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INFLUENCE OF *Tithonia diversifolia,leafbiomass,*N.P.KFERTILIZER,AND POULTRY MANURE ON THE GROWTH AND YIELD OF PEPPER (*Capsicum fructescens*)

By
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DECLARATION

I declare that, except for references to other people's work which have been duly acknowledged, this thesis submitted to the Board of Postgraduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi for the Degree of Masters of Science in Agroforestry, is the results of my own investigations and has not been presented for any degree elsewhere.

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TABLE OF CONTENTS

CHAPTER 3

Material and methods

CHAPTER 4

Results

CHAPTER 5

Discussion

CHAPTER 6

APPENDIX

LIST OF TABLES

ABSTRACT

Population growth and high demand of food has led to increases in the cultivated areas at the expense of restorative bush fallow. In the process, the resource base is depleted as many tropical soils are fragile, quickly losing organic matter and nutrients when intensively cultivated. Therefore there is an urgent need to replace this destructive cycle with economically and ecologically farming practices. It is justified that inorganic fertilizer has been responsible for sustained increases for food production. Organic inputs are needed to maintain the physical condition of soil (Hsieh and Hsieh, 1996). As soil fertility depletion is the single most important constraint to food security in Ghana there is the need to adopt practices that can help sustain crop production while maintaining sol fertility.

The objective of the study was to find out the influence of *Tithonia diversifolia*, NPK fertilizer and poultry manure on the growth and yield of pepper. The treatments consisted of control, *Tithonia diversifolia*, NPK fertilizer and poultry manure. These were applied in sole applications as well as in varying combination of different treatment as shown in the table below.

TREATMENT	PLANT HEIGHT	NUMBER OF BRANGHES	NUMBER OF FRUITS/ PLANT	WEIGHT OF FRUITS
Tithonia only	35.2b	5d	8d	5.6d
MPK Fertilizer only	33.9b	5d	8d	5.7d
Poultry manure only	54.4a	7c	14c	7.9b
Lithonia +Poultry manure	55.8a	8b	23ab	8.6ab
Lithonia + NPK	50.2a	6d	21b	8.0bc
NPK + Poultry manure	52.9a	9a	25a	8.7ab
Control	20.8c	3e	5e	3.7e

The treatment was replicated three times in a Randomized Complete Block Design. The results showed that all fertilization treatments significantly, enhanced pepper growth parameters and yield compared to control.

It also showed that, poultry manure and its combinations were most significant ($P < 0.05$) for growth and yield.

It was concluded that, the combination of *Tithonia* and poultry manure (8.6 ab) can be an alternative to NPK fertilizer + poultry manure (8.7 ab). However, there was high fertilizing potential of the combination of poultry manure and NPK fertilizer which ranked best method for high soil productivity and pepper yield.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF RESEARCH

One of the greatest challenges in agriculture is the need to develop viable farming for increase and sustained crop production with minimum soil degradation. For instance, in 1992 the population in Ghana was 8million, and in 2000 it was 18.9 million later in 2010 it increased to 25million. Much of the agricultural land in developing countries used for traditional farming is based on shifting cultivation and bush fallow systems. This is a biologically stable system and with long fallow period, can sustain agricultural production for many generations (Kang and Wilson, 1987).

However, because of increasing land pressure resulting from rapid population growth and other uses, it is no longer possible in many areas to maintain the long fallow periods crucial for soil fertility regeneration. This has resulted in the breakdown of the natural soil fertility replenishment system, to the point where large tracts of land are becoming degraded and left out of cultivation. This has led to the practice of continuous cultivation on low fertile soils resulting in inadequate food production or decline in crop yield. This is because shorter fallow periods are less effective in restoring soil fertility (Ruthenberg, 1971).

The traditional system, which is known to be stable and biologically efficient, operates effectively only when there is sufficient land to allow for long fallow periods to restore soil productivity (Kang et al., 1989). Today, however, because of rapid demographic and economic changes, the cultivated area has expanded onto marginal land and fallow periods are being reduced, resulting in systematic reduction of major areas of land leading to declining yield (Matlon and Spencer, 1984). Research results obtained at International Institute of Tropical Agriculture (IITA) (1992) Ibadan, Nigeria and elsewhere indicate that soil degradation can be halted or retarded by maintaining a crop cover or continuous incorporation of organic residue on the soil surface. Soil fertility depletion is the single most important constraint to food security in West Africa. Though the use of organic resources such as farmyard manure and compost have been in use for several years for improving soil fertility (Sridhar and Adeoye, 2003) and more recently use of inorganic fertilizers, varying constraints still make the use of these traditional and conventional methods of soil fertility improvement inadequate to meet the challenges of soil fertility depletion in the region. Such constraints include high procurement cost for mineral fertilizer sources, insufficient quantities to meet farmers' needs especially in less developed countries, and relatively low nutritive content of traditional crop residues or animal manure used for soil improvement.

1.2 IMPORTANCE OF INORGANIC FERTILIZER

Inorganic fertilizer has been the major means of achieving higher yield of crop. Even though Government subsidizes the cost of fertilizer, these inputs have become so expensive that small scale farmers who constitute about 80% of the farming population cannot buy and apply them. Though inorganic fertilizer contributes largely to soil fertility, it does not improve soil physical properties, such as soil structure,

water retention capacity and aeration for crop production. Many legume species, both herbaceous and shrubs are well adapted to the infertile soil of the tropics and therefore, their ability to improve the soil fertility status needs to be investigated. There is, therefore, the need to develop alternative or integrated low input
soil fertility management strategies based on maximum use of local biological nutrient sources and supplementation with chemical input when available.

Inorganic nitrogen compounds tend to increase the leaf, stem and the roots. The higher the rate of application of nitrogen to a plant, the more rapidly will the synthesized carbohydrate be converted to proteins. Leaves which are low in nitrogen often have a pale yellow or light green colour. However when nitrogen is present in excess, it increases the growing periods and delays maturity of fruits (Akinyosoye, 1985). The ripening of grain for instance is retarded by too great a proportion of nitrogen in the medium of growth. In addition to nitrogen, phosphorus is an essential component in the reaction of carbohydrate synthesis and also for carbohydrate degradation enabling energy to be liberated. When a crop such as pepper is deficient in phosphorus, growth is retarded and the formation and, ripening of seeds may be retarded, plants develop a stunted root system and leaf development is reduced.

Potassium is absorbed in fairly large quantities by plants. The response of plants to potassium intake depends on the concentration of nitrogen and phosphorus present in the soil. Potassium starvation becomes obvious, usually resulting in the premature death of the leaves. Fruits and seed become poor in quality and of reduced size and

weight (Akinyosoye, 1985). All crops which produce large quantities of carbohydrate use fairly high levels of potassium.

1.3 IMPORTANCE OF ORGANIC FERTILIZER

In addition to inorganic fertilizer use, another means of improving soil fertility involves incorporating green manure into the soil. This releases nutrients and provide farmers with viable and ecologically sustainable alternative to shifting cultivation. Green manuring supplies nutrients and organic matter from the decomposing material (Lal, 1975) and may be useful for farmers where external inputs for crop production are less likely to be available and the cost exceeds farmers cash on hand.

Nitrogen is the most limiting nutrient in crop production in tropical Africa. The inclusion of nitrogen-fixing leguminous species in the production system can help to meet the nitrogen requirement for crop production. In addition to a greater capacity to fix nitrogen in soil, legumes to be used should have large mass of tissue and high nitrogen concentration. Kang (1988) estimated the effective nitrogen contribution from *Leucaena leucocephala* and *Gliricidia sepium* pruning to alley cropped maize to be about 40 kg N/ha. Mulongoy and Vander der Meerch (1988) reported a lower nitrogen levels of 4.4 – 23.8 kg N/ha from L. *leucocephala* pruning to the associated maize crop, the nitrogen contribution representing less than 30% of nitrogen yield of the pruning. This low efficiency in the crops use of N from pruning probably results from the lack of synchronization between release from the pruning and nitrogen

demand, volatilization of nitrogen from pruning, and leaching, (Mulongoy and Akobundu, 1990).

In addition to inorganic fertilizer as a method to regenerate soil fertility and improve productivity, poultry manure is an excellent source of nutrients and can be incorporated into most fertilizer programmes. It is therefore, used as an alternative method of improving soil and crop yield besides the conventional inorganic fertilizer that has become expensive.

Legume species can also be used in cropping system to improve soil fertility in Ghana Legumes used as green manure can,

i) Provide biologically fixed nitrogen

ii) Increase soil organic matter.

iii) Provide protection against soil erosion.

iv) Improve soil structure.

v) Make other nutrient such as phosphorus, calcium more available.

Among the various shrubs and forage, legumes used as a biological nitrogen fixation for soil productivity, *Tithonia diversifolia*, a legume shrub, has been selected as an alternative option for improving agriculture productivity (Jama et al., 2000). *Tithonia* mulch, apart from being rich in nutrients including calcium, nitrogen and phosphorus can also increase the soil moisture retaining capacity (Jama et al., 2000).

Research further indicates that the ability of *Tithonia* to decompose quickly makes it the best way to replenish soil fertility. However long term benefits of the organic

matter storage can be achieved only when there is continuous application of the organic resource. Liasu and Atayese, (1999) reported that, the concentration of nutrients in *Tithonia* is highest in young plants and before the plant flowers. It is further reported that *Tithonia* has shown a great improvement in crop yield of 46 farms in western Kenya where the yield of green beans increased when the biomass was applied (Liasu and Atayese, 1999).

Tithonia has also been reported as a nutrient source for maize in Kenya, Malawi and Zimbabwe (Jama et al., 2000). Stems and leaves of *Tithonia* have been reported to contain sesquiterpene lactones such as tagitinins that prevent attack by termites, and possess antimicrobial properties (Adoyo et al., 1997).

1.4 PEPPER (*Capsicium fructescens*) USED AS TEST CROP

The crop selected as the test crop for the study is hot pepper (*Capsicium fructescens*). Pepper is one of the most widely used foods in the world. Hot pepper, a member of the family solanaceae is more important as a spice than a vegetable in the tropics. It originated from Mexico and Central America. Christopher Columbus encountered pepper in 1943 and because of its pungency, thought it was black pepper, *Piper nigrum* which is actually a different genus. He introduced the crop to Europe and it subsequently spread into Africa and Asia. The bulk of pepper produced in countries such as U. S. A is sweet pepper but hot pepper dominates in other countries such as Ghana. Peppers are important crop for Ghanaian farmers, but successful pepper production is not easily achieved. However pepper production has increased in recent

years partly because of its high consumption rate by most people and for its nutritional value.

Pepper production requires highly intensive management and marketing skills. Per-acre cost of production is high and yield can be severely limited by pest problem or environmental problems. A phenolic compound called capsicin is responsible for pungency in hot pepper, and various cultivars markedly differ in their content of this chemical. Pepper is a herbaceous perennial plant and will survive and yield for several years in the tropical climate provided there is moisture in the soil.

The crop can withstand temperatures as high as 38 °C but cannot withstand low temperature below 18°C. The ideal temperature range for good plant growth is 18°C - 32°C. Fruit set is greatly influenced by low humidity and high temperature. These conditions of very low humidity and very high temperature results in poor fruit set due to dropping of flower buds.

Pepper can be produced on a wide variety of soil types but it grows best in deep, medium textured sandy loam and well-drained soils. It grows well in soil within the pH range 5.0-7.0.

Soil rich in organic matter tends to promote excessive vegetative growth resulting in poor yield of the crop. The nursery period may range from 4 – 6 weeks depending on the fertility of the nursery soil. Compound fertilizer (N.P.K, 15-15-15) applied at the rate of 250 kg/ha 10 days after transplanting and top dressed with sulphate of

ammonia at the rate of 60 kg/ha two weeks after first application is recommended. The ideal time of planting is about mid or latter part of the rainy season, that is minor season, so that harvesting period falls in the dry season.

