EFFECTS OF PHOSPHORUS AND POULTRY MANURE RATE ON THE GROWTH AND YIELD OF HABANERO PEPPER (*Capsicum chinense* L.)

BY

ABDULRAHEEM, Halimat

P14AGAG8002

A DISSERTATION SUBMITTED TO SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN AGRONOMY

SEPTEMBER, 2018

DECLARATION

I hereby declare that the work in this dissertation "EFFECTS OF PHOSPHORUS AND POULTRY MANURE RATES ON THE GROWTH AND YIELD OF HABANERO PEPPER (*Capsicum chinense* L.)" was performed by me in the Department of Agronomy under the supervision of Professors L. Aliyu and B. A. Babaji, The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this work has been presented for another degree or diploma at any institution.

Abdulraheem Halimat	______________ Signature	____________ Date

The above declaration is confirmed by;

Prof. L. Aliyu (Chairman, Supervisory Committee)	______________ Signature	____________ Date

CERTIFICATION

This dissertation "EFFECTS OF PHOSPHORUS AND POULTRY MANURE RATES ON THE GROWTH AND YIELD OF HABANERO PEPPER (*Capsicum chinense* L.)" meets the regulations governing the award of the degree of Master of Science in Agronomy of the Ahmadu Bello University, and is approved for its contribution to knowledge and literacy presentation.

Prof. L. Aliyu Chairman, Supervisory Committee	______________ Signature	____________ Date
Prof. B. A. Babaji Member, Supervisory Committee	______________ Signature	____________ Date
Dr. M.A. Mahdi Head of Department	______________ Signature	____________ Date
Professor S.Z. Abubakar Dean, School of Postgraduate Studies	______________ Signature	____________ Date

DEDICATION

This work is dedicated to the Almighty Allah and my late father Mallam Abdullateef Abdulraheem for his efforts on me during his life time (May Allah grant him Aljannah Firdaus).

ACKNOWLEDGEMENTS

I want to start by thanking and praising Almighty Allah for the gift of life and all the mercies He bestowed on me. Alhamdullilah. I wish to express my profound gratitude to my supervisors, Professors L. Aliyu and B.A. Babaji for their constructive suggestions, criticisms and direction right from the proposal to the final stage of this work in spite of their tight schedules. My sincere thanks go to the H.O.D (Dr. M.A. Mahadi) and all my lecturers that contributed to the success of this work; Dr. A.S. Isah, Dr. U.L. Arunah, Dr. R.A. Yahya and all academic staff of the department. The field technicians Mallam Saleh Musa, Bala Shanu, Muazu Yaro, Buhari Tasiu and others for their help in the field work my sincere appreciation to all.

My sincere gratitude and appreciation goes to my late father (Mallam Abdullateef Abdulraheem), my mother (Mallama Fatima Abdulraheem) for their spiritual, moral, material and financial support. I am indeed grateful to my siblings (Abdulrazaq and Balqis, Mum Adeena, Muinat Abdulsalam, Mum Aliyu and Muhammed Kabir Abdulraheem) and the Ahmeds May Allah rewards them all.

My sincere appreciation, honor, regard and special thanks go to my fiancé (Abubakar Sadiq Adua) for his support and patience throughout the course of this study. Special thanks to Mr. James Yaduma (NIHORT, Bagauda), Sofiu Salaudeen, Zainab Ahmed, Sherifat Ahmed, Rayyanu, Samaila, Imrana, Hussaini, Yahya, my colleagues; Abubakar .I. Ciroma (Police), Aishatu Yunusa, Usman Ladan, Isaac, Oga Ezekial, Rotimi (Roo), Ghana, Oga K.B, Daddy Idris, Aminu crop, Oumarou, Adebisi and all those I could mention who contributed to the success of this work.

ABSTRACT

A field experiment was conducted to determine the performance of habanero pepper varieties as influenced by phosphorus and poultry manure fertilization. The experiments were carried out during the 2016 wet season at the Institute for Agricultural Research Farm Samaru, Kaduna State and NIHORT Farm Bagauda, Kano State. The treatments evaluated were four phosphorus rates (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and four poultry manure rates (0, 3, 6 and 9 t ha^{-1}) which were factorially combined and laid in a Randomized Complete Block Design (RCBD), replicated three times. Parameters measured were, plant height (cm), number of leaves, number of branches, leaf area (cm^2), leaf area index, crop growth rate (g wk^{-1}), relative growth rate (g g wk^{-1}), net assimilation rate (g m^{-2} wk^{-1}), number of days to 50% flowering, number of fruits per plant, fruit weight per plant (g), fruit yield t ha^{-1}. Plant height (30.13cm at10 WAT), number of leaves (247.42 at 10WAT), number of branches (42.92 at 10WAT), leaf area (4813.80cm^2 at 12 WAT), leaf area index (2.14 at 12 WAT), shoot dry matter (6.25g at 9WAT), leaf dry weight (6.47g at 12 WAT), number of fruit per plant (36.58), fruit weight per plant (280.21g) and fruit yield per hectare (14.63t ha^{-1}) showed significant response to phosphorus fertilizer with 60kg P_2O_5 ha^{-1} producing higher values in Samaru. While in Bagauda, number of leaves (140.67 at 10 WAT), leaf area (2775.20cm^2 at 10 WAT), leaf area index (1.23 at 12 WAT), shoot dry matter (5.96g at 12 WAT), leaf dry weight (1.56g at 9 WAT), stem dry weight (3.18g at 12 WAT), crop growth rate (0.93 at 9-12 WAT), number of fruits per plant (21.92), fruit weight per plant (168.13) and fruit yield per hectare (8.41) were significantly increased by application of 90 kg P_2O_5 ha^{-1}which led to early 50% flowering (32.58). Most growth and yield characters of habanero pepper were highest by application of poultry manure at 6 and 9 t ha^{-1}in Samaru and Bagauda respectively. Regression analysis showed the optimum rates of phosphorus and poultry manure for habanero pepper yield was 55.42 kg P_2O_5 ha^{-1} and yield of 9.98t ha^{-1}. Poultry manure when regressed against pepper yield showed an optimum of 4.90 t ha^{-1} yielded 11.93 t ha^{-1}. In conclusion, it could be suggested that combination of phosphorus and poultry manure at a rate of 55.42 kg $P_2O_5ha^{-1}$ and 4.90 t poultry manure ha^{-1} can be used by farmers in the Savannah zones.

TABLE OF CONTENTS

	TITLE PAGE	**i**
	DECLARATION	**ii**
	CERTIFICATION	**iii**
	DEDICATION	**iv**
	ACKNOWLEDGEMENTS	**v**
	ABSTRACT	**vi**
	TABLE OF CONTENTS	**vii**
	LIST OF TABLES	**x**
	LIST OF FIGURES	**xi**
	LIST OF APPENDICES	**Xii**
1.0	INTRODUCTION	**1**
1.1	Production and Importance of Pepper	**2**
1.2	Justification and Objectives	**3**
2.0	LITERATURE REVIEW	**6**
2.1	Roles of Phosphorus in Plant Nutrition	**6**
2.2	Roles of Manure in Plant Nutrition	**8**
2.3	Effect of Phosphorus on Growth and Yield of Habanero Pepper	**9**
2.4	Effect of Poultry Maure on Growth and Yield of Habanero Pepper	**12**
2.5	Interaction of Phosphorus and Poultry Manure on Pepper	**13**
3.0	MATERIALS AND METHODS	**14**
3.1	Experimental Sites	**14**
3.2	Treatments, Experimental Design and Plot Size	**14**
3.3	Source of Seed and Description of Variety	**14**
3.4	Cultural Practices	**15**
3.4.1	Nursery preparation and management	**15**
3.4.2	Soil and manure analysis	**15**
3.4.3	Land preparation and fertilizer application	**15**
3.4.4	Weed control	**16**

3.4.5	Pest control	**16**
3.4.6	Harvesting	**16**
3.5	Data Collection	**17**
3.5.1	Meteorological data	**17**
3.5.2	Number of days to 50% flowering	**17**
3.5.3	Growth characters	**17**
3.5.4	Growth indices	**18**
3.5.5	Yield characters	**20**
3.6	Data Analysis	**20**
4.0	RESULTS	**21**
4.1	Properties of Soil and Manure	**21**
4.2	Plant Height	**23**
4.3	Number of Leaves per Plant	**27**
4.4	Number of Branches	**29**
4.5	Leaf Area	**31**
4.6	Leaf Area Index	**33**
4.7	Shoot Dry Matter	**33**
4.8	Leaf Dry Weight	**37**
4.9	Stem Dry Weight	**37**
4.10	Crop Growth Rate	**38**
4.11	Net Assimilation Rate	**42**
4.12	Relative Growth Rate	**42**
4.13	Number of Days to 50% Flowering	**45**
4.14	Number of Fruits per plant	**48**
4.15	Fruit Weight	**49**
4.16	Fresh Fruit Yield per Hectare	**55**
4.17	Regression and Correlation Studies	**60**
4.17.1	Regression studies	**60**
4.17.2	Simple correlation of pepper	**60**
5.0	DISCUSSION	**68**
5.1	Response to Phosphorus Application	**68**

5.2 Response to Poultry Manure ....………. **70**
5.3 Interaction between Phosphorus Fertilizer and Poultry Manure on Pepper………. **73**
5.4 Regression... **74**
5.5 Correlation…………………………………………………………………….... **74**
6.0 SUMMARY, CONCLUSION AND RECOMMENDATION…………………… **76**
REFERENCES………………………………………………………………… **78**

LIST OF TABLES

1 Soil physical and chemical properties of the experimental site and nutrient content of Poultry manure used for the trial……………………………. **22**

2 Nutrient content of the poultry manure used in the experiments…………............... **22**

3 Effects of phosphorus and poultry manure rates on height (cm) of habanero pepper at 4, 6, 8 and 10WAT in Bagauda and Samaru during the 2016 wet season............ **25**

4 Interaction between phosphorus and poultry manure rates on plant height (cm) of habanero pepper at 6 WAT and 8 WAT in Samaru during the 2016 wet Season...... **26**

5 Effects of phosphorus and poultry manure rates on number of leaves of habanero pepper at 4, 6, 8 and 10WAT in Bagauda and Samaru during the 2016 wet season. **28**

6 Effects of phosphorus and poultry manure rates on number of branches of habanero pepper at 4, 6, 8 and 10WAT in Bagauda and Samaru during the 2016 wet season……………………………………………………………………… **30**

7 Effects of phosphorus and poultry manure rates on leaf area (cm^2) of habanero pepper at 6, 9 and 12WAT in Bagauda and Samaru during the 2016 wet season...... **32**

8 Effects of phosphorus and poultry manure rates on leaf area index of habanero pepper at 6, 9 and 12 WAT in Bagauda and Samaru during the 2016 wet season.... **35**

9 Effects of phosphorus and poultry manure rates on shoot dry matter (g) of habanero pepper at 6, 9 and 12 WAT in Bagauda and Samaru during the 2016 wet season………………………………………………………………………. **36**

10 Effects of phosphorus and poultry manure rates on leaf dry weight (g) of habanero pepper at 6, 9 and 12 WAT in Bagauda and Samaru during the 2016 wet season..... **39**

11 Effects of phosphorus and poultry manure rates on stem dry weight (g) of habanero pepper at 6, 9 and 12 WAT in Bagauda and Samaru during the 2016 wet season………………………………………………………………………… **40**

12 Effects of phosphorus and poultry manure rates on crop growth rate ($g\ m^{-2}wk^{-1}$) of habanero pepper at 6, 9 and 12 WAT in Bagauda and Samaru during the 2016 wet season………………………………………………………………………. **41**

13 Effects of phosphorus and poultry manure rates on net assimilation ($g\ m^{-2}\ wk^{-1}$)Rate of habanero pepper at 6-9 WAT and 9-12 WAT in Bagauda and Samaru during the 2016 wet season……………………………………………………… **43**

1 Effects of phosphorus and poultry manure rates on relative growth rate ($g\ g^{-1}wk^{-1}$) of **44**

4 habanero pepper at 6-9 WAT and 9-12 WAT in Bagauda and Samaru during the 2016 wet season ……………………………………………………………………

15 Effects of phosphorus and poultry manure rates on number of days to 50% flowering of habanero pepper in Bagauda and Samaru during the 2016 wet season…………………………………………………………………………………. 46

16 Interaction between phosphorus and poultry manure rates on number of days to 50% flowering of habanero pepper in Bagauda during the 2016 wet.................. 47

17 Effects of phosphorus and poultry manure rates on number of fruit per plant of habanero pepper in Bagauda and Samaru during the 2016 wet season…………… 51

18 Interaction between phosphorus and poultry manure rates on number of fruit per plant of habanero pepper in Bagauda and Samaru during the 2016 wet season… 52

19 Effects of phosphorus and poultry manure rates on fruit weight (g) per plant of habanero pepper in Bagauda and Samaru during the 2016 wet season………….. 53

20 Interaction between phosphorus and poultry manure rates on fruit weight per plant of habanero pepper in Bagauda and Samaru during the 2016 wet season............ 54

21 Effects of phosphorus and poultry manure rates on total fruit yield (tha^{-1}) per hectare of habanero pepper at in Bagauda and Samaru during the 2016 wet season... 58

22 Interaction between phosphorus and poultry manure rates on total fruit yield per hectare of habanero pepper in Bagauda and Samaru during the 2016 wet season…………………………………………... 59

23 Interaction between phosphorus and poultry manure rates on fruit yield per hectare of habanero pepper for the combine during the 2016 wet season…………………. 59

24 Matrix of Correlation between growth and yield attributes of habanero pepper as influenced by phosphorus and poultry manure rates in Bagauda during the 2016 wet season………………………………………………………………………… 66

25 Matrix of Correlation between growth and yield attributes of habanero pepper as influenced by phosphorus and poultry manure rates in Samaru during the 2016 wet season……………………………………………………………………………... 67

LIST OF FIGURES

1	Figure 1 Regression of habanero pepper fruit yield against phosphorus fertilizer rates in Bagauda and Samaru during the 2016 wet season……………………….	**62**
2	Figure 2 Regression of habanero pepper fruit yield against poultry manure rates in Bagauda and Samaru during the 2016 wet season...	**63**
3	Figure 3 Combined regression of habanero pepper fruit yield against phosphorus fertilizer rates during the 2016 wet season………………………………………..	**64**
4	Figure 4 Combined regression of habanero pepper fruit yield against poultry manure rates during the 2016 wet season…………………………………………	**65**

LIST OF APPENDICES

1 Bagauda meteorological observation 2016 wet season.................................... **88**

2 Samaru meteorological observation 2016 wet season.. **88**

CHAPTER ONE

1.0 INTRODUCTION

Habanero pepper (*Capsicum chinense* L.) belongs to a group of hot pepper popularly called atarodo or tarugu in Nigeria. Most often scientists mistakenly classify the habaneros as members of sweet pepper group. It is believed to have originated from Cuba (De Witt and Gerlach, 1964) from there it was introduced to South and Middle America (Mac Nesh, 1964). It is a tropical crop which can also be grown in the subtropical environments and it can grow on a wide range of altitudes, with rainfall between 600-1250mm. The crop requires well drained fertile soil with pH range of 6.5-7.5 (Matta and Cotter, 1994). The best fruits are obtained at temperature of 21- 25^{0}C during day time and night temperature of 15-20^{0}C. High temperature above 31^{0}C affect fruit quality, especially fruit color, however, growth cease at lower temperature below 10^{0}C (Grubben, 1977). In recent years, the habanero pepper has become increasingly important as a result of it high diversity and high fruit pungency, which makes it desirable species in many countries. Pungency of fruit depends on the environmental factors which include soil type, osmotic properties and nutrient compositions (Soria- Fregoso *et al*., 2002). Habanero pepper is usually grown as a rainfed crop and occasionally as an irrigated crop during the dry season in lowland areas (Poulos, 1993). Poorly distributed rainfall and limited water supply situation result in poor fruit set or fruit rot. Large scale production of habanero pepper is mainly during rainy season. However, it does not require high temperature. The rain fed crop (June-September) is also important due to continuous demand for fresh pepper (Muhammad, 1989).

Habanero pepper possesses an apple-cherry tomato flavor; mature fruits measure 2.5 to 3.8 cm in length and 2.5 to 3.8 cm in diameter (Gardner and Queeley 1999). Similar agricultural practices are often used for sweet and hot pepper species, although these crops differ in growth, habit, and fruiting characteristics.

1.1 Production and Importance of Pepper

Pepper is an important horticultural crop not only because of its economic importance but also due to the nutritional and medicinal value of its fruits as well as being an excellent source of natural colours and antioxidant compounds (Howard *et al.*, 2000). Comparatively, yield in the developing countries is about 10 – 30% higher to that obtained in developed countries (Erinle, 1989; Grubben and Tahir, 2004). However, Nigeria is known to be one of the major producers of pepper in the world accounting for about 50% of the African production and the major area of production is Northern Nigeria (Anonymous, 2007; Erinle, 1989). High potential pepper producing areas of Nigeria such as Kaduna, Kano, Jigawa, Katsina, Sokoto, Plateau and Bauchi States (most of which also lie within the derived savannah zone) produce enough pepper to meet the needs of the people in the deficit areas (e.g. Southwest i.e. Ogun, Oyo, Ondo, Osun, Ekiti and Lagos States).

The FAO world production statistics of fresh pepper regardless of type in 2013 was 31,131,226 metric tonnes, out of which Africa produced 2,873,802 metric tonnes. (FAO, 2014) West Africa produced 771,424 metric tonnes, while Nigeria produced 510,000 metric tonnes. The total area put under production in the world was 1,899,956ha, Africa accounted for 352,685ha, West Africa 155,153ha, and Nigeria 65,000 ha in 2013. China is the biggest pepper producing country in the world with 15,823,000 tonnes while Nigeria top countries in West Africa. Nigeria produces about 56% of West Africa and 18.5% of Africa's production (FAO, 2013). Annual yields of hot peppers range between 15 to 55 tha^{-1}. The yields are variable and dependent on cultivar which differs in size of fruits and of plants, and on the system of cultivation (Norman, 2002). For its wide use in Nigerian diet, habanero pepper is an important traditional crop mainly valued for its pungency, aroma and color particularly by Yoruba people. The crop is one of the important spices that serve as the source of income particularly for small scale producer in any part of northern Nigeria (Howard *et al*., 2000). Pepper has increased in popularity, value and importance over a long period, thus making it an indispensable part of the daily diet of millions of Nigerians. Pepper is normally used as a spice in the preparation of soups and stews. It can also be used as a condiment and extensively in flavoring of processed meat, coloring certain food preparation and also used for medicinal purposes (Alabi, 2006; UGCE, 2009). According to Marin *et al*. (2004), and Gil-guerrero *et al*. (2006), habanero pepper is an excellent source of natural colors and antioxidant compounds, ascorbic acid, carotenoids and phenolic compounds. It also contains vitamins A and C and it was reported that the pro-vitamin A (B Carotene) and ascorbic acid increase as hot pepper mature. The intake of these compounds in foods is an important health protecting factor, they have been recognized as being beneficial for prevention of widespread human diseases, including cancer and cardiovascular diseases, when taken daily in adequate amounts (Kaur and Kapoor, 2001; Sardas, 2003).

