KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

FACULTY OF AGRICULTURE

DEPARTMENT OF CROP AND SOIL SCIENCES

THE EFFECTS OF POULTRY MANURE AND NPK FERTILIZER ON HYDROLOGICAL AND PHYSICAL PROPERTIES, GROWTH AND YIELD OF GARDEN EGGS (*Solanum melongena*) IN A SANDY SOIL

BY

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MAY, 2010

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A THESIS SUBMITTED TO THE DEPARTMENT OF CROP AND SOIL SCIENCES
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BY
KHALID ABDUL AZIZ

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DECLARATION

I, Khalid Abdul Aziz, declare that I personally undertook this project and it has not been produced anywhere for award of a degree except other people`s works cited which have been dully acknowledged.

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(Crop and Soil Sciences)

DEDICATION

I dedicate this dissertation to my mother, Hawa Boahemaa and my late father Khalid Ibrahim

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ABSTRACT

Field experiment was conducted during the rainy season at the experimental field of the Department of Horticulture, Faculty of Agriculture, Collage of Agriculture and Renewable Natural Resources, KNUST to test the effects of poultry manure and NPK fertilizer on the hydrophysical properties of a sandy soil, growth and yield of garden eggs. There were five treatments with five replications. The experiment was laid in Randomized Complete Block Design. Data were collected on the following soil physical and hydraulic properties: bulk density, total porosity, aeration porosity, gravimetric water content, volumetric water content, infiltration amount, sorptivity, aggregate stability, steady state infiltrability and hydraulic conductivity. Plant height, leaf area index and yield were the plant parameters collected on the garden eggs. The poultry manure decreased the dry bulk density, increased the total porosity, increased the moisture content, decreased infiltration amount and hydraulic conductivity. On the other hand plant height, leaf area index and yield increased with increase poultry manure application. However, there were no significant improvement in aggregate stability and aeration porosity. The mineral fertilizer did not show any significant improvement in any of the parameters. Poultry manure was therefore found to improve the hydrophysical properties of the sandy soil, growth and yield of garden eggs. The significant decreases in water entry and movement suggest that poultry manure application can minimize excessive leaching of plant nutrients in sandy soil.

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CHAPTER ONE

INTRODUCTION

The garden eggs (*Solanum melongena*) is one of the major vegetables grown in West Africa. The local types as well as the aubergine (exotic types) are cultivated but the local types are more common in West African countries (Norman, 1992). The crop is known by several names like aubergine and egg plant in Europe and United States, "bringal" in South East Asia and it is only known as garden eggs in West Africa (Obeng-Ofori *et al*., 2007). The crop is grown for either the immature fruits or leaves depending on the locality. The immature fruits are either eaten raw or cooked (PROTA, 2004). The crop is cultivated in tropical Africa, tropical Asia, and tropical America and through out tropical and subtropical areas (Tindall, 1992).

The eggplant is an important vegetable due to its nutrient value. It is well adapted to the tropical climate and its growth is affected by nitrogen and phosphorus availability (Mengle and Kirkby, 1987). Nitrogen deficiency affects growth of new leaves and stem and phosphorus deficiency affects fruit formation.

Nitrogen is very important for plant growth because it is part of protein and nucleic acid which are basic component of plant protoplasm and chlorophyll, which are indispensable for photosynthesis. Phosphorus is also an essential element of plant structure as well as component of energy compound like Adenosine Tri-Phosphate (ATP) (Marschner, 1995). Over supply of nitrogen has negative impact on the quality of the fruit. Both the colour and flavour of fruits may be poor and sugar and vitamin content of certain vegetables are adversely affected by excessive nitrogen.

Fertilizers have been established to be important in *Solanum* species cultivation (Olaniyan and Nwachukwu, 2003) .While nitrogen is important in vegetative development, phosphorus is needed to stimulate flowering and fruit formation while potassium is for seed setting. NPK fertilizer is therefore needed for good crop yield in *Solanum* species (Ojo and Olufolaji, 1999).

However, before nutrients in the soil can be taken by plants, the soil physical properties must be in good condition to enhance free flow of water and nutrients in the soil.

In contemporary agriculture, soil must be resistance to various forms of degrading factors and soil properties must meet the requirement of sustainablity and input – saving crop cultivation technologies (Balesdent *et al*., 2000). These days because of high population densities, continuous farming is replacing bush fallowing which used to add a lot of nutrients and organic mater to the soil. This bush fallowing improves not only the nutrient content but also the hydrophysical properties of the soil. The improvement of the chemical and hydrophysical properties by the bush fallow system is due to the addition of organic matter to the soil. It is therefore important to know the right amendment that may improve physical properties of the soil so as to improve growth and yield of crops (Palojarvi and Nuutinen, 2002).

Also soil physical properties are being destroyed due to continuous farming and excessive use of fertilizer with no added organic matter to the soil. Therefore there is the need to investigate ways of improving the hydrophysical properties of soil to enhance growth, quality and yield of crops.

In order to obtain high yield of garden eggs there is the need to augment the nutrient status of the soil to meet the crop's requirement and thereby maintaining the fertility status of the soil. One of the ways of increasing the nutrient status is by boosting the soil nutrient content either with the use of organic materials such as poultry manure, other animal waste and use of compost with or without inorganic fertilizers (Dauda *et al*., 2008). Poultry manure is relatively resistant to microbial degradation. However, it is essential for establishing and maintaining the optimum soil physical condition for plant growth. Poultry manure is also very cheap and effective as a good source of N for sustainable crop production, but its availability remains an important issue due to its bulky nature, while inorganic fertilizer is no longer within the reach of resource-poor farmers due to its high cost (Rahman, 2000). However, John *et al*. (2004) had advocated for an integrated use of organic manure and inorganic fertilizers for the supply of adequate quantities of plant nutrients required to sustain maximum crop productivity and profitability, while minimizing environmental impact from nutrient use. According to Beckman (1973), the use of manure enhances soil productivity, increases the soil organic carbon content, enhances the activities of soil micro-organisms, improves soil crumb structure and the nutrient status of the soil as well as crop yield. Compost plays a vital role in improving soil properties and sustaining nutrients status.

Many investigators reported that application of composts led to beneficial effect on hydrophysical properties of studied soils such as bulk density, pore size distribution, aggregate stability, soil water retention, hydraulic conductivity and infiltration rate (Wanas, 2002b, Wanas and Omran, 2002). Amelioration of these properties is largely based on increasing organic carbon in the soils (Garcia etal., 1992). It will therefore be beneficial to study the effects of soil amendments on hydrophysical properties of soils, growth and yield of crops.

1.1 GENERAL OBJECTIVE

The overall objective of the work was to assess the effects of different levels of poultry manure combined with NPK on soil stability, water entry and movement in soil and growth and yield of garden eggs.

1.2 SPECIFIC OBJECTIVES

The specific objectives of this work were to:

- Assess the responses of garden eggs to different levels of poultry manure combined with NPK fertilizer in terms of growth and yield.
- Investigate how different levels of poultry manure combined with NPK fertilizer influence the infiltration behavior and saturated hydraulic conductivity of sandy soil growing garden eggs.
- Ascertain the overall effects of different levels of poultry manure combined with NPK fertilizer on aggregate stability, porosity, aeration porosity and water retention in a sandy soil.

CHAPTER TWO

LITERATURE REVIEW

2.1 Garden eggs

2.1.1 Botany

Garden eggisscientifically known as *Solanum melongena* and belongs to the family Solanaceae. (Obeng-Ofori *et al*., 2007). The fruits may be pear shaped, round or long and cylindrical depending on the variety. The local types have white or red fruits. They can grow up to 90cm in height (Norman, 1992). Obeng-Ofori *et al*. (2007) also reported that the plant can attain a height between 0.6to 1.2m and the root may extend to depths from 75 to 90cm in homogeneous soil. Rice *et al*. (1993) reported that the plant can grow up to 1.5m.The Plant Resource of Tropical Africa (PROTA, 2004) reported that the plant can grow up to 2.0 m tall with much branches and alternate simple leaves with petiole up to 11cm long. Thus different plant heights may be obtained under different environment based on the variety.

2.1.2 Climatic requirements

The egg plant is a warm season crop which prefers relatively high temperatures for optimum growth and development. It requires optimum day temperatures of 25-35^{o}C and optimum night temperatures of 20-27^{o}C (Norman, 1992; Obeng-Ofori, *et al*., 2007). Diurnal variation in temperature is not essential and the most satisfactory environmental conditions are normally found in low land coastal areas with stable high temperatures varying from 25-32^{o}C.High soil temperatures are injurious to the root system and can be reduced by mulching. The garden eggs can be grown in both wet and dry season but excessive rainfall will check vegetative growth and flower formation. Elevation of up to 800m is suitable for garden eggs cultivation (Rice *et al*., 1993). Tindall (1992) however reported that the crop can grow at an elevation of 1200m and most cultivars are day neutral.

2.1.3 Soil requirements

The garden eggs requires well-drained soil with good moisture retaining properties. The root system is sensitive to excess water and deep cultivation prior to planting is required (Rice *et al*., 1993). The soil should be rich in organic matter and pH ranging from 5.5 to 6.5 is suitable for good production. The early cultivars grow well in sandy loam soils while the local cultivars do well in clay loam soils (Obeng-Ofori *et al*., 2007). Norman (1992) reported that the crop should be grown on soils that have high organic matter content and soils deficient in organic matter should have compost or green manure incorporated in it at least two weeks before planting. Water logging is likely to cause leaf drop in garden eggs.

2.1.4 Fertilizer requirements

The crop is predominantly produced under rain fed conditions and sufficient organic matter in the soil is needed to retain adequate moisture. Cattle manure has been applied at 15-20 t ha^{-1}per hectare at the time of first ploughing and 350kg per hectare of 15-15-15 NPK compound fertilizer was applied as a split dose ten days after planting and two weeks after, the remaining was applied (Obeng-Ofori *et al*., 2007). According to Norman (1992), 250-400 kg per hectare of 15-15-15 compound fertilizer can be applied before planting in most West African soils and side dressed at 4,8,12, and 16 weeks after planting with sulphate of ammonia or calcium ammonium nitrate at the rate of 80-100kg per hectare because garden eggs occupy the soil for long period. Poultry manure at a rate of 10-20 tha^{-1}can be applied for good yield (PROTA, 2004).

2.1.5 Yield

Yield of garden eggs varies depending on the climate, the variety and the growing techniques. Obeng-Ofori *et al.* (2007) reported yield of up to 15-20 t ha^{-1} in Sudan and Guinea Bissau, 20-30 t/ha in Niger and Cote d`Ivoire, 20-45 t/ha in Kenya and Senegal, 25-35 t/ha in Garbon and 40-50 t/ha in Cape Verde and Mauritania. According to Norman (1992), the local egg plant can give an average yield of about 35-40 fruits per plant weighing between 0.9-1kg per plant. The urbergine types produce 5-10 fruits per plant depending on the cultivar and as the number of fruits produced increases, the size of the fruits decreases. Tindall (1992) also reported that 8-14 fruits per plant may be harvested with fruit size varying from 0.25-0.4kg per fruit with a yield of 2-5 t ha^{-1}. Also one plant may produce about 500g - 8kg of fruits with one fruit weighing about 30-40g. Without irrigation yield of about 5-8 t ha^{-1} can be obtained while with irrigation 12-20 t ha^{-1} can be obtained depending on the cultivar. Improved cultivar and good management of the crop grown under favourable condition may yield 50-80 t ha^{-1} (PROTA, 2004).

2.2 The effects of organic manure on soil hydrophysical properties

2.2.1 Soil bulk density and total porosity

Bulk density is the mass of dry soil per its unit volume, while porosity is the fraction of soil that is occupied by pores. Many people have investigated the responses of soil amendments to the physical properties of soil. Wanas (2006) reported that ploughing only exhibited highest values of soil bulk density against significant reduction with the treatments of ploughing accompanied by applied compost. He also reported an increase in total porosity when compost was applied. Organic matter contributed to improvement in soil physical properties. That is organic matter stabilized soil structure thereby reducing soil bulk density and increasing porosity (Obi and Ebo, 1995). Akanni (2005) reported that soil physical properties such as bulk density and total porosity were improved by cow dung. Compost has led to beneficial effects on hydrophysical properties of soils such as bulk density and pore size distribution (Wanas, 2002b).