Pepper requires about 75 days from transplanting to first harvest and can be harvested for several weeks before production wanes. The potential for extending the duration of fruiting period in order to improve yield output lies generally on genetic quality of plant but most importantly in soil conditions, as early growth termination is often caused by soil nutrient depletion, moisture stress, pest and diseases and root infection resulting from buildup of soil pathogens (Muller-Saman and Kotschi, 1994a).

To help the plant support continuous fruiting it is advisable to give a top dressing of compound fertilizer (NPK 15-15-15 or 20-20-0) as soon as the first flowers open, using 15 g per plant in a ring of 15 cm from the stem.

Inorganic fertilizer use has been the major means of achieving higher crop yield. They are fast acting and effective. However, with the removal of subsidy in agricultural inputs these inputs have become so expensive that small scale farmers cannot afford to buy and apply them. Hence the need to develop alternative farming systems, which could build up organic matter levels to improve the physical conditions of soil and at the same time supply the essential plant nutrients for sustainable agriculture at affordable cost. Organic manuring seems to provide a possible solution to this problem.

Pepper responds to both organic and inorganic fertilizer. But the high cost of inorganic fertilizer that limits affordability has made pepper production less encouraging among Ghanaian farmers. It is therefore necessary to explore other sources of material for use to regenerate soil fertility to improve crop production.

1.5 OBJECTIVES

The general objective of the study was to assess the overall potential or influence of N.P.K, fertilizer, poultry manure and *Tithonia diversifolia leaf biomas* on the growth and yield of pepper.

The specific objectives were:

1. To investigate the potential of leaf biomass of *Tithonia* as a substitute for NPK fertilizer for pepper cultivation.
2. To find the effect of combination of NPK fertilizer and *Tithonia* on the growth and yield of pepper.
3. To compare the effect of use of *Tithonia*, inorganic fertilizer and poultry manure on the production of pepper.

CHAPTER TWO

LITERATURE REVIEW

2.1 EFFECT OF POULTRY MANURE ON THE GROWTH AND YIELD OF PEPPER

One of the ways of increasing the nutrient status of the soil is by boosting the soil nutrient content either with poultry manure, animal waste, and use of compost or with the use of inorganic fertilizers.

Poultry manure is known to contain high levels of nitrogen, potassium and phosphorus for plant growth and it is known to improve chemical and physical properties of the soil for pepper growth in spite of the high labour and cost (Brian and West, 1997).

However, the nutrient composition of poultry manure varies with the type of bird, the feed ration, the proportion of litter to dropping, and the type of litter (Zublena and Carter, 1997).

To minimize nitrogen losses, manure must be applied as near as possible to the planting time or to the crop growth stage during which nitrogen is most needed.

In a study undertaken by Archer (1985) on the effect of farm yard manure on pepper yield, it was reported that plots treated with 2.5 tonnes poultry manure per hectare and

90-60-60 kg/ha of N.P.K fertilizer gave the highest yield. Similarly, Ofori (1995) reported that poultry manure was as good as mineral fertilizer in increasing yield of rice in inland valleys; one tonne per hectare of poultry manure produced almost the same amount of paddy rice as when 80-60-60 kg N-P-K fertilizer per hectare was

applied on sandy soil in the forest zone. Poultry manure is an organic manure with high fertilizer value (Yagodin, 1984). Hileman (1971) indicated that poultry manure has been successfully used on a wide variety of crops as the only direct source of plant food as a supplement to mineral fertilizer or as a soil amendment.

Bandel et al., (1972) reported that among the crops which make the most efficient use of poultry manure are tomato, pepper, egg plant, cucumber, water melon and sweet corn.

According to Beckman (1973) the use of manure application enhances soil productivity, increases the soil organic carbon content, soil micro-organisms, improves soil crumb structure, improve the nutrient status of the soil and enhances pepper yield.

He further stated that the application of nitrogen, a major constituent of poultry manure has been reported to improve the yield of pepper. Aliyu (2000) reported that the use of farm yard manure (FYM) plus poultry manure at 5 t ha^{-} resulted in higher fruit yield of pepper.

Poultry manure is relatively resistant to microbial degradation. However, it is essential for establishing and maintaining optimum soil physical condition and therefore important for plant growth. John et al., (2004) had advocated for an integral use of organic manure and inorganic fertilizers for the supply of adequate quantities of plant nutrients, required to sustain maximum pepper productivity and profitability

while minimizing environmental impact from nutrient use. Adediran et al., (2003) compared poultry manure, household waste and cow dung and found that poultry manure at 20 t ha¯ had highest nutrient contents and mostly increased yield of pepper and soil macro and micronutrients content.

According to Akinsanmi (2001) calcium is most important as a soil conditioner. Calcium compounds are added to acidic soil when its pH is below 5 to raise it to between pH 6 and 7. Akande and Adediran (2004) found that poultry manure at 5 t ha¯ significantly increased pepper and dry matter yield, soil pH, N, P, K, Ca and Mg nutrient uptake. Aliyu (1997) studied the effect of cow dung at 0, 10, 20 and 30 t/ha and poultry manure at 3, 6 and 9 t/ha on the growth and yield of pepper. He observed that poultry manure application significantly increased plant height, leaf area index, fruit length and diameter, number of fruits and fresh fruit yield compared with cow dung. Poultry manure at 9 t/ha increased plant height compared with 0 and 3 t/ha. He also found that application of poultry manure to soil increased soil organic matter, nitrogen and phosphorus and aggregate stability. The nutrient content of the manure is a direct bearing on the growth and yield of pepper. A high level of organic matter in the soil results in reduced bulked density, improved soil structure, aeration and high water holding capacity all of which are attributes of productive soil (Hsieh and Hsieh, 1990).

2.2 RATE, METHOD AND TIME OF POULTRY MANURE APPLICATION

Bandel et al., (1972) reported that the suggested application rate of poultry manure for tomato, sweet corn, pepper, egg plant and watermelon was 3 tons per ha. They however stated that due to losses and slow release of nutrients for each ton of broiler manure applied, there is the need to allow at least about 9 kg nitrogen, 4.5 kg P_2O_5 and 2.3 kg K_2O for maximum crop growth and yield. To prevent lodging in plants, the recommended rate of application was stated to be 3 tonnes per ha and below. On soils of high fertility and organic matter, poultry manure application is not desirable because poultry manure contains high amounts of nitrogen and other nutrients and organic matter decompose to release more nutrients, hence addition of poultry manure to soil of high fertility would lead to vegetative growth and lodging. Yagodin (1984) indicated that with dry poultry manure applied as a basal fertilizer to vegetables and potatoes at a rate of 1 to 2 tonnes per hectare the rate of fresh poultry manure in the same manner is applied in 4 to 6 tons per hectare.

Muller-Samann and Kotschi (1994a) reported that in broadcasting manure, it is important to get an even distribution over the field. It is advisable to plough manure under or disk it in immediately after spreading. The depth to which it should be worked into the soil depends on the nature of the soil, that is, whether the soil is light, porous, heavy or wet.

According to Muller-Samann and Kotschi (1994a) working the manure in, close to the surface is better than burying it deep. They further stated that, highly decomposed

or fermented manure can be ploughed in deeper than relatively fresh manure. The manure should be well mixed with the soil and no dense clumps should be left in the subsoil.

Application of larger amount of poultry manure at or shortly before planting may result in injury to crops, particularly young plants (Bandel et al., 1972). Hileman (1971) reported that there is a need for an incubation period after manure application, before planting a crop because of rapid chemical changes in the soil following broiler litter incorporation. Siegel et al., (1975) reported that an incubation period of about one month, after application and before planting would allow for nitrification of the ammonia produced. The plant then takes advantage of the mineralized nitrate-nitrogen without risk of ammonia toxicity. Germination and emergence of corn is improved with increased duration of pre-plant incubation (Siegel et al., 1975). They reported that emergence was 100% when corns were planted three weeks or more after incorporation with poultry manure.

2.3 EFFECT OF POULTRY MANURE ON SOIL CHEMICAL PROPERTIES

Hue (1992) showed that poultry manure is beneficial for the correction of zinc and iron deficiencies. Furthermore, the organic fraction of poultry manure is important in rendering zinc and iron more available to plants.

Poultry manure is capable of reducing soil acidity. This was attributed to the rapid release of ammonia from the litter when applied and incorporated. Chicken manure and sewage sludge tested on acid ultisol soil to assess their potential to reduce

aluminium of the soil, showed that soil acidity could be corrected by the application of poultry manure (Hue, 1992).

Agboola et al., (1975) and Charreau (1972) also reported that through regular application of manure, acidification is greatly reduced or reversed, the contents of exchangeable calcium and magnesium are increased, the content of free aluminium and manganese can be reduced and the uptake of phosphorus promoted. Agboola et al., (1975) further observed that applying decomposed organic matter could reduce iron toxicity noting that the danger of iron toxicity appear to be considerably less with manure.

2.4 EFFECT OF ORGANIC MATTER ON SOIL PHYSICAL PROPERTIES

Organic matter is simply an organic fraction of soil which includes plants and animals residue at various stages of decomposition by soil micro organisms ie. soil flora and fauna that inhabit the soil (Young 1977).

Organic material is anything that was alive and is now in or on the soil. It decomposes to form humus. Humus is organic material that has been converted by microorganisms to a resistant state of decomposition. Usually, only about 5 percent of it mineralizes yearly. That rate increases if temperature, oxygen and moisture conditions become favorable for decomposition which often occurs with excessive tillage (Plaster, 1996).

Beneficial effect is that, a high soil organic matter status leads to improved structural stability, a lower bulk density and a balance between fine and coarse pores. These properties lead to ease of root penetration erosion resistance, good soil moisture properties and permeability, combined with adequate aeration. Conversely, a decline of organic matter leads to degradation of these properties

with consequences such as pan formation and reduced water holding capacity (Young 1977). He further stated that, humified organic matter, or humus, holds stocks of nutrients as organic molecules is protected against leaching. These are slowly released into forms available to plants by mineralization, so providing a slow but controlled supply of macro and micro nutrients to plants.

In highly acidic soils, organic matter improves phosphorus availability, through blocking of fixation sites by organic complexes Young, 1977). Organic matter is reservoir of nutrients has the ability to absorb and hold up to 90 percent of water, and the matter will release most of the water that it absorbs to plants. In contrast, clay holds great quantities of water but much of it is unavailable to plants (Plaster, 1996).

Hsieh and Hsieh (1990) affirmed that productive soil should contain high level of organic matter which indicates reduced bulk density, improved soil structure, aeration and high water holding capacity.

Data used in the universal soil lost equation indicate that increasing soil organic matter from 1 to 3 percent can reduce erosion to 20 to 33 percent because of increased water infiltration and stable soil aggregate formation caused by organic matter (Brandy,1974).

2.5 EFFECT OF POULTRY MANURE IN COMBINATION WITH MINERAL FERTILIZER ON YIELD OF PEPPER

There is the complementary effect of poultry manure and mineral fertilizer when both are applied together. Agboola et al., (1975) reported that in an extremely acidic and humid site, a mineral phosphorus fertilizer had no effect on cowpea yield. But when the fertilizer was applied with relatively small amounts of farm yard manure, increasing the amount of phosphorus applied also increased yield.

In Samaru, Nigeria, a cultivated soil that had been inadequately supplied with nutrients for 20 years produced a substantially lower yield than soils receiving regular application of poultry manure. Even the largest doses of mineral fertilizer did not achieve the effect of moderate application of farm yard manure and mineral fertilizer in combined form (Muller-Samann and Kotschi, 1994b).

Yagodin (1984) also reported that combination of manure with fertilizer is more often than not more effective than equivalent amount of manure alone or those of separately applied inorganic fertilizers. Dennis et al., (1993) indicated that, the best fertilizer for savanna soil is a combination of organic and inorganic fertilizer since this does not only increase crop yield but also improves the fertility status of the soil. Baldwin (1975) reported that when manure is applied, there is reduced application rate for chemical fertilizer.

