proportionately more phosphorus than a non-fruiting or vegetative plant.

2.5.2 Potassium

The requirement for potassium is about the same as for nitrogen in the early crop stages (from seedling through until fruit development). After this, the requirement for potassium keeps increasing with fruit load while nitrogen levels off. While nitrogen is important and is used in large quantities for vegetative growth, potassium is the predominant cation in tomato fruit and has major effects on fruit quality. The majority of the potassium is absorbed by the plant during the active fruiting stage and ends in the fruit. This is why ratios of potassium need to be maintained at higher levels during the fruiting stages than during the vegetative and flowering stages. Thus, as crop load on the plant increases, so does the requirement and absorption of potassium which will become part of the fruit tissue. If potassium becomes deficient during the fruiting phase of a tomato crop, both yield and fruit quality will suffer greatly. Potassium is directly related to fruit quality, via the acidity and flavour of the fruit, firmness, ripening disorders, colour and shelf life. Fruit deficient in potassium has a lower overall flavour and shelf life quality and can also suffer from ripening disorders such as blotchy ripening, gray wall, cloud, lack of good colouration and can be described as `watery' (Niassy *et al.*, 2010).

2.5.3 Nitrogen

Despite the importance of potassium during fruit development, levels of nitrogen also need to be maintained particularly during the pre-flowering stage. It has been shown that the concentration of nitrogen before initiation of the first flower truss was of crucial importance in determining yield.

2.5.4 Calcium

Calcium is another mineral essential for fruit growth and development. The supply of calcium is more critical during the phase when there is rapid visible size increase as it is required for the formation of new cells and for strong cell structure. Lack of calcium transportation into the fruit can rapidly result in the development of blossom end rot (Morgan, 2006).

2.6 Sources of nutrients for tomato production

Diverse materials can serve as sources of plant nutrients. These can be natural, synthetic, recycled wastes or a range of biological products including microbial inoculants. Nutrient sources are generally classified as organic, mineral or biological. Supply of mineral and organic nutrient sources is present in soils, but these often have to be supplemented with external applications for better plant growth (Hanson *et al.*, 2010).

Prof. Neil Curtis of Victoria University writing on the topic Plant nutrition and soils chemistry in the garden, noted that plants need water, carbon dioxide and a range of trace minerals known as 'nutrients' to grow. They obtain these nutrients, and most of their water, from the soil. The nutrients available in a given soil ultimately depend on the rock from which the soil was made. If the plants grown from this soil die and decay where they have grown then their nutrients are recycled (Naika *et al*., 2005).

Sainju *et al*. (2003) argued that tomato requires at least twelve nutrients, also called "essential elements", for normal growth and reproduction. According to them without these nutrients, tomato cannot grow properly or bear fruits. These are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and molybdenum (Mo). They contended that because the soil cannot supply adequate amounts of N, P, and K for optimum growth and production of tomato, these nutrients are added as amendments in the form of manures and fertilizers to the soil. Nutrients, such as Ca and Mg, are applied when liming is done in acidic soils. Some soils contain abundant amount of Ca and Mg. Sulfur is usually supplied by N, P, and K fertilizers because many of these fertilizers contain S compounds. In contrast, micronutrients are usually supplied in adequate amounts by the soil unless deficiency in plant occurs. In the greenhouse tomato production where soil is not generally used for growing tomatoes, the growth medium, however, needs to be fortified with all of these nutrients (Sainju *et al*., 2003).

2.7 Factors that affect growth, yield and shelf life of tomato

The growth, yield and shelf life and/or quality of tomato are affected by physical, environmental and cultural factors. These include but not limited to soil, water, nutrition, climatic factors. Adekiya and Ojeniyi (2002) observed that among the factors that contribute to low tomato yield in Nigeria is low soil fertility and unfavourable soil physical properties such as bulk density.

Low soil fertility and physical limitations affect tomato production especially in Nigeria where there is often constraints of compaction, shallow depth, supra optimal temperature and nutrient deficiency (Akanni and Ojeniyi, 2007).

Major causes of post-harvest losses are decay of fruits, external injury during harvesting, handling and storage of tomato fruits. In addition, environmental factors such as soil type, temperature, frost and rainy weather during harvest can cause severe effect on storage life and quality of tomato. Field management practices also affect post-harvest quality. Tomato that has been stressed due to more or less irrigation application can cause high rate of nitrogen and mechanical injury in the form of scrapes, bruises and abrasion and is particularly susceptible to post harvest diseases (Shahnawaz *et al*., 2011).

2.8 Effect of organic manure and inorganic manure on growth, yield and shelf life

Vegetable growers, especially commercial growers, depend on either chemical fertilizers or organic manure or both to improve on plant growth and increase yield. Fertilization is one of the ways by which nutrient status of soils can be improved to meet crop needs and in so doing maintaining the fertility of the soil and increasing its productivity. Fertilization could have both negative and positive impacts on the state of the soil and its ability to provide the sound environmental conditions necessary that influence growth, yield and quality of vegetables. The amount and type of nutrients supplied to tomato can influence not only its yield but also its nutrient content, taste, and post-harvest storage quality (Sainju *et al*., 2003).

Dupriez and De Leener (1989) in their publication on Africa Gardens and Orchards reported that chemical fertilizers lower plant resistance to pest and disease attack and also reduce the quality of taste and shelf life of vegetable crops. Split application of fertilizers has been reported to be the most beneficial mode of nutrient supply to tomatoes for optimum growth and yield (Jones, 1999).

2.8.1 Growth

Plant growth can be defined as the progressive development of the plant. Frequently, the term growth is expressed as the amount of biomass in the plant or plant part. Heavy doses of nitrogen fertilizers like Ammonium sulphate or Ammonium nitrate can cause toxicity in water melon and muskmelon and as a result retard the growth of the plants (Sinnadurai, 1992).

John *et al*. (2004) indicated that extensive use of inorganic fertilizer had a depressing effect on the yield of watermelon. It causes reduction in the number of fruits, delayed and reduced fruit setting leading to delayed ripening. It also leads to heavy vegetative growth due to its supply of nitrogen. They also reported that poultry manure is effective as a good source of Nitrogen for sustainable crop production associated with high photosynthetic activity, vigorous vegetative growth and a dark green colour of the leaves. According to the findings of a study conducted by Hector *et al*. (1993), they observed that low nitrogen restricts growth, modifies the length-to-diameter ratio of fruit, reduces fruit set and colour development.

