KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

KUMASI, GHANA

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

FACULTY OF AGRICULTURE, DEPARTMENT OF HORTICULTURE

EFFECT OF FERTILIZER TYPE AND NODAL PINCHING ON GROWTH, FLOWERING PATTERN AND YIELD OF CUCUMBER (*Cucumis sativus*).

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (OLERICULTURE) DEGREE

BY

JOANA FRIMPONG

JUNE, 2011

DECLARATION

I do hereby declare that this work is my own original work and the results of my own investigations and that no such work has been presented in this University or elsewhere, in a previous application for MSc degree.

References made to the works of other authors which served as sources of information are duly acknowledged.

Joana Frimpong Signature.................................... Date...................................
Student's ID: 20067644

Certified by:
Patience Dzifa Kaledzi (Ms.) Signature.....................................Date....................................
(SUPERVISOR)

Dr. B.K. Maalekuu Signature.....................................Date....................................
(HEAD OF DEPARTMENT)

ACKNOWLEDGEMENTS

I wish to express my profound thanks to Ms. Patience D. Kaledzi, my supervisor and Lecturer at the Department of Horticulture, KNUST, Kumasi, for the encouragement she gave to me throughout the period of the project and also for going through the manuscripts with her useful suggestions. I thank Mrs. Gladys M. Timpo a former Senior lecturer at the Department of Horticulture, KNUST, Kumasi who earlier supervised the project and offered valuable suggestions during the design and conduct of the experiments.

I am most grateful to Dr. Ben K. Banful a Lecturer at the Department of Horticulture, KNUST who used his in-depth knowledge and experience in Research Methodology to assist me with a suitable format for presentation of statistical analyses and also assisted in the corrections of the write-up.

I also owe a debt of gratitude to Dr. Charles Kwoseh, a Plant Pathologist and Lecturer at the Department of Crops and Soil Sciences, KNUST for his assistance in the laboratory work to identify the fungal disease which attacked experimental plants on the field.

My sincere appreciation goes to all lecturers, staff, field workers and colleague students of the Department of Horticulture, KNUST who offered assistance in diverse ways to make the project successful.

Finally, I thank Mr. Kwadwo Boahene for his encouragement and financial support throughout this course.

ABSTRACT

Two field trials were conducted during the wet and dry seasons to study the effect of fertilizer type and pinching on the growth, flowering pattern and yield of cucumber (*Cucumis sativus)* at the Department of Horticulture, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology (KNUST) from May to August 2009 (Wet season) and from October to February 2010 (Dry season). The experiment was a 3 x 3 factorial in a Randomised Complete Block Design (RCBD) with 3 replications. Fertilizer type, as the first factor, comprised poultry manure, NPK (15-15-15) and no fertilizer. Pinching out of terminal bud which represented the second factor was made up of no pinching, pinching on 6th node and pinching on 10th node. Poultry manured treatments were fertilized with 1000kg ha^{-1} of the manure while NPK (15-15-15) treatments received 100kg ha^{-1} of the fertilizer. At the vegetative stage, with respect to the fertilizer types, plants fertilized with NPK (15-15-15) and poultry manure produced significantly more ($P < 0.05$) leaves, branches and taller plants than the control 21 days after germination for the two seasons. However, NPK (15-15-15) and poultry manured plants indicated comparable values for the number of leaves, branches and plants' height during that period. Poultry manured plants produced significantly greater number of branches ($P < 0.05$) compared to plants fertilized with NPK (15-15-15) and the unfertilized plants 28 days after germination in the wet season. Plants pinched at the 6th node without fertilizer also produced significantly more ($P < 0.05$) branches than 10th node pinched plants and un-pinched plants (control) 28 days after germination for the two seasons. However, the interactions of the two factors could not produce significant differences with respect to the parameters taken at the vegetative stage. At the reproductive stage, NPK (15-15-15) plants produced significantly greater number of female flowers ($P < 0.05$) than the poultry manured plants and the control plants. The number of female flowers produced by the 6th node pinched plants also showed significant differences ($P < 0.05$) in comparison to those produced by the 10th node pinched plants and the control in wet season. Increase in number of branches by either fertilizer type or pinching treatments resulted in increase in flower production, fruits set and consequently increase in harvested fruits. However, adverse weather in both seasons resulted in fruit abortion which reduced the fruit yields in the NPK (15-15-15) treatments. Nutrient deficiency was also a contributing factor. With regard to marketable yields in the wet season, plants that received poultry manure produced the greater number of marketable fruits than the control ($P < 0.05$). In the dry season, significantly ($P < 0.05$) greater number of marketable fruits were produced by the two fertilizer treatments over the control. The highest number of marketable fruits for the wet and dry seasons (53,300 and 29,200 fruits ha^{-1} respectively) were produced by plants that received poultry manure and were pinched at the 6^{th} node. In economic terms, application of 1000kg ha^{-1} of poultry manure and pinching at the 6^{th} node resulted in the highest net profit for both wet (GH₵4,292.56) and dry (GH¢4,755.21) seasons. In conclusion, application of 1000kg ha^{-1} poultry manure and pinching at 6^{th} node is recommended for adoption by farmers for high profit.

TABLE OF CONTENTS

LIST OF TABLES

PAGE

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

PAGE

LIST OF PLATES

PAGE

CHAPTER ONE

1.0 INTRODUCTION

Commercial vegetable production is gaining prominence in Ghana. This is partly due to the production of crops with export potential as well as public education from Health experts and Nutritionists on the need to consume more vegetables in the diet to avoid diseases like cancer, hypertension, coronary disease, diabetes, hepatitis B and anaemia (Gopalan, 2004). Matthew and Karikari (1995) suggested that 85-113g of leafy and 57- 113g of non-leafy vegetables should be consumed/day/person for healthy growth.

Vegetables produced in Ghana for both local and international markets include okra (*Abelmoschus esculentus)*, garden eggs (*Solanum melongena*), chili (*Capsicum annuum longum)*, onions *(Allium cepa)*, green beans (*Phaseolus vulgalis)* and cucumber (*Cucumis sativus)* (Norman, 2003). Cucumber has been identified as one of the cultivated exotic vegetable crops that has gained popularity in Ghana because of its export potential (Sinnadurai, 1992; MOFA, 2002). In the global market, Wehner and Maynard (2003) reported that about 80% of the World's production of cucumber is in Asia with China leading production (60%) followed by Turkey, Russia, Iran and the United States of America (U.S.A.) in that order.

Cucumber is believed to be indigenous to an area in India between the Himalayas and the Bay of Bengal and was introduced to West Africa by the Europeans in 1940 (Sinnadurai, 1992). Cucumber is a warm season crop that can tolerate high temperatures in the presence of sufficient moisture but cannot withstand waterlogged conditions (Messiaen, 1994). Optimum growth occurs between 20^0C -25^0C, with growth reduction occurring below 16^0C and above 30^0C. (Takeda, 1981). However, research by Shalaby and Hussein (1994) showed that lower temperatures and shorter days promote increased female tendencies in cucumber. High relative humidity encourages fungal diseases like Downy and Powdery Mildews, Angular Leaf Spot, Anthracnose and Scab. The preferred soil is well drained sandy loam which is rich in organic manure with a pH of 6.5-7.5 (Awuku *et al.,* 1993).

In Europe and the U.S.A., cucumber varieties can be grouped as pickles and slicing types. The pickles are those preserved in vinegar or brine (salt) or spices before they are served while those eaten fresh after peeling and slicing are called slicing cucumber (Kelly *et al.,* 2000). In Ghana, cucumber can be eaten raw as a relish or used in the preparation of vegetable salad, stew or sandwich (Sinnadurai, 1992). Cucumber fruit contains about 95% water and hence is recommended as a natural diuretic and for body building. It is low in Vitamin C, and potassium. The skin contains some amount of vitamin A. The fruit is also used to produce facial mask, body creams, lotions and shampoo. It helps to drop high blood pressure to healthier levels when eaten regularly and also helps to cure kidney ailments (Anonymous, 2006). Thus cucumber is not only needed as food for good health but also as raw material in the cosmetic industries.

There are different cultivars of cucumber but the most commonly grown in Ghana are the Ashley and the Poinsett. These are monoecious cultivars and bear separate male and female flowers on the same plant but genetically the female flowers are far less than the male flowers as compared to the gynoecious cultivars which produce only female flowers. Cucumber farmers in Ghana are therefore faced with the problem of low yields since the female flowers which ultimately produce fruits are few on the plants. Pinching out technique which is the removal of terminal bud is not practised by cucumber farmers in Ghana however, Dupriez and De Leener (1989) stated that the activity does not kill the plant but promotes the production of auxillary or lateral shoots which tend to increase female flowers. Experiments conducted by Hikosaka and Sigiyama (2004) in a greenhouse in France showed that pinching of terminal buds helped to increase female flower production in a monoecious type (multi-pistillate '028') of cucumber.

Commercial vegetable growers mostly rely on chemical fertilizers to speed up plant growth and increase yield. It is one of the ways by which the nutrient status of soil can be augmented to meet crop needs thereby maintaining the fertility of the soil. However, Dupriez and De Leener (1989) noted that chemical fertilizers lower plant resistance to pest and disease attack and also reduce the quality of taste and shelf- life of vegetable crops. Awuku *et al.* (1993) stated that for improvement of both soil structure and fertility, inorganic fertilizer should be avoided. A report by Wiggins (2005) indicated that inorganic fertilizer is no longer within the reach of poor-resource farmers due to its high cost. Magkos *et al.* (2006) also reported that consumers prefer organic foods to conventionally produced foods because they perceive organic foods as healthier and safer. Research conducted by IBSRAM *AFRICALAND* network on Sustainable Land Management with poultry manure as alternative fertilizer for soil amendment attested to this fact (Drechsel and Quansah, 1998). It was also observed that poor husbandry techniques and management practices are among factors hindering vegetable production in Ghana (Awuku *et al.*, 1993; Rosendahl *et al.*, 2008).

Cucumber is a fruit vegetable, hence requires soil containing nutrients that can assist in both vegetative growth and fruit development of the crop. Poultry manure has been rated among the best organic manures which is rich in phosphoric acid, a nutrient necessary for fruit development (Sinnadurai, 1992). Another factor that controls fruitfulness is the Carbon:Nitrogen (C:N) ratio of organic materials in the soil. According to Matthew and Karikari (1995), abundant carbon for photosynthesis and moderate supply of nitrogen to a developing fruit crop induces flowering. Poultry manure used by Vimala *et al.* (2001) to grow tomato in their research work was observed to show up these characteristics; the poultry manure had a C:N ratio of 8.3 and yielded 15.7kg per plot whilst green manure with C:N ratio of 19.2 yielded 11.0kg on the same plot size ($4m^2$).

The main objective of this research was therefore to assess the effects of poultry manure as a soil amendment and pinching of terminal bud on the growth, development and yield of cucumber.

The specific objectives were:-

1. To assess effects of poultry manure and NPK (15-15-15) on the development and yield of cucumber.

2. To study the effect of pinching of terminal bud at different growth stages on the development, flowering pattern and yield of cucumber.

3. To assess the interactive effects of fertilizer type and pinching on the growth, development and yield of cucumber.

CHAPTER TWO

2.0 LITERATURE REVIEW

2 .1 Botany of crop

Cucumber (*Cucumis sativus*) is a creeping vine belonging to the Cucubitaceae family. The plant has large leaves that form a canopy over the fruit. It develops thin spiraling tendrils which direct the plant to climb when provided with a support. Both male and female flowers are yellow but the female flower can be identified with a swelling at the base and is also borne on a short peduncle as compared with the male on a longer peduncle (Dupriez and De Leener, 1989). The sex expression of a cucumber plant can make it a monoecious cultivar (bear separate male and female flowers on the same plant), gynoecious cultivar (produce only female flowers) or parthenocarpic cultivar (female flowers require no pollination/fertilization for fruit production) (Papadopoulos, 1994). Both male and female flowers are yellow but the female flower can be identified with a swelling at the back and is also borne on a short peduncle as compared to the male on a long peduncle (Dupriez and De Leener, 1989). The fruit is roughly cylindrical, elongated, with tapered ends. Different varieties of cucumbers vary in length from about 10 to 76 cm. If the cucumber is allowed to mature, the fruit bulges in the middle, changes in colour from green to yellow, and is not fit to be eaten (Redmond, 2007). Having an enclosed seed and developing from a flower, cucumbers are scientifically classified as fruits. Much like tomatoes and squash, however, their sour-bitter flavor contributes to cucumbers being perceived, prepared and eaten as vegetables.

2.2 Factors affecting cucumber production

2 .2.1 Environmental factors that affect cucumber production

Cucumber grows best under conditions of high temperature, low humidity, moderate light intensity, good soil structure with an uninterrupted supply of water and nutrients (Papadopoulos, 1994).

Optimum temperature for cucumber growth is between 20^0C to 25^0C, with growth reduction occurring below 16^0C and above 30^0C (Hector *et al*., 1993). Singh (1997) reported that growth and development in cucumber were adversely affected at temperatures less than 5^0C but increased with increasing temperatures up to 40^oC, and above 40^oC decreased drastically.

Humidity is dependent on rainfall thus humidity is higher during the wet season than in the dry season. Papadopoulos (1994) stated that disadvantages of cropping under conditions of high relative humidity include the increased risk of water condensing on the plants and the development of serious diseases such as Downy and Powdery mildew. The resultant low transpiration rates are blamed for inadequate absorption and transport of certain nutrients, especially calcium to the leaf margins and fruits. At low relative humidity, irrigation becomes critical, because large quantities of water must be added to the growth medium without constantly flooding the roots and depriving them of oxygen. Furthermore, low relative humidity favours the growth of powdery mildew and spider mites. According to Sinnadurai (1992), the incidence of fungal disease is directly related to atmospheric humidity. Babadoost *et al.* (2004) also revealed that germination and growth of fungi spores (eg. conidia) are optimum at 96% relative humidity and temperature range of 22-27^0C.

Poincelot (2004) classified cucumber as a day-neutral crop. Research however indicated that high light intensity tends to increase the number of staminate (male) flowers while lower light levels tend to increase production of more pistillate (female) flowers. Leaf production is promoted under short day lengths and fruit production is stimulated under short day length and relatively high night temperatures (Anonymous, 2005). Camejo *et al*. (2005) also reported that high light intensity, for example, light bulb of 100 watts accompanied by high temperature example, 40^oC is harmful to fruit-set since it affects the internal temperature of the reproductive organ of cucumber. Wahid *et al*. (2007) explained that high temperature induced sterility of cucumber and this occurs before or during anthesis.

The soil provides a medium in which a proper balance exists between air, water and nutrients. If this balance is ensured, plant roots can easily obtain water and nutrients, resulting in rapid growth. Although cucumber can be grown on a wide variety of soils, the most suitable are those classified as loams, sandy loams, and some silty – loams, all with a high organic-matter content (Kelly *et al.*, 2000).

Water, an essential plant constituent for hydration, a medium for biochemical and metabolic reactions and nutrient absorption and translocation is in a continual state of flux. Water stress thus affects photosynthesis, respiration and all the above stated activities (Poincelot, 2004; Acquaah, 2005). Poincelot (2004) indicated that continued water deficiency eventually produces irreversible alterations of the plant that result in death. He further stated that under hot dry conditions, water loss may occur quite rapidly in plants that are not structurally adapted to prevent water loss. The cucumber plant, in spite of its extensive and moderately deep root system which enables it obtain greater quantities of water from the soil, tends to lose water rapidly under strong sunlight conditions because of its broad leaves (Yamaguchi, 1983). Research at Ohio State University Extension on Vegetable Gardening (Anonymous, 2003) revealed that fruit crops like tomatoes, cucumbers and peppers should be adequately watered between flowering and fruit production stages for best results in fruit development. Cucumber fruit contains about 95% water (Hector *et al.,* 1993) and Albert (2009) reported that water stress may cause a 50% reduction in cucumber fruit weight.

2.2.2 Influence of Soil pH on Vegetable crops

Soil pH measures how acidic or how alkaline a soil is. It affects the availability of nutrients in the soil to crop plants. Kelly *et al.,* (2000) indicated that pH of between 6.0 and 6.5 was best for cucumber production. Anonymous (2009) reported that pH values higher than 7. 2 resulted in the burning of cucumber roots due to excessive salt. Webster and Wilson (1989) also reported that soils with pH below 5.5 are considered low (strongly acidic) and may not have calcium, molybdenum, magnesium or phosphorus readily available to plants while soil pH of 7.8 or more is considered high and may have low availability of phosphorus, iron, manganese and zinc. Dupriez and De Leener (1989) reported that Magnesic lime fertilizer helped to correct a soil deficient of calcium and magnesium for the cultivation of tomato whilst Webster and Wilson (1989) also reported that liming some strong acid soils to pH 5.5 was observed to have increased phosphate availability. They further stated that organic phosphorus formed 20-30% of the total phosphorus in the top 15cm of most Ghanaian soils. They however added that increasing rainfall may cause organic phosphates to move down the profile beyond the reach of plant roots but such leaching is unlikely to happen to inorganic phosphates since it is held by iron and Aluminium. Sulphur and Aluminium compounds according to Potashcorp (2009), are usually added to reduce soil pH.

