GROWTH, YIELD AND FRUIT QUALITY OF SELECT VEGETABLES (TOMATO, GREEN PEPPER AND GARDEN EGGS) AS AFFECTED BY “ASASE GYEFO” PREMIUM ORGANIC FERTILIZER

BY

JOSEPH AMPAH
(10232203)

THESIS SUBMITTED TO THE DEPARTMENT OF CROP SCIENCE, UNIVERSITY OF GHANA, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY IN CROP (HORTICULTURE) DEGREE.

DEPARTMENT OF CROP SCIENCE

UNIVERSITY OF GHANA

LEGON

JULY 2019

DECLARATION

I hereby declare that, except for references to the works of other researchers, which I have duly cited, this work is the result of my own original research and that, this thesis has not been presented for an award of a degree in part or whole elsewhere.

…………………………………………………………

JOSEPH AMPAH
(STUDENT)

DATE……………………………………………….

……………………………………………………….

DR. NAALAMLE AMISSAH
(SUPERVISOR)

DATE………………………………………………

………………………………………………………….
PROF. GEROGE O. NKANSAH

(SUPERVISOR)

DATE………………………………………………….

ABSTRACT

Declining soil fertility has been found to be the main cause of reduction in crop yields. These soils lose their fertility through erosion, leaching and crop removal. Organic fertilizers prepared from human waste has been found to have a greater potential of being used to manage soil fertility and hence increase crop yields. The present study is to determine the nutrients content and effect of Asase Gyefo Organic Fertilizer (AGOF) prepared from human waste on the growth, yield and shelf life of select vegetables (garden eggs, green pepper and tomato). The experiments were laid out in Randomised Complete Block Design (RCBD) using ten treatments namely 5tons/ha AGOF, 7.5 tons/ha AGOF, 10.0 tons/ha AGOF, 12.5 tons/ha AGOF, 15.0 tons/ha AGOF, 17.5 tons/ha AGOF, 20.0/ha tons, 10 tons/ha Poultry Manure, NPK+SA (300kg/ha+150kg/ha) and Control, ran in three replicates. Data collected on the growth were on the 5th, 7th and 9th weeks after sowing. Fruit characteristics, yield and shelf life were also measured at maturity. The results showed that AGOF had all the nutrient elements needed for increased crop production. AGOF applied at 10 tons/ha produced a yield of 2664 kg/ha in garden egg experiment one, which was significantly higher than the yield obtained when the soil was not amended. In green pepper experiments 1 and 2, no significant differences were recorded in the yields. However, in tomato experiment, AGOF applied at 12.5 tons/ha yielded 1543 kg/ha which was significantly higher than 15 tons/ha AGOF and 20 tons/ha AGOF application rates. From the results, AGOF applied at the rate of 12.5 tons/ha gave optimum yield in tomato, while rates of 5 tons/ha of AGOF to 20 tons/ha of AGOF depending on the state of the soil gave the best of growth and yields in green pepper and garden egg test crops, comparable to yields obtained from poultry manure treatment and hence can be used as substitute organic fertilizer for vegetable production.

DEDICATION

I dedicate this thesis to God Almighty and my family.

ACKNOWLEDGMENTS

I thank God Almighty for this grace, gift of life and good health thought out this work. I express my sincere gratitude to A.G. Leventis Foundation and Safi Sana Ghana Limited for funding this study. I am also so grateful to my supervisors Dr. Naalamle Amissah and Prof. Geroge O. Nkansah for their guidance, patience, and corrections. Thank you so much. Profound thanks go to all my colleagues at the Department of Crop Science for your support and help in diverse ways. Finally, am so grateful to all the Senior Members of the Department of Crop Science for their support and guidance. May God bless you all.

TABLE OF CONTENT

CONTENT **PAGE**

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AGOF	**Asase Gyefo Organic Fertilizer.**
NPK	**Nitrogen, Phosphorus, Potassium**
SA	**Sulphate of Ammonia**
Ha	**Hectare**
Ton	**Tonne**
WAS	**Weeks After Sowing**
Mg	**Milligramme**
cmol	**Centi mol**
mm	**Millimetres**
Av P	**Available phosphorus**
NS	**Not Significant**
LSD	**Least Significant Difference**
et al	**And others**

CHAPTER ONE

1.0 INTRODUCTION

The declining soil fertility in most sub Saharan African small holder farms, has been found to be the main cause of reducing per capital food production. (Gruhn *et al.*, 2000*;* Sanchez, 2002*;* Farouque and Tekeya, 2008). This is mainly through erosion, leaching of nutrients and ultimately by crop removal as a result of continuous cropping, popularly referred to as nutrient mining. Traditional soil fertility management methods such as long-term land fallowing and crop rotation are phasing out with time due to population increase and other external factors (Agegnehu and Amede, 2017). It is imperative, therefore, to ensure that the soils are kept reasonably fertile to ensure sustained yields in small holder farms. This calls for the use of proper and careful soil management techniques. There are various methods used to restore the fertility of depleted soils to bring them to levels where near maximum yields are obtained. These include application of inorganic (synthetic) and organic fertilizers.

Increased use of synthetic fertilizers in agriculture has led to many health and near irreversible environmental pollutions (Yanar *et al*, 2011). These include contamination of water bodies, acidification of the soils and lowering of the health of these soils among others. Another very important factor to consider is the rapid increasing prices of inorganic fertilizers all over the world, justifying the search for alternative sources in recycling agricultural and other organic waste (Caldwell and Rosemari, 2010) to maintain the soil fertility.

The excessive use of inorganic fertilizers in crop production is known to result in a lot of negative effects on the soil, besides what has been stated above. To minimize, if not totally eliminate these negative effects of continued use of synthetic fertilizers and other agro chemicals on the consuming public and the environment, a new so-called production system known as organic agriculture or sustainable agriculture has been developed (Chowdhury, 2004). In this system, fertilizers from organic and biodegradable sources are rapidly replacing the use of inorganic fertilizers.

Organic fertilizers are known to provide all the nutrient elements for plant growth and suppression of plant pest populations. Additionally, their integration into the soil and subsequent mineralization increases microbial activity, anion and cation exchange capacity, organic matter accumulation and carbon-content of the soil. They ultimately increase yields and quality of produce just like inorganic fertilizers (Singh and Siataramaiah, 1970; Hoitink and Boehn, 1999; Bulluck and Ristaino, 2002; Bulluck *et al.*, 2002; Heeb *et al.*, 2005; Heeb *et al.*, 2006; Liu *et al.*, 2007; Tonfack *et al.*, 2009).

Neeson (2004), also confirms the fact that, organic fertilizers (compost) are known to improve the soil structure, release nutrient elements slowly and eventually encourage the growth of beneficial soil microbes, which contributes to the health of the soil. Considering the numerous benefits and advantages associated with organic fertilizers, there is the need to encourage its use in sub Saharan African small holder farms involved in vegetable production and indeed other crops.

Organic fertilizers like poultry manure and cow dung, which are the most popular and common farm yard manures widely used in organic agriculture in Ghana is fast becoming unavailable. This is due to the near collapse of the poultry production industry in particular and general serious decline in the animal production sector. Experts have attributed this to importation of cheap and substandard poultry and beef products into the country.

Vegetable production in Ghana in all its forms is beset to a large extent by soils with depleted nutrient, resulting in low crop yields (Sauerborn and Germer, 2006). Researches into the use of organic materials to increase soil fertility have largely focused on crop residue management, green manure, animal manures and leguminous cover crops. Researchers are exploring different organic sources, abundant in nature which can be obtained at very little or no cost at all. Human waste (toilet and urine) is one of them, and it is fast gaining popularity as a raw material for preparing organic fertilizers. However, a few detailed research studies have considered the use of treated faecal matter for crop production: although it is widely used by farmers in the Northern part of Ghana for soil fertility management (Cofie *et al* 2005). The use of faecal matter for crop production has been practiced for some time now in poor communities in the Northern Region of Ghana. In these poor communities, the cost of inorganic fertilizers and poor soil structures is fast making this practice an alternative to maintaining reasonable levels of soil fertility for good crop yields (Owusu-Agyeman and Kranjac- Kerisaljevic, 2009).

The current situation in most of our towns and cities where faecal matter are indiscriminately discharged into drains, rivers and the sea are unacceptable and possess a great deal of danger to the public health and the environment. This has resulted in the yearly incidence of Cholera and Typhoid outbreaks in the cities, claiming the lives of several people.

The potential for the use of faecal matter as raw material to produce organic fertilizer has a lot of advantages not yet fully exploited. These advantages include abundant raw materials (faecal matter) for production, since it is available where ever human settlements are found; at virtually no cost, except for transportation (inexpensive). It also has the added advantage of greatly improving, if not totally solving our sanitation problems in our towns and cities across the country. Besides the above-mentioned advantages, treated effluent water from this system can be used in irrigating crops during the crop production cycle and other horticultural uses.

In this present system of using faecal matter to produce high quality organic fertilizer, the faecal matter is treated in digesters to destroy all the harmful microorganisms. In the process of digestion of the waste, methane gas is generated. The gas generated, is used to power a gas generator to produce electricity. The sludge is drained off, dried and subsequently co-composted with agricultural and biodegradable waste from our farms and market centers respectively, to obtain high quality organic fertilizer for crop production. It is therefore imperative for researchers to critically examine this organic fertilizer made from human waste and other organic waste.

This research, therefore, seeks to critically examine the nutrient levels, efficacy and determine the optimum of rates of application that will result in maximum yields of selected vegetables (Tomato, Green pepper and Garden egg).

The specific objectives of this research are to determine:

- The nutrient levels of “Asase gyefo” premium organic fertilizer
- The effects of the “Asase gyefo” premium organic fertilizer on the growth, yield and shelf life of select vegetables (tomato, green pepper and garden egg)
- Optimum application rate of “Asase gyefo” premium organic fertilizer that will give optimum yields for the selected vegetable crops (tomato, green pepper and garden egg).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Test crops (Tomato, Green pepper and Garden eggs)

Tomato, green pepper and garden egg all belong to the Solanaeces family and are very important vegetables in the world. They are usually consumed fresh in salad, half cooked or fully cooked, paste or in soups and stews all over the world. (Welbaum, 2015). Their importance in human diet regarding fiber, vitamins and minerals and non-nutritive phytochemicals (phenol compounds, flavonoids, bioactive peptides etc. cannot be over stated. These nutrients and non-nutritive molecules have been found to greatly reduce the risk of diseases like cardiovascular diseases, diabetes, cancer and obesity (Welbarum 2015, Pennington 2009). They play very important role in diet of humans and subsequently the health. Tomato has become an important model crop for research into plant and fruit physiology, biochemistry and genetics (Vital *et al* 2014). These crops are all known to contain very good quantities of vitamin C, antioxidant which are very efficient in mobbing oxygen and other free radicals from the human system. They have also been cited as providing protection against cardiovascular diseases in humans (Tindall 1983,) while Obono and John (2018) also concluded that, consumption of diets rich in red tomato significantly reduces cardiovascular symptoms and by extension lower it incidence.

There are however several limiting factors to production of these vegetables in small holder farms in Ghana. Top on the list of these limiting factors to production of these crops (Tomato, Green Pepper and Garden Eggs) is declining soil fertility due mostly to crop removal resulting from continuous cropping. Hence there is urgent need to replenish the lost nutrient elements in these soils in a sustainable manner. Fertilizers, either organic or inorganic readily come to mind.

2.2 Fertilizers

Fertilizer use, both organic and inorganic is intended to replace lost soil nutrient elements and subsequently improve crop yields. Although inorganic fertilizers are known to improve growth and yield of crops, there are numerous disadvantages that comes along with its use as opposed to using organic fertilizers. Kark and Bhattacharya (2010) asserts that, applying inorganic fertilizers in an unbalanced manner has led to a significant decline in soil health, organic matter content and crop productivity during recent years. This assertion is also confirmed by Yadav *et al* (1998), when they stated that, yields of rice and wheat experienced linear decline trend in yield , the highest rate of decline being 89 kg/ha/year and 175kg/ha/year in wheat and rice respectively during a study which was conducted during a 19 years period, using inorganic fertilizers. Hu *et al* (2017) reported that, after 12 years of continuous application of NPK alone and NPK combined with organic fertilizer resulted in significant decrease in aggregate stability and macro porosity of the soil by 55.3% and 36.1% respectively relative to the control, and thus concluded that, the use of inorganic fertilizer alone over 12 years could not improve the soil structure of Calcareous silt loam soil. Other possible side effects of excessive use of inorganic fertilizers are the pollution of underground water as they leach beyond the root zones of the crop into the ground water. Therefore, in my view, alternatives in the form of organic fertilizers prepared from abundant organic materials in the environment should be fully exploited.

2.3 Organic fertilizers

In Ghana, sources of popular organic fertilizers used in small holder vegetable production are various farm yard manures, notably poultry manure and cow dung. Akuamoah-Boateng (2016) reported that, the application of 15tons/ha of well decomposed poultry manure applied to onion gave a very high yield of 14.6ton/ha. According to Huang *et al* (2005), huge volumes of animal droppings, generated as waste during intensive commercial animal farming are subsequently used in agricultural lands on small holder farms. These manures used in organic crop production are mostly applied to the soil as either raw (fresh or dried) or in the composted form (Kuepper, 2003). While a lot of attention has been given to the research into poultry manure and other farmyard manures as alternative organic fertilizer for managing soil fertility in vegetable production in Ghana, not much research has gone into the use of treated human waste (toilet and urine) co-composted with agricultural waste as organic fertilizer. This, in my estimation may be due to lack of appropriate technologies and technical knowhow, on how to treat these rather abundant so-called wastes of human settlements for agricultural use. Hence the urgent need to research into treated human waste used as organic fertilizer for increased crop yields in small holder farms in Ghana.

2.4 Effects of organic fertilizers on soil physiochemical properties

Organic fertilizers are natural nutrient elements source used for improving the health and fertility of soils, as they are cropped, to ensure sustained crop yields. A study by Aqeel *et al* (2007) on the use of olive mill by-product as soil amendments gave a positive result, and hence recommended its use; since it improved the crop productivity as well as improving the soil chemical and physical properties. Voor *et al* (2018) also found out that, application of poultry manure increased the organic matter content, which also improved the physical properties like texture, soil structure, water retention capacity and chemical properties of the soil, namely pH, Total N, Available P and exchangeable cations, just to mention a few.

In dealing with Calcareous soils (soils containing high levels of Calcium Carbonate and Magnesium Carbonates), organic fertilizers have been found to be useful in correcting long term effect of using salty water for irrigation and sustaining crop yields of rice-wheat system, thereby reducing the dependency on gypsum. (Choudhandy *et al* 2011). This observation agrees with Klaus *et al* (2008) when they demonstrated, through their study that, prolonged or long-term use of organic fertilizers during production promoted soil quality, microbial biomass and encouraged natural enemies and ecosystem engineers; suggesting enhanced nutrient cycling and pest control. A combination of farm yard manure and sustainable soil management practices like crop rotation, cover cropping, and green manuring has proven to be effective in improving soil quality (Kuepper, 2003). Finally, Agegnehu *et al* (2016) also established that, the incorporation of organic fertilizers or amendments optimizes soil physical and chemical properties and helps to maintain barley yields in Ethiopian highland. These findings by various researchers whose works have been referenced so far goes to enforce the assertion that, the use of organic fertilizers in crop production is the way to go in managing the health and fertility of soils of small holder farms for sustained yields.

2.5 Nutrient release pattern of organic fertilizers

Organic fertilizer is known to release their nutrient elements slowly over a period, known as nutrient release pattern. Masunga *et al* (2016), after their research into Nitrogen mineralization dynamics in organic amendments used in agriculture, concluded that, the timing of application and type of organic amendments used in crop production should be aligned to the nutrient needs of the crop. Therefore, if properly synchronizes, they can be applied and nutrients released at the time the plants need those nutrients for growth and development. The slow release pattern is largely due to the mineralization process which involves microorganisms in the soil. This process is greatly influenced by several factors, including soil moisture, temperature and type of soil. To determine the nutrient release pattern of organic fertilizers under controlled environment (room temperature of about 25°C -33°C), Carbon dioxide evolved is usually used as the main indication of pattern. One could also determine the pH, nitrogen, phosphorus and potassium during the period of incubation. Ipinmoroti (2013) established that, the carbon dioxide production during incubation studies of various organic farm waste (used as fertilizer) was significantly high and increased for the first 2 months, and decreased in the months after. This indicates that, there is higher microbial population, resulting in increased metabolism and subsequent nutrient release. It is therefore important to apply organic fertilizers to the land for some time (at least 10 days to two weeks) before planting or transplanting seedlings. This will ensure that, the nutrients are available at the time the plants are actively growing and needs them most.

2.6 What is Circular Economy?

Circular economy in broad terms is described as all activities that reduces, reuses and recycles during production, circulation and consumption (Jun and Xiang 2011). It is in effect seen as an economic system which aims at minimizing waste and making the maximum use of most resources. It is also defined as an economic system where products and services are traded in close loop or cycle. Its main character is regenerative and retains the highest value as possible of products, parts and materials. This means that, circular economy is all about a system where products are made in such a way to have a long-life span, optimal reuse, refurbishment, remanufacturing and recycling of products or resources from the environment (Kraaijenhagen *et al* 2016). This regenerative system ensures that, energy leakages are reduced to the lowest minimum. This is by slowing, closing, and narrowing material and energy loops, leading to long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing and recycling (Geissdoerfer *et al*., 2017).

2.7 Linear Economy verses Circular Economy

Linear economy (the usual way resources are used) works according to the principles of "**Take-Make- Dispose**". This means that resource is taken from the environment or the system and made into products, used and disposed as waste. The products are thus not made with the aim of reuse or recycling. This leads to exhaustion of finite resources and pollution of the environment. On the other hand, circular economy operates on the principle of 3Rs approach of **"Reduce-Reuse-Recycle"**. It is characterized by low consumption, low pollution levels, high efficiency, thus resources are put into effective use, at the same time saving the environment. This is in line with MacArthur (2015) who established the fact that, circular economy hinges on three principles, namely preserving and enhancing natural resources or capital, optimizing yields from resources in use and ensuring effectiveness of the system (i.e. minimizing negative externalities). In my view, a critical examination of these system shows that, circular economy has the potential to assist in the sustained management of our resources and the environment. Circular economy becomes even more relevant in agriculture, where almost all the by-products and waste can be recycled and used.

2.8 Ecological sanitation and circular economy

The holistic view of ecological sanitation is all about the strict protection of humans and the ecosystem health, at the same time preventing water pollution, conserving energy and capturing nutrients for alternative uses. It is also viewed as biological principle that; the earth is a closed system and uses natural processes (including composting and/or digesting human excreta) to change so called "waste" into life giving resource. This requires a multifaceted approach (i.e. technical, institutional, social and economic) management to close the loop as is the case in circular economy. Hence ecological sanitation has been advocated as a sustainable approach to promote close loop flow of resources and nutrients to agriculture and back into the system. In my view I see ecological sanitation as system directly embedded in circular economy, because it ensures capturing nutrients from so called waste for alternative use (in this case from human excreta to plant nutrients).

2.8.1 Concept of ecological sanitation

Ecological sanitation as a concept is seen as a set of systems and strategies designed to recover nutrients, energy and organic matter from human waste for safe crop production. (Anderson *et al* 2001, Esery, 2001). It is looked at in four main stages in dealing with human excreta, namely source separation, containment, sanitization and recycling. The aim is to protect human health and the environment; at the same time lowering the use of water in sanitation systems and recycling nutrients to assist in lowering the use of inorganic fertilizers in crop production (EcosanRes 2008). Fundamentally, the benefits therefore can be seen in (a) prevention of pollution instead of attempting to control it after its occurrence, (b) sanitizing faeces and making use of the resulting safe product in crop production (Winblad *et al*. 2004; Vodounhessi (2006) also emphasizes on some of the benefits of ecological sanitation as protecting the environment, saving money and water; effective barrier to pollution and other water borne diseases, recycling irrigation water and nutrients for crop production. It is against this background that Guzha *et al* (2005) recommends strongly the ecosan concept and the reuse of human excreta. They further recommend that governments should consider legislation and polices about human excreta, its management and declare it as resource and not waste.

From the above literature referenced so far, urine and human excreta should not be seen and regarded simply as waste product of the renal and alimentary canal, but instead a valuable resource which if properly handled and managed, can greatly contribute to improvement of sanitation in our societies and ultimately boost our food and fiber production. Other added benefits alluded to earlier are the improvement of soil structure and health. There are however a couple of methods used in treating human waste (toilet and urine) to obtain the desired products, namely organic fertilizer, methane gas and safe irrigation water.

2.8.2 Resource potential, nutrient composition and abundance of human faeces

Wherever human settlements are found, very good amounts of human excreta are sure to be produced. According to Schouw *et al* (2002), in Thailand, the amount of human waste obtained from 15 persons ranges between 730 to 1530g wet matter/cap/day with dry matter of 50-87g dry matter. This is not so different from excreta generated (total dry matter) for Denmark which is 59-81g/cap/day (Hansen and Tjell, 1979), showing that it is within the same range as in Thailand. This means that the amount of excreta produced (total dry matter) in various parts of the world is constant.