2.8.2 Yield

The yield of a crop is determined by the total biomass production, biomass partitioning and fruit dry matter content (Heuvelink and Dorais, 2005). According to Sainju *et al*. (2003) mineral nutrition of tomato from application of fertilizers and manures has proven to increase tomato yield and nutrient uptake by several folds compared with no fertilization.Williams *et al.* (1991) in a study on organic fertilizer responses of cucumbers on peat in Brunei reported that cucumber can be grown on almost any soil but for good yields in the tropics, the crop requires a deep soil with higher organic manure. Quansah *et al.* (1998) reported a significant increase in crop yields when a combination of organic and mineral fertilizers was applied compared with sole application of organic or mineral fertilizer. Tomato plants should be fertilized with organic (animal manure) and/or chemical fertilizers to produce high yields (Hanson *et al.*, 2000).

Sendur *et al.* (1998) observed superior performance with respect to growth and fruit yield of tomato due to application of organic manures in combination with recommended dose of inorganic fertilizers over their individual application.

2.8.3 Shelf life or quality of tomato fruit

Shelf life is a period of time which starts from harvesting and extends up to the start of rotting of fruits (Mondal, 2000). High quality tomato fruits have a firm, uniform and shiny colour, good appearance, without signs of mechanical injuries, shriveling and bruises (Shahnawaz *et al.*, 2011). Magkos *et al*. (2006) reported that consumers have much preference for foods produced with organic substrates compared to foods conventionally produced by application of synthetic fertilizers because they perceive organic foods as healthier and safer. Cucumber requires magnesium to help obtain a deep-green colouration of its fruit. Hector *et al*. (1993) found out that cucumber fields which received high NPK (15-15-15) fertilizer rates (>2,500kg ha^{-1}) resulted in a high deficiency of magnesium, causing fruits to develop light green colour and thus reduced quality of fruits.

Tindall (2000) noted that it is an established fact that use of inorganic fertilizer for crops is not so good for health because of residual effect but in the case of organic fertilizer such problem does not arise and on the other hand it increases the productivity of the soil as well as crop quality and yield. The reduction in tomato fruit shelf life is influenced by the percentage fruit calcium by fertilizer application at transplanting. Brady (1987) reported that high nutrient Nitrogen and Phosphorus availability depresses fruit calcium concentrations which consequently results in shortened shelf life.

Munson (1985) found that with proper potassium nutrition the fruit is generally higher in total soluble solids, carotenoids, sugars and acids and has a longer shelf life. Tucker *et al*. (1994) stated that supply of potassium nutrition resulted in thin skinned fruit promoting fruit spoilage, even though extra potassium is not always correlated with thick skinned fruit with increased shelf life; there should be appropriate dose of potassium.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

3.1.1 Location

The study was carried out in Dormaa Ahenkro, the capital of the Dormaa municipality which is located at the western part of the Brong Ahafo Region. It lies within longitudes 3^o and 3^o 30' West and latitudes 7^o and 7^o 30' North (Figure 1). The municipality is bounded by Jaman and Berekum Districts on the north, on the east by the Sunyani Municipal, on the south and southeast by Asunafo and Asutifi Districts respectively, on the southwest by the Western Region and on the west and northwest by la Cote d'Ivoire (Http://dormaa.ghanadistricts.gov.gh).

3.1.2 Land size

The Municipality has a total land area of 1,368 km^2, which is about 3.5 percent of the total land area of the Brong Ahafo Region and about 0.6 percent of that of Ghana Http://dormaa.ghanadistricts.gov.gh

3.1.3 Topography

The topography of the municipality is generally undulating and rises between 180m and 375m above sea level. The highest point is a little over 375m above sea level. The medium range rises gradually between 240m and 300m above sea level. The general height is between 180m and 240m above sea level (Http://dormaa.ghanadistricts.gov.gh).