Ibrahim and Gaheen (1999) reported that ploughing and/ or composts caused marked changes in soil porosity. Aluko and Oyedele (2005) found insignificant effects of organic waste on soil physical properties and they observed that poultry manure incorporation had no significant effect on bulk density and porosity. Poultry manure additions up to 50 t ha^{-1} improved soil physical properties as indicated by reduction in soil bulk density and increased in total porosity. Bulk density and total porosity reduced and increased with level of manure, respectively (Ewulo *et al*., 2008).Poultry manure improved soil physical properties significantly by reducing soil bulk density and temperature and increasing total porosity in 2004, 2005 and 2006. Yearly application of poultry manure had cumulative positive effect on soil physical properties. This is confirmed by the fact that means of soil bulk density reduced from 2004 to 2006, while porosity increased (Agbede *et al*., 2008).

Poultry manure applications ranging from 10 to 50 t ha^{-1} served to improve moisture availability in soil and reduced soil bulk density which resulted in improved nutrient availability, growth and yield of tomato (Ewulo *et al*., 2008). Adekiya and Ojeniyi (2002) observed that increase in soil bulk density reduced uptake of N, P, K, Ca and Mg by tomato plant in Alfisols of southwestern Nigeria. Therefore improvement in soil physical properties by applications of poultry manure will lead to improvement in up take of nutrients.

Application of municipal waste was found to increase soil porosity (Pagliai *et al*., 1987; Guidi *et al*., 1981).Amendments with organic by-products decreased bulk density measured with or without stones, the values ranged from 1 to 1.25 g cm^{-3} and were directly related to the amount of carbon present in the soil (Sikora *et al*., 2002). Decrease in Bulk density after compost and manure applications was reported by Tester (1990). Vilykis and Satkus (2008) observed that soil amendments of organic and inorganic origin had a greater effect on the improvement of the soil physical properties (bulk density, total and air-filled porosity, structure) in topsoil, than in subsoil. The positive effect of farmyard manure and lime lasted mostly three years and the effect of green manure one to two years after application. Incorporation of amendments into the soil was observed to decrease soil bulk density and increase total porosity in the subsoil during the whole three-year period of study (Vilykis and Satkus 2008)

2.2.2 Hydraulic conductivity and infiltration rate

Hydraulic conductivity of soil is the measure of the ability of the soil to transmit water, and infiltration is the process of water entry into the soil through the surface. Organic manure has beneficial effects on hydrologic properties of soils such as soil hydraulic conductivity and infiltration rate (Wanas, 2002a). Ibrahim and Gaheen (1999) reported that composts caused marked changes on soil infiltration rate. Wanas (2006) reported that there was increase in saturated hydraulic conductivity when compost was applied on a ploughed soil. Application of organic residues significantly decreased hydraulic conductivity in Sudanese poor sandy soil (Mubarak *et al*., 2009).

Diana *et al*. (2008) reported application of organic wastes improved soil hydrologic properties like infiltration rate and hydraulic conductivity. Jiao *et al*. (2006) reported that application of cattle manure at rate of 30 t ha^{-1} or greater significantly increased water stable aggregates of a sandy soil. This implied an improvement of the soil structure which might have positive effects on water retention capacity. Mubarak *et al*. (2009) observed that there was a decrease in water movement in sandy soils amended with organic residues. This offers a better chance for crops to absorb water and nutrients instead of nutrients being leached down rapidly. Zaongo *et al*. (1994) reported that rapid hydraulic conductivity of the Sahelian sandy soils is among the constraints that may limit sustainable production of crops. Wanas and Omran (2006) stated that the application of banana and cotton composts to sandy soil in Egypt resulted in a direct decrease in drainable pores (responsible for water loss under gravity) and consequently, in the reduction of hydraulic conductivity of the soil. Earlier, Kurnar *et al.* (1985) and recent study by Diana *et al*. (2008) reported positive effects of organic wastes on soil water retention and hydraulic conductivity.

2.2.3 Aggregate stability and moisture content

Aggregate stability describes the cohesiveness of soil aggregates and moisture content is the amount of water in the soil which can be expressed either on volume or mass basis.
Composts has led to beneficial effects on hydrophysical properties of soil such as pore size distribution, aggregate stability, and soil water retention (Wanas, 2002b).

Aggregate stability was markedly influenced by ploughing accompanied by composts addition compared to the control treatments (ploughing only) irrespective of the depth of ploughing. It is evident that composts has ability to increase aggregate stability. The vital role of composts for maximizing the efficiency of ploughing is considered one of the major tillage operations in soil management (Wanas, 2006).Adesodun *et al*. (2005) found that application of poultry manure to soil increased soil organic matter content, N and P and aggregate stability. The improvement in soil physical properties was attributable to increase in soil organic matter content. Improved soil moisture-relations associated with poultry manure was attributable to mulching effect of organic matter and improved moisture retention and water acceptance as a result of improved soil structure and macro porosity (Aluko and Oyedele,2005).Poultry manure additions up to 50 t ha^{-1} improved soil physical properties by increasing soil moisture content. Moisture content increased as the level of manure increased (Ewulo *et al*, 2008). Poultry manure improved soil physical properties by increasing moisture content with yearly application giving cumulative positive effect (Agbede *et al*., 2008).

Organic manure was found to improve soil hydraulic and mechanical properties that are important for positive crop responses. Applications of municipal sewage waste composts increased soil permeability and water holding capacity (Mays *et al*., 1973; Epstein, 1975), and decreased penetration resistance (Tester, 1990). Water content measured at –15 bar capillary pressure reflects the ability the soil to retain and transport nutrients and water (Sikora *et al*, 2002). Water content at –15 bar the wilting percentage (WP) is a good predictor of soil water retention (Rawls *et al*., 1982). An increase in WP values due to compost and amendment of other organic application was observed by Serra-Wittling *et al*, (1996). Sikora et al. (2002) observed that all amendments applied resulted in an increased in water content at –15 bars and the largest absolute increase occurred in the soils amended with poultry manure and cattle manure. Gupta *et al*. (1977) observed a linear increase in water content at –15 bars with increasing amounts of sewage sludge applied. The soil moisture content after harvest was observed to be significantly different among treatments. It was found that, application of organic waste had resulted in higher soil moisture content (3 - 4 folds) compared to the control or the fertilizer treatments (Mubarak *et al*., 2009). A preliminary investigation into the water relations confirmed that improved soil water retention was possible in compost incorporated and mulched soils (Uson and Cook, 1995). The benefits to the physical properties of mulched soils were generally manifest in terms of reductions in mid-day topsoil temperature and increased soil water retention status. Literature presents much evidence for a positive influence from soil organic matter amendment on both water retention and thermal regimes of top soils. The reduction in topsoil temperatures are shown to occur under temperate conditions. Likewise, compost mulch improved retention of soil water over a wetter summer, compared with a very dry summer, meaning mulches potentially conserve soil water provided there is adequate precipitation. Incorporation of compost in the topsoil was found to keep soil water contents unchanged, due to increased leaf area which encouraged crop transpiration during the wet part of the year (Movahedi *et al*., 2007).

El-Asswad *et al*. (1993) indicated that olive oil cake significantly increased the ability of two sandy soils to retain water.

2.3 Influence of organic manure on growth and yield of crops

Organic manure has been reported by many researchers to give significant improvement in crop growth and yield. Parameters such as Leaf Area Index (LA1), plant height, nodule dry weight, total dry matter per hectare, number of pods per plant in soybean, increased with the application of poultry manure. Organic manure is a reservoir of nutrients and these nutrients are released during humification, thus supplying the necessary elements for plant growth (Chiezey and Odunze, 2009). The application of organic manure has been observed to consistently increase the yields of horticultural crops such as egg plant (*Solanum melongena*), pepper (*Capsicum annum L*.) and tomatoes (*Lycopersicon esculentus*). Aliyu (2000) obtained highest yields of pepper with 5t Farmyard manure (FYM) + 5t of poultry manure + 50 kg N ha^{-1} or 10t of FYM + 5t of poultry manure. Lombin and Abdullahi, (1997) recommended 3 - 7 t ha^{-1} of organic manure for maize. According to Agbede *et al*, (2008) poultry manure increased plant N, P, K, Ca and Mg status by leaf analysis of sorghum. The manure increased plant height, leaf area, stem girth, number of roots, root weight, shoot weight, 100 seed weight and grain yield in 2004, 2005 and 2006 and at both sites of study.

Poultry manure had positive effects on growth and yield of water melon and this could be due to the fact that poultry manure contained essential nutrient elements associated with high photosynthetic activities and thus promotes roots and vegetative growth (John *et al.*, 2004)

Wanas, (2006) observed that there was significant increase in yield of corn grains under the treatments of ploughing with composts as compared to the treatment of ploughing only, regardless the level of ploughing (i.e., shallow or deep). Incorporation of individual vegetable residues, combined or along with manures had resulted in significantly higher dry matter weight of fodder sorghum compared to the control treatment (Mubarak *et al* 2009). In order to obtain high yield, there is the need to augment the nutrient status of the soil to meet the crop's need and thereby maintaining the fertility of the soil. One of the ways of increasing the nutrient status is either by the use of organic materials such poultry manure, animal waste and use of compost or with the use of inorganic fertilizers (Dauda *et al*., 2005a). Application of poultry manure however at higher application rates improves watermelon yield. Increasing yield of watermelon can thus translate in an increase in the standard of living of farmers who engaged in watermelon production. Also, there is a global trend towards organic farming, the use of poultry manure as a substitution for inorganic fertilizer will help to achieve this aim (Dauda *et al.*, 2008). According to Aliyu (2000), the increase in N as found in poultry manure has its profound effect on the vegetative development of plants and ensures healthy and vigorous growth. Barreto and Dynia (1988) reported that 42 tha^{-1} of cattle manure was economically beneficial to cowpea. The problematic aspect of these high rates of organic manure recommendations is the unavailability of such enormous amounts. Peasant farmers operating at subsistence level or slightly above subsistence cannot generate these quantities of organic manure even for their small plots of less than one hectare. Moreover, apart from unavailability of these high amounts recommended, the quality is also very low due to inadequate storage and handling (Chiezey and Odunze, 2009). According to Wanas (2006) one can suggest the necessity of using compost simultaneously with the ploughing for achieving maximum advantage for improving the physical properties of clayey soil for increasing crop production. Previous research at Wye College, University of London, has established the positive influence of garden waste compost on the yield of maize and this was attributed to nutrient released from compost applied as mulch or incorporated into the topsoil (Lee, 1997). Adediran et al. (2003) compared poultry manure, household, market and farm waste and found that poultry manure at 20 tons per hectare had highest nutrient contents and mostly increased yield of tomato and soil macro and micronutrients content. Akande and Adediran (2004) found that poultry manure at 5 t ha^{-1} significantly increased tomato and dry matter yield, soil pH, N, P, K, Ca and Mg and nutrient uptake. According to Ewulo *et al.*, (2008), 25 t ha^{-1} manure are recommended for maximizing fruit yield of tomato and that increased growth of tomatoes given by 40 and 50t ha^{-1} manure relative to 25 t ha^{-1} manure did not translate into fruit yield can be adduced to dilution effect of excess organic matter and high availability of N which led to vegetative growth at the expense of fruiting. This is explained by the dilution effect of excess N given by 40 and 50 t ha^{-1} manure. Saxena *et al*. (1975) had observedthat high rates of N reduced leaf Ca in tomato and increased blossom-end rot of tomato fruits in Guyana.