2.2.3 Chelating and cation exchange properties of organic matter

Chelate is a chemical compound in which metallic and non-metallic usually organic atoms are combined. The compounds are characterized by a ring structure in which a metal ion is attached to two non-metal ions by covalent bonds (Acquaah, 2005). Certain trace elements such as Fe, Mn, and Zn can be held in chelated form by organic matter present in the soil. Chelations keep these trace elements from forming chemical complexes in the soil with other nutrients. Such complexes tend to make the affected trace elements unavailable to plants though there are enough present in the soil (Acquaah, 2005). According to Poincelot (2004), when organic matter forms chelates with Fe and Al it reduces the ability of these two chemicals bonding chemically with phosphate. Phosphate complexes with Al and Fe make phosphate unavailable to the plant. Another property of organic matter is its ability to regulate available nutrients in the soil. Rashid *et al.* (2008) in a study to assess the fertility of soils from Peshawar and Charsadda districts in Pakistan reported that the humus content of loamy soil with its numerous negative charges (anions) eg. NO_2^- , NO_3^-, OH^- Cl^-. PO_4^- hold onto the positive charges (cations) eg. Ca^{2+} and K^{2+} to control leaching of such nutrients in a process referred to as cation-exchange. The chemical reactions in cation-exchange make it possible for these elements to be changed into water-soluble forms that plants can use for food. Therefore, a soil's cation exchange capacity is an important measure of its fertility (Papadopoulos, 1994). Poincelot (2004) reported that optimum organic matter content in soils for vegetable growing is considered to be 2.5-3.0 % for outdoor crops. Analysis of a soil sample at a depth of 0-15cm of a research site earmarked for the study of effect of soil amendments on the growing of water-melon gave organic matter content as 1.80% with exchangeable cations (mol/Kg) as follows, Ca-9.26, Mg- 4.46, Na- 91.07, K- 53.67, C E C-272 (Ajayi *et al.*, 2009).

Soil organic matter status has been identified as one of the most useful indicators of soil fertility (Agboola, 1993), thus it is imperative that agricultural practices be developed to guarantee stable soil organic matter levels.

2. 3 Debilitating effect of heavy use of inorganic fertilizer on curcubits

Mathew and Karikari (1995) stated that inorganic fertilizers are also called commercial or chemical fertilizers and have much higher concentration of nutrients than organic manures but lack their soil improving properties. John *et al*. (2004) indicated that extensive use of inorganic fertilizer had a depressing effect on the yield of water melon. They observed that it caused reduction in the number of fruits, delayed and reduced fruit setting leading to delayed ripening. They asserted that inorganic fertilizer is an important source of nitrogen hence resulted in heavy vegetative growth. The authors however advocated for an integral use of organic manure and inorganic fertilizers for the supply of adequate quantities of plant nutrients required to sustain maximum crop productivity and profitability while minimizing environmental impact from nutrient use. Magnesium is required in cucumbers to help obtain a deep-green fruit color However, a study conducted by Hector *et al.* (1993) revealed that cucumber fields which received high NPK (15-15-15) fertilizer rates (greater than 2,500kg ha^{-1}) resulted in a high deficiency of magnesium causing fruits to develop light green colour and thus reduced the quality of fruits. Sinnadurai (1992) indicated that heavy doses of nitrogen fertilizers like Ammonium sulphate (20.5% nitrogen, 23.4% sulphur) or Ammonium nitrate (32.5% N) can cause toxicity in water melon (*Citrulus vulgaris*) and muskmelon (*Cucurbita melo var reticulatus)* and as a result retard the growth of the plants. Dupriez and De Leener (1989) also added that chemical fertilizers lower plant resistance to attack by pests and diseases and also reduce quality of taste and shelf- life of curcubits. Sinnadurai (1992) however recommended that 220-1100kg per hectare of NPK (15-15-15) as suitable for good productive soils that have a pH of 5.5 to 6.5.

2.4 Studies on some organic and inorganic manures as nutrient sources for vegetable production

The organic vegetable grower depends solely on organic nutrient sources that are not fortified. Some of these organic sources are invariably low in nutrient contents compared to inorganic fertilizers. Inevitably, large quantities need to be used to provide all the macro- and micro-nutrients required for optimum growth and yield of crops. Studies on the yield response of cabbage to Palm Oil Mill Effluent (POME) showed that 60t ha^{-1} POME yielded 21t ha^{-1} while the application of 1.5 t ha^{-1} inorganic fertilizer increased yield to 34 t ha^{-1} (Vimala *et al.*,1998). Further, studies by Vimala *et al.* (2001) on the yield response of cabbage and tomato to 50 t ha^{-1} chicken manure yielded 39.33 t ha^{-1} for tomato and 37.30 t ha^{-1} for cabbage. Results of similar studies conducted by Vimala *et al.* (2001) to compare different organic nutrient sources on the yield of lettuce in the Cameroon Highlands showed that chicken manure out-yielded other organic and inorganic fertilizers used. The organic and inorganic fertilizers used in the research and their corresponding yields were as follows: Chicken manure - 22.90 t ha^{-1}, Kusocom-21.2 t ha^{-1}, Worm-compost-20.10 t ha^{-1}, NPK 15-15-15 –(600 kg ha^{-1}) -15.7 t ha^{-1}, Control - 9.3 t ha^{-1}. Another research on lettuce cultivar 'Green Fancy' was conducted by Paudel *et al.* (2004) to study the effect of 3 types of organic manures (cow dung, chicken manure, duck manure) and inorganic manures (NPK15-15-15 and Ammonium sulphate). The application rates were 4.5, 4.7 and 5.8 t ha^{-1}, respectively for the organic manures and 156 kg ha^{-1} NPK15-15-15 and 82kg ha^{-1} Ammonium sulphate. The crop grown with 4.7 t ha^{-1} of chicken manure alone and its combination with inorganic manures (2.35 ton chicken manure + 156 kg NPK15-15-15 together with 82 kg ha^{-1} of ammonium sulphate) gave a significantly higher yield throughout the crop season. These results indicate that nutrient availability in various organic fertilizers differ from one another and may not always provide sufficient quantities for high yields. A trial on the incorporation of green-manure on the yield of cucumber showed that green manure alone, applied at 29-37 t/ha gave low yields (13.53 t ha^{-1}) compared to green-manure + inorganic fertilizer (52.24 t ha^{-1}) (Vimala *et al.*, 2001). Thus green manure alone cannot be used as the only organic nutrient source. The researchers therefore recommended further studies on higher rates of green manures.

2 . 5 Poultry manure as an alternative organic fertilizer

Research conducted by Snrech (1994) revealed that the population growth rate for people living in the cities of West Africa would rise from 40% as was in1990 to 60% in 2020. This rise in population calls for increase in food production. Quansah *et al*. (1997) indicated that the limiting access of land for farming activities in West Africa is breaking down the traditional methods of maintaining soil fertility such as long fallow periods and clearance of new lands. The consequence is that the soil nutrient capital that once supported such settlements is gradually being depleted through harvest removals, and leaching. The authors further explained that the problem is exacerbated by the inability of most farmers to sufficiently compensate these losses by returning nutrients to the soil via crop residues, livestock and poultry manures and chemical fertilizers. Studies conducted by researchers as previously stated indicated that poultry manure could be used as an alternative fertilizer to increase vegetable production. Application of poultry manure to provide nutrients for crops also seeks to satisfy the five pillars of International Framework for Evaluating Sustainable Land Management as contained in a report by Dreschsel and Quansah (1998). These were indicated as follows:-

1. Maintaining or enhancing productivity.
2. Reducing levels of production risks.
3. Protecting the environment.
4. Economically viable.
5. Socially acceptable.

Reinhold *et al.* (1992) in his soil analysis for vegetable growing rated 3% nitrogen in soil as high and Hector *et al.* (1993) indicated that low nitrogen restricts growth, modifies the length-to-diameter ratio of fruit, reduces fruit set and colour development. Quansah *et al.* (1997) stated that poultry manure is rich in nitrogen, helps in the preservation of soil moisture, improves soil structure, provides quality and higher yields, is cheap, has long action on the field and controls nematodes in the soil. Secondly, poultry manure provides the soil with the necessary organic matter to replenish the ever-decreasing humus content of the soil which cannot be done by chemical fertilizer. Brady and Weil (1999) reported that broiler manure contains about 4.4% total Nitrogen, 2.1 % Phosphorus, 2.6 % Potassium, 2.3 % Calcium, 1.0 % Magnesium and 0.6 % Sulphur. John *et al*. (2004) also reported that poultry manure is very cheap and effective as a good source of N for sustainable crop production associated with high photosynthetic activity, vigorous vegetative growth and a dark green colour of the leaves.

2.6 Effect of poultry manure on nematodes

Chiudo (1990) experimented on the effect of poultry manure application on the severity of *Meloidogyne incognita* race 1 attack on tomato in the green house, in the field and *in-vitro* in Nigeria with 4 levels of poultry manure at 0, 2, 4 and 8t ha^{-1}. The three experiments showed that poultry manure had tremendous potential for controlling root knot nematodes. Both growth and yield of fruits of tomato increased significantly with rates of poultry manure at 4t ha^{-1} and above. According to Poincelot (2004) the predatory fungus that attacks nematodes thrives in soil rich in organic matter.

Hemeng *et al.* (1995) observed from a study of organic soil amendments and their multiple benefits to crop production that decrease in soil nematodes in addition to increase in yield occurred when rates of application of poultry manure were increased. Rates used were (0, 1, 2.5 and 5) tons poultry manure per hectare. Perry (1999) observed that adding organic matter to the soil helped to lessen the impact of nematodes on crops. He added that organic amendments are more useful in their ability to increase the water holding capacity of soils, especially in sandy soils, where root knot nematodes tend to be a greater problem.

2.7 Neem cake as nematicide

It was reported by Schmutterer (2002) that Cardamom growers in South India used neem cake to control nematodes. They incorporate 100-259 kg per hectare of neem cake in their cardamom fields every year and said that nothing worked as well than the neem cake. Parker (2005) reported that application of the Neem seed cake to crops when ploughed into soil protected plant roots from nematodes, white ants and other soil insects.

In a careful trial in Aligarh, India, amending soil with sawdust and neem cake dropped the root-knot nematode index to zero and of all the treatments tested and gave the greatest growth of tomatoes, a crop very sensitive to nematode attack (Ahmed 2009).

2.8 Effect of organic manure on growth and yield of cucurbits

Bandel *et al.* (1982) suggested that under normal conditions application rate of poultry manure for cucumber and water melon could be 8tons per hectare. They however stated that due to losses and low release of nutrients, for each ton of broiler manure applied, there is the need to allow for at least about 9kg N, 4.5kg P_20_5 and 2.3kg K_2O. George (1985) indicated that cucumber responds well to soils with relatively high organic matter content. Therefore if possible, the soil should receive a dressing of up to 8t ha^{-1} of well decomposed poultry manure during the early stages of soil preparation. Williams *et al.* (1991) asserted that cucumber can be grown on almost any soil but for good yields in the tropics, the crop requires a deep soil with higher organic manure. Stephens and Kostewicz (1992) in a soil amendment research with poultry manure on cucumber (Poinsett variety) harvested 150,000 fruits weighing 35.80 t ha^{-1} when they incorporated 4.5t ha^{-1} as against 60.000 fruits weighing 12.6t t ha^{-1} when no manure was added to the soil. Rice *et al.* (1993) indicated that poultry manure application rate of 2.5- 4.5t ha^{-1} is recommended for cucumber production. Messiaen (1994) also reported that for higher yields of cucumber, higher rates of organic manure at 50 – 70t ha^{-1} was needed.

Xiude *et al.* (1996) used poultry manure plus NPK fertilizer and micro elements including Zn and Mn. The formulation containing 88 % powered poultry manure, 4 % Urea, 40 % Potassium chloride and 4 % Boron sulphate was best for cucumber growth. Ajayi *et al.* (2009) in his soil amendment research work on water melon applied 9.0 t ha-^{1} of poultry manure which yielded 242,912 fruits ha^{-1} while 3.3t ha^{-1} application yielded 172,731 fruits ha^{-1}.

2 .9 Effects of poultry manure on other vegetable crops

Yagodin (1984) reported that dry poultry manure was applied as a basal fertilizer to vegetables and potatoes at a rate of 1- 2t ha^{-1} and the response was encouraging compared to compost. Corrales and Mareira (1990) and Hochmuth *et al.* (1993) both investigated the responses of cabbage to poultry manure, compost and conventional fertilizer NPK13-17-11. The rate of the organic manures (poultry manure, compost) application to the soil was 4t ha^{-1} for each of them. They reported of increased number of leaves and flowering rate in the poultry manure treatments as compared to the other soil amendments resulting in high yields. Hochmuth *et al.* (1993) reported that for the first marketable crop cabbage, poultry manure treatment gave maximum yield of 28.40t ha^{-1}, compost yielded 26.30t ha^{-1} while the NPK13-17-11 recorded 20.70t ha^{-1}. Oikeh and Asiegbu (1993) worked on four soil amendments using swine, poultry manure, compost and NPK fertilizer. The rate of application for the organic manures was 4t/ha each under field conditions for their comparative effect on tomato (*cv Rossol* VFN). Fruit yields were best with swine manure (10t ha^{-1}) followed by poultry manure, compost and NPK fertilizer in that order. Buchanan (1993) used poultry litter compost at 4 treatment levels (0, 2, 4, 6 tons ha^{-1} dry manure) in 3 replicates on a sandy loam soil plot previously under perennial rye grass for two years following spring broccoli (*Brassica oleracea*). In spring and autumn greater compost application led to greater broccoli yields.

2. 10 Flowering in cucumber

Several flowering habits exist in cucumbers. Most cultivars are monoecious, with separate male and female flowers in the same plant. Gynoecious or "all-female" cultivars produce only female flowers resulting in up to 13 times more female flowers than those obtained in monoecious cultivars. Many cultivars grown in greenhouses such as European cucumbers are parthenocarpic. In fact, pollination of these cultivars causes an off-shaped appearance of the fruit (Papadopoulos, 1994). Hector *et al.* (1993) indicated that sex expression in cucumber may be affected by several factors such as plant density, plant stress, temperature, and light intensity. Reduced rates of female flowers in gynoecious cultivars may result from exposure to stress caused by high plant population densities, insect attack, wind damage, and combinations of low light intensity and high ambient temperature. Research with monoecious plants has shown that good conditions, such as high temperature (27°C), sunny weather, high nitrogen, and ample water supply, promote male flower development while poor conditions promote more female flowers (Papadopoulos,1994). Myanmar (1997) indicated that some cucumber varieties produced female flowers and set fruits early such that the vegetative part would still be insufficient to support the normal growth of the fruit. According to the author, when this happens, further vegetative growth is restricted and additional fruit setting and development is equally affected. Riley (1998) indicated that while natural gibberellins increase the number of staminate flowers in cucumber, auxins found mostly at the tip of stems increased pistillate flowers thereby enhancing more fruits formation. Cucumbers will not pollinate with pumpkins, squashes, gourds, and watermelons, because they are not of the same genus, neither will they pollinate with some melons that belong to the same genus but are of different species (Kelley *et al.,* 2000).

2.11 Effect of pinching on vegetables

Pinching-out also known as stopping is the removal of the growing point of a stem to encourage lateral shoots or side branches which will eventually bear more flowers. It redirects auxin movement from the apical part to areas below the plant to stimulate lateral buds development (Lowes, 2009). Pinching just above the first set of Basil leaves (*Ocimum basilicum)* (vegetable herb) encouraged nodes under these little leaves to grow more side branches and removed apical dominance (Central Coast Gardening, 2010). Iannotti (2009) providing tips for growing tomato indicated that pinching prevents apical dominance and invigorates the growth of the lower parts. Lowes (2009) indicated that vegetables can be pinched back when they are 10-15cm high but Dupriez and De Leener (1989) and Massiaen (1994) recommended that cucumber can be pinched when the plant is 30cm long. Smakel (2006) however cautioned that there should be enough justification for the removal of a portion of a plant through long term observations and experience since such removal can be either injurious or beneficial. Akumani (1997) in his research work on the effect of pinching and water management on the yield and quality of okro (*Abelmoschus esculentus*) observed that pinching okro plants at 4 weeks gave a higher yield than pinching at 6 weeks. A study carried out by Arin and Ankara (2001) with the aim of determining the effects of pinching on tomato plant growth, earliness and total yield revealed the following results;-

For increased, early and quality fruit production, pinching of the growing point of tomato plant, leaving 4 or 5 fruit was found to produce good results. Tomato plants pinched at the 5-6 truss produced earliness, but total yield decreased. Early, high and regular yield was obtained from the 7-8 trussed plant. In 9-10 trussed plants, fruit yield increased but with comparatively short harvesting period.

2. 12 Pinching and flowering in cucumber

Mathew and Karikari (1995) asserted that pinching at the vigorously growing stage of a plant encourages both the vegetative growth of the side shoots and flower bud development than at the flowering stage. They stated further that judicial pinching or pruning increases the supply of nitrogen and other essential elements and in turn increases the production of carbohydrates for the reproductive phase. Hikosaka and Sugiyama (2004), experimented with 3 cucumber cultivars on characteristics of flower and fruit development; single pistillate type (monoecious), multipistillate type (monoecious) and plural pistillate type (gynoecious). Pinching was carried out on some of the 3 cultivars when the plant had obtained 8 nodes. The result was that the multi and plural pistillate cultivars produced more flowers and hence more fruits.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The experiment was carried out at the Horticulture Department of the Kwame Nkrumah University of Science and Technology (KNUST) Kumasi, located at longitude 01^0 33' W, latitude 06^0 41' N and altitude 261.4m. The area lies within the forest zone of Ghana and experiences double rainfall regimes; the major rainy season which is between April and July and a minor season between September and early November. The experiment was conducted in the wet season between May and August 2009 and was repeated in the dry season between October and February 2010.

3.2 Cropping history of site

The site had been under cultivation to various vegetable crops for a considerable number of years. Some of the cultivated vegetables included tomato (*Lycopersicon esculentum*), cabbage (*Brassica oleracea var. capitata)*, okra (*Hibiscus esculentus*), lettuce (*Lactuca sativa*), onions (*Allium cepa*). The last crop which preceded the experiment was sweet pepper (*Capsicum annuum*).

3.3 Soil and poultry manure sampling and analyses

Soil samples at depths, 0-15cm and 15-30 cm were taken from the experimental site and analyzed to determine soil particle size distribution (soil texture), nutrients content and soil pH before the site was ploughed. A sample of poultry manure used as soil amendment was also analyzed (Table 4.1). The analyses were carried out at the Department of Crops and Soil Sciences-Faculty of Agriculture, KNUST.