Research has shown that, human excreta (toilet and urine) contain good quantities of inorganic nutrient elements for plant growth. These include nitrogen, phosphorus, potassium and organic matter. It is also loaded with millions of pathogens which cause disease in humans and animals. It is however generally agreed that, the mass and composition of human excreta is mostly dependent on the eating and nutritional habits of the people. (Gotass, 1990). It important that we gain fair knowledge about the nutrient elements found in human excreta, and hence the potential value of this so-called waste.

In terms of generation rate of nutrients elements for 1 person per day is given in the table below: these values are not the means but extremes. The minimum values are typical of vegetarians, while the maximum figures are for meat eater who eats a lot.

Table 1. Average composition of human faeces and urine

	Faeces	**Urine**
Amount	150-300g/person/day	1-1.3L/person/day
Moisture Content	66-80%	93-96%
Dry Matter	40-81g/person/day	50-70g/person/day
Organic Compounds	88-97%	65-85%
N	5-7%	15-19%
P (as P2O5)	3-5.4%	2.5-5%
K (as K_2O)	1-2.5%	3.0-4.5%
C	40-55%	11-17%
Ca (as CaO)	4-5%	4.5-6%

Source: Daisy and Kamaraj, 2011

Based on the reference data present in the **Table 1** above, one can estimate the nutrient amounts in the faeces of the 30 million Ghanaians in a year which can be treated and recycled into crop production and agriculture, while at the same time greatly improving the worsen sanitation in the country.

A close study and analysis of the table presented above clearly shows that, human excreta contain large nutrient resources and could be very beneficial if handled in the right way. However, while the macronutrients are found mainly in the urine, the metals are mostly present in the faeces. To obtain a fertilizer having all the nutrient elements the plant needs, it is important to combine the faeces and urine in the treatment or digesting of this waste. In my estimation, the potential of using human excreta to produce organic fertilizer to supplement, if not replace inorganic fertilizers in the production of high valued crops needs to be evaluated.

2.9 Organic fertilizers prepared from human waste

2.9.1 Summary of compost preparation.

Human excreta pulled from public toilets and septic tanks plus abattoir waste are transported to the treatment site and fed into the anaerobic digester. During the digestion, methane gas which is generated as by product is used to power a gas generator to produce electric power. After three months of digestion, the mixture of sludge and water is pumped onto filtration beds for separation into treated sludge and irrigation water.

2.9.2 Sourcing and transportation of raw materials

Figure 1, shows the schematic diagram of sourcing and transportation of human waste from the personal septic tanks and communal septic tanks located 5 to 10 km from the treatment plant. This is usually done using a sewage pulling truck.

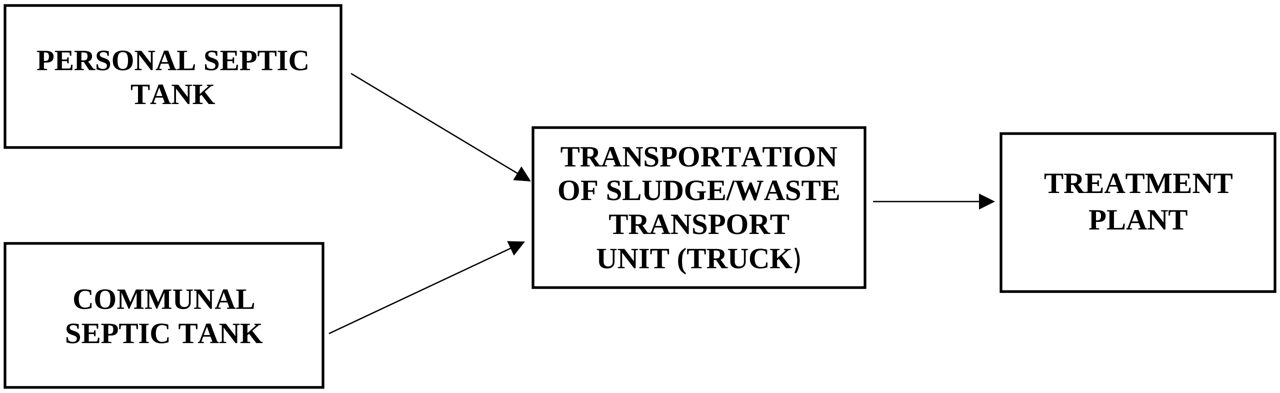


Figure 1. Schematic diagram of the collection and transportation of human waste to the treatment site.

2.9.3 Anaerobic digestion of human excreta and co-composting

Anaerobic digestion of organic waste (especially human excreta, abattoir waste and food waste) from municipalities takes place in bio digesters, specially designed for this purpose. Products obtained from this process includes methane gas, digestate (containing microbial biomass and half degraded organic matter) as well as inorganic nutrient elements or compounds (which can easily pass as soil conditioners) on farm lands (Alburqerque *et al* 2012). This process removes biochemical oxygen demand (BOD), conserves nutrients and most importantly reduces the pathogens which would otherwise be released in to the environment. However, in handling and treating human waste, it is imperative that, the system is designed in such way that, it eliminates direct handling by humans. This is because, the feed stock is known to contain millions of pathogens, and again after digestion, the effluent is also not sterile and still contains very good quantities of pathogens.

2.9.4 Pre heat treatment

Heat pretreatment, also called pasteurization is where the feed stock (human waste and other organic waste) is heated to 70^{o}c for some time before entering the digester. Waste steam, passive solar heating or combustion of biogas can be used for this process. This is one of the mechanisms to drastically reduce the pathogens associated with the raw materials for this process.

2.9.5 Treatment through retention

The feed stock is then emptied into the anaerobic digesting chamber (no oxygen) for between 60 to 90 days in warm climates for the anaerobic digestion to take place. During the digestion, methane gas generated is piped away and used appropriately. It is important to note that, during this anaerobic process, heat generated in the chamber further destroys pathogens still present.

2.9.6 Post treatment and sterilization

This stage of the process usually begins after 90 days retention in the bio digester. The contents of the digester are pumped into filter beds made of gravels and fine sand to separate the solids from the liquid. The filtrate (effluent) is channeled into ponds for further treatment while the residue is dried and co-composted.

2.9.7 Co-composting of dried residue.

The dried residue from the digestion is used as the main component for co-composting with other organic waste and biodegradable materials from the environment. After co-composting, the organic fertilizer obtained is air dried, sieved to obtain fine consistency and bagged in 30kg bags.

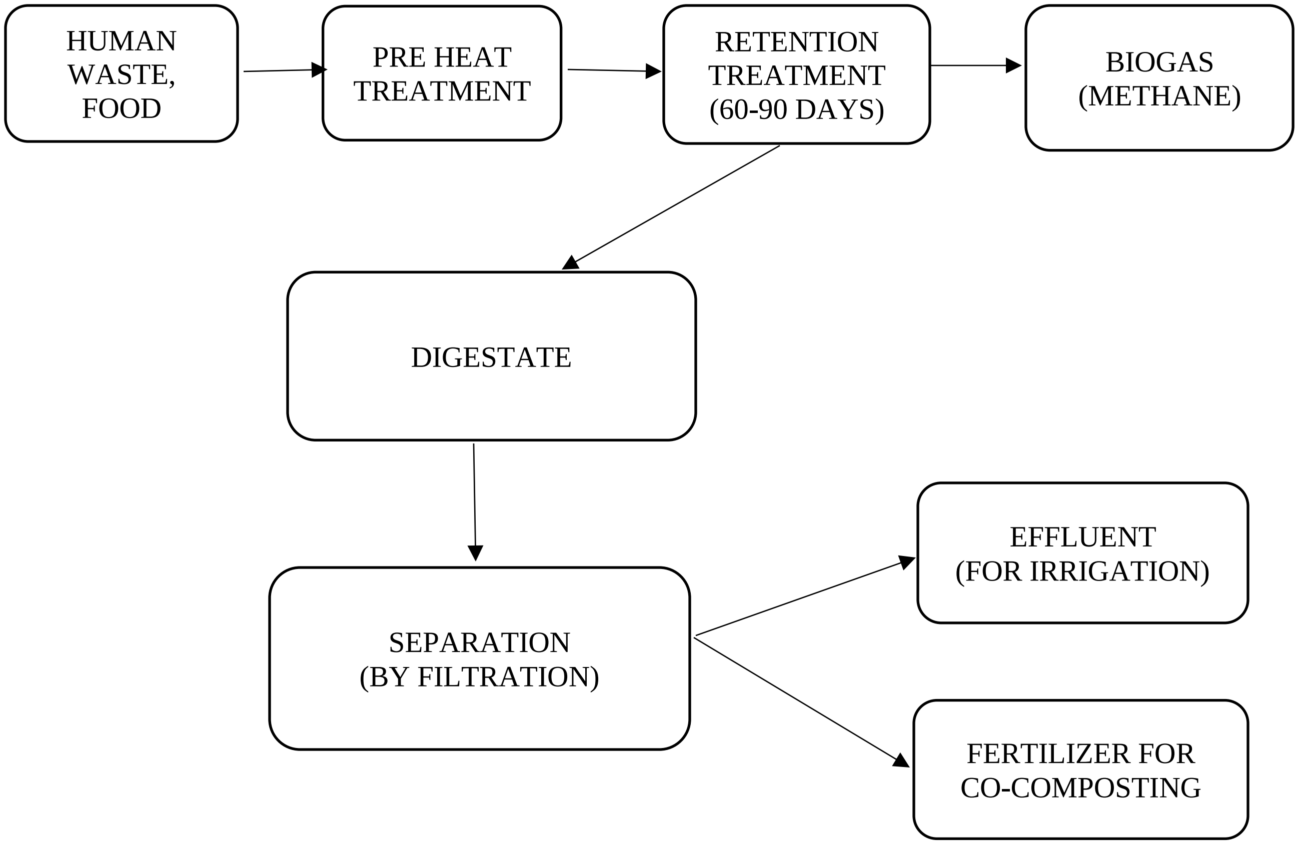


Figure 2. Processing of treatment of human waste and other organic materials to organic fertilizer.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 The experimental Site

The experiments were conducted at the University Farm, on Legon campus. The soil at the experimental site is **Adenta Series** (Brammer, 1967) and classified by FAO/UNESCO and the soil survey staff of USDA as **Ferric Acrisol** (FAO/UNESCO, 1990).

3.2 Rainfall data for the experimental area.

Table 2 shows the rainfall amounts in mm and number of days it rained in a month during the period of the study. The average monthly rainfall during the months of the study was 49.61mm and this was obtained in an average of three and half days per month. This was not adequate for the test crops and therefore water requirements were supplemented with irrigation.

Table 2. Rainfall data for the experimental area during the research period

YEAR	MONTH	RAINFALL (mm)	RAINFALL DAYS
2017	NOV	31.7	5
2017	DEC	63.7	4
2018	JAN	0	0
2018	FEB	20.2	3
2018	MAR	39	2
2018	APR	61.6	2
2018	MAY	131.1	9
MEAN		49.61	3.57
TOTAL		347.3	25

3.3 Land preparation and Soil sampling

The area for the experiments were cleared and ploughed with a tractor. A week later, the area was harrowed to obtain a well tilled land for crop growth. For the purpose of soil sampling, the experimental area was divided into nine sections. A sample each, was taken from the depth of 0-20cm with soil auger at each section. These soil samples were mixed thoroughly by zoning the sampling area into three, and composite samples were taken to the laboratory for analysis.

3.4 Soil and organic fertilizer analysis

Soil samples taken from the experimental site prior to the start of the experiments were sent to the Soil Science Laboratory and analyzed for pH, available Phosphorous (P), Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Nitrogen (N), Sulphur (S) and Organic Carbon (OC). The process and methods used are as described below. The soil samples and Asaase Gyefo organic fertilizer (AGOF) were air-dried, sieved to pass through a 2-mm mesh and chemically analysed. The soil pH was determined using glass electrode pH meter in a 1:2 soil – water ratio. Organic carbon content was determined by Walkley-Black dichromate oxidation method. Total Nitrogen was determined using the micro-kjeldahl method. Available P was extracted by the Bray-1 method and determined calorimetrically. Exchangeable Ca, K, Mg, and Na were extracted with 1.0N NH4OAc using a soil: solution volume ratio of 1:10. The K and Na in the extract were read using a flame photometer, while Ca and Mg were determined by Atomic Absorption Spectrophotometer (AAS).

3.5 Experimental design

The experiments were run twice for each test crop except for tomato, one in the dry or minor rainfall season, starting from November 2017 to mid-May 2018 and the major rainfall season starting from mid-March 2018 to July 2018. The experiments were laid out in a Randomized Complete Block Design (RCBD), made of ten treatments, replicated three times. There were in all thirty experimental plots.

3.6 Treatments

Ten treatments used in the experiments are listed below;

5.0 tons/ha AGOF,

7.5 tons/ha AGOF,

10.0 tons/ha AGOF,

12.5 tons/ha AGOF,

15.0 tons/ha AGOF,

17.5tons/ha AGOF,

20tons/ha AGOF,

10 tons/ha Poultry Manure,

NPK 300Kg/ha (15-15-15) + SA 150 Kg/ha

Control. **(No soil Amendment)**

The organic fertilizer Asaase Gyefo organic fertilizers (AGOF) were obtained from the Safi Sana feceal matter treatment plant located at Ashiaman in the Ashiaman Municipality. N P K (15-15-15) and Sulphate of Ammonia were purchased from Agrimat Company Limited, at Madina. The appropriate weights of the organic fertilizer according to the rates stated above were weighed and evenly spread on the experimental plots. These organic fertilizers were spread on the experimental plots two weeks prior to transplanting, with regular watering to facilitate decomposition and mineralization into the soil. This is in line with the normal practice of farmers spreading organic fertilizers like poultry manure on a piece of land two weeks to transplanting of vegetable seedlings (Personal communication).

Figure 3 Asase Gyefo Organic Fertilizer well packaged in bags, showing the nutrient contents.

3.7 Nursery Preparation and Practices

Seeds of Pectomech Tomato variety, Yolo wonder Sweet pepper variety and Legon 1 Garden Egg varieties, were purchased from AgriSeed Company in Accra and Department of Crop Science, Legon respectively. Seed beds of 1m*3m were prepared and leveled using hoes and rakes. The seed beds were properly leveled and seeded in drills. They were watered and covered with palm fronds and neem leaves to conserve moisture. After germination, the nurseries were managed properly by regular watering, removals of weeds and fertilization to generate healthy seedling for the experiments.

3.8 Transplanting

Four weeks after nursing, strong and healthy seedlings of the same sizes were carefully selected and transplanted onto the treated experimental plots. A starter solution of 10 g of NPK (15-15-15) in 10 L of water was prepared and applied to all the transplants. This ensured fast and uniform establishments of the seedlings.

3.9 Cultural practices

3.9.1 Weeding.

To prevent competition of weeds with our experimental plants during the experiments, regular hand weeding was done. It was ensured that weeds were removed timely and properly, especially during the early stages of the experiments.

3.9.2 Irrigation.

Regular watering was done to ensure that, there was always moisture in the soil to enhance proper plant growth and development, except on occasions when there was good rainfall.

3.9.3 Fertilizer application to inorganic fertilizer treatments

Inorganic fertilizer standard check, the treatment was applied at the rate of 300kg/ha of N-P-K, (15-15-15) and 150kg/ha of Sulphate of Ammonia. Split application method was used as follows; two weeks after transplanting, 150 Kg/ha of N-P-K (15-15-15), four weeks after transplanting, another 150 Kg/ha of N-P-K (15-15-15) was applied again. Finally, 150 Kg/ha of Sulphate of Ammonia was applied six weeks after transplanting. This ensured that, plants were supplied with the nutrients as and when they were needed.

3.9.4 Plant protection

Incidences of insect pest infestations were kept under check by spraying with broad spectrum insecticides including **Attack** (Emamectin Benzoate 5% at rate of application of 30g/15L of water)**, Cyidem Super** (36g Cypermethrin and 400g Dimethoate per litre at rate of 35mL/15L of water). These were repeated when necessary. During the dry season productions, the incidence of fungal diseases was virtually absent, hence no fungicides were used however, there were heavy mite infestation on the crops, and these were kept under control by using miticides like, **Orizon (active ingredient).** During the wet or rainy season, incidence of fungal diseases was kept under control with fungicides like **Goldazim** (Carbendazim 500g/Kg WP at rate of 50g/15 L of water) and **Mancozan Super** (Mancozeb 640g/Kg and Metalaxyl 80g/Kg; WP, at rate of 95g/15l water).

3.10 Plant sampling and measurements.

The following data were taken on six record plants every two weeks to determine the rate of growth of the test crops used in the experiment; Number of days to 50% flowering, plant height in (cm), plant girth in (mm), number of leaves, and chlorophyll content (spads). At maturity, the yield data taken were number of fruits per plant, total weight of fruits per plant, fruit diameter, and fruit length, yield per ha and shelf life of fruits.

3.11 Data handling and analysis

Data taken were arranged in Excel and subjected to analysis of variance using 12^{th} edition of ***GenStat*** Statistical Package. Where significant differences were observed, the means were separated using Least Significant Difference (LSD). The results are presented in tables and graphs where appropriate. Appropriate pictures are also shown were necessary.

CHAPTER FOUR

4.0 RESULTS

4.1 Initial soil testing of the experimental site and organic fertilizers.

The data on initial chemical properties of the soil at the experimental sites revealed that, the soils were slightly to moderately acidic with mean pH of 4.89 (Table 3) and low in organic carbon. Other soil nutrients were also low and inadequate for increased crop yields. However, the available P content of the soil was quite high 18.69 mg/kg (**Table 3**). Hence this site becomes a good site for trials involving the evolution of organic fertilizers.

Table 3. Initial soil analysis of experimental site.

					mg/kg	**cmol+/kg**	**cmol+/kg**	**cmol+/kg**	**cmol+/kg**
Parameter	**pH**	**%N**	**%OC**	**%S**	**Av P**	**Ca**	**Mg**	**K**	**Na**
Sample 1	5.65	0.049	0.918	0.009	24.5	3.38	0.19	1.06	3.65
Sample2	4.92	0.053	0.98	0.008	18.68	2.92	0.86	0.99	3.46
Sample 3	4.10	0.03	0.75	0.016	12.9	2.73	0.58	0.74	3.51
Mean	**4.89**	**0.04**	**0.89**	**0.01**	**18.69**	**3.01**	**0.78**	**0.93**	**3.54**

4.2 Nutrient content of organic fertilizer used

Samples of the organic fertilizers were also analyzed and the results are as presented in **Table 4.** The organic fertilizer had an average pH of 7.62 which indicates that it is slightly alkaline, and of high quality, coupled with the significantly high nutrients, especially nitrogen and organic carbon which are some of the good characteristics of organic fertilizers, i.e. 0.683% and 10.47% respectively.

Table 4. Nutrient levels of AGOF used in the study

					mg/kg	cmol+/kg	cmol+/kg	cmol+/kg	cmol+/kg
Parameter	**pH**	**%N**	**%OC**	**%S**	**Av P**	**Ca**	**Mg**	**K**	**Na**
Sample 1	7.64	0.682	10.469	0.10	28.04	16.05	6.40	4.29	1.49
Sample 2	7.63	0.648	10.468	0.09	28.08	16.06	6.34	4.30	1.47
Sample 3	7.60	0.683	10.462	0.08	28.07	16.02	6.36	4.26	1.42
Mean	**7.62**	**0.682**	**10.471**	**0.09**	**28.06**	**16.04**	**6.37**	**4.28**	**1.45**

4.3 Nutrient concentrations in soil five weeks after application of treatments

Five weeks after application of the treatments onto the experimental plots, soil samples were taken and analyzed in the laboratory to ascertain the extent of mineralization of the organic fertilizer in the soil (**Table 5**). The pH of all the experimental plots treated with organic fertilizers like AGOF and poultry manure had a slight increase from average of 4.89 to 5.47 for AGOF and 5.68 for Poultry manure. The other nutrients elements were also increased significantly, indicating very good rate of mineralization of the organic fertilizer (**Table 5**).

Table 5 Extent of mineralization of the organic fertilizer in the soil after five weeks of application.