1.2 Justification and Objectives of the Study

Pepper is a very important fruit vegetable in the tropics and the world. In Nigeria, it is second most important vegetable after tomato (Olaniyi and Ojetayo, 2010). Although pepper is widely cultivated throughout Nigeria, yields obtained by peasant farmers are often very low (Adigun, 2001). However there is need to increase production as indicated by the demand for pepper throughout the year, but this has been hampered as a result of low soil fertility and other factors.

Generally, farmers usually do not consider the use of phosphorus fertilizer in pepper cropping due to the fact that they do not know the importance of phosphorus fertilizer in pepper production and also because of it slow release. Sanchez *et al*. (1996) emphasized that sustainable crop production is impossible without the application of phosphorous fertilizer. As stated by Degeus (1973), phosphorus promotes the development of the root systems, seed formation, and hastens ripening in pepper. In order to stimulate early growth and development, care should be taken to provide the crop with sufficient amount of easily available phosphorus (Tisdale *et al.*, 1993). Slow release fertilizers also hold great promise for the production of solanaceous vegetables. To attain considerable production and quality yield for any crops it is necessary for ensure the availability of essential nutrient components in proper doses.

There is the need to augment the nutrient status of the soil to meet the crop requirement and maintain the fertility status of the soil. One of the ways of increasing the nutrient content is by boosting the nutrient content with organic materials such as poultry manure, with or without inorganic fertilizers (Ajayi *et al*., 2008). Poultry manure is relatively resistant to microbial degradation (Dauda *et al*., 2005a and b). However, it is essential for establishing and maintaining the optimum soil physical condition for plant growth.

.Organic farming provides several benefits to the growers. It reduces production cost and it is an environmentally friendly method of cultivation. The use of organic manure alone may not give reasonable economic yield, hence it is vital to find the appropriate combinations of phosphorus fertilizer with poultry manure to obtain financially viable yield of pepper.

The study was undertaken with a view to improve available literature on the rate of poultry manure and phosphorus fertilization for good performance of habanero pepper and also to increase the productivity of habanero pepper using manure and phosphorus at optimum rate. This study was conducted with the following objectives,

i. To determine the effect of phosphorus fertilization on growth and yield of habanero pepper
ii. To determine the effect of poultry manure rate on growth and yield of habanero pepper.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Roles of Phosphorus in Plant Nutrition

Phosphorus has long been known to be an essential element in the nutrition of plants. It plays key roles in cellular energy transfer, respiration, and photosynthesis (Price, 1970). In addition, Phosphorus plays an essential role in many physiological and biochemical processes and is an essential component of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) (Olsen and Khasawneh, 1980). Neither plants nor animals can grow without phosphorus. Phosphorus is an important constituent of nucleo proteins, high energy transfer compounds such as adenosine triphosphate and plays a key role in energy transfer in the metabolic processes (Siddesh, 2006). It is an essential component of the organic compound often called the energy currency of the living cell; ATP. Synthesized through both respiration and photosynthesis, ATP contains a high-energy phosphate group that drives most energy-requiring biochemical processes. For example, the uptake of nutrients and their transport within the plant, as well as their assimilation into different bio-molecules are energy-using plant processes that require ATP as stated by Sopher and Baird (1982).

Phosphorus is an essential component of DNA, the seat of genetic inheritance, and of ribonucleic acid RNA, which directs protein synthesis in both plants and animals. Phospholipids, which play critical roles in cellular membranes, are another class of universally important phosphorus-containing compounds. For most plant species, the total phosphorus content of healthy leaf tissue is not high, usually comprising only 0.2 and 0.4% of the dry matter (Brady and Weil, 2002).

Phosphorus is essential for numerous metabolic processes. Among the significant function and qualities of plants on which phosphorus has an important effects are, enhances many aspects of plant physiology, including the fundamental processes of photosynthesis, reproduction (flowering, fruiting and seed production), nitrogen fixation and maturation.

Phosphorus has pronounced effect on tomato and pepper plants. It is absorbed in relatively large quantities by most plants which plays a vital role in plant growth. It promotes root growth, flower, and fruit and seed development and stimulates stiffer stems. When a crop such as pepper and cereals are deficient in phosphorus, growth is retarded and the formation and ripening of seeds may be retarded, plant develops a stunted root system and leaf development is reduced (Addo-Quaye *et al*., 1993).

Root growth, particularly development of lateral roots and fibrous rootlets, is encouraged by phosphorus. In cereal crops, good phosphorus nutrition strengthens structural tissues such as those found in straw or stalks, thus helping to prevent lodging (falling over). Improvement of crop quality, especially in forages and vegetables, is another benefit attributed to this nutrient (Brady and Weil, 2002). Both inorganic and organic forms of phosphorus occur in soils and both are important to plants as sources of this element. The relative amounts in the two forms vary greatly from soil to soil. The organic fraction generally constitutes 20 to 80% of the total phosphorus in surface soil horizons. The deeper horizons may hold large amounts of inorganic phosphorus, especially in soils from arid and semiarid regions (Brady and Weil, 2002).

Phosphorous has a lower mobility in the soil than any other nutrients and it does not remain in a free state for long in which it is slowly available to plants (Parnes, 1990).

Plants deficient in phosphorus are stunted and in contrast to those lacking nitrogen, are often dark green colors. The effect of phosphorus on the formation and translocation of carbohydrates, roots development, nodulation, growth and other agronomic characters are well recognized. Phosphorus induces earliness in flowering and fruiting including seed formation (Buckman and Brady, 1969). Again secondary mechanism of interference was the absorption of phosphorus from the soil through luxury consumption, increasing the tissue content without enhancing smooth biomass accumulation (Santos *et al*., 2004).

2.2 Roles of Manure in Plant Nutrition

Manure benefits both the soil and the crop. It improves the tilth of heavy soils, and increases the water holding capacity of light soils. The full benefit of manure is obtained only when the soil is well cultivated, well drained, and well limed (Russell, 2004). Animal waste can make substantial contribution to nitrogen, phosphorus, potassium and other nutrient needs. Total supply, however, depends on the nature and size of animal enterprises and methods used in decomposing, storing, and application of the manure (Habtemariam, 2003; Russell, 2004). There is variability in the nutrient composition of manures and this depends on the type of animal, its age, the feed supplied, bedding material used, storage and handling of manure (Anon, 1980; Aliyu, 2002), hence the reason for the differential response of crops to different manures. Nitrogen from manure is lost from the soil. In fact some loss is inevitable no matter how the manure is stored or applied. Phosphorus and potassium losses are less likely except through direct run off and leaching from open storage lots or as a result of setting in open lagoons. Besides N, P and K, manures contain all other essential elements. However the nutrient contents of manures may vary depending upon the feed, bedding and the individual animal (Ofori and Santana, 1990). The nutrient content of the manure has a direct bearing on the growth and yield of pepper. A high level of organic matter in the soil results in reduced bulked density, improved soil structure, aeration and high water holding capacity all of which are attributes of productive soil (Hsieh and Hsieh, 1990). One of the ways of increasing the nutrient status of the soil is by boosting the soil nutrient content either with poultry manure, animal waste, and use of compost or with the use of inorganic fertilizers.

Poultry manure is known to contain high levels of nitrogen, potassium and phosphorus for plant growth and it is known to improve chemical and physical properties of the soil for pepper growth in spite of the high labor and cost (Brian and West, 1997). However, the nutrient composition of poultry manure varies with the type of bird, the feed ration, the proportion of litter to dropping, and the type of litter (Zublena and Carter, 1997). To minimize nitrogen losses, manure must be applied as near as possible to the planting time or to the crop growth stage during which nitrogen is most needed. Poultry manure is organic manure with high nutrients value (Yagodin, 1984). Hileman (1971) indicated that poultry manure has been successfully used on a wide variety of crops as the only direct source of plant food as a supplement to mineral fertilizer or as a soil amendment. Bandel *et al*. (1972) reported that among the crops which make the most efficient use of poultry manure include tomato, pepper, eggplant, cucumber, watermelon and sweet corn.

Poultry manure is relatively resistant to microbial degradation. However, it is essential for establishing and maintaining optimum soil physical condition and therefore important for plant growth.

2.3 Effect of Phosphorus on Growth and Yield of Habanero Pepper

Phosphorus is also one of the important macro essential elements for normal growth and development of plant. Phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 1986). Phosphorus shortage restricts the plant growth and the plant remains immature (Hossain, 1990). Emongor and Mabe (2012) conducted a field experiment to evaluate the effects of phosphorus on growth, yield and yield components of chilli pepper variety (Long Slim Cayenne). Phosphorus was applied during transplanting at the rate of 0, 20, 40 and 60 kg Pha^{-1}. The results showed that phosphorus application significantly ($P<0.05$) increased plant height, leaf area, shoot and root dry matter, number of fruit per plant, fruit length and fruit yield per hectare compared to control plants. The increase in chilli plant variables measured with increasing P application was quadratic and 40 kg Pha^{-1} giving the optimum vegetative growth, fruit length, fruit number per plant, fruit water content and fruit yield per hectare. However, phosphorus application significantly ($P<0.05$) decreased fruit dry matter content. Due to the increase in growth, yield and yield components of chilli pepper due to P application, the authors concluded that under sandy loam soils, farmers should apply 40 kg Pha^{-1} at transplanting in order to optimize on chilli fruit yield.

Alabi (2006) reported that the effect of five phosphorus levels (0, 25, 50, 75, 100 and 125 $kgha^{-1}$) and five poultry dropping (0, 100, 200, 300, 400 and 500 $kgha^{-1}$) levels on the growth, yield, yield components, nutrients concentration and food values of pepper (*Capsicum annuum* L) were observed. Phosphorus levels resulted in pepper plant height, number of leaves per plant, number of branches per plant and leaf area up to 125 $kgha^{-1}$ level. The phosphorus application also significantly decreased days to flowering and maturity and increased fruit yield (ton ha^{-1}) of the treated plants.

Peck and MacDonald (1975) reported that pepper produce well when it is adequately supplied with the essential nutrients of fertilizations. Peck *et al*. (1980) had indicated that the nutritional quality of the edible portion of pepper just like the overall yield should be given adequate consideration in fertilization programme. The few available information gave fertilizer phosphorus ranging from as low as 20 kg Pha^{-1} as influencing pepper yield NIHORT (1986) to as much as 140 kg Pha^{-1} (Anon, 1987).

In a study of the effect of phosphorus application rates on seed yield of Sweet pepper, phosphorus rates increased early flowering (Gill et *al*., 1974). Phosphorus rates increased the number of branches per plant from 4.1 to 5.8. Increased P rates resulted in significant yield increases; higher P rates increased considerably the number of fruits per plant as well as seed yield. The effect of phosphate on growth and yield of field grown chillies were studied (Wanknade and Morey, 1982). Higher P rate increased plant height, dry matter, and yield. Bajaj *et al*. (1979) reported an increase in capsaicin content of pepper pods with increasing P rates. This suggests that capsaicin content of chillies is increased by phosphorus application. The yield response of eggplant to increased phosphorus fertilization has been previously studied (López-Cantarero *et al*., 1998). The higher P rate significantly increased total and commercial yields compared to low P rate. In addition, the higher P rate sharply decreased noncommercial yield. Similar results on the effect of P in increasing eggplant fruit yield were also reported by Zipelevish *et al*. (2000). The researchers suggested that P was important to overcome the salinity effect on fruit yield of eggplants in irrigation solution. Increased P concentration from 18 to 54 gm^{-1} significantly increased the number of high quality fruits at both salinity levels of the irrigation solutions (2.3 and 3.9 dSm^{-1}).

An experiment was conducted at the Hill Agricultural Research Station, Khagrachari to phosphorus (80, 100 and 120 kg ha^{-1}) on the growth and yield of okra in hill slope condition during the rainy season, the highest yield of 15.77 t ha^{-1} was obtained from 120 kg P ha^{-1} and was closely followed by the dose of 100 kg P ha^{-1} (4.73 t/ha) (Firoz, 2009).

2.4 Effect of Poultry Manure on the Growth and Yield of Pepper

Poultry manure is essentially the waste, droppings from birds used to improve the soils physical and chemical properties. Manures contain essentially plant nutrients that could be used to improve soil fertility and organic matter that is necessary for the maintenance of soil structure, porosity and water holding capacity. Nitrogen happens to be the highest in proportion of the elements present in analysed poultry manure samples (Aliyu and Kuchinda, 2002).

Akande and Adediran (2004) found that poultry manure at 5 t ha^{-1} significantly increased pepper yield, dry matter yield, soil pH, N, P, K, Ca and Mg nutrient uptake. Aliyu (2003) studied the effect of cow dung at 0, 10, 20 and 30 t ha^{-1} and poultry manure at 3, 6 and 9 t ha^{-1} on the growth and yield of pepper. He observed that poultry manure application significantly increased plant height, leaf area index, fruit length and diameter, number of fruits and fresh fruit yield compared with cow dung. Poultry manure at 9 t ha^{-1} resulted in tallest plants compared with 0 and 3 t ha^{-1}. He also found that application of poultry manure to soil increased soil organic matter, nitrogen and phosphorus and aggregate stability. Adediran *et al*. (2003) compared poultry manure, household waste and cow dung and found that poultry manure at 20 t ha^{-1} had highest nutrient contents and mostly increased yield of pepper and soil macro and micronutrients content.

Aliyu (2000) reported increase in seed and fruit yield in sweet pepper as a result of poultry manure application. Fagimi and Odebode (2007) reported that poultry droppings applied at the rate of 10 t ha^{-1} and 20 t ha^{-1}, increased plant height, number of leaves and fruit yield of pepper, while the incidence and severity of Pepper Veinal Mottle Virus (PVMV) was reduced. In another experiment in which N, P, K and poultry manure were used, Doikova, (1977) found out that total dry matter content increases with an increasing rate of poultry manure up to 4 t ha^{-1} though manure alone proved less effective than mineral fertilizer. Other Solanaceous crops have also been reported to show positive responses to manure application. Addition of poultry manure to the soil resulted in long term nutrient availability to *Capsicum* (Omori *et al.*, 1977). Whereas Cerna, (1981) found that application of N and K in the absence of poultry manure retarded the formation of vegetative organs in *Capsicum*, while poultry manure promoted vegetative mass, dry weight, plant height, rate of dry matter increment per leaf unit area, photosynthetic potential and consequently the yield of Capsicum cultivar zlaten-7 was obtained with poultry manure rate of 29 t ha^{-1} (Yacheva, 1981).

2.5 Interaction of Phosphorus Fertilizer and Poultry Manure on Pepper

A significant increase in fresh fruit weight of chilli pepper (*Capsicum frutescens*) was reported when poultry manure at a rate of 2% by volume in combination with 60kg P ha^{-1} was applied (Anon., 1991). Organic fertilizers take time to break down and release nutrients more slowly; therefore organic and inorganic fertilizers may be combined so that nutrients are available to plants rapidly and for an extended period of time (Swanson, 2000). He further reported that, the year to year availability of N and P for the plants depends strongly on the depth and duration of soil wetting and the distribution of organic matter in the soil profile.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1. Experimental Sites

The experiment was conducted at the Institute for Agricultural Research (I.A.R) farms, Ahmadu Bello University, Zaria (Latitude 11^0N 39' Longitude 08^0 02' E, 686m above sea level) and at Bagauda (Latitude 11^0 11' N Longitude 7^0 38' E), 500m above sea level in Northern Guinea and Sudan Savannah ecological zone of Nigeria, respectively during the 2016 wet season.

3.2 Treatments, Experimental Design and Plot Size

The treatments consisted of four rates of poultry manure (0, 3, 6 and 9 t ha^{-1}) and four phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) rate. Treatment combinations were factorially arranged in a Randomized Complete Block Design (RCBD) and replicated three times. The gross plot was 3 x 4.5 m ($13.5m^2$) while the net plot size of 3 mx 2 m (6 m^2) and intra-row and inter-row spacing of 30 cm and 75 cm respectively, were adopted.

3.3 Seed Source and Description of Variety

Safi: It is a newly introduced variety of habanero pepper from ZAC Actpare de Jumelles France imported to Nigeria through Technisem Seed Company, Jos Plateau State, and high yielding variety with light green to deep red pod at maturity. The fruit is globular, wrinkled and average fruit size (2.54-6.35cm in length and 2.54-5.08cm in diameter). It matures 80 days after transplanting (DAT) and has a very good export quality, very pungent and aromatic characteristics with a yield potential of 18-35 tonnes per hectare if properly managed (Grubben and Tahir, 2004).

3.4 Cultural Practices

3.4.1 Nursery preparation and management

The seeds were drilled in well prepared nursery beds of 2 m x 1 m on rows 15cm apart. These were covered with thin layer of soil, polythene mulch and watered regularly until the seedlings emerged. The mulch material was removed and the emerged seedlings were watered twice a week and weeded regularly until the time of transplanting at 5 weeks after sowing (WAS).

3.4.2 Soil and manure analysis

Soil samples were randomly collected from depth of 0 -30 cm across the experimental site during 2016 wet season prior to transplanting using 30 cm auger. The soil samples were thoroughly mixed, air dried, and sieved using 2 mm mesh sieve and later analyzed for physical and chemical properties. The soil particle size analysis was determined by the hydrometer method (Day, 1965) and the textural class determined using textural triangle (USDA, 1960). Soil pH was determined using pH meter (Black, 1965). Total nitrogen was determined by macro Kjeldahl digestion (Bremner, 1965). Organic carbon was analyzed by Walkley and Black (1934). Available P was extracted by Bray No. 1 method (Bray and Kurtz 1945). Exchangeable bases were determined in neutral NH_4OAC extract (Black, 1968) by atomic absorption spectrophotometer. The CEC was estimated by summation. Manure samples were taken before applying to the soil and analyzed for N, P and K using the same procedure for the soil analysis but P and K was dissolved using mixed acid.

3.4.3 Land preparation and fertilizer application

The experimental sites were harrowed and later ridged 75 cm between rows. Phosphorus fertilizer was applied at transplanting while manure was incorporated after land preparation two weeks to transplanting by splitting the ridge and the manure applied and thereafter buried as per treatment.

3.4.4 Weed control

Pre-planting herbicide (Glyphosate 1.5kg a.i ha^{-1}) was sprayed 2 weeks to land preparation for weed control using knapsack sprayer and this was followed by 3 hoe weeding beginning from 4 weeks after transplanting (WAT) and continuous at 3 weeks interval until the plants formed adequate canopy cover (4, 7 and 10 WAT).

3.4.5 Pest control

The plant was spread at 2 weeks interval starting from flowering till two weeks before harvesting using cypermethrin and dimethoate at a quantity of 10ml per 20L of water so as to prevent insect pests attack. There was no disease incidence occurrence.

3.4.6 Harvesting

Harvesting was done when fruits at color break stage, which began when the fruits changed color from green to red (12 WAT). The matured fruits were harvested during the cool hours of the day by hand picking. Care was taken not to damage or severe the fruiting branches in the course of the harvest. The fruits were also placed directly into well labeled field baskets before weighing. Harvest was done five times at weekly interval.