3.4 Lay-out and land preparation.

The land was ploughed and harrowed on 20th May 2009 for the wet season and 30th September 2009 for the dry season. It was measured to cover a land size of 532m^2 (38m x 14m) for the experiment. Lining and peegging to divide the area into blocks (3) and plots (27) were carried out. Mounds measuring 1m in diameter and 30cm in height were moulded on each plot; giving 16 mounds per plot. The intra and inter row spacing between mounds were 1m x 1m respectively. There were a total of 432 mounds for the 3 replications. Three hundred grams ground Neem seed cake was incorporated into every mound to control nematodes.

3.5 Experimental design and treatments

The experiment was a 3 x 3 factorial in a Randomized Complete Block Design (RCBD) with 3 replications. Factors considered were;-

- Fertilizer type
- Pinching of terminal bud

The following were the treatment combinations:

Treatment 1 - N.P.K. (15-15-15) and pinching at 6th node above soil level

Treatment 2 - N.P.K. (15-15-15) and pinching at 10th node above soil level

Treatment 3 - N.P.K. (15-15-15) + no pinching (Control)

Treatment 4 - No N.P.K. (15-15-15) + pinching at 6th node above soil level

Treatment 5 - No N.P.K. (15-15-15) + pinching at 10th node above soil level

Treatment 6 - No N.P.K. (15-15-15) and no pinching (Control)

Treatment 7 - Poultry manure and pinching at 6th node above soil level

Treatment 8 - Poultry manure and pinching at 10th node above soil level

Treatment 9 - Poultry manure + no pinching

3.5.1 Fertilizer treatments

For the fertilizer treatments, each mound designated for poultry manure was mixed thoroughly with 500g of the manure placed in a hole made in the middle of the mound after which the mound was reshaped. The mounds were left for three weeks before sowing. At flowering stage 500g poultry manure was applied per plant as side dressing. Mounds designated for NPK (15-15-15) were each mixed with 5g of the fertilizer two days before sowing and 5g of the NPK (15-15-15) per plant was used as side dressing at flowering stage.

3.5.2 Pinching out of terminal buds

Pinching out of terminal buds were made up of no pinching, pinching at 6th node and pinching at 10th node.

3.6 Seed sowing

Direct sowing of seeds of the cucumber variety 'Royal Poinsett 76' was done directly into each mound on 8th July and15th December 2009 for the wet and dry seasons respectively. The mounds were moulded to have a concave top to enable them hold water during the application of water. Three seeds were sown per mound to a depth of about 1.5-2.0 cm. and dry grass or straw was used to mulch the top of the mounds. Judicious watering was done immediately.

3.7 Cultural practices

Regular watering, hand weeding, hoeing and reshaping of mounds were done. Gradual thinning began when plants had obtained 3-4 true leaves and by the end of two weeks after seeds germinated, each mound was left with one plant. Each plant was staked using bamboo sticks with branches three weeks after germination. During the growing season, 'Nemazal', (neem seed oil) with active ingredient azadirachtin, an organic insecticide was used to control insect pests whilst sulphur- based 'Topcop', an approved organic multipurpose disease control chemical was used to control fungal diseases. The rate of the Nemazal was 4ml/litre at 7 days intervals while 'Topcop' had initial rate of 6.5ml/litre when the plants were 4 weeks old and was increased to10ml/litre at flowering and fruiting stages at 10 days intervals. 'Topcop' was applied during fruiting stage in the wet season when symptoms of fungal disease were observed but in the dry season application was done at the seedling stage of plant growth .

3.8 Harvesting

The first harvesting was done 42 days after sowing in the wet season and 45 days after sowing in the dry season.

3.9 Parameters studied

3.9.1 Vegetative growth parameters

- **Number of days from sowing to germination**.

Three days after sowing, germinated seeds (seedlings) were counted per treatment to check the rate of germination / germination percentage to find out the viability of seeds.

- **Plant height**

Plant height was measured weekly from the soil level to the tip of the plant starting from 14 days after germination till 1st pinching was done (ie on treatments designated for 6th node pinching -21 days after germination).

- **Number of leaves per plant on the main stem**.

Leaves were counted 14 days after germination and thereafter at 7 days intervals until the appearance of the first flower.

- **Other data taken on the main stem;-**

I. Number of days from sowing to the appearance of first, second and third branches.

II. Nodes at which the first, second and third branching occurred.

III. Number of nodes to first male flower appearance.

IV. Number of nodes to first, second and third female flowers.

- **Data were taken on branches after pinching**;-

a. Number of days to first, second and third branching after pinching at 6th or 10th nodes.

b. Number of nodes to first, second and third female flowers.

c. Number of nodes to first, second and third male flowers.

3.9.2 Reproductive growth parameters

- Number of days from sowing to the first, second and third female flowers.

Plate (i) - Female flower

- Number of female flowers on the first three branches.
- Number of male flowers before the first, second and third female flowers.

Plate (ii) - male flowers and female flower

- Number of fruits set per un- pinched plant.
- Number of fruits set per pinched plant.
- Number of days from sowing to first harvest.
- Fruit shape index (length to diameter ratio-LDR)

Fruit length and diameter were measured from 10 randomly sampled fruits per treatment. A pair of calipers was used to measure the diameter while a flexible measuring tape was used to measure the length of fruits. The sum of length and diameters were divided by the number of sampled fruits.

3.9.3 Yield parameters

- **Total fruit number per treatment**

  All harvested fruits were counted per treatment for the three replicates and projected to per hectare basis.

- **Weight of total yield per treatment.**

  An electronic weighing scale was used to weigh all harvested fruits per treatment for all three replicates and projected to per hectare basis.

- **Total number of marketable fruits per treatment**

  Marketable yields (uniform colour, size and shape, undamaged by pests and also disease free) were sorted out and counted per treatment and projected to per hectare basis.

Plate (iii)-Selected marketable cucumber fruits

- **Weight of marketable yield per treatment.**

  Marketable fruits per treatment were weighed using an electronic weighing scale and projected to per hectare basis.

- **Non marketable yield per treatment.**

  Non marketable yield was determined as the difference between the total and marketable yields per treatment on per hectare basis.

3.9.4 Statistical analysis of data

- All data collected were statistically analyzed using the GenStat Analysis of Variance (ANOVA) software. Differences between means were determined using the Least Significant Difference (LSD) test at 0.05 level.

CHAPTER FOUR

4.0 RESULTS

4.1 Physio-chemical properties of study area for the wet and dry seasons

Analysis of soil samples taken at depths, 0-15cm and 15-30 cm from the experimental site revealed that the soil contained 89.2% sand and a low percentage of 4.9% silt and 5.9% clay. The soil could not be moulded into any lumps when wet without falling apart. The organic carbon and organic matter values were 0.75% and 1.29% respectively all indicated their low content in the soil. The soil nitrogen content which was less than 0.2% on the average (0.14%) according to soil nutrient analysis (Table 4.1) was also considered to be low. However, analysis of exchangeable cations such as potassium (K^{+}), sodium (Na^{+}), calcium (Ca^{2+}) and magnesium (Mg^{2+}) indicated that the soil contained values greater than 0.5cmol/kg. An average of 147.52 ppm of available phosphorus was recorded. The soil indicated a pH value of 5.11.

Table 4.1 Physio-chemical properties of soil of study site

SAMPLE IDENTIFICATION SOIL	% Organic Carbon	% Organic Matter	% Total Nitrogen	Exchangeable Cation cmol/kg) or me/100g				Available P (mg/kg or ppm)	pH
				K	Na	Ca	Mg		
0-15cm	0.90	1.55	0.14	0.49	0.95	5.60	1.40	155.56	5.3
15-30cm	0.60	1.03	0.13	0.23	0.87	5.80	2.40	139.47	4.92
SOILTEXTURE	SAND (%)	SILT (%)	CLAY (%)	REMARKS					
0-15cm	90.20	3.90	5.90	SAND					
15-30cm	88.20	5.90	5.90	SAND					

4.2 Chemical properties of poultry manure as a fertilizer for wet and dry seasons

Chemical analysis of the poultry manure used as a fertilizer type for the experiment contained 5.03% of organic carbon, 8.67% of organic matter and 3.0% of total nitrogen. High values were obtained for all the exchangeable cations analyzed (K, Na, Ca and Mg (Table 4.2) since they were all above 0.5cmol/kg (Table 4.2). The pH was slightly acidic (6.7) and available phosphorus in the poultry manure on the basis of nutrient analysis was also considered to be high (23.95 ppm).

Table 4.2 Chemical analysis of Poultry manure

SAMPLE IDENTIFICATION POULTRY MANURE	% Organic Carbon	% Organic Matter	% Total Nitrogen	Exchangeable Cation (cmol/kg) or me/100g				Available P (mg/kg or ppm)	pH
				K	Na	Ca	Mg		
	5.03	8.67	3.0	3.43	3.43	4.00	8.00	23.95	6.7

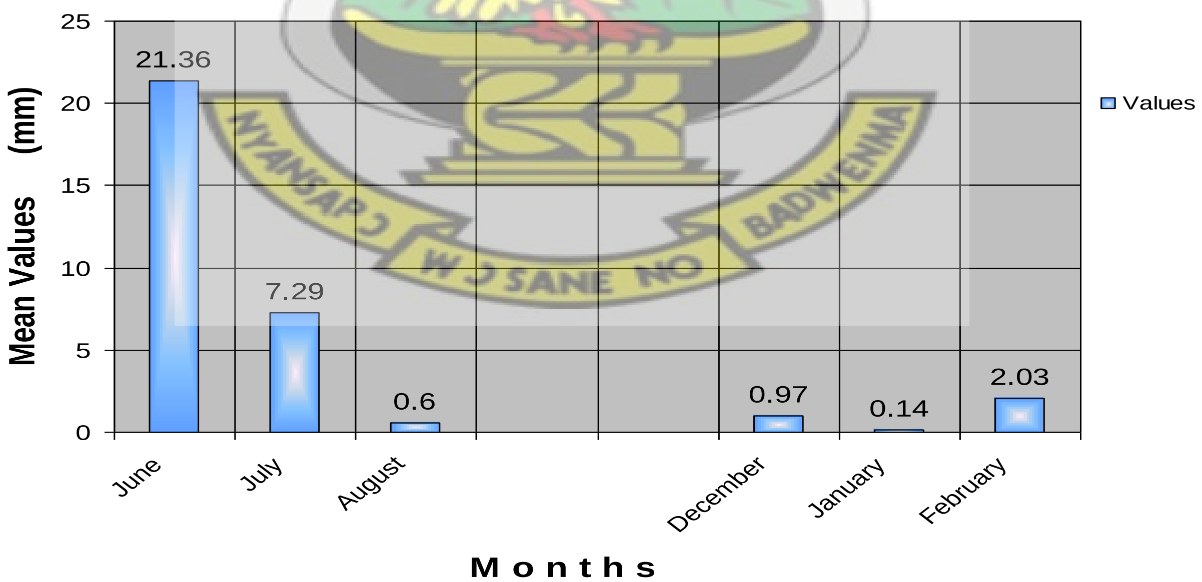
4.3 Climatic conditions over study period

4.3.1 Rainfall

In the wet season, the highest rainfall occurred in the month of June which recorded a daily mean value of 21.36mm followed by the month of July with a mean value of 7.29mm and then August, which recorded less than 1.00mm mean daily rainfall (Figure 4.1).

The dry season however had some amount of rainfall with February recording the highest (2.03mm) but December and January recorded traces of rainfall 0.97mm 0.14mm respectively.

Figure 4. 1



Wet Season **Dry Season**

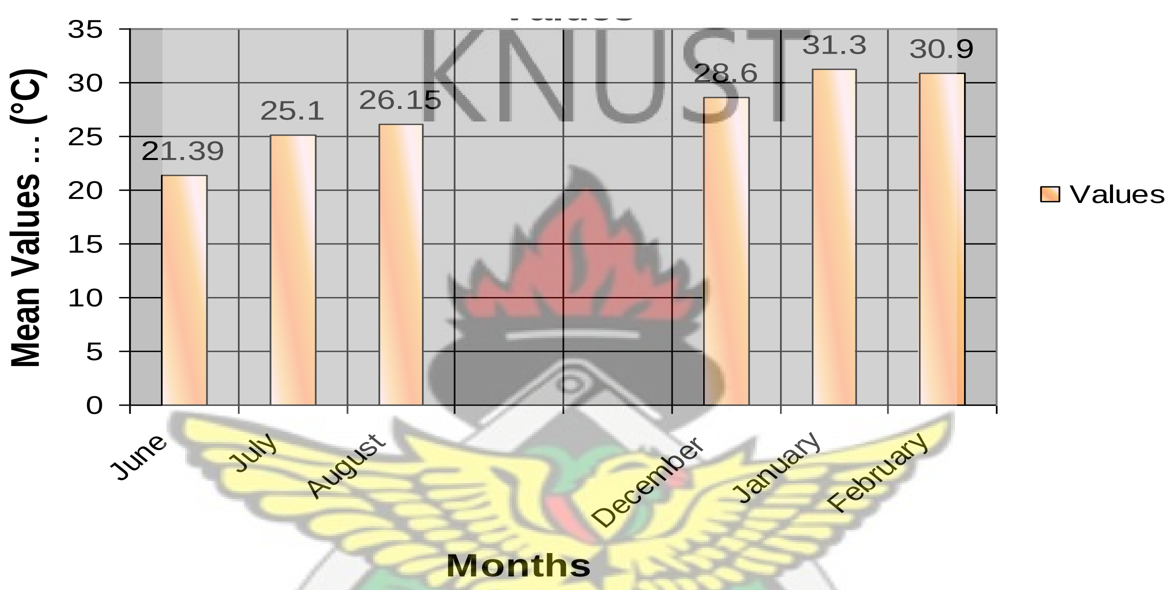
Figure 4.1 Rainfall - Wet and Dry Seasons (Daily mean values)

4.3.2 Temperature

The daily mean temperature in the major wet season was lowest in June (21.4^{0}c) and highest in August (26.2^{0}c).

In the dry season, the lowest temperature was recorded in December 28.6^{0}c and the highest in January (31.3^{0}c). In general daily mean temperatures were higher in the dry season than the wet season.

Figure 4.2



Wet Season **Dry Season**

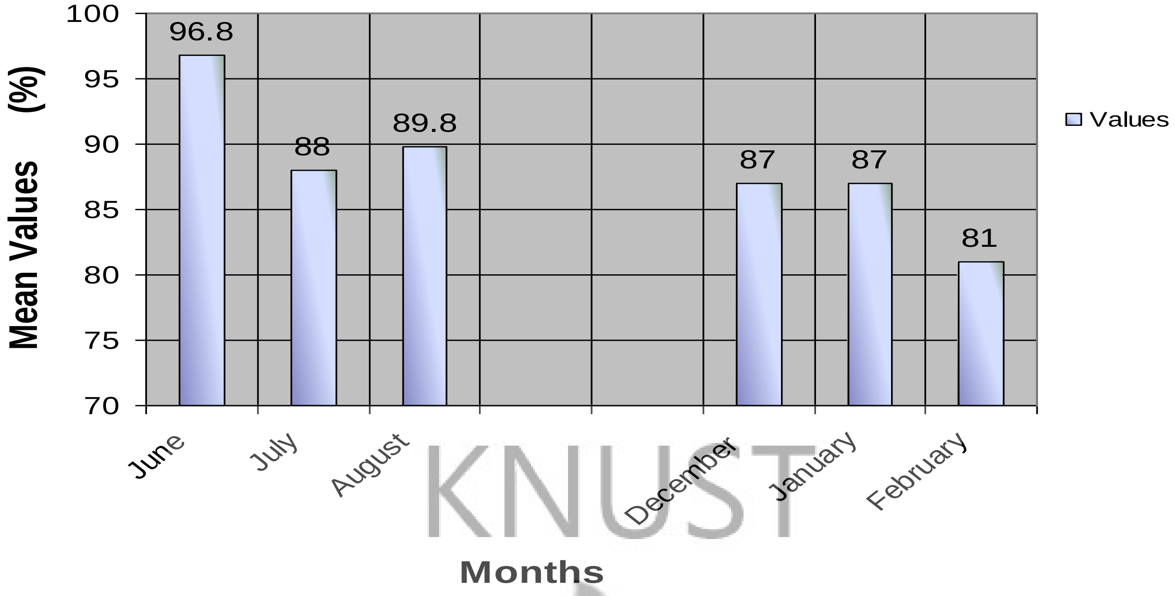
Figure 4.2 Temperature-Wet and Dry Seasons (Daily mean values)

4.3.3 Humidity

As a result of the high rainfall experienced in June, relative humidity was expectedly high in June (96.8%). There was a decline in humidity in the succeeding months which corresponded with the rainfall experienced in those months (figure 4.3).

In the dry season, humidity in the month of December and January remained the same (daily mean values of 87.0%). However it fell quite steeply to 81.0% in February.

Figure 4.3



Wet Season **Dry Season**

Figure 4.3 Humidity - Wet and Dry Seasons (Daily mean values)

4.4 Flowering pattern in cucumber plants at wet and dry seasons

Twenty eight days after sowing, all the plants had developed male flower buds with a few NPK (15-15-15) treated plants showing female anthesis at the 3rd node. For all plants, the 1st male flower developed at the 2nd node while the 1st female flower developed at the 3rd node from soil level. Second female flowers were found at either 5th or 6th nodes and the third female flower occurred at the 10th to 12th nodes irrespective of treatments applied. The flowering pattern for branches had the 1st female flower at the 1st node of the branch with the 2nd and 3rd female flowers emerging at similar nodes as the main stem (ie, 5th or 6th nodes and 10th to 12th nodes, respectively).

