UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF AGE OF TRANSPLANTING AND DIFFERENT SPACING ON GROWTH, YIELD AND YIELD COMPONENTS OF PEPPER

REGINALD ASANGALISAH

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A DISSERTATION IN THE DEPARTMENT OF CROPSAND SOIL SCIENCES EDUCATION, FACULTY OF AGRICULTURE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION- WINNEBA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF EDUCATION IN AGRICULTURE (CROP SCIENCE)

SEPTEMBER, 2022

DECLARATION

I do hereby declare that this work submitted is the outcome of my own effort and that in no previous application for a similar degree in Master of Education in Agriculture (Crops and Soil Sciences) in this University or elsewhere has this work been presented, except where due acknowledgement has been made in the text.

ASANGALISAH REGINALD (Student)

Signature……………….....................

Date………………………………….

REV. KWAME NKRUMAH HOPE (Supervisor)

Signature……………….....................

Date………………………………….

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Many thanks to my lovely wife Abayeta Bernice Teni and my mother Ms Winifred Apanka For their supports and encouragement throughout my course of study I say may God richly bless them abundantly.

DEDICATION

This work is dedicated to the Almighty God, my wife Abayeta Bernice Teni, my parent, Ms Winifred Apanka, my sister AsangalisahEulaliaAlimiswon, my little brother Geoffrey AtindanaApatiwon, uncles, aunties and friends.

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ABSTRACT

Chilli pepper (*Capsicum annuum*), a member of solanaceous family is thought to be originated from the Southern America (Alegbejo*et al*., 1999) and is one of the vegetable crops that is highly admired and demanded worldwide because of its nutrient, attractive color and flavor (Kim *et al*.,). According to Grubben and El Tahir (2004) *Capsicum annuum*is consumed all over the world and an important crop as source of vitamins A, E and C. The cultivation of Chilli pepper in West Africa is influenced by its ability to be consumed fresh and as processed spices, therefore its cultivation is important and given much attention in both developed and developing countries, notwithstanding the reported increase in income from this pepper, the average expectation of its product remains low in many of the West African Countries (Dagnoko*et al*., 2007&Grubben and El-Tahir, 2004). The main objective of the study is to determine the effect of age of transplant and spacing effects on growth, yield and yield components of Pepper (*Capsicum annuum* L.). Assess the effect of age of transplant on the growth and yield of pepper. Evaluate the interactive effect of age of transplant and spacing on the yield and yield components of hot pepper.Farmers are encouraged not to grow pepper by using 37 days old of transplanted on 40 cm × 30 cm in other to limit or reduce number of rotten fruits. It is recommended that pepper growers should transplant seedlings on 60 cm × 30 cm for optimum plant establishment and for number of branches for higher yield. Seedling transplanted 37 DAP on 50 cm × 30 cm performed better in days for 50% flowering, days for 50% fruiting, number of fruits per plant. 50 cm × 30 cm produced significantly higher number of branches per plant than other treatments for the entire growing period.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of study

Chilli pepper (*Capsicum annuum*), a member of solanaceous family is thought to be originated from the Southern America (Alegbejo *et al*., 1999)and is one of the vegetable crops that is highly admired and demanded worldwide because of its nutrient, attractive color and flavor (Kim *et al*.,). According to Grubben and El Tahir(2004)*Capsicum annuum*is consumed all over the world and is an important crop as source of vitamins A, E and C. The cultivation of Chilli pepper in West Africa is influenced by its ability to be consumed fresh and as processed spices, therefore its cultivation is important and given much attention in both developed and developing countries, notwithstanding the reported increase in income from this pepper, the average expectation of its product remains low in many of the West African Countries (Grubben and El-Tahir, 2004&Dagnoko*et al*., 2007). FAOSTAT, 2012 reported clearly in support of the thoughts of Dagnoko *et al*.2007and Grubben & El-Tahir, 2004 as much as it was recorded that Ghana and Nigeria produced 110,000 MT and 500,000 MT of *Capsicum annuum*in 2012, meanwhile these two (2) countries are the leading producers of Chilli in West Africa and are ranked 25th and 8thworldwide respectively (FAOSTAT, 2013).

The associated cause of low production of chilli in West Africa includes both pathogenic and non-pathogenic diseases, inadequate knowledge on farm management techniques and the use of unimproved varieties and inappropriate agronomic practices on the farm (Adusei-Fosu & Fiscian, 2012).

Agronomic practices like age of transplant and different spacing in any crop production system is often investigated by growers in other to increase production potential, the transplanting time determines the extent to which crops will be exposed to disease. Islam *et al.* (2010) reported that growth parameters and yield component traits of sweet pepper increased significantly at earlier planting and this was also confirmed by Bevacqua and Vanleeuween (2003).In that of Lee *et al.* (2006), the experiment was conducted to determine the effect of planting distance (in-row spacing) on *Capsicum annuum cv. Sierra Fuego* and it was observed that there was an improvement in the yield per plant with increasing in-row spacing; but yield per unit area increased as in-row spacing decreases. Nasto *et al.*(2009)also observed that there was higher yield with increasing the planting density of bell pepper.