Gupta and Shukla (1977) reported an increase in number of fruits and size due to increase in N application. Poultry manure has profound effect on the vegetative development of the plant and ensures healthy and vigorous growth (Aliyu, 2000).Dauda *et al*., (2005b) reported increase in growth with increased poultry manure rates. The yield increase with an increase in poultry manure rates suggests that poultry manure supplies nutrients that enhance vigorous growth that culminates in increase in fruit yield (Dauda et al. 2008). A study carried out by Mtambanengwe and Mapfumo(2006) on sandy soils in Zimbabwe to investigate the effect of organic resource quality on maize yield showed that maize yield increased linearly with total N added in the form of organic matter in combination with N fertilizer. They documented improvements in soil physical properties and in maize yield and showed significant correlations between soil organic matter and porosity, water holding capacity and yield. Gioacchini *et al*. (2006) reported that mixing of hoof and horn with fur and farm yard manure can be a slow release fertilizer.

The application of N a major component of poultry manure has been reported to improve the yield of egg plant (Dauda *et al*., 2005b). Aliyu (2000) reported that the use of farm yard manure (FYM) at 5 t ha^{-1} resulted in higher fruit yield of egg plant.

2.4 Effects of organic fertilizer on soil chemical properties

It is ascertained that improved soil nutrient contents caused by poultry manure addition up to 25 t/ha led to increased uptake of N, P, K, Ca and Mg by tomato plant (Akande and Adediran, 2004).There was reduction in P, K, Ca and Mg concentration after 25 tha^{-1} level of poultry manure and this could be due to high soil acidity due to production of nitrates. Hence it was found that the least soil pH was recorded at40 and 50 t ha^{-1} of manure levels. The relative high soil acidity with application of 40 and 50 t/ha manure should have neutralized availability of cations (K, Ca, Mg) and enhanced fixation of P by Al and Fe ions (Ewulo *et al.*, 2008).The organic matter component of decomposed poultry manure led to the release of nutrients to the soil. Hence it was found that poultry manure increased soil N, P, K, Ca, and Mg significantly (Agbede *et al*.,2008).Akande and Adediran (2004)found that poultry manure at 5 t ha^{-1} significantly increased tomato fruit and dry matter yields, soil pH, N, P, K, Ca and Mg and nutrient uptakes. Gupta *et al*. (1997) observed that poultry manure is a very rich animal manure by given considerable increase in soil organic matter, available P and exchangeable cations and the cumulative effect of poultry manure supports the observation that poultry manure adds organic matter and nutrients to soil.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location and site characteristics

3.1.1 Location

The work was done at the experimental farm of the Department of Horticulture, Faculty of Agriculture, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi Ghana.

3.1.2 Site characteristics

The area is within semi-deciduous forest zone and is subjected to marked wet and dry season with a bimodal rainfall pattern. The two rainfall peaks make two growing seasons possible. There is heavy rainfall in May-June-July, which is interrupted by a dry period of about four weeks in August; this is followed by another period of heavy rainfall from September to October. Dry season length is between 120 -130 days. Annual rainfall is about 1375mm. Annual temperature ranges from 25^{o}C to35^{o}C. The type of soil in the area is the Akroso series of Chromic Lixisol (forest Ochrosols) lying on a lower middle slope catena developed over Cape Coast granite parent material. It is sandy loam and has been cultivated for long time. The soil is well drained with considerable amount of gravel with pH of 4.64 (Ablor, 1992).

3.2 Land Preparation

The field was prepared by clearing the bush. It was then ploughed and harrowed. The field was then lined and pegged. The field was divided into 25 plots with a plot size of 2 m^2. The poultry manure was applied two weeks before planting

3.3 Nursery practices

Nursery beds measuring 2 m long and 1.2 m wide were prepared. Seeds were sown thinly in rows of 10 cm apart. The seeds were nursed in June and transplanted in July. The seed beds were watered and covered with mulch after sowing. After germination the mulch was removed and shade was erected to protect the young seedlings against sunshine. The seedlings were pricked out to avoid overcrowding. The seedlings were watered until they reached transplanting stage.

3.4 Experimental design

There were five treatments in the experiment. The Randomize Complete Block Design was used in designing the experiment. There were five replications. Table 3.1 shows the treatment details of the experiment.

Table 3.1: Treatment detail

Treatment code	Treatments
T1	5 t ha^{-1} of poultry manure with NPK (225 kg ha^{-1})
T2	7 t ha^{-1} of poultry manure with NPK (225 kg ha^{-1})
T3	9 t ha^{-1} of poultry manure with NPK (225 kg ha^{-1})
T4	NPK fertilizer (225 kg ha^{-1})
T5	Control

3.5 Transplanting

The seedlings were transplanted when they were about five weeks old. The seedlings were watered before uprooting for transplanting to soften the soil for easy lifting. The seedlings were lifted and sent to the field for transplanting and watered copiously. The plants were spaced 50 cm by 50 cm with a total of 15 plants per plot size of 2 m^2.

3.6 Cultural practices

The plot was cleared of weeds three times to prevent weeds from competing with the crop for nutrients, sunlight and water. The plants were also watered as and when necessary. The plants were also sprayed with insecticide (Cyprus) to prevent insect attack.

3.7 Soil analysis

Surface (0 – 15 cm) soil samples were taken from each plot before the start of the experiment. The samples were bulked and air-dried for routine analysis as described by Carter (1993). Organic matter (O.M) was determined by Walkley-Black dichromate digestion method (Nelson and Sommers, 1982) and total soil nitrogen was determined by the kjeldahl method (Bremner and Mulvancy, 1982). Available P was determined by Bray-1 method (Murphy and Riley, 1962). Exchangeable K^+, Ca^{2+} and Mg^{2+}were extracted using ammonium acetate. Potassium was determined using the flame photo meter and Ca and Mg by EDTA titration. The soil pH in 0.01 M $CaCl_2$ was determined using a glass electrode.

3.8 Poultry manure analysis

The nutrients were extracted by dry ashing method describe by Piper (1944). Air – dried and ground manure samples were sieved through 2 mm sieve and ignited at 450^{o}C for 2 h, the ash was extracted with HCl. Organic matter (O.M) was determined by Walkley-Black dichromate digestion method (Nelson and Sommers, 1982) and total nitrogen was determined by the kjeldahl method (Bremner and Mulvancy, 1982).The P was determined by ammonium molydate/ammonium vanadate method. Potassium was determined using the flame photometer and Ca and Mg by EDTA titration. The pH in 0.01 M $CaCl_2$ was determined using a glass electrode

3.9 Plant height and Leaf area index

Plant height was measured one week after transplanting with a meter rule. Height measurements were then continued every week until the plant started fruiting. The leaf area was also taken on the same days. The leaf length (L) and width (W) were measured and multiplied by a constant of 0.8 to get the leaf area (A). $A = L \times W \times 0.8$

3.10 Soil moisture content

Moist soil samples were taken from the field two days after a heavy rainfall with the core sampler and sent to the laboratory where they were weighed to find their initial masses. They were then oven-dried at a temperature of 105 ^{o}C to a constant mass M_s. The loss of water upon drying constituted the mass of water Mw contained in the sample. The volumetric water content (θv) was determined from the formula: $\theta v = \theta g.p_b / p_w$,where θg =Mw/Ms thereforeθv = $\theta g.p_b$ (Assuming p_w =1), θg is gravimetric water content. p_b is bulk density of the soil and p_w is the bulk density of water.

3.9 Dry bulk density

The dry bulk density was determined from soil cores collected from the field with core sampler (Klute, 1987). The cylindrical metal sampler (core sampler) with a diameter of 5 cm and a height of 5 cm was driven into the soil vertically with the aid of wooden plank and a mallet to fill the sampler. In order to prevent the compression of the soil, another cylinder of equal diameter was placed directly on top of the sampling cylinder. The sampler and its contents was then removed carefully so as to protect the natural structure and packing of the soil from being disturbed. Soil that extended beyond the sampler was trimmed with a sharp knife. The volume of the soil was taken to be the same as the volume of the cylinder. The cylinders were closed, sent to the laboratory and oven dried at 105 ^{o}C to constant mass. The oven dried soils were weighed and the dried bulk densities were calculated by dividing the oven dried mass (mass of solid component of the soil) by the volume of the soil (that is the cylinder).

3.11 Porosity

Total porosity was calculated by the formula; $f = 1-p_b/ p_s$ where f is total porosity, p_b is bulk density and p_s is particle density (2.65gcm^{-1})

Air filled porosity was calculated by the formula, $af = f - \theta v$ where af is air filled porosity, f is the total porosity and θv is volumetric water content.

3.12 Field infiltration

Field infiltration was measured with a cylinder infiltrometer of a diameter of 10 cm and driven into the soil to depth of 10 cm with the aid of a wooden plank and a mallet. The soil surface was highly mulched with plant debris (dry grass and leaves) to prevent the disturbance of soil surface which could lead to false measurement of infiltration. A constant water level of 5 cm from the soil surface was maintained in the cylinder with water from a 1000 ml measuring cylinder. The vertical infiltration was measured in the cylinder for one hour. The initial infiltration was measured at 30 seconds interval for the first three minutes when infiltration was very fast after which the interval was increased as infiltration slowed down towards the steady state.

3.13 Hydraulic conductivity (Ks)

Core samples were obtained from each field. The saturated hydraulic conductivity measurements were made on the cores in the laboratory using the falling head permeameter method similar to that described by Bonsu and Laryea (1989). In the measurement, a cylinder of the same diameter was fitted to the top of the core to allow imposition of a hydraulic head. The cores were soaked in water overnight or until saturated. A large empty can with perforated bottom was filled with fine gravel. The core was placed on the gravel supported by a plastic sieve. The whole system was placed over a sink in the laboratory and water was gently added to give hydraulic head in the extended cylinder. The fall of the hydraulic head (H_t) at the soil surface was measured as a function of time t using a water manometer with a meter scale. Ks was calculated by the standard falling head equation as:

$$Ks = (AL/A't) \ln (H_0/H_t) \quad (1)$$

Where A is the surface area of the cylinder, A' is the surface area of the soil, H_0 is the initial hydraulic head and L is the length of the soil sample. By rearranging equation (1), a regression of $\ln(H_0/Ht)$ on t with slope $b = KsA'/LA$ was obtained. Since A = A' in this particular case, Ks was simply calculated as:

$$Ks = bL \quad (2)$$

3.14 Textural analysis

The hydrometer method (Klute, 1987) was used in the determination of the textural class. This method was used because it allows for multiple measurements on the same suspension so that detailed particle-size distribution can be obtained with minimum effort. Fifty one grams of air dried soil from each plot were weighed into milk-shake cup bottles. Ten milliliters of 5 % Calgon (Sodium hexametaphosphate) alongside with 100 ml of distilled water were added to the soil. The calgon served as a dispersing agent for the soil particles. The mixture was shaken with a mechanical shaker for 20 minutes. The content was poured into a 1000 ml measuring cylinder, the milk –shake bottle cap was rinsed with distilled water and added to the content to reach the 1000 ml mark. The cylinder with the content was shaken to distribute the particles equally throughout the suspension and first hydrometer and temperature readings were taking after 40 seconds. The suspension was left to stand for 3 hours to allow the soil particles to settle. Hydrometer and temperature readings were taken after three hours and the percent fractions of each soil component was calculated as follows:

$\%Sand = 100-\{H_1+0.2(T_1-20)-2.0\}*2$

$\%Clay = \{H_2 +0.2(T_2-20)-2.0\}*2$

$\%Silt =100-(\%Sand-\%Clay)$,

Where H1 is the first hydrometer reading, H_2 is the second hydrometer reading, T_1 is the first temperature reading and T_2 is the second temperature reading.

The textural class was determined from tracing the point of intersection of the percent composition of any two components of the three (sand, silt, and clay) on the textural triangle.

3.15 Aggregate stability

A modified wet sieving method was used. Soil was sampled from each field and air dried in the laboratory. The aggregate size between 2 and 4 mm were prepared. Twenty grams (20 g) of the aggregates were weighed unto a 0.25 mm sieve. The aggregates were wetted with an atomizer spray. The sieve was immersed in water contained in a basin and manually rotated gently for five minutes. It was ensured that the aggregates on the sieve were totally covered with water during sieving. The wet sieved aggregates were emptied into pyrex beaker and oven dried to a constant mass. Another 20 g sub-sample was weighed and oven dried to a constant mass. After oven drying, the wet sieved aggregates were divided by the sub sample to give the aggregate stability, which was expressed as a percentage.