2.6 EFFECT OF INORGANIC AND ORGANIC FERTILIZER ON GROWTH OF PEPPER

Nitrogen, phosphorus and potassium are the main elements which affect the growth of plants including pepper. Inorganic fertilizers are the most important source of nitrogen. Adequate supply of nitrogen is associated with high photosynthetic activity, vigorous vegetative growth and a dark green colour of the leaves (John et al., 2004). However, extensive use of inorganic fertilizer has a depressing effect on yield. This causes reduction in number of fruits, delays and reduces fruit setting which subsequently delay ripening and leads to heavy vegetative growth (John et al., 2004).

Gupta and Shukla (1977) reported an increase in number of fruits and size due to nitrogen applied to pepper plant.

Among the factors that contribute to the low pepper yield in Nigeria is low soil fertility and unfavourable soil physical properties. Although studies conducted in the tropics showed significant increase in nutrient status and yield of pepper due to application of inorganic fertilizer (Sobulo, 1980), however high cost and scarcity of inorganic fertilizer pose constraints to its use especially among small-scale farmers in Africa. Also the attendant soil acidity and soil physical degradation hinder sustainable use of inorganic fertilizer in the tropics. Hence research attention has recently shifted to the use of animal manure which is abundantly produced and poses less environmental problems.

Flores et al., (2007) found out that increasing mineral fertilizer rate was found to increase vegetative growth at the expense of fruit quantity. He further stated that insufficient fertilizer or nutrient deficient soil can slow down growth or cause deficiency symptoms such as leaf chlorosis, stunted growth and leaf death in pepper.

Adeniyan and Ojeniji (2003) did a comparative study of the effect of organic and inorganic fertilizer on maize plant growth. From the result, organic fertilizer gave the best result followed by the N.P.K fertilizer, and then the control. Both organic and inorganic fertilizer can be used to supply plant nutrients. However, inorganic

fertilizers are usually highly soluble and are more rapidly available to the plant than organic fertilizers. Nutrients play important roles in the physiological function on the development of plants. They contribute and form part of the plant cell wall or protoplasm. Each element has one or more specific task in the metabolism of the plant. In general, pepper growth development is vigorous with adequate supply of nutrients (Sanchez, 1986).

Organic fertilizers take time to break down and release nutrients more slowly; therefore organic and inorganic fertilizers may be combined so that nutrients are available to plants rapidly and for an extended period of time (Swanson, 2000). He further reported that, the year to year availability of N and P for the plants depends strongly on the depth and duration of soil wetting and the distribution of organic matter in the soil profile. Wetting of the first 50 cm of soil leads to mineralization of organic matter from which plants absorb an average of about 10 kg N ha^{-1} and 1 kg P ha^{-1}.

Effect of nitrogen on vegetative growth and fruit yield is more obvious than any other nutrients, as it promotes the setting of flowers and fruits. However nitrogen deficiency causes stunted growth and accelerates flowers dropping, while its excess supply delays maturity and decreases fruit size (Saxena et al., 1975). A low nitrogen supply reduces stem extension, and leaves become pale yellow or light green colour which becomes darker immediately after the nitrogen supply is increased. Inadequate amount of nitrogen limit yield and reduce fruit quality (Akinyosoye, 1985). He further reported that when nitrogen is present in excess, it increases the growing period and delays maturity of fruits. The ripening of maize for instance is retarded by too great a proportion of nitrogen in the medium of growth.

Phosphorus has pronounced effect on tomato and pepper plants. High level of available phosphorus throughout the root zone is essential for rapid root development and good utilization of water and other nutrients by the plants (Togun and Akanbi, 2002). Phosphorus is absorbed in relatively large quantities by most plants and it plays a vital role in plant growth. It promotes root growth, flower, fruit and seed development and stimulate stiffer stems. When a crop such as pepper and cereals are deficient in phosphorus, growth is retarded and the formation and ripening of seeds may be retarded, plant develops a stunted root system and leaf development is reduced (Addo-Quaye et al., 1993).

Potassium has been found to improve the quality of tomato and pepper fruits. Potassium is one of the elements which are absorbed in fairly large quantities by plants and it is important in the synthesis of amino acids and protein from ammonium ions. Insufficient supply of potassium results in fruits and seeds becoming poor in quality, and of reduced size and weight (Russel, 1973).

The potential for extending the duration of fruiting period in order to improve yield output lies generally on genetic quality of plant but most importantly on soil conditions as early growth termination in pepper is often caused by soil nutrient depletion and root infection resulting from buildup of soil pathogens. Pepper plants were found to respond positively to foliar application of calcium and potassium (Nassar et al., 2001).

2.7 GREEN MANURE

Green manure is a plant material ploughed down into the soil while green to enrich it with organic matter and other plant nutrients (Yagodin, 1984). In other words green manuring in its narrowest sense involves the growing of plant materials usually legumes, for the express purpose of incorporating them into the soil.

Shiping (1982) defined green manuring as the working into the soil of fresh, green non-woody plants rich in water, sugar, starch, protein and other nutrients. He added that such plants include plant roots still alive at the time of ploughing which are killed and incorporated at the same time.

Green manure is therefore plant material incorporated into the soil while green or soon after maturity for improving the soil. The green plant material may be grown in situ or cut and brought in for incorporation to improve soil productivity.

According to Shiping (1982) almost any crop that will grow satisfactorily in a given climate may be used as a green manure, but as practical matter, the choice is usually very limited. Among the important points that determine the suitability for use as a green manure include the following. The crop should,

a) Produce lager biomass with soft tops in the shortest possible time.
b) Provide rapid soil cover.
c) Be able to compete with weeds and even suppress them.
d) Have the ability to enrich the soil, preferably able to fix nitrogen.
e) Have a strong capacity to assimilate nutrients.

2.8 SUITABILITY OF *Tithonia diversifolia* AS GREEN MANURE AND ITS APPLICATION TO THE SOIL

Incorporation of green manure (*Tithonia*) into the topsoil leads to accumulation of nitrogen and other nutrients. The roots extract all elements present during their vegetative period not only from the topsoil, but also from the deeper horizon (Yagodin, 1984). By decomposing rapidly, green manure can liberate large quantities of nutrients in the soil (Russell, 1973). The time of incorporation of plant material should not be too close to the planting of the crop, since they can be damaged by heat during decomposition. Generally 3 – 6 weeks are sufficient to ensure adequate decomposition of the plant material in the tropics (Arakeri et al., 1962).

When green manure is incorporated into a soil and has been thoroughly decomposed, there is an improvement in tilth of the finer-textured soil. There is rapid increase in biological activity after incorporation; and excretion from these soil organisms promote the formation of crumbs and of a stable aggregate structure. Green manure can decompose in shorter interval in soil which is light sandy soil while it requires longer period to decompose in loamy-clayey soil (Muller-Samann and Kotschi, 1994b). They stated that factors that hinder decomposition include dryness of soil, waterlogging, and burying green manure too deep in or anaerobic conditions. Mixing the green manure evenly into loose, moist soil near the surface is the best way to ensure a good effect (Muller-Samann and Kotschi, 1994b).

2.9 EFFECT OF TITHONIA ON GROWTH AND YIELD OF PEPPER

Liasu and Atayese (1999) reported that, the concentration of nutrients in *Tithonia* is highest in young plants and before the plant flowers. Research indicates that the ability to decompose quickly makes it the best way to replenish soil fertility. In Western Kenya, the Kenya Agricultural Research Institute observed an improvement in crop yield in 10 farms where the yield of pepper increased when *Tithonia* biomass was applied (Jama et al., 2000).

Dupriez and De-Leener (1989) reported that, when soil is rich in organic nutrients such as those derived from *Tithonia* mulch, cultivated plants are often hardier and healthier than when nutrients come to them straight from factory made minerals (inorganic fertilizer).

The use of *Tithonia* as an effective source of biomass for annual crops has also been reported for rice (*Oryza sativa*) but it has been more recently reported as nutrient source for maize in Kenya (Jama et al., 2000).

Jama et al., (2000) reported that, addition to incorporated *Tithonia* biomass and NPK fertilizer to the pepper plant produced better and healthier growth of pepper and subsequently produced high yield. This could be attributed to the addition of nutrient and probably phyto-chemical from the leaves of *Tithonia diversifolia* to the soil. The phyto-chemicals may play important roles in the control of termite infestation and suppression of soil pathogens. *Tithonia* is a high quality organic source in terms of nutrient release and supplying capacity. Lower C/N ratio of *Tithonia* compares to *Chromolaena* and *Panicum* indicates a faster rate of decomposition.

Palm and Rowland (1997) also listed high nitrogen and phosphorus contents and high soluble fraction and moderate lignin content resulting in high biodegradability as the strong points for *Tithonia* as a source of organic matter. According to Jama et al., (2000), rapid nutrient release from added organic materials is essential, especially, to short duration crops such as the vegetables and most annual crops.

Most incorporated *Tithonia* as green manure decompose and mineralize to release their nutrient usually between 3 and 6 weeks (Arakeri et al., 1962) which may then be leached or rendered unavailable to plant. All these processes would invariably reduce the level of the nutrients remaining in the soil after pepper harvest.

Organic matter decreases in tropical soil once the vegetative cover is removed. Therefore, to increase organic matter for high pepper productivity, there is the need for repeated application of green manure over period of time in order to maintain high level of organic matter (Agboola and Fayemi, 1972).

Gachengo et al., (1999) demonstrated increased maize yield following incorporation of fresh *Tithonia* biomass at the equivalent of 5 tonnes dry matter per hectare on a site deficient in N.P.K in Western Kenya.

Tithonia green manure, apart from being rich in nutrients including calcium, nitrogen and phosphorus, can increase the soils moisture retaining capacity, which helps to improve and maintain the biological and physiochemical qualities of the soil thereby improving the growth performance of pepper (Jama et al., 2000).

The cessation of growth in field grown pepper often result from accumulation of pests, and pathogens, for example, termites, bacteria, fungi and nematodes which invade the roots and spread through the plant body causing diseases and symptoms that are terminal. Such diseases affect fruit quality, flower initiation and fruit formation leading to premature termination of fruiting and even death. *Tithonia* has been shown to contain substances that prevent infestation of termites (Adeoye, 1990) and posses antibiotic qualities. This unique quality of *Tithonia* green manure is potential for extending the lifespan of pepper on the field, promoting fruit production and at the same time increasing farmer's output.

Buresh and Niang (1997) found greater maize yield following incorporation of *Tithonia* biomass than biomass of other common shrubs and trees in Western Kenya.

In addition, the use of *Tithonia* biomas has been tested by hundreds of farmers and on farm research has demonstrated that soil fertility benefits are greater for green biomass than for dried biomass of *Tithonia* (Liasu and Atayese 1999). They further reported that green leaf biomass of *Tithonia* decomposes more rapidly after incorporation into the soil than dry leaf biomass. Considering the current knowledge on the role of organic residue in increasing soil biological activity it is hypothesized that, the combination of organic and inorganic nutrient sources is
more beneficial than the sole application of inorganic fertilizer. In low input system, the combination to *Tithonia* and fertilizer is a valuable alternative when resources are scarce and an added benefit can be obtained by maximizing the proportion of *Tithonia* in the mixture.

Green biomass of *Tithonia* is undoubtedly a potential source of N.P.K for crops. The quantities of green biomass available from *Tithonia* growing on small holder agricultural field, however, will not typically supply all the nutrients required to eliminate nutrient deficiencies over large areas of the field (Jama et al., 2000). The integration of *Tithonia* and mineral fertilizers would have added advantage, as compared to sole use of mineral fertilizer (Jama et al., 2000)

Green biomass of *Tithonia diversifolia* has been identified as a useful resource for biomass transfer (Gachengo et al., 1999). Concentration of nitrogen, phosphorus and potassium are rapidly released in plant-available forms during decomposition (Gachengo et al., 1999). *Tithonia* can perform well as top quality organic manure with good fertilizing value.

Studies by Spaccini et al., (2002) showed that application of *Tithonia* residues to soils increased soil organic matter, improved aggregate stability and enhanced water retention capacity of soils and as a result increased growth and yield of pepper production.

Banding and incorporation of the organic materials have shown to be more effective than surface application. The positive effect on the crop of incorporating *Tithonia* pruning on the soil may stem partly from lower nitrogen volatilization loss (Read et al., 1985).