Parameters	PH	%N	%OC	%S	mg/kg Av P	cmol+/kg Ca	cmol+/kg Mg	cmol+/kg K	cmol+/kg Na
5.0 ton/ha AGOF	5.33	0.231	1.715	0.009	30.66	6.57	2.54	1.79	3.50
7.5 tons/ha AGOF	5.34	0.230	2.636	0.001	31.12	6.92	2.52	1.66	3.46
10.0ton/ha AGOF	5.35	0.238	2.804	0.002	39.10	6.80	2.60	1.72	3.43
12.5tons/ha AGOF	5.20	0.217	2.497	0.006	35.36	6.83	2.47	1.66	3.41
15.0ton/ha AGOF	5.19	0.227	2.633	0.003	46.52	6.82	2.80	1.63	3.37
17.5tons/ha AGOF	5.54	0.343	2.720	0.002	43.20	6.25	2.95	1.80	3.57
20.0ton/ha AGOF	5.47	0.332	3.703	0.002	58.06	7.56	2.98	1.95	3.48
Poultry Manure 10 ton/ha	5.68	0.236	2.836	0.003	56.44	4.44	2.59	1.77	3.47
NPK(15-15-15) + SA	3.83	0.0219	0.599	0.004	16.14	7.75	3.43	2..52	3.35
Control	4.22	0.0250	0.620	0.006	28.98	2.69	0.45	0.63	3.42

4.4 Results of Experiment 1 (Garden egg)

4.4.1 Number of days to 50% flowering of garden egg, experiment 1

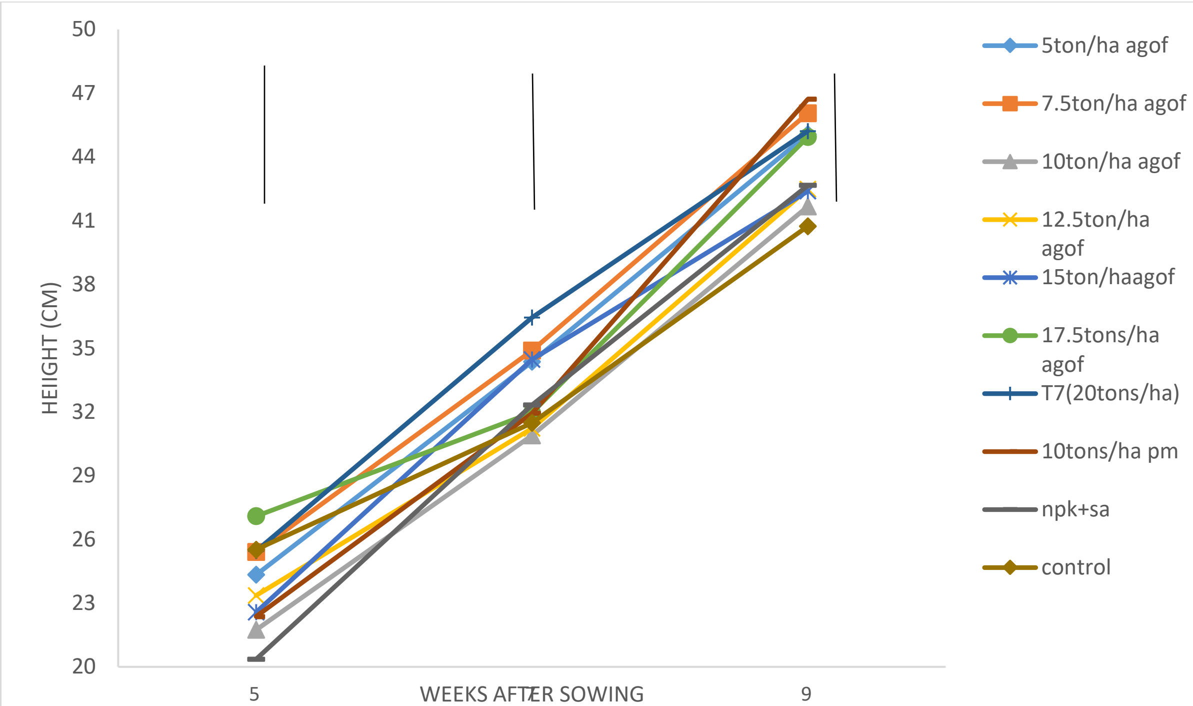
The effects of treatments on the number of days to 50% flowering of garden eggs are as recorded in **Table 6**. Significant differences were observed among the treatments. Inorganic fertilizer (NPK+ SA) flowered 51days after sowing, which was significantly earlier than control (no soil amendment) which flowered late at 57 days. AGOF applied at 15 tons/ha and 20 tons/ha also flowered late at 56 days after sowing, a day earlier than the control of 57 days (**Table 6**).

Table 6. Effects of treatments on number of days to 50% flowering of Garden eggs, Experiment 1

Treatments	**Mean days to flowering**
5.0 tons/ha of AGOF	54 ± 0.33
7.5 tons/ha of AGOF	55 ± 0.33
10.0 tons/ha of AGOF	55 ± 0.58
12.5 tons/ha of AGOF	53 ± 0.33
15.0 tons/ha of AGOF	53 ± 0.67
17.5 tons/ha of AGOF	56 ± 0.33
20.0 tons/ha of AGOF	56 ± 1.20
10 tons/ha Poultry Manure	52 ± 0.33
NPK (15-15-15) and SA	51 ± 1.00
Control (No soil Amendment)	57 ± 0.33
LSD (0.05)	**1.876**

4.4.2 Plant Height (cm) of Garden egg, experiment 1

The effect of the treatments (various rates of application) on plant height measured in centimeters are shown in figure 4. Generally, the treatments affected the heights positively, increasing from fifth week to ninth week. Inorganic fertilizer NPK (15-15-15+SA) had the shortest plant height of 20.46 cm while 17.5 tons/ha of AGOF, had the tallest height of 27.1cm at 5 WAS. At the ninth week, Poultry Manure at 10 tons/ha recorded the tallest height of 46.7cm while a height of 40.7cm was recorded for the Control treatment (No Soil Amendments). No significant differences were observed among the treatments.

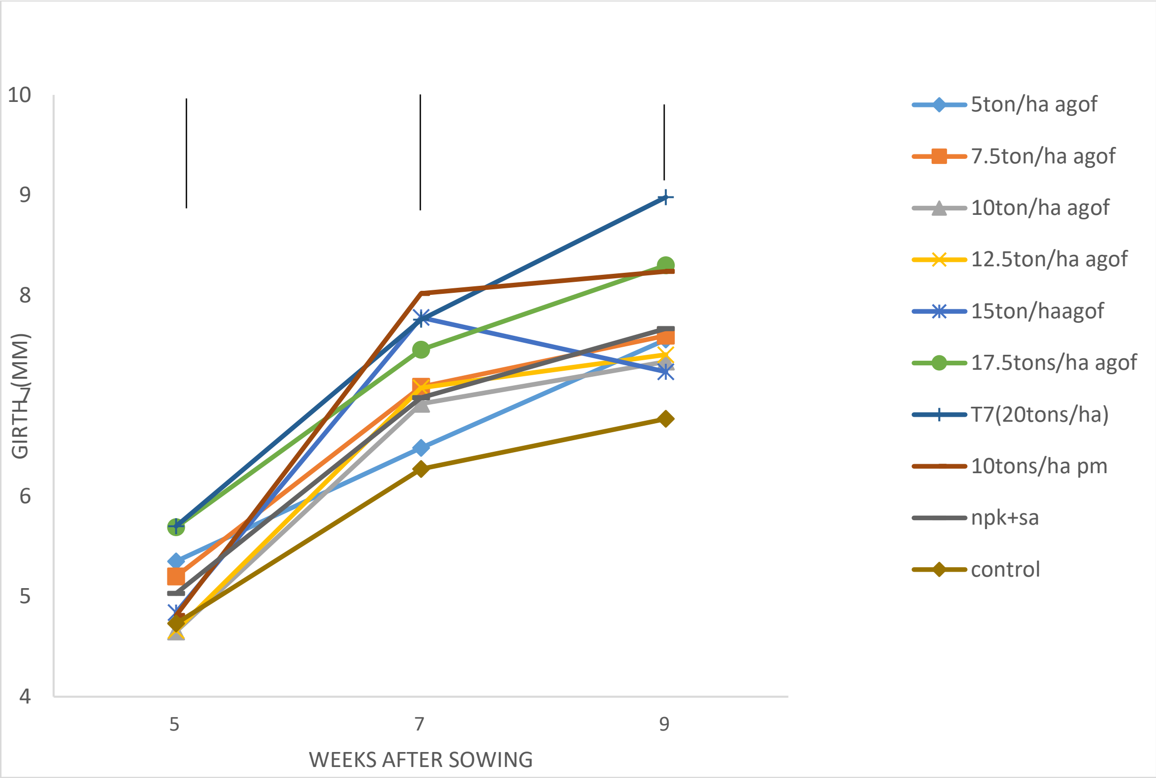


NB: Bars represent LSDs

Figure 4 Treatment effects on plant height during the vegetative growth phase of garden egg, Experiment 1

4.4.3 Plant Girth (mm) of Garden egg, experiment 1

As shown in Figure 5 the treatments did not have significant effect on the stem girth of the plants measured in millimeters on the fifth week. However significant differences were observed in seventh and ninth weeks. 10 tons/ha Poultry Manure had the biggest stem girth at the seventh week while the control and 5tons/ha AGOF had significantly smaller girth.

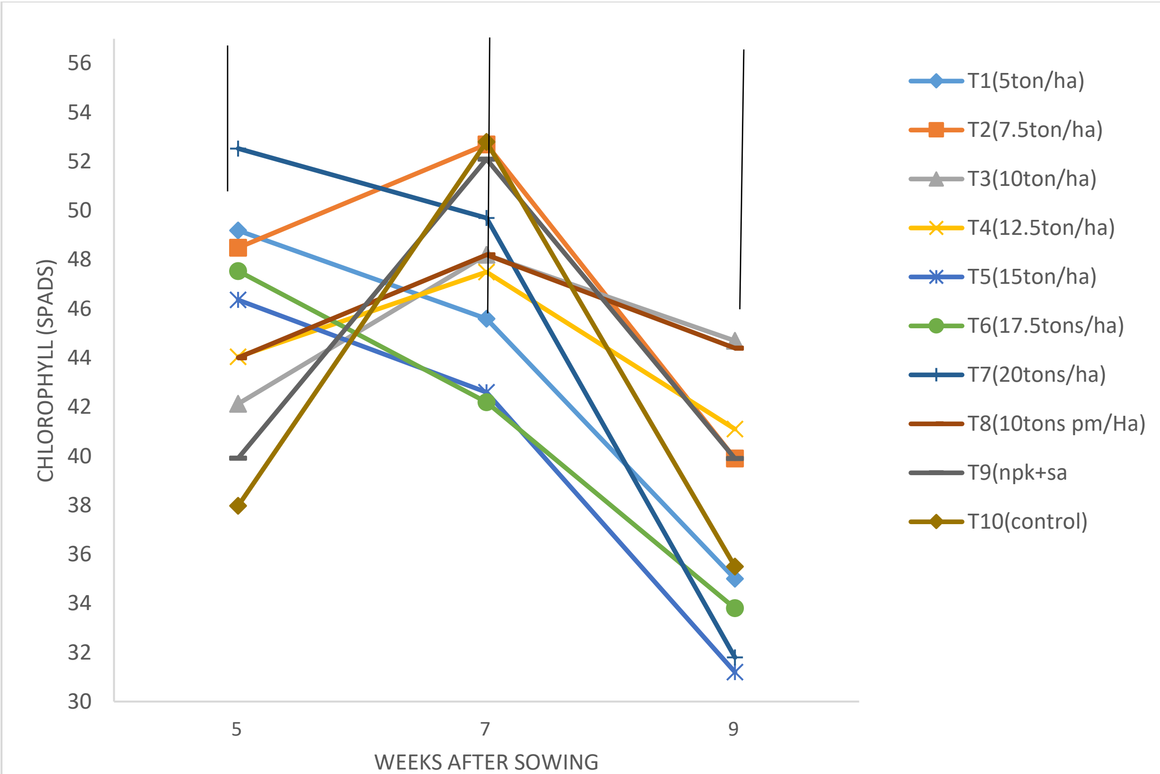


NB: **Bars represent LSDs**

Figure 5 Treatment effects on number of leaves during the vegetative growth phase of garden egg.

4.4.4 Chlorophyll content of leaves, experiment 1

Chlorophyll content of the test crop as affected by the treatments during the vegetative growth phase are as presented in Figure 6. Significant differences were observed at the fifth week, however, no significant differences were observed during the seventh and ninth weeks. The chlorophyll contents generally decreased sharply at the ninth week for all the treatments even though no significant difference were detected.

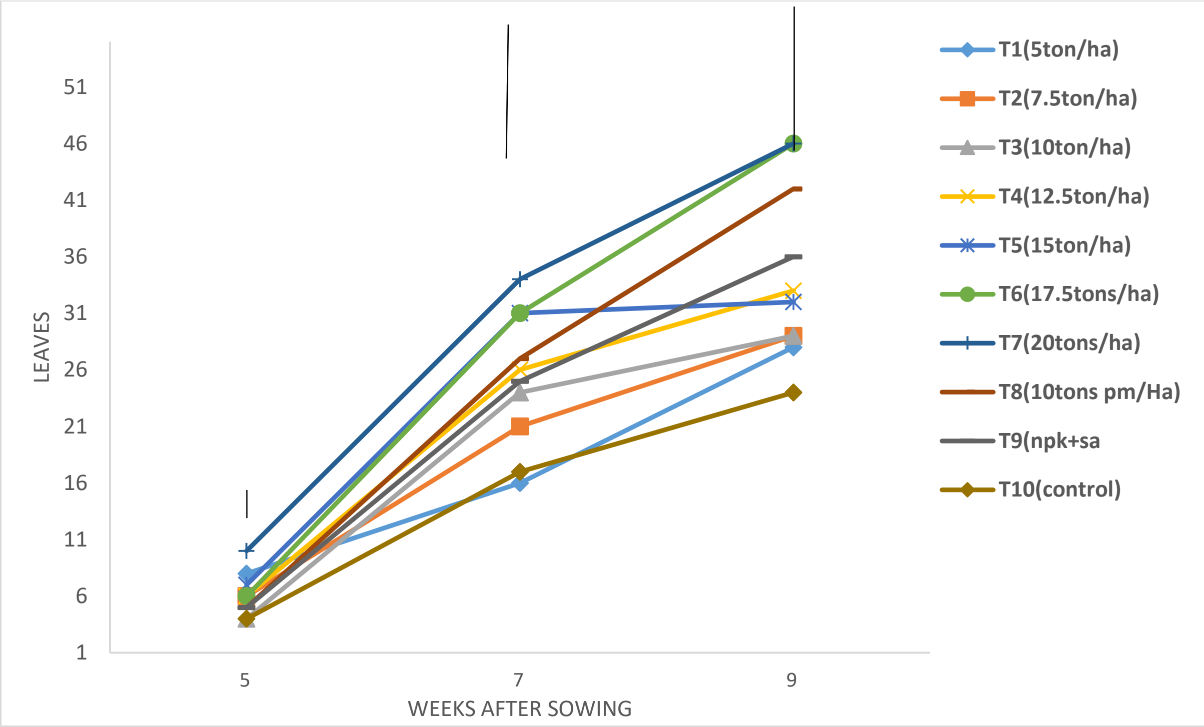


NB: Bars represent LSDs

Figure 6. Treatment effect on chlorophyll content during the vegetative growth phase of garden egg

4.4.5 Number of leaves, experiment 1

Shown in Figure 7 is the graphical presentation of number of leaves during the vegetative phase of the test crop. Generally, number of leaves increased during the vegetative stages of the test crop. Significant differences were observed at the seventh and ninth weeks, with 20tons/ha AGOF and 17tons/ha AGOF recording the highest number of leaves.



NB: Bars represent LSDs

Figure 7 Treatment effect on Number of leaves during the vegetative growth phase of garden egg.

4.4.6 Fruit characteristics and yield of garden egg

Table 7 shows the results of fruit diameter in (mm), fruit length in (mm), number of fruits per plant and the yield per hectare as affected by the treatments applied. While the treatments did not have any significant effect on the fruit diameter, there were however significant differences observed in the fruit length, number of fruits and ultimately the yield in kilogrammes per hectare.

Table 7 Treatment effect on selected characteristics and yield of garden egg, experiment 1

Treatment	Fruit diameter(mm)	Fruit length (mm)	Number of fruits/plant	Yield in kg/ha
5ton/ha AGOF	29.25 ± 0.998	35.87 ± 2.332	37 ± 3.913	2479 ± 268.3
7.5ton/ha AGOF	30.47 ± 0.933	37.04 ± 2.050	36 ± 2.609	2481 ± 183.4
10ton/ha AGOF	28.2 ±2.560	37.42 ± 2.120	39 ± 1.517	2664 ± 104.4
12.5ton/ha AGOF	31.44 ±2.115	40.95 ± 1.327	37 ± 1.122	2411 ± 72.62
15ton/ha AGOF	29.65 ± 1.568	40.47 ± 1.898	37 ± 2.315	2373 ± 147.4
17.5tons/ha AGOF	28.59 ±2.089	38.02 ± 1.915	37 ± 1.567	2416 ± 102.0
20tons/ha AGOF	31.51 ±1.047	40.56 ± 1.332	40 ± 1.311	2449 ± 81.10
10tons pm/ha	25.99 ±1.409	33.41 ± 3.266	43 ± 0.547	2990 ± 36.98
NPK+SA	30.67 ±0.855	38.14±0.681	48 ± 0.859	3971 ± 65.04
Control (No amendment)	28.67 ±1.630	35.91±1.119	34 ± 1.090	1981 ± 64.38
LSD (p<0.05)	**NS**	**5.52**	**5.52**	**371.8**

4.4.7 Shelf life of garden eggs, experiment 1.

The shelf life of garden eggs as affected by the treatment used in the study is as shown in Table 8. The shelf life of fruits harvested from AGOF treated plots lasted between 13 days and 14 days being significantly longer than inorganic fertilizer treated plots i.e., 12 days.

Table 8. Treatment effect on the shelf life of garden eggs, Experiment 1

Treatment	**Shelf life**
5ton/ha AGOF	13.33
7.5ton/ha AGOF	13.67
10ton/ha AGOF	14.00
12.5ton/ha AGOF	13.33
15ton/ha AGOF	13.67
17.5tons/ha AGOF	14.00
20tons/ha AGOF	13.67
10tons pm/ha	13.67
NPK+SA	12.33
Control(No amendment)	13.76
LSD (p<0.05)	**0.855**

4.5 Results of Experiment 2 (Garden eggs)

4.5.1 Number of days to 50% flowering of garden eggs, experiment 2

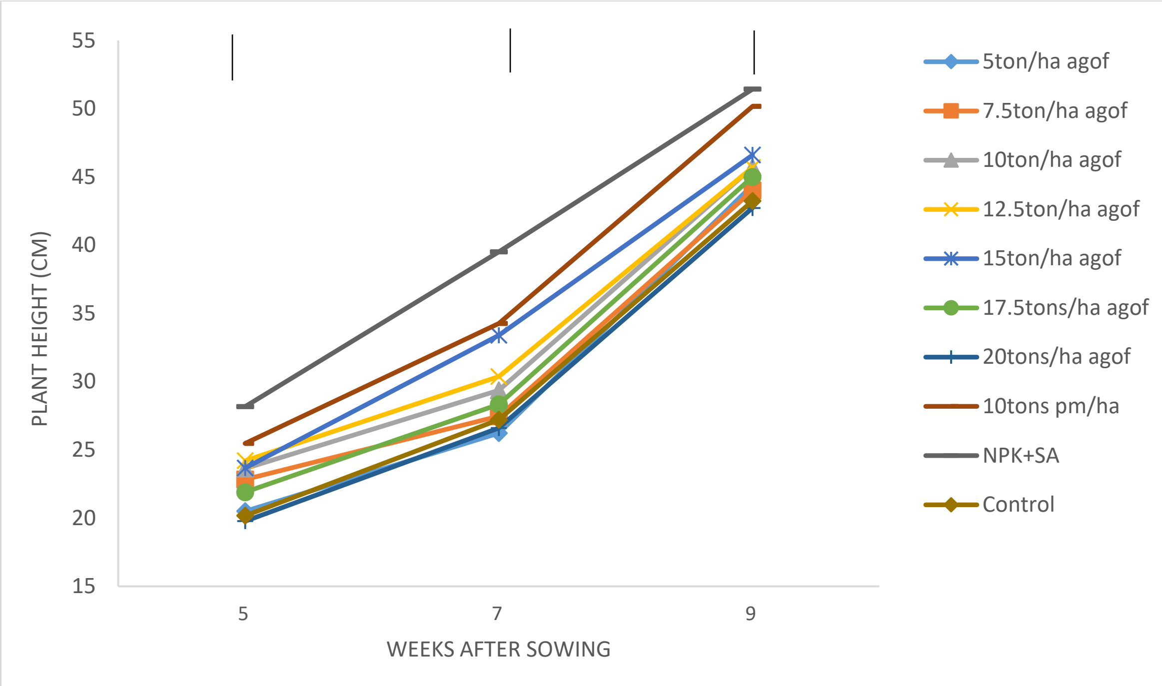
Table 9 shows results of the effects of various treatments on number of days to 50% flowering of garden eggs. Inorganic fertilizer treatment of NPK+SA flowered significantly earlier at 49 days than all the organic fertilizer treatments which flowered between 53 to 56 days after sowing.

Table 9 Effects of treatments on number of days to 50% flowering on garden egg, experiment 2

Treatment	Days to 50% flowering
5ton/ha AGOF	52.67±0.333
7.5ton/ha AGOF	53.33±0.577
10ton/ha AGOF	53.00±0.577
12.5ton/ha AGOF	53.00±0.577
15ton/ha AGOF	52.67±0.333
17.5tons/ha AGOF	55.33±0.333
20tons/ha AGOF	56.00±0.577
10tons pm/ha	50.33±0.333
NPK+SA	49.33±0.333
Control(No amendment)	55.33±0.333
LSD ($p<0.05$)	**1.308**

4.5.2 Plant height of Garden eggs, experiment 2

Plant heights of the test crop, garden eggs as affected by the various treatments during the growth phase of the crop is as presented in figure 8. Inorganic fertilizer treatments recorded the highest plant heights during the growth phase, followed closely by the Poultry Manure. These were significantly taller than all AGOF rates used in the study.