3.16 Data analysis for field infiltration

Plots of cumulative infiltration amount (I) as a function of time (t) were obtained.

Plots of infiltration rate (i) against time (t) to determine the steady state infiltrability (Ko) were done.

Plots of Cumulative infiltration amount (I) as function of the square root of time ($t^{1/2}$) for the first five minutes were done to determine Sorptivity (S).

3.17 Statistical analysis

The data collected on various parameters were subjected to analysis of variance using Genstat software programme (2010). The means were separated using Least Significant Difference (LSD) at 5 % probability level.

CHAPTER FOUR

RESULTS

Table 4.1 is the results for the analysis of the poultry manure use for the experiment

Table 4.1: The quality of the poultry manure

Nutrients	Percentages	pH
Nitrogen	2.13	6.10
Phosphorus	0.53	
Sodium	1.80	
Calcium	1.43	
Magnesium	1.54	
Organic carbon	18.5	

Table 4.2 is the results of the soil chemical properties before the experiment.

Table 4.2: The chemical properties of the soil before the experiment

Nutrient	
% Organic carbon	0.62
% Organic matter	1.07
% Total Nitrogen	0.12
Exchangeable Cations (cmol/kg)	
Potassium	0.53
Sodium	1.16
Calcium	3.2
Magnesium	1.8
Available phosphorus (mg/kg)	77.78
pH	4.64

4.1 The particle size distribution (texture)

Table 4.3 shows the particle size distribution. The sand content for the plots ranged between 72 and 78%. The clay content ranged between 7.2 and 12.2% while the silt content ranged between 14.8 and 16.8%. Indication from the textural triangle showed that, the soil type for all the treatment plots was sandy loam. Therefore with reference to soil texture the soil at the site was quite uniform. The slight changes in the values of the particle sizes could be attributed to spacial variability due to soil heterogeneity.

Table 4.3: The soil texture after application of treatment

Treatment ($t\ ha^{-1}$)	% Sand	% Clay	% Silt	soil texture
5 t poultry manure +NPK fertilizer	74.0	12.0	14.0	Sandy loam
7 t poultry manure + NPK fertilizer	72.0	11.2	16.8	Sandy loam
9 t poultry manure + NPK fertilizer	72.0	11.2	16.8	Sandy loam
NPK Fertilizer (225 $kgha^{-1}$)	76.0	9.2	14.8	Sandy loam
Control	78.0	7.2	14.8	Sandy loam

4.2 The effects of soil amendment on hydrophysical properties of the soil

4.2.1 The effects of soil amendment on bulk density of the soil

Table 4.4 shows the effects of soil amendments on soil bulk density. The application of 9 t ha^{-1} poultry manure + NPK recorded the lowest bulk density value of 1.36gcm^{-3},while the application of 5 t ha^{-1} poultry manure + NPK and 7 t ha^{-1} poultry manure + NPK gave the same bulk density value of 1.38 gcm^{-3}. The control and NPK fertilizer treatments recorded 1.42 gcm^{-3} and 1.41 gcm^{-3}, respectively. At five per cent probability level the application of 9 t ha^{-1} poultry manure + NPK gave significantly lower bulk density than all the treatments. The 5 t poultry manure + NPK and 7 t poultry + NPK manure applications gave significantly lower bulk density values than the control and the NPK fertilizer treatments. However there was no significant difference between the control and the NPK fertilizer treatmemts.

Table 4.4: The effects of soil amendments on bulk density

Treatments (t ha^{-1})	Bulk Density (g cm^{-3})
5 t poultry manure + NPK fertilizer	1.38 (0.04)
7 t poultry manure + NPK fertilizer	1.38 (0.03)
9 t poultry manure + NPK fertilizer	1.36 (0.04)
NPK Fertilizer (225 kg ha^{-1})	1.41 (0.05)
Control	1.42 (0.04)
LSD (P < 0.05)	0.02
CV (%)	3.4

Figures in bracket represent standard deviation

4.2.2 The effects soil amendments on total porosity and aeration porosity

Table 4.5 shows the effects of soil amendments on total porosity and aeration porosity. The application of 9 t poultry manure + NPK gave the highest total porosity value of 48.7 %, followed by the 5 t poultry manure + NPK and the 7 t poultry manure + NPK which recorded 47.9 % each. The NPK fertilizer treatment and the control recorded 46.8 % and 46.4 %, respectively. At 5 % probability level there were no significant differences between the treatments with poultry manure application. However they were significantly higher than the control and the NPK Fertilizer treatment. Values recorded for control and fertilizer treatments were also not significantly different.

The aeration porosity for the application of 9 t poultry manure + NPK recorded the lowest value of 28.6 % followed by the application of 5 t poultry manure + NPK and 7 t poultry manure + NPK which gave the same value of 28.7 %. The NPK fertilizer and the control recorded the 30.1and 29.0 % respectively. However the values of the aeration porosity of all the treatments did not differ significantly.

Table 4.5: The effects soil amendments on total porosity and aeration porosity

Treatments (t ha^{-1})	Total porosity (%)	Aeration porosity (%)
5 t poultry manure + NPK fertilizer	47.9 (3.5)	28.7 (2.6)
7 t poultry manure + NPK fertilizer	47.9 (3.0)	28.7 (2.4)
9 t poultry manure + NPK fertilizer	48.7 (3.4)	28.6 (2.0)
N.P.K Fertilizer (225 $kgha^{-1}$)	46.8 (3.2)	30.1 (2.5)
Control	46.4 (3.8)	29.0 (2.2)
LSD ($P < 0.05$)	1.2	4.4
CV (%)	4.2	8.0

Figures in bracket represent standard deviation

4.2.3 The effects of soil amendments on field moisture content

Table 4.6 shows the effects of soil amendments on the soil moisture content. The application of 9 t poultry manure + NPK gave the highest value of 0.15 gg^{-1} for the gravimetric water content (moisture content on mass basis) and 20.4 % volumetric wetness. The application of 5 t poultry manure + NPK and 7 t poultry manure + NPK gave the same gravimetric water content value of 0.14 gg^{-1} and volumetric wetness of 19.3 %. The NPK fertilizer also recorded the gravimetric water content value of 0.12 gg^{-1} and volumetric wetness of 17.0 % as the control. At 5 % probability level the treatments with poultry manure application did not differ significantly among themselves. However they were significantly higher than the NPK fertilizer treatments and the control, the values of which did not show significant difference.

Table 4.6: The effects of soil amendments on moisture content

Treatments (t ha^{-1})	Gravimetric water content (gg^{-1})	Volumetric water content (%)
5 t poultry manure + NPK fertilizer	0.14 (0.02)	19.3 (2.5)
7 t poultry manure + NPK fertilizer	0.14 (0.03)	19.3 (2.0)
9 t poultry manure + NPK fertilizer	0.15 (0.02)	20.4 (2.2)
NPK Fertilizer (225 $kgha^{-1}$)	0.12 (0.02)	16.9 (2.6)
Control	0.12 (0.02)	17.0 (2.3)
LSD ($P < 0.05$)	0.02	2.6
CV (%)	9.1	4.3

Figures in bracket represent standard deviation

4.2.4 The effects of soil amendments on the aggregate stability.

Table 4.7 shows the effects of soil amendments on the aggregate stability obtained by the wet-sieving method. The application of 9 t poultry manure + NPK gave the highest value of 55.8 %. The application of 7 t poultry manure + NPK, 5 t poultry manure + NPK, NPK fertilizer and control treatments also gave values of 53 %, 50 %`, 49.3 %, and 49.8 % `respectively. There was no significant difference among the treatments and the control.

Table 4.7: The effects of soil amendments on aggregate stability

Treatments (t ha^{-1})	Aggregate stability (%)
5 t poultry manure + NPK fertilizer	50.8 (4.5)
7 t poultry manure + NPK fertilizer	53.0(5.2)
9 t poultry manure + NPK fertilizer	55.8 (4.0)
N.P.K Fertilizer (225 $kgha^{-1}$)	49.3 (5.0)
Control	49.9 (4.8)
LSD ($P < 0.05$)	9.4
CV (%)	4.3

Figures in bracket represent standard deviation

4.2.5.1 Effects of soil amendments on infiltration and infiltration parameters

Plots of the cumulative infiltration amounts of the various treatments and the control are shown in Figure 1. At one hour duration the control gave the highest value of 257mm. The application of 9 t poultry manure + NPK recorded the lowest infiltration value of 159mm. The application of 5 t poultry manure + NPK, 7 t poultry manure + NPK and NPK fertilizer recorded 198.7mm, 182.9mm and 207.3mm, respectively. The initial infiltration at thirty seconds was also highest in the control which recorded 6.6mm and the 7 t poultry manure recorded the lowest value of 4.7 mm. At thirty seconds the differences between the treatments were not significant but at one hour the control was significantly higher than all the treatments and the 9 t poultry manure was also significantly lower than all the treatments.

(Appendix Table 5)

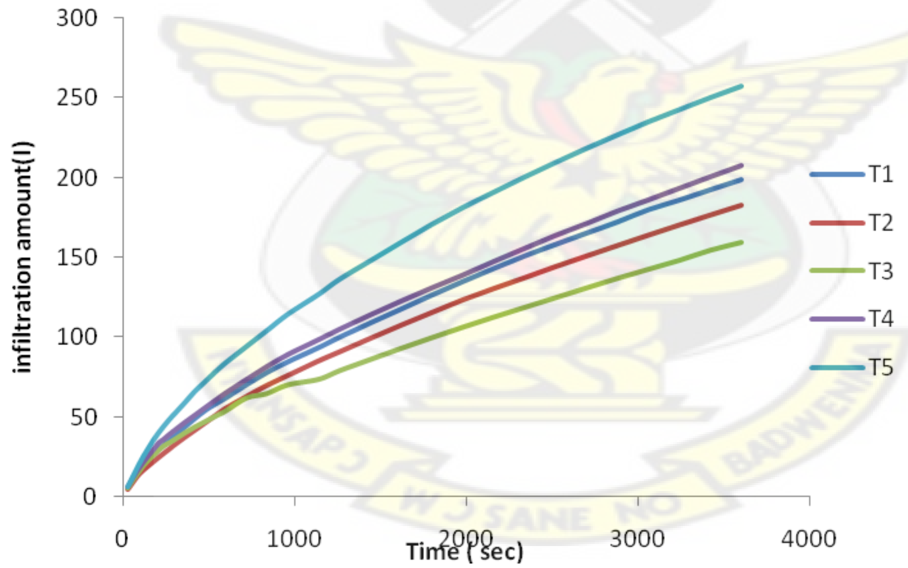

Figure 4.1: The relationship between cumulative infiltration amount (I) and time. (Table 3.1)

4.2.5.2Sorptivity (S)

The plot of cumulative infiltration as function of square root of time for period of five minutes for all the treatments is shown in Figures 4.2a to 4.2e Straight line plots were obtained and the slopes of the graphs gave the values for the sorptivity. Sorptivity is the measure of the ability of the soil to absorb water. The sorptivities were higher in the control and NPK fertilizer treatments without manure than the treatments with poultry manure. (Table 4.8)