The study was therefore undertaken to assess the effect of ages of transplanting and different spacing on growth, yield and yield component of *Capsicum annuum*.

1.2Problem statement

The production of hot pepper in Ghana is lower than expected; if Nigeria and Ghana are the leading producers of hot pepper in West Africa and their production rate is estimated to be 500,000 MT and 110,000 MT respectively (FAOSTAT, 2012). Ghana's performance on the export market has gone down due to low standards as a result of lack of extension officers in communities to monitor farmer’s activities; lack of improved seeds has been rated as the most important problem contributing to the low standards in the vegetable industry (Weiss, 2012). Farmers with their indigenous knowledge also attribute the poor yield to various reasons, according to their observations and their past experiences; the low production is as a result of using inappropriate cultural practices such as transplant age, geographical location and plant spacing during production (Stofella and Bryan, 2015&Weston, 2018).

1.3 Justification

In order to improve on the morphological development of chili pepper and its overall production, research on the effect of ages of transplanting and different planting spacing on growth, yield and yield components of pepper including reproduction characteristics. Competition for available water and mineral nutrients from the soil and light is greater at high plant population densities. (Alabi *et al.* 2014). This study was conducted in order to use the results to make a recommendation to farmers and to guide farmers in making good choice when selecting a planting spacing in chili pepper cultivation.

1.4Objective of the study

1.4.1 Main objective

The main objective of the study is to determine the effect of age of transplant and spacing effects on growth, yield and yield components of Pepper (*Capsicum annuum* L.)

1.4.2 The specific objectives:

The specific objectives of the study are to:

1. Determine the effect of spacing on the yield of pepper

2. Assess the effect of age of transplant on the growth and yield of pepper

3. Evaluate the interactive effect of age of transplant and spacing on the yield and yield components of hot pepper.

CHAPTER TWO

2.0 LITEERATURE REVIEW

2.1Origin and Distribution of Hot pepper

The origin of *Capsicum* species is extended from Mexico in the North to Bolivia in the South of Latin America, where it has been part of the human diet since about 7500BC (Purseglove *etal*., 1981). Spanish and Portuguese explorers spread pepper around the world. Pepper was introduced to Spain in 1493, England in 1548, and Central Europe in 1585(Felicity moran and Amy troolin, 2022). Then, from Europe, it spread to Asia. Currently, the crop is produced in various countries around the world including India, China, Pakistan, Indonesia, Sri Lanka, Thailand, and Japan in Asia and Nigeria, Uganda and Ethiopia in Africa. India and Indonesia have been the largest producers. Currently China is the main producer and exporter in the world (Produce report, 2017). Hot pepper (*Capsicum annuum* L.) belongs to the genus *Capsicum* and family Solanaceae. The genus consists of approximately 22 wild species and five domesticated species. Among the cultivated species the cultivation of *Capsicum annuum*is the most widely spread all over the world (Berke *etal*., 2005). It is believed to have originated in Central and South America. Peru and Mexico might have been the second centers of origin, after which it was spread into the New World Tropics before its subsequent introduction into Asia and Africa in 1493. Columbus has been given credit for introducing hot pepper to Europe, and subsequently to Africa and Asia. Tropical Asia, tropical Africa and South America (Mexico) and the Caribbean are the main producers. It is a national spice and believed to be introduced to Ethiopia probably by the Portuguese in the 17th century (FetleworkTefferi, 2013).

2.2 Importance of hot pepper

Both hot and sweet peppers are processed into many types of sauces, pickles, relishes and canned products. According to Bosland and Votava (2000), sweet pepper and hot pepper, like tomato and eggplant are rich in vitamins A and C and a good source of B_2, potassium, phosphorus and calcium and both hot and sweet peppers contain more vitamin C than any other vegetable crops. Hot pepper is an important vegetable crop both economically and nutritionally because these are excellent sources of natural colours and antioxidant compounds (Ou*etal*,2002). Wide spectrum of antioxidant vitamins, carotenoids, ascorbic acids, capsaicinoids and phenolic compounds are present in hot pepper fruits (Nwose, 2009). The capsaicinoids are being studied as an effective treatment for a variety of sensory nerve disorders, cystitis and human immune deficiency virus (Perucka and Materska, 2001).According to Bosland and Votava (2000), pepper is the most recommended tropical medication for arthritis and extracts are used in wide range of medicines against tonsillitis, loss of appetite, flatulence, intermittent fever, sore throat, swellings and hardened tumors'. The pharmaceutical industry uses capsaicin as a counter-irritant balm (cream), for external application of sore muscles.