4.5 Vegetative growth of cucumber under fertilization and nodal pinching in two seasons.

4.5.1 Effect of fertilizer type on mean number of leaves of cucumber

In the major wet season, no significant differences ($P > 0.05$) were observed in the mean number of leaves of cucumber under both inorganic and organic fertilizer types at 14 days after germination (DAG) (Table 4.3a.). However, in comparison to the control, fertilized cucumber plants produced significantly greater number of leaves (P < 0.05) at 14 DAG. Both NPK (15-15-15) and poultry manured plants produced the highest and equal mean number of leaves (6.11 leaves) 14 DAG while the 'control' recorded the least (5.33 leaves) during the same period.

In the dry season, although there was no significant difference in number of leaves between NPK (15-15-15) and poultry manure treated plants at 14 DAG, poultry manure treatments produced significantly (P < 0.05) greater number of leaves than the control (Table 4.3b). Poultry manured plants recorded the highest mean number of leaves (3.33 leaves) 14 DAG while the control recorded the least (2.78 leaves).

Table 4.3. Effect of fertilizer type on mean number of leaves of cucumber in two seasons

Fertilizer type	Wet Season (a) No. of leaves 14 DAG	Dry Season (b) No. of leaves 14 DAG
NPK (15-15-15)	6.11	3.11
Poultry manure	6.11	3.33
Control	5.33	2.78
Mean	5.85	3.07
LSD = (0.05)	0.509	0.451
CV (%)	8.70	14.70

*DAG= days after germination

4.5.2 Effect of fertilizer type on mean plant height of cucumber

In the major wet season there was no significant difference (P > 0.05) in the plant height of cucumber under the two fertilizer types at 14 and 21 DAG (Table 4.4a). However, in comparison to the control, cucumber plants under NPK (15-15-15) were significantly taller than those under the control (P < 0.05) 14 DAG. At 21 DAG cucumber plants under both NPK (15-15-15) and poultry manure were significantly taller than those under the control (P < 0.05). Plants treated with poultry manure were the tallest (56.22cm) and the shortest were plants without fertilizer (control) (46.67cm).

In the dry season no significant difference was observed in the plant height of cucumber under the two fertilizer types 21 DAG (Table 4.4b). However, in comparison to the control, cucumber plants under both NPK (15-15-15) and poultry manure were significantly taller than those under the control (P < 0.05) 21 DAG.

Table 4.4 Effect of fertilizer type on mean plant height of cucumber in two seasons

Fertilizer Type	Wet Season (a) Plant height (cm)		Dry Season (b) Plant height (cm)
	14 DAG	21 DAG	21 DAG
NPK (15-15-15)	17. 33	54.56	30.22
Poultry manure	16.89	56.22	31.52
Control	15.25	46.67	25.69
Mean	16.49	52.48	29.15
LSD = (0.05)	1.663	3.825	4.085
CV (%)	10.10	7.60	14.00

*DAG= days after germination

4.5.3 Effect of fertilizer type on mean number of branches of cucumber 14 days after germination

The mean number of branches in the cucumber plants at14 DAG was not different in the major wet season under both NPK (15-15-15) and poultry manure. In comparison to the control however, the number of branches produced by the cucumber plants under fertilization were highly significantly greater at 14 DAG (P < 0.001) (Table 4.5). Poultry manured plants produced the highest number of branches at 14 DAG while the unfertilized (control) produced the least during the same periods (14DAG).

Table 4.5 Effect of fertilizer type on mean number of branches of cucumber in two seasons

Fertilizer type	Wet Season Number of branches 14 DAG
NPK (15-15-15)	1.33
Poultry manure	1.56
Control	0.33
Mean	1.07
LSD = (0.05)	0.950
CV (%)	46.10

*DAG= days after germination

4.5.4 Effect of fertilizer type and nodal pinching on mean number of leaves of cucumber 21 days after germination

In the major wet season, no significant difference (P > 0.05) was observed in the mean number of leaves among NPK (15-15-15) and poultry manured cucumber plants 21 DAG. However, in comparison to the control, fertilized cucumber plants produced significantly greater number of leaves (P < 0.05) 21 DAG. During the same period pinching did not produce any significant difference among plants (Table 4.6). There was however, significant fertilizer type and pinching interactions (P < 0.05) such that plants fertilized with either NPK (15-15-15) or poultry manure and pinched at 6th or 10th nodes produced a greater number of leaves than plants without fertilizer and pinched at either 6th or10th nodes. In addition plants not pinched but received fertilizer application produced more leaves than plants not pinched and not fertilized (Table 4.7). Poultry manured plants that were pinched at the 6th node produced the highest mean number of leaves (24.33 leaves) while the unfertilized and not pinched plants (control) produced the least value (15.67 leaves).

In the dry season, there was no significant difference in the mean number of leaves of cucumber plants under both organic and inorganic fertilizer types 21 DAG. However, they produced significantly ($P < 0.05$) greater number of leaves than the control at the same period. Plants under the three levels of pinching did not produce any significant difference.

In the dry season also there was significant fertilizer type and pinching interactions such that plants fertilized with poultry manure and pinched at the 6th nodes produced greater number of leaves than plants that received poultry manure and were pinched at the 10th node and also plants that received NPK (15-15-15) and were pinched at either the 6th or 10th nodes (Table 4.6). In addition, the greater number of leaves produced by poultry manured and 6th node pinched produced significant difference in comparison to the number of leaves produced by plants that received poultry but not pinched and plants that received neither of the two fertilizer types. Poultry manured plants that were pinched at the 6th node produced the highest mean number of leaves (7.33 leaves) while plants that were not fertilized but pinched at the 10th node produced the least value (5.67 leaves).

Table 4.6 Effect of fertilizer type and nodal pinching on mean number of leaves of cucumber at 21 days after germination

Wet season (a)				
Fertilizer Type	Nodal pinching			
	Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	15.67	16.67	14.00	15.45
NPK (15-15-15)	22.33	22.33	22.30	22.33
Poultry manure	22.67	24. 33	23.33	23.44
Mean	20. 20	21.11	19.89	
LSD =(0.05) P = 0.05	Pinching = 1.901 Fertilizer type = 1.901 Pinching × fertilizer type = 3.293			

Dry Season (b)				
Fertilizer Type	Nodal pinching			
	Pinch 0	Pinch 6th node	Pinch 10th	Mean
Control	6.00	6.00	5.67	5.89
NPK (15-15-15)	6.67	6.67	6.67	6.67
Poultry manure	6.33	7.33	6.67	6.78
Mean	6.33	6.67	6.56	
LSD (0.05) P = 0.05	Pinching = 0.54 Fertilizer type = 0.54 Pinching × fertilizer type = 0.935			

4.5.5 Effect of fertilizer type and nodal pinching on mean number of branches of cucumber at 21 days after germination

The number of branches among the cucumber plants 21 DAG did not show any significant difference under NPK (15-15-15) and poultry manure treatments. However, in comparison to the control, the number of branches produced by the cucumber plants under the two fertilizer types were significantly greater at 21 DAG. Plants pinched at the 6th node also produced significantly greater mean number of branches compared to those pinched at 10th node and those not pinched (Table 4.7a). Fertilizer type and pinching interactions in plants that received either NPK (15-15-15) or poultry manure and pinched at the 6th and 10th nodes at 21 DAG produced greater number of branches such that when compared to the number of branches in plants that were neither fertilized nor pinched significant differences were observed. Also, these two fertilizer type plants that were pinched at the 6th node produced significant number of branches in comparison to number of branches produced by plants pinched at the 6th and 10th nodes but not given any of the two fertilizers. Poultry manured plants that were pinched at the 6th node produced the highest mean number of branches (5.00 branches) while plants that were not fertilized but pinched at the 10th node produced the least value (2.67 leaves).

In the dry season, branches developed 21 DAG. At this stage there was no significant difference in the number of branches among the NPK (15-15-15) and poultry manure (Table 4.7b). However, a significant difference was observed in the number of branches among these two fertilizer type plants and the control. Pinching produced no significant difference in the number of branches during the same period. Fertilizer type and pinching interactions in plants that were fertilized with NPK (15-15-15) or poultry manure and pinched at the 6th node produced significant number of branches in comparison to plants that received no fertilizer and no pinching. Plants that received poultry manure and pinched at the 10th node also produced more branches than plants that were without fertilizer and were also not pinched. Poultry manured plants that were pinched at the 10th node produced the highest mean number of branches (1.67 branches), while plants not pinched and without fertilizer produced the lowest mean number of branches (0.33 branches).

Table 4.7 Effect of fertilizer type and nodal pinching on mean number of branches of cucumber 21 days after germination

Wet Season (a)

Fertilizer type	Nodal pinching			Mean
	Pinch 0	Pinch 6th node	Pinch 10th node	
Control	2.33	3.00	2.67	2.67
NPK (15-15-15)	3.33	4.33	3.67	3.78
Poultry manure	3.67	5.00	4.00	4.22
Mean	3.11	4.11	3.44	
LSD = (0.05) P = 0.05	Pinching = 0. 634 Fertilizer type = 0 634 Pinching × fertilizer type =1.099			

Dry Season (b)

Fertilizer type	Nodal pinching			Mean
	Pinch 0	Pinch 6th node	Pinch 10th	
Control	0.33	1.00	0.67	0.67
NPK (15-15-15)	1.00	1.33	1.00	1.11
Poultry manure	1.00	1.33	1.67	1.33
Mean	1.78	1.22	1.11	
LSD = (0.05) P = 0.05	Pinching = 0. 634 Fertilizer type = 0 634 Pinching × fertilizer type =1.099			

4.5.6 Effect of fertilizer type and nodal pinching on mean number of branches of cucumber 28 days after germination

In the major wet season, the mean number of branches produced by cucumber plants that received poultry manure 28 DAG was significantly greater than those produced by NPK (15-15-15) treatments while branches produced by NPK (15-15-15) treatments were significantly greater than those produced by the control. Branches produced by poultry manured plants were however highly significant when compared to the control. Plants pinched at the 6th node produced significantly greater number of branches in comparison to those produced by plants pinched at the 10th node and the control. Under fertilizer type and pinching interactions, plants fertilized with either NPK (15-15-15) or poultry manure and pinched at the 6th node, 28 DAG produced significant number of branches in comparison to the number of branches produced by plants without fertilizer and were also not pinched (Tables 4.8a). Plants treated with only poultry manure and those that received both poultry manure and pinched at the 10th node also produced significant number of branches when compared to those produced by plants pinched at the 10th node but not fertilized and then those that were neither pinched nor fertilized. Plants that received poultry manure and were pinched at the 6th node produced the highest number of branches (6.00 branches) while plants that were neither pinched nor fertilized or pinched at the 10th node but not fertilized produced the least (3.00 branches).

In the dry season, the mean number of branches produced by NPK (15-15-15) and poultry manured plants did not show any significant difference 28 DAG. However, in comparison to the control, branches produced by both treatments showed significant difference in the same period. Branches produced by plants pinched at the 6th node were significantly greater than those produced by plants pinched at the 10th node and those produced by plants not pinched (control). Under fertilizer type and pinching interaction, the number of branches produced by both NPK (15-15-15) and poultry manured plants pinched at the 6th node were significantly greater than branches produced by plants without fertilizer but pinched at the 10th node and those without fertilizer and were also not pinched (Table 4.8b). In addition, poultry manured treatments pinched at the 10th node produced significantly greater number of branches than branches produced by plants without fertilizer and without pinching 28 DAG. Plants that were pinched at the 6th but without fertilizer produced the highest number of branches (5.00 branches) while plants that were neither pinched nor fertilized or pinched at the 10th node but not fertilized produced the least (3.00 branches).

Table 4.8 Effect of fertilizer type and nodal pinching on mean number of branches of cucumber 28 days after germination

Wet Season (a)				
Fertilizer Type	Nodal pinching			Mean
	Pinch 0 node	Pinch 6^{th} node	Pinch 10^{th}	
Control	3.00	4.33	3.00	3.44
NPK (15-15-15)	4.00	5.00	4.00	4.33
Poultry manure	4.67	6.00	5.33	5.33
Mean	3.09	5.11	4.11	
LSD = (0.05) P = 0.05	Pinching = 0.83; Fertilizer type = 0.83; Pinching × Fertilizer type = 1.438			

Dry Season (b)				
Fertilizer type	Nodal pinching			Mean
	Pinch 0 node	Pinch 6^{th} node	Pinch 10^{th}	
Control	3.00	5.00	3.00	3.67
NPK (15-15-15)	3.67	4.67	3.67	3.73
Poultry manure	4.33	4.67	4.00	2.33
Mean	3.67	4.78	3.56	
LSD = (0.05) P = 0.05	Pinching = 0.754 Fertilizer type = 0.754 Pinching × Fertilizer type = 1.306			

4.6 Reproductive growth of cucumber under fertilization and nodal pinching in two seasons

4.6.1 Effect of fertilizer type and nodal pinching on mean number of female flowers on main stem and first three branches 30 days after germination

In the major wet season, the mean number of female flowers produced by NPK (15-15-15) fertilized plants was significantly greater than that of poultry manured plants and unfertilized plants (control) 30 DAG ($P < 0.05$). (Table 4.9a). The mean number of female flowers produced by cucumber plants pinched at the 6^{th} node was observed to show significant ($P < 0.05$) and highly significant differences ($P < .001$) in comparison to number of female flowers from plants that were pinched at the 10^{th} node and those that were not pinched (control) respectively. There was significant fertilizer type and pinching interaction such that plants that received NPK (15-15-15) and pinched at the 6^{th} node produced significantly greater number of female flowers ($P < 0.05$) in comparison to all fertilizer type and pinching interactions with the exception of poultry manured plants pinched at the 6th node. Poultry manured plants that were pinched at the 6th node also produced significantly greater number of female flowers than plants that were neither pinched nor fertilized, plants that were not fertilized but pinched at the 10th node and NPK (15-15-15) plants pinched at the 10th node.

In the dry season, no significant difference was observed among cucumber plants mean number of female flowers on the main stem and first three branches 30 DAG under the two fertilizer types. In contrast to the wet season, plants pinched at the 6th node could not produce more female flowers. However, the mean number of female flowers produced by pinching at the 6th node (2.67 female flowers) was significant ($P < 0.05$) in comparison to the mean number of female flowers produced by plants that were not pinched (1.67). Under fertilizer type and pinching interactions plants that received NPK (15-15-15) and pinched at the 6th node again produced significantly greater number of female flowers in comparison to the number of female flowers produced by the following treatments; plants without fertilizer and not pinched, plants without fertilizer but pinched at the 6th node, NPK (15-15-15) plants and poultry manured plants not pinched and poultry manured plants pinched at 10th node (Table 4.9b).

Table 4.9 Effect of fertilizer type and nodal pinching on mean number of female flowers on main stem and first three branches 30 days after germination

Wet Season (a)

Fertilizer type	Nodal pinching: Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	3.67	4.67	2.67	3.67
NPK (15-15-15)	4.33	6.67	2.67	4.56
Poultry manure	4.33	5.67	5.00	3.45
Mean	4.11	5.67	3.19	
LSD = (0.05) P = 0.05	Pinching = 0.917; Fertilizer type = 0.917; Pinching × Fertilizer type = 1.589			

Dry Season (b)

Fertilizer type	Nodal pinching: Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	1.33	2.00	2.67	2.00
NPK (15-15-15)	1.67	3.33	2.33	2.44
Poultry manure	2.00	2.67	2.33	2.33
Mean	1.67	2.67	2..44	
LSD = (0.05) P = 0.05	Pinching = 0.76; Fertilizer type = 0.76; Pinching × Fertilizer type = 1.317			

4.6.2 Effect of fertilizer type and nodal pinching of cucumber on the mean number of fruits set 34 days after germination

There was no significant difference in the mean number of fruits set in cucumber plants under fertilizer type treatments at 34 DAG in the major wet season ($P > 0.05$). Under pinching treatments, plants pinched at the 6th node produced highly significant mean number of fruits set ($P < .001$) in comparison to fruits set produced by plants that were not pinched (control) and also produced significant mean number of fruits set than those produced by plants pinched at the 10th node during the same period. There was significant fertilizer type and pinching interaction where plants fertilized with NPK (15-15-15) and pinched at the 6th node produced greater number of fruits set than the following treatments; plants that were neither pinched nor fertilized, plants pinched at the 10th node but not fertilized, plants that received either NPK (15-15-15) or poultry manure but not pinched and poultry manured plants that were pinched at the 10th node (Table 4.10a). Plants that received NPK (15-15-15) and pinching at the 6th node produced the highest mean number of fruits set (3.00 fruits set) while those that were neither pinched nor fertilized produced the least (0.67 fruits set).

In the dry season, no significant difference was observed in the number of fruits set among plants that received either NPK (15-15-15) or poultry manure or among the fertilizer types and the control 34 DAG. The 6th node pinched plants produced significant number of fruits set in comparison to the mean number of fruits set produced by plants not pinched (control) at the same period. Under fertilizer type and pinching interaction, NPK (15-15-15) plants pinched at the 6th node produced significantly greater number of fruits set than plants without fertilizer and not pinched and also plants that received NPK (15-15-15) application only (Table 4.10b). Plants that received NPK (15-15-15) and pinched at the 6th node produced the highest mean number of fruits set (2.00 fruits set) while those that were neither pinched nor fertilized produced the least (0.33 fruits set).

Table 4.10 Effect of fertilizer type and nodal pinching of cucumber on mean number of fruits set 34 days after germination

Wet Season (a)				
Fertilizer type	Pinching			
	Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	1.00	2.00	1.00	1.33
NPK (15-15-15)	1.00	3.00	2.00	2.00
Poultry manure	1.33	2.67	1.67	1.89
Mean	1.11	2.56	1.56	
LSD = (0.05)	Pinching = 0.693			
	Fertilizer type = 0.693			
P = 0.05	Pinching × Fertilizer type = 1.201			

Dry Season (b)				
Fertilizer type	Pinching			
	Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	0.33	1.00	1.67	1.00
NPK (15-15-15)	0.67	2.00	1.00	1.22
Poultry manure	1.00	1.67	1.33	1.33
Mean	0.67	1.56	1.33	
LSD = (0.05)	Pinching = 0.693			
	Fertilizer type = 0.693			
P = 0.05	Pinching × Fertilizer type = 1.201			

4.6.3 Effect of fertilizer type and nodal pinching on the mean number of fruits of cucumber harvested per hectare

There was no significant difference (P > 0.05) in the number of cucumber fruits harvested per hectare in the major wet season under the two fertilizer types. However, in comparison to the control, cucumber plants that received poultry manure application produced significantly greater mean number of fruits than plants that were not fertilized (control). Cucumber plants pinched under the three levels of pinching did not produce any significant difference in the mean number of fruits harvested per hectare in the same period (Table 4.11a). There was also no significant difference in the number of fruits harvested per hectare among cucumber plants under fertilizer type and pinching interaction. However, plants that received poultry manure and pinched at the 6th node recorded the highest number of harvested fruits (70,000 fruits) while plants which were neither fertilized nor pinched recorded the least (40,000 fruits).