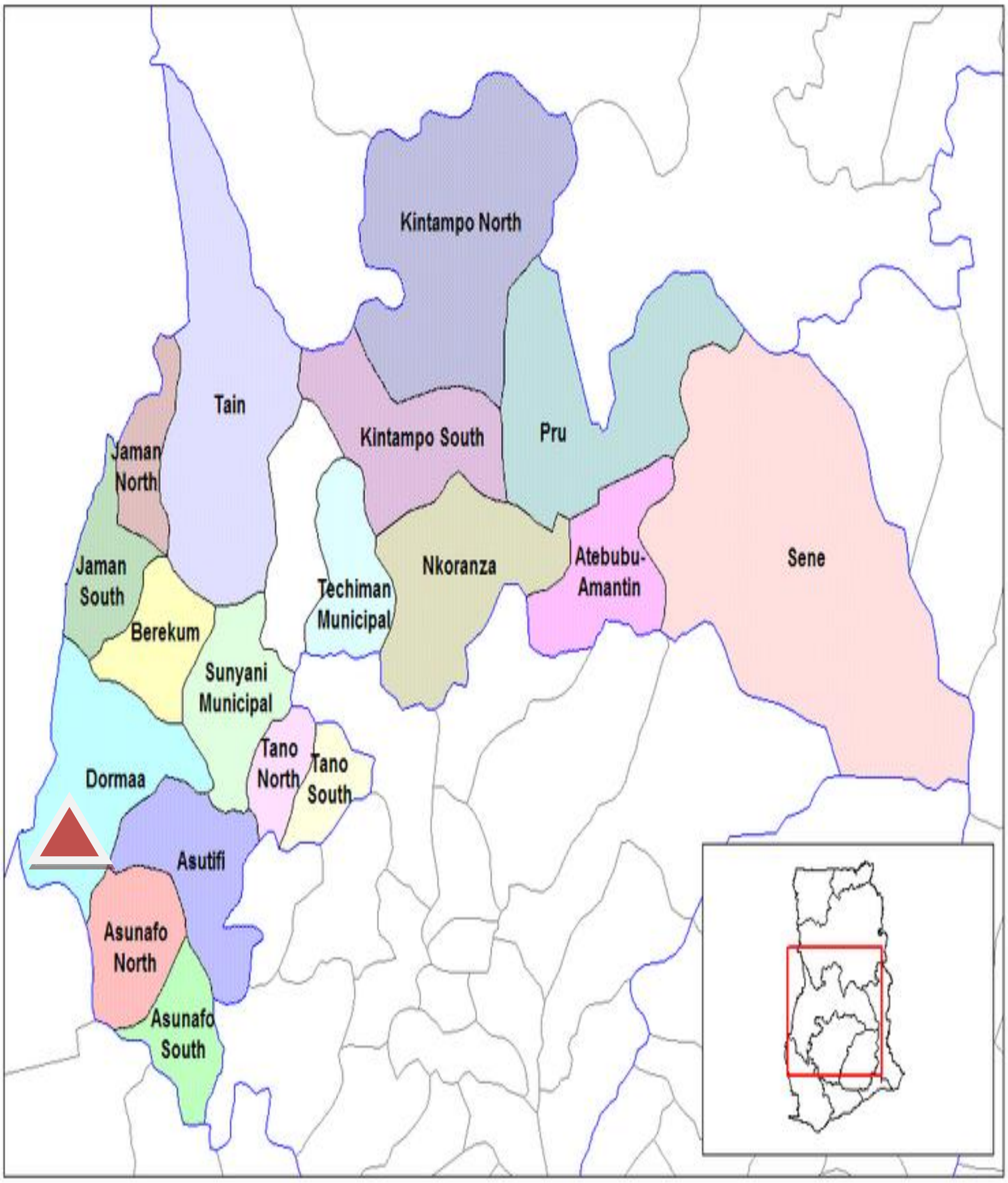

Figure 1: Map of Brong Ahafo Region,Ghana showing the study area (red triangle)

(Source: http://dormaa.ghanadistricts.gov.gh/)

3.1.4 Drainage

The drainage pattern of the Dormaa Municipality is basically dendritic and flows in the north-south direction. The area is well drained as evidenced by the dense network of rivers spread out over the municipality. The rivers are mostly perennial due to the double maximal rainfall experienced. Notable among them are the Bia, Nkasapim and Pamu rivers
(Http://dormaa.ghanadistricts.gov.gh).

3.1.5 Climate

The Dormaa Municipality is located within the wet semi-equatorial climate region with a double maximal rainfall regime. The mean annual rainfall is between 125cm and 175cm. The major rainy season is from May to June with the heaviest rainfall occurring in June while the minor rainy season is from September to October. The dry seasons are quite pronounced with the main season beginning around the latter part of November and ending in February. It is often accompanied by a relative humidity of 75% – 80% during the two rainy seasons and 70% – 72% during the rest of the year. The highest mean temperature of the municipality is about 30ºC and occurs between March and April and the lowest about 26.1ºAugust
(http:/dormaa.ghana.gov.gh).

3.1.6 Vegetation

The major vegetation types are the unused forest, broken forest, grassland and extensively cultivable forestland and forest reserves. The major types of flora found in these forests range from shrubs and climbers to giant silk cotton trees. Timber species including Wawa (*Tripolichiton scleroxylon*), Odum (*Milicia excela)*, Sapele

(*Entandrophragma cylindricum*) and Mahogany (*Khaya ivorensis*) are found here. The forest has been extensively cultivated leading to an invasion of grassland vegetation (Http://dormaa.ghanadistricts.gov.gh).

3.1.7 Geology and soil

The rocks underlying the soils are of the Birimian formation which covers more than three quarters of the closed forest zone. Economically, it is the most important geological formation in Ghana since it contains all the minerals exported from the country such as gold, diamond, bauxite and manganese. Associated with the Birimian formation are extensive masses of granite which occur in parallel belts. Soils in the municipality belong to the Bekwai-Nzema compound associations. The Nkrankwanta association dominates the south-western section of the municipality. The Nzema series, which are made up of quartz gravels and ironstone are moderately well-drained. These soil types tend to support both industrial and food crops which include cocoa, coffee, oil palm, citrus, cola-nuts, plantain, cassava and maize. (Http://dormaa.ghanadistricts.gov.gh).

3.2. Methodology

3.2.1 Treatment and Experimental Design

The field used for the experiment had been used in the cultivation of pepper two years prior to the conduct of this experiment. The tomato (*Lycopersicon esculentum*) Pecmotech seedlings were raised in a nursery, watered twice daily and transplanted 25 days after germination into farm beds filled with sandy loam soil. Transplanting was done when seedlings were about 15cm (6 inches) high with about 5-6 leaves. Transplanting was done late afternoon to prevent transplanting shock at 45 cm between rows and 45 cm within rows. Fertilizer at a rate of 0.0 g, 20 g, 40 g, 60 g and 80 g of poultry manure and inorganic manure (N.P.K15:15:15) was applied per treatment plot. The experimental layout was a Randomized complete block design (Fig. 2) with three replicates per treatment. The plants were staked two weeks after transplanting.

3.2.2 Sowing

Tomato seeds were nursed on prepared nursery beds and transplanting onto the field beds was done four weeks after germination

3.2.3 Weed Control

Weeding was done after transplanting to prevent competition between the tomato plants and weeds. Weeding was done with a hoe three times during the study period. The first weeding was carried out four weeks after transplanting and the second and third weeding were carried six and eight weeks respectively after transplanting.

3.2.4 Disease control

Funguran was applied at 170 g per 25 litres of water to the experimental fields to prevent infection of fungal disease to the tomato plants. This was done every 10 days after germination till time of harvest.

3.3. Data collection

Data were collected on growth, yield and shelf life to assess the influence of the various treatments on these parameters. Data were taken during the late afternoon after 16:00 GMT. They were taken using five tagged randomly sampled plants per plot.