Creams containing capsaicin ($CH_{18}H_{27}O_3N$) have reduced pain associated with postoperative pain for mastectomy patients and for amputees suffering from phantom limb pain. Peppers also stimulate the flow of saliva and gastric juices that serve in digestion (Aticho, 2011). Hot pepper pungency is a desirable attribute in many foods. Pungency is produced by the capsaicinoids, alkaloid compounds ($C_{18}H_{27}NO_3$) that are found only in the plant genus, *Capsicum*. The capsaicinoids are produced in glands on the placenta of the fruit. While seeds are not the source of pungency, they occasionally absorb capsaicin because of their proximity to the placenta. No other plant part produces capsaicinoids (Hoffman *et al*., 1983). Pepper (*Capsicum annuum*L.) is an important spice and vegetable crop in Ethiopia. The history of pepper in Ethiopia is perhaps the most ancient than the history of any other vegetable product (Ethiopian Export promotion Agency, 2003). Capsicums are the most popular salad vegetables (Esayas, 2009). Dried ripe pods of many different varieties of capsicum are utilized to prepare cayenne pepper, ground pepper and crushed red pepper (Ethiopian Export promotion Agency, 2003).This is because it increases the acceptance of the insipid basic nutrient foods. People consume hot pepper for intake enhancement as well as to supplement the dietary needs. It is also one of the major income-generating crops for most households of the pepper producing areas and it plays a vital role in food security in Ethiopia (Roukens, 2005).

Ethiopians have strong attachment to dark red pepper, which has high value principally for its high pungency. The fine powdered pungent product is an indispensable flavouring and colouring ingredient in the common traditional sauce 'Hot' whereas the green pod is consumed as a vegetable with other food items. Hot pepper spice is used to impart the desired colour, flavour and pungency in various dishes made from cereals. There is a general belief among Ethiopians that a person who frequently consumes hot pepper has resistance to various diseases. It is in the daily diet of most Ethiopians. The average daily consumption of hot pepper by an Ethiopian adult is estimated at15g, which is higher than the consumption of tomatoes and most other vegetables. In addition to having major role in Ethiopians daily dish, pepper also plays an important role in the national economy. It is a crop of high value in both domestic and export markets. Since it is a commercial and industrial crop, it generates employment to urban and rural workers. Oleoresin (colouring) and capsaicin(hot) are extracted from red pepper (capsicum) for export purposes. The deep red coloured and large pod cultivars have a very high processing demand in the country. The main processed product, oleoresin, is exported to different countries and the spiced ground is supplied to local market. From 1992/93to 2003/04, a total of 616.16 tons of oleoresin, which worth106.6 million Birr, was exported to different countries by Ethiopian Spices Extracting Factory (ESEF, 2005).

Pepper cultivation in both rural and urban Ghana is a germane economic activity. This is because of its importance as a major source of quick employment and income generation for both the rural and urban poor. Pepper farming has the potential to alleviate poverty and improve food security in Ghana. According to the AVRDC (Asian Vegetable research and development center, 2006), vegetable farming provides smallholder farmers with much higher income and more jobs per hectare than staple crops. Chili pepper (Capsicum annuum) is an important high value cash crop in Ghana and it is largely cultivated for export and domestic consumption by both the urban and rural poor. Its cultivation and consumption has long been part of Ghana’s agriculture and diet (MiDA, 2010). Chili pepper is called "green gold" by some farmers because of its economic value to them. Chilies produced in Ghana are known for their good reputation in the European markets in contrast to chilies from other parts of the world especially the Legon 18 variety which has become famous for its great taste and longer shelf-life. The Bird’s Eye chili variety furthermore offers an emerging opportunity for higher value chili exports in Ghana (MiDA, 2010). Chilies are the fourth most harvested crop in Ghana after cassava, plantain and yam with about 984,586 households engaging in its cultivation (GSS, 2014). Ghana has been identified to have both comparative and competitive advantages over other African countries in terms of chili pepper production. Despite these advantages, the country is currently ranked fourth in chili production in Africa after Egypt, Nigeria and Algeria (MiDA, 2010). The world's chili demand is on the ascendancy and this continuous increase in demand means that the world's chili production still has space for improvement, through increasing land productivity and raising its yield potentials.

Improvement in yield is therefore a necessity and needs to be pursued with all the resources it requires for efficient production. Knowledge of the overall productive efficiency status and its determinants, in addition to the key drivers of productivity of chili farms are relevant from policy perspective in a country where new technologies are scarce and productive resources are inadequate. This is because, gains in the efficiency and productivity of chili farms are essential for increasing the farm income of both the rural and urban dwellers who are engaged in its cultivation (Jacob Asravor,etal 2016). The challenge of low productivity on Ghanaian chili farms can be attributed to some key constraints militating against the attainment of the potential frontier output. Such constraints may include the attack of pests and diseases, limited land, poor prices for produce, low adoption of improved chili pepper cultivation technologies and inefficiencies arising from the allocation of production resources (Michael Kwabena Osei,etal 2021). This implies that efforts at improving the productivity of chili farms cannot overlook identifying and addressing these key factors.