In the dry season, no significant difference was observed in the mean number of fruits harvested from both NPK (15-15-15) and poultry manure treatments. However, poultry manured treatments produced significantly greater mean number of harvested fruits than the plants without fertilizer (control). Cucumber plants pinched under the three levels of pinching did not show significant differences in the mean number of fruits harvested per hectare during the same season In the dry season, however, plants that received poultry manure and were pinched at the 6th nodes produced significantly more harvested fruits than the following treatments under fertilizer type and pinching interaction; NPK (15-15-15) plants pinched at the 10th node, unfertilized plants pinched at the 6th node and then unfertilized and un-pinched plants (Table 4.11b).

Table 4.11 Effect of fertilizer type and nodal pinching on mean number of fruits of cucumber harvested per hectare

Wet Season (a)				
Fertilizer type	Nodal pinching			
	Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	40,000	50,000	36,700	42,200
NPK (15-15-15)	46,700	50,000	50,000	48,900
Poultry manure	63,300	70,000	66,700	66,700
Mean	50,000	55,600	48,900	
LSD = (0.05) P = 0.05	Pinching = 19,695.40 Fertilizer type = 19,695.40 Pinching × Fertilizer type = 34,113.40			

Dry Season (b)				
Fertilizer type	Nodal pinching			
	Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	24,200	24,200	28,300	25,600
NPK (15-15-15)	40,800	41,700	26,700	36,400
Poultry manure	33,300	50,800	44,200	42,800
Mean	32,800	38,900	33,100	
LSD = (0.05) P = 0.05	Pinching = 13,333.10 Fertilizer type = 13,333.10 Pinching × Fertilizer type = 23,093.60			

4.6.4 Effect of fertilizer type and nodal pinching on mean weight of harvested cucumber fruits (tons per hectare)

There was no significant difference (P >0.05) in the weight of harvested fruits (tons per hectare) under the two fertilizer types in the major wet season. However, in comparison to the control, the weight of fruits of plants that received the poultry manure treatment was significantly greater than that of the control ((P < 0.05). Pinching at the three levels did not produce significant differences in mean weight of harvested cucumber fruits (tons per hectare). Under fertilizer type and pinching interaction, the only significant difference among the treatments occurred between poultry manured plants pinched at the 6th node and unfertilized plants pinched at the 10th node (Table 4. 12a). Poultry manured plants pinched at the 6th node produced the highest weight for harvested fruits per hectare (19.00 tons per hectare) while plants without fertilizer and which were not pinched produced the least fruit weight (11.00 tons per hectare).

In the dry season, both NPK (15-15-15) and poultry manured plants produced significantly heavier fruits weight than those of the control. Pinching of plants at the 3 levels did not produce significant difference in cucumber fruits weight (tons per hectare). However, under fertilizer type and pinching interactions, poultry manured plants produced significantly higher weight of fruits than the following treatments; plants that were neither fertilized nor pinched, plants fertilized and pinched at either the 6th or 10th nodes (Table 4.12b).

Table 4.12 Effect of fertilizer type and nodal pinching on the mean weight of harvested cucumber fruits (tons per hectare)

Wet Season (a)

Fertilizer type	Nodal pinching: Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	8.70	12.00	6.70	9.10
NPK (15-15-15)	11.00	12.70	12.20	12.00
Poultry manure	14.50	19.00	18.00	17.20
Mean	11.40	14.60	12.30	
LSD = (0.05) P = 0.05	Pinching = 6.840 Fertilizer type = 6.840 Pinching × Fertilizer type = 11.840			

Dry Season (b)

Fertilizer type	Nodal pinching: Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	2.00	2.00	2.00	2.00
NPK (15-15-15)	4.90	4.00	3.00	4.00
Poultry manure	3.40	5.20	4.40	4.00
Mean	3.40	3.70	3.10	
LSD = (0.05) P = 0.05	Pinching = 1.369 Fertilizer type = 1.369 Pinching × Fertilizer type = 2.372			

4.6. 5 Effect of fertilizer type and nodal pinching on the mean number of marketable cucumber fruits per hectare

There was no significant difference in the number of marketable fruits ($P > 0.05$) per hectare under the two fertilizer types in the major wet season. However, in comparison to the control, plants that received poultry manure fertilization produced significantly greater mean number of marketable fruits ($P < 0.05$) than the control (Table 4.13a). The three levels of pinching did not produce significant differences in the number of marketable cucumber fruits per hectare during the same period. The number of marketable fruits obtained in the wet season in cucumber plants under fertilizer type and pinching interaction did not show any significant differences. Plants pinched at the 6th node and treated with poultry manure however produced the highest number of marketable fruits per hectare (53,300 marketable fruits) and the least was produced by treatments that were not fertilized but pinched at the 10th node (20,000 marketable fruits).

In the dry season, although there was no significant difference in the mean number of marketable fruits between poultry manured and NPK (15-15-15) plants, the number of marketable fruits the treatments produced was such that each of them showed significant difference when compared to the control (Table 4.13b). The three levels of pinching without fertilization did not produce significant difference in the marketable fruits per treatment. However, the greater number of marketable fruits produced by plants that received poultry manure only and poultry manured plants pinched at the 6th node resulted in a significant difference in comparison to the few marketable fruits obtained from plants that received the three levels of pinching under fertilizer type and pinching interaction.

Table 4.13 Effect of fertilizer type and nodal pinching on the mean number of marketable cucumber fruits per hectare

Wet Season (a)				
Fertilizer type	Nodal pinching			
	Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	26,700	40,000	20,000	28,900
NPK (15-15-15)	36,700	43,300	30,000	36,700
Poultry manure	50,000	53,300	50,000	51,100
Mean	37,800	45,500	33,300	
LSD = (0.05)	Pinching = 16,944.50			
	Fertilizer type = 16,944.50			
	Pinching × Fertilizer type			
P = 0.05	= 29,348.80			

Dry Season (b)				
Fertilizer type	Nodal pinching			
	Pinch 0	Pinch 6th node	Pinch 10th node	Mean
Control	13,300	10,800	6,700	10,300
NPK (15-15-15)	25,800	19,2 00	15,800	22,200
Poultry manure	29,200	29,200	21,700	24,700
Mean	21,400	19,700	16,100	
LSD = (0.05)	Pinching = 7,329.30			
	Fertilizer type = 7,329.30			
	Pinching × Fertilizer type			
P = 0.05	= 12,694.70			

4.6.6 Effect of fertilizer type and nodal pinching on mean the marketable fruits weight of cucumber (tons per hectare)

In the major wet season, there was no significant difference (P > 0.05) between the mean marketable fruits weight per hectare under the two fertilizer types. However, the lower marketable fruits weight per hectare obtained from the control treatment as compared to the fruit weight in the poultry manured plants was significant. There was also no significant difference in the mean number of marketable fruit weight of cucumber plants under the three levels of pinching during the same period. Plants that were pinched at the 10th node and were unfertilized had the least marketable fruit weight per hectare and this when compared to the heavy weight of marketable fruits of plants that received poultry manure application and were pinched at either 6th or 10th nodes produced significant fertilizer type and pinching interactions ($P < 0.05$) (Table 4.14a).

In the dry season, there was significant difference between mean marketable fruits weight of poultry manured treatment and NPK (15-15-15) treatment.. Both poultry manured and NPK (15-15-15) treatments also produced significantly heavier mean marketable fruits weight in comparison to the unfertilized treatment (control). However, pinched treatments did not produce significant difference among mean marketable fruit weight of cucumber plants during the same period. There was significant fertilizer type and pinching interaction ($P < 0.05$) with poultry manure such that, all plants that were supplied with poultry manure and were either pinched or not pinched, produced significantly heavier marketable fruit weight than marketable fruit weight of all plants under the three levels of pinching (Table 4. 14b). In addition, plants that received poultry manure application and pinched at the 6th node produced heavier marketable fruit weight than those obtained from NPK (15-15-15) and pinched at the 10th node.

Table 4.14 Effect of fertilizer type and pinching on mean number of marketable fruits weight of cucumber (tons per hectare)

Wet Season (a)

Fertilizer type	Nodal pinching			
	Pinch 0	Pinch 6^{th} node	Pinch 10^{th} node	Mean
Control	5.30	9.20	4.20	6.30
NPK (15-15-15)	9.20	10.10	6.00	8.40
Poultry manure	11.70	14.30	13.60	13.20
Mean	8.70	11.20	7.90	
LSD = (0.05) P = 0.05	Pinching = 5.019 Fertilizer type = 5.019 Pinching × Fertilizer type = 8.694			

Dry Season (b)

Fertilizer type	Nodal pinching			
	Pinch 0	Pinch 6^{th} node	Pinch 10^{th} node	Mean
Control	1.70	0.80	0.80	1.10
NPK (15-15-15)	2.90	2.50	1.90	2.43
Poultry manure	3.70	4.00	3.20	3.60
Mean	2.77	2.65	1.97	
LSD = (0.05) P = 0.05	Pinching = 1.172 Fertilizer type = 1.172 Pinching × Fertilizer type = 2.030			

4.6.7 Effect of fertilizer type and nodal pinching on mean marketable fruit shape index (length/diameter) of cucumber

Marketable fruits randomly sampled (10 fruits) to measure their fruit shape index (length/diameter) showed no significant difference under the two fertilizer types in the major wet season (Table 4.15). However, in comparison to the control, marketable fruit shape index in cucumber plants under the two fertilizer types were highly significantly greater ($P > .001$) than those under the control. Fruit shape index obtained from plants that were only pinched showed no significant difference. There was significant fertilizer type and pinching interaction in the wet season ($P < 0.05$). This was as a result of plants fertilized with NPK (15-15-15) or poultry manure and pinched at 10^{th} node producing higher fruit shape indices than plants under the three levels of pinching. In addition, these plants with high fruit shape indices together with plants fertilized with NPK (15-15-15) and pinched at the 6^{th} node produced significant fertilizer type and pinching interaction in comparison to fruit shape index of plants that received poultry manure and pinched at the 6^{th} node. Plants that received poultry manure but not pinched also produced significant fruit shape index ($P < 0.05$) compared to those not pinched and not fertilized (Table 4.15).

In the dry season, no significant difference ($P > 0.05$) was observed in any treatment.

Table 4.15 Effect of fertilizer type and pinching on marketable mean fruit shape index (length/diameter) of cucumber

Fertilizer Type	Wet season			
	Nodal pinching			Mean
	Pinch 0	Pinch 6th node	Pinch 10th node	
Control	4.57	4.40	4.35	4.44
NPK (15-15-15)	4.60	4.83	4.87	4.77
Poultry manure	4.83	4.63	4.93	4.80
Mean	4.67	4.62	4.72	
LSD = (0.05) P = 0.05	Pinching = 0.102 Fertilizer type = 0.102 Pinching × Fertilizer type = 0.176			

4.7 Cost benefit analysis for wet and dry seasons

Four treatments namely NPK (15-15-15), poultry manure, NPK (15-15-15) and 6th node pinching and poultry manure and 6th node pinching were selected for cost benefit analysis for this study based on farmers practice. In Ghana, commercial farmers use chemical fertilizers and do not practise pinching. For this reason NPK (15-15-15) treatment was chosen as the 'control' to compare production cost and the resulting net profit for the two growing seasons. Tables 4.16a, 4 .16b and 4.16c show the Cost Benefit Analysis for the wet season while Tables 4.17a, 4.17b and 4.17c also show the Cost Benefit Analysis for the dry season.

The total cost of production for the dry season (GH₵3662.80) was slightly higher than that of the wet season (GH¢3,537.85). With regard to fertilizer type, plants that received poultry manure application gave higher net profit (GH¢3,969.35 and GH¢3457.92) than plants that were fertilized with NPK (15-15-15); (GH¢1,853.82 and GH¢ 2,737.20) for the wet and dry seasons respectively. Seasonal effect on fertilizer type revealed that that plants fertilized with poultry manure in the wet season produced higher net profit than plants that received poultry manure in the dry season. However, plants fertilized with NPK (15-15-15) in the wet season produced lesser net profit in comparison to the net profit of plants supplied with the same amount of NPK (15-15-15) in the dry season. Under fertilizer type and pinching interaction, the net profit in plants that received poultry manure and pinching at the 6th node was higher (GH¢4,292.56 and GH¢ 4,755.21) than those plants that received NPK (15-15-15) and pinching at the 6th node (GH¢2,823.44 and GH¢1,872.33) for the wet and dry seasons respectively.

The highest net profits out of the four selected treatments were obtained from plants fertilized with poultry manure and pinched at the 6th node for both wet and dry seasons while the least came from plants which were neither fertilized nor pinched (wet season) and plants fertilized with NPK (15-15-15) and pinched at the 6th node (dry season).

Table 4.16a Estimated cost of production in the wet season (Fixed Costs)

Material	Quantity	Unit Cost (GH¢)	Total Cost (GH¢)	Cost/growing season(GH¢)
Land	1 ha.	75.00	75.00	37.50
Wheel barrow	3	65.00	195.00	9.75
Cutlass	3	5.50	16.50	2.75
Hoe	5	3.00	15.00	0.60
Spade	3	6.00	18.00	1.50
Watering can	3	7.00	21.00	1.55
Weighing scale	1	16.00	16.00	0.80
Total				54.45

Table 4.16b Estimated cost of production in the wet season (Variable Costs)

Material/ Activity	Quantity	Unit Cost (GH¢)	Total Cost (GH¢)
Seeds	1kg	10.00	10.00
NPK15-15-15	100kg	0.46/kg	46.00
Neem seed cake	1,500kg	1.50/kg	2,250.00
Nemazile	5000ml	5.00/500ml	25.00
Top Cop	20,000ml	6.00/500ml	240.00
Slashing	20 persons	GH¢2/person man-day	40.00
Ploughing	1ha		50.00
Harrowing	1 ha		25.00
Mounds moulding	8,120 mounds	0.02/mound	162.40
Soil Analysis			21.00
Poultry manure analysis			15.00
Seed sowing	20 persons	GH¢2/person/man-day	40.00
Fertilizer Application	20persons × 2	GH¢2/person/man-day	80.00
Weeding and earthen-up	20 persons× 4	GH¢2/person/man-day	160.00
Mulching	10 persons	GH¢2/person/man-day	20.00
Thinning-out	10 persons	GH¢2/person/man-day	20.00
Staking	20 persons	GH¢2/person/man-day	40.00
Fungicide application	3 persons×4	GH¢2/person/man-day	24.00
Watering	10 persons × 5	GH¢2/person/man-day	100.00
Harvesting	10 persons × 5		100.00
Transportation (poultry manure & neem seed cake)			15.00
Total			3483.40

Total Cost of Production for Wet Season:

(Fixed Costs) + (Variable Costs)

→ GH¢54.45 + GH¢3483.40 = GH¢3,537.85

Table 4.16c Cost, Revenue and Profit - Wet Season

Treatments	Cost/Ha (GH¢) (a)	Revenue/Ha (GH¢)		Profit (GH¢) (b – a)
		No. of marketable fruits	Income (b)	
NPK15-15-15 (control)	3,537.85	36,700	5,391.67	1,853.82
Poultry manure	3,537.85	51,100	7,507.20	3,969.35
NPK(15-15-15) + 6th node pinching	3,537.85	43,300	6,361.29	2,823.44
Poultry Manure + 6th node pinching	3,537.85	53,300	7,830.41	4,292.56

Table 4.17a Estimated cost of production in the dry season (Fixed Costs)

Material	Quantity	Unit Cost (GH¢)	Total Cost (GH¢)	Cost/growing season(GH¢)
Land	1 ha.	75.00	75.00	37.50
Wheel barrow	3	65.00	195.00	9.75
Cutlass	3	5.50	16.50	2.75
Hoe	5	3.00	15.00	0.60
Spade	3	6.00	18.00	1.50
Watering can	3	7.00	21.00	1.55
Weighing scale	1	16.00	16.00	0.80
Total				54.45

Table 4.17b Estimated cost of production in the dry season (Variable Costs)

Material/ Activity	Quantity	Unit Cost (GH¢)	Total Cost (GH¢)
Seeds	1kg	10.00	10.00
NPK15-15-15	100kg	0.46/kg	46.00
Neem seed cake	1,500kg	1.50/kg	2,250.00
Top Cop (Fungicide)	30,000ml	6.00/500ml	360.00
Soil Analysis			21.00
Poultry manure analysis			15.00
Slashing	20 persons	GH¢2/person man-day	40.00
Ploughing	1ha		50.00
Harrowing	1 ha		25.00
Mounds moulding	8,120 mounds	0.02/mound	162.40
Seed sowing	20 persons	GH¢2/person/man-day	40.00
Fertilizer Application	20persons × 2	GH¢2/person/man-day	80.00
Weeding and earthen-up	15 persons× 3	GH¢2/person/man-day	90.00
Mulching	10 persons	GH¢2/person/man-day	20.00
Thinning-out	10 persons	GH¢2/person/man-day	20.00
Staking	20 persons	GH¢2/person/man-day	40.00
Fungicide application	3 persons×4	GH¢2/person/man-day	24.00
Irrigation	10 persons× 10	GH¢2/person/man-day	200.00
Harvesting	10 persons × 5	GH¢2/person/man-day	100.00
Transportation (poultry manure & neem seed cake)			15.00
Total			3,608.40

Total Cost of Production for Dry Season:

(Fixed Costs) + (Variable Costs)

→ GH¢54.45+ 3608.40 = GH¢3662.80

Table 4.17c Cost, Revenue and Profit - Dry Season

Soil amendments and Pinching	Cost/ha (GH¢) (a)	Revenue/Ha (GH¢)		Profit (GH¢) (b – a)
		No. of fruits marketable	Income (b)	
NPK15-15-15 (control)	3662.80	22,200	6,400.00	2,737.20
Poultry manure	3662.80	24,700	7,120.72	3,457.92
NPK(15-15-15) + 6th node pinching	3662.80	19,200	5,535.13	1,872.33
Poultry Manure + 6th node pinching	3662.80	29,200	8,418.01	4,755.21

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of climatic conditions, fertilizer type and pinching on vegetative growth of cucumber

Statistical analyses showed no significant differences among plants under the two fertilizer types {poultry manure and NPK (15-15-15)} on the number of leaves, plant height and branches but there was significant difference when the controls of these vegetative parts were compared to those of the fertilizer types 21 days after germination in both wet and dry seasons. Bergman (1992) stated that in most fast growing vegetables, vigorous growth occurs during the first 2-3 weeks after emergence. However, the study area soil (indicated to be sandy) without any fertilizer type (control) had slow growth because of low nutrient levels hence the delay in growth. Comparison of the vegetative growth rate for the two seasons showed wide differences. The greatest growth rate occurred 21 days after germination when number of leaves and plant height were about tripled in the wet season and doubled in the dry season. Plants which received poultry manure recorded the highest values for all vegetative parameters measured. Contributing factors to the trend in vegetative pattern are:-

1. The fertilizer types {poultry manure and NPK (15-15-15)} used as soil amendments;-

These might have influenced the comparable values for vegetative growth recorded. Analysis of their nutrient status showed higher nitrogen level {poultry manure-3%; NPK (15-15-15)-15%} than the control which had only 0.14% nitrogen. Reinhold *et al.* (1992) rated 3% nitrogen in soil as high and according to John *et al.* (2004) nitrogen encourages vegetative growth. Even though there was higher percentage of nitrogen (15%) in NPK (15-15-15) compared to that in poultry manure (3%) it did not cause higher vegetative growth. For example 21 days after germination in the wet season, the mean number of leaves in plants that received poultry manure was 23.44 and 6.78 for the dry season while plants that received NPK (15-15-15) recorded 21.67 and 6.67 for number of leaves in wet and dry seasons respectively.