3.5 Data Collection

3.5.1 Meteorological data

Data on temperature, relative humidity and sunshine hours were obtained from the meteorological Station at Samaru and Bagauda (Appendix I).

3.5.2 Number of days to 50% flowering

The number of days it took 50% of the plants to start flowering after transplanting were observed.

3.5.3 Growth characters

Growth parameters were assessed through random sampling of five tagged plants from each net plot that were later tagged. Observation and measurement of growth characters were done at intervals of two weeks beginning from 4 WAT and terminated at 10 WAT. Characters measured included;

3.5.3.1 *Plant height (cm)*

Heights of five randomly tagged plants per plot were determined by measuring the height from the ground level to the main shoot apex of the plant using a meter rule, and the mean thereafter recorded.

3.5.3.2 *Number of branches per plant*

The numbers of primary and secondary branches per plant were carefully counted from the five tagged plants and the mean was determined and recorded per plant for each plot.

3.5.3.3 *Number of leaves per plant*

The number of leaves was counted per plant from the five tagged plants from each plot and the mean was determined and recorded.

3.5.3.4 *Leaf area (cm^{-2})*

Three plants were removed from each net plot and three leaves were detached from each which was inserted inside leaf area machine (LT-3100C area meter) in the laboratory to determine the leaf area, the remaining leaves were counted which was used to compute for the leaf area and the mean was determined and recorded.

3.5.3.5 *Shoot dry matter production (g)*

The dry matter produced per plant was determined by oven drying the whole three samples to a constant weight at 70^oC. Metler balance (Metler Toledo, model SB16001) was used for weight determination and the mean was computed and recorded as per treatment.

3.5.3.6 *Leaf dry weight (g)*

Separated leaves from the stem were oven dried to a constant weight at 70^0C and the weight was determined using Metler balance (Metler Toledo, model SB16001) and the mean was computed and recorded for each plot.

3.5.3.7 *Stem dry weight (g)*

The stems of three sampled plants were oven dried to a constant weight at 70^0C and the weight was determined using Metler balance (Metler Toledo, model SB16001) and the mean was computed and recorded.

3.5.4 Growth indices

Three plants from outside net plot were used for growth indices which were uprooted at three weeks interval beginning from 6 WAT and terminated at 12 WAT. Indices measured include:

3.5.4.1 Leaf area index (LAI)

The leaf area index was derived from the result of the leaf area and calculated as shown below

$$LAI = \frac{\text{Total leaf area per plant}}{\text{Area of ground covered}}$$

3.5.4.2 Crop growth rate (CGR)

The crop growth rate expresses the dry matter increment of plant material per unit area of ground per unit time. It was computed as suggested by Watson (1958) and recorded on per plot basis.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \quad (g\ wk^{-1})$$

Where W_2 and W_1 represent total dry weights at time t_2 and t_1 respectively.

Values obtained were recorded for each treatment.

3.5.4.3 Net assimilation rate (NAR)

The cumulative dry matter increment per unit time was computed as described by Radford (1967) as follows:

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \quad \frac{(\log_e A_2 - \log_e A_1)}{(A_2 - A_1)} \quad (g\ m^{-2}\ wk^{-1})$$

Where W_2 and W_1 represent the total dry matter of the plant when corresponding leaf area was A_2 and A_1 at times t_2 and t_1 respectively. The values obtained thereafter were recorded for each plot.

3.5.4.4 Relative growth rate (RGR)

This represents the photosynthetic efficiency of assimilatory surfaces. It was computed using the following formula given by Blackman (1919) and recorded on per plot basis.

$$RGR = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \quad (g\ g\ wk^{-1})$$

Where W_2 and W_1 represent total dry weights at time t_2 and t_1 respectively. Values obtained were recorded for each treatment.

3.5.5 Yield characters

3.5.5.1 Number of fruits per plant

The numbers of harvested fruits from the net plot were counted at each sampling period. The cumulative total number of harvested fruits per plant was thereafter mean.

3.5.5.2 Fresh fruit weight per plant (grammes)

The harvested fruits from the net plot were weighed using Metler balance (Metler Toledo, model SB16001) at each sampling period. The cumulative total weight of harvested fruits per plant obtained.

3.5.5.3 Total fruit yield per hectare (t/ha)

The harvested fruits from each net plot were weighed at each harvesting period (five times) using weighing balance i.e Metler balance (Metler Toledo, model SB16001) which was recorded. The cumulative fruit weights per net plot was later converted to yield ha^{-1} and thereafter recorded.

3.6 Data Analysis

The data collected were subjected to analysis of variance (ANOVA) using F test as described by Snedecor and Cochran (1967). The treatment means were compared using Duncan's New Multiple Range Test (Duncan, 1955). Regression analysis was done to determine the optimum phosphorus and poultry manure rates for maximum yield as suggested by Garg and Bansal (1972) and Reddy and Reddi (1975). The relationship between characters was determined by correlation analysis using the procedure described by Little and Hills (1978).

CHAPTER FOUR

4.0 RESULTS

4.1 Soil Physical and Chemical Properties of the Experimental Site and Nutrient Content of Poultry Manure Used for the Trial

The soils of the two experimental sites (Bagauda and Samaru) were loam and sandy loam, respectively (Table 1). According to soil data interpretation (savanna areas), the soil of Bagauda had moderate level of nitrogen, low level of available phosphorus and organic carbon, calcium, magnesium, sodium and CEC were moderate, low potassium content while pH was moderately acidic in H_2O. In Samaru the soil had high level of nitrogen, low level of available phosphorus and organic carbon, moderate calcium, magnesium and sodium contents, low potassium while the pH was slightly acidic in H_2O and moderately acidic in $CaCl_2$.

Generally, the soil of Samaru had more nutrient compared to that of Bagauda, whereas the optimum soil nutrient of the savanna soil is 0.15-0.2% (1.5-2.0g kg^{-1}) Nitrogen, 10-20ppm (mg kg^{-1}) Phosphorus and 2-5 meq/100g soil.

Poultry manure analysis indicated high levels of nitrogen and potassium and low level of phosphorus (Table 2).

Table 1: Physical and chemical properties of the soil of the experimental sites at 0-30 cm depth during 2016 wet season.

Soil Properties	Bagauda	Samaru
Physical properties(gkg^{-1})		
Clay	130	700
Silt	430	250
Sand	440	680
Textural class	loam	sandy loam
Chemical properties		
pH(H_2O) 1: 2.5	5.99	6.20
pH 0.01M$CaCl_2$	5.56	5.86
Total Nitrogen (gkg^{-1})	2.10	2.90
Available P (gkg^{-1})	3.15	4.34
Organic Carbon (gkg^{-1})	10.4	12.4
Exchangeable bases (cmolkg^{-1})		
Calcium	3.33	3.90
Magnesium	0.71	0.80
Potasium	0.09	0.10
Sodium	0.12	0.17
CEC	4.13	4.83

Source: Soil analysis laboratory, Agronomy department, Ahmadu Bello University, Zaria

Table 2: Nutrient content of the poultry manure used in the experiment during 2016 wet season

Nutrient content	Value (g kg^{-1})
Total Nitrogen	22.90
Available Phosphorus	8.00
Potassium	4.20

Source: Soil analysis laboratory, Agronomy department, Ahmadu Bello University, Zaria

4.2 Plant Height

Table 3 shows plant height of habanero pepper as influenced by phosphorus and poultry manure rate during 2016 wet season at Bagauda and Samaru. Phosphorus had significant effect on pepper plant height at 6 and 8 WAT at Samaru only. Application of 60 kg P_2O_5 ha^{-1} resulted in taller plants compared with only 0 kg P_2O_5 ha^{-1} and 90kg P_2O_5 ha^{-1} at 6 WAT and 30kg P_2O_5 ha^{-1} at 8 WAT. There was no significant differences in height among plants at 4 and 10 WAT at Samaru and throughout at Bagauda.

Likewise application of poultry manure significantly affected the height of plant at 6 and 8 WAT in Samaru. Application of 3 t ha^{-1} produced the tallest plants at 6 WAT that were at par with that of 6 t ha^{-1} poultry manure at 8 WAT only. The interaction between phosphorus and poultry manure rates on the height of habanero pepper was significant at 6 and 8 WAT in Samaru (Table 4).

At 6WAT, when various rates of phosphorus were compared at same rate of poultry manure, it was observed that at 0, 3 and 9t ha^{-1} poultry manure rates, plant height did not significantly differ with increase in phosphorus rates. However, when 6 t ha^{-1} poultry manure was applied, application of 60 kg P_2O_5 ha^{-1} resulted in significantly tallest plants which were statistically similar to plants supplied with 30 kg P_2O_5 ha^{-1}. When the different poultry rates were compared at similar rates of phosphorus, it was found that at 0 kg P_2O_5 ha^{-1} all manure rates were statistically comparable. Application of 6 t ha^{-1} poultry manure significantly increased height of pepper plant with other rates when 30 and 60 kg P_2O_5 ha^{-1} were applied. At 8 WAT, when various rates of phosphorus were compared at same rate of poultry manure, it was observed that at 9 t ha^{-1} poultry manure there was no significant difference between the phosphorus rates. However, when 6 t ha^{-1}

poultry manure was applied, application of 60 kg P_2O_5 ha^{-1} resulted in significantly tallest plants, although it did not differ from 30 kg P_2O_5 ha^{-1}. When the different poultry manure rates were compared at similar rates of phosphorus, it was found that 0 and 90 kg P_2O_5 ha^{-1} at all manure rates were statistically comparable. Application of 6t ha^{-1} poultry manure significantly increased height of plant compared with other rates when 30 and 60 kg P_2O_5 ha^{-1} were applied. The combination of 6 t ha^{-1} poultry manure and 60 kg P_2O_5 ha^{-1} resulted in the highest value for plant height at 6 and 8 WAT while plant with neither poultry manure nor phosphorus fertilizer had the least values for plant height.

Table 3: Effects of phosphorus and poultry manure rates on height (cm) of habanero pepper during the 2016 wet season

	Bagauda				Samaru			
Treatment	4WAT	6WAT	8WAT	10WAT	4WAT	6WAT	8WAT	10WAT
Phosphorus (P_2O_5 $kgha^{-1}$)								
0	10.95	13.19	15.06	18.46	13.67	18.13b	21.89c	28.64
30	11.12	14.19	16.61	19.02	13.52	19.68ab	24.51b	30.13
60	10.99	13.62	16.92	19.34	14.83	21.00a	26.68a	28.64
90	10.85	13.53	16.64	19.35	13.58	18.94b	25.15ab	28.64
SE±	0.762	0.782	0.811	0.764	0.471	0.652	0.704	1.023
Poultry manure (tha^{-1})								
0	10.89	13.04	16.12	18.24	13.39	17.69c	23.84b	27.98
3	11.15	13.28	15.91	18.48	14.08	21.76a	26.27a	30.83
6	10.91	13.68	15.95	19.29	14.32	19.85b	24.31ab	30.86
9	10.96	14.53	17.25	20.17	13.81	18.46bc	23.81b	28.81
SE±	0.762	0.782	0.811	0.764	0.471	0.652	0.704	1.023
Interaction								
(P x M)	NS	NS	NS	NS	NS	**	**	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.

WAT= Weeks after transplanting

**= Significant at 1%

NS = Not significant.

Table 4: Interaction between phosphorus and poultry manure on plant height (cm) of habanero pepper at 6 WAT and 8 WAT in Samaru during the 2016 wet Season.

Treatment	Poultry manure (t ha^{-1})			
`	0	3	6	9
Phosphorus (P_2O_5 $kgha^{-1}$)	6 WAT			
0	16.61d	16.96cd	19.04cd	17.83cd
30	17.13cd	19.28cd	24.28ab	18.16cd
60	18.37cd	19.93bcd	27.31a	19.87bcd
90	16.65d	21.14bc	18.28cd	17.97cd
SE±	1.309			
	8 WAT			
0	20.63f	21.21ef	22.84def	22.87def
30	24.56c-f	22.92def	29.94ab	24.14def
60	28.66abc	25.93bcd	30.97a	25.27c-e
90	21.21ef	25.55b-e	23.66def	22.94def
SE±	1.411			

Means followed by different letter(s) in any set of treatment are significantly different at 5% level probability using DMRT.
WAT= Weeks after transplanting

4.3 Number of Leaves

Number of leaves of habanero pepper as influenced by phosphorus fertilizer and poultry manure rate at various sampling periods during 2016 wet season in Bagauda and Samaru are presented in Table 5. Application of 30 kg P_2O_5 ha^{-1} significantly increased number of leaves of habanero pepper at 10 WAT at both locations while the parameter remained statistically same at other sampling periods at both locations. Further increase to 60kg P_2O_5 ha^{-1} significantly increased leaf production only at 6WAT in Bagauda and 4WAT in Samaru while at other sampling periods in both locations; the character was significantly not affected. Generally, applications of P beyond 60kg P_2O_5 ha^{-1} did not significantly affect leaf production.

Application of poultry manure significantly influenced number of leaves of habanero pepper at all assessment periods except at 4 and 6WAT in Bagauda only. Increase in poultry manure rate from 0 to 3t ha^{-1} enhanced leaf production only at Samaru while the parameter remained statistically the same at Bagauda. Further increase to 6t ha^{-1} of poultry manure led to significant increase in the number of leaves only at Bagauda while at Samaru no significant response was recorded. Increase in poultry manure rate to 9t ha^{-1} increased leaf production only at 10WAT in Bagauda while in the parameter remained statistically same at 8WAT in Bagauda and all the sampling periods in Samaru.

The interaction of phosphorus fertilizer and poultry manure rates on number of leaves per plant was not significant throughout the period of study.

Table 5: Effects of phosphorus and poultry manure rates on number of leaves of habanero pepper during the 2016 wet season.

	Bagauda				Samaru			
Treatment	4WAT	6WAT	8WAT	10WAT	4WAT	6WAT	8WAT	10WAT
Phosphorus (P_2O_5 kgha^{-1})								
0	21.08	40.08b	88.50b	107.17c	30.00b	67.00b	163.58b	201.00b
30	23.25	46.50b	97.92ab	123.50b	32.92b	97.67ab	181.00ab	246.13a
60	21.58	56.08a	103.08a	131.25ab	38.83a	108.08a	207.67a	274.42a
90	22.17	56.83a	106.92a	140.67a	43.33a	87.67b	200.25a	239.83a
SE±	3.985	4.478	4.525	5.234	1.819	4.439	10.410	11.784
Poultry manure (tha^{-1})								
0	23.17	45.25	88.75b	108.92c	33.00b	76.67c	163.67b	202.58b
3	18.92	49.33	90.50b	116.67c	39.00a	97.58ab	203.92a	258.67a
6	22.92	49.83	103.33a	130.92b	40.00a	101.25a	218.33a	282.25a
9	23.08	55.08	113.83a	146.08a	33.08b	84.92bc	166.58b	218.33a
SE±	3.985	4.478	4.525	5.234	1.819	4.439	10.410	11.784
Interaction								
(P x M)	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.

WAT= Weeks after transplanting

**= Significant at 1%

NS = Not significant

4.4 Number of Branches

Number of branches of habanero pepper as influenced by rates of phosphorus fertilizer and poultry manure rates at various sampling periods in Bagauda and Samaru during 2016 wet season is presented in Table 6. Phosphorus had significant effect on number of branches of pepper at Samaru and at 8 WAT at Bagauda only. Application of 60 kg P_2O_5 ha^{-1} resulted in more branches only than for 0 kg P_2O_5 ha^{-1} at 4, 6 and 10 WAT, 90 kg P_2O_5 ha^{-1} and 30 kg P_2O_5 ha^{-1} at 6 and 10 WAT. There was no significant difference between number of branches produced when 60 kg P_2O_5 ha^{-1} and 90 kg P_2O_5 ha^{-1} at 6 WAT and 10 WAT while that of 60 kg P_2O_5 ha^{-1} and 90 kg P_2O_5 ha^{-1} at 4 WAT were statistically similar. At Bagauda, application of 90 kg P_2O_5 ha^{-1} resulted in more branches which were statistically at par with application of 30 and 60 kg P_2O_5 ha^{-1}.

Application of poultry manure significantly increased the number of branches at 8 and 10 WAT in Bagauda and at all sampling period in Samaru. The application rate of 3 t ha^{-1} poultry manure led to increased number of branching in Samaru while at Bagauda the parameter was not affected. Further increase in manure to 6 t ha^{-1} significantly increased branching at 10 WAT in Bagauda but reduced branching at all except 10 WAT in Samaru which recorded no significant response.

The interaction of phosphorus fertilizer and poultry manure rates on number of branches per plant was not significant throughout the period of study.

Table 6: Effects of phosphorus and poultry manure rates on number of branches of habanero pepper during the 2016 wet season

	Bagauda				Samaru			
Treatment	4WAT	6WAT	8WAT	10WAT	4WAT	6WAT	8WAT	10WAT
Phosphorus (P_2O_5 $kgha^{-1}$)								
0	2.08	6.08	12.67b	17.25	4.50b	11.00b	23.67	31.17b
30	2.25	6.67	13.67ab	18.42	5.17ab	13.58ab	26.25	36.00ab
60	2.33	7.08	15.17ab	20.75	5.33a	15.58a	31.00	42.92a
90	2.50	7.50	16.08a	21.42	5.50a	13.67ab	29.75	38.67ab
SE±	0.328	0.515	1.402	1.650	0.270	1.002	2.745	3.079
Poultry manure (tha^{-1})								
0	1.09	6.17	12.25b	16.25b	4.33b	11.33c	21.92b	29.08b
3	2.33	6.33	12.50ab	16.25b	4.75b	11.83bc	23.25b	30.50b
6	2.42	7.25	16.17a	22.58a	6.33a	16.00a	33.42a	45.42a
9	2.50	7.58	16.67a	22.75a	5.08b	14.67ab	32.08a	43.75a
SE±	0.328	0.515	1.402	1.650	0.270	1.002	2.745	3.079
Interaction								
(P x M)	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.

WAT= Weeks after transplanting

**= Significant at 1%, NS = Not significant.

4.5 Leaf Area

Table 7 shows leaf area of habanero pepper as influenced by phosphorus fertilizer and poultry manure rates during the 2016 wet season at Bagauda and Samaru. Application of 30 kg P_2O_5 ha^{-1} increased leaf area which was statistically similar with 60 and 90 kg P_2O_5 ha^{-1} at 6 WAT at both locations. At 12 WAT, application of 90 kg P_2O_5 ha^{-1} increased leaf area significantly at Bagauda when compared to other rates (0, 30 and 90 kg P_2O_5 ha^{-1}) which were statistically similar. At 12 WAT in Samaru, 60 kg P_2O_5 ha^{-1} produced wider leaves which were statistically at par with 30kg P_2O_5 ha^{-1} but statistically more than other rates. Leaf Area was not significantly affected by phosphorus fertilizer at 9 WAT in both locations

Application of poultry manure significantly influenced leaf area at all sampling periods in Bagauda and 9 and 12 WAT only in Samaru. Applied poultry manure rates produced similar leaf area at 6 and 9 WAT in Bagauda and at 9 and 12 WAT in Samaru.