Green manure decompose most rapidly when there is an adequate supply of moisture and air in the soil, for anaerobic condition and waterloging generally lead to a restricted bacterial population (Akinyosoye, 1985). The soil pH should not be too

low; otherwise the micro organisms may also die. The temperature of the soil should preferably be fairly high since temperature above 40 ˚C and below 25 ˚C favour low rate of decomposition (Akinyosoye, 1985).

2.10 FACTORS AFFECTING THE DECOMPOSITION AND NUTRIENT RELEASE OF ORGANIC MANURE

Decomposition of plant organic material is the mechanical disintegration of the dead plant material until a stage where the gross cell structure is no longer recognizable. This is usually accompanied by the breakdown of complex organic molecules to carbon dioxide, water and mineral component (Satchel, 1974).

During decomposition, organic material release nutrients beneficial for plant growth and development. The rate of decomposition of organic material is influenced by a number of factors including moisture, temperature, substrate quality and micro organisms active in the decomposition process (Witkamp, 1971).

The rate of decomposition is regulated by three groups of variables which are, the nature of decomposer community, the characteristics of organic matter which determine its dependability and the physio-chemical environment operating at the area. However, the two most important control of the rate of decomposition are substrate quality and moisture (Meentemayer, 1978).

2.10.1 Temperature

Among climate variables, temperature and rainfall have been found to be of major importance in decomposition of plants residue (Singh and Gupta, 1977). The chemical process and activities of micro organisms which convert plant nutrients into available forms are influenced by temperature. For instance microbial activity increases with increasing temperature (Edward, 1990)

A low temperature in dry soil limits microbial activity in decomposition and is greatest during warm conditions (Jenkinson and Ayanaba, 1997). In addition, water uptake may be delayed since water uptake was reported to be improved by warming up the nutrient solution (Park et al., 1995). Increasing root zone temperature resulted in the increment in plant height. Nwoboshi (1985) further reported that fluctuation in soil and air temperature influence pepper growth by altering the rate of various important physiological processes such as chlorophyll synthesis, photosynthetic respiration, cell division and enzymatic activities.

2.10.2 Rainfall

Deka and Mishra (1982) reported that decomposition rate of plant material was accelerated during the rainy season. During this period, the microbial population was quite high. The greatest rate of decomposition is known to occur usually during warm and wet period of the year. Rainfall and temperature have been observed to be important for decomposition of organic matter but rainfall is an important parameter than temperature. Lack of soil moisture reduces litter decomposition and

mineralization thereby reducing the levels of soil nutrients available for pepper growths. As much as lack of soil moisture reduces litter decomposition, it also reduces leaf area and this decreases the amount of photosynthetic activity available for plant's growth (Kimmins, 1997). Lack of water may also reduce mineral element uptake by pepper through reduction in diffusion co-efficient.

2.10.3 Nature of plant material

The most important chemical index influencing the decomposition and release of nutrients from organic material include lignin content, polyphenolic content, nitrogen content and carbon / nitrogen ratio (Berg and Ekbohn, 1983). Litter of high quality decays and release large amount of nutrients rapidly whilst that of low quality decays slowly. Plant material with high lignin concentration is described as low quality and decomposes more slowly than those with low lignin concentration (Melilo et al., 1982).

Leaves low in polyphenolic content release nitrogen more rapidly than those high in polyphenolics (Palm and Sanchez, 1991). Plant materials which are high in nitrogen are known to decompose faster than the leaves of non-nitrogen fixing plants. This means that species with high nitrogen content are considered to be of high resource quality to micro-organism and decompose more rapidly than species low in nitrogen (Weeraratna, 1979).

Similarly, Singh and Gupta (1977) reported that nitrogen broad-leaf material decompose at a faster rat than the more needle-leaf litter. Yamoah et al., (1986) also

reported that litters with high nitrogen content decompose very fast. In the Northern Guinea Savanna of Nigeria, Adeoye (1990) reported that mulch material incorporated into the soil positively influenced the N, P and K nutrient content of pepper crop after four years of repeated application.

The primary decomposition of plant materials is largely attributed to the soil microflora and soil fauna. During decomposition of plant materials, micro organisms may utilize the plant nutrients. Therefore, the effect of residue decomposition on the level of ammonium and nitrate is not always positive. Dawson et al., (1948) found larger populations of fungi, aerobic bacteria, and actinomyetes in the surface soil when crop residues were left on the surface than when they were ploughed under. They observed that the rate of the

decomposition process was influenced by lower temperature and higher moisture content under mulching. Incorporated material with Kudzu and guinea grass, had little effect in increasing the availability of N.P.K Ca and Mg in an experiment at Yarimaguas, Peru (Wade and Sanchez, 1983). Jenkinson and Ayanaba (1997) showed that, the decomposition of plant material was more rapid in soils with less clay content because the clay protected the organic matter from decomposition. Decomposition is more rapid for buried residue than on the soil surface (Mulongoy and Akobundu, 1990). It was also found that increasing the incorporation depth up to 30 cm increased the decomposition rate due to a more favourable water regime.

2.10.4 Acidity and nutrients release

Olayinka (1990) reported that soil acidity together with nutrient imbalance hindered sustainable use of inorganic fertilizer and recommended that compost and poultry manure should be made use in vegetable production. Lowering of pH may improve the availability of certain nutrient in the soil. In the tropics, acid soil negatively affects nitrogen fixation. In soils with low pH, nitrogen mineralization rate of plant residue were reduced when nitrogen fertilizer was applied to soil (Graham et al., 1982). The success of pepper growth is intimately associated with soil reaction where the optimum pH for nutrients release plants growth is in the range of 6.0 to 6.5

(Townsend, 1977). He further reported that as acidity increases there is reduction of available nitrogen as nitrifying organisms are depressed.

2.11 SOME FACTORS AFFECTING GROWTH AND YIELD OF PEPPER

These include water stress, temperature and soil acidity, water stress. Drought at flowering is reported to reduce assimilation of sucrose resulting in abortion of flower shortly after fertilization (Schussler and Westgate, 1985). One of the damaging effects of water stress is reduction in leaf area and this decreases the amount of photosynthetic acidity available for plant growth (Kimmins, 1997). Whenever, the rate of transpiration exceeds that of water absorption for any appreciable length of time, the volume of water within the pepper plant shrinks, thereby reducing the growth and yield of the plant (Nwoboshi, 1985). He added that water stress was

known to reduce the photosynthetic activity available of plants through stomatal closure.

Olanrewaju (1981) worked on the effect of water stress on flower and fruit set on sweet pepper and found that, unmulched plants produced fewer flowers most of which aborted due to soil moisture stress and concluded that total fruit yield of mulched plants were significantly higher than fruit yield of unmulched plots.

2.11.1 Temperature

Increasing root zone temperature resulted in the increment in plant height. Nwoboshi (1985) reported that fluctuation in soil and air temperature influenced pepper growth by altering the rate of various important physiological processes such as chlorophyll synthesis, photosynthetic respiration, cell division and enzymatic activities. Temperature influences plant rate of growth, multiplication and activity of microorganism and to a large extent, determines the survival of planted pepper seedlings. Exposure to relatively high temperature often causes reduced growth of pepper (Nwoboshi, 1985). High soil temperature values above 35°C retards root growth, impairs water and nutrient uptake and photosynthesis required for pepper growth. Adams et al., (2001) asserted that soil temperature above 30°C is deleterious to normal growth and reproductive development of pepper. They further stated that the maximum fruit growth rate was achieved at 25°C.

2.11.2 Acidity

Success of plant growth is amongst other things, intimately associated with soil reaction, and the optimum reaction for the majority of agricultural crops is in the range of pH 6.0 to 6.5. Hence soil reaction around pH of 6.5 should be the farmers aim (Townsend 1977).

Buerkert et al., (1990) showed that liming of soils in southern Mexico increased production and nitrogen fixation, resulting in better establishment and increased fruit number of cowpea per plant, seed number per fruit and seed weight and therefore, contributed to a significant yield increase. In the tropics, acid soil adversely affects nitrogen fixation (Andrew, 1982).

SUMMARY OF LITERATURE REVIEW

There was literature review on the effect of poultry manure on the growth and yield of pepper. It was discovered that poultry manure was known to contain high levels of nitrogen, potassium and phosphorus for plant growth and it is known to improve chemical and physical properties of the soil for pepper growth and yield in spite of the high labour and cost (Brian and West 1997).

It was also observed by Aliyu (1997) that poultry manure application significantly increased plant height, leaf area index, fruit length, number of fruits and fruit yield compared with cow dung.

On the study of the rate, method and time of poultry manure application, Bandel et al.,(1972) reported that application of larger amount of poultry manure at or shortly before planting may result in injury to crops, particularly young plants. Hileman(1971) also asserted that, there is a need for an incubation period after manure application before planting a crop because of rapid chemical changes in the soil following their incorporation. Siegel et al, (1975) also reported that an incubation period of about one month, after application and before planting would allow for nitrification of the ammonia.

On the effects of poultry manure on soil chemical properties, Aboola et al, (1975) and Charreau (1972) reported that through regular application of manure, acidification is greatly reduced, the contents of exchangeable calcium and magnesium are increased, the content of free aluminum and manganese can be reduced and the uptake of phosphorus promoted.

On the effect of organic matter on soil physical properties, Hsieh and Hsieh (1990) found that, a high level of organic matter in the soil indicates reduced bulk density, improved soil structure, aeration and high water holding capacity all of which are attributes of a productive soil.

A study on the effect of combined use of poultry manure and mineral fertilizer, showed that the combination of manure with mineral fertilizer is more often than not, more effective than equivalent amount of manure alone or those of separately applied inorganic fertilizer, Yagodin (1984). Dennis et al., (1993) indicated that, the best fertilizer for savanna soil is a combination of organic and inorganic fertilizer since this does not only increase crop yield but also improves soil fertility. Balwin (1975) reported that when manure is applied, there is reduced application rate for chemical fertilizer.

On the issue of green manuring, it is found that, in general, 3-6 weeks are sufficient to ensure adequate decomposition of the plant material in the tropics (Arakeri et al, 1962). Green manure can decompose in shorter interval in soil which is light sandy soil while it requires longer period to decompose in loamy-clayey soil (Muller-Samann and Kotschi, 1994). They added that factors that hinder decomposition include dryness of soil, water logging and burying green manure too deep in anaerobic conditions.

On the effect *Lithonia* on plant growth, it is found that the concentration of nutrients in *Lithonia* is highest in young plants and before the plant flowers. Leaves of Lithonia contain phyto- chemicals which controls termite infestation and suppression of soil pathogens (Jamal et al., 2000). *Lithonia* is a high quality source in terms of nutrient release and supplying capacity. It has a faster rate of decomposition as it has lower C/N ratio. Soil fertility benefits are greater for green biomass than for dried biomass of Lithonia (Liasu and Atayese 1999). They also reported that green leaf biomass of *Lithonia* decomposes more rapidly after incorporation into the soil than dry leaf biomass. *Lithonia* will not typically supply all the nutrients required to eliminate all nutrient deficiencies (Jamal et al., 2000), therefore integration of *Lithonia* and mineral fertilizers would have added advantage, as compared to sole use of mineral fertilizer (Jamal et al., 2000).

On the issue of factors affecting the decomposition of organic manure, it is known that the rate of decomposition of organic material is influenced by a number of factors including moisture, temperature, substrate quality and micro organisms active in the decomposition process (Witkamp, 1971). The rate of decomposition is regulated by three groups of variables which are the nature decomposer community, the characteristics of organic matter, and the physio-chemical environment operating at the area.

Microbial activities increase with increasing temperature (Edward, 1999). A low temperature in dry soils limits microbial activity in decomposition and is greatest during warm conditions (Jenkinson and Ayanaba, 1997.

Rainfall and temperature have been observed to be important for decomposition of organic matter but rainfall is an important parameter than temperature. Lack of moisture reduces litter decomposition and mineralization thereby reducing the levels of soil nutrients available to plants.