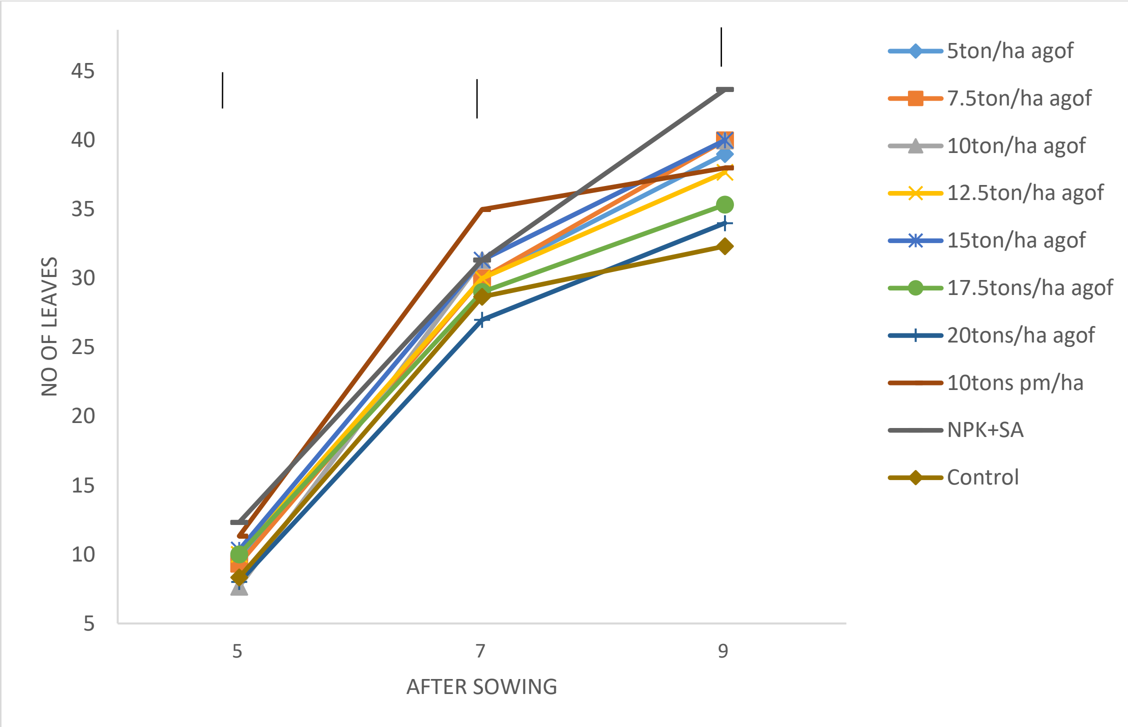


NB: Bars represent LSDs

Figure 8 Effects of various treatments on the plant height during growth phase

4.5.3 Number of leaves garden egg, experiment 2

Number of leaves generally increased during the growth phase of the test crop, garden eggs, with inorganic fertilizer treatment recording significantly higher number of leaves compared with AGOF applied at 20tons per ha and control, as seen in figure 9.

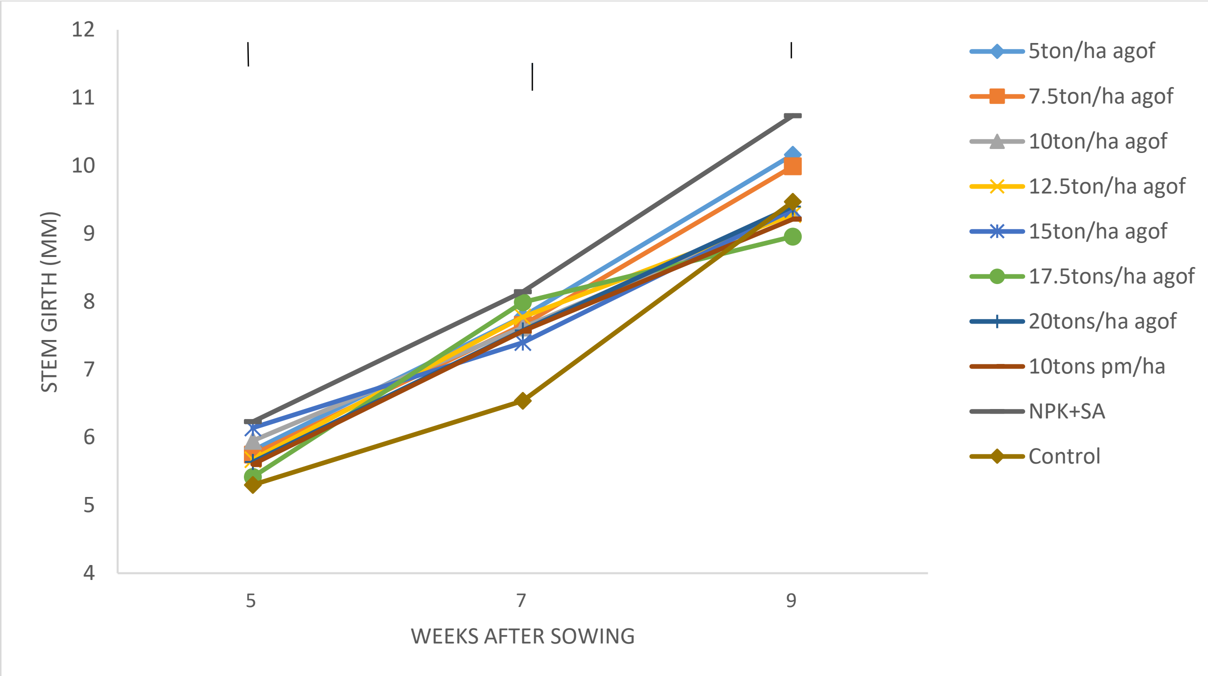


NB: Bars represent LSDs

Figure 9 Treatment effect on number of leaves, of garden egg, experiment 2

4.5.4 Stem Girth of Garden egg, experiment 2

The stem girth of garden eggs as affected by the treatments used in the experiment are as presented in Figure 10 below. Significant differences were observed in the stem girth throughout the growth phase of the test crop. Inorganic fertilizer treatment and 5ton/ha of AGOF recorded significantly bigger stems than the control.

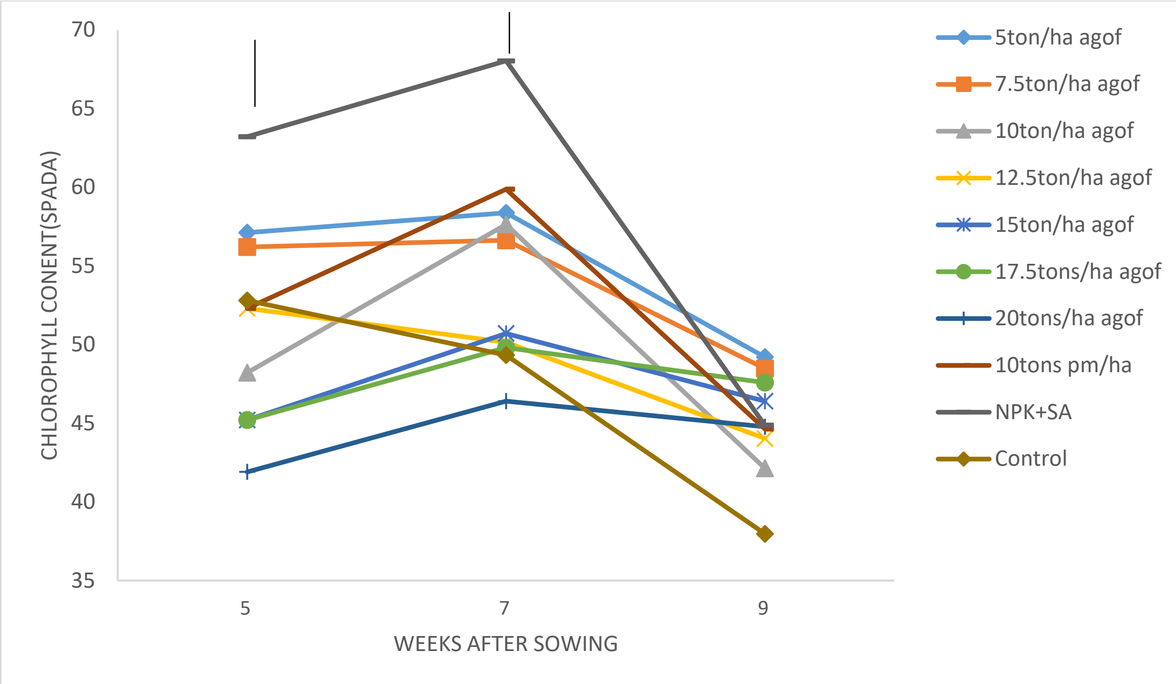


NB: Bars represent LSDs

Figure 10 Treatment effect on stem girth of garden egg during growth phase, experiment 2

4.5.5 Chlorophyll content of leaves garden eggs, experiment 2.

Significant differences were observed in the mean chlorophyll contents of the test crop during the 5^{th} and 7^{th} weeks after sowing as shown in figure 11 below. Inorganic fertilizer treatment recorded significantly higher mean chlorophyll content of 63.2 spads, and this was followed by 57.1 spads of AGOF applied at 5 tons/ha. However, the lowest mean chlorophyll content during the 5^{th} and 7^{th} weeks were recorded in AGOF applied at 20tons/ha.



NB: Bars represent LSDs

Figure 11 Effect of treatments on chlorophyll content during the vegetative growth phase, experiment 2

4.5.6 Fruit characteristics and yield of Garden egg, experiment 2

Table 10 shows the results of fruit diameter in (mm), fruit length in (mm), number of fruits per plant and yield per hectare as affected by the treatments applied. Significant differences were observed in all these parameters. However, the highest mean yields of 3676 kg/ha were recorded in Poultry Manure treatment applied at the rate of 10tons/ha and this was significantly different from the highest yield obtained in the best performing AGOF, i.e. 3146 kg/ha at rate of 17tons/ha.

Table 10 Treatment effect on selected characteristics and Yield of garden egg, experiment 2

Treatment	Fruit diameter(mm)	Fruit Length(mm)	Number of Fruits/plant	Yield in kg/ha
5ton/ha agof	41.66±1.12	39.69±1.30	54.33±2.67	2639±27.97
7.5ton/ha agof	42.47±0.86	46.37±2.23	52.33±0.88	2793±20.94
10ton/ha agof	43.69±1.71	42.11±0.56	56.33±1.67	2826±11.60
12.5ton/ha agof	43.42±0.77	37.83±0.72	54.33±2.03	2836±54.45
15ton/ha agof	43.32±0.93	43.56±0.59	55.00±1.53	2881±13.04
17.5tons/ha agof	35.81±0.85	44.61±1.86	66.00±4.00	3146±73.78
20tons/ha agof	37.44±1.64	40.94±2.38	55.67±2.67	2354±20.63
10tons pm/ha	43.33±2.20	45.88±0.81	67.33±0.67	3679±42.29
NPK+SA	42.5±0.25	45.12±1.46	65.00±1.53	3539±42.69
Control	39.86±1.76	39.06±1.84	66.67±2.33	3100±30.61
LSD(P≤0.05)	**4.103**	**4.715**	**3.76**	**116.3**

4.5.7 Shelf life of garden egg, experiment 2

The shelf life of garden egg as affected by the various treatments are as resented in Figure 11 below. There were no significant differences in the number of days it took the harvested produce to lose its market value and spoilage.

Table 11 Treatment effect on the shelf life of garden eggs, Experiment 2

Treatment	Shelf life
5ton/ha agof	13.3±0.33
7.5ton/ha agof	13.67±0.33
10ton/ha agof	13.33±0.33
12.5ton/ha agof	13.67±0.33
15ton/ha agof	12.67±0.33
17.5tons/ha agof	13.33±0.33
20tons/ha agof	12.67±0.33
10tons pm/ha	13.67±0.33
NPK+SA	12.33±0.88
Control	13.33±0.33
LSD(P≤0.05)	**1.231**

4.6 Results of Experiment 1 (Green pepper)

4.6.1 Number of days to 50% flowering, experiment 1

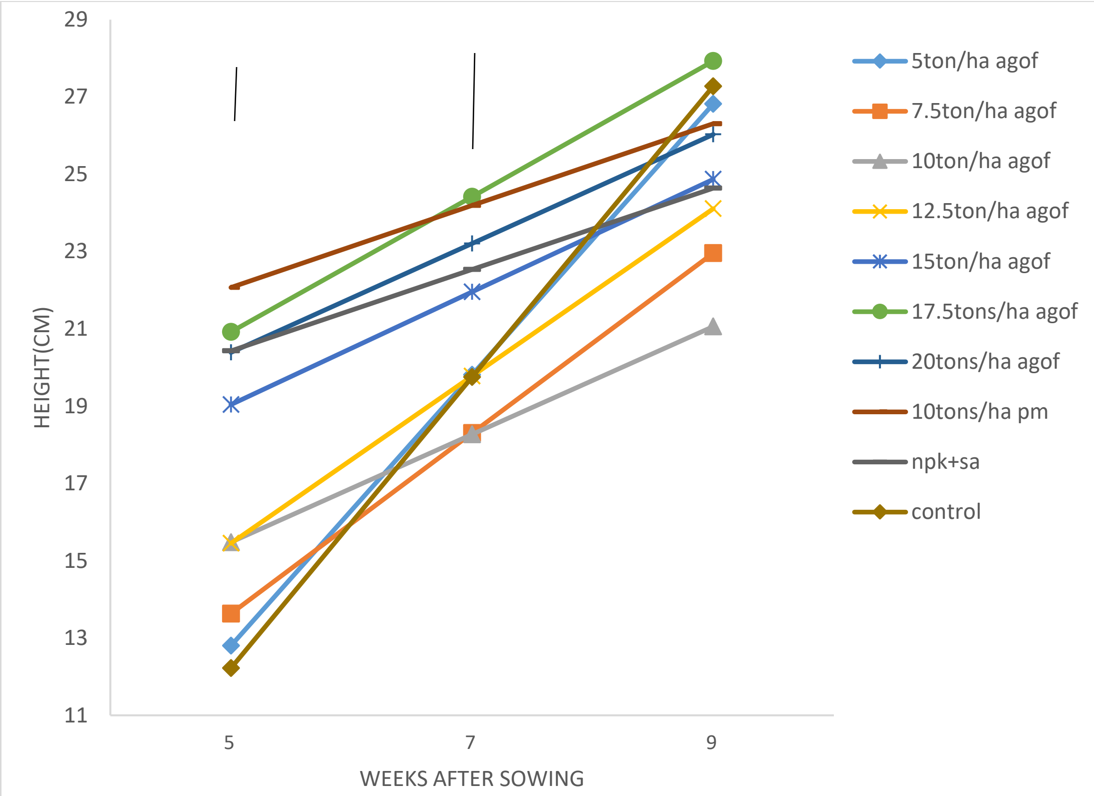
The effect of treatments on the number of days to flowering of green pepper is as shown in Table 12. Significant differences were observed among the treatments. Inorganic fertilizer (NPK+ SA) flowered 51days after sowing, which was significantly earlier than the control (no soil amendment) which flowered late at 56 days. 17.5 tons/ha of AGOF and 20tons/ha of AGOF also flowered late at 56 and 57 days after sowing respectively.

Table 12. Treatment effect on days to 50% flowering on green pepper

Treatment	**Mean days to flowering**
5ton/ha AGOF	53.33
7.5ton/ha AGOF	53.33
10ton/ha AGOF	52.67
12.5ton/ha AGOF	52.00
15ton/ha AGOF	54.00
17.5tons/ha AGOF	55.67
20tons/ha AGOF	56.67
10tons pm/ha	52.67
NPK+SA	51.00
Control	55.67
LSD (0.05)	**0.97**

4.6.2 Plant Height of Green pepper, Experiment 1

The effects of the treatments used in the study on plant heights measured in centimeter are as shown in Figure 12. Significant differences were recorded in the 5th and 7th weeks. Poultry Manure applied at 10 ton/ha gave significantly taller plants than AGOF at 12.5 tons/ha and control at the 7th week.



NB: Bars represent LSDs

Figure 12. Effects of treatments on plant height in green pepper Experiment 1

4.6.3 Plant Girth of Green pepper, experiment 1

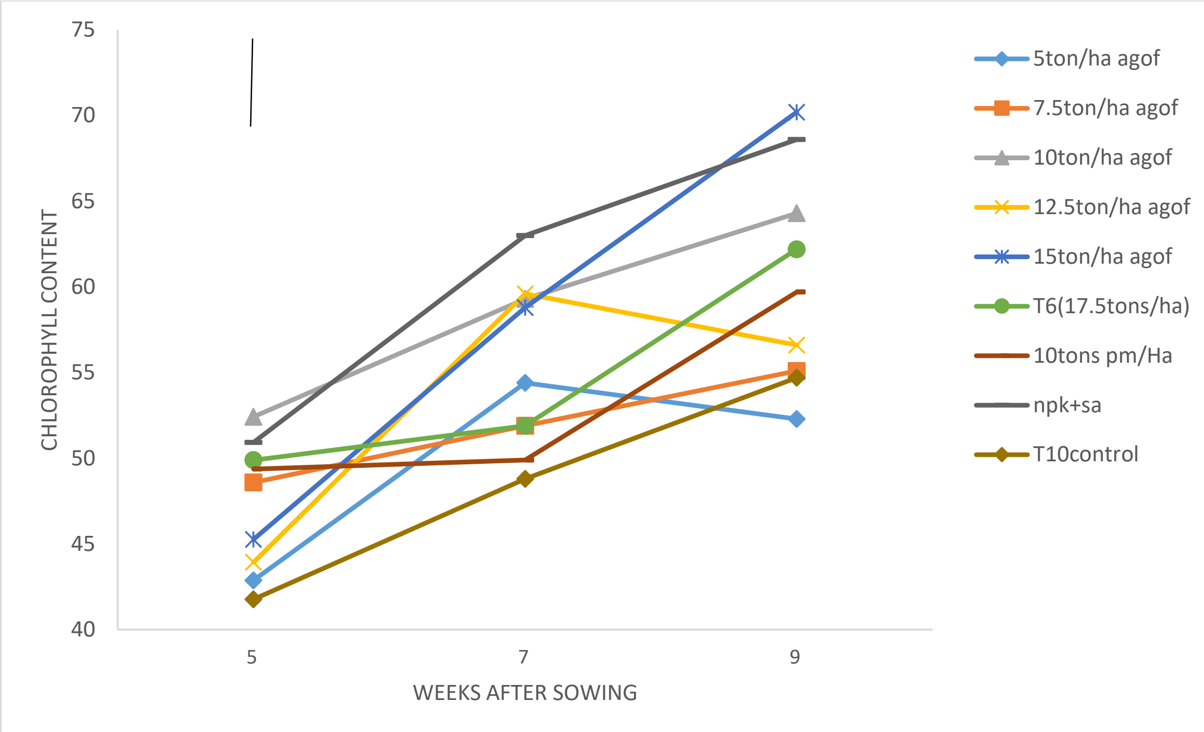
Plant girth measured in millimeters during the vegetative growth phase of the test crop, green pepper is as shown in Table 13. There were no significant differences in the plant girth recorded during the growth phase.

Table 13. Plant stem girth of green pepper as affected by treatments used in experiment 1

Treatment	**5 weeks**	**7 weeks**	**9 weeks**
T1(5ton/ha)	3.2 ± 0.05	4.91 ± 0.20	6.62 ± 0.41
T2(7.5ton/ha)	3.2 ± 0.06	4.49 ± 0.15	5.77 ± 0.25
T3(10ton/ha)	3.39 ± 0.12	4.55 ± 0.18	5.71 ± 0.30
T4(12.5ton/ha)	3.54 ± 0.17	4.81 ± 0.11	6.07 ± 0.18
T5(15ton/ha)	3.27 ± 0.42	4.57 ± 0.27	5.86 ± 0.46
T6(17.5tons/ha)	3.6 ± 0.17	5.16 ± 0.12	6.72 ± 0.37
T7(20tons/ha)	3.34 ± 0.08	5.3 ± 0.36	7.26 ± 0.80
T8(10tons pm/Ha)	3.76 ± 0.15	7.2 ± 1.63	10.64 ± 3.24
T9(npk+sa)	4.03 ± 0.12	4.99 ± 0.29	5.96 ± 0.70
T10(control)	3.28 ± 0.10	4.77 ± 0.12	6.26 ± 0.16
LSD ($P \leq 0.05$)	NS	NS	NS

4.6.4 Chlorophyll content of leaves, experiment 1.

AGOF applied at 10 tons/ha and inorganic fertilizer (NPK and SA) recorded chlorophyll contents of 52.4 and 50.93 spads respectively at the 5th week after sowing, being significantly higher than AGOF at 5 tons/ha and control treatments as seen in Figure 13 below. However, no significant differences were recorded in the 7th and 9th weeks.