As a result of the lack of access to productive resources, coupled with the low rate of adoption of improved chili production technologies in Ghana, improvement in the efficiency of chili farms has become paramount for enhancing the productivity level of chili farms. Although a plethora of efficiency studies on Ghana's agricultural production exist in the literature, much of these studies focus on technical rather than all the locative and economic efficiencies. However, it is only through substantial gains in overall economic efficiency that significant gains in output can be achieved (Brav-Ureta and Pinheiro, 1993).

2.3Hot Pepper Production

The production of *Capsicum* species for spice, vegetable and other uses increases every year. (www.worldatlas.com) report as per 2014 world production statistics, the total global production of chili was in the region of 33.2 million tonnes. This figure is inclusive of both peppers and fresh green chili. As previously stated, the Asian region dominated this production with nearly eighty percent of the world’s total production(Maureen Shisia,2017).China is on the top of the list producing around 16.1 million tonnes of chili in 2014. To put that into perspective, China produced roughly 48% of the total global production that year alone. Compared to the closest competitor, Mexico, China produced at least five times the amount produced by Mexico which was a paltry 2.7 million tonnes.

Coming in at third was Turkey with a total production of 2.1 million tonnes. Following closely behind by Indonesia with 1.9 million tonnes and then again by India with 1.5 million tonnes. This further puts into perspective just how dominant Asia has been. India is a curious case, because 32% of the 1.5 million tones, it produces were composed of dried chilies.

Closing the top list at position six and seven are Spain and the United States with a production of 1.1 million tonnes and 0.9 million tonnes respectively. The case of Spain should not be alarming because of trade and obviously because of the spicy nature of their venerated and delicious cuisine. Pepper production accounts for 34% of the total spice production in the three regions of the country namely Amhara, Oromiya and Southern Nations Nationalities and Peoples Regional States (Roukens, 2005).Chilli pepper is a major vegetable crop of huge market potentials. Globally, 31 million tons are produced on approximately 1.9 million hectares of land (MiDA, 2010).

Global production over the past 1-2 decades has increased on average by about 3.9% per year during the last 10 years, leading to a steady increase of global demand. Reports show that China, Mexico and Turkey are the leading producers of Chilli pepper. Together, the three countries account for more than 70% of the global production. Evidences also indicate that the bulk of Chillies produced in each of these countries is consumed locally (FAOSTAT 2016).

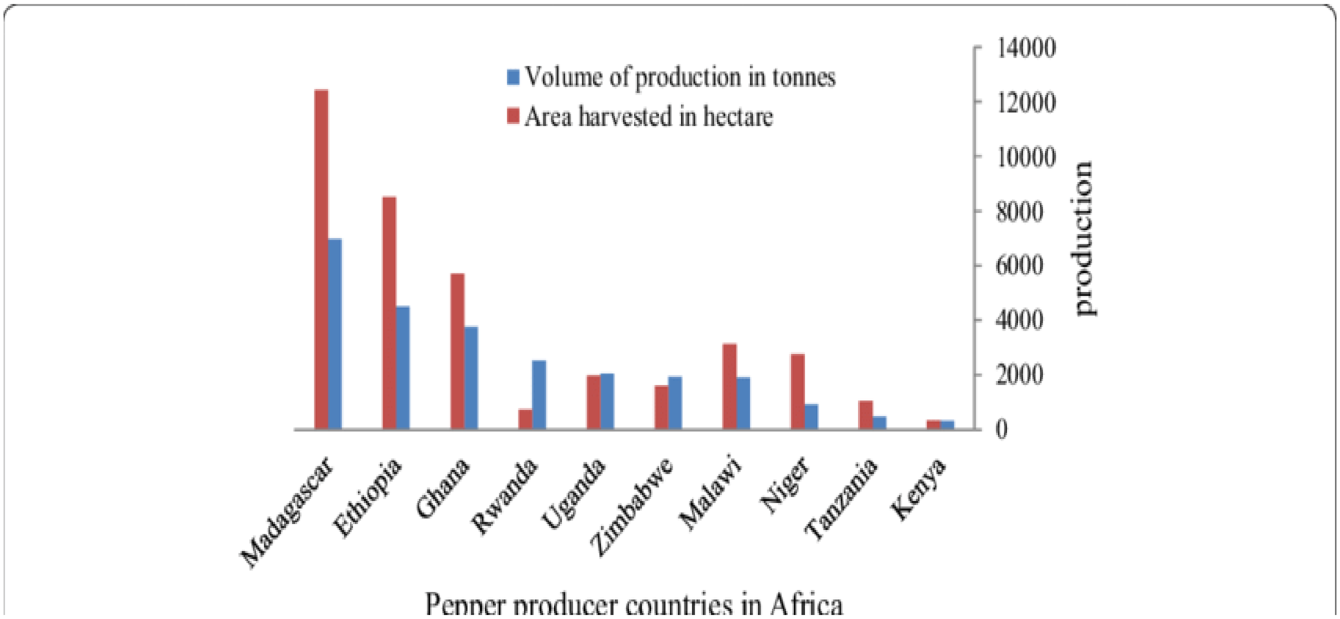

Figure 2.1 Shows estimates of the contribution of some major Chilli producing countries across Africa to global output. (FAO, 2018)