This could mean that vegetative growth does not depend on only nitrogen but probably also on trace elements like Fe^{2+} and Mn^{2+} as found in poultry manure for the synthesis of chlorophyll used in photosynthesis (Clerk, 1984; Vimala *et al.*, 2001; Anonymous, 2004).

2. The availability of water;-

The average daily rainfall during the three months growing period for the wet season (major wet season) was 9.75mm while that of the dry season was 1.05mm. Availability of water in the soil during the wet season might have increased the rate of decomposition of poultry manure and thus facilitated the release of nutrients from poultry manure and the subsequent uptake of nutrients in general. On the contrary in the dry season, though the same quantity of nutrients was given to treatment plants they could not get full access to them because water as a transporting medium for nutrients (Acquaah, 2005) was inadequate in the soil. The consequence of this was reduction in manufactured food. Less water and nutrients absorption might have caused stomates to be partially or completely closed leading to decreased rate of diffusion of carbon dioxide into chlorophyll-containing cells which could have resulted in the production of less photosynthates. Less water in plants in the dry season might have also impeded translocation of manufactured food and other metabolic activities. Poineclot (2004) stated that water is an essential plant constituent needed for metabolic reactions, nutrient absorption and translocation and is also in a continual state of flux. Water stress thus affects photosynthesis, biosynthesis and respiration in plants leading to the reduction in vegetative growth.

3. Evapo-transpiration activities during the growth period**;-**

The average daily temperature of 24.21^0C during the major wet season encouraged vegetative growth. This may be due to less evapo-transpiration activity taking place at that temperature which enhanced water and nutrients absorption for photosynthesis, translocation and other metabolic activities. The prevailing temperature for the major wet season therefore resulted in higher vegetative growth. Hector *et al*. (1993) stated that the optimum temperature for cucumber growth ranges between 20^{0}C to 25^{0}C. On the other hand the average daily temperature during the dry season was 30.27^{0}C and this may have caused the excessive evapo-transpiration leading to reduction in the number of leaves and plant heights. For example, whereas the wet season recorded 23.44 as mean number of leaves and 56.22 cm. as mean plant height for plants that received poultry manure 21 days after germination, in the dry season the mean number of leaves was 6.78 and mean plant height was 31.52cm for the same period.

4. Sunlight Intensity;-

Cucumber plant is not structurally adapted to prevent water loss hence tends to lose water quite rapidly under hot sunny conditions (Yamaguchi, 1983; Poincelot, 2004). Some cloudy days experienced during the wet season therefore helped to reduce sunlight intensity and resulted in favourable temperature (24.21^{0}C) and less water loss to the plant. This created conducive environmental conditions for photosynthetic activities leading to increase in vegetative growth but the opposite occurred during the dry season.

Pinching encourages the development of more lateral shoots or branches (Dupriez and De Leener 1989; Lowes, 2009; Iannotti, 2009). Plants pinched at 6th node showed significant difference in the number of branches 28 days after germination when compared to the 10th node pinching and the control for the same period for both wet and dry seasons. The 6th node produced mean values of 5.11 branches in the wet season and 4.78 branches in the dry season while plants pinched at the 10th node produced mean values of 4.11 and 3.56 in wet and dry seasons respectively (Table 4.6). The average plant height at the time of pinching at the 6th the node was 31. 11cm. and that of the 10th node was 55. 00cm. The increased number of branches for the 6th node pinching might be due to the age at which pinching was performed. Generally the removal of terminal buds removes apical dominance. Auxins were thus redirected to auxillary bud/shoot which later developed into branches but the effect of late pinching (10th node pinching) in producing auxillary shoot and later to branches delayed. In similar studies, Dupriez and De Leener (1989) and Massiaen (1994) pinched cucumber plants when they were

30cm long and reported of increase in lateral shoots. This agrees with height of pinching at the 6th node carried out in this trial. Albert (2009) indicated that early vegetative growth is essential for maximum fruit production. In the dry season however 'no pinching' plants obtained more branches than pinching at the 10th node indicating that the conditions in the dry season (high temperature, high evapo-tranpiration, reduced water and nutrients absorption) contributed to the lower number of branches obtained in the present study. Mathew and Karikari (1995) asserted that pinching at the vigorously growing stage of a plant encourages more vegetative growth. Plants in the dry season however were not growing vigorously due to inadequate water supply as discussed earlier. For example the mean number of leaves 21 days after germination for the 6th node pinching in the wet season was 21.11 while that of the dry season was 6.44 and the mean number of branches 28 days after germination for 6th node pinching in the wet season was 5.11 while that of the dry season was 4.78.

The two fertilizer types and pinching interactions at the 6th or 10th nodes showed no significant effect in the number of leaves and branches in the two seasons. However, the two factors combined showed improved vegetative growth than the individual factors in the wet season while in the dry season this was noticed only in plant fertilized with poultry manure at the two levels of pinching. The relative growth increase was probably caused by the level of nutrients in the two soil amendment treatments, the ages at which pinching were performed and prevailing environmental conditions as discussed earlier.

Pinching at 6th node in cucumber plants was done 21 days after germination for the wet season cropping and 23 days after germination for the dry season cropping and this may be due to slower growth rate in the dry season in order to attain the required number of nodes before pinching.

5.2 Effect of climatic conditions, fertilizer type and pinching on flowering pattern of cucumber

Similar flowering patterns occurred in all treatments irrespective of fertilizer type or stage of pinching or both. Generally the first male flower developed at the 2nd node while the first female flower developed at the 3rd node from soil level on the main stem. The second female flower was found at either the 5th or 6th node while the third female flower occurred between the 9th and 13th nodes. The flowering pattern for branches had the 1st female flower development at the 1st node from the point of the branch with the 2nd and 3rd female flowers emerging at either the 5th or 6th node while the third female flower occurred between the 9th and 13th nodes as they occurred on the main stem. Male flowers dominated female flowers especially in the dry season. High temperature (average, 30.27^{0}C/day), hours of sunshine (average, 6.4hours/day-Agro-meteorology division-KNUST, Kumasi) and high nitrogen content in soil emanating from fertilizer type could have contributed to the increased number of male flowers in the dry season. Papadopoulos (1994) indicated in his research that monoecious cucumber plants which experienced such conditions produced more male than female flowers. However, it should be noted that, monoecious cultivars by virtue of their genetic make-up produce fewer female flowers than the gynoecious type which could produce 13 times more female flowers than those obtained in monoecious cultivars (Hector *et al.*, 1993; Schultheis *et al*, 1998). In Ghana monoecious cultivars are commonly grown and popular among them are 'Poinsett 76' and 'Ashley' (personal communication; Gyawu - Amankwah, a reputable vegetable seeds dealer in Kumasi).

In the present study however, considering the fertilizer type used, plants that received NPK (15-15-15 developed female flowers earlier and also produced more female flowers than those that were given poultry manure though not significant. This might be due to the NPK (15- 15-15) ability to make nutrients like potassium and phosphorus known to be necessary ingredients for reproduction (Awuku *et al*., 1993; Anonymous, 2004) more readily available for uptake by plants roots. However, Myanmar (1997) reported that early flowering restricts further vegetative growth and consequently affects additional fruit setting and development due to reduction in photosynthates.

The highly significant increase in female flowers for the 6th node pinched plants in the wet season might be due to the increased number of branches since each branch produced flowers. Riley (1998) indicated that increased number of branches has the tendency to stimulate the production of female flowers. However, under fertilizer type and pinching interaction, plants that received either poultry manure or NPK (15- 15-15) and pinched at the 6^{th} nodes produced comparable high number of female flowers hence could not result in significant difference in the two seasons. The favourable stage for pinching plants coupled with the relatively high proportions of nutrients from the two fertilizers might have led to the results as already indicated. The poor performance of plants that received poultry manure and pinched at the 10^{th} nodes in comparison to all other fertilizer type and pinching interactions could be more of the delay in pinching than the fertilizer type comparing the performances of plants fertilized with poultry to those only pinched at the 10^{th} node. Mathew and Karikari (1995) stated that pinching at the vigorously growing stage of a plant encourages flower bud development than when plant growth rate slows down.

5.3 Cucumber fruit set response to climatic conditions, fertilizer type and pinching

The high number of female flowers produced in plants fertilized with NPK (15-15-15) reflected in the higher number of fruits set 34 days after germination but there were no significant difference under the two fertilizer types and the controls in both seasons. Faster release of nutrients from NPK (15-15-15) for plant use as compared to poultry manure as discussed earlier might have been a contributing factor for the rapid growth in fruits development. Dupriez and De Leener (1989) indicated that chemical fertilizers are more soluble than poultry manure and Bandel *et al.* (1982) reported of the slow release of nutrients from poultry manure in their study on cucumber and water melon. However, experiments conducted in Northern Nigeria with poultry manure revealed that the relatively slow decomposition of the organic matter in the manure resulted in a steady supply of balanced available nutrients (Webster and Wilson 1989). This might have helped to increase steadily the number of female flowers in poultry manure causing the comparable number of female flowers in the two fertilizer types and thereby resulting in the no significant difference. The control plants number of flowers marching those of the two fertilizer types in the dry season may probably be due to the plants enjoying prolonged residual effect from existing organic manure in the soil of the control. According to Webster and Wilson (1989) such residual effect supplies plants with non-mobile nutrients such as phosphorus or trace elements essential for the plants reproductive development.

Pinching cucumber plants at the 6th node resulted in more fruits set than the 10th node pinching and 'no pinching' for the two seasons. The extra vegetative growth resulting from pinching at the 6th node provided the needed carbohydrates during fruit development stage. Mathew and Karkari (1995) stated that judicial pinching or pruning increases the supply of nitrogen and other essential elements and in turn increases the production of carbohydrates for the reproductive phase.

Under fertilizer type and pinching interactions, the greater number of fruits set produced by plants that received NPK (15-15-15) and pinched at the 6th node in wet season influenced most of the interactions (with the exception of number of fruits set in plants fertilized with either poultry manure or NPK (15-15-15) and pinched at 6th and 10th nodes respectively, and then no fertilizer and no pinching plants) to produce significant differences. In the dry season also plants that received NPK (15-15-15) and pinched at the 6th node produced greater number of fruits set but during this period, it influenced lesser number of treatment plants to result in significant differences. These were in plants that received NPK (15-15-15) without pinching and those neither pinched nor fertilized. These behaviours of fertilizer type and pinching interactions could be partly attributed to the rate of nutrients release from the two fertilizer types coupled with the different levels of pinching and their resultant increases in vegetative growth leading to the production of carbohydrates to feed the developing fruits as previously discussed.

Temperature and hours of sunshine per day experienced by the plants during the cropping seasons also contributed to the differences in number of fruits set. The average daily temperature in the wet season (24.21^0C) was optimum for cucumber growth (Hector *et al.*, 1993) but the dry season experienced an average daily temperature of 30.27^0C. Camejo *et al*. (2005) indicated that temperatures above optimum could be harmful to fruit-set and affect the internal temperature of the reproductive organ leading to a decrease in number of fruits set by plants. Wahid *et al*. (2007) also reported that high temperature induced sterility before or during anthesis. The reduction of sunlight intensity (average hours of sunshine/day, 3.00 hours-Agro-meteorology division-KNUST, Kumasi) as a result of cloudy conditions experienced by plants during the wet season also created conducive environmental conditions for rapid development of fruits. However in the dry season, high sunlight intensity (average hours of sunshine/day 6.40 hours) had adverse effects on fruit development.

5.4 Effect of climatic conditions, fertilizer type and pinching on the yield parameters of cucumber

5.4.1 Effect on number of harvested fruits

The number of fruits harvested was not a reflection of the number of fruits set. Even though plants that were fertilized with NPK (15-15-15) produced higher number of fruits set than poultry manure, the number of fruits from poultry manure was significantly higher than that of NPK (15-15-15) and control plants in the wet season. This could be due to fruit drop/abortion as a result of heavy rains. The heavy rains might have caused both nitrogen and potassium ions which are mobile (Potashcorp, 2009) to be leached from both the NPK (15-15-15) and the control soils (sandy soil) since the two soils contained low levels of humus as compared to the poultry manured soil and thus had low cation exchange capacity (Rashid *et al.*, 2008). With regards to the phosphorus in NPK (15-15-15), Webster and Wilson (1989) reported that leaching is unlikely to happen to inorganic phosphorus since it is held by iron and Aluminium. The low nitrogen content in the soils led to less production of photosynthates for fruit development. Potassium is also a vital nutrient for fruit and seed formation. In situations like this fruit drop could occur (Clerk, 1984; Dupriez and De Leener, 1989; Anonymous, 2004). The observation made by Myanmar (1997) that early flowering affects additional fruit development as stated previously might have occurred in plants fertilized with NPK (15-15-15) leading to less harvested fruits. Low level of nutrients in the sandy soil of the control could also not prepare plants adequately at the vegetative stage for later growth and development. Bergman (1992) asserted that the nutrition of many vegetables during the first 2-3 weeks after emergence has a major effect on the final yields. On the other hand, the steady supply of balanced available nutrients from the poultry manure as Webster and Wilson (1989) indicated might have proved its worth during the fruit formation stage leading to increased harvest in plants that received poultry manure fertilization.

In the dry season plants that received poultry manure again performed better than those that received NPK (15-15-15) and produced significantly more fruits than the control. The humus content in the poultry manure enabled it to reduce the rate of water loss from the soil in the dry season as compared to that of the NPK (15-15-15) plants and the control since the organic matter in poultry manure has the ability to hold water and this water facilitated the release of more nutrients to support fruit development. Though Irrigation facility was provided as a means to solve the problem of water stress, electricity power fluctuations interrupted the efficiency of the irrigation. High rate of evapo- transpiration caused by strong sunshine accompanied by the high temperature and the low relative humidity in the dry season coupled with the low nutrient status in NPK (15-15-15) and control plants as discussed earlier led to low yields. Schultheis (1998) stated that cucumbers have high water requirement and are very susceptible to water stress. The author added that the lack of water could result in reduced fruit quality and yields.

Plants pinched at the 6th node produced more fruits than those pinched at 10th node and the control in both seasons though the differences were not significant.

The steady supply of balanced available nutrients from the poultry manure as Webster and Wilson (1989) indicated and the effectiveness of pinching at the 6thnode reflected in their interactions and produced the highest number of fruits per hectare (70,000 fruits ha^{-1}). Poultry manure also reacted favourably with 10th node pinching (66,700 fruits ha^{-1}) as compared to plants that were fertilized with NPK (15-15-15) and pinched at either the 6th or 10th nodes. The fertilizer type and pinching interactions of these plants produced 50,000 fruits ha^{-1} each. These high values were recorded in the wet season though the same trend occurred in the dry season but with lower values. According to Bergman (1992), at the fruit formation stage, cucumber plants need over 80% of the total crop nutrient requirement but NPK (15-15-15) as fertilizer for sandy soil may not have satisfied this requirement due to its nutrient deficiencies and influence of other adverse environmental conditions such as leaching, water stress and high temperature as discussed earlier. Perry (1999) stated that organic amendments are probably more useful in their ability to increase the water holding capacity of soil, especially in sandy soils such as existed at the experimental area.