CHAPTER THREE

MATERIAL AND METHODS

3.1 LOCATION AND CLIMATE OF THE SITE

The field experiment was carried out at the Faculty of Renewable Natural Resources Farm at the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. The study site is subjected to marked wet and dry season with a bimodal rainfall pattern. The two rainfall peaks make two growing season possible. There is heavy rainfall from March to July, which is interrupted by a dry period of about two weeks in August. This is followed by another period of rainfall from September to

October/November. The project was conducted in the minor season from October to December 2008.

The mean annual rainfall of the study area ranges between 1200 – 1500 mm per year. The relative humidity is 67.6%. The area has minimum temperature of 22 °C and maximum temperature of 31 °C.

The soil of the study site is the Asuansi series which belongs to the Bomso Asuansi Association. The soil taxanomy at the family level is Ferric Acrosols. The soil is predominantly sandy loam, well drained but acidic (pH 4.7).

3.2 EXPERIMENTAL DESIGN

The experimental design used was a Randomized Complete Block Design (RCBD) with three replications and seven treatments. The treatments were as follows.

T_1: *Tithonia* only, 5 t fresh wt. ha^{-1} (100%)

T_2: N.P.K fertilizer (23-10-5) Only, 200kg ha^{1} (100%)

T_3: Poultry manure only, 10 t ha^{-1} (100%)

T_4: 2.5 t/ha *Tithonia + 5 t/ha* poultry manure

T_5: (2.5 t *Tithonia* ha^{-1} + 100 kg NPK ha^{-1})

T_6: (100 kg NPK ha^{-1} + 5 t/ha poultry manure)

T_7: control (no external input)

3.3 SOIL ANALYSIS

Surface soil (0-15cm) samples were taken from each block of field before the start of the experiment. The samples were bulked and air-dried for physical and chemical analysis. After the experiment, samples were taken again per plot for analysis as described by Carter (1993). This was done to determine nutrient accumulation in the amended soil during the growing season up to harvest time. The physical and chemical soil analyses were done at the Soil Research Institute, of the Council for Scientific and Industrial Research Kwadaso, Kumasi.

3.3.1 SOIL TEXTURE

The soil texture was determined by the Hydrometer method. 40 g of soil was weighed and oven dried at 105 °C over night. The sample was removed from the oven and then placed in a desiccator and the oven dry weight taken. A 100 ml of the dispersing agent, calgon (sodium bicarbonate and sodium hexa-metaphosphate) was measured and added to the soil. It was then placed on a hot plate and heated until the first sign of boiling was observed. The sample was sieved through a 50 micron sieve mesh into a 1.0 litre cylinder. The sand portion was dried and further separated using grade sieves of varying sizes into coarse, medium and fine sand. These were weighed and their weights taken. The Hydrometer method was used to determine the silt and the clay content. It was then placed on the bench and hydrometer readings taken at 30 seconds, 4 minutes, 1 hour, 4 hours and 24 hours intervals. The various portions were expressed in percentage and using the textural triangle, the soil texture was determined.

3.3.2 TOTAL NITROGEN

The nitrogen was determined by the Kjeldahl digestion and distillation procedure. 0.2 g of soil was weighed into a Kjeldahl digestion flask and 5 ml distilled water added. After 30 minutes a tablet of selenium and 5 ml of concentrated H_2SO_4 were added to the soil and the flask placed on a Kjeldahl digestion apparatus and heated initially gently and later vigorously for 3 hours. The flask was removed after a clear a mixture was obtained and then allowed to cool: 40 ml of distilled water was added to the digested material and transferred into 100 ml distillation tube.

3.3.3 PHOSPHORUS

Phosphorus was extracted with a HCl: NH_4 mixture, the Bray's No. 1 extract. Phosphorus

was determined as a spectrophometer by the blue ammonium molybdate method with ascorbic acid as reducing agent. 5 g soil was weighed into 100 ml extraction bottle and 35 ml of extracting solution of Bray's No. 1 was added. The bottle was shaken for 10 minutes after which the content was filtered. The resulting clear solution was collected into 100 ml volumetric flask. 5 ml of the supernatant solution was pipetted into 25 ml test tube and 10 ml colouring reagent was added as well as a pinch of ascorbic acid and then mixed very well. The mixture was allowed to stand for 15 minutes to develop a blue colour to its maximum. The colour was measured photometrically using a spectronic 210 spectdrophotometer at 66 nm wavelength. Available phosphorus was extrapolated from the absorbance read.

3.3.4 DETERMINATION OF AVAILABLE POTASSIUM

Available potassium extracted using the Bray's No. 1 solution was determined directly using the Gallenkamp flame analyzer. Available potassium concentration was determined from the standard curve. Potassium standard solutions were prepared with the following concentrations: 0, 10, 30, and 50 ug K per litre of solution. The emission values were read on the flame analyzer. A standard curve was obtained by plotting emission values against the respective concentration.

3.3.5 SOIL pH

Soil pH was measured in a 1:1 soil water ratio using a glass electrode pH meter, 25 g of soil was weighed into a 50 ml polythene beaker and 25 ml of distilled water was

added to the soil. The soil-water solution was stirred thoroughly and allowed to stand for 20 minutes. After calibrating the pH meter, the pH value recorded.

3.3.6 SOIL ORGANIC CARBON

Soil organic carbon was determined by the modified Walkley-Black method as described by Nelson and Sommers (1972). The procedure involves a wet combination of the organic matter with a mixture of potassium decahromate and sulphuric acid. After the reaction, the excess dichromate was titrated against ferrous sulphate. 1.0 g of air-dried soil was weighed into a clean and dry 250 ml Erlenmeyer flask. 20 ml of concentrated sulphuric acid (H_2SO_4) was dispersed rapidly into the soil suspension and swirled vigorously for 1 minute and allowed to stand on a porcelain sheet for 30 minutes. 100 ml of distilled water was added and mixed well. 10 ml of orthophosphoric acid and 1 ml of diphenylamine indicator was added and titrated by adding 1.0 M ferrous sulphate until the solution turned dark green at end-point from an initial purple colour. The titration was completed by adding $FeSO_4$ drop-wise to attain a stable end-point. The volume of $FeSO_4$ solution used was recorded and percentage carbon calculated.

3.3.7 EXCHANGEABLE CATIONS

Exchangeable bases (calcium, magnesium, potassium and sodium) in the soil were determined in 1.0 m ammonium acctate (NH_4OH_5) and exchangeable acidity (hydrogen and aluminium) was determined in 1.0 M KCl.

3.3.7.1 CALCIUM AND MAGNESIUM

Exchangeable calcium and magnesium were determined by the extraction technique using 10 g of soil sample and titrating 0.01M EDTA (ethulene diamine tetra ecetic acid). Thus 1.0 ml hydroxylamine hydrochloride, 1.0 ml potassium cyanide buffer, 1.0 ml potassium ferro cynide and 10.0 ml ethanolamine buffer were added. The solution was titrated with 0.01 M EDTA to apure turquoise blue colour. A 20 ml 0.01 M magnesium chloride solution was also titrated with 0.01 M EDTA in the presence of 1.0 M acetate solution to provide a standard blue colour for the titration.

3.3.7.2 EXCHANGEABLE POTASSIUM AND SODIUM

Potassium and sodium in the percolate were determined by flame photometry. A standard series of potassium and sodium were prepared by diluting both 1000 mg potassium per litre and sodium solutions to 100 mg/1. This was done by taking a 25 ml portion of each into 150 ml of the 100 mg/1 standard solution and was put into 200 ml volumetric flask respectively. Potassium and sodium were measured directly in the percolate by flame photometry at wavelengths of 766.5 and 589 nm respectively.

3.3.7.3 EXCHANGEABLE ACIDITY

Exchangeable acidity is defined as the sum of aluminium and hydrogen. The soil sample was extracted with unbuffered 1.0 M KCl, and the sum of aluminium and hydrogen was determined by titration. Ten grams of soil sample was put in a 100 ml

bottle and 50 ml of 1.0 M KCl solution added. The bottle was capped and shaken for 1.0 hour and then filtered. A 25 ml portion of the filtrate was taken with a pipette into a 250 ml Erlenmeyer flask and 2-3 drops of phenolphthalein indicator solution added. The solution was titrated with 0.1 M NaOH until the colour just turned permanently pink.

3.4 PLANT AND MANURE ANALYSIS

The chemical analysis of *Tithonia* leaf and poultry manure were done at the CSIR-Soil Research Institute, Kwadaso, Kumasi. Dried samples were ground in a Waley and Mill and ignited at 450 °C for 2 h, the ash was extracted with HCl. The P was determined by ammonium molydate flame photometry and Ca and Mg by EDTA titration. Determination of N was by the Kjeldahl method. Air-dried and ground manure samples were sieved through 2 mm sieve, and N.P.K analyzed using similar methods as for the leaf analysis.

3.4.1 NITROGEN

0.2 g of the plant material was weighed into Kjedahl flask, a tablet of selenium catalyst was added and 5 ml of concentrated H_2SO_4 was added to the mixture. This was digested on the electrothermal Kjeldahl apparatus for three hours. After the clear digest has cooled, 20 ml of distilled water was poured into the Kjeldhal flask containing the digested material before it was transferred into a 100 ml distillation tube. In the distillation tube, 20 ml distilled water was added plus 20 ml 40% NaOH and then distilled for 4 minutes. The distilled water was received in a conical flask containing 20 ml of 4% boric acid methyl red and bromocreol green indicators. The received greenish solution was against 0.1 M HCl. Percentage Nitrogen was calculated from the volume of HCl used to attain end-point.

3.4.2 PHOSPHORUS

Phosphorus in the plant was determined using the Vanado-Molybdenum method. 0.5 g of the plant material was weighed into a porcelain crucible and ashed in a muffler a temperature of 400-500 °C. The ashed sample was removed from the oven after cooling and then made wet with 1 – 2 drops of distilled water and 10 ml of dilute HNO_3 added. The crucible was then heated on a water bath until the first sign of boiling was observed. The crucible was removed and allowed to cool. The content was filtered into a 100 ml volumetric flask using a No. 540 filter paper. 10 ml each of ammonium vanadate and ammonium molybdate solutions were added and shaken thoroughly. The solution was allowed to stand for 10 minutes for full colour development. A standard curve was developed concurrently with P concentrations ranging from 0, 1, 2, 5, 10 and 15 Mg P per litre of solution. The absorbance of the sample and standard solution were read on the spectrophometer at wavelength of 470 nm. Phosphorus concentration of the samples was determined from the standard curve.

3.4.3 POTASSIUM

Potassium in the ash solution was determined using a flame amalyzer. Potassium standard solutions were prepared with the following concentration 0, 10, 20, 40, 60

and 100 µg K per litre of solution. The emission values were read on the flame analyzer.

3.4.4 CALCIUM AND MAGNESIUM

The ethylene-diamine tetra-acetic acid (EDTA) method was used to determine calcium and magnesium, which involved dry ashing of 2.0 g of the tissue sample and dissolving the ash in dilute HCl.

3.5 SEED COLLECTION

Hot pepper was used as the test crop. The pepper variety used was Legon 18 and it was obtained from the CSIR-Crops Research Institute, Kwadaso Station, Kumasi.

3.6 NURSERY

The seeds were nursed on a seed bed by the drilling method in the first week of September. The soil was watered before and after planting of the seeds. Wetting of the nursery continued every day until they were planted out.

3.7 FIELD PREPARATION

The site which had been cultivated to maize before left to fallow for three years was cleared. The area measured 21.6 m x 9 m, giving a total of 194 m^2. The plot was divided into three blocks, with 7 plots in each block giving total of 21 plots. Each plot within each block was measured 2 m x 2.5 m with 1 m between blocks.

3.8 TRANSPLANTING

The pepper seedlings were allowed to grow for four weeks after which they were transplanted on to the field. The seedlings were transplanted in the evening in order to give the seedlings enough time to get acclimatized to their new environment, thus safeguarding them from transplanting shock. The spacing used was 70 cm between rows and 60 cm between planting row (23, 800 plants/ha).