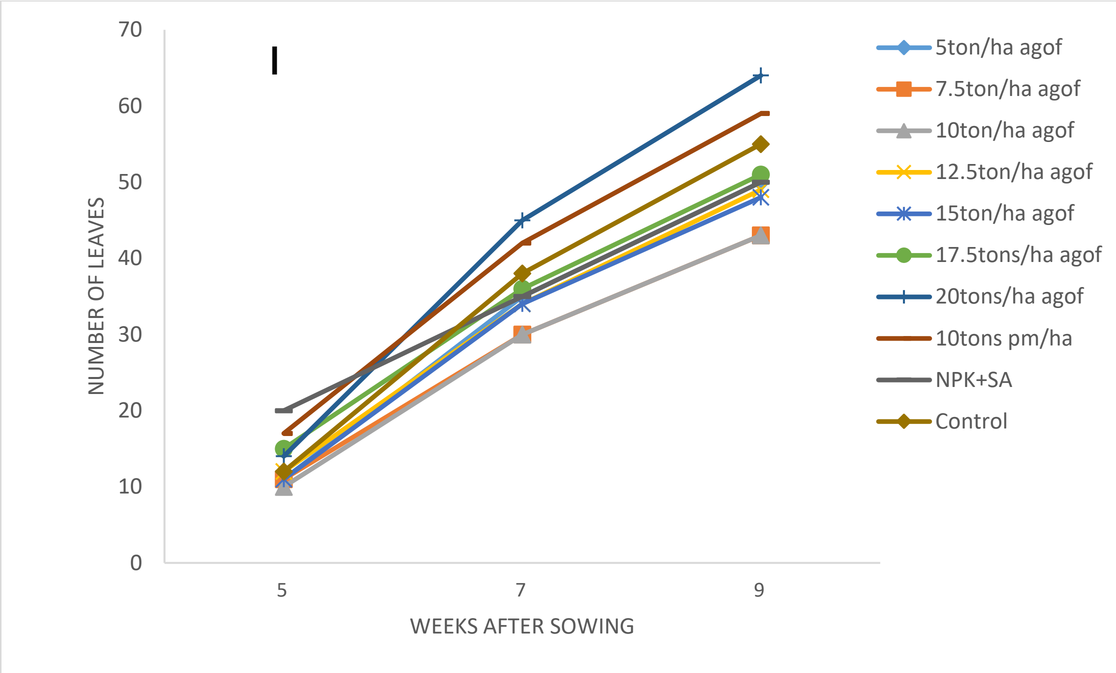


NB: Bars represent LSDs

Figure 13 Effect of treatments on chlorophyll content during the vegetative growth phase

4.6.5 Number of leaves of Green pepper, experiment 1

Number of leaves as influenced by the treatments used in the study is as shown in the Figure 14. Significantly higher number of leaves i.e., 20 were recorded in inorganic fertilizer treatment as against 11 leaves in 15 tons/ha AGOF in the 5th week. There were no significant differences seen in the 7th and 9th weeks during the growth phase



NB: Bars represent LSDs

Figure 14 Treatment effect on number of leaves during the growth phase of green pepper

4.6.6 Fruit characteristics and yield of Green pepper

Table 14 shows the results of fruit diameter in (mm), fruit length in (mm), number of fruits per plant and the yield per hectare as affected by the treatments applied. Treatments used in the study did not have any significant effect on the fruit diameter, fruit length, number of fruits and the yield in kilogrammes per hectare. The highest mean yield was recorded in AGOF applied at the rate of 17.5 tons/ha AGOF.

Table 14 Effect of treatments on selected characteristics and Yield of green pepper

Treatment	**Fruit diameter(mm)**	**Fruit length (mm)**	**Number of fruits/plant**	**Yield in kg/ha**
5ton/ha AGOF	19.44±1.088	26.65±2.008	23.05±0.808	1169±40.06
7.5ton/ha AGOF	19.04±1.320	27.51±2.815	21.78±1.262	1160±116.8
10ton/ha AGOF	19.7±1.320	26.41±3.903	25.10±1.669	1327±113.6
12.5ton/ha AGOF	18.9±0.444	26.46±1.410	22.38±1.610	1200±119.9
15ton/ha AGOF	20.21±0.129	26.88±0.784	24.80±2.485	1343±193.9
17.5tons/ha AGOF	20.03±0.700	27.13±0582	25.28±1.535	1382±142.6
20tons/ha AGOF	17.78±1.570	25.15±0.783	24.50±1.331	1336±135.6
10tons pm/ha	19.88±1.375	27.74±1.531	22.03±1.591	1118±99.38
NPK+SA	21.11±0.69	27.23±1.080	22.23±2.142	1106±128.0
Control(No amendment)	21.67±1.947	28.04±2.393	22.76±1.408	1105±69.61
LSD (p<0.05)	**NS**	**NS**	**NS**	**NS**

4.6.7 Shelf life of green pepper, Experiment 1

Shelf life of green pepper as influenced by the various soil amendments are as presented in the table 15 below. Inorganic fertilizer treatment had significantly shorter shelf life of 12 days as compared to the organic and no soil amendment.

Table 15. Effect of treatments on the shelf life of green pepper. Experiment 1

Treatment	**Shelf life**
5ton/ha AGOF	**13.67**
7.5ton/ha AGOF	**14.00**
10ton/ha AGOF	**14.33**
12.5ton/ha AGOF	**14.33**
15ton/ha AGOF	**13.67**
17.5tons/ha AGOF	**13.67**
20tons/ha AGOF	**13.67**
10tons pm/ha	**14.00**
NPK+SA	**12.00**
Control (No amendment)	**14.00**
LSD (p<0.05)	**0.968**

4.7. Results of experiment 2 (Green pepper)

4.7.1 Number of days to 50% flowering, Experiment 2

The effect of treatments on the number of days to 50% flowering of green pepper is as shown in Table 16. Significant differences were observed among the treatments. Inorganic fertilizer (NPK+ SA) treatment flowered 48 day after sowing, which was significantly earlier than the control (no soil amendment) flowering late at 56 days. AGOF applied at the rates of 5.0tons/ha to 12.5 tons/ha also flowered earlier at between 48 and 49 days after sowing. Flowering rather delayed as the rates of application of AGOF increased to 20 tons/ha (Table 10).

Table 16. Effects of treatments on days to 50% flowering, Experiment 2

Treatment	**Days to flowering**
5ton/ha AGOF	49.33
7.5ton/ha AGOF	49.67
10ton/ha AGOF	49.00
12.5ton/ha AGOF	48.67
15ton/ha AGOF	50.67
17.5tons/ha AGOF	52.67
20tons/ha AGOF	55.00
10tons pm/ha	49.00
NPK+SA	48.00
Control (No amendment)	56.33
LSD (p<0.05)	**1.195**

4.7.2 Plant Height of Green pepper, experiment 2

The effects of the treatments used in the study on plant heights measured in centimeter are as shown in Table 17. There were no significant differences recorded in plant heights among the treatments during the growth phase of the test crop. Poultry Manure applied at 10 ton/ha however gave the highest plant height measurement, followed by AGOF applied at 15 tons/ha at the 9th week.

Table 17. Effects of treatments on plant height in green pepper, experiment 2

Treatments	5 weeks	7 weeks	9 weeks
5ton/ha AGOF	32.12±1.35	38.58±0.96	51.90±1.97
7.5ton/ha AGOF	31.75±2.16	36.75±3.76	41.80±3.34
10ton/ha AGOF	32.17±2.03	36.67±3.58	45.30±6.21
12.5ton/ha AGOF	27.00±2.90	32.25±5.75	44.20±5.77
15ton/ha AGOF	30.67±1.80	37.75±0.76	50.62±1.69
17.5tons/ha AGOF	33.83±2.84	38.75±2.65	44.41±0.85
20tons/ha AGOF	30.42±3.23	35.08±4.80	43.70±7.74
10tons PM/Ha PM	33.96±1.28	42.25±1.67	51.80±2.33
NPK+ SA	29.53±2.25	34.00±2.57	45.50±3.25
Control	31.27±2.03	34.67±0.80	41.80±3.09
LSD (P≤0.05)	NS	NS	NS

4.7.2 Plant Girth of Green pepper, Experiment 2

The effects of the various treatments on plant girth measured in millimeters are as presented in Table 18. No significant differences were detected in the mean stem girths during the growth phase.

Table 18. Effect of treatment on stem girth of green pepper, experiment 2

Treatment	5 weeks	7 weeks	9 weeks
5ton/ha AGOF	6.31±0.45	7.73±0.14	9.61±0.40
7.5ton/ha AGOF	6.15±0.33	7.25±0.70	8.95±1.32
10ton/ha AGOF	6.29±0.64	6.97±0.52	8.79±1.22
12.5ton/ha AGOF	5.94±0.78	7.07±1.09	8.70±0.76
15ton/ha AGOF	6.24±0.18	7.22±0.47	8.87±0.25
17.5tons/ha AGOF	7.13±0.34	8.03±0.42	8.81±0.10
20tons/ha AGOF	6.23±0.50	6.86±0.70	9.20±1.70
10tons PM/Ha	7.04±0.23	7.83±0.21	9.59±0.36
NPK+SA	6.16±0.42	7.23±0.27	10.07±0.77
Control	6.40±0.47	6.86±0.37	8.27±0.86
LSD (P≤0.05)	NS	NS	NS

4.7.3 Number of leaves of Green pepper, experiment 2

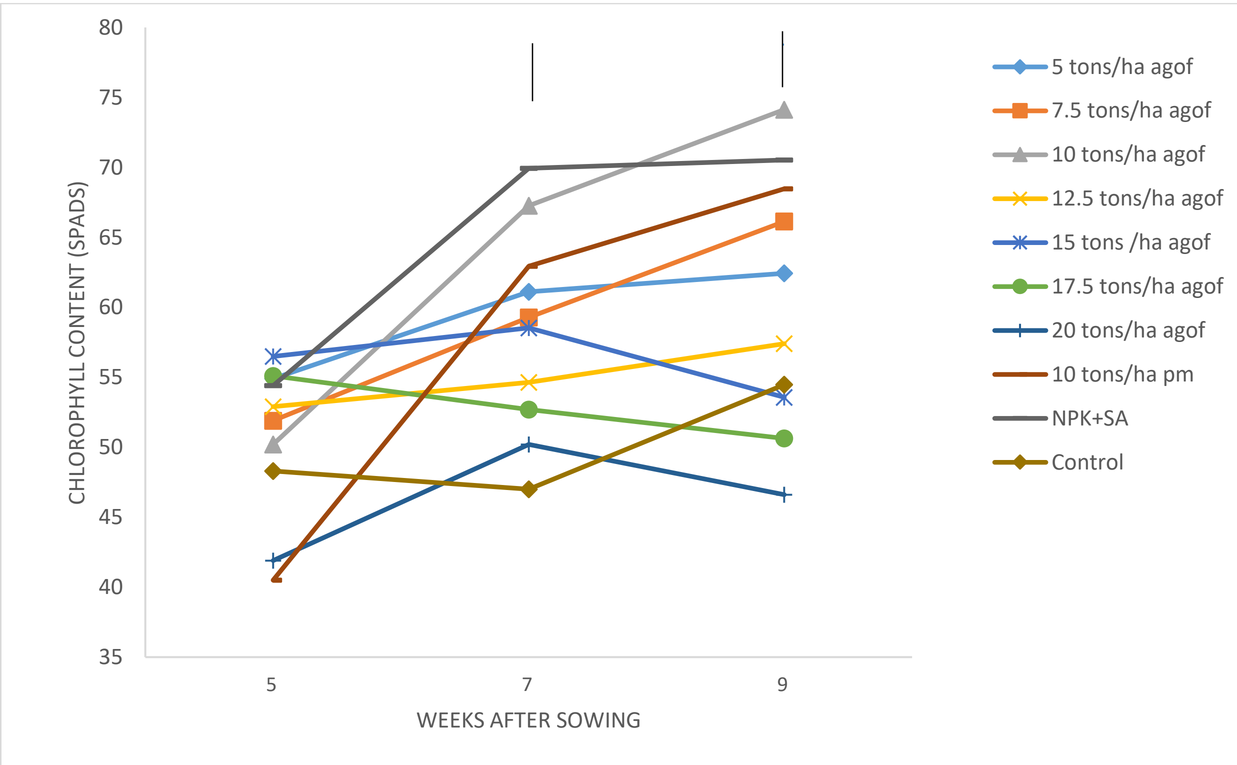
Number of leaves as influenced by the treatments applied in the study are as presented in Table 19. No significant differences were observed during the growth phase of the test crop. While high mean leaf numbers were recorded in inorganic fertilizer treatment, low numbers were recorded in AGOF at 20 tons/ha.

Table 19. Effects of treatments on Number of Leaves in green pepper, experiment 2

Treatment	5weeks	7 weeks	9 weeks
5ton/ha AGOF	32.3±2.83	39.6±2.95	61.6±6.30
7.5ton/ha AGOF	31.7±2.65	38.1±8.47	55.6±7.10
10ton/ha AGOF	32.6±2.82	38.4±10.81	54.8±12.50
12.5ton/ha AGOF	30.3±5.90	42.5±5.84	51.0±3.75
15ton/ha AGOF	36.5±2.39	39.2±12.90	58.1±9.34
17.5tons/ha AGOF	38.1±1.88	39.3±4.02	58.8±9.18
20tons/ha AGOF	34.9±4.20	34.9±9.56	42.2±7.35
10tons PM/Ha	41.4±5.34	41.6±4.29	47.0±9.00
NPK+AS	41.2±5.88	67.9±10.10	76.0±4.41
Control	38.6±2.10	36.3±7.38	56.3±7.26
LSD (P≤0.05)	NS	NS	NS

4.7.4 Chlorophyll content of leaves green pepper, experiment 2

Chlorophyll content of green pepper measured during the growth phase is as shown in figure 15. No significant differences were observed in the 5th week, but was rather seen in the 7th and 9th weeks. It should be noted that, plants growing on plots treated with AGOF applied at 17.5tons/ha and 20tons /ha rather recorded the lowest chlorophyll contents.



NB: Bars represent LSDs

Figure 15 Chlorophyll content as influenced by fertilizer treatments, experiment 2

4.7.5 Fruit characteristics and yield of Green pepper, experiment 2

Table 20 shows the results of fruit diameter in (mm), fruit length in (mm), number of fruits per plant and the yield per hectare as affected by the treatments applied in green pepper. The treatments did not have any significant effect on the fruit characteristics and yield. There were however differences observed in the yield worth noting. AGOF applied at 20tons/ha had the lowest yield per kg, far lower than the control (no soil amendment) treatment.

Table 20. Effect of treatments on selected characteristics and Yield of green pepper, Experiment 2

Treatment	**Fruit diameter(mm)**	**Fruit length (mm)**	**Number of fruits/ plants**	**Yield in kg/ha**
5ton/ha	56.83±0.6566	54.10±3.320	8.33±2.603	3558±1222
7.5ton/ha	58.27±1.313	52.73±0.4910	7.00±0.5774	2967±140.1
10ton/ha	57.67±1.105	56.87±0.6888	8.43±1.202	2092±996.8
12.5ton/ha	55.27±1.988	55.97±0.8570	7.94±1.402	2750±506.0
15ton/ha	56.9±0.8737	51.97±3.910	11.00±5.132	4783±2232
17.5tons/ha	52.27± 1.510	52.1±1.963	7.33±1.453	3549± 382.9
20tons/ha	50.53±1.398	57.17±1.348	5.67±0.3333	1161± 583.2
10tons pm/Ha	57.07±1.821	55.63±3.055	7.33±0.6667	3441±580.3
npk+sa	56.93±2.347	50.83± 2.085	8.87±0.6667	3731± 358.1
Control	57.43± 3.115	53.17±1.099	6.00±1.000	1936±606.3
LSD (p<0.05)	**NS**	**NS**	**NS**	**NS**

4.7.6 Shelf of green pepper, experiment 2

Shelf life of green pepper as affected by the various soil amendments used in the study are as presented in the table 21. Inorganic fertilizer treatment had shorter shelf life of 11 days as compared to the organic and no soil amendment treatments.

Table 21. Shelf life of green pepper as influenced by various treatments experiment 2

Treatment	Shelf life
5ton/ha AGOF	13.67± 0.3333
7.5ton/ha AGOF	14.00±0.0000
10ton/ha AGOF	13.67±0.3333
12.5ton/ha AGOF	13.67±0.3333
15ton/ha AGOF	13.67±0.3333
17.5tons/ha AGOF	14.00± 0.000
20tons/ha AGOF	13.33±0.3333
10tons pm/Ha PM	14.33±0.3333
npk+sa	11.33±0.5774
Control	13.00± 0.3333
LSD (0.05)	NS

4.8 Results of Experiment 1 (tomato)

4.8.1 Number of days to 50% flowering

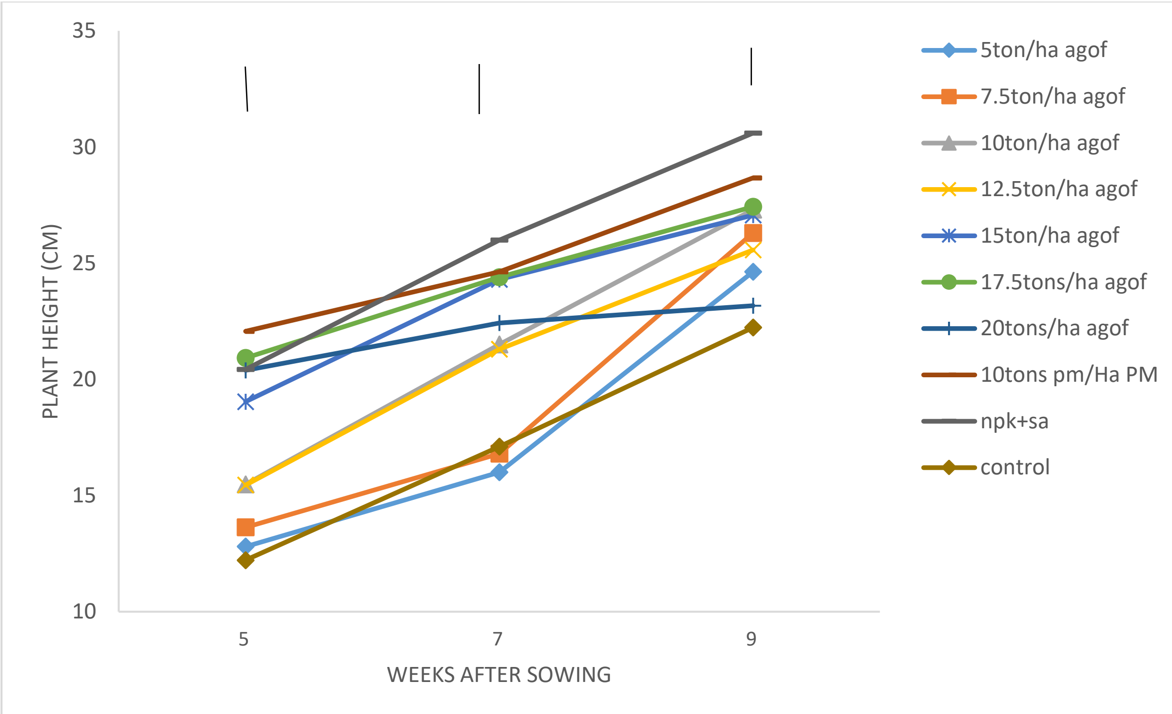
Days to 50% flowering of tomato test crop as affected by the treatments applied are as presented in table 22. While inorganic fertilizer and poultry manure treatments used as standard checks flowered significantly earlier at 45days, AGOF applied at 20 tons/ha rather flowered late at 49 days after sowing.

Table 22, Effects of treatments on days to 50% flowering as influenced by various treatments

Treatment	% Flowering
5ton/ha AGOF	45.67±0.8819
7.5ton/ha AGOF	46.00±0.5774
10ton/ha AGOF	46.00±0.5774
12.5ton/ha AGOF	46.33±0.3333
15ton/ha AGOF	47.67±0.3333
17.5tons/ha AGOF	47.00±0.5774
20tons/ha AGOF	48.67±0.3333
10tons pm/Ha PM	45.33±0.3333
npk+sa	45.33±0.3333
Control	47.33±0.3333
LSD (0.05)	1.502

4.8.2 Plant Height of Tomato

Plant height of tomato as influenced by the treatments used in the study are presented in Figure 16. Significant differences were observed throughout the growth phase of the test crop, with Inorganic fertilizer in the form of NPK+SA giving the highest mean plant height. AGOF applied at the rate of 20 tons/ha resulted in significantly shorter plant height at the 9^{th} week.

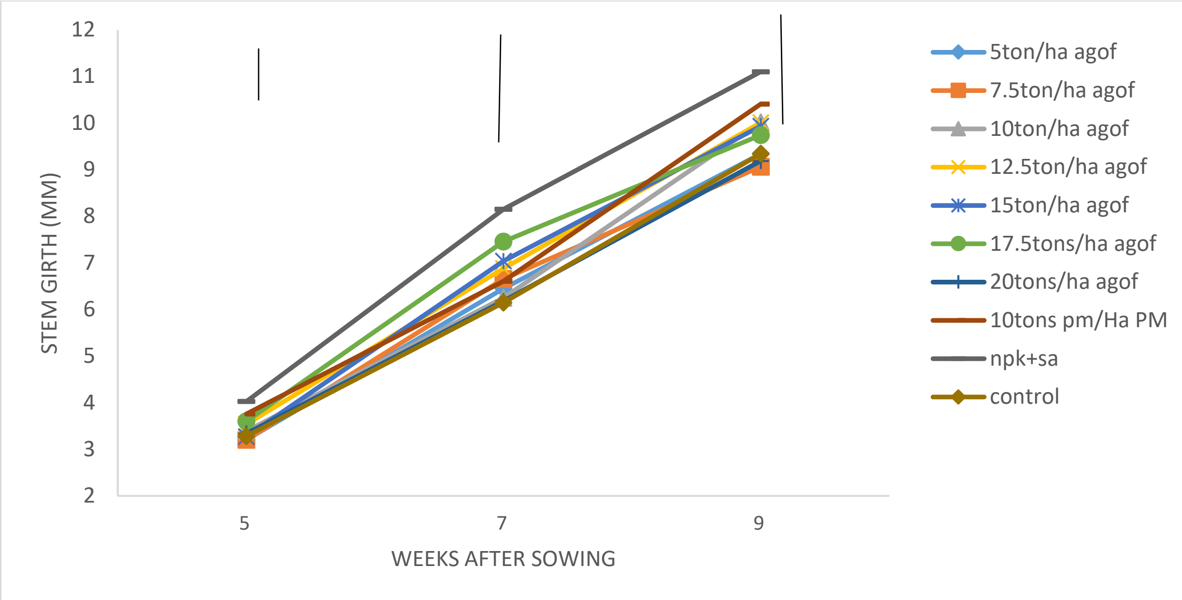


NB: Bars represent LSDs

Figure 16. Treatment effect on plant height of tomato during the growth phase.