'Poinsett 76' though described by Schultheis (1998) as a low yielding cultivar due to low production of female flowers could have yielded higher in the wet season if the harvesting period had been prolonged but due to a sudden attack by a fungal disease during harvesting period, this could not be realized. The disease was diagnosed by the Pathology section of the

Crop and Soil Sciences Department – KNUST to be Anthracnose caused by the fungus *Colletotrichum orbiculare*. It started with mottling of leaves, followed by holes in leaves and then at latter stages, drying of leaves hence reduced photosynthetic activities. Infected fruits had lesions with sunken water soaked areas on the surfaces An approved organic fungicide 'Top Cop' (active ingredients;- Sulphur as element 50.0%, Tribasic Copper sulphate 8.4%) was sprayed at the recommended rate but the disease could not be controlled due to the prevailing humid condition (average relative humidity, 95.6%) which was favourable to the fungal development (Babadoost *et al.,* 2004).

5.4.2 Effect on fruits yield

Generally the number of fruits harvested in plants per treatment corresponded to the fruit weight gained. That is the greater the number of harvested fruits the higher the corresponding weight and vice versa. However, there were some instances where in some treatments more fruits were harvested but the corresponding weight was less compared to those in other treatments. There were also some instances where the same number of fruits were harvested in different treatments but their corresponding weights differed. For example in the fertilizer type and pinching interactions in the wet season, plants which were pinched but without fertilizer and those that received NPK (15-15-15) and were pinched at either the 6th or 10th nodes produced equal numbers of harvested fruits (50,000 fruits each) but recorded different weights(12.00, 12.70, 12.20 tons per hectare). The differences in weight could be due to nutrients availability or pinching effect as discussed earlier. It could also be due to increase in vegetative growth (leaves and branches) during the wet season which caused some of the fruits to be hidden during the period of harvesting thus giving them the chance to grow bigger than those harvested earlier.

Comparing differences in fruits weight in the two seasons, loss in fruits weight in the dry season as compared to wet season could be attributed to water stress. Cucumber, according to Hector *et* *al.* (1993) and Albert (2009) contains about 95% water and water stress has the tendency of reducing fruit weight by 50%.

5.4.3 Effect on number and weight of marketable fruits

The selection of marketable fruits of 'Poinsett 76' was based on length and diameter ratio (fruit index), uniform shape, firmness, skin colour (using the fruit colour chart) and absence of growth and handling defects, no cracks, and no pitting. Shalaby, and Hussein (1994) indicated that length/diameter ratio (LDR) values ≥ 4 indicate thicker skinned fruits, an attribute of good quality. Garden Action (2000) also stated that cucumbers taste best when young and should therefore be harvested when they are around 20 cm long. The average length and diameter of harvested fruit was 18cm and 3.8cm respectively.

Plants that received poultry manure recorded significantly higher number of marketable fruits and weight compared to those of the controls for both seasons but plants that received NPK (15-15-15) made such impact only in the dry season. Seasonal variations, roles played by the different fertilizer types and staking contributed to these results. In the wet season, sorting of unmarketable fruits indicated that the control suffered most (31.52% unmarketable fruits) followed by plants that received NPK (15-15-15), (24.95% unmarketable fruits) and then plants that received poultry manure (23.39% unmarketable fruits). The cause for the high number of unmarketable fruits with the corresponding low fruit weight in the control and NPK (15-15-15) treatments could be attributed to insufficient nutrients like potassium in the soil due to leaching as previously discussed. This led to the development of small sized fruits below both local and export market standards. There were also some crooked fruits. Insufficient potassium can cause misshape in fruit (Hector *et al.* 1993; Anonymous 2004). For the export market cucumber fruit should be straight and medium sized. Cucumber variety like Poinsett 76 should have marketable fruit length ranging from 17cm - 20cm weighing 250g - 450g (Schultheis, 1998; Acquaah, 2005). In the case of poultry manure plants and its corresponding unmarketable fruits, the cause could be traced from the rich humus content in the manure which encouraged high absorption of water by the plant in the wet season. However, the cloudy weather conditions during the period reduced the rate of transpiration causing excessive water concentration in some fruits. In such situations fruit cells become unduly stretched and this may have resulted in the bulging end of affected fruits causing blossom end rot. In the dry season all treatments suffered water stress with the control being seriously affected. As already stated cucumber fruit is about 95% water and therefore low rates of water absorption and high rates of transpiration caused the formation of small misshaped fruits. Acquaah (2005) stated that in the event of water stress, fruit crops like tomato and cucumber leaves draw water from the fruit causing a marked decrease in the volume of the fruit. In the wet season, the 10th node pinching had the highest percentage of unmarketable fruits (35.56%) followed by 'no pinching' (34.40%) and then 6th node pinching (17.98%). Availability of water and early pinching might have enhanced the activities of auxins for their role in fruit development thereby reducing the number of unmarketable fruits for 6th node pinching treatments. Akumani (1997) in his research work on the effect of pinching and water management on the yield and quality of okro (*Abelmoschus esculentus*) observed that pinching okro plants at 4 weeks gave a higher yield than pinching at 6 weeks and Srivastava (2002) indicated that auxins regulate specific protein synthesis during fruit development. The dry season results indicated that pinching at any level did not produce good results since there was increased number of small misshapen fruits. Water stress and high temperature hampered the effectiveness of pinching to produce quality fruits compared to what occurred with the 6th node pinching in the wet season.

In the case of fertilizer type and pinching interactions, all treatments produced comparable number of marketable fruits in the wet season hence there was no significant difference. However, plants fertilized with either poultry manure or NPK (15-15-15) and pinched at the 6th node produced increased number of marketable fruits in comparison to those produced by the individual factors while plants with or without NPK (15-15-15) fertilizer and pinched at the

10th node produced less marketable fruits. Plants that received poultry manure and pinched at the 6th node produced the highest marketable fruits (53,300 fruits) with corresponding marketable fruit weight of 14.30 tons per hectare. Plants without fertilizer but pinched at the 10th node produced the least (20,000 marketable fruits and 4.20 tons per hectare fruit weight). Available nutrients and stage of pinching as discussed previously could be possible causes for such results.

The dry season however, did not prove productive for fertilizer type and pinching interactions for plants that received NPK (15-15-15) and pinching treatments not even those pinched at the 6th node as it did for plants in the wet season. Water stress might have greatly hindered nutrient absorption, translocation and other metabolic reactions leading to increased number of poor quality fruits. Yamaguchi (1983) indicated that cucumber is not classified among drought resistant crops and Poincelot (2004) added that such plants lose water rapidly under hot dry conditions and continued water deficiency can produce irreversible alterations. Albert (2009) also indicated that for fast, even growth and development of cucumber fruits there is the need to water regularly but in the dry season irrigation facilities posed problems as already stated in the 'Materials and Methods'.

Unmarketable fruits from the various treatments could have also been the result of harsh weather conditions such as heavy rains in the wet season or extreme high temperatures in the dry season which obstructed the activities of bees in pollination leading to the formation of misshapen fruits (Kelly *et al.*, 2000).

The sudden attack by Anthracnose disease which was as a result of high humidity in the wet season did not allow the plants to reach their full potential yield hence contributed to the low marketable yields obtained.

Plants were however able to utilize available nitrogen and sunlight to maintain the dark green colour (emerald green) typical of the 'Poinsett 76' cultivar (Schultheis 1998).

Generally, staking assisted fruit not to come in contact with the ground and thus minimized discolouration, disease infection and rotting. Staking also helped to produce clean fruits (Hanna and Adams 1991).

In the present study, results so far have indicated that the quantity of poultry manure used (10 tons ha^{-1}) in the sandy soil combined with pinching at 6^{th} node helped to increase both total harvest (70,000 fruits ha^{-1}) and marketable yield (53,300 fruits ha^{-1}). Rice *et al*. (1993) reported that poultry manure application rate of 2.5- 4.5t ha^{-1} could be recommended for cucumber production. However the type of soil and other climatic conditions were not indicated.

5.4.4 Sale of fresh cucumber fruits

The age at which cucumber is harvested depends on the market demand (Sinnadurai, 1992). In Ghana, two markets are available for the sale of fresh produce: The usual open market where consumers prefer large size fruits for high market price which is an advantage to the seller since such fruit size attracts low market price on the export market. In big towns (Accra, Kumasi, Takoradi), markets often referred to as 'European market' are patronized by foreigners and some elites. Such people prefer smaller and immature fruit types (average length, 17cm and diameter, 3.6cm) which attract higher prices.

In the wet season of the experiment, bigger sized fruits were sold at 3 fruits for GH¢0.50 at the local open market while the smaller sized fruits were sold at 6 fruits for GH¢0.50 but at the 'European market' these small sized fruits attracted a higher price of 4 fruits for GH¢0.50. During the dry season, prompt harvesting was employed to reduce the number of bigger fruit size in order to maximize profit. Most of the marketable fruits therefore were of smaller sizes after sorting and were sold at 3 for GH¢1.00 at the "European market" market while the few bigger ones were sold at 5 for GH¢1.00 at the open market

5.5 Comparative cost benefit analysis of seasonal cucumber production system

The cost of production for each treatment was the same because the experiment was carried out under the same field conditions with no variation in spacing and nutrients supply.

However with respect to seasons, the cost of production in the dry season was higher than it was in the wet season. Irrigation in the dry season was a major factor leading to the increased cost of production compared to the wet season though labour cost increased during the wet season due to frequency of weeding caused by the proliferation of weeds.

The fertilizer type and pinching interaction in plants that received poultry manure and 6th node pinching recorded the highest profit margin for both seasons while plants fertilized with NPK (15-15-15) in the wet season recorded the least profit margin.

Farmers' practice, which aims at application of chemical fertilizers (for example, NPK15-15-15) to boost production for high income could not record high yield to increase profit under this study when compared with poultry manure and pinching treatments. The outcome of the two seasons' experiments is similar to a study conducted by Bamire and Oke (2003) on 'Profitability of vegetable farming under rainy and dry seasons' production in South-Western Nigeria. The authors recorded higher yield during the rainy season but higher total revenue was obtained under dry season conditions. This according to the authors raised the standard of living of producers and ensured a year round supply of vegetables to consumers.

Fungal disease attack (Anthracnose) on crops during the wet season and electricity power fluctuation encountered with the irrigation facility at the Horticulture Department-Faculty of Agriculture, KNUST during the dry season shortened the harvesting periods; thus crop plants did not attained their maximum yield potential hence the decreased profit margins of crops for both seasons.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In the present study, the application of 1000kg ha^{-1} of poultry manure proved to increase marketable yield of cucumber better than application of 100kg ha^{-1} of NPK (15-15-15) for both seasons since plants that were fertilized with NPK (15-15-15) though flowered earlier and set more fruits, suffered fruit abortions.

Pinching plants at either 6th or 10th node in the dry season could not produce increased marketable yield even with the two fertilizer types and pinching interaction. Fertilizer type application without pinching performed better than all pinched plants in the dry season especially in plants fertilized with poultry manure. However, in the wet season plants that received poultry manure and pinched at the 6th node recorded the highest marketable yield (53,300 fruits ha^{-1}) thus gave the highest net profit (GH¢4,755.21).

.

6.2 Recommendation

1. It is recommended that the experiment should be repeated using the same two factors (fertilizer type and pinching) but to include combinations of the two fertilizer types at different rates to find their effect on flowering and yield of cucumber.

2. Fungal diseases should be prevented at the early stage of the plants growth especially in the wet season in order to prolong the harvesting period to enable plants yield potential number of fruits for more profit.

3. The use of poultry manure and pinching at the 6th node is recommended for high marketable yields during the wet seasons.

4. To maximize profit, it is recommended that cucumber farmers in Ghana grow the bigger size cultivar types for sale at the open markets where market women prefer big fruits for high prices. The smaller fruited types could be grown and harvested when they are between 17.0-

20.0cm long and 3.5- 4.5cm diameter to serve customers at the vegetable markets designated as 'European market' where these smaller fruited types (immature fruits) attract high prices.

5. It would be useful to conduct a study on the location of poultry farms and vegetable farms with respect to their proximity in Kumasi and its environs on effective disposal of poultry manure at vantage points to benefit vegetable farmers.

REFERENCES

Acquaah, G. (2005). Horticulture : Principles and Practices . Pearson Education, Inc., Upper Saddle River, New Jersey, USA. pp 627-721

Agboola, A.A. (1993). Orgainc fertilizer, the key to sustainable agricultural production in Africa. *Report on workshop on policies, local resources and usage of fertilizers in Africa. SOFERNET Paper No. 9. Dakar, Senegal.*

Ahmed, N. (2009). Effect of neem cake on root- knot nematodes in the cultivation of tomatoes Horticulture Abstract (25) 5-9.

Akumani, P. (1997) Effect of stopping and water management on the yield and quality of okro (*Abelemoschus esculentus) Thesis pp. 38.*

Albert, S. (2009) How to grow cucumber. *Bulletin from National Garden Association, Amazon store, USA. pp.3.*

Anonymous (2009). Talking about pollution in open field cucumber cultivation techniques. Internet- http://www.hi138.com

Anonymous (2006) Health Benefits of cucumbers (2).hmt. Internet-http:// www.everynutrient.com/referencescucumbers.html.

Anonymous (2005). Farmer's Bookshelf: - An information system of tropical crops in Hawaii Department of Tropical Plant & Soil Sciences University of Hawaii at Manoa - (Internet –http://www.ctahr.hwwaii, edu. /fb/).

Anonymous (2004). Nutrients disorders of greenhouse Lebanese cucumbers (2).hmt, Agfact H8. 3.3 Internet- NSW Department of Primary Industries.

Anonymous (2003). Vegetable Gardening . *Journal-Ohio State University Extension.34: 23-36.*

Arin, L. and Ankara, S. (2001). Effect of low-tunnel mulch and pruning on yield and earliness of tomato in unheated glasshouse. *Journal of applied horticulture. Vol. 3(1): pp.23-27.*

Ayoola, O. T. and Adeniyan, O. N (2006). Influence of poultry manure and NPK fertilizer on yield and yield components of crops under different cropping systems in South West Nigeria. African Journal of Biotechnology Vol. 5 (15), pp. 1386-1392.

Awuku, K.A., Brese, G.K., Ofosu, G.K. and Baiden, S.O. (1993). Agriculture and Environmental Studies. Evans Brothers Limited, Chiltern Street, London. pp 62-73.

Babadoost, M., Weinzierl, A.R. and Masiunas, B.J.(2004): Identifying and Managing Cucurbits Pests- Diseases, Insects and Weeds. University of Illinois Extension, Urbana, U.S.A. 6.

Bamire, A.S. and Oke, J.T.O. (2003) Profitability of Vegetable Farming under rainy and dry season production in Southern Nigeria. *Journal Vol. 9 No. 2 Haworth Food Press U.S.A. and Canada.*

Bandel, V. A., Shaffeur, C. S. and McClurge C. A. (1982). Poultry manure – valuable fertilizer. University. of Maryland Cooperative. Extension Service. *Factsheet 39*.

Bergman, W. (1992). Nutritional Disorders of Plants. Published by Gustav Fischer Verlag Jena, New York. pp.386 - 402.

Brady, N.C. and Weil, R.R. (1999). The Nature and Properties of Soils. Prentice-Hall Inc. New Jersey, U.S.A. 625-629.

Buchanan, M.(1993). A Study to Examine the Efficient use of Compost. Horticulture Abstract 11 (1) 9-10, 16.

Camejo, D., Rodriguez, P., Morales, A.M., Amico, J.M., Torrecillas, A. and Alarcon, J.J. (2005). High temperature effects on photosynthetic activity of two tomato cultivars with different heat susceptibility. *Journal of Plant Physiology* .162: 281-289.

Central Coast Gardening (2010). Basil plant- Pinching back- Internet-http:// centralcoastgardening.com/wp-content/uploads/2010/06/IMG 0010.jpg

Chiudo, P.S. and Khan, F. A. (1990). Control of Root Knot Nematode (*Meloidogyne* species) on Tomato species (*Lycopersicon esculentum)* with Poultry manure. Journal on Tropical Pest Management 36 (4): 332-335

Clerk, G.C. (1984) Crops and their Diseases in Ghana, Ghana Publuishing Cooperation. pp.112-136.

Corrales, O. V, and Mareira, M.A. (1990). Effect of Organic matter on Control of Rot in Sweet pepper (*Capsicum annum)* caused by *Phytophthora capsicum.*

Drechsel, P. and Quansah, C. (1998). Sustainable Land Management with Alternatives Fertilizer. A successful Approach of IBSRAM in Ghana. *Proceedings of the 16th World Congress of Soil Science, August 1998, Montpellier, France. International Society of Soil Science.*

Dupriez, H. and De Leener, D. P.(1989). Africa Gardens and Orchards. Published in association with Terres et Vie, rue Laurent Delvaux 13, 1400 Nivelles, Belgium.Pp79- 143.

Gallup (1986) Gallup Organization-National Gardening Survey 1985- 1986, *Documentary from National Gardening Association Burlington Vt. North Carolina pp . 13.*

Garden Action Mini-Project: (2000). How to care for ridge (outdoor) pp.1- 3.

George, R.A. T. (1985) Vegetable Seed Production. Longman Group Limited. London 168-179.

Gopalan, C. (2004).Towards National Nutrition Security, *Journal on nutrition, 2 (2):1-5.*

Hanna, H.Y. and Adams, A.J. (1991). Staking fresh market cucumbers for higher yields: A long term research report. Proc. Fla. State Hort. Society. 104:237-240.

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

Hemeng, B.M.S., Gaitu, M.C. and Otoo, E. (1995). Organic Soil Amendments and their Multiple Benefits to Crop Production. *Proceedings of Seminar on Organic and Sedentary Agriculture, Accra, 96-105.*

Hikosaka, S. and Sugiyama, N. (2004). Characteristics of flower and fruit development of multipistillate type of cucumber. *Journal of Horticulture Science and biotechnology, 2(4): 1-7.*

Hochmoth, R.C., Hochmoth, G.J. and Donley, M.E. (1993). Responses of Cabbage Yields on Fertilizer. *Documentary- Soil and Crop Science Society of Florida 52, 126-130.*

Iannotti, M, (2009). Growing great tomatoes.- Internet–http://gerdening.about com/biombiopage.