3.9 APPLICATION OF *Tithonia* AND POULTRY MANURE

The fresh leaf biomass of wild sunflower *Tithonia diversifolia* was cut. Only the leaflets were used to exclude the lignified branches. It was applied by incorporating into the soil one week before transplanting. Poultry manure was also applied and incorporated into the soil, one week before transplanting.

3.10 CULTURAL PRACTICES

3.10.1 Weed control

Weeds were controlled using hoe and hand pulling. Weeds were controlled twice, two weeks after transplanting and just before fruiting.

3.10.2 Watering

The plants were watered twice daily as the vegetative growth period coincided with the drought.

3.10.3 Fertilizer application

Inorganic fertilizer (N.P.K 23-10-5) was applied to the soil at 200 kg ha^{-1} two weeks after transplanting. The method used was band placement.

3.10.4 Insect control

To prevent pest infestation, the insecticide thiodan, (endosulfan $C_9H_6Cl_6O_3S$) was applied two times during the growing period, at three weeks after transplanting and during the flowering stage.

3.11 DATA COLLECTION AND ANALYSIS

The crops were allowed to grow for twelve weeks and growth and development of crop were monitored starting from the first week after transplanting to the harvesting stage. The following data was collected during the growth period:

i) Plant height at 40 days after transplanting

ii) Number of branches per plant.

iii) Number of plants flowered per plot, 40 days after transplanting.

iv) Number of fruits per plant.

v) Weight (yield) of the fruits.

Sixteen seedlings were planted on each plot but eight plants per plot were tagged for the data collection. The height of each plant was measured from the ground level to the apex of a new leaf appearing. The branches were counted by hand and the number of each plant recorded. The number of fruits per plant was also counted and recorded. At maturity, ripe fruits were harvested. The number of fruits from each plant were put in paper envelope and weighed to determine the fresh weight.

Data collected were analyzed using the analysis of variance procedure, and treatment means were compared using the (DMRT) method at the 5% level of significance

CHAPTER FOUR

RESULTS

4.1 SOIL PHYSICAL AND CHEMICAL PROPERTIES

The results of the physical and chemical analysis of the soil used prior to the commencement of the experiment are presented in Table 1

Table 1: PHYSICAL AND CHEMICAL PROPERTIES OF SOIL AT STUDY SITE

PROPERTIES	VALUE

pH	4.73
Texture	Sandy loam
Sand (%)	70.10
Silt (%)	27.78
Clay (%)	2.12
Organic matter (%)	2.05
Carbon (%)	1.09
Nitrogen (%)	0.11
Phosphorus (mg/kg)	8.20
Potassium (mg/kg)	59.90
Calcium (meg/100g)	3.20
Magnesium (meg/100g)	0.80
Sodium (meg/100g)	0.11
Potassium (meg/100g)	0.29

The soil was acidic (pH 4.73). The soil contained relatively high proportion of sand (70%). Silt content was 27.98% and clay was 2.12%. The nitrogen, potassium and organic matter were moderate while phosphorus and calcium levels were relatively low. Similarly, potassium exchangeable base was moderate (Appendix A1).

4.2 NUTRIENTS OF *Tithonia* AND POULTRY MANURE

The percentage nutrients levels in the plant (dry matter) and the poultry manure are presented in Table 2.

Table 2: NUTRIENT LEVELS OF *Tithonia* AND POULTRY MANURE

PLANT NUTRIENTS	Tithonia diversifolia (Dry Weight)	POULTRY MANURE
Nitrogen (%)	1.02	1.50
Phosphorus (%)	1.11	1.59
Potassium (%)	1.04	0.48
Calcium (%)	0.38	3.56
Magnesium (%)	0.89	0.74

The results of the plant analysis showed that nitrogen, phosphorus and potassium were the major constituents of the plant with calcium and magnesium also present in appreciable quantities. Phosphorus had the highest value (1.11%) while calcium had the lowest value (0.38). The analysis of the poultry manure also showed that the most highly concentrated nutrient was calcium (3.56%). This was followed by phosphorus (1.59%) and then nitrogen (1.50%). The least available nutrient was potassium (0.48%). Generally, the amount of nitrogen, phosphorus and potassium was high in *Tithonia* while poultry manure contained higher amount of nitrogen and phosphorus but as calcium was the highest in poultry manure, calcium was the lowest value in *Tithonia* as seen in Table 2. The estimated amounts of nutrients supplied by the various treatments to the soil are given in Figure 1.

4.3 MAJOR NUTRIENTS SUPPLIED BY THE VARIOUS TREATMENTS

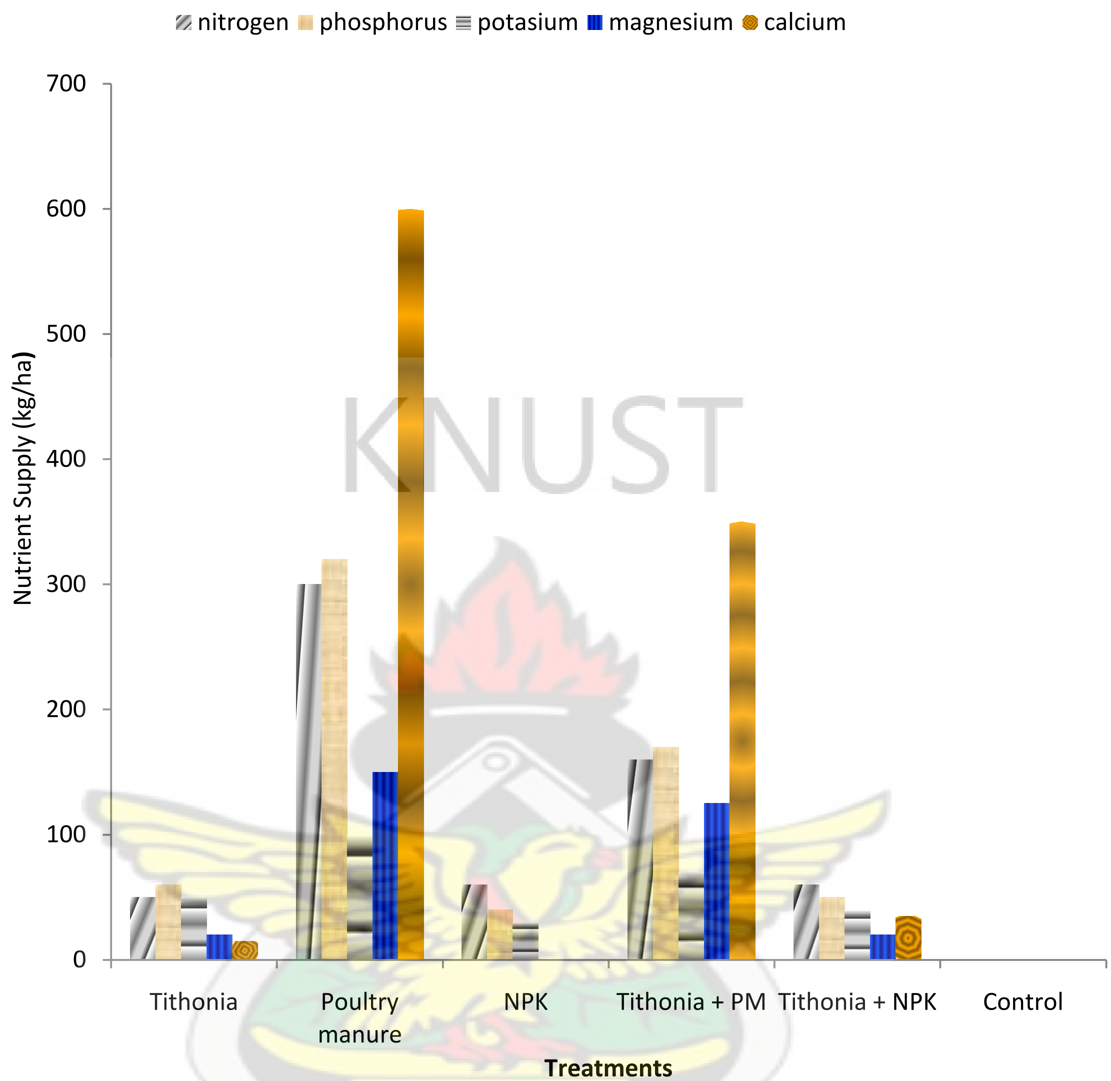

Figure 1 :Major nutrients supplied to soil with application of *Tithonia* diversifolia biomass, NPK fertilizer and poultry manure.

4.4 PLANT HEIGHT

TABLE 3: INFLUENCE OF *Tithonia*, NPK FERTILIZER AND POULTRY MANURE ON PEPPER HEIGHT AT 40 DAYS AFTER PLANTING

TREATMENT	PLANT HEIGHT (CM)
T_1 *Tithonia* (5t/ha)	35.2b
T_2 NPK fertilizer only	33.9b
T_3 Poultry Manure (10t/ha)	54.4a
T_4 *Tithonia* + Poultry Manure	55.8a
T_5 *Tithonia* + NPK	50.2a
T_6 NPK + Poultry manure	52.9a
T_7 Control	20.8c

Means having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability.

The influences of treatments on pepper plant height are presented in Table 3. Significant effect ($P<0.05$) was observed with the treatment compared to control. The highest plant height was produced from the treatment that received *Tithonia* + Poultry manure T_4 (55.8 cm) which was not significantly different from plant treated with sole poultry manure (T_3) (54.4 cm), *Tithonia* + NPK (T_5) 50.2cm and NPK + P. M. (T_6) 52.9cm. The effect of use of sole *Tithonia* and NPK only on pepper height was not significantly different. Analysis of variance is shown in Appendix A2. All treatments significantly increased plant height compared with the control.

4.5 NUMBER OF BRANCHES PER PLANT

Table 4: INFLUENCE OF *Tithonia*, NPK FERTILIZER AND POULTRY MANURE ON THE NUMBER OF BRANCHES OF PEPPER

TREATMENT	NUMBER OF BRANCHES PER PLANT
Tithonia (T_1) only	5 d
NPK (T_2) fertilizer	5 d
Poultry Manure (T_3)	7 c
Tithonia + Poultry Manure (T_4)	8 b
Tithonia + NPK (T_5)	6 d
NPK + Poultry manure (T_6)	9 a
Control (T_7)	3 e

Means having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability.

With respect to the number of branches, the combined treatment of NPK and Poultry Manure (T_6) recorded the highest number of branches (9) compared to the combination of poultry manure and *Tithonia* T_4 (8). There was significant difference between T_6 (NPK + Poultry Manure) and their sole application T_2 (5) and T_3 (7) respectively. Application of sole *Tithonia* (T_1) and NPK (T_2) did not produce significant difference in plant height but both were significantly higher than control T_7 (3). The ANOVA is provided in Appendix A3.

4.6 NUMBER OF FRUITS PER PLANT

Table 5: INFLUENCE OF *Tithonia*, NPK FERTILIZER AND POULTRY MANURE ON THE NUMBER OF FRUITS PER PLANT

TREATMENT	NUMBER OF FRUITS/PLANT
Tithonia only (T_1)	8 d
NPK fertilizer only (T_2)	8 d
Poultry Manure only (T_3)	14 c
Tithonia + Poultry Manure (T_4)	23 ab
Tithonia + NPK (T_5)	21 b
NPK + Poultry manure (T_6)	25 a
Control (T_7)	5 e

Means having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Significant ($P<0.05$) treatment effect was obtained in the number of fruits per plant (Table 5). In terms of number of fruits, the highest value was obtained in plants treated with NPK and poultry manure T_6 (25) and *Tithonia* and Poultry manure (23). Both were not significantly different (DMRT). There was increase in number of fruit of combined treatment NPK and poultry manure (25) over their respective sole application (8 and 14 respectively). The lowest value was obtained from the control (5). The analysis of variance is shown in Appendix A4

4.7 FRUIT WEIGHT

Table 6: INFLUENCE OF *Tithonia* NPK FERTILIZER AND POULTRY MANURE ON WEIGHT OF FRUITS

TREATMENT	WEIGHT OF FRUITS PER PLANT (g)
Tithonia only (T_1)	5.6 d
NPK fertilizer only (T_2)	5.7 d
Poultry Manure only (T_3)	7.9 b
Tithonia + Poultry Manure (T_4)	8.6 ab
Tithonia + NPK (T_5)	8.0 c
NPK + Poultry manure (T_6)	8.7 ab
Control (T_7)	3.7 e

Means having the letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability.