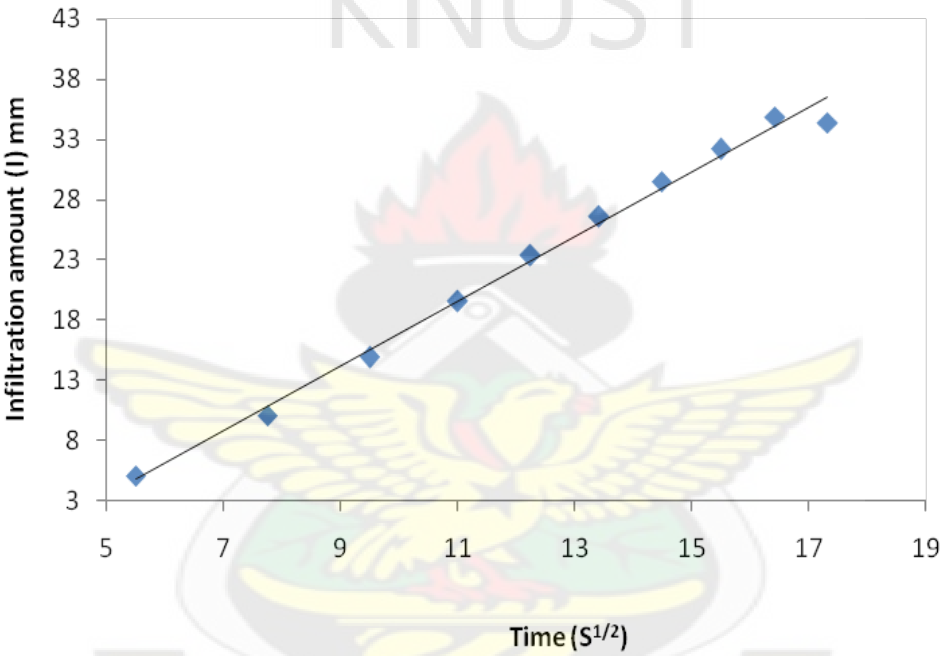

Figure 4.2a: The relationship between cummulative infiltration amount and $t^{1/2}$ for 5 t ha^{-1} of poultry manure for determination of sorptivity

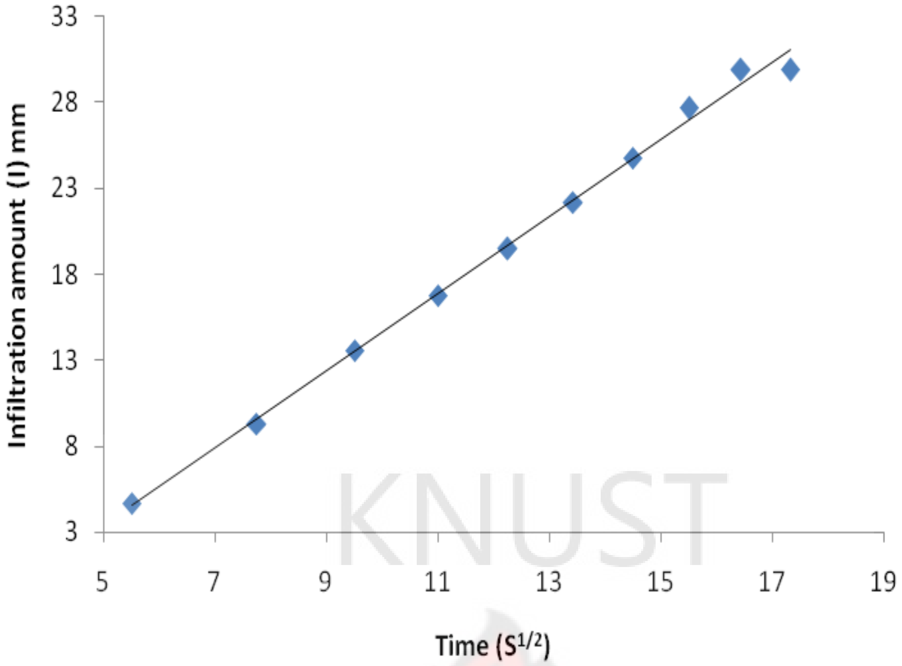

Figure 4.2b: The relationship between cummulative infiltration amount and $t^{1/2}$ for 7 t ha^{-1} of poultry manure for determination of sorptivity

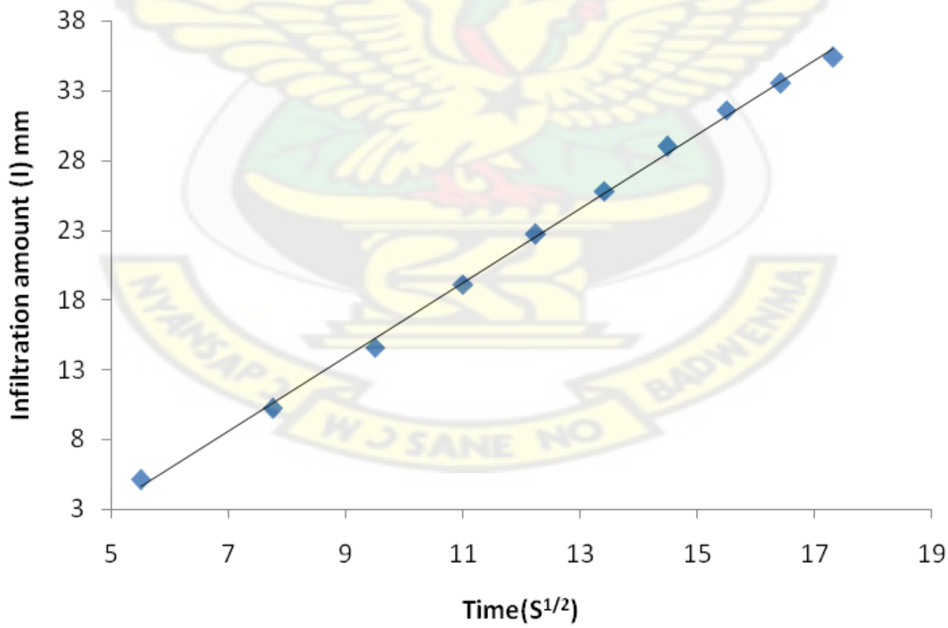

Figure 4.2c: The relationship between cummulative infiltration amount and $t^{1/2}$ for 9 t ha^{-1} of poultry manure for determination of sorptivity

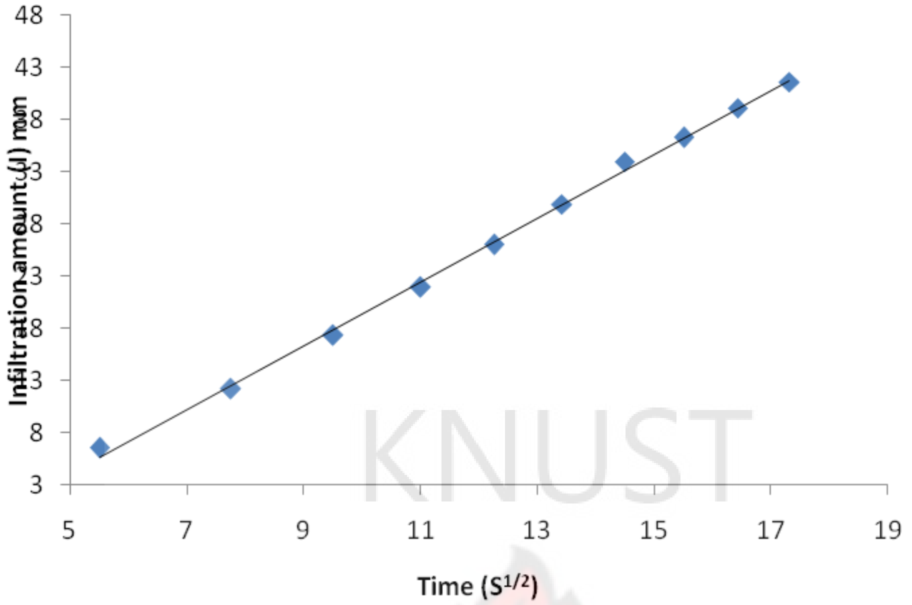

Figure 4.2d: The relationship between cummulative infiltration amount and $t^{1/2}$ for NPK fertilizer for determination of sorptivity

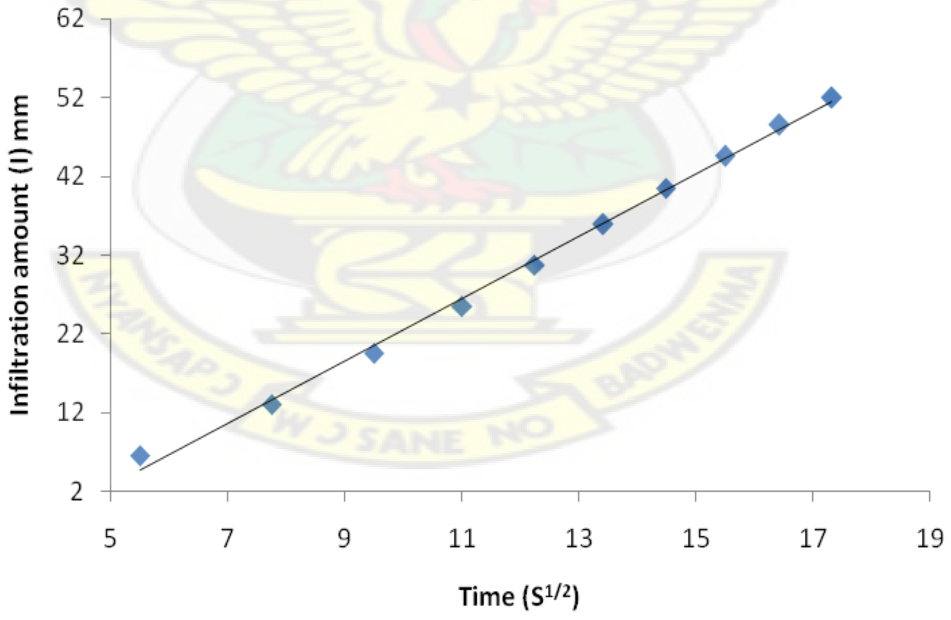

Figure 4.2e: The relationship between cummulative infiltration amount and $t^{1/2}$ for control for determination of sorptivity

4.2.5.3 Steady state infiltrability

The plot of infiltration rates as a function of time for all the treatments are shown in Figure 4.3. The steady state infiltrability (K_0) was determined by extrapolating the line asymptotic to the x-axis to cut the y-axis. The Ko value for the control was the highest and the 9 t application of poultry manure was the lowest. The Ko values ranged from 0.04 mms^{-1} for 9 t poultry manure to 0.07 mms^{-1} for the control. (Table 7)

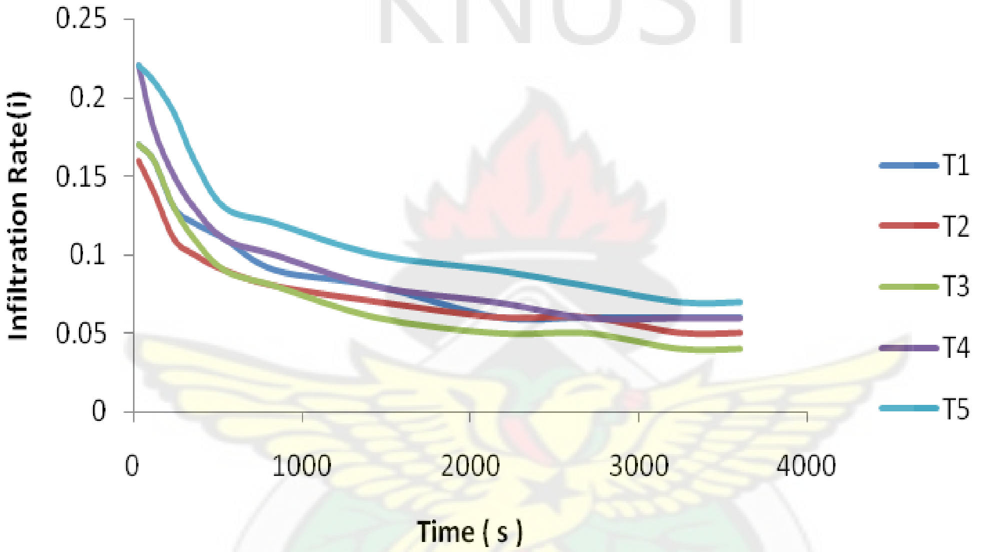

Figure4.3: The relationship between infiltration rate (i) and time (t) for the determination of steady state infiltrability (K_O) (Table 3.1)

Table 4.8: Sorptivity (S) and Steady state infiltrability (K_o)

Treatment (tha^{-1})	**Sorptivity ($mms^{-1/2}$)**	**steady state Infiltrability (mms^{-1})**
5 t poultry manure + NPK fertilizer	2.79	0.06
7 t poultry manure + NPK fertilizer	2.34	0.05
9 t poultry manure + NPK fertilizer	2.65	0.04
NPK Fertilizer (225 $kgha^{-1}$)	3.05	0.06
Control	3.9	0.07

4.2.6 Effects of soil amendments on saturated hydraulic conductivity (Ks)

Table 4.9 shows the effects of soil amendments on saturated hydraulic conductivity. The NPK fertilizer treatment recorded the highest value of $1.72 \times 10^{-4} ms^{-1}$ and the control recorded the second highest of 1.67×10^{-4} m s^{-1}. Saturated hydraulic conductivity values of 1.28×10^{-4}m s^{-1}, 1.20×10^{-4}m s^{-1} and 1.17×10^{-4}m s^{-1} were recorded for 5 t poultry manure + NPK, 7 t poultry manure + NPK and 9 t poultry manure + NPK, respectively. The results showed that Ks decreased as the amount of poultry manure applied increased. The treatments with poultry manure did not differ significantly among themselves. However they were significantly lower than the control and the NPK fertilizer treatments whose values did not differ significantly.