Leaf area value recorded by the unfertilized pepper at 12 WAT in both location and 9 WAT at Samaru only did not differ with that of 3 t ha^{-1} poultry manure at these sampling periods and as well as 9 t ha^{-1} poultry manure and 9 and 12 WAT in Samaru only. During the later sampling period of 12 WAT in Bagauda 6 and 9 t ha^{-1} poultry manure recorded statistically similar and higher leaf area when compared with 0 and 3 t ha^{-1} poultry manure rates.

The interaction of phosphorus fertilizer and poultry manure on leaf area was not significant throughout the period of study.

Table 7: Effects of phosphorus and poultry manure rates on leaf area (cm^{-2}) of habanero pepper during the 2016 wet season

	Bagauda			Samaru		
Treatment	6WAT	9WAT	12WAT	6WAT	9WAT	12WAT
Phosphorus (P_2O_5 $kgha^{-1}$)						
0	628.92b	1776.60	1971.25b	657.20b	3029.90	3389.70b
30	915.23a	1974.40	1993.80b	1205.90a	3566.00	3918.20ab
60	919.00a	2023.50	2277.80b	1318.80a	3965.90	4813.80a
90	993.34a	2037.80	2775.20a	1100.50a	3349.70	3565.50b
SE±	68.069	129.469	158.785	144.922	309.417	388.227
Poultry manure (tha^{-1})						
0	572.03b	1526.10b	2013.30b	823.20	2841.80b	3365.30b
3	912.55a	2059.10a	2098.20b	1200.20	3563.10ab	3957.20ab
6	947.29a	2107.70a	2104.60a	1208.10	4196.00a	4615.20a
9	1024.61a	2118.80a	2801.90a	1050.90	3310.70ab	3749.30ab
SE±	68.069	129.469	158.785	144.922	309.417	388.227
Interaction						
(P x M)	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

4.6 Leaf Area Index

Table 8 shows leaf area index of habanero pepper as influenced by phosphorus and poultry manure rates during the 2016 wet season at Bagauda and Samaru. Leaf area index was significantly influenced by application of P rates at 6 and 12 WAT at both locations. The control generally had lower values for leaf area index values than for other rates at 6 WAT at both sites. At 12 WAT at Bagauda only 90 kg P_2O_5 ha^{-1} was significantly higher than others. While at Samaru 60 kg P_2O_5 ha^{-1} was comparable to 90 kg P_2O_5 ha^{-1} but higher than other rates. Application of poultry manure had significant effect on leaf area index at all the sampling periods in Bagauda and all except at 6 WAT at Samaru. At 6 and 9 WAT at Bagauda, the applied manure rates had statistically similar and higher leaf area index than the control. The lower leaf area index values recorded by the control was at par with that of 3 and 6 t ha^{-1} poultry manure at 12 WAT in Bagauda and 3 and 9 t ha^{-1} poultry manure in Samaru.

The interaction of phosphorus and poultry manure rates on leaf area index was not significant.

4.7 Shoot Dry Matter (g)

Shoot dry matter of habanero pepper as influenced by phosphorus and poultry manure rates at various sampling periods at Bagauda and Samaru during the 2016 wet season is presented in Table 9. Significantly comparable shoot dry matter was produced by application of phosphorus from 30 up to 90 kg P_2O_5 ha^{-1} at 6 and 9 WAT at Samaru and 9 and 12 WAT at Bagauda. The control was significantly similar to 30 and 90 kg P_2O_5 ha^{-1} at 6 and 9 WAT, Samaru and also 30 and 60 kg P_2O_5 ha^{-1} at 12 WAT and 30 kg P_2O_5 ha^{-1} at 9 WAT in Bagauda. Shoot dry matter was not significantly influenced by application of phosphorus fertilizer at 6 WAT in Bagauda and 12 WAT in Samaru.

Application of poultry manure had significant effect on shoot dry matter at all sampling period in both sites. All applied poultry manure rates were significantly similar throughout the period of study but higher than the control only at 12 WAT in Bagauda. The control was comparable to 3 and 6 t ha^{-1} at 6 WAT and 3 t ha^{-1} only at 9 WAT in Bagauda. At 9 and 12 WAT in Samaru, 6 t ha^{-1} had the highest value for shoot dry matter that was similar to that of other applied manure rates but more than for the control. The control resulted in significantly similar shoot dry matter with 3 and 9 t ha^{-1} at 6 WAT and 9 t ha^{-1} only at 12 WAT in Samaru.

Interaction of phosphorus and poultry manure rates on shoot dry matter was not significant.

Table 8: Effects of phosphorus rates and poultry manure rates on leaf area index of habanero pepper during the 2016 wet season

	Bagauda			Samaru		
Treatment	6WAT	9WAT	12WAT	6WAT	9WAT	12WAT
Phosphorus (P_2O_5 kgha^{-1})						
0	0.28b	0.79	0.88b	0.29b	1.35	1.51b
30	0.41a	0.88	0.89b	0.49a	1.48	1.59b
60	0.41a	0.90	1.01b	0.59a	1.60	2.14a
90	0.44a	0.91	1.23a	0.54a	1.59	1.74ab
SE±	0.030	0.035	0.071	0.064	0.145	0.173
Poultry manure (tha^{-1})						
0	0.25b	0.68b	0.90b	0.37	1.27b	1.50b
3	0.41a	0.92a	0.93b	0.53	1.44ab	1.66ab
6	0.42a	0.94a	0.94b	0.54	1.87a	2.05a
9	0.46a	0.94a	1.25a	0.47	1.46ab	1.76ab
SE±	0.030	0.035	0.071	0.064	0.145	0.173
Interaction						
(P x M)	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

Table 9: Effects of phosphorus and poultry manure rates on shoot dry matter (g plant^{-1}) of habanero pepper during the 2016 wet season

	Bagauda			Samaru		
Treatment	6WAT	9WAT	12WAT	6WAT	9WAT	12WAT
Phosphorus (P_2O_5 kgha^{-1})						
0	0.95	2.52b	4.63b	1.33b	4.01b	10.16
30	1.18	3.17ab	5.22ab	2.00ab	5.64ab	13.34
60	1.22	3.36a	5.69ab	2.10a	6.25a	14.80
90	1.16	3.50a	5.96a	1.67ab	5.70ab	11.68
SE±	0.118	0.304	0.571	0.240	0.667	1.677
Poultry manure (tha^{-1})						
0	0.91b	2.35b	3.67b	1.33b	3.88b	8.23b
3	1.10ab	3.13ab	5.81a	1.71ab	6.03a	13.43a
6	1.19ab	3.52a	5.93a	2.13a	6.15a	15.25a
9	1.31a	3.54a	6.10a	1.93ab	5.54ab	13.06ab
SE±	0.118	0.304	0.571	0.240	0.667	1.677
Interaction						
(P x M)	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

4.8 Leaf Dry Weight (g)

Leaf dry weight of habanero pepper as influenced by phosphorus fertilizer and poultry manure rates during the 2016 wet season at various sampling periods at Bagauda and Samaru is presented in Table 10. Application of phosphorus fertilizer on Leaf dry weight at 6 and 12 WAT at Bagauda and 6 and 9 WAT at Samaru are not significant. At 9 WAT, application of 90 kg P_2O_5 ha^{-1} recorded heavier dry leaves of habanero pepper than for the control only but was statistically at par with 30 and 60 kg P_2O_5 ha^{-1} in Bagauda while in Samaru, application of 60 kg P_2O_5 ha^{-1} had heavier leaves than for control and 90 kg P_2O_5 ha^{-1} was statistically at par with 30 kg P_2O_5 ha^{-1}.

Application of poultry manure had significant effect on leaf dry weight at both locations and at all sampling periods except 12 WAT in Samaru that was not significant. The highest poultry manure rate of 9 t ha^{-1} had heavier dry weight than the control at 6 and 9 WAT in both location and 6t ha^{-1} poultry manure at 12 WAT in Bagauda. Values recorded by 9 t ha^{-1} poultry manure was in turn statistically at par with those of other applied rates.

The interaction of phosphorus fertilizer and poultry manure rates on leaf dry weight was not significant.

4.9 Stem Dry Weight (g)

Stem dry weight of habanero pepper as influenced by phosphorus fertilizer and poultry manure rates at various sampling periods in Bagauda and Samaru during the 2016 wet season are presented in Table 11. Application of phosphorus fertilizer on Stem dry weight at 6 WAT in Bagauda and all sampling period in Samaru are not significant. P application at 90 kg P_2O_5 ha^{-1} significantly increased stem dry weight of habanero pepper at 9 and 12

WAT in Bagauda only which was statistically the same with 60 kg P_2O_5 ha^{-1} at 12WAT and at par with 9 WAT at the same rate.

Application of poultry manure significantly influenced stem dry weight at 9 and 12 WAT in Bagauda only. Increase in poultry manure rate from 0 to 3 t ha^{-1} enhanced shoot dry weight while at Samaru no significant response was recorded throughout the sampling period and at 4 WAT in Bagauda.

The interaction of phosphorus fertilizer and poultry manure rates on shoot dry weight was not significant.

4.10 Crop Growth Rate (g wk^{-1})

Crop growth rate of habanero pepper as influenced by phosphorus fertilizer and poultry manure rates at various sampling periods in Bagauda and Samaru during the 2016 wet season as presented in Table 12. Application of 60 kg P_2O_5 ha^{-1} significantly increased crop growth rate at all sampling periods in Bagauda only, further increase to 90 kg P_2O_5 ha^{-1} was statistically at par at 6- 9 WAT and similar at 9- 12 WAT, while in Samaru no significant effect was recorded.

Application of poultry manure significantly influenced the crop growth rate at 6-9 WAT in Bagauda and 9-12 WAT in Samaru only. Increase of poultry manure rates from 0 to 3 t ha^{-1} influenced crop growth rate at both locations but were statistically at par, in Bagauda further increase at to 6 t ha^{-1} remained statistically similar with 3 t ha^{-1} but in Samaru it was statistically at par. Increasing the manure rate to 9 t ha^{-1} increased the parameter significantly but remained statistically at par with 6 t ha^{-1}.

The interaction of phosphorus fertilizer and poultry manure rates on crop growth rates was not significant.

Table 10: Effects of phosphorus and poultry manure rates on leaf dry weight (g plant^{-1}) during the 2016 wet season.

	Bagauda			Samaru		
Treatment	6WAT	9WAT	12WAT	6WAT	9WAT	12WAT
Phosphorus (P_2O_5 kgha^{-1})						
0	0.52	1.12b	2.30	0.75	2.04	4.39b
30	0.69	1.42ab	2.34	1.04	2.49	5.02ab
60	0.72	1.46ab	2.36	1.08	2.77	6.47a
90	0.62	1.56a	2.69	0.93	2.62	4.46b
SE±	0.072	0.126	0.236	0.122	0.280	0.609
Poultry manure (tha^{-1})						
0	0.47b	1.05b	1.53b	0.72b	1.97b	4.88
3	0.64ab	1.40ab	2.62a	0.95ab	2.42ab	5.00
6	0.67ab	1.50a	2.69b	1.18a	2.86a	5.31
9	0.77a	1.60a	2.85a	0.95ab	2.67ab	5.14
SE±	0.072	0.126	0.236	0.122	0.280	0.609
Interaction						
(P x M)	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

Table 11: Effects of phosphorus and poultry manure rates on stem dry weight (g plant^{-1}) of habanero pepper during the 2016 wet season.

	Bagauda			Samaru		
Treatment	6WAT	9WAT	12WAT	6WAT	9WAT	12WAT
Phosphorus (P_2O_5 kgha^{-1})						
0	0.43	1.13b	2.23b	0.74	2.12	4.30
30	0.49	1.45ab	2.77ab	0.83	3.04	6.20
60	0.50	1.60ab	3.15a	0.85	3.12	6.30
90	0.48	1.64a	3.18a	0.79	2.83	6.04
SE±	0.051	0.202	0.385	0.101	0.412	0.827
Poultry manure (tha^{-1})						
0	0.38	1.03b	1.98b	0.66	2.04	4.74
3	0.46	1.43ab	2.86a	0.78	3.13	6.11
6	0.53	1.64a	3.14a	0.91	3.28	6.49
9	0.54	1.72a	3.36a	0.86	2.67	5.51
SE±	0.051	0.202	0.385	0.101	0.412	0.827
Interaction						
(P x M)	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

Table 12: Effects of phosphorus and poultry manure rates on crop growth rate (g wk^{-1}) of habanero pepper during the 2016 wet season

	Bagauda		Samaru	
Treatment	6-9WAT	9-12WAT	6-9WAT	9-12WAT
Phosphorus (P_2O_5 $kgha^{-1}$)				
0	0.52b	0.39b	0.87	2.00
30	0.66b	0.78ab	1.21	2.04
60	0.73ab	0.90a	1.39	2.87
90	1.03a	0.93a	1.34	2.56
SE±	0.136	0.165	0.205	0.492
Poultry manure (tha^{-1})				
0	0.51b	0.44	0.85	1.45b
3	0.74ab	0.80	1.21	2.42ab
6	0.79ab	0.85	1.48	3.24a
9	0.93a	0.90	1.28	2.36ab
SE±	0.136	0.165	0.205	0.492
Interaction				
(P x M)	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

4.11 Net Assimilation Rate (g m^{-2} wk^{-1})

Table 13 shows the response of Net assimilation rate to the application of phosphorus and manure in 2016 at Bagauda and Samaru. The various rates of phosphorus had no significant effect on net assimilation rate throughout the period of study at both locations. Application of poultry manure significantly influenced net assimilation rate at 6- 9 WAT at Bagauda only. Increase in manure from 0 to 6 t ha^{-1} did not statistically influence net assimilation rate. Further increase to 9 t ha^{-1} significantly increased net assimilation rate compared with 0 and 3 t ha^{-1}.

The interaction of phosphorus fertilizer and poultry manure rates on net assimilation rate was not significant.

4.12 Relative Growth Rate (g $g^{-1}$$wk^{-1}$)

Relative growth rate of habanero pepper as influenced by phosphorus fertilizer and poultry manure rates at various sampling periods at Bagauda and Samaru during 2016 wet season is presented in Table 14. No significant response was recorded at all sampling periods at both locations with both phosphorus and poultry manure rates.

The interaction of phosphorus fertilizer and poultry manure rates on relative growth rate was not significant.

Table 13: Effects of phosphorus and poultry manure rates on net assimilation rate ($g\ m^{-2}\ wk^{-1}$) of habanero pepper during the 2016 wet season

	Bagauda		Samaru	
Treatment	6-9WAT	9-12WAT	6-9WAT	9-12WAT
Phosphorus (P_2O_5 $kgha^{-1}$)				
0	0.21	-0.04	0.41	-0.06
30	0.22	0.01	0.53	-0.13
60	0.24	0.04	0.56	0.29
90	0.29	0.09	0.52	0.12
SE±	0.053	0.052	0.106	0.192
Poultry manure (tha^{-1})				
0	0.18b	-0.02	0.37	-0.24
3	0.19b	0.002	0.49	0.074
6	0.26ab	0.04	0.66	0.23
9	0.34a	0.07	0.50	0.16
SE±	0.053	0.052	0.106	0.192
Interaction				
(P x M)	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

Table 14: Effects of phosphorus and poultry manure rates on relative growth rate (g $g^{-1}wk^{-1}$) of habanero pepper during the 2016 wet season

	Bagauda		Samaru	
Treatment	6-9WAT	9-12WAT	6-9WAT	9-12WAT
Phosphorus (P_2O_5 $kgha^{-1}$)				
0	0.34	0.13	0.37	0.27
30	0.35	0.14	0.37	0.30
60	0.35	0.21	0.46	0.45
90	0.55	0.28	0.40	0.36
SE±	0.106	0.055	0.055	0.137
Poultry manure (tha^{-1})				
0	0.34	0.12	0.34	0.27
3	0.35	0.17	0.37	0.32
6	0.42	0.18	0.46	0.39
9	0.49	0.27	0.43	0.39
SE±	0.106	0.055	0.055	0.137
Interaction				
(P x M)	NS	NS	NS	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

4.13 Number of Days to 50% Flowering

The response of days to 50% flowering to phosphorus and poultry manure rates is shown in Table 15. At Bagauda, 0 kg P_2O_5 ha^{-1} significantly delayed days to 50% flowering when compared to other rates, this was followed by pepper which received 30 kg P_2O_5 ha^{-1}. Application of 60 or 90 kg P_2O_5 ha^{-1} resulted in statistically similar and earlier crops. In Samaru, application of phosphorus did not significantly affect the parameter.

Application of poultry manure had significant effect on number of days to flowering where 9 t ha^{-1} poultry manure resulted in early significantly compared to other rates in Bagauda. At Samaru, all the applied manure rates were significantly the same but only 9 t ha^{-1} resulted in significantly early flowering compared with the control.

The interaction of phosphorus fertilizer and poultry manure rates on number of days to 50% flowering was significant in Bagauda only.

Table 16 shows the interaction of phosphorus fertilizer and poultry manure rates on number of days to 50% flowering. At various rates of phosphorus and same rates of poultry manure, it was observed that 0 and 9 t ha^{-1} poultry manure there was no significant difference between the phosphorus rates at 30, 60 and 90 kg P_2O_5 ha^{-1}. However, when 9 t ha^{-1} poultry manure was applied, application of 30 and 60 kg P_2O_5 ha^{-1} led to early flowering which was statistically the same with application of 6 t ha^{-1} at 90 kg P_2O_5 ha^{-1}. When different poultry manure rates were compared at similar rates of phosphorus, it was found that 30, 60 and 90 kg P_2O_5 ha^{-1} at manure rates of 0 t ha^{-1} likewise 9 t ha^{-1} which led to lesser days to flowering. Application of 9 t ha^{-1} poultry manure significantly led to early flowering compared to other rates when 30 and 60 kg P_2O_5 ha^{-1} were applied.

Table 15: Effects of phosphorus and poultry manure rates on number of days to 50% flowering of habanero pepper in Bagauda and Samaru during the 2016 wet season

Treatment	Bagauda	Samaru
Phosphorus (P_2O_5 $kgha^{-1}$)		
0	37.33a	34.83
30	33.83b	32.83
60	32.83c	32.17
90	32.58c	31.83
SE±	0.221	0.351
Poultry manure (tha^{-1})		
0	34.01ab	33.58a
3	34.83a	32.67ab
6	34.08b	33.00ab
9	33.00c	32.42b
SE±	0.221	0.351
Interaction		
(PXM)	**	NS

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

Table 16: Interaction between phosphorus and poultry manure rates on number of days to 50% flowering of habanero pepper in Bagauda during the 2016 wet

Treatment	Poultry manure (t ha^{-1})			
Phosphorus (P_2O_5 $kgha^{-1}$)	0	3	6	9
0	39.600a	37.00b	37.00b	36.33bc
30	33.33ef	35.00cd	35.33cd	31.67h
60	33.33ef	34.33de	32.33gh	31.33h
90	33.00efg	33.00efg	31.67h	32.67gh
SE±		0.442		

Means followed by different letter(s) of any set of treatment are significantly different at 5% level using DMRT.