The response of the crop to application of *Tithonia* leave biomass,NPK fertlilizer and poultry manure on weight of fruits per plant is shown in Table 6. It could be observed from the result that all treatments that had application of NPK + PM obtained a higher value than sole application of individual fertilizers. In terms of weight of fruits, the highest yields were obtained from T_3, T_4, T_5, and T_6. NPK + PM, T_6, (8.7 g) *Tithonia* + PM, T_4 (8.6 g) *Tithonia* and NPK. (T_5) (8.0 g) and poultry manure only (T_3) that is T_6=T_4=T_5=T_3. The trend was similar to the trend observed in the number of fruits per plant. The value of *Tithonia* + NPK was not significantly different from the sole application of poultry manure (7.9 g). The values obtained from sole application of *Tithonia* and NPK were not significantly different from each other (5.6 and 5.7 d respectively). All treatments had significant effect on crop growth and development than the control. Analysis of variance is presented in Appendix 5.

4.8 EFFECT OF NPK FERTILIZER, *TITHONIA* AND POULYRY MANURE AFTER HARVEST

Table 7: EFFECT OF NPK FERTILIZER, *TITHONIA* AND POULYRY MANURE AFTER HARVEST

Treatment	pH	Organic matter %	Nitrogen (%)	P (ppm)	K(ppm)
Control	4.7	2.05	0.11	8.20	39.9
NPK	4.9	2.12	0.16	20.18	60.10
Tithonia	5.1	2.48	0.17	25.17	70.4
Poultry manure	5.5	2.80	0.20	40.03	83.65

There were increased values after application of treatments. The soil pH values for the top soil sample (0- 15 cm) indicate a slight increase in the soil pH (that is 4.7 to 5.5). The use of treatments affected soil chemical properties. The macro nutrient namely nitrogen, phosphorus and potassium were high compared to control. The treatment that released more nutrients to the soil was poultry manure (N 0.20%, P

40.03 ppm, K 83.65 ppm). Organic matter was increased from 2.05% (control) to 2.80% (poultry manure).

4.8 EFFECT OF TREATMENTS ON MATURITY

Table 8: NUMBER OF PLANTS FLOWERING 5 WEEKS AFTER TRANSPLANTING (EXPRESSED IN PERCENTAGE)

TREATMENT	PERCENTAGE NO. OF PLANTS THAT FLOWERED
Tithonia only (T_1)	45.8 c
NPK only (T_2)	45.8 c
Poultry Manure only (T_3)	70.8 ab
Tithonia and Poultry Manure (T_4)	83.3 a
Tithonia and NPK (T_5)	58.3 bc
NPK and Poultry Manure (T_6)	75.0 a
Control (T_7)	29.2 d

The means having the same letters are not significantly different according to Duncan Multiple Range Test (DMRT) at 5% level of probability.

At 5 weeks after transplanting, most plants had flowered. The treatments that obtained the highest percentage of flower were T_4 (*Tithonia* and poultry manure, 83.33%), NPK and poultry manure T_6 (75.0%) and poultry manure only (T_3, 70.8%) which were not statistically different from each other. The flowering percentage from sole *Tithonia* and sole NPK were statistically the same (44.83%) was significantly different from the combined treatment of *Tithonia* and NPK (58.33%). Analysis of variance is presented in Appendix 6.

CHAPTER FIVE

DISCUSSION

Responses of pepper plants to organic and inorganic fertilizer treatments were studied with regard to plant growth and yield. Specifically, the study involved the physiological parameters such as plant height, number of branches per plant, number of fruits per plant and weight of fruits per plant. Although the application of poultry manure, *Tithonia* and NPK increased plant height and number of branches compared to control, the application of poultry manure and its combination mostly affected biomass production more than the other parameters measured. Generally all the parameters were significantly increased by all treatments compared to the control.

5.1 PHYSICAL AND CHEMICAL PROPERTIES

The results showed that the soil at the experimental site was acidic (pH 4.73) with moderate fertility levels. Some improvement in the chemical properties of the soil was observed following application of poultry manure and *Tithonia* leaf biomass.

These increases might have come from addition through nitrogen incorporation and nutrient release during decomposition of the organic material. This observation came about through growth response to application of fertilizers compared to control. This implies that addition of significant amount of organic matter to these tropical soils can help reduce the trend of soil nutrient depletion in the tropics. Slight improvement in organic matter status of the soil showed *Tithonia* and poultry manure as significant for organic matter content in their amended soils compared to control. This observation buttresses the fact that *Tithonia* can perform well as quality organic manure with good fertilizing value (Olabode et al., 2007), while poultry manure acting as soil conditioner improves soil properties by building soil organic matter (Aliyu, 1997). Studies by Spaccini et al., (2002) showed that application of organic residues to soils could increase soil organic matter, buffer soil, improve aggregate stability and enhance water retention capacity of soils. This trend indicates the potential ability and capacity of these organic resources to significantly build organic matter in eroded soils when applied to such soils. In this study, addition of organic manure in the form of *Tithonia* biomass and poultry manure also increased soil organic matter (Table 7).

When organic manure was applied to the soil, it increased the amount of organic matter content of the soil and this in turn improved the soil chemical properties. The observation is in agreement with studies by Agboola and Fayemi (1972) that maintaining the levels of organic matter in tropical soil requires application of green manure over a period of time.

5.2 HEIGHT OF PLANTS

Height response due to *Tithonia* + NPK Fertilizer incorporation was significantly different from their respective sole application, that is, NPK fertilizer only (33.9 cm, b) and *Tithonia* only (35.2 cm, b). This indicates that *Tithonia* may have other beneficial effects on the soil in addition to the contribution from the NPK. This observation agrees with Jama et al., (2000) when they asserted that, *Tithonia*, apart from being rich in nutrients including calcium, nitrogen and phosphorus, can increase the soils moisture retaining capacity, which helps to improve and maintain the biological and physiochemical qualities of the soil thereby improving the growth performance of pepper. There was marked improvement in height for all treatments involving poultry manure, that is, *Tithonia* + Poultry manure, and NPK + Poultry manure. However, *Tithonia* + Poultry manure produced plant height which was not statistically different from the poultry manure and other combined treatments. The increase in height due to poultry manure application and their combination was also observed by Aliyu (1997) who asserted that poultry manure application significantly increased plant height, leaf area index and fruit length of pepper. The increase in plant height also seemed to be due to maximum release of nutrient to the plant especially nitrogen, phosphorus, potassium and calcium as seen Fig. 1. This implies that, higher rate of poultry manure and its combination with *Tithonia* or NPK would lead to increased plant height since more nutrients required for growth would be released to the soil.

Large amount of nitrogen and calcium in poultry manure may be a factor to high growth rate. Because low nitrogen content will lead to poor green colouration of plant which in turn will reduce the rate of photosynthetic activity, and this may adversely influence plant height. This conforms to a report made by Akinyosoye (1985) which stipulates that a low nitrogen supply reduces stem extension with pale leaf colouration which becomes darker immediately after nitrogen is increased. The maximum supply of available phosphorus and calcium may also be a cause to the plant height. This was observed by Togun and Akanbi, (2002) who reported that, high level of available phosphorus throughout the root zone is essential for rapid development and good utilization of water and other nutrients by the plants. The low plant height recorded for NPK fertilizer only (T_2) and *Tithonia* only (T_1) may also be due to the presence of soil acidity which might have retarded effective growth and development of plant. This is because the ideal pH for vegetable production or the optimum reaction for the majority of agricultural crops is in the range of 6.0 to 6.5 (Townsend, 1977). This observation is in agreement with Olayinka (1990) who asserted that soil acidity together with nutrients imbalance hinder sustainable use of inorganic fertilizers and recommended that compost and poultry manure should be made to use in vegetable production. To explain further the soil was acidic and the high amount of nitrogen in the NPK fertilizer (23-10-5) added to the acidic soil further increased the soil acidity and soil acidity is a factor which adversely affected yield of pepper in southwest Nigeria (Obi and Akinsola, 1995).

5.3 NUMBER OF BRANCHES

All application involving poultry manure caused high branching of plants. Combined treatment of NPK + Poultry manure recorded the highest number branches (9) and this was significantly different from the effect of *Tithonia* + poultry manure as shown in Table 4. These high number of branches may be due to the fact that both organic and inorganic manure were able to release most nutrients to the plant. When nutrients are in low supply, healthy and vigorous growth would be retarded and more branching may not occur. This finding is confirmed by Flores et al., (2007) when he asserted that insufficient fertilizer or nutrient deficient soil can slow down growth or cause stunted growth. Since nutrient play important roles in the physiological function in the development of plants, it is evident that, both organic and organic fertilizers can be used to supply nutrients. In effect maximum supply of nutrients would lead to vigorous and luxuriant growth by way of producing more branches. However, when there is excessive vegetative growth, fruit setting is reduced and yield is reduced. This was observed by Flores et al., (2007) when they found out that increasing mineral fertilizer rate was found to increase vegetative growth at the expense of fruit quantity. The low number of branches obtained from Treatment 1 (*Tithonia* only) and Treatment 2 (NPK fertilizer only) may be due to low application rate of the treatments. This is because nitrogen, phosphorus and potassium are the main elements which affect the growth and branching of plants including pepper. Therefore a low nitrogen supply causes stunted growth and accelerated flower abortion. Sanchez (1986) affirmed that generally, pepper growth and branching is vigorous with adequate supply of nutrients. The high number of branches due to treatment (T_6). NPK + Poultry Manure, may also be due to the fact that organic manure supplied nutrients regularly and slowly making nutrients available to the plants at all time. This regular supply of nutrients contributed to the large number of branches as pertained to Treatment 6 (NPK + Poultry manure) and T_4 (*Tithonia* + Poultry manure). In support to this observation, Swanson, (2000) stated that to ensure continuous supply of nutrients for luxuriant growth, organic and inorganic fertilizer may be combined so that nutrients are available to plants for an extended period of time.

5.4 NUMBER OF FRUITS AND WEIGHT OF PEPPER

The results on the number of fruits as well as on yield parameters showed a positive effect of T_6, T_4, T_5 on pepper production (Table 5 and 6). The differences among the treatments were significant at ($P<0.05$) The combined treatment of poultry manure + NPK registered the highest number of fruit and fruit weight but this was not significantly different from the combined effect of *Tithonia* + poultry manure as well as *Tithonia* and NPK.

The increase in number of fruits and average weight could be attributed to the ability of poultry manure and *Tithonia* to promote vigorous growth, increase in physiological activities in the plants due to supply of plant nutrient and improvement in the soil properties. This resulted in the synthesis of more photo-assimilate which is used in producing fruits. Gupta and Shukla (1977) reported an increase in number of fruit and size of fruits due to increase in nitrogen application. The results show that poultry manure is rich in nutrients more especially calcium as shown in Figure 1. However, the quantity and nutrient supplies depend on the type of bird (layer or broiler) and the age of birds (chicks, pullet or adult) (Zublena and Carter, 1997). The improved performance of *Tithonia* and poultry manure treatments over the control in growth and yield parameter could be due to the fact that, poultry manure together with *Tithonia* contained essential plant nutrients for high photosynthetic activities which promoted the pepper growth. This results for high photosynthetic activities which promoted the pepper growth. This resulted in increase in both number of fruits and fruits weight.

The increase in yield may also result from higher percentage of flowers and fruit set. When more flowers are developed, there is likelihood of more fruits being produced for yield. More flowers can be obtained when the right quantity and quality of plant nutrients are supplied. Poultry manure and its combination contained appreciable amount of nutrients, with calcium being the most available nutrient as observed in Fig 1. Therefore, if large amounts of poultry manure are applied to plants, more yield would be obtained. This was observed by Aliyu (1997) when he studied the effect of farmyard manure and poultry manure on growth of pepper and found that poultry manure at 9 t ha^{-1} significantly increased plant height, number of fruits and fruit yield of pepper compared with 3 t ha^{-1}. The release of nutrients from poultry manure and its combination which resulted in high yield is in conformity with Aliyu (1997) who reported application of poultry manure led to increased soil organic matter, nitrogen and phosphorus and this had direct bearing on the growth and yield of pepper.