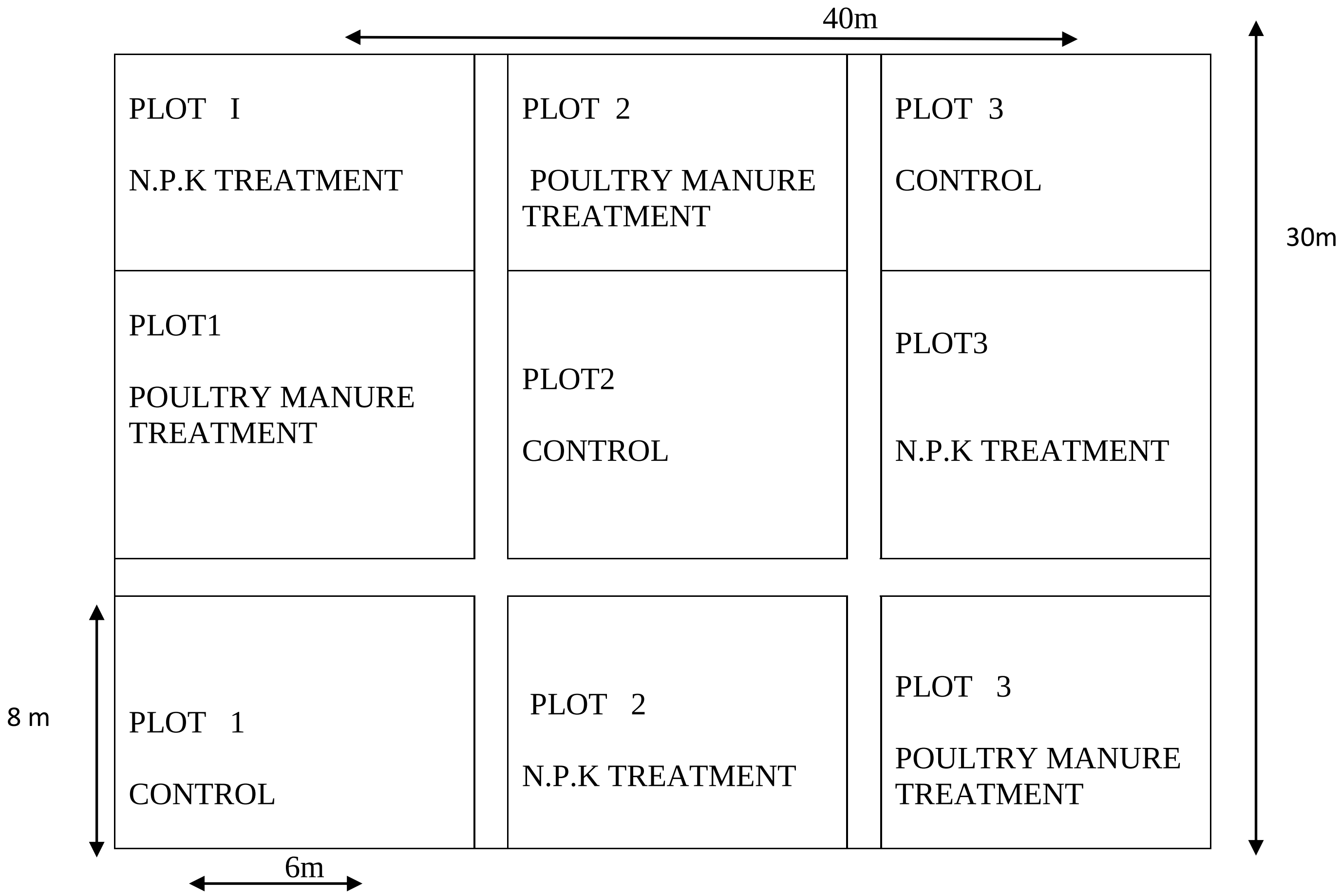

Fig 2. Experimental plot layout (Randomized complete block design)

3.3.1 Growth data

Plant growth can be defined as the progressive development of the plant. Growth is expressed as the amount of biomass in the plant or plant part. Data on growth were taken six weeks after application of treatment. Growth parameters measured included plant height, number of stem branches, number of leaves and leaf length.

3.3.1.1 Plant height

Plant height was measured with a ruler. This was done by measuring the plant from the base at the ground level to the terminal growth point. The height was recorded for the sampled plants and the mean average determined by dividing the total heights by the number of plants.

3.3.1.2 Number of stem branches

The number of branches per sampled plants were counted and recorded. The total number of stem branches was calculated by adding up all samples and the total divided by number of samples to obtain the average number of stem branches per treatment plot.

3.3.1.3 Number of leaves

This was determined by singly counting the matured leaves per plant. The total of all five sampled plants was determined by adding up all the counts and the average number of leaves per treatment plot was calculated by dividing the total number of leaves by the number of plants sampled.

3.3.1.4 Leaf length

The length of the plant leaves was measured with the aid of a ruler. This was done by measuring from the base of the petiole to the tip of the leaf. Average leaf length per treatment was calculated by dividing the total lengths of leaves of sampled plants by the number of plants.

3.3.2. Yield data

The yield of a crop is determined by the total biomass production, biomass partitioning and fruit dry matter content. Data on yield were taken five weeks after transplanting and when fruits had reached maturity ready for harvesting. Parameters measured were number of flowers per plant, number of fruits per plant and total weight of fresh fruits per plant at harvest.

3.3.2.1 Number of flowers per plant

The number of flowers on the tagged plants was counted. Total number of flowers per experimental treatment of tagged plants was recorded. This was done at 2, 5, 7 and 10 weeks after fertilizer application.

3.3.2.2 Number of fruits per plant

The number of fruits harvested from five sampled plants was counted from which total number of fruits per plant was calculated.

3.3.2.3 Fruit weight per plant

Fruits from the five randomly tagged plants were weighed with the help of a weighing scale from which the total weight of fruits per plant was calculated. The average weight of fruits from

the experimental plot was estimated by dividing the total weight by the number of fruits.

3.3.3. Shelf life data

Shelf life is calculated as the period of time between harvesting and period of start of rotting of fruits. Parameters measured were number of days for fruits to wrinkle and number of days to watery. The harvested ripe fruits were placed on a clean table in a store at room temperature whiles observing the changes critically daily. Signs of wrinkleness were observed and the number of days it took to wrinkle. The number of days it took to watery was also noted for each treatment samples taken.

3.4. Data analysis

The data were subjected to a one way Analysis of Variance (ANOVA) to determine the differences in growth, yield and shelf life for the various treatments. Least Significant Difference (LSD) was carried out using MS Excel to determine difference from control and between the treatments ($p \leq 0.05$).

CHAPTER FOUR

4.0 RESULTS

4.1 Growth

Growth of *Lycopersicon esculentum* was significantly affected by the various treatments at 2, 5, 7 and 10 weeks after fertilizer application. The number of leaves, average leaf length, number of stem branches and average plant height increased with increase in the levels of poultry manure and NPK fertilizer (Table 1). It was observed that for the number of leaves, PM3 and PM4 (for treatments of 60g and 80g respectively) recorded the same number of 18.0 (Table1).