4.14 Number of Fruits per Plant

Number of fruit per plant of habanero pepper as influenced by phosphorus fertilizer and poultry manure rates at Bagauda and Samaru during the 2016 wet season is presented in Table 17. Application of 30 kg P_2O_5 ha^{-1} significantly increased number of fruits per plant of habanero pepper at both locations compared with 0 kg P_2O_5 ha^{-1}, increasing P rate to 60 kg P_2O_5 ha^{-1} significantly increased number of fruit per plant at Samaru only. Further increase to 90 kg P_2O_5 ha^{-1} significantly increased the parameter at Bagauda while it recorded significant reduction at Samaru.

Application of poultry manure significantly influenced number of fruit per plant at both locations. Pepper that received 3 t ha^{-1} poultry manure had increased number of fruit per plant. Further increase in poultry manure rate to 6 t ha^{-1} increased number of fruits per plant. Beyond 6 t ha^{-1} of poultry manure the parameter increased and decreased at Bagauda and Samaru respectively.

The interaction of phosphorus fertilizer and poultry manure rates on number of fruit per plant was highly significant at both locations. Table 18 shows the interaction of phosphorus and poultry manure rates on number of fruit per plant. At various rates of phosphorus and same rates of poultry manure, it was observed that 0 t ha^{-1} poultry manure at both locations didn't differ significantly between the phosphorus rates at 0, 30 and 60 kg P_2O_5 ha^{-1}. However when 9 t ha^{-1} was applied at Bagauda, application of 60 kg P_2O_5 ha^{-1} produced the highest number of fruit while at Samaru, application of 6t ha^{-1} poultry manure with 60 kg P_2O_5 ha^{-1} produced the highest number of fruits when the different poultry manure rates were compared at similar rates of phosphorus, it was found that 0 and 30 kg P_2O_5 ha^{-1} at manure rates of 3, 6 and 9 t ha^{-1} were statistically the same at

Bagauda, application of 9 t ha^{-1} poultry manure significantly increased the parameter compared to other rates that was applied. In Samaru, 90 kg P_2O_5 ha^{-1} at 3 and 6 t ha^{-1} poultry were statistically same. Application of 6 t ha^{-1} poultry manure significantly increased the number of fruit per plant. The combination of 9 t ha^{-1} poultry manure and 60 kg P_2O_5 ha^{-1} produced the highest number of fruits per plant at Bagauda while at Samaru, the combination of 6 t ha^{-1} poultry manure and 60 kg P_2O_5 ha^{-1} had the highest values for number of fruits per plant while the absolute control had the least values at both locations.

4.15 Fruit Weight per Plant (g)

Fruit weight per plant of habanero pepper as influenced by phosphorus fertilizer and poultry manure rates at Bagauda and Samaru during the 2016 wet season is presented in Table 19. Application of 90 kg P_2O_5 ha^{-1} produced heavier fruit weight than other rates that were at par in Bagauda. In Samaru, application of 60 kg P_2O_5 ha^{-1} had heavier fruit weight per plant than for 0, 30 and 90 kg P_2O_5 ha^{-1} that were at par statistically.

Application of poultry manure significantly influenced weight of fruit per plant of habanero pepper at both locations. Increase in poultry manure rate from 0 to 3 t ha^{-1} enhanced pepper fruit weight at both locations. Further increase to 6 t ha^{-1} of poultry manure led to significant increase in habanero pepper at Samaru only while the parameter remained statistically same at Bagauda. Increase in poultry manure rate to 9 t ha^{-1} increased weight of pepper fruit at Bagauda while the parameter recorded significant reduction at Samaru.

The interaction of phosphorus fertilizer and poultry manure rates on fruit weight per plant was highly significant in both locations. Table 20 shows the interaction of phosphorus fertilizer and poultry manure rates on fruit weight per plant. Application of 3 t ha^{-1} poultry manure increased fruit weight per plant for each of the applied phosphorus rates in both locations. Further increase to 6t ha^{-1} also increased the parameter in both locations except for 30 kg P_2O_5 ha^{-1} in Bagauda and 90 kg P_2O_5 ha^{-1} at Samaru where the parameter remained same. Likewise, increase to 9 t ha^{-1} at each phosphorus rate significantly increased pepper fruit weight per plant in both locations except for 0 and 90 kg P_2O_5 ha^{-1} at Bagauda and 0 kg P_2O_5 ha^{-1} at Samaru. Application of 30 kg P_2O_5 ha^{-1} significantly increased the weight of pepper fruit per plant only for 3 and 9 t ha^{-1} poultry manure at Bagauda and 6 and 9 t ha^{-1} poultry manure at Samaru, while it remained statistically unaffected at other instances. Further increase to 60 kg P_2O_5 ha^{-1} produced heavier fruit weight per plant except for 0 and 3 t ha^{-1} in both locations where the parameter remained unaffected statistically.

Application of phosphorus beyond 60 kg P_2O_5 ha^{-1} significantly decreased weight of pepper fruit per plant for 9 t ha^{-1} at both locations and 6 t ha^{-1} poultry manure at Samaru only. Fruit weight significantly increased at 0t poultry manure when phosphorus was raised to 90 kg ha^{-1}. At fixed poultry manure of 3 t ha^{-1} in both location and 6 t ha^{-1} at Bagauda only, increase in Phosphorus rate to 90 kg ha^{-1} did not affect fruit weight per plant significantly.

The combination of 9 t ha^{-1} poultry manure and 60 kg P_2O_5 ha^{-1} produced heavier weights of pepper fruit per plant at Bagauda while 6 t ha^{-1} produced heaviest fruit weight at Samaru. The lowest value for fruit weight per plant in both locations was when neither of the fertilizer type was used.

Table 17: Effects of phosphorus and poultry manure rates on number of fruit per plant during the 2016 wet season

Treatment	Bagauda	Samaru
Phosphorus (P_2O_5 kgha^{-1})		
0	12.25c	20.25c
30	16.58b	28.17b
60	16.83b	36.58a
90	21.92a	27.92b
SE±	1.371	2.272
Poultry manure (tha^{-1})		
0	7.92d	13.33d
3	13.75c	23.00c
6	19.00b	44.83a
9	26.92a	31.75b
SE±	1.371	2.272
Interaction		
(PXM)	**	**

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

Table 18: Interaction between phosphorus and poultry manure rates on number of fruit per plant of habanero pepper in Bagauda and Samaru during the 2016 wet season

Treatment	Bagauda				Samaru			
	Poultry manure (t ha^{-1})							
Phosphorus (P_2O_5 $kgha^{-1}$)	0	3	6	9	0	3	6	9
0	4.67f	13.33e	14.00e	15.00e	7.67e	24.67d	26.33c	20.33d
30	5.33f	15.33d	16.00d	19.00cd	9.33e	31.33c	41.67b	23.33d
60	8.00f	12.33e	25.00b	48.67a	13.33e	38.33b	81.00a	25.67c
90	13.67e	18.33d	18.67d	23.00bc	23.00d	31.00c	32.00c	22.33d
SE±			0.961				1.593	

Means followed by different letter(s) of any treatment are significantly different at 5% level using DMRT.

Table 19: Effects of phosphorus and poultry manure rates on fruit weight (g) per plant of habanero pepper during the 2016 wet season

Treatment	Bagauda	Samaru
Phosphorus (P_2O_5 kgha^{-1})		
0	101.48b	169.19b
30	115.54b	192.57b
60	115.58b	280.21a
90	168.13a	192.64b
SE±	11.152	18.587
Poultry manure (tha^{-1})		
0	54.14c	90.28c
3	112.47b	187.45b
6	134.45b	332.80a
9	199.68a	224.08b
SE±	11.152	18.587
Interaction		
(P x M)	**	**

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

Table 20: Interaction between phosphorus fertilizer and poultry manure rates on fruit weight per plant (g) of habanero pepper in Bagauda and Samaru during the 2016 wet season

Treatment	Poultry manure (t ha^{-1})							
	`Bagauda				Samaru			
Phosphorus (P_2O_5 $kgha^{-1}$)	0	3	6	9	0	3	6	9
0	27.43e	95.75d	97.93c	107.22c	45.92e	159.59d	178.69c	184.41c
30	38.35e	107.46c	128.03c	154.02b	63.92e	163.22c	286.45b	213.38c
60	55.07e	110.64c	148.63b	393.60a	91.78e	179.10c	656.10a	247.55b
90	95.70d	122.55c	148.73b	171.87b	159.51d	247.89b	256.69b	204.25c
SE±			7.825				13.042	

Means followed by different letter(s) in any set of treatment are significantly different at 5% level using DMRT.

4.16 Total Fruit Yield per Hectare (t ha^{-1})

The effects of phosphorus and poultry manure rates on fruit yield per hectare in Bagauda and Samaru during the 2016 wet season is presented in Table 21. Application of 90kg P_2O_5 ha^{-1} produced significantly higher fruit yield of habanero pepper than for other rates that were at par in Bagauda. In Samaru, application of 60kg P_2O_5 ha^{-1} resulted in significantly highest fruit yield per hectare than 0, 30 and 90kg P_2O_5 ha^{-1} which were at par statistically.

Application of poultry manure significantly influenced fruit yield of habanero pepper at both locations. Increase in poultry manure rate from 0 to 3t ha^{-1} enhanced pepper fruit yield at both locations. Further increase to 6t ha^{-1} of poultry manure led to significant increase in habanero pepper fruit yield at Samaru only while the parameter remained statistically same at Bagauda. Increase in poultry manure rate to 9t ha^{-1} increased yield of pepper in Bagauda while the parameter recorded significant reduction at Samaru.

The result is not consistent, 90 kg P_2O_5 ha^{-1} was best in Bagauda while 60 kg P_2O_5 ha^{-1} was highest in Samaru. Similarly, 9t ha^{-1} poultry manure was the highest in Bagauda while 6t ha^{-1} was the best in Samaru. A combine analysis is therefore necessary to average out and give the best treatment for high yield.

The combined analysis showed that there was significant response of fruit yield per hectare to the treatments applied. Application of 60 kg P_2O_5 ha^{-1} produced significantly higher fruit yield of pepper than for other rates that were same statistically. Increase in poultry manure rate from 0 to 6t ha^{-1} enhanced pepper fruit yield, further increase to 9t ha^{-1} of poultry manure led to significant increase in pepper fruit yield while the parameter remained statistically same at 3 and 9t ha^{-1}.

The interaction of phosphorus fertilizer and poultry manure rates on fruit yield per hectare was highly significant at both locations and for the combine. Table 22 and 23 shows the interaction of phosphorus and poultry manure on fruit yield per hectare and combine respectively. At Bagauda, when various rates of phosphorus were compared at same rate of poultry manure, it was observed that at 0t ha^{-1} poultry there was no significant difference between the phosphorus rates at 0, 30 and 60 kg P_2O_5 ha^{-1} likewise at 3t ha^{-1}, phosphorus rates of 30, 60 and 90 kg P_2O_5 ha^{-1} does not differ significantly. However, when 9t ha^{-1} was applied, application of 60 kg P_2O_5 ha^{-1} resulted in significantly highest fruit yield. When the different poultry manure rates were compared at similar rates of phosphorus, it was found that at 0 and 30 kg P_2O_5 ha^{-1} manure rates of 3, 6 and 9t ha^{-1} were statistically the same. Application of 9t ha^{-1} at 60 kg P_2O_5 ha^{-1} significantly increased fruit yield of pepper when compared with other rates when 30 and 90 kg P_2O_5 ha^{-1} were applied.

At Samaru, when various rates of phosphorus were compared at same rate of poultry manure, it was observed that 0t ha^{-1} poultry manure; there was no significant difference between the phosphorus rates at 0, 30 and 60 kg P_2O_5 ha^{-1} likewise at 3t ha^{-1} between the phosphorus rates. However, when 6t ha^{-1} was applied, application of 60 kg P_2O_5 ha^{-1} resulted in significantly highest fruit yield. When the different rates of poultry manure was compared at similar phosphorus rates, it was found that 0 kg P_2O_5 ha^{-1} rates was statistically the same at 3, 6 and 9t ha^{-1} poultry manure, likewise at 30 kg P_2O_5 ha^{-1} but at 6 and 9t ha^{-1} poultry manure. Application of 6t ha^{-1} poultry manure significantly increase fruit yield of pepper when combined with 60 kg P_2O_5 ha^{-1} compared with other rates when 30 and 90 kg P_2O_5 ha^{-1} were applied.

The combination of 9t ha^{-1} poultry manure and 60kg P_2O_5 ha^{-1} phosphorus fertilizer produced the best pepper yield fruit in Bagauda while in Samaru, the combination of 6t ha^{-1} poultry manure and 60kg P_2O_5 ha^{-1} phosphorus fertilizer gave the highest pepper fruit yield. The lowest value for fruit yield in both locations was when neither of the fertilizer type was used.

From interaction Table (Table 23), it was observed that when various rates of phosphorus were compared at same rates of poultry manure, application of 0t ha^{-1} had no significant difference between 0, 30 and 60 kg P_2O_5 ha^{-1} whereas at 9t ha^{-1} there was no significant differences between the phosphorus rates applied as clearly shown in the interaction table. However, when 6t ha^{-1} was applied, application of 60 kg P_2O_5 ha^{-1} resulted in significantly higher yields. When the different rates of poultry manure were combined at similar phosphorus rates, it was found that at 0 kg P_2O_5 ha^{-1} and 3, 6 and 9t ha^{-1} of poultry rates were statistically comparable while at 90 kg P_2O_5 ha^{-1}, all manure rates were statistically comparable.

Table 21: Effects of phosphorus and poultry manure rates on total fruit yield (t ha^{-1}) **per hectare of habanero pepper during the 2016 wet season**

Treatment	Bagauda	Samaru	Combined
Phosphorus (P_2O_5 kg ha^{-1})			
0	5.07b	8.46b	6.77b
30	5.32b	9.63b	7.75b
60	5.83b	14.63a	11.21a
90	8.41a	9.63b	7.73b
SE±	0.550	0.930	0.570
Poultry manure (t ha^{-1})			
0	2.71c	4.51c	3.16c
3	5.62b	9.37b	9.01b
6	6.68b	16.64a	13.34a
9	10.04a	11.20b	7.50b
SE±	0.550	0.930	0.570
Interaction			
(P x M)	**	**	**

Means in a column of any set of treatments followed by different letter(s) are significantly different at 5% level of probability using DMRT.
WAT= Weeks after transplanting
**= Significant at 1%, NS = Not significant.

Table 22: Interaction between phosphorus and poultry manure rates on total fruit yield (t ha^{-1}) of habanero pepper in Bagauda and Samaru during the 2016 wet season

Treatment	Bagauda				Samaru			
	Poultry manure (t ha^{-1})							
Phosphorus (P_2O_5kgha^{-1})	0	3	6	9	0	3	6	9
0	1.37e	4.79d	4.90c	5.36c	2.29d	7.98c	8.95c	8.96c
30	1.92e	5.37c	6.40c	8.03b	3.20d	9.22c	14.32b	12.84b
60	2.75e	5.74c	7.43b	19.68a	4.59d	10.21c	32.81a	12.38b
90	4.79d	6.13c	7.44b	8.59b	7.98c	10.62c	12.40b	8.10c
SE±			0.386				0.653	

Table 23: Interaction between phosphorus and poultry manure rates on total fruit yield (t ha^{-1}) of habanero pepper for the combined during the 2016 wet season

Treatment	Poultry manure (t ha^{-1})			
Phosphorus (kgha^{-1})	0	3	6	9
0	1.83e	8.17cd	7.15c	9.92bc
30	2.56e	11.46b	10.44bc	6.53c
60	3.67e	8.53cd	26.24a	6.38c
90	6.38c	7.48c	9.90bc	7.16c
SE±		0.570		

Means followed by different letter(s) of any set of treatment are significantly different at 5% level using DMRT.

4.17 Regression and Correlation Studies

4.17.1 Regression studies

The polynomial responses of habanero pepper to application of phosphorus and poultry manure are presented in Figures 1-4. The estimated fruit yield gave a quadratic relationship to applied phosphorus and poultry manure rates in Samaru and for the combined while at Bagauda a linear relationship was obtained. The following equations were derived;

$Y = 7.769 + 0.183x - 0.002x^2$ and $= 4.578 + 0.035x$ --------Phosphorus rates for Samaru and Bagauda respectively (Figure 1)

$Y = 3.754 + 3.486x - 0.286x^2$ and $2.805 + 0.768x$ --------Poultry manure rates for Samaru and Bagauda respectively (Figure 2)

$Y = 6.299 + 0.133x - 0.0012x^2$ ------------------- Phosphorus rate (Figure 3)

$Y = 4.454 + 3.055x - 0.3122x^2$ ------------------- Poultry manure rate (Figure 4)

Where Y refers to expected yield at Phoshorus fertilizer and poultry manure rate. X when computed the following expected yield were derived;

Phosphorus rate of 53.82kg P_2O_5 ha^{-1}, the yield of 12.69 t ha^{-1} and poultry manure rate of 6.09 tha^{-1}, yield of 14.364 t ha^{-1} were obtained for Samaru Location while for the combined Phosphorus rate of 55.42kg P_2O_5 ha^{-1}, the yield of 9.98t ha^{-1} and poultry manure rate of 4.90tha^{-1}, yield of 11.93t ha^{-1} were obtained.

4.17.2 Simple correlation of pepper

The matrices of correlation coefficient among growth and yield parameter of habanero pepper during 2016 wet season in Bagauda and Samaru is presented on Tables 24 and 25. It revealed that the relationship between fruit yield per hectare and number of leaves, number of branches, number of fruit per plant, fruit weight per plant were positive and strongly correlated in both locations ($p \leq 0.01$).

Fruit yield of pepper per hectare had significant and positive relationship with plant height and total dry matter in Bagauda while in Samaru significant and positive relationship was observed between fruit yield and plant height, number of branches, total dry matter, crop growth rate, and net assimilation rate ($p \leq 0.05$).

Fruit yield per hectare had the strongest relationship with fruit weight per plant and number of fruit per plant in both locations.

A non-significant relationship was observed in Bagauda between leaf area, leaf area index, crop growth rate, net assimilation while in Samaru, it was between leaf area and leaf area index and leaf dry weight.

The relationship that exist among other parameter too were generally positive except between dry weight and number of fruits per plant that was negative and not significant (-0.02) in Samaru only. Some of the relationships were positive and not significant while others either positively significant or highly significant.