4.8.3 Plant Girth of Tomato

The effects of the various treatments on stem girth of tomato in millimeters are as presented in Figure 17. No significant differences were detected in the mean stem girths during the growth phase.



NB: Bars represent LSDs

Figure 17. Effects of treatment on stem girth of tomato during the growth phase

4.8.4 Number of leaflets of Tomato

Figure18 shows the number of leaflets produced by the test crop as influenced by the treatments applied. Inorganic fertilizer treatment produced significantly higher numbers of leaflets in comparison to 20 tons/ha of AGOF which produced the lowest number of leaflets of 11 at the 9th week.

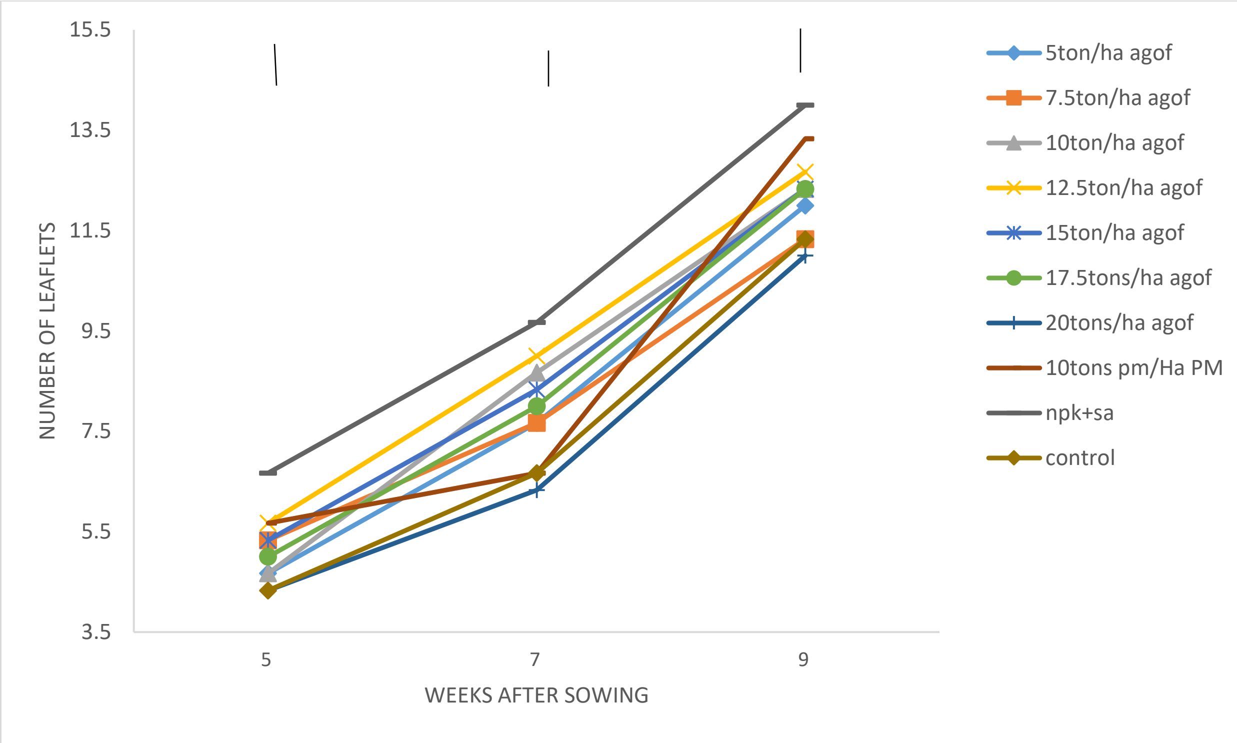
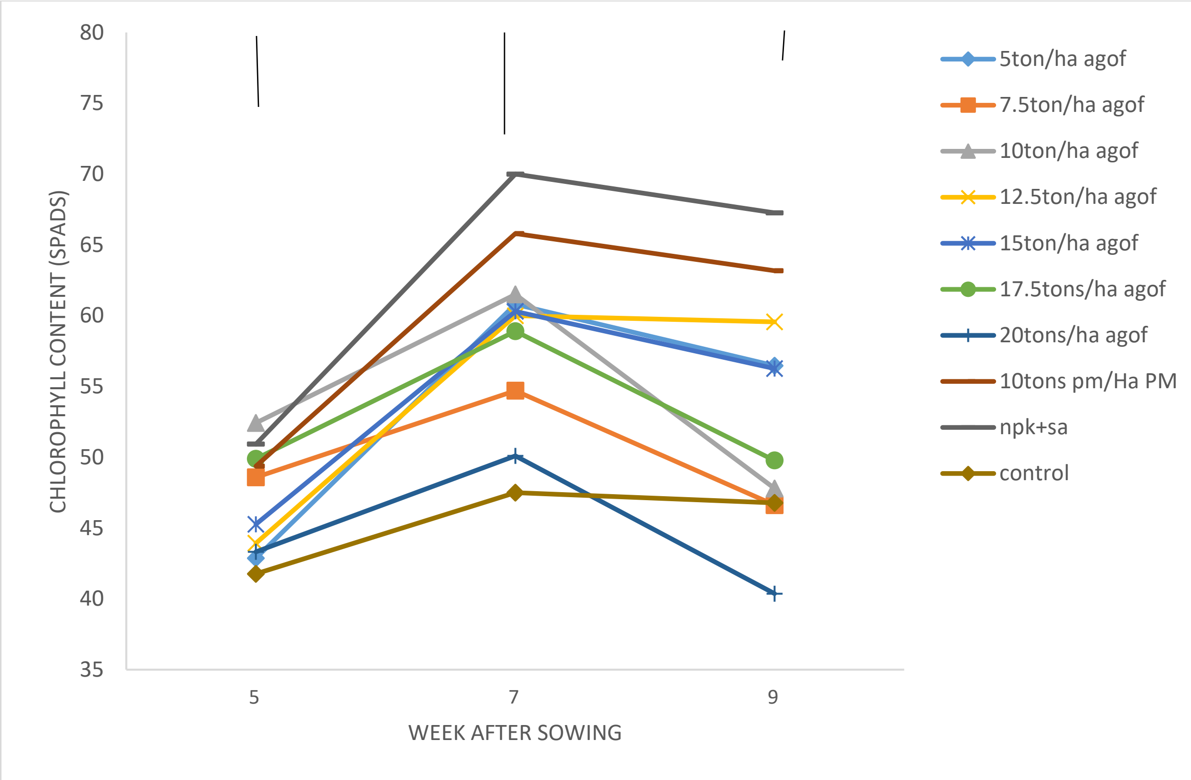


Figure 18. Effect of treatments applied on the number of leaflets of tomato

4.8.5 Chlorophyll content of leaves

The chlorophyll content of the test crop as influenced by the treatments applied during the growth phase is presented in Figure 19. Chlorophyll contents were significantly higher in Inorganic fertilizer and Poultry manure treatments while AGOF applied at the rate of 20 tons/ha had the lowest chlorophyll contents.



NB: Bars represent LSDs

Figure 19 Chlorophyll content as influenced by the treatments used in the study in tomato

4.8.6 Fruit characteristics and yield of Tomato

Table 23 shows the results of fruit diameter in (mm), fruit length in (mm), number of fruits per plant and the yield per hectare as affected by the treatments applied in tomato. The treatments did not have any significant effect on the fruit diameter and length. There were however real differences observed in the number of fruits per plant and yield. NPK+SA treatment gave the highest yield of 1695.5 kg/ha, which was not significantly different from AGOF applied at the rate of 12.5tons/ha. 15tons/ha of AGOF had the lowest yield of 1174.8 kg/ha, far lower than the control (no soil amendment) treatment.

Table 23 Effect of treatments on selected characteristics and Yield of Tomato

Treatment	Fruit diameter(mm)	Fruit length(mm)	Number of fruits/plant	Yield kg/ha
5ton/ha AGOF	45.78±0.85	52.44±0.84	17.00±0.58	1239.7±94.13
7.5ton/ha AGOF	42.54±2.01	50.47±2.23	19.33±1.20	1354.8±82.60
10ton/ha AGOF	44.46±0.84	53.19±2.44	18.00±0.58	1355.8±59.26
12.5ton/ha AGOF	44.54±0.45	53.29±0.18	19.67±0.88	1543.5±82.61
15ton/ha AGOF	43.29±0.13	49.35±0.91	20.33±0.88	1174.8±58.19
17.5tons/ha AGOF	41.92±0.85	50.78±1.46	21.00±0.58	1470.8±38.36
20tons/ha AGOF	44.74±0.74	53.39±1.23	14.67±0.33	1268.7±74.13
10tons pm/Ha PM	43.93±0.40	52.12±1.62	20.33±0.88	1405.6±73.07
NPK+SA	43.56±1.51	51.4±2.28	24.67±1.20	1695.5±26.14
control	45.55±0.85	53.83±0.63	14.33±0.33	1359.6±86.12
LSD(0.05)	**NS**	**NS**	**2.337**	**2032.9**

4.9 Optimum levels of application of AGOF

4.9.1 Optimum rate of application of AGOF for garden egg

Figure 20 shows the rate of increase in yields as the rate of application of AGOF in tons per hectare is increased. After a regression analysis presented in graph shown in the figure 20, yield increases steadily from 5 ton/ha to 20 tons/ha. Hence the regression equation shown on the graph can be used to predict the yield one will obtain at any rate of application of AGOF used at an accuracy of 85.21 %.

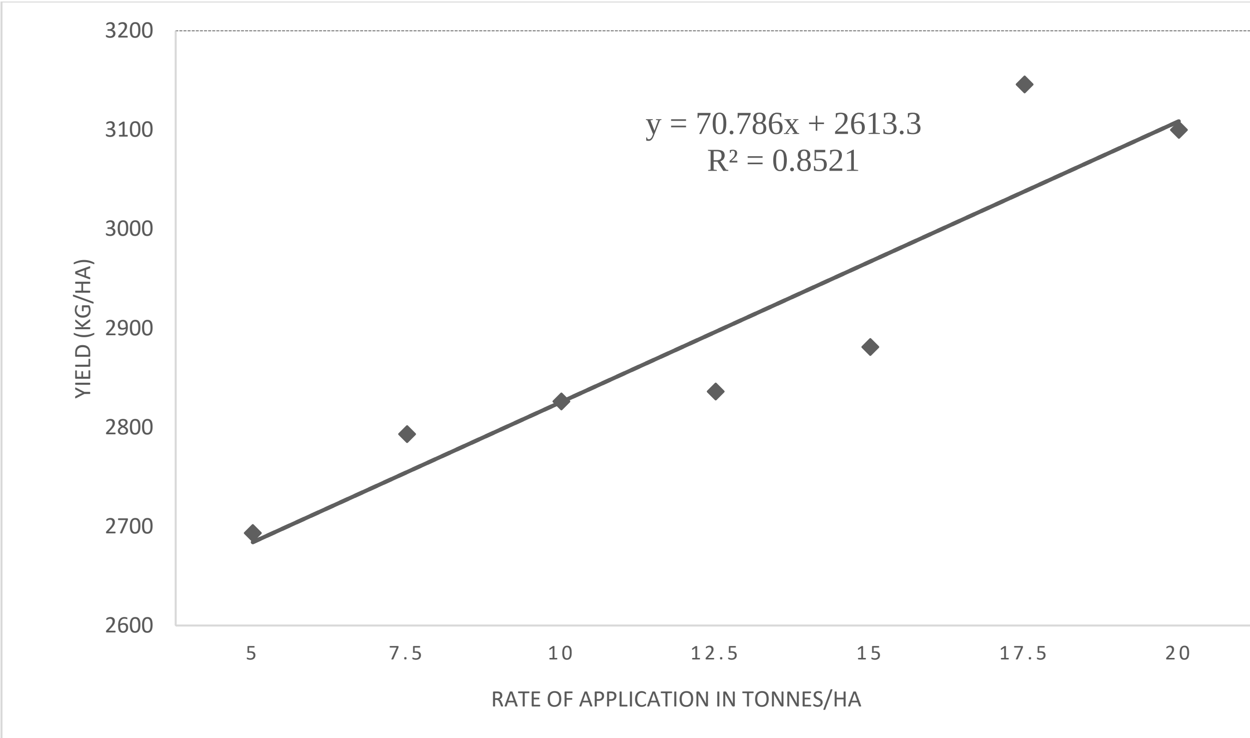


Figure 20, Optimum level of application of AGOF in garden egg production

4.9.2 Optimum rate of application of AGOF for green pepper

Yields obtained with gradual increase in rates of application of AGOF is as presented in Figure 21. The regression analysis presented graphically in figure 20 show a steady increase in yield as the rate of application is increased gradually from 5 ton/ha to 20 tons/ha and that, one can predict the yield to be obtain with certainty of 62.74%.

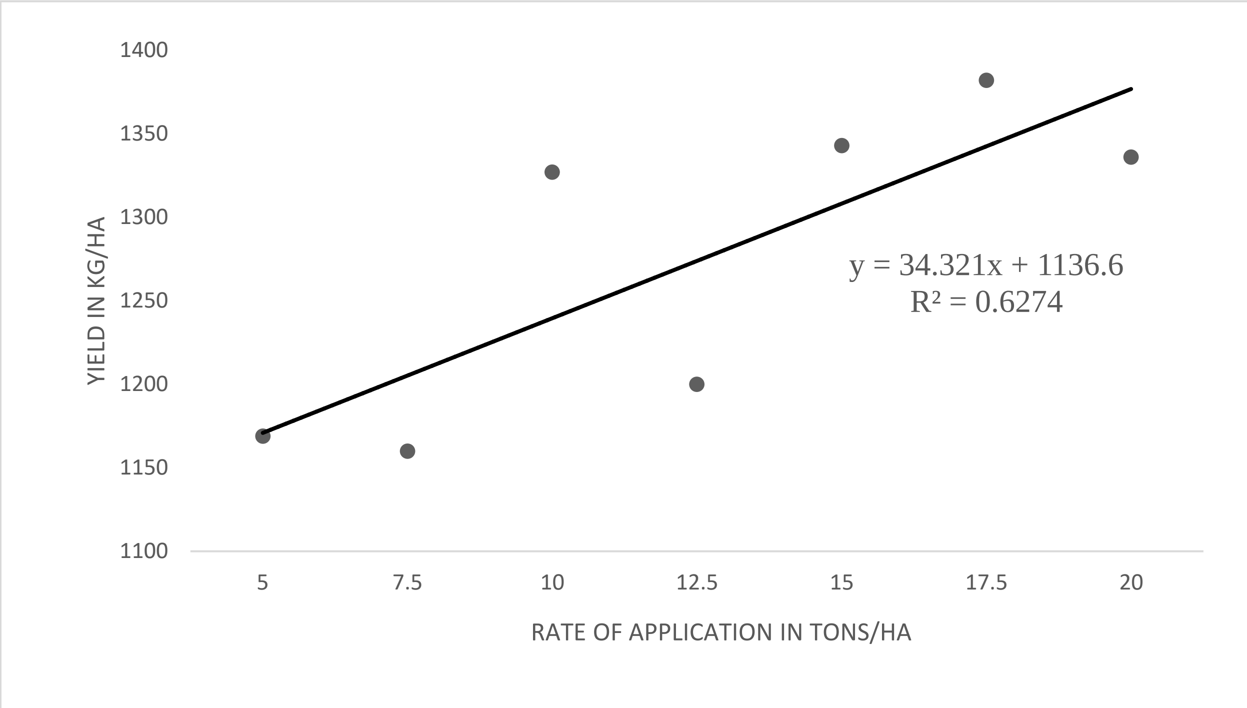


Figure 21, Optimum level of application of AGOF in Green Pepper production

4.9.3 Optimum rate of application of AGOF for Tomato

Yields obtained with gradual increase in rates of application of AGOF in tomato experiment is as presented in Figure 22. The highest yield of 1543.5 kg/ha was obtained when AGOF was applied at 12.5 ton/ha, being the optimum rate of application. Yields decrease as the rates of application goes beyond 12.5 tons/ha

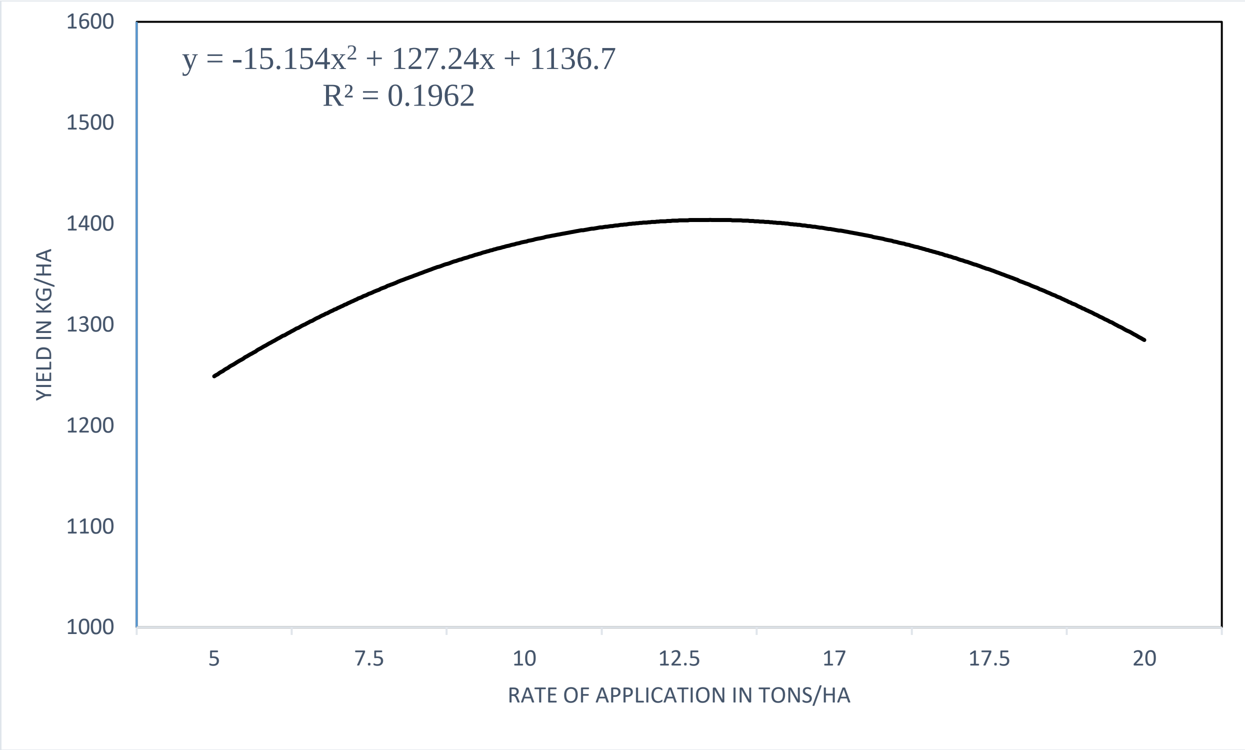


Figure 22, Optimum level of application of AGOF in Green Tomato production

CHAPTER FIVE

5.0 DISCUSSION

The soils at the site of the experiments were very low in N (0.049%), however, it contained 18.693mg/kg Av P, 0.93cmol/kg K and 3.01cmol/kg Ca. The low levels of N could be attributed to the fact that N is easily lost in the soils as a result of heavy rains, its volatile nature and also the fact that they are taken up by plants in larger quantities, while very good levels of Av. P could be due to its relative stability and lack of mobility compared to N. The critically low level of N will not support increased yields of high valued vegetables like tomato, green pepper and garden eggs. This is in relation to their nutrient demands, especially during the vegetative growth phase. The low levels of other nutrients in soils at the experimental sites, for example organic carbon content of less than 1% , 3.01 cmol+/kg Ca and 0.78 cmol+/kg Mg, shows that these soils or land have been cropped for some time, and have gradually lost its fertility, reflecting the nutrient status of most soils of sub Saharan African small holder farms and gardens. This justifies the need to use appropriate methods for sustaining these soils to ensure increased yields in vegetable production. It has been established that, organic fertilizers are known to provide good measures of organic matter to improve soil physical and chemical properties (Adesodun *et al*, 2005, Aluko and Oyeleke, 2005), hence AGOF should be the organic fertilizer of choice, considering its superior quality as indicated by the laboratory analysis of samples. The use of AGOF will also provide the added advantage of improving our sanitation and environmental challenges.