Table 1: Growth of tomato as influenced by different rates of poultry manure and NPK 15.15.15 fertilizer treatments

Treatment		Treatment g/plant	No. of leaves 2WAFA/ plant	Average leaf length 5WAFA (cm)	No. of stem branches 7WAFA	Average plant height 10WAFA (cm)
Control		0.0	7.0	4.1	5.0	7.2
Poultry manure	PM1	20	13.0	5.3	9.0	9.1
	PM2	40	17.0	5.5	12.0	9.7
	PM3	60	18.0	6.2	13.0	10.0
	PM4	80	18.0	6.7	15.0	10.6
N.P.K. (15-15-15)	NPK1	20	9.0	4.8	5.0	8.7
	NPK2	40	12.0	5.1	8.0	9.1
	NPK3	60	13.0	6.0	9.0	9.6
	NPK4	80	16.0	6.8	11.0	10.0

PM- Poultry manure treatment
NPK- Inorganic fertilizer (NPK) treatment
WAFA – Weeks after Fertilizer Application (Source: Field work, 2013)
WAT- Weeks after Transplanting

The results indicated that all treatments: control (soil only without fertilizer applied), poultry

manure and NPK showed significant differences with respect to the various parameters being measured. There is a signifcant difference in the treatments ($p<0.05$) for number of leaves in all three treatments. Both poultry manure and NPK fertilizers had varying effects on the growth of tomato. The highest number of leaves was recorded in plants grown in soils with poultry manure applied at 60g/plant and 80g/plant. This was significantly different from the control with the lowest number of leaves where no manure or NPK fertilizer was applied.

Leaf length of tomato in various treatments showed a significant difference. The highest mean leaf length at 5WAFA (6.8cm) was recorded in NPK fertilizer at 80g/plant and the lowest (4.1cm) recorded for control at 0.0g/plant and 4.8cm for NPK at 20g/plant. Poultry manure applied at 80g/plant recorded the highest number of stem branches of 15 at 7WAFA. The lowest number of stem branches (5.0) was recorded at 20g/plant for NPK fertilizer and control. Highest average plant height at 10WAFA of 10.6cm was recorded at 80g/plant for poultry manure and the lowest of 7.2cm was recorded by the control treatment followed by 8.7cm recorded for NPK at 20g/plant.

4.2 Yield

Results on yield of tomato from the different treatments are presented in Table 2. There were significant differences ($P<0.05$) in the yield between different treatments.

For average number of flowers per plant at 5WAT, the highest of 14.0 was recorded for PM3 and PM4 at 60g/plant and 80g/plant respectively and the lowest 8.0 recorded for the control followed by NPK1 at 20g/plant recording a count of 9.0. Average number of fruits per plant at 7WAFA recorded high values at various levels of application comparatively for poultry manure and NPK fertilizer. The control recorded the least of 6.0 fruits per plant; poultry manure recorded the highest number of 13.0 fruits at 80g/plant and NPK fertilizer recorded 11.0 fruits per plant at 80g/plant. Average fresh fruit weight at harvest was highest in poultry manure at 30.6g for 80g/plant followed by NPK fertilizer at 26.4g for 80g/plant with the control recording the least of 11.6g.

Table 2: Yield of tomato as influenced by different rates of poultry manure and Inorganic fertilizer NPK15.15.15 treatments

Treatment		**Treatment g/plant**	**Average no. of flowers per plant (5WAT)**	**Average no. of fruit per plant (7WAFA)**	**Average weight of fresh fruit at harvest (g)**
Control		0.0	6.0	8.0	11.6
Poultry manure	PM1	20	11.0	9.0	21.4
	PM2	40	13.0	10.0	26.0
	PM3	60	14.0	12.0	29.2
	PM4	80	14.0	13.0	30.6
N.P.K.(15-15-15)	NPK1	20	9.0	7.0	18.0
	NPK2	40	10.0	9.0	20.1
	NPK3	60	12.0	10.0	23.3
	NPK4	80	13.0	11.0	26.4

PM- Poultry manure treatment
NPK- Inorganic fertilizer (NPK) treatment
(Source: Field work, 2013)

4.3 Shelf life

At all levels of aplication, the average number of days it took tomato to wrinkle was higher in poultry manure than in the inorganic manure (NPK 15:15:15) Table 3. At 20g/plant and 40g/plant, poultry manure recorded the same number of days to wrinkle (4 days) as in the control treatment but lower number of days (3 days) for the same levels in NPK. At levels of 60g/plant and 80g/plant, poutry manure recorded average number of three days to wrinkle as against two days for the same level of treatment for inorganic fertilizer.

Table 3: Shelf life of tomato as influenced by different rates of poultry manure and NPK15.15.15 fertilizer treatments

Treatment		Treatment g/plant	Average No. of days to wrinkle	Average No. of days to get watery
Control		0.0	4.0	4.0
Poultry manure	PM1	20	4.0	5.0
	PM2	40	4.0	5.0
	PM3	60	3.0	3.0
	PM4	80	3.0	3.0
N.P.K. (15-15-15)	NPK1	20	3.0	4.0
	NPK2	40	3.0	4.0
	NPK3	60	2.0	3.0
	NPK4	80	2.0	3.0

PM- Poultry manure treatment
NPK- Inorganic fertilizer (NPK) treatment
(Source: Field work, 2013)

Poultry manure recorded five days for the fruits to get watery for treatment levels of 20g/plant and 40g/plant as against four days for inorganic fertilizer for the same levels of treatment as well as for control treatment (Table 3). However, for levels of

60g/plant and 80g/plant both poultry manure treated plants and NPK treated plants took three days on the average to get watery
(Table 3).

CHAPTER FIVE

5.0 DISCUSSION

5.1 Growth

Poultry manure recorded higher values in various parameters measured at various levels than the control treatment and NPK fertilizer. With increase in quantity of fertilzer (poultry and NPK), the measure of the various parameters also increased. This indicates that poultry manure had a stronger effect on growth of tomatoes than the inorganic fertilizer.The finding is consistent with that of Xu *et al.* (2005) who assessed yield and quality of leafy vegetables grown with organic and inorganic fertilizers and showed that vegetables grown with organic fertilizers grew better and resulted in a higher total yield than those grown with chemical fertilizers. Their research concluded that vegetables grown with organic fertilizers showed higher growth and yield than those grown with inorganic fertilizers.