TheGlobal chilli pepper production Country Global Output. The country that grows the most chilli peppers is China, with an annual production volume of 18,535,308 tonnes (20.43 million tons) of fresh and dried chillies as of 2018, according to the United Nation's Food and Agriculture Organization (FAO, 2018). This accounts for 45.2% of the global production of chillies. China is significantly ahead of the next country, Mexico, which produced 3.44 million tonnes (3.79 million tons) in the same year. In third place is Turkey, with 2.56 million tonnes (2.82 million tons). The FAO estimates the global production of chillies to be 40.9 million tonnes (45.0 million tons) annually. By export value, however, the largest producer is Mexico, with $1.4 billion (£1.06 billion) of exports in 2019; China, by comparison, exported $97.3-million-worth (£74.1-million) of chillies in the same year. (FAO, 2018).

Although Ghana did not feature as one of the recognized producers of Chilli, area of production and output levels for pepper have been increasing steadily, in absolute terms over the last decade. (Mohammed et al., 2016; Asase, 2014; Abbay, 2010) have identified several challenges facing Chili farmers. They include the spread of pests and diseases on the farm, difficult harvesting due to hand picking (bending over for long periods of time). Production is largely seasonal due to lack of irrigation facilities. In addition, the farmers face various challenges trying to access credit facilities to sustain and expand production.

Problems related to wrongful application of pesticides are also common among farmers. Overall, price fluctuations have been identified as the most severe constraint in Chilli pepper production and marketing (Mohammed *et al.*, 2016). This is believed to be driven by speculative activities of middlemen (Suleiman and Isah, 2010) whose role in the value chain seems to be assuming exploitative status, to the disadvantage of the farmers. According to MoFA (2015), Chilli pepper farming in the region is mainly carried out by the old people who do not have the necessary energy to work and manage the farms As such, they depend heavily on household and hired labour, which are increasingly becoming scarce and expensive. The use of hired labour becomes evident around the peak labour period, especially during land clearing and weeding activities.

The cost of labour is high for most farmers, whose resource capacities are often limited relative to what they actually need. As a result, the farms are often not properly maintained and these, in the long run, affect output. The different forms of labour and their challenges, according to Jeremy *et al.* (2014) have different impacts on productivity. Pepper produced in

Ghana is grouped into two main varieties. These are "bell pepper" (capsicum annum) and hot pepper (capsicum frutescens) (Tweneboah, 2000). A number of the hot pepper varieties are cultivated in Ghana, some of which include Bird's eye, Legon 18, M12, Frenso and Jalapo (Obeng-Ofori*et al.,* 2007). These varieties have been categorized as fast growing. Exotic types include California wonder, world beater, Florida giant, Neopolitan and Cuban. Some local types found in Asesewa and surrounding communities (the study area) are listed below. Local types of hot pepper Local name (Dangme) and (English) 1. SorkwerLegon 18 2.KpakposhitoTrinicongo 3.Yolornguer Bird's eye 4.Daliwa Scotch bonnet 5.Yowi Bird's eye 6.Tongor Seven pod 7.Tokukwadaa Goat pepper 8. Kwadaayumu Black pepper same local types (Akan) described by (Tweneboah, 2000) include Kokromotie (thumb) hwe-Nyame (pointed upwards) hwenta (pointed hoses) Ohenebansansia (sixfingered prince), Makohwam (fragrant pepper) and Basatia (short arm) Ogyenma and Legon 18. The Legon 18, selected from an original cross from Sri Lanka is known for its high yielding characteristics and resistant to the leaf curl viral disease (www.udsspace.uds.edu.gh).

It is thus the most commonly produced variety in Ghana. Although Scotch Bonnet and Bird-Eye Chilies are also produced, they are often in smaller quantities. Economics of chilli pepper production in recent years, interest and demand for pepper has increased dramatically across the globe, making the produce to achieve economic significance in the global market (Mohammed, 2015). Bunyinza and Mugagga (2010) reported that despite the fact that the price of pepper varies widely within the season, it can be cultivated as a cash crop which can help reduce poverty. Asase (2014) suggests that Chili cultivation delivers higher and more stable incomes to farmers, as production is highly profitable despite the many associated production challenges (Mohammed *et al.,* 2016). Ayorinde(2011) also found pepper production to be a profitable enterprise, yielding a 2.62 return on investment for producers. Mohammed *et al.* (2016) thus contend that Chilli pepper contributes about 42% of the total farm income in the study area. This finding corroborates that of Suleiman and Isah (2010), who reported that pepper production is very important to addressing food security issues among the farmers. There is further research to enlighten the industrial use of Chilli pepper, particularly for use in pharmaceutical industries and in food manufacturing industries, where it is used for seasoning of processed foods in the preparation of curry powder, hot sauce and in pickling (Ayorinde, 2011).