Analysis of the “Asase gyefo organic fertilizer” (AGOF) prior to the start of the study showed that, the organic fertilizer was of very high quality and contained high levels of macro and micro nutrients. It also contained high levels of organic carbon (10.47 %), which translates into very high levels of organic matter, humic acids and amino acids. These ensures the continuous slow release of nutrients needed for plant growth as a result of increase microbial activity. It also regulates plant growth, promotes root development, absorption of nutrient elements, and improved chlorophyll content and hence photosynthesis. Five weeks after the application of the AGOF, a mean soil pH of 4.98 was raised to 5.34, N level of 0.044% was also raised to 0.23% and organic carbon (0.88%) in the soil was also raised to 2.8% after AGOF was applied at 10 tons/ha. Pointing to the fact that, the organic fertilizer applied to the experimental plots had mineralized to some extent, thus the increase in the nutrient seen. This confirms what Ano and Agwu (2006) established, that organic manure (organic fertilizers) increases soil pH and macronutrients when applied to soil. The improvement of the soils at the experimental site is clearly noticed when a comparison is made between growth and yield parameters of the organically treated plots and control plots (no soil amendment). In my estimation this organic fertilizer (AGOF) has the potential to ensure a quick and lasting fertilizer effect on depleted soils and as well improve the soil structure, health, promote stable and high yields in vegetable production when used continuously over time.

Generally, AGOF at all levels of application had positive effects on the growth and flowering of all the test crops used in the study. This is evident in increase in the vegetative growth and yield parameters measured in comparison to the no soil amendment plots (control). This may be attributed to the fact that addition of AGOF improved most of the soil chemical properties like pH, organic carbon, total Nitrogen, Av.P, and other nutrients and may have influenced the microbial activities of the soil. The positive effects on the growth of the test crops means that AGOF could be used for soil fertility management for sustainable vegetable production. This is in line with literature reviewed, pointing to the positive effects of organic fertilizers on soil structure, physical and chemical properties. Specifically, the results of the present study show that higher values of plant growth were recorded between AGOF applied at the rates of 5tons/ha and 12.5 tons/ha across all the test crops. The higher growth rates may be attributed to increased levels of nutrients like nitrogen, phosphorus, potassium etc. which may have resulted in the increased formation of metabolites that help build plant tissue. This agrees with findings by Birkhofer *et al* (2008), where they established that, organic manures have beneficial and positive effects on soil quality, subsequently improving nutrient release and their availability to the crop. However higher rates of AGOF rather suppressed and slowed the rate of plant growth and yields of tomato used as a test crop. This may be the result of nutrient elements reaching toxic levels which were injurious to tomato and suppressed the growth of microorganisms involved in the mineralization process in the soil (Meena *et al*, 2019). These levels rather reduce the pH levels in the soil, making nutrients unavailable to the crop. Thus, the beneficial effects of application of AGOF on soils and subsequently on the growth of tomato can be confirmed to range from rates of 5tons/ha AGOF to 12.5tons/ha AGOF with 12.5 tons/ha being the optimum rate of application for tomato. However, the picture was different when green pepper and garden eggs were used as test crops. As the rate of application of AGOF was increased gradually from 5 tons/ha to 20 tons/ha, corresponding yields also increased steadily in these test crops. This may be due to the high nutrient requirements of these crops. Thus, with regression equations and R^2 values obtained, one can safely predict with a certainty of 63% and 85% respectively the yields of green pepper and garden eggs. Therefore, with green pepper and garden eggs as test crops, one cannot talk about an optimum rate of application, as yields increased with increasing rate of fertilizer application in a linear fashion. While certain rate of AGOF makes the soil conducive for optimum yields to be obtained, in some crops, same rates become toxic to certain crops and hence suppresses growth resulting in low yields, and therefore AGOF is crop specific with regards to rate of application to obtain optimum yields.

AGOF applied at various levels positively influence the yield of all the test crops used in the experiments, and was comparable with the standard check of poultry manure and inorganic fertilizer. This means that, these rates of applications were as good as the standard check of inorganic fertilizer (NPK+SA: 300kg/ha+150kg/ha) and poultry manure (what rate??) used in the study. Implying that, one can easily replace these inorganic and organic fertilizers (poultry manure) with AGOF and obtain similar results due to the subsequent improvement of the soils as indicated above. The shelf life of fruits of the test crops were longer in organic treatments than in inorganic treatment. This confirms a study by Solaiman *et al* (2015), where they established that, shelf life of tomatoes was greatly extended when different types of organic manures were used in their cultivation, regardless of the tomato variety used.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- AGOF is a high-quality organic fertilizer and contains very high levels of macronutrients and the right pH necessary for plant growth and increased crop yields based on the present study.
- Application of AGOF at rates of 5 tons/ha to 20 tons/ha resulted in increased yields and shelf life of garden egg and green pepper. Thus 20 tons/ha AGOF will give optimum yield per the present study.
- Application of AGOF at the rates 12.5 tons/ha had positive influence on the growth, yield and shelf life of tomato and can be said to be the optimum application rate for increased tomato production.

6.2 Recommendations

- The use of AGOF compares favorably with poultry manure and inorganic fertilizers and therefore its use for production of garden egg, green pepper and tomato should be promoted and encouraged among the small holder farmers in the study area and for that matter Accra.
- The use of AGOF in combination with lower rates of inorganic fertilizer rates should be studied to ascertain its effect on yield and quality of the garden egg, green pepper and tomato.

- AGOF fertilizer should be tested with different crops in other agro-ecological zones to ascertain its efficacy.
- On farm adaptive trials with different high value crops across the major agro ecological zones should be carried out.

REFERENCES

Agegnehu, G., & Amede, T. (2017). Integrated soil fertility and plant nutrient management in tropical agro-ecosystems: a review. *Pedosphere*, *27*(4), 662-680.

Agegnehu, G., Bass, A. M., Nelson, P. N., & Bird, M. I. (2016). Benefits of biochar, compost and biochar–compost for soil quality, maize yield and greenhouse gas emissions in a tropical agricultural soil. *Science of the Total Environment*, *543*, 295-306.

Alburquerque, J. A., de la Fuente, C., Ferrer-Costa, A., Carrasco, L., Cegarra, J., Abad, M., & Bernal, M. P. (2012). Assessment of the fertilizer potential of digestates from farm and agroindustrial residues. *Biomass and bioenergy*, *40*, 181-189.

Adesodun, J.K., Mbagwu, J. S. C. andOti W. (2005).Distribution of carbon, nitrogen, phosphorus in water stable aggregates of an organic wastes amended ultisol in southern Nigeria. Bioresource Technology. 96: 509 – 516.

Akuamoah-Boateng, M. (2016). *Effect of poultry manure and NPK fertilizer on the growth, yield and mineral composition of onion (Allium cepa L.) grown in acid soil* (Doctoral dissertation, University of Ghana).

Aluko, O.B. and Oyeleke, D.J. (2005). Influence of organic wastes incorporation on changes in selected soil physical properties during drying of a Nigerian alfisol. *Journal of Applied Science.* 5: 257 – 362.

Ano, A. O., & Agwu, J. A. (2006). Effect of animal manures on selected soil properties: II. Nitrogen, potassium and phosphorus. *Nigerian Journal of soil science*, *16*(1), 145-150.

Andersson, K. (2016). *Sanitation, wastewater management and sustainability: from waste disposal to resource recovery*. UN Environmental Programme Global Programme of Action for the protection of the Marine Environment from Land Based activities and Stockholm Environment Institute (SEI).

Andersson, E. (2015). Turning waste into value: using human urine to enrich soils for sustainable food production in Uganda. *Journal of Cleaner Production*, *96*, 290-298.

Aqeel, A.M., Hammeed, K.M. and Alaudatt, M. (2007). Effect of olive oil mill my products on minral status, growth and productivity of faba bean.journal of agro, 6(3):403-408

Birkhofer, K., Bezemer, T.M., Bloem, J., Bonkowski, M., Christensen, S., Dubois, D., Ekelund, F., Fließach, A., Gunst, L., Hedlund, K., Ma¨der, P., Mikola, J., Robin, C., Seta¨la, H., Tatin-Froux, F., Van Der Putten, W.H., Scheu, S. (2008). Long-term organic farming fosters below and aboveground biota: implications for soil quality, biological control and productivity. *Soil Biol. Biochem*. 40, 2297–2308.

Brammer, H. (1967). Soils of the Accra Plains. Memoir No. 3. *Soil Research Institute, Ghana Academy of Sciences, Kumasi*.

Bulluck Iii, L. R., Brosius, M., Evanylo, G. K., & Ristaino, J. B. (2002). Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms. *Applied Soil Ecology*, *19*(2), 147-160.

Bulluck Iii, L. R., & Ristaino, J. B. (2002). Effect of synthetic and organic soil fertility amendments on southern blight, soil microbial communities, and yield of processing tomatoes. *Phytopathology*, *92*(2), 181-189.

Chowdhury, R. (2004). Effects of chemical fertilizers on the surrounding environment and the alternative to the chemical fertilizers. *IES-ENVIS Newsl*, *7*, 4-5.

Choudhary, O.P.,Ghuman, Bijay-Singh,N.T., and Burest, R.J. (2011) Effect of long term use of sodic water irrigation, amendments and crop residues on soil properties and crop yields in rice-wheat cropping system in calcareous soil. *Field crops Res*, 121(3): 363-372.

Caldwell, I & Rosemari, A. (2010) Human urine and feace as a fertilizer. UNEP/GRID-Arendal. The environment times. Environment and poverty times .no.5

Cofie, O. O., Kranjac-Berisavljevic, G., & Drechsel, P. (2005). The use of human waste for peri-urban agriculture in Northern Ghana. *Renewable Agriculture and Food Systems*, *20*(2), 73-80.

Daisy, Antony, and S. Kamaraj. "The impact and treatment of night soil in anaerobic digester: a review." *J. Microbial Biochem. Technol* 3, no. 043050.38 (2011): 63-65.

Ecosan,(2008) The main features of Ecological Sanitation. Ecosan Factsheet2, 2008. Stockholm Environmental Institute .Stockholm, Sweden

Esray, S. A. (2001). Towards a recycling society: ecological sanitation-closing the loop to food security. *Water Science and Technology*, *43*(4), 177-187.

Esrey, S., Gough, J., Rapaport, D., Sawyer, R., Simpson-Hébert, M., Vargas, J., & Winblad, U. (1998). Ecological sanitation. Swedish International Development Cooperation Agency. *Stockholm, Sweden*.

FAO/UNESCO, 1990. Soil Map of the World, Revised Legend. FAO, pp 119.

Farouque, M. G., & Tekeya, H. (2008). Farmers' use of integrated soil fertility and nutrient management practices for sustainable crop production: a field-level study in Bangladesh. *American Journal of Agricultural and Biological Sciences*, *3*(4), 716-723.

Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm? *Journal of cleaner production*, *143*, 757-768.

Germer, J., & Sauerborn, J. (2008). Estimation of the impact of oil palm plantation establishment on greenhouse gas balance. *Environment, Development and Sustainability*, *10*(6), 697-716.

Gotass in F. Tanguay. Petit manuel d'auto-construction. Mortagne, Quebec, 1990(data source 1) *International Journal of Agriculture and Forestry* p-ISSN: 2165-882X e-ISSN: 2165-8846 2013; 3(4): 185-189

Gruhn, P., Goletti, F., & Yudelman, M. (2000). *Integrated nutrient management, soil fertility, and sustainable agriculture: current issues and future challenges*. Intl Food Policy Res Inst.

Guzha, E., Nhapi, I., & Rockstrom, J. (2005). An assessment of the effect of human faeces and urine on maize production and water productivity. *Physics and Chemistry of the Earth, Parts A/B/C*, *30*(11-16), 840-845.

Heeb, A., Lundegårdh, B., Ericsson, T., & Savage, G. P. (2005). Nitrogen form affects yield and taste of tomatoes. *Journal of the Science of Food and Agriculture*, *85*(8), 1405-1414.

Heeb, A., Lundegårdh, B., Savage, G., & Ericsson, T. (2006). Impact of organic and inorganic fertilizers on yield, taste, and nutritional quality of tomatoes. *Journal of Plant Nutrition and Soil Science*, *169*(4), 535-541.

Hansen JA, Tjell JC. (1979). Human Excretion of Heavy Metals and others Elements. Working document. Technical University of Denmark: The laboratory for Technical Hygiene, presently know as Environment and Resources, DTU.

Hoitink, H. A. J., & Boehm, M. J. (1999). Biocontrol within the context of soil microbial communities: a substrate-dependent phenomenon. *Annual review of phytopathology*, *37*(1), 427-446.

Hu Zhou, Huan Fang, Chunsheng Hu, Sacha Jon Mooney, Wenxu Dong [*] and Xinhua Peng [*a] Inorganic Fertilization Effects on the Structure of a Calcareous Silt Loam *Soil.Agronomy Journal Abstract - Soil Fertility & Crop Nutrition 2017 Vol. 109 No. 6*, p. 2871-2880 doi:10.2134/agronj2016.10.0590

Huang, G.F., Wong, J W.C., Nagar, B.B., Wu, Q.T., and Li, F.B. (2005) Bioavailability of heavy metals during humification of organic matter in pig manure compost. ECO Services International. http://www.eco-web.com/edi/index.htm

Ipinmoroti, R. R. (2013). Decomposition and nutrient release patterns of some farm wastes under controlled room temperature. *International Journal of Agriculture and Forestry*, *3*(4), 185-189.

Jun, H., & Xiang, H. (2011). Development of circular economy is a fundamental way to achieve agriculture sustainable development in China. *Energy Procedia*, *5*, 1530-1534.

Kark and Bhattacharya (2011), Human urine as source alternative natural fertilizer in agriculture: A flight of fancy or an achievable reality. *Res., Cons and Rec* 55(4): 400-408 -

Kraaijenhagen, C., Van Oppen, C., & Bocken, N. (2016). *Circular business: collaborate and circulate*. Chris Bernasco en Lucy Goodchild-van Hilten.

Kuepper, G. (2003) Manures for organic production. http://attra.neat.org/attra-pub/manures.html.

Liu, B., Gumpertz, M. L., Hu, S., & Ristaino, J. B. (2007). Long-term effects of organic and synthetic soil fertility amendments on soil microbial communities and the development of southern blight. *Soil Biology56 and Biochemistry*, *39*(9), 2302-2316.

MacArthur, E. (2013). Towards the circular economy, economic and business rationale for an accelerated transition. *Ellen MacArthur Foundation: Cowes, UK*.

MacArthur, E., Zumwinkel, K., & Stuchtey, M. R. (2015). Growth within: a circular economy vision for a competitive Europe. *Ellen MacArthur Foundation*.

Masunga, R. H., Uzokwe, V. N., Mlay, P. D., Odeh, I., Singh, A., Buchan, D., & De Neve, S. (2016). Nitrogen mineralization dynamics of different valuable organic amendments commonly used in agriculture. *Applied Soil Ecology*, *101*, 185-193.

Meena, M. D., Yadav, R. K., Narjary, B., Yadav, G., Jat, H. S., Sheoran, P., ... & Meena, V. S. (2019). Municipal solid waste (MSW): Strategies to improve salt affected soil sustainability: A review. *Waste management*, *84*, 38-53.

Neeson, R, 2004. Organic processing tomato production. Agfact H8.3.6, first edition

Obono, O. N., & John, E. J. (2018). Nutritional and therapeutic importance of lycopene: a strong antioxidant present in red tomatoes for effective reduction of plasma lipid profile (hyperlipidemia) and prevention of cardiovascular diseases in humans. *IJAR*, *4*(9), 242-247.

Owusu Agyeman, F., & Kranjac-Berisavljevic, G. (2009). Use of feacal sludge for Agriculture in Tamale Metropolis: perception of Farmers, Consumers and Relevant Agencies.

Pennington JAT, Fisher RA. Classification of fruits and vegetables. Journal of Food Composition and Analysis. 2009; 22 (1):23-31

Sanchez, P. A. (2002). Soil fertility and hunger in Africa. *Science*, *295*(5562), 2019-2020.

Sauerborn, J., and Germer, J., (2006). Exploring the Potential for Recycling Nutrients from Waste water to enhance Agricultural productivity. The example of Valley View University in Accra, Ghana. *Presentation at Tropentag 2006*- International Research on Food Security, Natural Resource Management and Rural Development.University of Bonn, October 11-13.

Schouw, N. L., Tjell, J. C., Mosbæk, H., & Danteravanich, S. (2002). Availability and quality of solid waste and wastewater in Southern Thailand and its potential use as fertiliser. *Waste management & research*, *20*(4), 332-340.

Singh, R. S., & Sitaramaiah, K. (1970). Control of plant parasitic nematodes with organic soil amendments. *PANS Pest Articles & News Summaries*, *16*(2), 287-297.

Solaiman, A. H. M., Nishizawa, T., & Roy, T. S. (2015). Efficacy of Organic Manures on the Productivity, Shelf-life and Economic Efficiency of Tomato Varieties in a Long-term Fertilized Field by Chemical Fertilizers. *American Journal of Experimental Agriculture*, *6*(3), 181.

Tindall, H. D. (1983). *Vegetables in the Tropics*. Macmillan International Higher Education.

Tonfack, L. B., Bernadac, A., Youmbi, E., Mbouapouognigni, V. P., Ngueguim, M., & Akoa, A. (2009). Impact of organic and inorganic fertilizers on tomato vigor, yield and fruit composition under tropical andosol soil conditions. *Fruits*, *64*(3), 167-177.

Welbaum GE. Vegetable production and practices; IARC handbooks of cancer prevention: Fruit and vegetables. In: Vegetable History, Nomenclature, and Classification. 2015;8: 1-15

Winblad, U., Simpson-Hébert, M., Calvert, P., Morgan, P., Rosemarin, A., Sawyer, R., & Rapaport, D. (2004). *Ecological sanitation*.

Vodounhessi, A., & von Münch, E. (2006). Financial challenges to making faecal sludge management an integrated part of the ecosan approach: Case study of Kumasi, Ghana. *Water Practice and Technology*, *1*(2).

Voor, V. M., Nkansah, G. O., Smith, M. S., Page, Z. C., & Luther, Z. (2018). Effects of Different Water Regimes and Poultry Manure on Growth, Development and Yield of Hot Pepper (Capsicum annum L.). *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, *44*(1), 32-57.

Yadav, R. L. (1998). Factor productivity trends in a rice–wheat cropping system under long-term use of chemical fertilizers. *Experimental Agriculture*, *34*(1), 1-18.

Yanar, D., Gebologlu, N., Yanar, Y., Aydin, M., & Cakmak, P. (2011). Effect of different organic fertilizers on yield and fruit quality of indeterminate tomato (Lycopersicon esculentum). *Scientific Research and Essays*, *6*(17), 3623-3628.

APPENDICES

Variate: height

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	192.24	96.12	6.07	
Treatment	9	117.65	13.07	0.83	0.601
Residual	18	284.85	15.82		
Total	29	594.74			

Variate: girth

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.6024	1.3012	2.79	
Treatment	9	4.3597	0.4844	1.04	0.449
Residual	18	8.4004	0.4667		
Total	29	15.3625			

Variate: branches

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.12407	0.06204	1.20	
Treatment	9	0.41574	0.04619	0.89	0.550
Residual	18	0.93148	0.05175		
Total	29	1.47130			

Variate: leaves

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	15.672	7.836	1.57	
Treatment	9	96.922	10.769	2.15	0.079
Residual	18	90.050	5.003		
Total	29	202.644			

Variate: chlorophyll

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	80.48	40.24	2.70	
Treatment	9	539.36	59.93	4.02	0.006
Residual	18	268.04	14.89		
Total	29	887.88			

Variate: days to 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.800	0.900	0.75	
Trt	9	119.467	13.274	11.10	<.001
Residual	18	21.533	1.196		
Total	29	142.800			

Variate: days_to_flower

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.2000	0.1000	0.17	
Treatment	9	122.0333	13.5593	23.32	<.001
Residual	18	10.4667	0.5815		
Total	29	132.7000			

Variate: shelf_life

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.6000	0.3000	1.14	
Treatment	9	10.6667	1.1852	4.51	0.003
Residual	18	4.7333	0.2630		
Total	29	16.0000			

Variate: plant height at week 5 garden eggs 2

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	4.8260	2.4130	2.77	
Treatment	9	183.0763	20.3418	23.38	<.001
Residual	18	15.6607	0.8700		
Total	29	203.5630			

Variate: height 7

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.4047	0.7023	0.78	
Treatment	9	488.7137	54.3015	60.43	<.001
Residual	18	16.1753	0.8986		
Total	29	506.2937			

Variate: height 9

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	3.741	1.870	1.52	
Treatment	9	219.603	24.400	19.78	<.001
Residual	18	22.206	1.234		
Total	29	245.550			

Variate: fruit diameter mm

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	19.651	9.826	1.29	
Trt	9	77.170	8.574	1.12	0.396
Residual	18	137.468	7.637		
Total	29	234.289			

Variate: fruit length mm					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	37.54	18.77	1.81	
Trt	9	156.35	17.37	1.68	0.167
Residual	18	186.38	10.35		
Total	29	380.27			

Variate: number of fruits					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	38.22	19.11	1.85	
Trt	9	441.87	49.10	4.74	0.002
Residual	18	186.38	10.35		
Total	29	666.47			

Variate: number of fruits					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.0615	0.5308	1.85	
Trt	9	12.2742	1.3638	4.74	0.002
Residual	18	5.1772	0.2876		
Total	29	18.5129			

Variate: weight kg					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.06323	0.03161	1.87	
Trt	9	1.58020	0.17558	10.38	<.001
Residual	18	0.30443	0.01691		
Total	29	1.94786			

Variate: weight g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1756.3	878.2	1.87	
Trt	9	43894.4	4877.2	10.38	<.001
Residual	18	8456.5	469.8		
Total	29	54107.2			

Variate: weight g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	63227.	31614.	1.87	
Trt	9	1580200.	175578.	10.38	<.001
Residual	18	304433.	16913.		
Total	29	1947860.			