The finding that all levels of poultry manure performed better than the NPK fertilizer could be attributed to the fact that poultry manure supplies more nutrients than NPK fertilizer. The poultry manure could have supplied micronutrients which are essential for tomato growth. This assertion is supported by Stephenson *et al*., (1990) and Oladotun (2002) who in their separate studies reported that poultry manure contains macro and micro nutrients such as N, P, K, S, Ca, Mg, Cu, Mn, Zn, Bo and Fe which could not be readily supplied by inorganic fertilizers (NPK). For instance, calcium has been found to be highly associated with growth and development of tomato. The supply of calcium is more critical during the phase when there is rapid visible size increase as it is required for the formation of new cells and for strong cell structure.

Poultry manure contains macro and micro nutrients, vitamins, growth promoting factors and beneficial microorganisms (Sreenivasa *et al*, 2010). Agele (2001) also found that poultry manure litters resulted in better growth and yield of tomato compared to NPK fertilizer treatments. Gad *et al.* (2007) collaborated the finding that farmyard manure significantly increased both fresh and dry weights of tomato shoots and roots. Moez *et al.,* (2001) found that chicken manure increased growth of fresh and dry weights of pepper in vegetative and yield stages compared with control by 19% and 27.3% respectively.

Organic manures can improve soil-water-plant relations through modifying bulk density, total porosity, soil water relation and consequently, increasing plant growth and water use efficiency (Obi and Ebo, 1995). Addition of organic manure to soil enhances microbial activity and increases their ability to conserve fertilisation and consequently increasing their fertility and fertiliser use efficiency as a final goal (Nanwai *et al*., 1998).

5.2 Yield

All yield parameters measured were higher with poultry manure application than the NPK fertilizer. This is an indication that inorganic fertilizers resulted in lower yields compared to poultry manures in the production of tomatoes. This result is supported by other research findings carried out in different parts of the world. For instance, Owen (2003) reported that industrial fertilizers do not possess good characteristics of aggregating the soil particles. As a result, the plants produced by inorganic fertilizers showed relatively lower yield compared to organic materials. Oikeh and Asiegbu (1993) in their work on four soil amendments using swine manure, poultry manure, compost and NPK fertilizer found that organic manure was most effective on yield of tomatoes with an application of organic manures at 4t/ha each under field conditions for their comparative effect on tomato. Niassy *et al.* (2010) in a study on the effect of organic fertilizers on the susceptibility of tomato to *Helicoverpa armigera in* Senegal concluded that tomato fields treated with poultry manure showed a good overall yield and therefore recommended it to be a suitable replacement for inorganic fertilizers in tomato production.

5.3 Shelf life

Good tomato fruit qualities include but not limited to excellent red colour, low pH, high titratable acidity, high soluble carbohydrates, low seed content, firm fruits, crack resistance and long shelf life. These quality attributes besides being largely dependent on inherent genetic control have been reported to be influenced by the type, amount and time of fertilizer application (Ogunlela *et al.*, 2005).

The shelf life of tomato is a measure of the period of time which starts from harvesting and extends up to the start of rotting of fruits. Tomato is one of the very perishable fruits. It changes continuously after harvesting. When a fresh fruit of tomato is harvested, the processes of life continue in a different way. It can no longer add food materials or water, so it has to depend on its stored reserves. When they are exhausted, the fruit undergoes an ageing process leading to breakdown and deterioration. It will finally become unacceptable as food because of this natural rot. This physiological transformation process is influenced by several factors including the process and conditions of storage as well as the concentration or presence of certain nutrient elements in the tissues of the fruit, critical amongst them being calcium. Calcium is a critical nutrient for the growth, quality and shelf life of tomatoes. It is, therefore, needed for both pre and post-harvest. Calcium has a desirable effect on reducing respiration, delaying ripening and resultantly extends shelf life of fresh fruit (Morgan, 2006).

Comparatively, it could be stated that tomato fruits from poultry manure treated plants had a longer shelf life than those from inorganic fertilizer (NPK) treated plants. This finding is however disputed by other researchers. Nyamah *et al.*, (2011) reported that NPK fertilized tomatoes recorded longer shelf life than poultry manure fertilized ones. They found that fruits harvested from NPK plus 'Asasewura' cocoa fertilizer amended fields recorded the highest shelf life (9.39 days) followed by fruits harvested from fields amended with poultry manure (8.32 days), NPK plus Sulphate of ammonia (7.92 days) and Control (7.58 days) fields. They further reported that fruits harvested from fields amended with NPK plus 'Asasewura' cocoa fertilizer recorded the lowest weight loss (2.68g) followed by fruits from fields amended with NPK plus Sulphate of ammonia (3.44g), Poultry manure (3.36g) and Control (3.07g) fields. They adduced this might be as a result of the relatively high and readily available calcium in 'Asasewura' cocoa fertilizer which has the ability to increase cell formation and reduce respiration rates which might have contributed to the reduction of weight loss in fruits harvested from NPK plus 'Asasewura' cocoa fertilizer amended fields as observed by Sharma *et al.*, (1996).

Poultry manure treated fields produced tomatoes with longer periods to get watery than NPK treated fields and control fields. That means inorganic fertilizer treated tomatoes get watery earlier in storage and hence have a shorter shelf life relative to poultry manure treated tomato plants. This could be attributed to the readily available calcium levels in NPK fertilized fields which might have caused relatively low loss of membrane integrity resulting from membrane damage as noted by Boros-Matovina and Blakes (2001) that, membrane ion leakage is a measure of loss of membrane integrity resulting from membrane damage which leads to water loss and loss of other membrane-bound solutes. This could have caused the lowest weight (water) loss rate which might have also led to low membrane ion leakage of fruits harvested from fields amended with NPK fertilizer than those from fields amended with Poultry manure.

Also, longer shelf life of poultry manure treated tomato plants could be attributed to the higher levels of Potassium (K) in these plants as released from soil to fruits. Potassium is required for maintaining osmotic potential of cells. That is, Potassium makes fruits look turgid. Since Potassium regulates the osmotic potential of cells, and the close or open conditions of stomata, it plays an important role in water relations in the plant. Potassium is involved in water uptake from the soil, water retention in the plant tissue, and long distance transport of water in the xylem and of photosynthates in the phloem. Fruits and vegetables grown with adequate K seem to have a longer shelf life in storage (Hue, n.d).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Growth in tomato is more highly influenced by poultry manure than inorganic fertilizer (NPK) treatments.The study recorded higher values in all growth parameters measured under poultry manure than in NPK and control treatments. With increase in quantity of fertilzer (poultry and NPK), the measure of the various parameters also increased. The highest number of leaves was recorded in plants grown from poultry manure applied at 60g/plant and 80g/plant. This was significantly different from the control applied at 0.0 g/plant and the lowest obtained from the NPK fertilizer treatment at 20g/plant. The highest average leaf length at 5WAFA was recorded in NPK fertilizer (6.8cm) at 80g/plant and the lowest recorded for control (4.1cm) at 0.0g/plant and 4.8cm for NPK at 20g/plant. Poultry manure applied at 80g/plant recorded the highest number of stem branches of 15 at 7WAFA. The lowest number of stem branches was recorded at 20g/plant for NPK fertilizer and for control recording five stem branches. Highest average plant height at 10WAFA of 10.6cm was recorded at 80g/plant for poultry manure and the lowest of 7.2cm was recorded by control treatment followed by 8.7cm recorded for NPK at 20g/plant. This finding indicates that poultry manure had a strong effect on growth of tomatoes than inorganic fertilizer.