Table 4.9: Effects of soil amendment on hydraulic conductivity

Treatments (t ha^{-1})	**Hydraulic conductivity (ms^{-1})**
5 t poultry manure + NPK fertilizer	1.28×10^{-4}(0.03)
7 t poultry manure + NPK fertilizer	1.20×10^{-4}(0.04)
9 t poultry manure + NPK fertilizer	1.17×10^{-4}(0.02)
NPK Fertilizer (225 kgha^{-1})	1.72×10^{-4}(0.04)
Control	1.69×10^{-4}(0.05)
LSD ($P < 0.05$)0.25×10^{-4}	
CV (%)8.6	

Figures in bracket represent standard deviation

Figure 4.4a to 4.4e show the relationship between log of hydraulic head ratio ln (Ho/Hi) and time (t) for the determination of slope use for the calculation of hydraulic conductivity determined by falling head method in the laboratory.

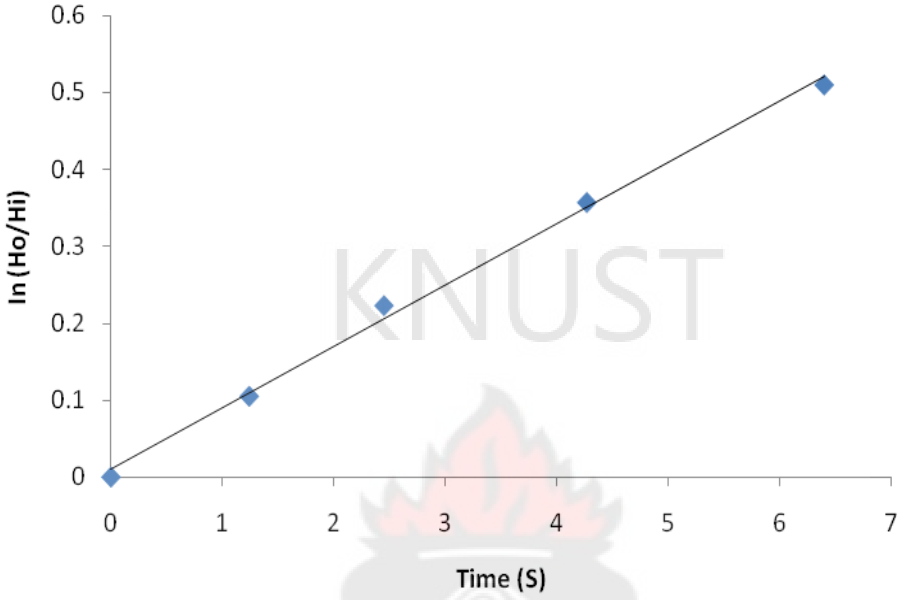

Figure 4.4a: The relationship between In (Ho/Hi) and time (s) for 5 t ha^{-1} poultry manure for determination of Ks

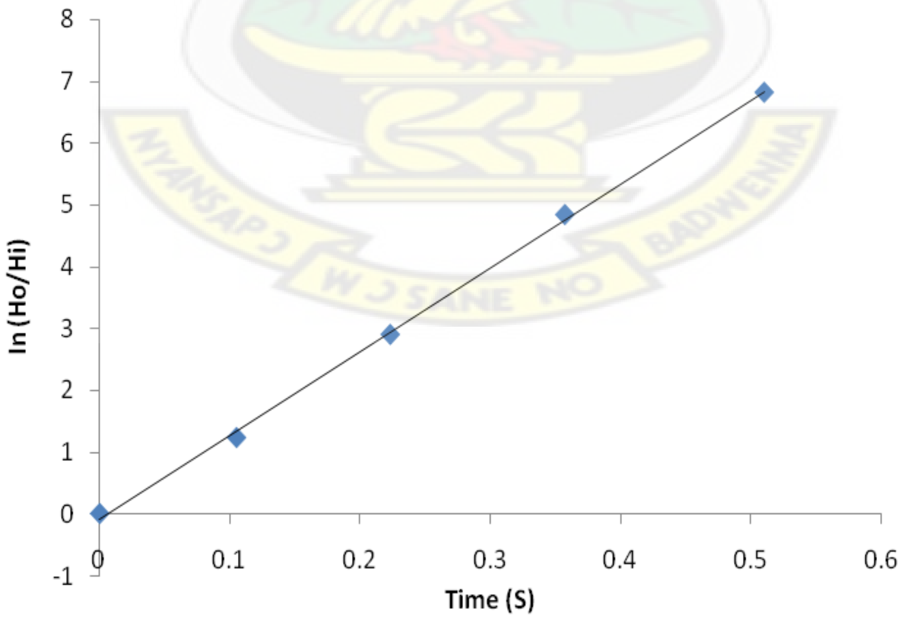

Figure 4.4b: The relationship between In (Ho/Hi) and time (s) for 7 t ha^{-1}poultry manure for determination of Ks

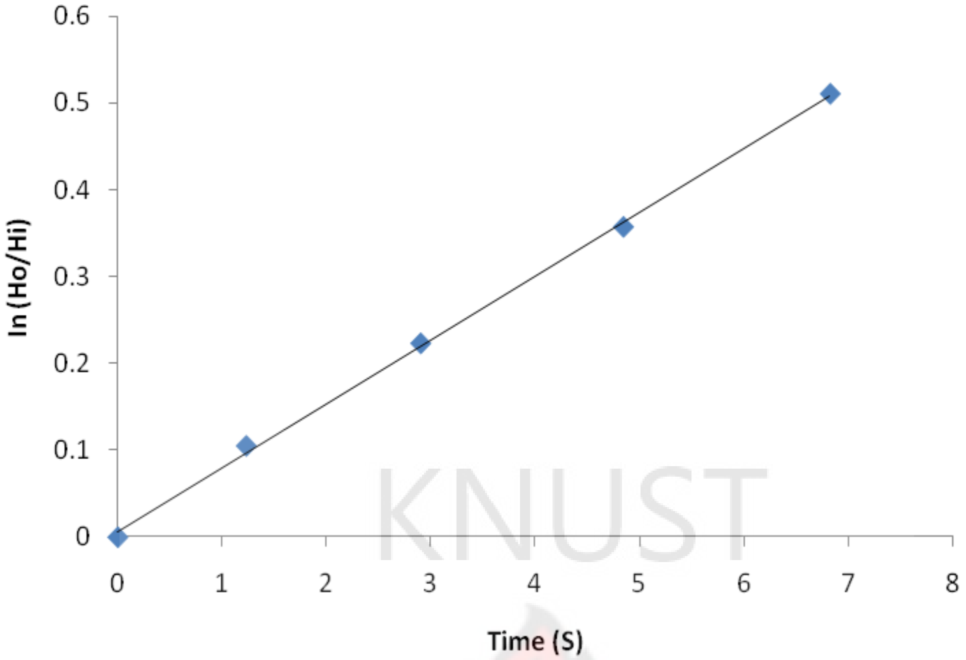

Figure 4.4c: The relationship between In (Ho/Hi) and time (s) for 9 t ha^{-1}poultry manure for determination of Ks

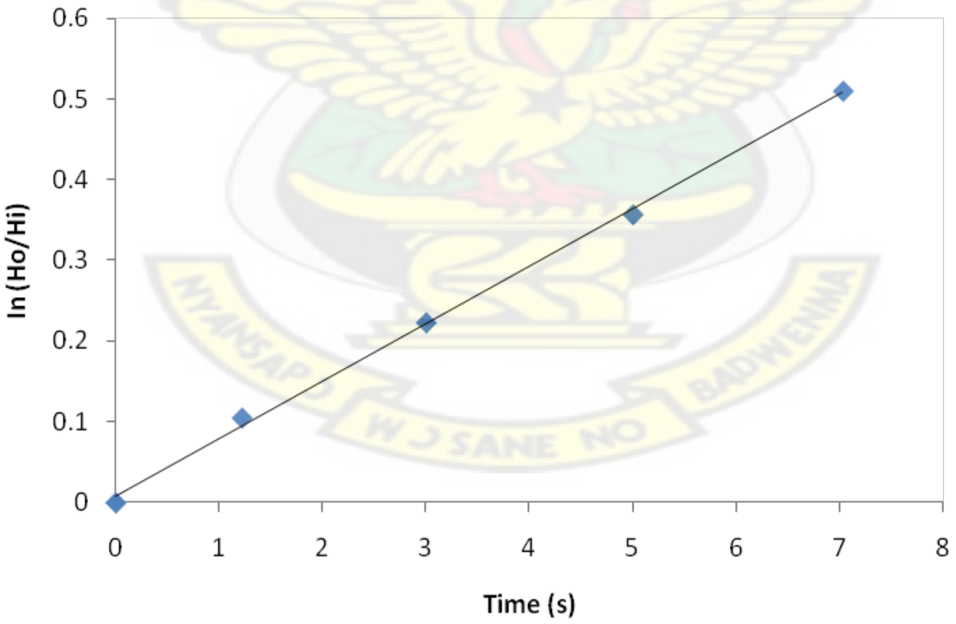

Figure 4.4d: The relationship between In (Ho/Hi) and time (s) forNPK fertilizer for determination of Ks

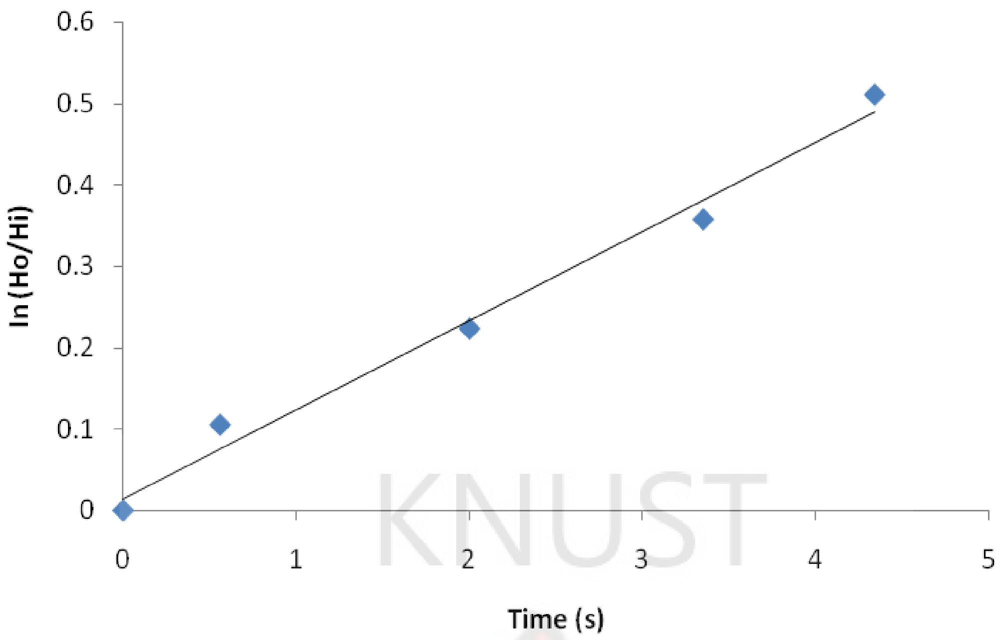

Figure 4.4e: The relationship between In (Ho/Hi) and time (s) for control for determination of Ks