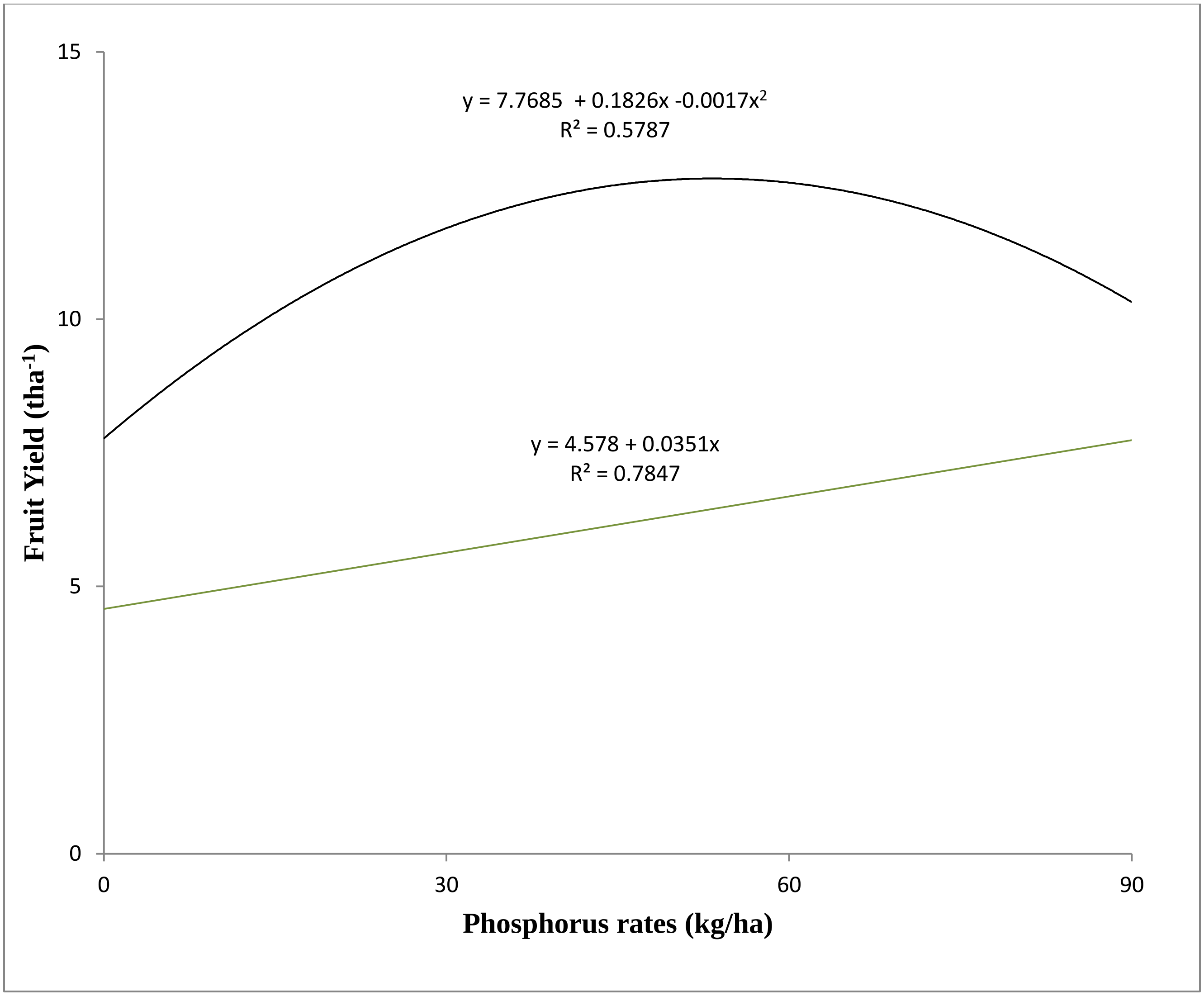

Figure 1: Regression of habanero pepper fruit yield against phosphorus rates at both locations during the 2016 wet season.

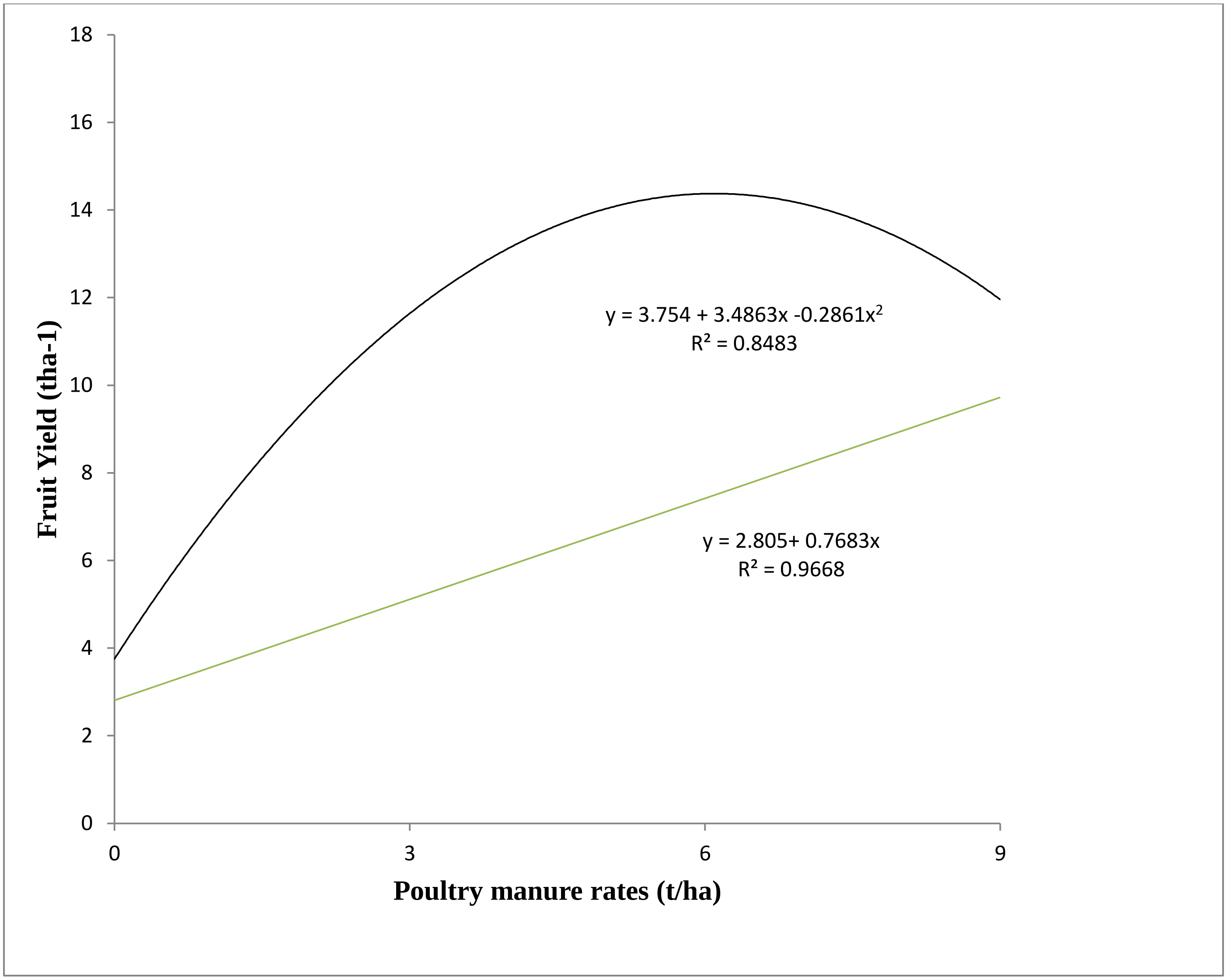

Figure 2: Regression of habanero pepper fruit yield against poultry manure rates at both locations during the 2016 wet season.

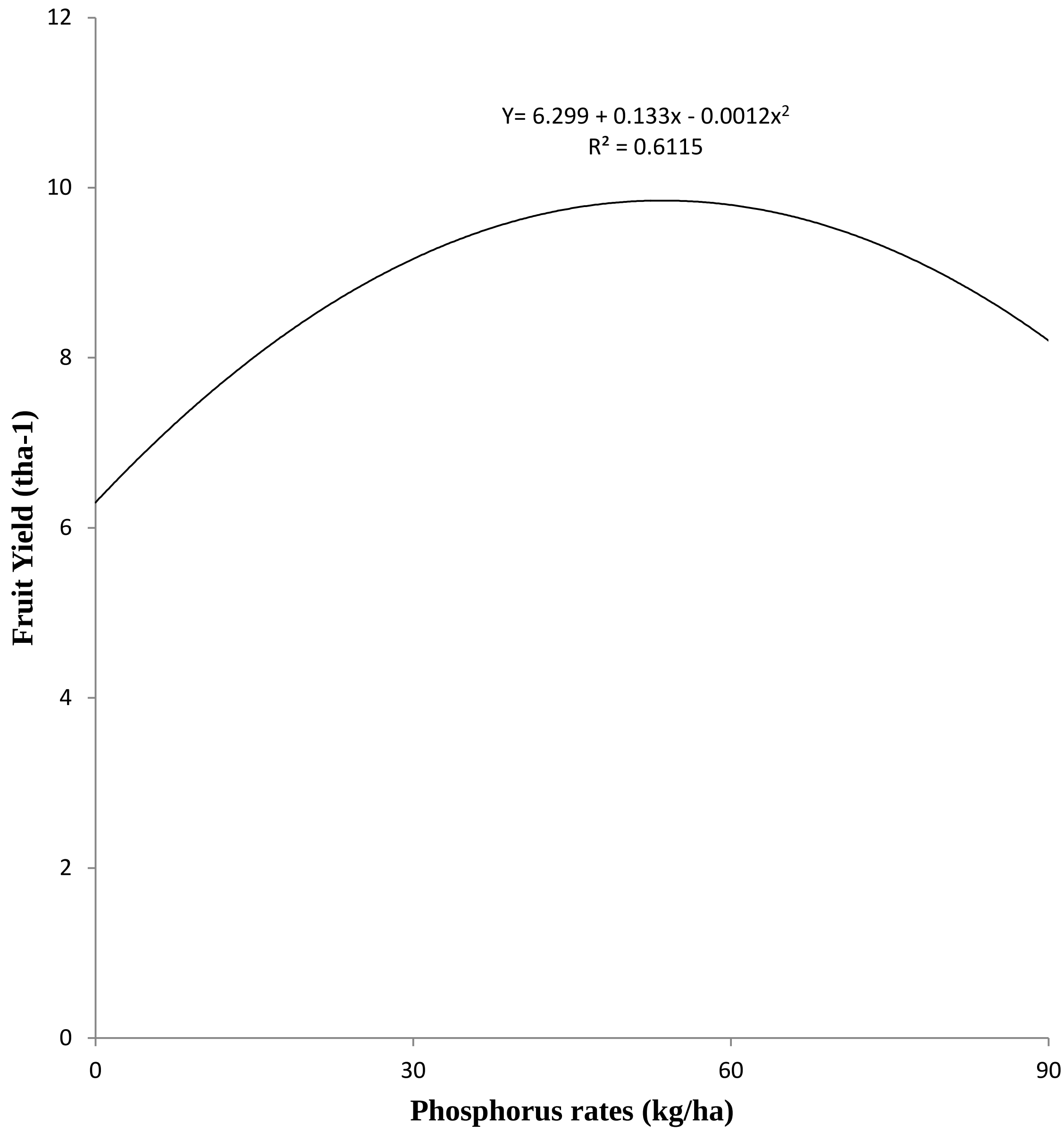

Figure 3: Combined regression curve of habanero pepper fruit yield against phosphorus rates during the 2016 wet season

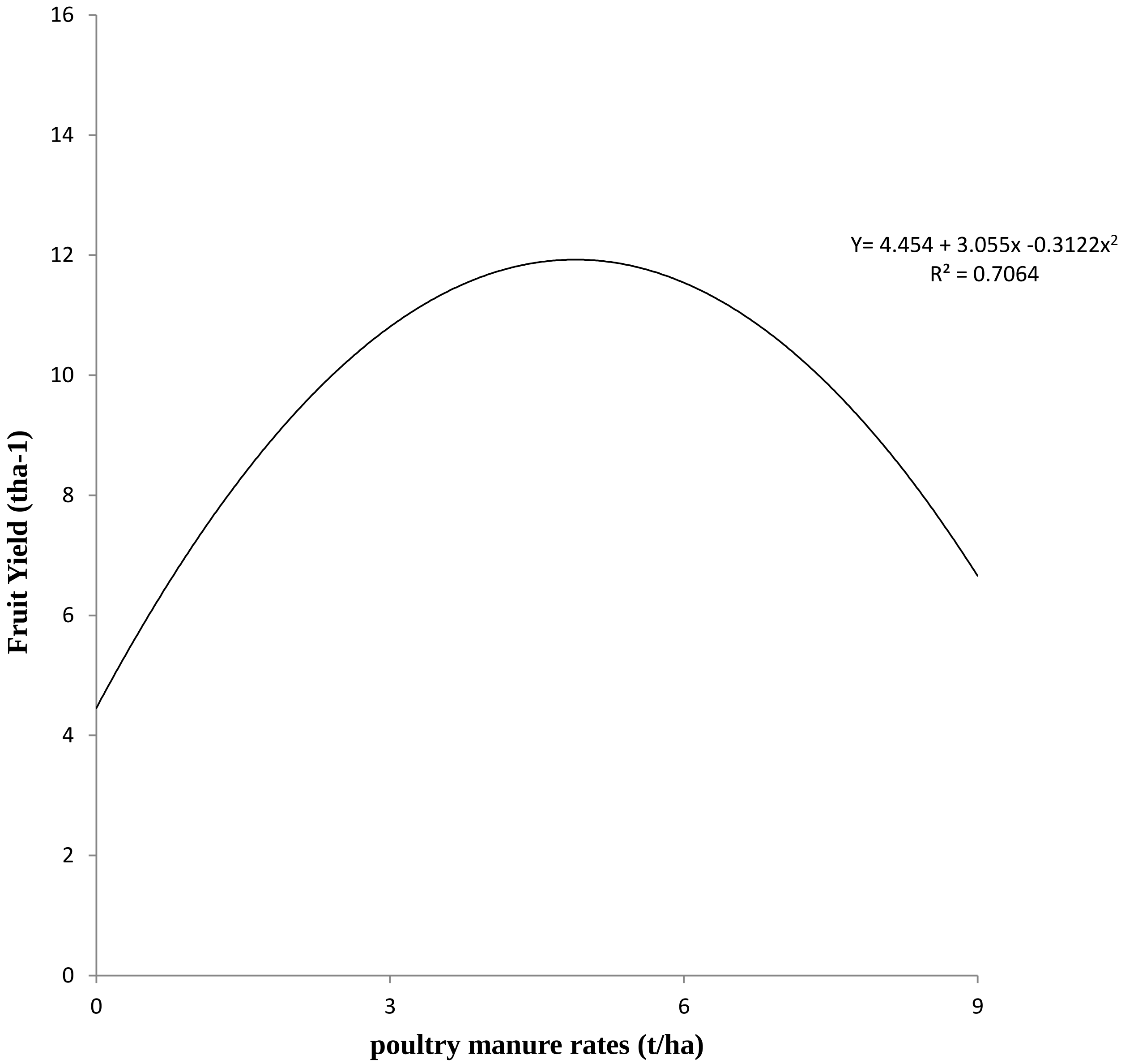

Figure 4: Combined regression of habanero pepper fruit yield against poultry manure rates during the 2016 wet season.

Table 24 Matrix of correlation between growth and yield attributes of habanero pepper as influenced by phosphorus and poultry manure rates in Bagauda during the 2016 wet season

	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	0.289*	1										
3	0.616**	0.460**	1									
4	0.384**	0.364*	0.668**	1								
5	0.193	0.250	0.155	0.408**	1							
6	0.193	0.250	0.155	0.408**	1.000**	1						
7	0.310*	0.064	0.312*	0.533**	0.266	0.266	1					
8	0.402**	0.172	0.317*	0.487**	0.217	0.217	0.894**	1				
9	0.167	0.047	0.165	0.318*	0.323*	0.323*	0.471**	0.484**	1			
10	0.218	0.081	0.282*	0.330*	0.025	0.025	0.483**	0.475**	0.802**	1		
11	0.940**	0.299*	0.679**	0.380**	0.225	0.225	0.258	0.321*	0.115	0.198	1	
12	0.999**	0.296*	0.615**	0.379**	0.189	0.188	0.301*	0.400**	0.161	0.213	0.936**	1

***= significant at 5% level of significance **= significant at 1% level of significance**

1= Fruit yield per hectare, 2= Plant height (10WAT), 3= Number of leaves (10WAT), 4= Number of branches (10WAT), 5= Leaf area (12WAT), 6= Leaf area index (12WAT), 7= Total dry matter (12WAT), 8= Leaf dry weight (12WAT), 9= Crop growth rate (9WAT), 10= Net assimilation rate (9WAT), 11= Number of fruit per plant, 12= Fruit weight per plant

Table 25 Matrix of Correlation between growth and yield attributes of habanero pepper as influenced by phosphorus and poultry manure rates in Samaru during the 2016 wet season

	1	2	3	4	5	6	7	8	9	10	11	12
1	**1**											
2	**0.298***	**1**										
3	**0.595****	**0.421****	**1**									
4	**0.456****	**0.438****	**0.867****	**1**								
5	**0.226**	**0.127**	**0.142**	**0.290***	**1**							
6	**0.226**	**0.127**	**0.142**	**0.290***	**1.000****	**1**						
7	**0.287***	**0.289***	**0.591****	**0.601****	**0.157**	**0.157**	**1**					
8	**0.050**	**0.119**	**0.064**	**0.202**	**0.183**	**0.183**	**0.483****	**1**				
9	**0.365***	**0.294**	**0.513****	**0.517****	**0.316***	**0.316***	**0.513****	**0.358***	**1**			
10	**0.288***	**0.163**	**0.458****	**0.517****	**0.293***	**0.293***	**0.506****	**0.503****	**0.876****	**1**		
11	**0.936****	**0.236**	**0.649****	**0.483****	**0.259**	**0.259**	**0.278***	**-0.023**	**0.330***	**0.192**	**1**	
12	**0.999****	**0.298***	**0.595****	**0.457****	**0.226**	**0.226**	**0.289***	**0.050**	**0.365***	**0.288***	**0.937****	**1**

***= significant at 5% level of significance **= significant at 1% level of significance**

1= Fruit yield per hectare, 2= Plant height (10WAT), 3= Number of leaves (10WAT), 4= Number of branches (10WAT), 5= Leaf area (12WAT), 6= Leaf area index (12WAT), 7= Total dry matter (12WAT), 8= Leaf dry weight (12WAT), 9= Crop growth rate (9WAT), 10= Net assimilation rate (9WAT), 11= Number of fruit per plant, 12= Fruit weight per plant

CHAPTER FIVE

5.0 DISCUSSION

5.1 Response to Phosphorus Application

Pepper generally responded to phosphorus application in this trial. This could have been probably as a result of low phosphorus status of the experimental soil. This is in conformity with the findings of Alabi (2006) that reported positive response of pepper growth parameters to applied phosphorus in P-deficient soil. Application of phosphorus fertilizer had resulted in the production of taller pepper with large leaf area and enhanced growth rate. This in turn means greater light interception thereby leading to greater assimilate production that led to higher stem and total plant dry weights. Similar result was earlier reported by Alabi (2006) who observed increased growth parameters of pepper such as plant height, number of leaves per plant, number of branches and leaf area to application of phosphorus fertilizer.