2.4 Agro-Ecological Requirement of Hot Pepper

Capsicums flourish in warm, sunny conditions and require 3-5 months growth period with a temperature range of 18-30ºC; below 5ºCgrowth is retarded and frost kills plants at any growth stage. A seedbed temperature of 20-28ºC is the optimum for germination, which is slowed at 15ºC and cease at 35ºC(Weiss, 2002). If seeds are planted when soil temperatures are too cool, germination rate is retarded, affecting emergence and growth of the seedlings. Higher yields result when daily air temperature ranges between 18 and 32ºC during fruit set (Bosland and Votava, 2000). Pepper is adapted to high temperature but in excessively hot and dry weather may produce infertile pollen thereby reducing fruit set. Temperature above 32ºC with a fairly low relative humidity may also cause excessive transpiration, resulting in dropping of buds, flowers, and fruits.

A drop in temperature below 16ºC at flowering may result in poor fruit set and seedless fruits (Rice *et al.,* 1990). Pepper (*Capsicum annuum*L.) grows on almost all soil types, but is most suited to well drain sandy or loamy soils, rich in lime, with a pH of 5.5- 6.8 and high water retention capacity. However, pepper can also tolerate a wider soil pH range of 4.5 (acidic) to 8.0 (slightly alkaline). Light sands, clay sandy and sandy loams are also suitable for growing pepper (Dennis, 2013). Similarly, Anonymous (2014) reported that the quality and quantity of pepper fruits are of crucial importance and are greatly influenced by the fertility and nutrient levels of the soil. Pepper prefers sandy to loam soils. *Capsicum* is moderately sensitive to soil salinity (Berke*et al*., 2005). In addition to crop nutrient requirements and general soil types, fertilizer recommendations should take into consideration soil pH, residual nutrients, and inherent soil fertility (Decoteau, 2000). Therefore, fertilizer recommendations based on soil analyses have the greatest potential for providing peppers with adequate but not excessive fertility (Weiss, 2002). *Capsicum* can be grown as a rain-fed or irrigated crop and different soil types. In areas with regular and ample rain, irrigation is not needed. An annual rainfall of 600-1250 mm is suitable; above 1500 mm, soils must be free-draining since plants cannot tolerate water logging, even for short periods, especially at seedling stage (Weiss, 2002).

Heavy rain at fruit bloom adversely affects pollination and reduces fruit yield, and promotes fungal damage of nearly ripe or ripe fruits (Weiss, 2002). Irrigation is essential in arid and semi-arid regions to provide adequate moisture for production of peppers. Studies show that irrigation increases pepper yields by an average of at least 60 percent over dry land production and that quality of irrigated peppers is also much better (Rice *et al.,* 1990). The most critical stages for watering of pepper crop are at transplanting, flowering and fruit development stages. According to Bosland and Votava (2000), moisture stress during blooming causes dropping of blossoms, immature pods and flowers. If plant growth is slowed by moisture stress, sun scald and dry rot of fruit may become severe though fruits may become more pungent. Moreover, moisture stress during the period of rapid vegetative growth and at flowering reduces yield by up to 50% depending on cultivar. Decoteau (2000) also reported that water stress during flowering and fruit development can cause poorly developed, small, misshapen fruit or blossom-end rot while over watering can promote disease such as *phytophtora* and other root-rotting organisms.

2.5 Nutrients Requirement of Pepper

The amount of fertilizer to be applied depends on soil fertility, fertilizer recovery rate, and organic matter, soil mineralization of nitrogen (N), and soil leaching of N (Berke*et al.*, 2005). The solanaceous groups of vegetables (tomato, eggplant and pepper) generally take up large amounts of nutrients. The amount of nutrients they take up depends on the quantity of fruit and dry matter they produce, which in turn is influenced by a number of genetic and environmental variables. In the absence of any other production constraints, nutrient uptake and yield are very closelyrelated (Hegde, 1997). Pepper, like other crops produces well when it is adequately supplied with the essential nutrients through fertilization (Fagbayide, 1997). Optimum dose of fertilizers improve the proper growth and development and maximize the yield of pepper (Roy *et al*., 2011). Pepper needs to absorb more nutrients than tomato to produce a unit of dry matter or fruit yield; concentrations of NPK are highest in the leaf, followed by the fruit and the stem. The author also reported, in pepper, dry matter production continues to the end of the life cycle. According to Decoteau (2000) over fertilizing peppers can have negative effects on fruit earliness, yield and quality? *Capsicum* *annuum* species require adequate amount of macro and micro nutrients since nutrient uptake and dry matter production (fruit yield) of pepper are closely related (Hedge, 1997). According to Siddesh(2006) major nutrients like nitrogen (N), phosphorus (P_2O_5)and potassium (K_2O) play an important role in vegetative and reproductive phase of crop growth.