4.3 The effects of soil amendments on growth and yield of garden eggs

4.3.1 The effects of soil amendments on plant height

Figure 4.5 shows the effects of soil amendments on plant height. For the first week all the treatments gave plant height of approximately 7 cm. In the second week the application of 9 t poultry manure + NPK gave the highest plant height value of 11.8 cm and the control gave the lowest value of 9.5 cm. The plant height values of 10.4, 10.9, and 10.1 cm were recorded for 5 t poultry manure + NPK, 7 t poultry + NPK and NPK fertilizer treatments respectively. The 9 t poultry manure + NPK was significantly higher than the control but did not differ from the other treatments. In the third week the following were recorded: 15.1, 15.8, 16.7, 14.2, and 11.7 cm for 5 t poultry manure + NPK, 7 t poultry manure + NPK, 9 t poultry manure + NPK, NPK fertilizer and control, respectively. The 9 t poultry manure + NPK was significantly higher than the control and the NPK fertilizer but did not differ significantly from the other poultry manure treatments which also did not differ significantly from the

NPK fertilizer treatment. In the fourth week application of 9 t poultry manure + NPK continued to record the highest value of 22.8 cm while the control gave the lowest value of 14.0 cm. This week also follow the same trend as in third week in terms of differences except that 9 t poultry manure was significantly higher than 5 t poultry manure. In the fifth and sixth weeks, it also follows the same trend as the previous week. The 9 t poultry manure + NPK recorded the highest value of 30 cm and 38 cm for the fifth and sixth weeks, respectively while the control recorded the lowest values of 18.8 cm and 24 cm for fifth and sixth weeks, respectively.

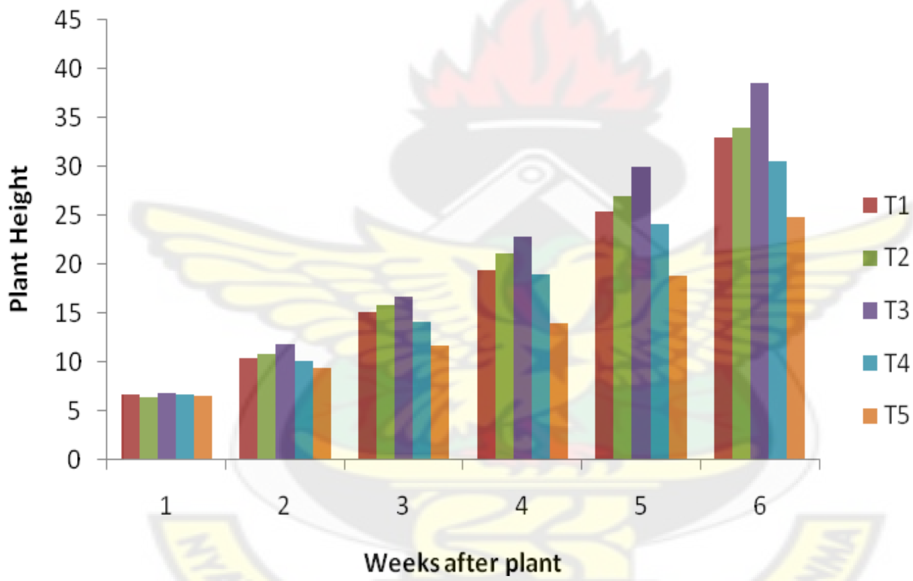

Figure 4.5: Effects of soil amendment on plant height (Table 3.1)

4.3.2 The effects of soil amendments on leaf area index (LAI)

Fig 4.6 shows the effects of soil amendments on leaf area index. In the first week the following recordings were made: 0.023, 0.023, 0.025, 0.025, and 0.025 for 5 t poultry manure + NPK, 7 t poultry manure + NPK, 9 t poultry manure NPK, NPK only and control, respectively. At 5 % probability level there were no significant differences among treatments.

In the second week the application of 9 t poultry manure recorded the highest value of 0.099 while the control gave the lowest value of 0.066. The LAI values of 0.095, 0.096 and 0.080 were obtained for 5 t poultry manure + NPK, 7 t poultry manure +NPK and NPK fertilizer, respectively.

In the third week also the application of 9 t poultry manure + NPK gave the highest value of 0.248. The 5 t poultry manure + NPK, 7 t poultry manure + NPK, NPK fertilizer only and the control recorded 0.223, 0.245, 0.147 and 0.101, respectively. The treatments with poultry manure were significantly higher than the control and NPK fertilizer only.

The fourth, fifth, and sixth weeks also followed the third week trend with 9 t poultry manure + NPK giving the highest values of 0.634, 1.134, 1.398 and the control recording the lowest values of 0.186, 0.474, 0.564, in that order. In the fourth, fifth and sixth weeks there were significant differences between the manure treatments and the other treatments.

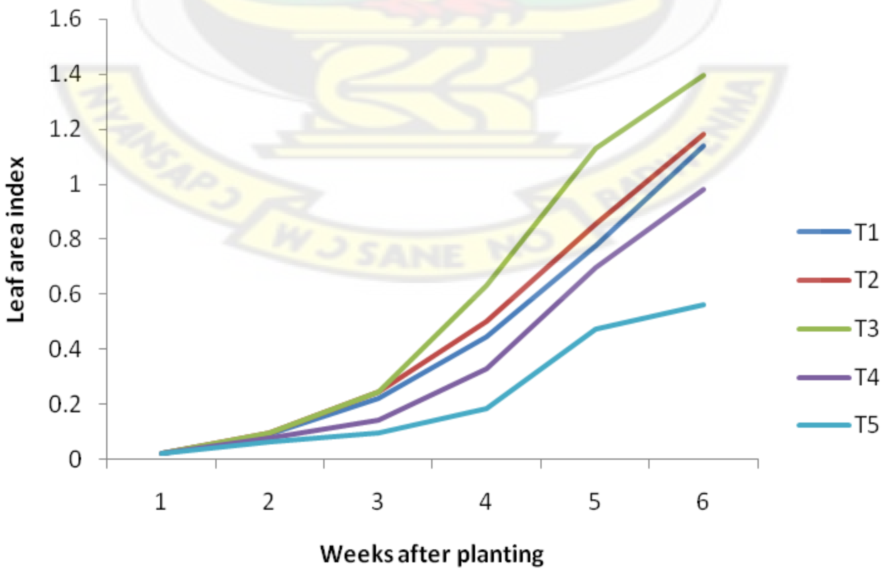

Figure 4.6: Effect of soil amendment on leaf area index (Table 3.1)

4.3.3 The effects of soil amendments on the yield of egg plant

Table 4.10 shows the effects of soil amendments on yield of egg plant. The application of 9 t poultry + NPK manure gave the highest yield of 3.5kg per plant and 262.5 t ha^{-1}. The control recorded the lowest yield of 2.4 kg per plant and 180 t ha^{-1}. At five per cent probability level the application of 9 t poultry manure + NPK was significantly higher than all the other treatments. The 5 t and 7 t poultry manure + NPK were also significantly higher than the control and NPK fertilizer treatments, which did not differ significantly in yield.

Table 4.10: The effects of soil amendments on yield

Treatments t/ha	**Yield per plant (kg)**	**Yield t/ha**
5 t poultry manure + NPK fertilizer	2.8 (0.6)	210
7 t poultry manure + NPK fertilizer	3.1 (0.6)	232.5
9 t poultry manure + NPK fertilizer	3.5 (0.5)	262.5
NPK Fertilizer (225 kgha^{-1})	2.5 (0.3)	187.5
Control	2.4 (0.4)	180
LSD (P < 0.05)	0.3	
CV (%)	29.9	

Figures in bracket represent standard deviation

CHAPTER FIVE

DISCUSSION

5.1 The effects of soil amendments on hydrophysical properties of the soil

5.1.1 Bulk density

The results indicated that the bulk density for the treatments with poultry manure applications were significantly lower than NPK fertilizer treatment and the control, which did not receive any poultry manure. This indicates that poultry manure + NPK has the ability to decrease soil bulk density. It was also observed that increased rate of poultry manure applications resulted in decreasing bulk density because the 9 t application was significantly lower than other poultry manure applications. This is consistent with the earlier studies by Agbede *et al*. (2008) who observed that poultry manure improved soil physical properties significantly by reducing soil bulk density in 2004, 2005 and 2006. They further noted that yearly application of poultry manure had cumulative positive effects on soil physical properties. Ewulo *et al*. (2008) also observed reduction in soil bulk density with different levels of poultry manure application. The reduction in bulk density may be attributed to the fact that the manure is lighter compared to the soil particles and therefore there would be reduction in the mass of the soil to which manure has been added which consequently resulted in the reduction in bulk density.

5.1.2 Total porosity and aeration porosity

The total porosity for the treatments with poultry manure was significantly higher than the control and NPK fertilizer treatments. The reduced bulk density due to the application of poultry manure resulted in higher porosity. It has earlier been reported that poultry manure significantly increased total porosity (Ewulo *et al.*, 2008, Agbede *et al.* 2008.). It was also observed in the present study that increased poultry manure application up to 9 t ha^{-1} significantly gave higher porosity than the 5 t ha^{-1} and 7 t ha^{-1}. This suggests that addition of poultry manure to soils has cumulative positive effect on porosity.

The aeration porosity for the treatments with poultry manure applications were lower than the control and the fertilizer treatment. However the differences were not significant. This could be attributable to the fact that the treatments with poultry manure retained more water hence the low aeration porosity.

5.1.3 Moisture Content

The soils for the treatments with poultry manure significantly retained higher moisture than the control and the treatment with NPK fertilizer. This suggests that poultry manure has the ability to increase soil moisture content. The improvement in soil moisture content could be attributed to increase in organic matter content as a result of poultry manure application. This observation is in line with the work of Adesodun *et al*. (2005) who found that application of poultry manure to soil increased soil organic matter content. Also improvement in soil moisture associated with poultry manure could be due to the mulching effects of the manure which improved moisture absorption and retention as a result of improved soil structure and porosity (Aluko and Oyedele, 2005).

As reported by Ewulo *et al*. (2008), poultry manure additions up to fifty tons per hectare increasing soil moisture content. It can therefore be said that poultry manure is a good source of organic amendment for improving soil moisture content of sandy soils.

5.1.4 Aggregate Stability

The aggregate stability increased with poultry manure application but the differences were not significant. This may be attributed to the short period of the experiment which could not allow enough time for the poultry manure to homogenize with the soil to form stable aggregates. Also the sandy nature of the soil could not favour inter-particle bonding to enable the poultry manure bind the soil particles to form stable aggregates. Wanas (2002b) reported that compost led to the beneficial effects on hydrophysical properties of soil such as pore size distribution, aggregate stability and soil moisture retention. This was possible because the work was done for about three years. Since there has been some increase in aggregate stability as a result of poultry manure application, allowing the experiment to continue for longer time may result in significant increase in the aggregate stability.

5.1.5 Infiltration

The infiltration amount was highest in the control treatment, followed by the NPK fertilizer treatment while the lowest infiltration amount was observed in the application of 9 t poultry manure + NPK. The infiltration amount reduced as the amount of poultry manure application increased. This shows that poultry manure has the ability to reduce the rapid rate of water entry into sandy soil. The reduction in infiltration amount could be attributed to the fact that the poultry manure coated the surfaces of the soil particles thereby reducing the macro pores which favour the rapid infiltration in sandy soil.