The growth component of pepper such as plant height, number of leaves, number of branches in Samaru, leaf area and leaf area index, shoot dry matter and stem dry matter, crop growth rate in Bagauda were significantly affected by phosphorus fertilizer. The significant response of these parameters to phosphorus application might be due to the role phosphorus play in promoting plant growth, this agrees with the work of Mengel and Kirkby (1987), Stroeheline *et al*. (1979) which reported that plants suffering from P deficiency produced low lateral shoots which results into low developed number of leaves. Corroborating the results of this study, Fredeen *et al*. (1989) reported that in P-deficient plants, there was reduction in leaf expansion leading to narrow leaf area and leaf area index. Phosphorus plays an indispensable role in energy metabolism and hydrolysis of phosphate bonds being used to induce chemical reactions.

Plant height increased with increase in phosphorus rate up to 60kg P_2O_5 ha^{-1}which conforms the findings of Khan *et al*. (2010) who reported that the maximum plant height was obtained at 60 kg P_2O_5 ha^{-1}. This could be attributed to the fact that phosphorus plays greater role in enhancing translocation of carbohydrates to respective parts during plant development. Similarly Babu *et al*. (1988) also reported that increase in P_2O_5 from 0 to 65kg P_2O_5 ha^{-1} had significantly increased pepper plant height and shoot dry weight significantly. Likewise, Wanknade and Morey, (1982) also reported increased plant height, dry matter and yield as a result of phosphorus fertilizer application.

The delay in flowering observed with lower phosphorus rates (0, 30 and 60kg P_2O_5 ha^{-1}) when compared with early flowering observed with higher phosphorus dose could mean that only the higher dose of phosphorus could trigger faster growth and development in pepper. This result is in agreement with that of Brady and Weil (2002) who stated that phosphorus enhances flowering and hasten maturity of crops.

The significant increase in yield attributes such as number of fruits per plant, fruit weight per plant and fruit yield per hectare as a result of application of phosphorus fertilizer at both locations could be connected to the positive influence phosphorus played in enhancing the vegetative growth while 90 kg ha^{-1} produced the best yield parameters in Bagauda, in Samaru yield parameters were mostly highest at 60 kg ha^{-1}. This differential response between the two locations could be attributed to higher soil phosphorus status at Samaru soils. The positive response of fresh fruit yield and yield parameters of pepper to phosphorus application could be attributed to significant role phosphorus plays in enhancing vegetative growth, fruit yield and quality of pepper as observed by Baghour *et al*. (2001) who reported that pepper yield significantly improved through phosphorus fertilization. Application of phosphorus upto 60 kg P_2O_5 ha^{-1} in Samaru was found to be effective in increasing the yield per hectare significantly due to significant increase in number of fruits per plant, weight per plant and yield per hectare. Further increase to 90kg P_2O_5 ha^{-1} in the level of phosphorus showed a marginal decrease in yield attributes in Samaru which is due to the presence of more soil phosphorus in this location. These findings are in agreement with that of Syeed *et al*. (2002) who reported that beyond 60kg P_2O_5 ha^{-1} yield parameters of pepper significantly reduced.

5.2 Response to Poultry Manure Rate

The positive response of growth components such as plant height, number of leaves and branches, leaf area and leaf area index, shoot dry matter, stem dry matter, leaf dry weight, crop growth rate to application of poultry manure, net assimilation rate in both locations could be attributed to the role manure plays in supplying many of the plant nutrients, increased water holding capacity and soil structure. This could also be attributed to the low organic matter, phosphorus and potassium in the experimental soils. The supply of essential nutrient by the manure might have resulted in high photosynthetic activities and thus promoted vegetative growths (John *et al*., 2004). The increase in the number of leaves, plant height, leaf area and number of branches as a result of manure application could be attributed to role it plays in improving soil conditions (moisture retention, soil structure and aeration and increase nitrogen availability). Nitrogen which is one of major component of manure is known to enhance physiological activities in crops thereby improving the synthesis of photo-assimilates (Aliyu, 2000). The increase in vegetative growth in treatments that received high poultry manure rate could be due to high nitrogen content (Frank, 1965). Studies have shown that application of poultry manure to pepper leads to an increase in plant height, leaf area index and number of branches. Significant increase in leaf area index observed as a result of application of poultry manure might be due to positive role the manure plays in leaf area development and expansion, then more assimilates might have been made available to such plants. The observed increase in the size of leaf area implies effective utilization of nutrients from the soil. This result is in consonance with that Aliyu (2002, 2003) and this confirmed the ability of poultry droppings to supply the required N and other nutrients contents needed by pepper plants to enhance their growth and general performance (Alabi, 2006).

Number of days to 50% flowering is a function of nitrogen, phosphorus, potassium and other nutrient concentration and was well supplied by the poultry manure applied to the soil (Dauda *et al*., 2005a). The significant early flowering caused when 9 t ha^{-1} poultry manure was applied as compared with the lower rates and this could be attributed to rich nutrients composition of the manure that led to rapid growth and development and consequently the attainment of early flowering. This also is attributed to rapid crop growth and more vegetativeness from the manured plots which might have consequently resulted in early flowering when compared with the control plot which had limited nutrient and organic matter supply. This confirmed the findings of Dauda *et al*. (2005b) that observed that there was delay in flower initiation in plots with nutrient deficiency.

The increase in number of fruits per plant, fruit weight per plant and fruit yield per hectare as a result of poultry manure application could be attributed to the fact that the poultry manure supplied essential nutrients for enhanced productivity (Dauda *et al*., 2008). The increase in leaf area and branching recorded as a result of application poultry manure might have enhanced light interception necessary for production of more assimilate used in the formation of fruits. The result showed that at higher rate of manure (9 t ha^{-1}) in Samaru, number of fruit, fruit weight per plant and fruit yield tend to decrease which implies that the optimum rate could be found between 6 and 9 t ha^{-1}. Likewise the higher vegetative growth sustained at 9 t ha^{-1} poultry manure might have drawn and compete significantiy for the assimilates produced by the crop. This agrees with the report of Aliyu (2003) that excess nitrogen application reduced number of fruits and yield. Also Mitchel *et al.* (1978) reported that application of manure above agronomic rate may result in accumulation of heavy metals in both soils and plant tissue with adverse effect on crop growth and performances. In addition, high rate of poultry manure may release phototoxic quantities of ammonia and nitrate salts which may adversely affect soil micro-organisms responsible for mineralization of plant nutrients (Weil and Kroonje, 1979). This apparently explains the observations made on some agronomic parameters with higher poultry manure rates used in this study.

The yield increase with increase in poultry manure rates in Bagauda could be linked to enhanced growth that might result in high assimilate production for fruit production and yield. This result tallies with that of Nicholson *et al*. (1999), Dileep, (2005), Dauda *et al.* (2005a, b) and Ajayi *et al*. (2009) who reported significant yield response to manure rate applications.

The response of growth and yield components such as number of leaves and branches, number of fruits per plant, fruit weight per plant and fruit yield per hectare to poultry manure in both locations could be attributed to the ability of poultry manure to slowly supply N, P and K and many other nutrients leading to longer period of supply, that induced sustained luxuriant growth. Also the ability of manure to improve the physical and chemical properties such as soil structure and water holding capacity of the soil ensured stress free crop development and hence the high yields recorded. This observation agrees with the findings of Aliyu and Kuchinda (2002), Aliyu (2002), Dauda *et al*. (2005a) and Anon (2007) who reported that nutrients in manures most especially nitrogen and other nutrients like phosphorus, potassium become available more slowly and a considerable amount were available towards the latter part of the growing season.

5.3 Interaction of Phosphorus and Poultry Manure on Pepper

The taller plants recorded at 6 and 8 WAT when pepper received combination of 6t poultry manure ha^{-1} and 60 kg P_2O_5 ha^{-1} revealed that combined application of poultry manure and phosphorus fertilizers produced better growth and development of pepper. The result of this study confirms the finding of Gonzalez *et al.* (2001) who reported that organic manure and inorganic fertilizer supplied most of the essential nutrients at growth stage resulting in increased growth variables including plant height.

The same combination of 60 kg $P_2O_5ha^{-1}$ and 6 t ha^{-1} poultry manure produced highest yield attributes (number of fruit per plant, fruit weight per plant and fruit yield per hectare) in Samaru while in Bagauda application of 60 kg $P_2O_5ha^{-1}$ plus 9 t ha^{-1} poultry manure produced the highest yield. This demonstrates the beneficial effects of combined application of poultry manure with inorganic fertilizers. The variation in the optimum rates between locations could be attributed to higher nutrient status of Samaru over Bagauda site.

The high fruit yield of the pepper crop as a result of the combined use of poultry manure and phosphorus fertilizer confirmed the assertion made by Smith *et al*. (1987) when they hypothesized that the combination of organic and inorganic nutrients sources is more beneficial than the sole application of either source of plant nutrient. The combined application of these fertilizers ensured maximum supplies of nutrients that are needed for use by plants.

5.4 Regression Analysis

The regression analysis showed a quadratic response of pepper fresh fruit yield against phosphorus and poultry manure rates at Samaru and combined location which indicate that the optimum phosphorus and poultry manure requirement for the crop was attained using the result of the combined analysis which indicate that the optimum phosphorus and poultry manure rates requirement for the crop was attained. Neetson and Wadman (1987) reported that quadratic response predicts economic optimum application rate of fertilizers i.e. the minimum amount of fertilizer needed for maximum profit. He also stated that recommendations was not based on prediction of the optimum rate of fertilizer, but separately on the recommended amount of fertilizer and the yield obtained. In Bagauda, a linear response was observed between yield against phosphorus and poultry manure rate which indicated that optimum phosphorus and poultry manure was not attained, that means for the optimum yield to be attained, the phosphorus fertilizer and manure rate should further be increased.

5.5 Correlation

The positive significant relationship that was recorded between fruit yield and most of the growth parameters measured signifies an inter dependency between the parameters. Such consistent correlation in both Bagauda and Samaru is a proof that the growth parameters such as plant height, number of leaves, number of branches, shoot dry matter, leaf dry weight and net assimilation rate contributed to yield of habanero pepper. This observation signifies the importance of these parameters in assimilates production and distribution as earlier reported Aliyu, (1994) and Dauda *et al*. (2005a) who also observed positive and significant relationship between growth and yield parameters.

CHAPTER SIX

6.0 Summary, Conclusion and Recommendation

6.1 Summary

A field experiment was conducted to determine the performance of habanero pepper varieties as influenced by phosphorus and poultry manure fertilization. The experiments were carried out during the 2016 wet season at the Institute for Agricultural Research Farm Samaru, Kaduna State and NIHORT Farm Bagauda, Kano State. The treatments evaluated were four phosphorus rates (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and four poultry manure rates (0, 3, 6 and 9 t ha^{-1}) which were factorially combined and laid in a Randomized Complete Block Design (RCBD), replicated three times. Parameters measured were, plant height (cm), number of leaves, number of branches, leaf area (cm^2), leaf area index, crop growth rate (g wk^{-1}), relative growth rate (g g wk^{-1}), net assimilation rate (g m^{-2} wk^{-1}), number of days to 50% flowering, number of fruits per plant, fruit weight per plant (g), fruit yield t ha^{-1}. Plant height (30.13cm at10 WAT), number of leaves (247.42 at 10WAT), number of branches (42.92 at 10WAT), leaf area (4813.80cm^2 at 12 WAT), leaf area index (2.14 at 12 WAT), shoot dry matter (6.25g at 9WAT), leaf dry weight (6.47g at 12 WAT), number of fruit per plant (36.58), fruit weight per plant (280.21g) and fruit yield per hectare (14.63t ha^{-1}) showed significant response to phosphorus fertilizer with 60kg P_2O_5 ha^{-1} producing higher values in Samaru. While in Bagauda, number of leaves (140.67 at 10 WAT), leaf area (2775.20cm^2 at 10 WAT), leaf area index (1.23 at 12 WAT), shoot dry matter (5.96g at 12 WAT), leaf dry weight (1.56g at 9 WAT), stem dry weight (3.18g at 12 WAT), crop growth rate (0.93 at 9-12 WAT), number of fruits per plant (21.92), fruit weight per plant (168.13) and fruit yield per hectare (8.41) were significantly increased by application of 90 kg P_2O_5 ha^{-1}which led to early 50% flowering (32.58).

Most growth and yield characters of habanero pepper were highest by application of poultry manure at 6 and 9 t ha^{-1}in Samaru and Bagauda respectively. Regression analysis showed the optimum rates of phosphorus and poultry manure for habanero pepper yield was 55.42 kg P_2O_5 ha^{-1} and yield of 9.98t ha^{-1}. Poultry manure when regressed against pepper yield showed an optimum of 4.90 t ha^{-1} yielded 11.93 t ha^{-1}.

6.2 Conclusion

In conclusion, it could be suggested that combination of phosphorus and poultry manure at a rate of 55.42 kg $P_2O_5ha^{-1}$ and 4.90 t poultry manure ha^{-1} can be used by farmers in the Savannah zones.

6.3 Recommendation

From the result obtained, it could be recommended that phosphorus application at 55.42 kg $P_2O_5ha^{-1}$ in combination with 4.90 t poultry manure ha^{-1} is the optimum rate required to produce the optimum yield of habanero pepper in the Sudan and Guinea savanna of Nigeria

References

Addo-Quaye, Tetteh, J.P , Saah, M.K., Tachie, M., Adaam, I., Rockson, V.K, and Kitson, J.E. (1993) *General agriculture for senior secondary school*. (1993) Gangaran and sons Bombay, India. 506.

Adediran J. A., Taiwo, L. B. and Sobulo, R. A.(2003) Organic waste and their effect on pepper yield. *African Soils*, 33: 99-116.

Adigun, J.A. (2001): Influence of intra-row spacing and chemical weed control on the growth and yield of chilli pepper (*Capsicum frutescens L*.) in the Nigerian Northern Guinea Savannah. *Nigerian Journal of Horticultural Science* 5:67-73.

Ajayi, F. A., Dauda S. N. and Ndor E. (2009) *G*rowth and yield of water melon (*citrullus lanatus*) as affected by poultry manure application. *Electronic Journal of Environment, Agricultural and Food Chemistry. 8 (4),* 305-311

Akande, M. O and Adediran, J. A. (2004). Effects of fertilizer on growth, uptake and dry matter yield of vegetable crops. *Moor Journal of Agricultural Resources.* 5:12-17.

Alabi, D. A. (2006) Effects of fertilizer phosphorus and poultry droppings treatments on growth and nutrient components of pepper (*Capsicum annuum* L). *African Journal of Biotechnology* 5(8): 671-677.

Aliyu, L. (1994). Growth and yield of pepper (*Capsicum annunm* L.) as influenced by nitrogen and phosphorus levels and plant density. *Ph.D. dissertation, Department of Agronomy Post-Graduate School*, Ahmadu Bello University, Zaria, P. 191.

Aliyu, L. (2000). The effect of organic and mineral fertilizer on the growth, yield and composition of pepper. *Biological Agriculture and Horticulture.* 19:29-36.

Aliyu, L. (2002) Growth and yield of pepper (*Capsicum annuum L*.) as affected by nitrogen and phosphorus application and plant density. *Crop Research* 23(3):467-475.

Aliyu, L. (2003) Effect of manure type and rate on growth and yield of pepper. *Journal of Sustainable Agriculture and the Environment*. 5(1): 92-98

Aliyu, L. and Kuchinda N.C. (2002). Analysis of chemical composition on some organic manures and their effect on the yield and composition on pepper (*Capsicum chinenses* L.) *Crop Research* 23(2):362-368.

Anonymous (1980) Fertilizers and their application to crops in Nigeria. *Fertilizers use series*. Federal Department of Agriculture, Federal Ministry of Agriculture and Rural Development, Nigeria 1 P.26.

Anonymous (1987). *Agrotechnology Roy Technology Institute*. (RT1) *Journal*. 15(1):

114- 119.

Anonymous (1991). Effect of Tillage operation on the yield of pepper *C annum L*. *Research bulletin.* No 11 P. 6

Anonymous (2007). AgStat Socio Economic and Planning Centre, Department of Agriculture, Sri Lanka 4-9.

Babu, S.H., Lokeshwar, D., Rao, N.S. and Rao, B.R.B. (1988). The response of chili (*Capsicum annuum* L.) plants to early innoculation with mycorrhizal fungi at different levels of phosphorus. *Journal of Horticultural Science* 63(2): 315- 320.

Baghour, M., Sanchez, E., Ruiz, J.M., Romero. L. (2001). Metabolism and efficiency of phosphorus utilization during senescence in pepper plants: Response to Nitrogenous and Potassium fertilization. *Journal of Plant Nutrition* 24(11): 1731 1743.

Bajaj, K. L., Kaur G., Singh J., and Brar J.S. (1979). Effect of nitrogen and phosphorus levels on nutritive values of sweet peppers (*Capsicum annuum* L.). Qualitas Plantarum, *Plant Foods for Human Nutrition*, 28(4), 287-292.

Bandel, V. A., Shaffeur C. C. and McClurge, C. A. (1972). Poultry Manure, A valuable Fertilizer. University of Maryland. *Crop Cooperation Extension Service* Factsheet P.39.

Black, C. A. (1965). Method of soil analysis II. Chemical and microbiological properties. *American Society of Agronomy,* Madison, Wisconsin P.106.

Black, C. A. (1968). Soil plant relationship. *John Wiley and Soil Inc.* New York. P. 792.

Blackman, V. H. (1919). The compound interest law and plant growth. *Annals of Botany* 23: 353-360.

Bose, S. and Som, K. (1986). Nutrients composition in vegetable crops. *Indian Journal of the Agricultural Science*. 59(2): 196 – 208.

Brady, N.C. and Weil, R.R., (2002). The nature and properties of soils. Thirteenth edition. *Pearson Education Asia*. Delhi, India. P.960.

Bray, R. H. and Kurtz, L. T. (1945). Determination of total organic and available forms of P in soil. *Soil Science,* 59:39-45.

Bremner, H. M. (1965). Total nitrogen. **In** :Black, C. A. (Ed.) Method of soil analysis II. *American Society of Agronomy,* 1149-1178.

Brian, D and West D. (1997). Tree fertilization: Reasons and Methods. *Arbor Age Magazine* 29 (2).

Buckman, H.O. and Brady, N.C. (1969). *The nature and properties of soils*. The MacMillan Company, New York. P. 59.

Cerna, K. (1981). Effect of fertilizer application on *Capsicum* growth. *Horticultural Science Abstract*. 52(7), 460.

Dauda, S.N., Aliyu L. and Chiezey U.F.. (2005a) Effect of variety, seedling age and poultry manure on growth and yield of garden egg *(Solamun gilo* L.). *The Nigerian Academic Forum* 9 (1): 88-95.

Dauda, S.N., Aliyu L. and Chiezey, U.F. (2005b) Effect seedling age at transplant and poultry manure on fruit yield and nutrients of garden egg (*Solamun gilo* L.) varieties. *Journal of Tropical Sciences* 5: 38–41

Day, P. R. (1965). Particle fractionation and particle size analysis. **In**: Black, C. A. (Ed.) Method of soil analysis II. *American Society of Agronomy, Madison, Wisconsin.* P. 562-566.