Variate: height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	115.57	57.78	3.46	
Treatment	9	95.97	10.66	0.64	0.751
Residual	18	300.96	16.72		
Total	29	512.50			

Variate: girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	5.7564	2.8782	7.79	
Treatment	9	8.7878	0.9764	2.64	0.038
Residual	18	6.6482	0.3693		
Total	29	21.1923			

Variate: branches					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	6.1399	3.0699	6.88	
Treatment	9	13.4187	1.4910	3.34	0.014
Residual	18	8.0366	0.4465		
total	29	27.5952			

Variate: leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	823.88	411.94	11.97	
Treatment	9	909.52	101.06	2.94	0.025
Residual	18	619.24	34.40		
Total	29	2352.63			

Variate: chlorophyll					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	248.71	124.35	3.42	
Treatment	9	400.69	44.52	1.23	0.339
Residual	18	653.72	36.32		
Total	29	1303.11			

Variate: height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	633.81	316.91	17.74	
Treatment	9	112.39	12.49	0.70	0.702
Residual	18	321.48	17.86		
Total	29	1067.68			

Variate: girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.5106	1.2553	5.26	
Treatment	9	10.7758	1.1973	5.01	0.002
Residual	18	4.2978	0.2388		
Total	29	17.5841			

Variate: branches					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.3507	1.1753	3.55	
Treatment	9	10.4592	1.1621	3.51	0.011
Residual	18	5.9640	0.3313		
Total	29	18.7739			

Variate: leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	350.97	175.48	4.26	
Treatment	9	1651.36	183.48	4.46	0.003
Residual	18	740.67	41.15		
Total	29	2743.00			

Variate: chlorophyll					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	21.67	10.83	0.23	
Treatment	9	664.12	73.79	1.56	0.200
Residual	18	849.49	47.19		
Total	29	1535.28			

Variate: fruit diameter/mm					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	19.651	9.826	1.29	
Trt	9	77.170	8.574	1.12	0.396
Residual	18	137.468	7.637		
Total	29	234.289			

Variate: fruit length mm					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	37.54	18.77	1.81	
Trt	9	156.35	17.37	1.68	0.167
Residual	18	186.38	10.35		
Total	29	380.27			

Variate: number fruits					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	38.22	19.11	1.85	
Trt	9	441.87	49.10	4.74	0.002
Residual	18	186.38	10.35		
Total	29	666.47			

Variate: number fruits					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.0615	0.5308	1.85	
Trt	9	12.2742	1.3638	4.74	0.002
Residual	18	5.1772	0.2876		
Total	29	18.5129			

Variate: weight in/kg					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.06323	0.03161	1.87	
Trt	9	1.58020	0.17558	10.38	<.001
Residual	18	0.30443	0.01691		
Total	29	1.94786			

Variate: weight of fruit/g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1756.3	878.2	1.87	
Trt	9	43894.4	4877.2	10.38	<.001
Residual	18	8456.5	469.8		
Total	29	54107.2			

Variate: weight of fruit/g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	63227.	31614.	1.87	
Trt	9	1580200.	175578.	10.38	<.001
Residual	18	304433.	16913.		
Total	29	1947860.			

Variate: weight rruit/g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.031612	0.015806	1.91	
Trt	9	164.224792	18.247199	2206.95	<.001
Residual	18	0.148825	0.008268		
Total	29	164.405230			

Variate: yield ha/g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.756e+11	8.782e+10	1.87	
Trt	9	4.390e+12	4.877e+11	10.38	<.001
Residual	18	8.457e+11	4.698e+10		
Total	29	5.411e+12			

Variate: yield m²					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1756.4	878.2	1.87	
Trt	9	43896.2	4877.4	10.38	<.001
Residual	18	8456.8	469.8		
Total	29	54109.4			

Variate: yield kg/ha					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	175639.	87819.	1.87	
Trt	9	4389619.	487735.	10.38	<.001
Residual	18	845682.	46982.		
Total	29	5410939.			

Garden egg experiment two week 5

Variate: sten_girth_5					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.25113	0.12556	2.73	
Treatment	9	2.33870	0.25986	5.66	<.001
Residual	18	0.82707	0.04595		
Total	29	3.41690			

Variate: leaves 5					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	16.8000	8.4000	15.32	
Treatment	9	57.6333	6.4037	11.68	<.001
Residual	18	9.8667	0.5481		
Total	29	84.3000			

Variate: chlorophyll at week 5					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	219.18	109.59	3.47	
Treatment	9	1124.90	124.99	3.96	0.006
Residual	18	568.52	31.58		
Total	29	1912.60			

Garden egg experiment two week 7

Variate: stem girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.10946	0.05473	0.87	
Treatment	9	5.06903	0.56323	8.98	<.001
Residual	18	1.12894	0.06272		
Total	29	6.30743			

Variate: number of leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	4.467	2.233	0.72	
Treatment	9	122.300	13.589	4.35	0.004
Residual	18	56.200	3.122		
Total	29	182.967			

Variate: chlorophyll content					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	32.49	16.24	1.26	
Treatment	9	1166.44	129.60	10.09	<.001
Residual	18	231.30	12.85		
Total	29	1430.23			

Garden egg experiment two week 9

Variate: stem girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.3054	0.1527	1.50	
Treatment	9	8.0224	0.8914	8.73	<.001
Residual	18	1.8372	0.1021		
Total	29	10.1650			

Variate: leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	5.600	2.800	0.80	
Treatment	9	301.333	33.481	9.56	<.001
Residual	18	63.067	3.504		
Total	29	370.000			

Variate: chlorophyll					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	81.85	40.92	1.62	
Treatment	9	291.04	32.34	1.28	0.312
Residual	18	454.30	25.24		
Total	29	827.19			

Yield of garden egg experiment two

Variate: fruit diameter					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	3.762	1.881	0.33	
Treatment	9	205.218	22.802	3.99	0.006
Residual	18	102.976	5.721		
Total	29	311.956			

Variate: fruit length					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.857	1.428	0.19	
Treatment	9	249.035	27.671	3.66	0.009
Residual	18	136.013	7.556		
Total	29	387.904			

Variate: number of fruits plant					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	174.200	87.100	18.13	
Treatment	9	1003.633	111.515	23.21	<.001
Residual	18	86.467	4.804		
Total	29	1264.300			

Variate: weight kg					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	6637.	3319.	0.72	
Treatment	9	4320568.	480063.	104.36	<.001
Residual	18	82803.	4600.		
Total	29	4410008.			

Variate: shelf life					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.4000	0.7000	1.36	
Treatment	9	6.1333	0.6815	1.32	0.292
Residual	18	9.2667	0.5148		
Total	29	16.8000			

Green pepper experiment one week5

Variate: plant height cm					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	31.339	15.669	15.02	
Treatment	9	373.285	41.476	39.75	<.001
Residual	18	18.779	1.043		
Total	29	423.403			

Variate: girth mm

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr
Rep stratum	2	0.27036	0.13518	1.52	
Treatment	9	1.95938	0.21771	2.45	0.051
Residual	18	1.60223	0.08901		
Total	29	3.83197			

Variate: number of branches

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.	0.		
Treatment	9	0.	0.		
Residual	18	0.	0.		
Total	29	0.			

variate: number of leaves

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	5.006	2.503	0.91	
Treatment	9	252.988	28.110	10.23	<.001
Residual	18	49.484	2.749		
Total	29	307.478			

Variate: chlorophyll content

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	10.64	5.32	0.32	
Treatment	9	394.04	43.78	2.65	0.037
Residual	18	297.19	16.51		
Total	29	701.87			

Green pepper experiment one week7

Variate: plant height cm

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	4.144	2.072	0.69	
Treatment	9	146.359	16.262	5.45	0.001
Residual	18	53.700	2.983		
Total	29	204.203			

Variate: girth mm

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.9600	0.4800	0.49	
Treatment	9	16.9142	1.8794	1.92	0.114
Residual	18	17.5922	0.9773		
Total	29	35.4664			

Variate: number of branches

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.

Rep stratum	2	0.55972	0.27986	3.32	
Treatment	9	1.31852	0.14650	1.74	0.153
Residual	18	1.51898	0.08439		
Total	29	3.39722			

Variate: number of leaves

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	145.79	72.89	2.33	
Treatment	9	577.23	64.14	2.05	0.093
Residual	18	562.95	31.28		
Total	29	1285.97			

Variate: chlorophyll content

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	753.61	376.80	7.03	
Treatment	9	661.67	73.52	1.37	0.271
Residual	18	964.92	53.61		
Total	29	2380.19			

Green pepper experiment one week9

Variate: pant height cm

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	46.83	23.42	2.24	
Treatment	9	120.27	13.36	1.28	0.313
Residual	18	188.10	10.45		
Total	29	355.20			

Variate: girth mm

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	4.210	2.105	0.54	
Treatment	9	58.459	6.495	1.67	0.170
Residual	18	70.039	3.891		
Total	29	132.708			

Variate: number of branches

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.2389	1.1194	3.32	
Treatment	9	5.2741	0.5860	1.74	0.153
Residual	18	6.0759	0.3376		
Total	29	13.5889			

Variate: number leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	297.52	148.76	2.33	
Treatment	9	1178.02	130.89	2.05	0.093
Residual	18	1148.88	63.83		
Total	29	2624.43			

Variate: chlorophyll content					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	286.7	143.4	1.29	
Treatment	9	1562.0	173.6	1.56	0.203
Residual	18	2007.8	111.5		
Total	29	3856.5			

Variate: fruit diameter mm					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	4.937	2.469	0.58	
Treatment	9	33.084	3.676	0.87	0.569
Residual	18	76.282	4.238		
Total	29	114.303			

Variate: fruit length mm					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	54.88	27.44	2.67	
Treatment	9	18.19	2.02	0.20	0.991
Residual	18	185.03	10.28		
Total	29	258.11			

Variate: number of fruits					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	9.253	4.627	0.57	
Treatment	9	51.214	5.690	0.70	0.698
Residual	18	145.417	8.079		
Total	29	205.884			

Variate: number of fruits plants					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.2570	0.1285	0.57	
Treatment	9	1.4226	0.1581	0.70	0.698
Residual	18	4.0394	0.2244		
Total	29	5.7190			

Variate: weight of fruit kg					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.30780	0.15390	2.47	
Treatment	9	0.51948	0.05772	0.93	0.525
Residual	18	1.12058	0.06225		
Total	29	1.94786			

Variate: weight fruit					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	184.24	92.12	7.76	
Treatment	9	184.75	20.53	1.73	0.154
Residual	18	213.58	11.87		
Total	29	582.58			

Variate: weight of fruit plant/g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	8550.	4275.	2.47	
Treatment	9	14430.	1603.	0.93	0.525
Residual	18	31127.	1729.		
Total	29	54107.			

Variate: weight of fruit/g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	307803.	153901.	2.47	
Treatment	9	519480.	57720.	0.93	0.525
Residual	18	1120577.	62254.		
Total	29	1947860.			

Variate: yeld m^2/g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1938.9	969.4	2.47	
Treatment	9	3272.2	363.6	0.93	0.525
Residual	18	7058.6	392.1		
Total	29	12269.7			

Variate: yield ha/g					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.939e+11	9.694e+10	2.47	
Treatment	9	3.272e+11	3.636e+10	0.93	0.525
Residual	18	7.059e+11	3.921e+10		
Total	29	1.227e+12			

Variate: yield/kg					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	193887.	96944.	2.47	
Rep.*units* stratum					
Treatment	9	327224.	36358.	0.93	0.525
Residual	18	705859.	39214.		
Total	29	1226970.			

Green pepper experiment two, week 5

Variate: number of days to 50% flowering					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	5.2667	2.6333	5.43	
Treatment	9	222.1667	24.6852	50.88	<.001
Residual	18	8.7333	0.4852		
Total	29	236.1667			

Variate: plant height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	125.59	62.80	6.16	
Treatment	9	113.73	12.64	1.24	0.332
Residual	18	183.42	10.19		
Total	29	422.75			

Variate: plant stem girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	4.5760	2.2880	4.88	
Treatment	9	4.0299	0.4478	0.95	0.506
Residual	18	8.4428	0.4690		
Total	29	17.0488			

Variate: number of leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	110.96	55.48	1.25	
Treatment	9	432.86	48.10	1.08	0.422
Residual	18	801.16	44.51		
Total	29	1344.97			

Variate: number of branches					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	11.1359	5.5679	20.42	
Treatment	9	2.4918	0.2769	1.02	0.464
Residual	18	4.9077	0.2726		
Total	29	18.5354			

Variate: chlorophyll content					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	214.7	107.4	0.37	
Treatment	9	2438.9	271.0	0.94	0.517
Residual	18	5198.7	288.8		
Total	29	7852.3			

Green pepper experiment 2, week 7

Variate: plant height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	149.34	74.67	2.92	
Treatment	9	220.48	24.50	0.96	0.503
Residual	18	460.08	25.56		
Total	29	829.89			

Variate: girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.7346	1.3673	1.56	
Treatment	9	4.6436	0.5160	0.59	0.790
Residual	18	15.7955	0.8775		
Total	29	23.1737			

Variate: number of branches					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.8000	0.4000	1.10	
Treatment	9	2.9667	0.3296	0.91	0.539
Residual	18	6.5333	0.3630		
Total	29	10.3000			

Variate: number of leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	414.9	207.4	1.12	
Treatment	9	2189.5	243.3	1.32	0.296
Residual	18	3329.8	185.0		
Total	29	5934.2			

Variate: plant height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	149.34	74.67	2.92	
Treatment	9	220.48	24.50	0.96	0.503
Residual	18	460.08	25.56		
Total	29	829.89			

Green pepper experiment 2, week 9

Variate: plant height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	119.15	59.57	1.14	
Treatment	9	414.06	46.01	0.88	0.557
Residual	18	936.74	52.04		
Total	29	1469.94			

Variate: girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.517	1.259	0.47	
Treatment	9	7.682	0.854	0.32	0.957
Residual	18	47.905	2.661		
Total	29	58.104			

Variate: number of branches					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	431.7	215.8	1.06	
Treatment	9	2377.9	264.2	1.30	0.305
Residual	18	3672.3	204.0		
Total	29	6481.9			

Variate: number of branches					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.0000	0.0000	0.00	
Treatment	9	2.3000	0.2556	1.15	0.381
Residual	18	4.0000	0.2222		
Total	29	6.3000			

Variate: plant height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	119.15	59.57	1.14	
Treatment	9	414.06	46.01	0.88	0.557
Residual	18	936.74	52.04		
Total	29	1469.94			

Variate: number of fruits					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	31.40	15.70	1.39	
Treatment	9	114.00	12.67	1.13	0.395
Residual	18	202.60	11.26		
Total	29	348.00			

Variate: yield/ kg/ha					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	11165918.	5582959.	2.32	
Treatment	9	43511589.	4834621.	2.01	0.099
Residual	18	43227722.	2401540.		
Total	29	97905229.			

Variate: shelf life					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.2667	0.6333	1.54	
Treatment	9	8.7000	0.9667	2.35	0.059
Residual	18	7.4000	0.4111		
Total	29	17.3667			

Variate: fruit diameter					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	11.049	5.524	0.57	
Treatment	9	173.322	19.258	1.99	0.102
Residual	18	174.051	9.670		
Total	29	358.422			

Variate: fruit length					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	44.62	22.31	1.64	
Treatment	9	140.35	15.59	1.14	0.384
Residual	18	245.29	13.63		
Total	29	430.26			

Variate: height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr
Rep stratum	2	192.24	96.12	6.07	
Treatment	9	117.65	13.07	0.83	0.601
Residual	18	284.85	15.82		
Total	29	594.74			

Variate: girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.6024	1.3012	2.79	
Treatment	9	4.3597	0.4844	1.04	0.449
Residual	18	8.4004	0.4667		
Total	29	15.3625			

Variate: branches

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.12407	0.06204	1.20	
Treatment	9	0.41574	0.04619	0.89	0.550
Residual	18	0.93148	0.05175		
Total	29	1.47130			

Variate: leaves

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	15.672	7.836	1.57	
Treatment	9	96.922	10.769	2.15	0.079
Residual	18	90.050	5.003		
Total	29	202.644			

Variate: chlorophyll content

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	80.48	40.24	2.70	
Treatment	9	539.36	59.93	4.02	0.006
Residual	18	268.04	14.89		
Total	29	887.88			

Variate: days to 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr
Rep stratum	2	1.800	0.900	0.75	
Trt	9	119.467	13.274	11.10	<.001
Residual	18	21.533	1.196		
Total	29	142.800			

Variate: days to flower

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.2000	0.1000	0.17	
Treatment	9	122.0333	13.5593	23.32	<.001
Residual	18	10.4667	0.5815		
Total	29	132.7000			

Variate: shelf life

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.6000	0.3000	1.14	
Treatment	9	10.6667	1.1852	4.51	0.003
Residual	18	4.7333	0.2630		
Total	29	16.0000			

Variate: plant height at week 5 garden eggs

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	4.8260	2.4130	2.77	
Treatment	9	183.0763	20.3418	23.38	<.001
Residual	18	15.6607	0.8700		
Total	29	203.5630			

Variate: height 7

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.4047	0.7023	0.78	
Treatment	9	488.7137	54.3015	60.43	<.001
Residual	18	16.1753	0.8986		
Total	29	506.2937			

Variate: height 9

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	3.741	1.870	1.52	
Treatment	9	219.603	24.400	19.78	<.001
Residual	18	22.206	1.234		
Total	29	245.550			

Variate: fruit diameter /mm

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	19.651	9.826	1.29	
Trt	9	77.170	8.574	1.12	0.396
Residual	18	137.468	7.637		
Total	29	234.289			

Variate: fruit length mm

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	37.54	18.77	1.81	
Trt	9	156.35	17.37	1.68	0.167
Residual	18	186.38	10.35		
Total	29	380.27			

Variate: number fruits

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	38.22	19.11	1.85	
Trt	9	441.87	49.10	4.74	0.002
Residual	18	186.38	10.35		
Total	29	666.47			

Variate: number fruit

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1.0615	0.5308	1.85	
Trt	9	12.2742	1.3638	4.74	0.002
Residual	18	5.1772	0.2876		
Total	29	18.5129			

Variate: weight in kg

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	0.06323	0.03161	1.87	
Trt	9	1.58020	0.17558	10.38	<.001
Residual	18	0.30443	0.01691		
Total	29	1.94786			

Variate: weight of fruit/g

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	1756.3	878.2	1.87	
Trt	9	43894.4	4877.2	10.38	<.001
Residual	18	8456.5	469.8		
Total	29	54107.2			

Variate: weight of fruit/g

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
rep stratum	2	63227.	31614.	1.87	
Trt	9	1580200.	175578.	10.38	<.001
Residual	18	304433.	16913.		
Total	29	1947860.			

Variate: height

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	115.57	57.78	3.46	
Treatment	9	95.97	10.66	0.64	0.751
Residual	18	300.96	16.72		
Total	29	512.50			

Variate: girth

Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	5.7564	2.8782	7.79	
Treatment	9	8.7878	0.9764	2.64	0.038
Residual	18	6.6482	0.3693		
Total	29	21.1923			

Variate: branches					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	6.1399	3.0699	6.88	
Treatment	9	13.4187	1.4910	3.34	0.014
Residual	18	8.0366	0.4465		
Total	29	27.5952			

Variate: leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	823.88	411.94	11.97	
Treatment	9	909.52	101.06	2.94	0.025
Residual	18	619.24	34.40		
Total	29	2352.63			

Variate: chlorophyll content					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	248.71	124.35	3.42	
Treatment	9	400.69	44.52	1.23	0.339
Residual	18	653.72	36.32		
Total	29	1303.11			

Variate: height					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	633.81	316.91	17.74	
Treatment	9	112.39	12.49	0.70	0.702
Residual	18	321.48	17.86		
Total	29	1067.68			

Variate: girth					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.5106	1.2553	5.26	
Treatment	9	10.7758	1.1973	5.01	0.002
Residual	18	4.2978	0.2388		
Total	29	17.5841			

Variate: branches					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	2.3507	1.1753	3.55	
Treatment	9	10.4592	1.1621	3.51	0.011
Residual	18	5.9640	0.3313		
Total	29	18.7739			

Variate: leaves					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	350.97	175.48	4.26	
Treatment	9	1651.36	183.48	4.46	0.003
Residual	18	740.67	41.15		
Total	29	2743.00			

Variate: chlorophyll content					
Source of variation	d.f.	s.s.	m.s.	v.r.	f pr.
Rep stratum	2	21.67	10.83	0.23	
Treatment	9	664.12	73.79	1.56	0.200
Residual	18	849.49	47.19		
Total	29	1535.28			