The sorptivity and the steady state infiltrability are also higher in the control and the NPK fertilizer treatments and lower in the treatments with poultry manure application. The steady state infiltrability which is the infiltration flux at which free water become available at the soil surface at atmospheric pressure also decreases with increasing level of poultry manure application. This support the finding that poultry manure reduces infiltration rate in sandy soil. This means more water will be retained in the soil pores. Jiao et al. (2006) reported that application of cattle manure significantly increased water stable aggregates of sandy soil; that implies an improvement of soil structure which might have positive effect on water retention capacity of soil.

5.1.6 Hydraulic Conductivity

The hydraulic conductivity was highest in the control and the NPK fertilizer treatments. The hydraulic conductivity also decreased with the increasing level of poultry manure, with the application of 9 t poultry manure + NPK being the least. This indicates that poultry manure can reduce the rapid hydraulic conductivity of sandy soils. This reduction in hydraulic conductivity will improve soil moisture retention and prevent nutrient leaching in sandy soils. This observation confirms the earlier studies by Wanas and Omran (2006) who reported that the application of banana and cotton compost to sandy soil in Egypt resulted in direct decrease in drainable pores and consequently reduction of hydraulic conductivity of the soil.

The poultry manure did not find binding site in order to form new aggregates but rather occupied part of the macro pores which helped in reducing the hydraulic conductivity. Mubarak *et al*. (2009) also stated that application of organic residue significantly decreased hydraulic conductivity of Sudanese poor sandy soil. The present work has confirmed that poultry manure can help decrease hydraulic conductivity of sandy soils. This condition is necessary to improve water retention and reduce excessive leaching of soil nutrients in sandy soils thereby improving crop growth and yield.

5.2 The effect of soil amendments on growth and yield of garden eggs

5.2.1 The effects on growth of garden eggs

The plant height for the first two weeks did not show significant difference except that the application of 9 t poultry manure + NPK was significantly higher than the control at the end of the second week. This shows that the crops did not benefit from the soil amendments in the first two weeks. However from the third week the treatments that received poultry manure and NPK fertilizer significantly grew faster than the control. At the end of the sixth week the plant height increased as the amount of poultry manure application increased. This indicates that the poultry manure in combination with the inorganic fertilizer was able to release enough nutrients for the growth of the garden egg. John *et al*. (2004) reported that poultry manure contains essential nutrient elements associated with high photosynthetic activities and thus promotes roots and vegetative growth.

Also the leaf area index increased significantly from the third week with poultry manure application. This indicates that poultry manure was able to increase the vegetative growth. It has earlier been reported by Aliyu (2000) that poultry manure has profound effect on the vegetative development of garden eggs and it ensures healthy and vigorous growth of the crop. The application of 9 t poultry manure + NPK was also significantly higher than the other amount of poultry manure application. This observation may be due to the release of more nutrients from the highest amount of poultry manure application and also improvement in soil physical properties. Dauda *et al*. (2008) reported that poultry manure promotes vigorous growth, increases meristematic and physiological activities in the plant due to supply of plant nutrient and improvement in soil properties. These often result in the synthesis of more photoassimilates which are used in producing fruits. It can therefore be said that increase in the amount of poultry manure application results in increased in vegetative growth as reported by Dauda *et al.* (2005b).

5.2.2 The effects of soil amendments on yield of garden eggs

The yield of the garden egg increased significantly with the application of poultry manure. The NPK fertilizer alone did not give significant increase in yield. Adediran *et al*. (2003) compared poultry manure, house, market, and farm waste and found that poultry manure at 20 t per hectare had the highest nutrient content and greatly increased the yield of tomato and availability of soil macro-nutrient and micro-nutrients. The significantly high yields obtained in the present study could be attributed to the nutrient content of poultry manure which was translated into high vegetative growth giving rise to high photosynthesis which culminated in the high yield. John *et al*. (2004) also reported that poultry manure had positive effects on growth and yield of water melon which they said could be due to the fact that poultry manure contained essential nutrient elements that favour high photosynthetic activities to promote prolific root and vegetative growth. Yield also increased significantly as the amount of poultry manure increased. This suggests that the higher the amount of application of manure the more the nutrients that are released for the growth and yield of the garden egg. Aliyu, (2002, 2003) had earlier reported significant response in yield to different types of manure rate application.

CHAPTER SIX

Conclusions and Recommendations

6.1 Conclusions

The following conclusions can be drawn from the study:

- Poultry manure releases enough nutrients that supplement mineral fertilizer to result in significant increase in growth and yield of garden eggs.
- Poultry manure serves as good source of organic amendment for the improvement of soil hydrophysical properties of a sandy soil.
- The highest poultry manure application result in the highest growth and yield of garden eggs as well as the highest improvement in hydropysical properties of the sandy soil.
- Poultry manure decrease bulk density, infiltration and hydraulic conductivity of a sandy soil. Thus it can reduce excessive leaching of nutrients in sandy soils which is an advantage.

6.2 Recommendations

- Farmers are advised to add small amount of mineral fertilizer to poultry manure to improve soil properties and enhance crop growth and yield.
- In places where the manure is in abundance, higher rates, about 10 t ha^{-1} may be applied to maximize the needed good effects.
- The study could be repeated for a longer period to ascertain the lasting impact of poultry manure on soil properties.

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Plate 1 the investigator performing infiltration measurement in the field

Plate 2 some egg plants of the treatments in the field

APPENDICES

Appendix I: Analysis of Variance

Variate: Bulk_density

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	4	0.0448160	0.0112040	35.40	
Replication.*Units* stratum					
Treatment	4	0.0119760	0.0029940	9.46	<.001
Residual	16	0.0050640	0.0003165		
Total	24	0.0618560			

Variate: Gravimetric water content

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	4	0.0002742	0.0000685	0.46	
Replication.*Units* stratum					
Treatment	4	0.0029514	0.0007378	4.97	0.008
Residual	16	0.0023750	0.0001484		
Total	24	0.0056006			

Variate: Total_porosity

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	4	0.00797600	0.00199400	23.74	
Replication.*Units* stratum					
Treatment	4	0.00221600	0.00055400	6.60	0.002
Residual	16	0.00134400	0.00008400		
Total	24	0.01153600			

Variate: Volumetric water content

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	4	0.0012692	0.0003173	0.83	
Replication.*Units* stratum					
Treatment	4	0.0067760	0.0016940	4.45	0.013
Residual	16	0.0060868	0.0003804		
Total	24	0.0141320			

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	4	14.74034	3.68509	74.25	
Replication.*Units* stratum					
Treatment	4	4.04574	1.01144	20.38	<.001
Residual	16	0.79406	0.04963		
Total	24	19.58014			

Variate: Aeration porosity

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	4	0.010213	0.002553	2.32	
Replication.*Units* stratum					
Treatment	4	0.013628	0.003407	3.10	0.046
Residual	16	0.017589	0.001099		
Total	24	0.041430			

Variate: Aggregate stability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	3	0.001380	0.000460	0.12	
Replication.*Units* stratum					
Treatment	4	0.006080	0.001520	0.41	0.800
Residual	12	0.044720	0.003727		
Total	19	0.052180			

Appendix II: Tables for the figure

Appendix Table 1: The effects of soil amendments on leaf area index

Treatments t/ha	1 WAP	2 WAP	3WAP	4WAP	5WAP	6WAP
5 t poultry manure + N.P.K fertilizer	0.023	0.095	0.223	0.447	0.776	1.140
7 t poultry manure + N.P.K fertilizer	0.023	0.096	0.245	0.500	0.857	1.180
9 t poultry manure + N.P.K fertilizer	0.025	0.099	0.248	0.634	1.134	1.398
N.P.K Fertilizer	0.025	0.080	0.147	0.331	0.697	0.980
Control	0.025	0.066	0.101	0.186	0.474	0.564
LSD	0.005	0.038	0.047	0.073	0.279	0.301
CV%	23	32	20	12	35	21

Appendix Table 2: Plant height

Treatments t/ha	1 WAP	2 WAP	3WAP	4WAP	5WAP	6WAP
5 t poultry manure + N.P.K fertilizer	6.70	10.40	15.10	19.40	25.40	33.00
7 t poultry manure + N.P.K fertilizer	6.40	10.90	15.80	21.20	27.00	34.00
9 t poultry manure + N.P.K fertilizer	6.80	11.80	16.70	22.80	30.00	38.60
N.P.K fertilizer	6.70	10.10	14.20	19.00	24.20	30.60
Control	6.50	9.50	11.70	14.00	18,8	24.80
LSD	1.45	1.95	2.10	2.81	3.81	3.72
CV%	15.0	8.3	12.7	10.9	13.7	11.4

Appendix Table 3: Cumulative infiltration amount and square root of time for 5min

Square root of time ($S^{1/2}$)	T1	T2	T3	T4	T5
5.5	5.1	4.7	5.1	6.5	6.6
7.75	10.1	9.3	10.2	12.2	13.1
9.5	14.9	13.6	14.6	17.3	19.6
11	19.616.8	19.1	21.925.5		
12.25	23.4	19.5	22.7	26.0	30.8
13.42	26.6	22.2	25.8	29.9	35.9
14.49	29.5	24.8	29.0	33.9	40.5
15.5	32.2	27.4	31.0	36.3	44.6
16.43	34.9	29.9	33.5	39.1	48.5
17.32	37.5	32.5	35.4	41.6	52.0

Appendix Table 4: Cumulative infiltration amount for an hour

Time (s)	T1	T2	T3	T4	T5
30	5.1	4.7	5.1	6.5	6.6
60	10.1	9.3	10.2	12.2	13.1
90	14.9	13.6	14.6	17.3	19.6
120	19.6	16.8	19.1	21.9	25.5
150	23.4	19.5	22.7	26.0	30.8
180	26.6	22.2	25.8	29.9	35.9
210	29.5	24.8	29.0	33.9	40.5
240	32.2	27.4	31.6	36.3	44.6
270	34.9	29.9	33.5	39.1	48.5
300	37.5	32.5	35.4	41.6	52.0
360	43.4	37.3	39.6	46.6	59.0
420	48.8	41.9	43.4	51.3	66.3
480	53.9	46.5	46.8	56.0	72.4
540	57.9	51.1	50.2	60.6	78.5
600	61.7	55.6	53.5	65.2	84.2
720	70.0	63.0	61.6	73.6	94.3
840	77.7	70.0	64.4	81.7	104.3
960	84.3	76.1	69.8	89.1	114.1
1140	93.3	85.3	73.3	98.5	126.9
1260	99.7	90.9	78.5	104.9	136.2
1440	108.7	99.4	85.7	113.9	147.8
1620	117.5	107.7	92.7	122.6	159.4
1800	126.3	115.7	99.4	130.9	170.7
1980	134.8	123.6	106.0	138.9	181.2
2160	144.0	130.7	112.3	147.4	190.8
2340	150.9	137.7	118.4	155.6	200.3
2520	158.1	144.5	124.5	163.7	209.4
2700	165.2	151.1	130.6	171.1	218.2
2880	172.2	157.7	136.6	178.5	226.6
3060	179.2	164.2	142.3	185.9	234.8
3240	185.9	170.2	147.9	193.5	242.4
3420	192.4	176.8	154.2	200.3	249.9
3600	198.7	182.9	159.1	207.3	257.0

Appendix Table 5: Infiltration rate and time (s)

Time (s)	T1	T2	T3	T4	T5
30	0.17	0.16	0.17	0.21	0.22
300	0.13	0.11	0.11	0.14	0.17
600	0.10	0.09	0.09	0.11	0.14
840	0.09	0.08	0.08	0.10	0.12
1440	0.08	0.07	0.06	0.07	0.10
2160	0.07	006	0.05	0.07	0.09
3060	0.06	0.05	0.05	0.06	0.08
3600	0.06	0.05	0.04	0.06	0.07

Appendix Table 6: Hydraulic head ratio (Ho/Hi) and time (S)

Ln(Ho/Hi)	Time				
T1	T2	T3	T4	T5	
0.105	1.24	1.23	1.22	0.56	0.58
0.223	2.45	2.90	3.00	2.00	1.55
0.357	4.27	4.84	5.00	3.35	3.00
0.510	6.4	6.82	7.03	4.34	4.03