John, P., Russell, D., and Andrew, B. (2004). From farmer field schools to community IPM. FAO Community IPM Programme in Asia. Bangkok, Thailand. pp 6.

Kelley, W.T., Darbie, M.G. and Boyham, G.E. (2000). Commercial Production and Management of Squash and cucumber. *University of Georgia College of Agriculture and Environmental Sciences Cooperative Bulletin, 117(8): 1-15*

Lowes, R (2009). Deadhead, Pinch Back, Disbud and Candle. Internet- http://www.lowes.com.

Magkos, F., Avaniti F. and Zampelas A. (2006). Organic food: Buying more safety or just peace of mind? A Critical Review of the Literature. *Journal on Food Science and Nutrition 46: 23-56.*

Maynard (2000). Cucumber, melons and watermelons. In: Kiple KF and Ornelas KC (eds). *Journal-The Cambridge World History of Food. Cambridge University Press 2:35-40.*

Mathew, I.P. and Karikari, S.K. (1995). Horticulture: Principles and Practices. Published by Macmillan Education Limited, London. pp.7, 63-67.

Messiaen, C.M. (1994), The Tropical Vegetable Garden. The Macmillan Press Ltd.London. pp. 255-259.

MOFA (2002). Ministry of Food and Agriculture Manual-Accra, 4: 54-56.

Myanmar, Than Than Nu (1997) Pruning Effect on Yield of Different Cucumber Varieties. *Journal, ARC-AVRDC, KPS Thailand. 2(6): 7-12*

Norman, J.C. (2003). The Horticulture Industry in Tropical Africa, *Ghana Journal of Horticulture. 13(3): 33-46.*

Oikeh, S.O. and Asiegbu, J.E. (1993). Growth and Yield Responses of Tomato to sources and rate of Organic manures in Ferrolitic soils. *Journal on Biosource Technology. 45 (1): 21-25*

Papadopoulos, A.P. (1994). Growing greenhouse cucumber in soil and soiless media. *Documentary from Agriculture and Agri-Food Ottawa: Canada. pp. 5-126*

Parker, M. (2005). Roles of Organic Soil Amendments and soil organisms in the biological control of plant parasitic nematodes. *Journal on Bioresource Technology (74) 1.*

Paudel, K., Prasad, S. S., Krung S. and Yongyut O. (2004). Effects of Organic Manures on Production of Lettuce (*Lactuca sativa* L.) in reference to Chemical Fertilizer. *Journal- Kasetsart University for Agriculture. (National Science.) 38 : 31 – 37.*

Perry, E. (1999) Farm Advisor. *Documentary- University of California Cooperative Extension pp.1-3.*

Poincelot, R.P. (2004). Sustainable Horticulture, Today and Tomorrow. Upper Saddle River, New Jersey, USA. pp.130-182.

Potashcorp, (2009). Gardening and fertilizer. Internet- http://www.potashcorp.com/learn about fertilizer/gardening fertilizer.

Quansah, C., Drechsel, P. and Lefroy, R.D.B.(1997). Peri-urban Interface Agricultural. Production Systems: Soil fertility issues. Paper presented at the NRI Soil Fertility Workshop, UK. pp. 3

Rashid, M., Bhatti, A.U., Khan, F. and Wasiullah, F. (2008). Physico-chemical properties and fertility status of soils of Peshawar and Charsadda districts. *Journal on Soil and Environment, 27: 228-235.*

Redmond, W.A. (2007). "Cucumber " Microsoft ® Student 2008 [DVD]. Microsoft ® Encarta ® 2008. © 1993-2007 Microsoft Corporation.

Reinhold, J., Mikutta, R., Kleber, M., and Tarn, M.S. (1992). Stabilization of soil organic matter in association with minerals or chemical recalcitrance. *Journal on Biochemistry Vol.77 No. 1, 25, 56.*

Rice, R.P., Rice, L.W., Tindall, H.D. (1993): Fruit and Vegetable Production in Africa. Macmillarn Press Limited, London and Basingstoke. pp. 329.

Riley, K.W. (1998). International collaboration in plant genetic resources: The role of IBPGR on Plant Germplasm Conservation: *Proceedings of International Symposium held at the Taiwan Agricultural Research Institute. pp. 111-122.*

Rosendhal, I., Laabs, V., Agbotse, S.K. and Glitho, I.A. (2008). Living with Pesticides- A Case Study in Vegetable Production, Systemwide-Integrated Pest Management for Improved Methods Manual. 4: 13-15.

Schmutterer, H. (2002). The *Neem* Tree (*Azadirachta indica* A. Juss) and other Meliaceous and Plants: Sources of Unique Natural Products for Integrated Pest Management, Medicine, Industry other Purposes. Mumbai: *Neem Foundation International Journal on Sustainable Crop Production 4(2):1-5.*

Schultheis, J.R., C.W. Averre, M.D. Boyette, E.A. Estes, G.J. Holmes, D.W. Monks, and K.A. Sorensen. 1998. *Commercial Production of Pickling & Slicing Cucumbers in North Carolina*. Ag-552. Published by North Carolina Cooperative Extension Service.

Shalaby, G.I. and Hussein, H.A. (1994). The Possibility of using F_2 Seeds for Cucumber Production Under Plastic Houses. Research Publication, Department of Horticulture, Faculty of Agriculture, Assiut University, Egypt, 6: 301-310.

Singh, S P. (1997). Principles of vegetable production, first edition, Agrotech Publishing Academy. Udaipur pp 60-80. Manila, The Philippines.

Sinnadurai, S. (1992). Vegetable Cultivation. Asempa Publishers, Advent Press Accra. pp 3, 166-170.

Smakel, H. J. (2006) Pruning, Pinching and Disbudding. *Documentary from Avocado Association Yearbook Califonia USA 14:135-136.*

Snrech, S. (1994). Preparing the future of West Africa towards Vision 2020 (Pour préparer l'avenir de l'Afrique de l'ouest: Une vision a l'horizon 2020, OCDE/BAD/CILSS) *Documentary. 25: 12-15.*

Srivastava, L. M.(2002). Plant growth and development: Hormones and Environment. Academic Press- Amsterdam. pp 140.

Stephen, J.M. and Kostewicz, S.R. (1992). Organic Soil Amendments for Florida gardens. *Documentary from Florida State Horticultural Society, 105: 263-267.*

Takeda, K.Y. (1981). Cucumber Production. *Documentary from University of Hawaii Cooperative Extension. Service. 3:1-15.*

Vimala, P., Salbiah, H., Zaharah, T. and Ruwaida, M. (2001). Yield responses of vegetables to organic fertilizers. *Journal on Tropical Agriculture and Food Science. 29: 11-21.*

Wehner, T.C. and Maynard, D.N. (2003). Cucurbitaceae (Vine Crops). *Documentary from Universities of North Carolina-Raleigh and Florida-Bradenton, USA. 38;1-10.*

Wahid A., Gelani, S., Ashraf, M.and Foolad, M.R. (2007). Heat tolerance in plants: An overview. *Environmental and Experimental Botany*. 61: 199-223.

Webster C.C. and Wilson P.N. (1989). Agriculture in the Tropics. Longman Group Limited, Longman House, Burnt Mill, Harlow, Essex, U.K. pp. 56-90.

Wiggins, S. (2005) Success Stories from African Agriculture: What are the Key Elements of Success? Institute of Development Studies. *IDS Bulletin 36 (2): 20.*

Williams, C. N., Madanlar, N., Z. Yoldas, M. and Gumus, I.H. (1991). Organic Fertilizer Responses of Cucumbers on Peat in Brunei. *Experimental Agriculture,* 14 : 299-302.

Xuide, W., Tao, W.F. Zhaoxiong, L., Yuan, L.Y. and Pei, M. (1996) Study on formular Selection and Rational Application Amount of Organic-Inorganic Granular Fertilizer for some vegetable species. Acta Agriculture Shangai 12 (1) 61-65.

Yagodin, B.A. (1984): Manure in Agricultural Chemistry 2, Mir Publication, Moscow. 132-144.

Yamaguchi, M. (1983): Cucurbits in World Vegetable Principles, Production and Nutritive Values. AVI Publishing Company Inc. West Port, Connecticut 317-322.

APPENDIX

Analysis of Variance (ANOVA)

(Table 4.3a) Mean number of leaves 14 days after germination (Wet Season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.5185	0.2593	1.00	
Fertilizer type	2	3.6296	1.8148	7.00	0.007
Pinching	2	0.2963	0.1481	0.57	0.576
Fertilizer type and pinching	4	0.8148	0.2037	0.79	0.551
Residual	16	4.1481	0.2593		
Total	26	9.4074			

(Table 4.3b) Mean number of leaves 14 days after germination (Dry Season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	2.7407	1.3704	6.73	
Fertilizer type	2	1.4074	0.7037	3.45	0.057
Pinching	2	0.0741	0.0370	0.18	0.835
Fertilizer type and pinching	4	0.3704	0.0926	0.45	0.768
Residual	16	3.2593	0.2037		
Total	26	7.8519			

(Table 4.4) Mean plant height (cm) 14 days germination (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.825	0.413	0.15	
Fertilizer type	2	21.771	10.885	3.93	0.041
Pinching	2	7.598	3.799	1.37	0.282
Fertilizer type and pinching	4	3.751	0.938	0.34	0.848
Residual	16	57.926	3.620		
Total	26	78.256			

(Table 4.4a) Mean plant height (cm) 21 days germination (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	14.74	7.37	0.46	0.15
Fertilizer type	2	468.96	234.48	14.60	<.001
Pinching	2	5510.69	2755.34	171.59	<.001
Fertilizer type and pinching	4	177.93	44.48	2.77	0.063
Residual	16	256.93	16.06		
Total	26	6429.24			

(Table 4.4b) Mean plant height (cm) 21 days germination (Dry season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.06	0.03	0.00	
Fertilizer type	2	168.32	84.16	5.04	0.020
Pinching	2	11.83	5.91	0.35	0.707
Fertilizer type and pinching	4	68.84	17.21	1.03	0.422
Residual	16	267.32	16.71		
Total	26	516.37			

(Table 4.5) Mean number of brunches 14 days after germination (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	1.4074	0.7037	2.87	
Fertilizer type	2	7.6296	3.8148	15.55	<.001
Pinching	2	0.5185	0.2593	1.06	0.37
Fertilizer type and pinching	4	0.3704	0.0926	0.38	0.821
Residual	16	3.9259	0.245		
Total	26	13.8519			

(Table 4.6a) Mean number of leaves 21 days after germination (Wet Season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	39.407	19.704	5.44	
Fertilizer type	2	317.630	158.815	43.87	<.001
Pinching	2	16.074	8.037	2.22	0.141
Fertilizer type and pinching	4	7.037	1.759	0.49	0.746
Residual	16	57.926	3.620		
Total	26	438.074			

(Table 4.6b) Mean number of leaves 21 days after germination (Dry Season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.0000	0.0000	0.00	
Fertilizer type	2	4.2222	2.1111	7.24	0.006
Pinching	2	0.2222	0.1111	0.38	0.689
Fertilizer type and pinching	4	1.5556	0.3889	1.33	0.300
Residual	16	4.6667	0.2917		
Total	26	10.6667			

(Table 4.7a) Mean number of branches 21 days after germination (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	1.5556	0.7778	1.93	
Fertilizer type	2	11.5556	5 .7778	14.34	<.001
Pinching	2	4.6667	2.3333	5.79	0.013
Fertilizer type and pinching	4	0.4444	0.1111	0.28	0.889
Residual	16	6.4444	0.4028		
Total	26	24.6667			

(Table 4.7b) Mean number of branches 21 days after germination (Dry season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.2963	0.1481	0.78	
Fertilizer type	2	2.0741	1.0370	5.46	0.016
Pinching	2	0.9630	0.4815	2.54	0.110
Fertilizer type and pinching	4	0.5926	0.1481	0.78	0.554
Residual	16	3.0370	0.1898		
Total	26	6.9630			

(Table 4.8a) Mean number of branches 28 days after germination (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r	F pr
Blocks stratum	2	0.9630	0.4815	0.70	
Fertilizer type	2	16.0741	8.0370	11.65	<.001
Pinching	2	7.6296	3.8148	5.53	0.015
Fertilizer type and pinching	4	0.5926	0.1481	0.21	0.926
Residual	16	11.0370	0.6898		
Total	26	36.2963			

(Table 4.8b) Mean number of branches 28 days after germination (Dry season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	4.2222	2.1111	3.71	
Fertilizer type	2	2.0000	1.0000	1.76	0.204
Pinching	2	8.2222	4.1111	7.22	0.006
Fertilizer type and pinching	4	2.4444	0.6111	1.07	0.402
Residual	16	9.1111	0.5694		
Total	26	26.0000			

(Table 4.9a Mean number of female flowers 30 days after germination (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	3.8519	1.9259	2.29	
Fertilizer type	2	12.5185	6.2593	7.43	0.005
Pinching	2	31.6296	5.8148	18.77	<.001
Fertilizer type and pinching	4	7.2593	1.8148	2.15	0.121
Residual	16	13.4815	0.8426		
Total	26	68.7407			

(Table 4.9b) Mean number of female flowers 30 days after germination (Dry season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	1.4074	0.7037	1.22	
Fertilizer	2	0.9630	0.4815	0.83	0.453
Pinching	2	4.9630	2.4815	4.29	0.032
Fertilizer type and pinching	4	2.5926	0.6481	1.12	0.382
Residual	16	9.2593	0.5787		
Total	26	19.185			

(Table 4.10a) Mean number of fruits set 34 days after germination (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr
Blocks stratum	2	0.9630	0.4815	1.00	
Fertilizer type	2	3.1852	1.5926	3.31	0.063
Pinching	2	11.1852	5.5926	11.62	<.001
Fertilizer type and pinching	4	0.5926	0.1481	0.31	0.869
Residual	16	7.7037	0.4815		
Total	26	23.6296			

(Table 4.10b) Mean number of fruits set 34 days after germination (Dry season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr
Blocks stratum	2	5.6296	2.8148	5.85	
Fertilizer type	2	0.5185	0.2593	0.54	0.594
Pinching	2	3.8519	1.9259	4.00	0.039
Fertilizer type and pinching	4	2.3704	0.5926	1.23	0.337
Residual	16	7.7037	0.4815		
Total	26	20.0741			

(Table 4.11a) Mean number of cucumber fruits harvested per hectare (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr
Blocks stratum	2	16520×10^{5}	82590×10^{4}	2.13	
Fertilizer type	2	28740×10^{5}	14370×10^{5}	3.70	0.048
Pinching	2	1407×10^{6}	7037×10^{4}	0.18	0.836
Fertilizer type and pinching	4	2370×10^{5}	5926×10^{4}	0.15	0.959
Residual	16	62150×10^{5}	38840×10^{4}		
Total	26	11120×10^{6}			

(Table 4.11b) Mean number of cucumber fruits harvested per hectare (Dry Season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	30020×10^{5}	15010×10^{5}	8.43	
Fertilizer type	2	13640×10^{5}	68220×10^{4}	3.83	0.044
Pinching	2	2144×10^{5}	1072×10^{5}	0.60	0.560
Fertilizer type and pinching	4	7148×10^{5}	1787×10^{5}	1.00	0.434
Residual	16	28480×10^{5}	17800×10^{4}		
Total	26	$8{,}1440\times10^{5}$			

(Table 4.12a) Mean weight of harvested fruits (tons per hectare) (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	258.80	129.40	2.76	
Fertilizer type	2	300.57	150.29	3.21	0.047
Pinching	2	48.02	24.01	0.51	0.608
Fertilizer type and pinching	4	33.43	8.36	0.18	0.946
Residual	16	748.87	46.80		
Total	26	1389.69			

(Table 4.12b) Mean weight of harvested fruits (tons per hectare) (Dry season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	50.832	25.416	13.53	
Fertilizer type	2	28.447	14.224	7.57	0.005
Pinching	2	1.505	0.753	0.40	0.676
Fertilizer type and pinching	4	8.459	2.115	1.13	0.379
Residual	16	30.048	1.878		
Total	26	119.292			

(Table 4.13) Mean number of marketable fruits per hectare (Dry Season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	$1,2670\times10^{5}$	$6,3330\times10^{4}$	2.20	
Fertilizer type	2	$2,2890\times10^{5}$	$1,1440\times10^{5}$	3.98	0.040
Pinching	2	6.889×10^{5}	3.444×10^{5}	1.20	0.327
Fertilizer type and pinching	4	2.222×10^{5}	5.556×10^{4}	0.19	0.938
Residual	16	$4,6000\times10^{5}$	$2,8750\times10^{4}$		
Total	26	$9,0670\times10^{5}$			

(Table 4.14a) Mean weight of marketable fruits (tons per hectare) (Wet season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	151.96	75.98	3.01	
Fertilizer type	2	226.21	113.10	4.48	0.028
Pinching	2	39.67	19.84	0.79	0.472
Fertilizer type and pinching	4	40.83	10.21	0.40	0.803
Residual	16	403.62	25.23		
Total	26	862.29			

(Table 4.14b) Mean weight of marketable fruits (tons per hectare) (Dry season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	30.349	15.174	11.04	
Blocks stratum	2	30.349	15.174	11.04	
Fertilizer type	2	226.21	113.10	4.48	0.028
Pinching	2	39.67	19.84	0.79	0.472
Fertilizer type and pinching	4	40.83	10.21	0.40	0.803
Residual	16	403.62	25.23		
Total	26	862.29			

(Table 4.15) Mean fruit shape index (length/diameter) (Wet Season)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Blocks stratum	2	0.28907	0.14454	13.94	
Fertilizer type	2	0.71685	0.35843	34.56	<.001
Pinching	2	0.04019	0.02009	1.94	0.176
Fertilizer type and pinching	4	0.30370	0.07593	7.32	0.001
Residual	16	0.16593	0.01037		
Total	26	1.51574			