Degeus, J.G., (1973). *Fertilizer Guide for the Tropics and Subtropics*. 2nd Edition. Center d1 Etudede 1' Azote. P. 774.

De Witt, D. and Gerlach, J. (1964). *The whole Chilie pepper book.* Little, Brown, and Co., Boston. P. 204.

Dileep, S.N. (2005). Studies on effect of organic manures on the productivity and quality of chilli CV K1, *MSC (Horticultural). Thesis*. Tamil Nadu Agricultural University, Coimbatore.

Doikova, M. (1977) Eggplant productivity in relation to nutrients.*Grandimastro* 57(9):23-31 Cited in *Horticultural Abstract.48 pp137*

Duncan, D.B. (1955). Multiple Range and Multiple F-test. *Biometrice.* 11: PP 1-42.

Emongor, V.E. and Mabe, O. (2012). Effects of phosphorus on growth, yield and yield components of chilli pepper (Capsicum annum L.). *Acta Horticulturae*. International Society Horticultural Science. 936: 327-334.

Erinle, I. D. (1989). Present status and prospects for increased production of tomato and pepper in Nigeria. **In**: *Proceedings of International Symposium on Intergrated Management Practices*. Asian Vegetable Research and Development Centre. Shauhua Taiwan: 548.

Fagimi, A. A. and Odebode, C. A. (2007). Effect of Poultry Manure on Pepper Veinal Mottle Virus (PVMV), yield and agronomic parameters of Pepper (*Capsicum annum*) in Nigeria. *East Africa Journal of Science* 1(2), 104-111.

FAO, (2013). Quarterly Bulletin of statistics. Number 2/3/4. http://fao.org/faostat.

Assessed on 19/11/2015.

FAOSTAT. (2014). Food and Agriculture organization of the United Nations (FAO), FAO Statistical Database, from *http:// faostat.fao.org.*

Firoz, Z.A. (2009). Impact of nitrogen and phosphorus on the growth and yield of okra (*Abelmoschus esculentus*) in hill slope condition. *Bangladesh Journal of Agricultural Resources.* 34(4):713-722.

Frank, G. V. (1965). The plant needs for and use of nitrogen in soil. Edited by Bartaacorew W. U. Francis, E. C. *American Society of Agronomy*. Inc. U. S. A. pp. 58-509.

Fredeen, A. L., Rao, I. M. and Terry, N. (1989). Influence of phosphorus nutrition on George Hochmuth and Ed. Hanlon A, *Summary of N, P, and K Research with Tomato in Florida*.

Gardner, C. S. and Queeley G. L. (1999). Production guidelines for the Scotch Bonnet hot pepper. *Resource Extension Bulletin*. FAMU Research and Extension. Tallahassee FL. PP 21.

Garg, J.S and Bansal M.G. (1972). Optimum dose of nitrogen for high yielding dwarf wheat. *Fertilizer news 17 (10):53:55.*

Gil-Guerrero, J.L. Martinez-Guirano C., Rebolloso-Fontes M. and Carrique-Perez A. (2006). Nutrient composition and antioxidant activity of 10 pepper (Capsicum *annuun)* varieties. *European Food Resource Technology*. 224: 1–9.

Gill, H.S. Thakur P.C. and Thakur T.C. (1974). Effect of nitrogen and phosphorus application on seed yield of sweet pepper *Capsicum annuum* L. *The Indian Journal of Horticulture.* 31(1): 74- 78.

Gonzalez, D., Avarez, R. and Matheus, J. (2001). Comparison of three organic fertilizers for the production of sweet corn. *Proceedings of the International American Society for Tropical Horticulture*. Mexico city,Mexico.45: 106-109.

Grant, C.A. Flaten, D.N., Tomasiewicz, D.J. and Sheppard, S.C. (2001). The importance of early season phosphorus nutrition. *Canadian Journal of Plant Science,* 81: 211-224.

Grubben, G.J.H. (1977). Tropical vegetables and their resources. *International Board for Plant genetics*. Great Britain-UK. PP 25-28.

Grubben, G.J.H and El Tahir, I.M. (2004). *Capsicum annuum* L. **In**: Grubben, G.J.H and OA Denton (eds). *PROTA 2: Vegetables/ Legumes*. [CD-Rom]. PROTA, Wageningen, The Netherlands. PP 154-163

Gupta, A. and Shukla, V. (1977). Response of tomato (*Lycopersicorn esculentum* Mill.) to plant spacing, Nitrogen, phosphorus and potassium fertilization. *Indian Journal of Horticulture* 34: 270-276.

Habtemariam, K. (2003). Livestock and livelihood security in the Harar highlands of Ethiopia. *An implication for research and development*. Doctoral Thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden. P. 163

Hileman, L.H. (1971). Effect of rate of poultry manure application on soil chemical properties. **In**: *Proceedings of International Symposium on Livestock Wastes*, ed. V.C. Nielson, Voorburg, J.H. and Hermite, P. L. 247-248., St. Joseph, Michigan: American Society of Agricultural Engineers.

Hossain, M. E. (1990). Effect of different sources of nutrients and mulching on the growth and yield of amaranth. *MSC Thesis, Department of Horticulture*, Bangladesh Agricultural University. Mymensingh, Bangladesh. pp. 95.

Howard, L.R., Talcott S.T., Brenes C.H. and B. Villalon, (2000). Changes in phytochemical and antioxidant activity of selected pepper cultivars (*Capsicum species*) as influenced by maturity. *Journal of Agricultural Food and Chemical Biodiversity*. 48: 1713–1720.

Hsieh, H.C. and Hsieh C.F. (1990). The use of organic matter in crop production. Food and Fertilizer Technology Centre. *Taipei, China, Extension Bulletin* No. 315: PP 18

John, L.W, Jamer, D.B. Samuel, L.T. and Wanner, L.W. (2004). Soil fertility and Fertilizers: *An introduction to Nutrient Management*. Pearson Education, India, 354.

Kato, T. and Tanaka, M. (1971).Studies on the fruit setting and development of sweet peppers. Fruiting behavior. *Journal of the Japanese Society for Horticultural Science* 40**:** 359–366.

Kaur, C. and Kapoor, H.C. (2001). Antioxidants in fruits and vegetables. The millennium health International *Journal of Food Science Technology.* (36): 703-772

Khan, A. A and Asign, M. I. (1981) Studies on the translocation of 14c- labeled photosynthates in Onion (*Allium cepa*) *Journal of Horticultural Sciences* 4:537 541.

Khan, M. S. I., Roy, S.S. and Pall, K. K. (2010) Nitrogen and phosphorus efficiency on the growth and yield attributes of *Capsicum*. *Academic Journal of Plant Sciences 3 (2): 71-78pp.*

Kulvinder, S. and Srivastova, B.K. (1988). Effect of various levels of nitrogen and phosphorus on growth and yield of chilli. (*Capsicum annuum*). *Indian Journal of Horticulture*. 45 (3-4) 319-324.

Little, J. M. and Hills, F. J. (1978). *Agricultural Experimental Design and Analysis*, John Willy and Sons, Inc., New York. P. 350

López-Cantarero, I. J., Ruiz M. Hernandez J. and Romero L. (1998). Phosphorus metabolism and yield response to increases in nitrogen-phosphorus fertilization: Improvement in greenhouse cultivation of eggplant (*Solanum melongena* cv. Botanica). *Journal of Agricultural and Food Chemistry*, 46 (4): 1603-1608.

MacDonald, G.E. (1975). Plant response to concentrated superphosphate Kcl fertilizer for sweat corn (Zea *mays* L.) var. rugosa). New York State Experiment. *Station Search* 2(4): 1-8.

Mac Nesh, R.S. (1964). Ancient Mesoamerican civilization. *Science.*143: 531-537.

Marin, A., Ferreres, F., Tomas-Barberan, F.A. and Gil, M.I. (2004). Characterization and quantitation of antioxidant constituents of sweet pepper (*Capsicum annuum* L.). *Journal of Agricultural Food Chemistry*. 52: 3861–3869

Matta, F.R. and Cotter, D.J. (1994). Chilli production in North-Central New Mexico. New Mexico *Cooperative Extension Circular*. Las Cruces NM: 18/9/2009. PP 21-24

Maynard, A. A. (1991). Intensive vegetable production using composted animal manure. *Bulletin of Connect Agricultural Experiment Station* No. 892, P.13.

Mengel, K. and Kirkby, E.A. (1987). *Principles of Nutrition*. International potash Institutes. Switheland. P. 567.

Mitchel, G. A. Binghan, F. T. and Page, A. L. (1978). Yield and metal composition of Lettuce and wheat grown on soils amended with sewage sludge enriched with cadmium, nickel and zinc. *Journal of Environmental Quality*. 7(2): 165.

Muhammad,L .Y. (1989). Effects of irrigation frequency on yield and fruits composition of pepper. (*Capsicum pubescens* L.). *Journal of acta Horticulture* (138):141-148.

Muller-Samann, K. M. and Kotschi K., (1994). *Sustaining Growth: Soil Fertility Management in Tropical Small Holdings*. Magraf, Verlag, Weikersheim. P. 112

Naeem, M., Iqbal, J. and Bakhsh, M. A .A (2006). Comparative Study of Inorganic Fertilizers and Organic Manures on Yield and Yield Components of Mungbean (*Vigna radiat* L.). *Journal of Agriculture and Social Science* 2: 227–9.

Neetson, J. J. and Wadman, W. P. (1987). Assessment of economically optimum application rates of fertilizer N on the basis of response curves. *Fertilizer Research* 12: 37-52.

Nicholson, F.A., Chambers B.J., Smith K.A. and Harrison R. (1999). Spring applied organic manure as a source of nitrogen for cereal crops: Experiments using field scale equipment. *Journal of Agricultural Sciences*. 133:353-363.

NIHORT (1986). Advances in Fruit and vegetable research at Nigerian Institute of Horticultural Research. *A commemorative publication, Ibadan*, P. 89.

Norman, J.C. (2002). *Tropical Vegetable Crops*. Arthur Stock well Ltd. Devon P.252.

Ofori, C. S. (1995). *The need for long term soil management research in Africa*. CRC Press Inc. New York. P. 107.

Ofori, C.S. and Santana, R. (1990). Fertilizers, their potential use in African Agriculture in organic matter management and tillage in sub-humid Africa. **In**: *Proceedings of international Board for Soil Research and Management* Inc. 10: 213-219.

Olaniyi, J. O and Ojetayo, A. E. (2010). The effect of organomineral and inorganic fertilizers on the growth, fruit yield and quality of pepper *(Capsicum frutescence)*. *Journal of Animal & Plant Sciences,* 8 (3): 1070- 1076.

Olsen, S.R. and Khasawneh, F.E. (1980). Use and limitation of Physical and chemical criteria for assessing the status of phosphorus in soils, **In**: Khasawnech (eds.). The Role of Phosphorus in Agriculture. *American Society of Agronomy*. Madison Wisc.

Omori S. Sugimoto M and Ogural I (1977) Nutrition of vegetable crops Ed: Mitra S.K;Sardhu M.K and Bose T.K. *Naya Prakash Publication India 1990,* P. 75

Parnes, R., 1990. Fertile soil: *A grower guide to organic and inorganic fertilizers*, Agaccess, California, 190pp.

Peck NH and MacDonald GE (1975). Plant response to concentrated superphosphate Kcl fertilizer for sweat corn (*Zea mays* L.) var. rugosa). *New York State Experiment Station. Search* 2(4): 1-8.

Peck N.H, Drunes D.L, Welch R.M, MacDonald G.F. (1980). Nutritional qualities of vegetable crops as affected by phosphrous and Zinc fertilizers. *Agronomy Journal* 72: 528-534.

Poulos, J.M., (1993). Pepper breeding. In Breeding of Solonaceous and Cole crops. *Research Journal of the American Society for horticultural Science*, 129:826-832.

Price, C.A., (1970). *Molecular approaches to plant physiology*. McGraw-Hill., New York P. 375.

Radford P.J. (1967) Growth Analysis formulae. Their uses and Abuse. *Crop Science 7 (3).* 171-175.

Reddy T.Y Reddi G.H (1975). *Principles of Agronomy 2nd edition* Kalyani publishers New Delhi 110001. P. 223.

Russell, E.J., (2004). Manuring for Higher Crop Production. *Agrobios*, India. Saleem. P. 68

Sanchez, P.A. (1986) *Properties and management of soil in the tropics*. New York. U.S.A. John Wiley and sons. P. 78.

Sanchez, P.A., Shepherd, K.D., Soule, M.J., Place, F.M., Buresh, R.J., Izac, A.N., Mukwunye, A.U., Kwesiga, F.R., Ndritu, C.G. and Woomer, P.L., (1996). Soil replenishment in Africa. *Soil science society of America*. Special publication 51. PP. 1-46.

Santos, B. M., Dusky, J. A., Stall, W. M., Bewick, T. A. and Shilling, D. G. 2004. Mechanisms of interference of smooth pigweed and common purslane on lettuce as influenced by phosphorous fertility. *Weed Science* 52 (1): 78-82.

Sardas, S., (2003). The role of antioxidants in cancer prevention and treatment. *Indoor Built Environment.*12: 401–404

Siddesh K., (2006). Studies on integrated nutrient management on seed yield and quality of chilli. *Msc.thesis, Department of Seed Science and Technology,* College of Agriculture, Dharwad University of Agricultural Sciences Dharwad

Smith P.G.B., Villalon and Vila P.L. (1987). Horticultural Classification of pepper grown in the United States. *Journal of Horticultural Science 22:* 11-13.

Snedecor, G.W. and Cochran, W.G. (1967). *Statistical methods,* 6th edition, Iowa State University Press, Iowa, U.S.A. P. 607.

Sopher, C.D. and Baird, J.V.,(1982). *Soils and soil management*. 2nd edition. Prentice hall. New Jersey. P. 312.

Soria Fregoso, M.J., Trejo Rivero, J.A., Tun Suarez, J.M., Teran-Saldivar, R.(2002) *Paquete tecnológico para la producción de chile habanero* (*Capsicum chinense* Jack) Instituto Tecnológico de Mérida. PP 23–74.

Stewart MW, Dibb WD, Johnston EA and Smyth JT. (2005).The Contribution of Commercial Fertilizer Nutrients to Food Production. *Agronomy Journal*; 97: 1-6.

Stroeheline. J.I., Oebker, N.F. (1979). Effects of nitrogen and phosphorus on yield and tissue analysis of chilli pepper. Community of Soil Science. *Plant Analogue.* 10: 551– 563.

Swanson, B. (2000). Plant fertilization. *A guide for fertilizing new and established plants in the landscape*: John Wiley and Sons. New York.

Syeed,M., Gandroo, M.Y., Ahmed, N. and Kanaujia, S.P. (2002)**.**Effect of plant spacing and different nitrogen and phosphorus levels on growth and yield of sweet pepper (*Capsicum annuum* var. grossum L.). *International Conference on Vegetable Abstract*, pp 170. Dr. Prem Nath, Agricultural Science Foundation, Bangalore.

Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin. J.L, (1993). *Soil Fertility and Fertilizers*. 5th edn. MacMilln Company, New York. pp. 634.

U.G.C.E, College of Agricultural and Environmental Sciences (2009). *Commercial Pepper Production Handbook Bulletin* 1309. P 683.

USDA (1960). Soil classification, a comprehensive system, 7th approximation.United States of America Department of Agriculture, Washington. P. 134.

Waknade, B. N., and D. K. Morey.,(1982). Effect of phosphate and plant densities on growth and yield of chillies (*Capsicum annuum* L.) [peppers, India]. *The PKV Resource Journal* 6(1): 23-27.

Walkey, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and proposed modification of chronic extraction method. *Soil science 37, pp 29-38.*

Watson,D.J. (1958). The dependent of net assimilation rate on leaf area index. *Annals of Botany*,22(2): 37-54.

Wiel R. R. and Kroonje W. (1979). Physical conditions of Davidson clay loam after five years of poultry manure application. *Journal of Environment Quality*. 18: 387 392.

Yacheva (1981). Nutrition of vegetable crop (Ed) Mitra S.K; Sardhu M.K and Bose T.K. *Naya Prakash Publication of India Journal 1990*, P. 75

Yagodin, B.A. (1984). Manure in *Agricultural Chemistry 2*. English Translation, Mir Publication, Moscow.

Zipelevish, E., Grinberge A. Amar S. Gilbo Y. and Kafkafi U. (2000). Eggplant dry matter composition fruit yield and quality as affected by phosphate and total salinity caused by potassium fertilizers in the irrigation solution. *Journal of Plant Nutrition,* 23(4): 431-442.

Zublena, J.P. and T.A. Carter (1997). *Poultry manure as a fertilizer source*. North Carolina Co-Operative Service, U.S.A. 439-500.

APPENDIX 1 Bagauda Meteorological Record 2016

	% RELATIVE HUMIDITY		TEMPERATURE (^0C)		EARTH TEMP (30cm)				
MONTH	10 a.m	3 p.m	Max	Min	10 a.m (0C)	3 p.m (0C)	SUNSHINE HOURS	RAINFALL (mm/day)	EVAPORATION (mm/day)
MARCH	35.8	18.2	27.0	26.8	NA	NA	NA	0.00	NA
APRIL	39.7	40.5	40.1	29.9	NA	NA	NA	0.00	NA
MAY	23.1	14.4	38.3	29.7	NA	NA	NA	2.1	NA
JUNE	36.6	20.2	28.5	26.9	NA	NA	NA	5.0	NA

JULY	55.7	47.0	26.8	25.1	NA	NA	NA	6.2	NA
AUGUST	59.5	52.3	29.9	20.6	NA	NA	NA	7.5	NA
SEPTEMBER	50.1	38.2	35.1	26.0	NA	NA	NA	3.5	NA
OCTOBER	43.0	33.6	35.1	24.5	NA	NA	NA	0.6	NA

Source: Bagauda Meteorological Unit, Kano.

APPENDIX 2 Samaru Meteorological Record 2016

	% RELATIVE HUMIDITY		TEMPERATURE (^0C)		EARTH TEMP (30cm)				
MONTH	10 a.m	4 p.m	Max	Min	10 a.m (0C)	4 p.m (0C)	SUNSHINE HOURS	RAINFALL (mm/day)	EVAPORATION (mm/day)
MARCH	33.3	23.10	34.7	24.1	28.8	29.9	6.5	0.8	7.9
APRIL	50.9	30.4	39.5	25.8	30.9	41.7	7.8	0.07	9.9
MAY	66.4	45.8	35.2	24.2	28.6	29.8	7.8	2.6	7.4
JUNE	75.5	65.4	31.4	23.2	52.6	28.4	7.1	4.4	4.6
JULY	80.4	71.5	30.8	22.9	26.9	26.6	5.9	7.1	3.7
AUGUST	81.9	74.3	30.6	21.9	26.2	26.8	6.7	8.7	5.5
SEPTEMBER	74.7	NA	NA	24.6	26.0	26.5	6.0	11.5	6.0
OCTOBER	60.4	54.7	34.3	18.3	27.3	28.2	8.4	0.00	6.7

Source: IAR Meteorological Unit, Samaru- Zaria. Kaduna.

NA; NOT AVAILABLE