Similarly, Akande and Adediran (2004) also studied the effect of poultry manure on yield of pepper and reported that poultry manure at 5 t ha^{-1} significantly increased pepper yield and as well increased nitrogen, phosphorous, potassium, calcium and magnesium uptake. From figure. 1, the maximum nutrient supplied is calcium and this perhaps contributed to the high yield of crop. This is because calcium as supplied by poultry manure is most important as a soil conditioner and as a nutrient (Akinsami 2001). He further added that calcium strengthens plant cell wall, neutralizes acidity and helps in the translocation and storage of carbohydrate and proteins into seed and tubers.

In this study, the high levels of calcium released by the organic material could have raised the pH levels to desirable levels required by the pepper plant because of its neutralization effect on soil acidity. The high yield of the crop contributed by poultry manure and its combinations confirmed the assertion made by Smith et al., (1993) when they hypothesized that the combination of organic and inorganic nutrients sources is more beneficial than the sole application of inorganic fertilizers. This ensures that maximum amount of nutrients are needed for use by plants. Furthermore, the response of organic manure, both green manure (*Tithonia*) and poultry manure combinations, contribute to the high yield of pepper as was observed by Beckman (1973) when he reported that use of organic manure application enhances soil productivity, increase soil micro organisms, improves soil crumb structure, improves nutrient status of the soil and enhances pepper yield. Therefore, improvement in soil physical properties, caused by application of poultry manure, let to improve growth and yield of crop.

Considering the nutrients supplied by various treatments (Figure 1), it was observed that, the major nutrients that contributed to the high yield of pepper included nitrogen, phosphorus, potassium, magnesium and calcium and each element had its unique contribution to the yield of the crop. For instance, the addition of nitrogen promoted vegetative growth as well as the setting of flower and fruits (Saxena et al., 1975). Akinyosoye (1985) also confirmed that insufficient amount of nitrogen limits yield and produce fruit of poor quality. Phosphorus also promoted root growth, flower, fruit and seed development and stimulate stiffer stems (Addo-quaye, et al., 1993). Potassium, according to Russel, (1973) improves quality of pepper fruit and that insufficient supply of potassium results in fruits and seeds becoming poor in quality and of reduced size and weight. These assertions support the idea that pepper growth and development is vigorous with adequate supply of nutrients as observed by Sanchez, (1986).

The fruit weight of treatment 6 (NPK + Poultry manure) and treatment 4 (*Tithonia* + Poultry manure) were generally heavier than that of the other combinations and this could be due to better nutrient status of organic material applied to the soil.

The effect of N.P.K fertilizer on number of fruits and weight was low compared to the other treatments, except the control. This may result from the fact that, the soil was strongly acidic (pH 4.7), and as affirmed by Olayinka (1990) acid soil hinders sustainable use of inorganic fertilizer in the soil. However poultry manure and its combinations were able to effect high yield of the crop. This yield increase with poultry manure and its combinations can be attributed to the high calcium content and other minerals. Calcium can neutralize acid soil and raise pH making more nutrients available to soil (Akinsanmi, 2001). He affirmed that calcium is most important as a soil conditioner and can increase ion exchange capacity and makes more nutrients available for plant use.

When the soil is acidic and more nitrogen is applied (NPK 23-10-5) it may increase the acidity of soil because of the high nitrogen composition, and yield would be reduced. Thus on acidic soils, extensive use of nitrogen containing fertilizer (NPK 23-10-5) may have a depressing effect on yield of pepper. This causes reduction in number of fruits, reduces fruit setting which subsequently leads to heavy vegetative growth (John et al., 2004).

The sole application of *Tithonia* also recorded low value for the number of fruits and weight of fruits. The low value may also be attributed to many factors including acidity which does not facilitate the release and nutrients uptake. The assumption that the low yield which is attributed to many environmental factors including soil acidity is confirmed by Obi and Akinsola (1995) when they reported that, soil acidity was a factor which adversely affected yield of tomato, and pepper in South-West Nigeria. Similarly, Andrew (1982) also asserted that acid soil adversely affects nitrogen uptake. However, when organic manure is continuously added to the soil it will reduce the rate of acidity. This idea agrees with Agboola et al., (1975) and Charreau (1975) who reported that through regular application of manure, acidification is greatly reduced or reversed, the content of exchangeable calcium and magnesium are increased and the uptake of phosphorus is promoted.

The low yield of crop from *Tithonia* may have resulted from the fact that the rate of decomposition to release nutrients was not effective. This is because, the decomposition of organic materials depends on the amount of water regime in the soil, temperature, substrate quality and micro organisms active in the decomposition process (Witkamp, 1971). Since the experiment was conducted in the dry season, perhaps, the watering might have been insufficient for effective decomposition.

Meentemayer (1978) reported that the two most important control of the rate of decomposition are substrate quality and moisture; Organic matter was moderate, and with insufficient water retention fresh green *Tithonia* may not be able to decompose well to release the desired nutrients for good yield of crop.

The low yield from *Tithonia* may also be attributed to the fact, the quantity of *Tithonia* applied was not enough to release the required nutrients for growth and yield. This agrees with the assertion by Jama et al., (2000) when they reported that the quantities of green biomass available for *Tithonia* will not typically supply all the nutrients required to eliminate nutrient deficiencies and hence asserted that integration of *Tithonia* and mineral fertilizer would have added advantage as compared to sole use of mineral fertilizer or *Tithonia.*

The soil water retention capacity of the soil was low during the experimental period, therefore during watering soil water quickly dried up due to intense sunlight. This condition led to abortion of some flowers and even fruits which eventually accounted for the low yield of the crop. This condition of flower abortion and poor fruit set was also observed by Schussler and Westigate (1995) when they reported that water stress during flowering stage reduced assimilation of sucrose resulting in abortion of flower shortly after fertilization. Soils high in organic matter can retain more moisture and thus enhances better yield of crops.

Similarly, when the amount of moisture needed for plant growth is not available, it tends to reduce the leaf area of plant and this reduces the amount of nutrients and photosynthetic activity available for plant growth. This situation was also observed by Marschner (1986) when he reported that water stress tend to reduce mineral element uptake by pepper through reduction in diffusion co-efficient.

The combination of NPK and poultry manure or NPK and *Tithonia* resulting in appreciable yield of crop implies that, there is possibility of combining appreciable rate of poultry manure with a low rate of NPK during crop production. In this way, chemical fertilizer application is reduced when poultry manure is used. This agrees with the finding of Baldwin (1975) that when manure is applied, there is reduced application rate of commercial fertilizers. The good performance of pepper under poultry manure + mineral fertilizer in this study indicates the importance of integrated plant nutrient system simply because the current low level of mineral fertilizer use in the country is grossly inadequate to maintain soil fertility levels for high yield. On the other hand, the low nutrient content of organic matter means that large quantities are required to produce comparable effects to those of mineral fertilizer. Furthermore, the low yield of crops also implies that addition of large amount of organic matter should be added to tropical soil and this can help reduce the trend of soil nutrient depletion and leaching problems in the tropics and this will sustain crop productivity.

Better crop performance observed in plots treated with poultry manure and *Tithonia* over the control might have resulted from an increased nutrient availability and beneficial effect of organic matter leading to a more favourable soil condition. A high level of organic matter in the soil indicates reduced bulk density, improved soil structure, aeration and high water holding capacity all of which are attributes of a productive soil (Hsieh and Hsieh, 1990) and hence a high yield of crops.

CHAPTER SIX

CONCLUSION

This study generally showed that the combined treatment of poultry manure and *Tithonia diversifolia* as well as poultry manure and NPK fertilizer, produced better and healthier growth of pepper, than sole application of *Tithonia diversifolia* and N.P.K fertilizer.

Consequently, the combined applications produced higher yields of pepper. The poultry manure and *Tithonia* or N.P.K fertilizer improved macronutrients availability. Again the decomposition of green manure (*Tithonia*) and poultry manure produced humic material which increased the nutrient retention capacity of the soil and this condition provided sustained source of macro and micro nutrients to plant growth. It is therefore concluded that the application of organic residues to nutrient depleted soil ensures a sound nutrient management system, by improving the chemical properties of soil.

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Finally combined treatment of *Tithonia* and poultry manure (8.6ab) was not significantly different from NPK fertilizer + *Tithonia* (8.0 ab). However poultry manure + NPK fertilizer (8.7ab) would be a more sustainable strategy to maximize crop yield as this ranked the best parameter for crop growth and yield. There was a complimentary effect of organic manure and inorganic fertilizer when both were used together and this indicates potential for sustainable growth of crops in Ghana.

RECOMMENDATION

It is recommended that with reference to the effects of the combined treatment of poultry manure and N.P.K fertilizer, integrated management approach is ideal for adoption in Ghanaian agricultural productivity. Therefore, the use of poultry manure and *Tithonia* in supplementation with inorganic fertilizer is highly recommended.

Again when using organic manure for crop productivity there is the need for heavy doses of organic manure, because micro organisms may use some of the nutrients during the decomposition process and the quantity released will reduce, preferably poultry manure should be used. *Tithonia diversifolia* can also be planted in situ at places where vegetable production is to be established so that they can be cut and incorporated before planting.

To researchers, I recommend that for plants to achieve their best growth in relation to their environmental condition, study may be conducted during the rainy season.

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APPENDIX

APPENDIX A1 – SOIL PROPERTIES

PROPERTIES	RANK/GRADE
Soil pH Distilled water method	
<5.0	Very Acidic
5.0 – 5.5	Acidic
5.6 – 6.0	Moderately
Acidic	
6.1 – 6.5	Slightly Acidic
6.6 – 7.0	Neutral
7.1 – 7.5	Slightly Alkaline
7.6 – 8.5	Alkaline
>8.5	Very alkaline
ORGANIC MATTER (%)	
<1.5	Low
1.6 – 3.0	Moderate
>3.0	High
NITROGEN (%)	
>0.1	Low
0.1 – 0.2	Moderate
>0.2	High

PHOSPHORUS, P(ppm)

>10	Low
10 – 20	Moderate
>20	High

POTASSIUM, k(ppm)

>50	Low
50 – 100	Moderate
>100	High

CALCIUM, Ca (cmol(+)kg^{-1})

>5	Low
5 – 10	Moderate
>10	High

EXCHANGEABLE POTASSIUM (comol(+)kg^{-1})

<0.2	Low
0.2 – 0.4	Moderate
>20	High

SOURCE: SOIL RESEARCH INSTITUTE (CSIR)

APPENDIX A2 - PLANT HEIGHT

ANOVA

	Sum of squares	Df	Mean square	F	Sig
Between group	207704.286	6	34550.714	46.771	
	0.000				
Within group	10342	14	738.714		
Total					

APPENDIX A3 - NO OF BRANCHES PER PLANT

ANOVA

	Sum of squares	Df	Mean square	F	Sig
Between groups	5370.28	6	896.048	7.101	
	0.001				
Within groups	1764.667	14	126.048		
Total	7134.962	20			

APPENDIX A4 – NUMBER OF FRUITS PER PLANT

ANOVA

	Sum of squares	Df	Mean square	F	Sig

Between groups	811468.37	6	13578.095	17.455	
	0.000				
Within groups	10890.66	14	777.905		
Total	92359.238	20			

APPENDIX A5 - WEIGHT OF FRUITS IN GRAMS

ANOVA

	Sum of squares	Df	Mean square	F	Sig
Between groups	4704.667	6	784.111	16.854	
	0.000				
Within groups	651.333	14	46.524		
Total	5356.000 20	20			

APPENDIX A6 – PERCENTAGE EARLY FLOWERING

ANOVA

	Sum of squares	Df	Mean square	F	Sig
Between groups	6666.667	6	1111.111	16.593	
	0.000				
Within groups	937.500	14	66.964		
Total	7604.167	20			