2.6 Nitrogen fertilizer requirement of hot pepper

Nitrogen is the main plant nutrient which limits plant growth (Sabri*et al*., 2001). More nitrogen is required for production than phosphous (P) and potassium (K) since it has both structural and enzymatic activity function. Nitrogen has the greatest effect on the average nutrients needed for optimum yield of *Capsicum* in which the crop is particularly responsive to nitrogen for plant growth (Bosland and Votava, 2000). Nitrogen is a component of protoplasm, protein, nucleic acid, chlorophyll and plays a vital role in both vegetative and reproductive phase of crop growth. During growth; further nitrogen may be applied to achieve more yields. A side dressing of 22-34 kg Ha^{-1} of nitrogen is applied when the first flower buds appear and when the first fruits are set (Bosland*et al*., 1994).Too much nitrogen on the other hand can over stimulate growth, resulting in large plants with few early fruits, or delaying maturity, reduces firmness by reducing wall thickness and causes flowers and small fruits to abscise and increasing risk of blossom-end rot or pod rots. But adequate amount of Nitrogen has been shown to increase the number and size of pepper marketable fruits, fruit pungency and overall yield. Roy *et al.* (2011) also found that the length of pepper significantly increased with the increase of nitrogen level. They reported, the highest length of pepper (7.63 cm) found with 150 kg N Ha^{-1}, which was statistically similar (7.41 cm) with 100 kg N Ha^{-1}while the lowest length (5.83 cm) was found in the control treatment. Likewise, Prabhakar and Naik (1997) also observed highest dry matter production of pepper 98.4 and 98.8g per plant with highest level of nitrogen (180 kg N Ha^{-1}) in two years studies, Whereas, the control plots produced 43.8 and 32.0g per plant respectively. Fertilizer trials conducted in different sites of Ethiopia showed difference in yield performance pepper (Sam-Aggrey&Bereke-Tsehai, 1985). In the fertilizer trail conducted at Bako, 100 kg Ha^{-1} N and 100 kg P_2O_5 Ha^{-1} gave higher marketable and total dry pod yield. However, Jackson *et al.*,(1985) recommendation of inorganic fertilizers for better performance of pepper was that application of140 kg Ha^{-1} ofP_2O_5 and 130 kg Ha^{-1} of N as optimum level. Application of95.22 kg Ha-1 P_2O_5 and 97.06 kg Ha-1 of N provided optimum yield of pepper variety OdaHaro at Bako (MoARD, 2005).This indicated that the nitrogen and P_2O_5 requirement of hot pepper in different parts of Ethiopia is different as the result of difference in environmental conditions, varieties and soil types.

2.7 Phosphorus fertilizer requirement of hot pepper

Phosphorus is a constituent of nucleoproteins, and it is involved in energy transfer of compounds like ADP, ATP. It also plays an important role in the transfer of energy in the metabolic processes (Siddesh, 2006). Phosphorous is absorbed by plants in different forms. Gupta (2011) reported that Plants absorb most of their P as the primary orthophosphate ion (HPO_4^{2-} and H_2PO^{4-}) soil pH greatly influences the availability and uptake of phosphorus (P) by plants. It is believed that phosphorus results in a better yield and more red colored fruit. Fertilizer requirements vary with soil type and previous crop history. And thus a balanced nutrient level is required for maximum production. In Ethiopia, the recommended fertilizer rate for the hot pepper is, 100 kg Ha^{-1} DAP and 100 kg Ha^{-1} for UREA (EARO, 2004). There were no differences on plant height, foliage dry weight, and number of fruits per plant. In a study of the effect of nitrogen and phosphorus application rates on seed yield of sweet pepper, phosphorus rates decreased the days to flower. Phosphorus rates alone increased the number of branches per plant from 4.1 to 5.8. Increased P rates resulted in significant yield increases; higher P rates increased considerably the number of fruits per plant as well as seed yield. The effect of phosphate and plant densities on growth and yield of field grown capsicum were studied (Wanknade and Morey, 1982). Higher Rates increased plant height, dry matter, and yield. Bajaj *et al*. (1979) reported an increase in capsaicin content of pepper pods with increasing P rates. The combination of the highest N and highest P rate reduced capsaicin content 0.40 g/100g compared to 0.52 g/100 g obtained with the combination of lower P and highest N rate.