All yield parameters measured were higher with poultry manure application than with NPK fertilizer. Inorganic fertilizer resulted in lower yields compared to poultry manure in the production of tomatoes. For average number of flowers per plant at

5WAT, the highest of 14.0 was recorded for PM3 and PM4 at 60g/plant and 80g/plant respectively and the lowest recorded by control recording six followed by NPK1 at 20g/plant recording a count of nine flowers per plant. Average number of fruits per plant at 7WAFA recorded high values at various levels of application comparatively for poultry manure and NPK fertilizer. Poultry manure recorded the highest number of fruits of thirteen at 80g/plant and NPK fertilizer recording a low of seven fruits per plant at 20g/plant with control recoding the least of six fruits per plant. Average fresh fruit weight at harvest was highest in poultry manure at 30.6g for 80g/plant and was low in NPK fertilizer at 18.0g for 20g/plant with control recording the least of 11.6g.

With respect to shelf life, poultry manure was superior to NPK and control treatments. At all levels of application, the average number of days it took to wrinkle was higher in poultry manure than in inorganic manure (NPK). At 20g/plant and 40g/plant, poultry manure recorded the same number of four days to wrinkle as in the control treatment but lower for the same levels in NPK of three days. At levels of 60g/plant and 80g/plant, poutry manure recorded average number of three days to wrinkle as against two days for the same level of treatment for inorganic fertilizer. Poultry manure recorded five days as the average number of days to wrinkle for treatment levels of 20g/plant and 40g/plant against four days for inorganic fertilizer for the same levels of treatment as well as for control treatment.

6.2 Recommendation

The study indicated that for all parameters measured poultry manure treatment was superior to inorganic fertilizer (15:15:15) and control treatments. Notwithstanding these results as per other studies conducted elsewhere, the following recommendations are made to help achieve higher potential of tomato plant under various treatments in various locations:

i. Soil conditions prior to treatment and at harvest should be investigated to ascertain its effect on the performance of tomatoes planted on them.

ii. Poultry manure should be processed well for easy packaging and transport and to remove the foul odour from the manure.

iii. A combination of Inorganic fertilser N.P.K 15:15:15 and poultry manure could be applied on tomato plant to assess the effect on growth, yield and shelf life of tomato.

REFERENCES

Adekiya, A.O. and Ojeniyi, S.O (2002). Evaluation of tomato growth and soil properties under methods of seedling bed preparation in an alfisol in the rainforest zone of southwest Nigeria. Soil and Tillage Res. 64: 275-279.

Agele, S. O. (2001). Growth and yield of tomato grown on degraded soil amended with organic wastes. Proceedings of the 35th Conference of the Agricultural Society of Nigeria. Sept. 16-21. University of Agriculture, Abeokuta, Nigeria pp. 151-154.

Akanni, D.I. and Ojeniyi, S.O (2007). Effects of different levels of poultry manure on soil physical properties, nutrient status, growth and yield of tomato (*Lycopersicon esculentum).* Research Journal of Agronomy 1 (1): 1-4.

Anum L.A. (2009) . Demand for fresh tomato increases (Daily Guide Interviewer, Feb.17,2009).

Boros-Matovina, V. and Blaake, T.J. (2001). Seed treatment with the antioxidant ambiol enhances membrane protection in seedling exposed to drought and low temperature. Trees 15: 163-167.

Brady, C.J. (1987). Fruit ripening. Annual Review of Plant Physiology 38(2): 155-158.

Dupriez, H. and De Leener, D. P. (1989). Africa Gardens and Orchards. Published in association with Terres et Vie, Nivelles, Belgium Pp 79- 143.

FAO (1993). Proceedings, Expert Consultation on Integrated Plant Nutrition Systems. FAO, Fertilizer and Plant Nutrition Bulletin No. 12, Rome.

FAO (2004). Scaling soil nutrient balances. FAO Fertilizer and Plant Nutrition Bulletin No. 15. Rome.

Gad, A.A., Ghamriny, E.A., Bardisi, A., and Shazly, A.A. (2007). Effect of farmyard manure and mineral nitrogen sources and rates on dry weight, photosynthetic pigments and yield of tomato grown in sandy soil. Zagazig.J.Agric. 34(5): 845- 869.

Hanson, P., Chen, J., Kuo, C., Morris, R., and Opeña, R. (2000). Suggested Cultural Practices for Tomato. International Cooperator's Guide pp 004-008.

Hector, V., Randall, T. H. and Fukuda, S. (1993) Vegetable Gardening guide. Journal of University of Hawaii Cooperative Extension Services 16: 23-48.

Heuvelink and Dorais (2005). Plant Nutrition Guide pp 003-006

Http://dormaa.ghanadistricts.gov.gh. Profile of Dormaa retrieved on 9/7/2015.

Hue, N.V (n.d). Organic fertilizers in sustainable agriculture. Available at http://www.ctahr.hawaii.edu.huen/hue.htm

John, P., Russell, D. and Andrew, B. (2004). From farmer field schools to community IPM. FAO Community IPM Programme in Asia. Bangkok, Thailand.

Jones, J. B. (1999). Tomato Plant Culture. CRC Press, LLC, Boca Raton, Florida. pp 121 –123

Jones, J. B. (2013). Tomato Plant Nutrition. Growing Tomatoes.com.

Magkos, F., Avaniti, F. and Zampelas, A. (2006). Organic food: Buying more safety or just peace of mind? A Critical Review of the Literature. Journal on Food Science and Nutrition 46: 23-26.

Marti, H. R. and Mills, H. A. (1991). Nutrient uptake and yield of sweet pepper as affected by stage of development and form. Journal of Plant Nutrition 14 (11): 1165 – 1175.

MOFA (1998). National fertility management action plan – Ministry of Food and Agriculture, Accra, Ghana.

MoFAIR Centre (2008). Production guide for tomato. Ministry of Food and Agriculture Information Resource Centre, Accra-Ghana. Available online at http://www.mofaircentre.info/production-guide-for-tomato.

Moez, A.E., Gad, N., and Wanas, S.A. (2001). Impact of banana compost added with or without elemental sulphur on nutrients uptake, yield, soil moisture depletion and water use efficiency of pepper plants Annals of Agric. Sci. 39 (2): 1355-1372.

Mondal, M. F. (2000) Production and storage of fruits (in Bangladesh). BAU Campus, Mymensingh-2202. pp 310-312.

Morgan, L. (2006). Greenhouse tomato nutrition. The Tomato Magazine.

Munson (1985) cited in Javaria, S., Khan, M.Q., Rahman , H.U. and Bakhsh, I. (2012) Response of tomato (*Lycopersicon esculentum*) yield and post harvest life to potash levels. Sarhad J. Agric. 28(2): 227-235.

Naika, S., Jeude, J. V., Goffau, M. D., Hilmi, M., and Dam, B. V. (2005). Cultivation of tomato: production, processing and marketing. Agromisa Foundation and CTA, Wageningen.

Nanwai, R.K., Sharma, B.D., and Taneja, K.D. (1998). Role of organic and inorganic fertilizers for maximizing wheat (*Triticum aestivum*) yield in sandy loam soils. Crop Research16 (2): 159-161.

Niassy, S., Diarra, K., Niang, Y., Niang, S., and Pfeifer,H.-R. (2010). Effect of organic fertilizers on the susceptibility of tomato (*Lycopersicon esculentum*: *solanacea*) to *helicopeverpa armigera* (*Lepidoptera;Noctuide)* in the Niayes Area, Senegal. Research Journal of Agriculture and Biological Sciences 6(6): 708-712.

Nyamah E. Y., Maalekuu, B. K. and Oppong-Sekyere, D. (2011). Influence of different soil amendments on postharvest performance of tomato (*Lycopersicon esculentum*). Journal of Stored Products and Postharvest Research 3(1): 11-13.

Obi, M.E, and Ebo, P. (1995). The effect of organic and inorganic amendments on soil physical properties and production in a severely degraded sandy soil in southern Nigeria. Bioresource Technology 51(2-3): 117- 123.

Ofori, C. S. and Fianu, F. (1996). Sustaining soil fertility in Ghana: An integrated nutrient management approach. Pp. 41-60.

Ogunlela, V.B., Masarirambi, M.T. and Makuza, S.M. (2005). Effect of cattle manure application on pod yield and yield indices of okra (*Abelmoschus esculentus* L. Moench) in a semi-arid sub-tropical environment. Nigerian Journal of Agriculture, Food and Environment 3 (1): 125-129.

Oikeh, S.O. and Asiegbu, J.E. (1993). Growth and yield responses of tomato to sources and rate of organic manures in ferrolitic soils. Journal on Biosource Technology 45 (1): 21-25.

Oladotun, A. O. (2002). Managing manure as a fertilizer. Saskatchewani Agriculture, Food and Rural Revitalization.

Owen,M. (2003). Origin and distribution of lettuce. Available at

http.//www.calettuceresearchboard.org/origin.html

Palm, C. A. (1995). Contribution of agroforestry trees to nutrient requirements of intercropped plants. Agroforestry Systems 30: 105-124.

Prasithikhet, J., Mongkolporn, P., Sritanan, V., and Sonmuang, P. (1993). Use of organic and inorganic fertilizers in farmer's rice fields in the Northeast Parkisthan. Soil Management Abstracts 5: (2) 1458.

Quansah, C., Asare, E., Safo, E. Y., Ampontuah, O., Kyei-Baffour, N. and Bakang, J. A. (1998). The effect of poultry manure and mineral fertilizer on maize/cassava intercropping in peri-urban Kumasi, Ghana.

Riofrio, M. (2000). Tomato culture. Ohio State University Extension.

Sainju, U. M., Dris, R., and Singh, B. (2003). Mineral nutrition of tomato.

Sendur, K. S., Natarajan, S. and Thamburaj, S. (1998). Effect of organic and inorganic fertilizers on growth, yield and quality of tomato. South Indian Hortic. 46 (3 and 4): 203-205.

Shahnawaz, M., Sheikh, S. A., Khaskhel, S. G., Soomro, A. H., and Kumar, D. (2011). Effect of wrapping materials on the quality and storage life of tomatoes at ambient temperature. Journal of Middle East Applied Science and Technology, 23: 1-6.

Sharma, R.M., Yamdagni, R., Gaur, H., and Shukla, R.K. (1996). Role of calcium in horticulture - A review. Haryana J. Hortic. Sci. 25(4): 205.

Sinnadurai, S. (1992). Vegetable Cultivation. Asempa Publishers. Accra, Ghana.

SRID, MOFA (2008) Statistical Research Information Department, Food import to Ghana.

Sreenivasa, N, Bhat,S.N. (2010). Beejamruth: A source for beneficial bacteria. Karnataka Journal of Agriculture and Science 17(3):72-77.

Stephenson, A. H., McCaskey, T. A. and Ruffin, B. G. (1990). A survey of broiler litter composition and potential value as a nutrient resource. Biological Wastes 34: 1-9.

Stone, D. M. and Elioff, J. D. (1998). Soil properties and Aspen development five years after compaction and forest floor removal. Canadian Journal of Soil Science 78(1): 51-58.

Sutanto, R. Suproyo, A. and Mass, A. (1993). The management of upland acid soils for sustainable food crop production in Indonesia. Soil management Abstracts 5 (3): 1576.

Tindall, M. (2000). Mineral and organic fertilizing in cabbage. Residual effect for commercial cultivation on yield and quality performance with organic farming. Hort Bras. 6:15-20.

Williams, C. N., M, Yoldas, M. and Gumus, I.H. (1991). Organic fertilizer responses of cucumbers on peat in Brunei. Experimental Agriculture. 14: 299-302.

Xu, H.L., Wang, R., Xu, R.Y., Mridha, M.A.U. and Goyal, S. (2005). Yield and quality of leafy vegetables grown with organic fertilizations. Acta Hort. 627: 25-33.