2.8Potassium fertilizer requirement of hot pepper

Potassium is responsible for regulation and maintenance of electrochemical equilibrium in cells and other parts involved in enzyme activities. In addition, it takes part in protein synthesis, carbohydrate metabolism, regulation of activities of the essential elements, and control in plants (Siddesh, 2006). Peppers have a high K demand and the harvested fruit removes a large amount of K from the soil. Pepper has the greatest requirement for potassium (40%) and nitrogen (31 %) in relation to the total amount of absorbed nutrients. Soil K status influences K uptake by plant roots (Gupta, 2011).Potassium is also involved to facilitate the uptake of nitrogen by plants (Akram *et al*., 2007). High potassium could increase shriveling of harvested pepper and reduce shelf life. In general, the amount of K removed by plants depends on the production level, soil type, and the retention or removal of crop residues (Yadvinder *et al*., 2005). (Fawzy *et al*. 2005) found that potassium fertilizer had a significant effect on the fresh weights of leaves and stems as well as early and total yield of sweet pepper plants. In another study, potassium is shown to affect pod pigment biosynthesis and pungency because of its effect on enzymes. Potassium fertility affects pepper plant growth, pod yield and pungency in which biomass, fruit count and fruit weight per plant increased linearly with increasing K rate (Charles and Decoteau, 2000). In contrary, field experiment conducted by (Chattopadhyay*etal, 2000*) on potassium fertilization revealed that different rates of potassium fertilizers did not register any significant variation with respect to growth and fruit characters in pepper where soil potassium test was high. Various studies have revealed that the kinds of potassium fertilizers used influence yield, size and quality, (Michalojc and Buczkowska, 2007). The authors added that supplying the plants with potassium greatly determines fruit quality in eggplant. Therefore, selecting an appropriate potassium fertilizer kind and dose appears to be very important.

2.9Sulfur fertilizer requirement of hot pepper

Sulfur (S) is one of the essential macro elements of plant and is regarded as the fourth key element after N, P and K (Malakouti, 2008). Most often sulfur(S) deficiencies are observed in low OM soils and coarse-textured soils where S can be easily leached out. It is used as a soil amendment to improve the availability of nutrients such as P, K, Zn, Mn and Cu (Hassaneen, 1992) where they found that sulfur element reduced pH and convert the unavailable phosphorus to available form for plant tissues. Sulfur is required for the synthesis of important essential amino acids by increasing allylpropyldisulphide alkaloid (43% S) and the capsaicin which is the principle alkaloids responsible for pungency in onion and sweet pepper respectively and also it makes a key role in the defense of plants against nutrients stress, attacks of pests and increases the synthesis of chlorophyll and vitamins in the cell. (Hasseneen, 1992) Nitrogen application in higher rates increases the intensity of sulfur deficiency. Without nitrogen fertilizer application, plants show no visible sulfur stress, whereas nitrogen fertilizer application to plants especially at higher levels without applying sulfur shows severe physiological disorders (Kopriva and Rennenberg, 2004). Moreover, Randle and Bussard (1993) reported that sulfur often ranked immediately after nitrogen, phosphorus and potassium in terms of importance to crop productivity. Complete yield potential of a crop cannot be obtained where soil is suffering from sulfur deficiency, even irrespective of all the other nutrients application and under excellent management practices. Carrying out a systematic research is needed to find out the knowledge of these nutrient elements (Sulfur) in order to develop comprehensive information about the response of hot pepper to these elements. Sulfur deficiency symptoms first appear in the younger leaves because sulfur (S) is not easily translocated in the plant. Root development is restricted, and shoot–root ratios usually decrease for plants grown under sulfur (S) deficiency. The total dry matter yields of crops increase as the sulfur fertilization increased and enhance the yield of barley, cabbage and onion compared to the NPK fertilized thus; highest yield was obtained after the application of 40 kg sulfur (S) and 80 kg sulfur (S)(Skwierawska *et al*., 2008).

2.10Micronutrient requirement of hot pepper

Micronutrients are usually required in small quantities, nevertheless are vital to the growth of plant. Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003)

2.11Transplanting Ages in Pepper

The effect of transplant age on yield is an issue often broached by growers of horticultural and agronomic crops in an effort to maximize production potential (Vavrina, 1995). Nicklow (1963) in a study in New York State found that pepper transplants without flower buds or with unopened flower buds produced more large fruit (early and total) than transplants with open blooms or small fruit. McCraw and Greig (1986) used 8-and 11-week-old transplants of four cultivars in a pepper transplant age study in Kansas in 1975-76. Pooling the data from the four cultivars, they found no differences due to transplant age in early yield (number, weight) the first year, but a greater number of heavier fruit with 8-week-old transplants the following year. Three of the four cultivars tested showed that the 11-week-old plants produced more total fruit per plant than the younger transplants (12 vs. 10 fruit). Studies conducted by a study in Kentucky using containerized pepper transplants of 4, 6, 7, and 9 weeks. She found 70% earlier U.S. Fancy and No. 1 fruit with 9-week-old transplants. However, total U.S. Fancy and No. 1 fruit yield and total overall yield were unaffected by transplant age. Vavrina and Armbrester (1991) conducted a 1 - year trial in Florida with transplant age of 4, 6, and 11 weeks. They found no effect of transplant age on yield (number, weight) in three of four harvests, but a significant yield increases at the fourth harvest with 4-week old transplants. The yield effect here was due to a greater number of fruit not greater individual fruit weight. McCraw and Greig (1986) as noted above had a similar finding with 11 week old transplants. Three of the studies cited here imply that pepper transplants of 8 to 11 weeks may have a yield advantage for early size and number of fruit (Nicklow, 1963;McCraw and Greig, 1986; Weston, 1988). Yet Vavrina and Armbrester (1991) offered evidence that younger transplants may eventually exceed yields produced by older plants. These researchers used different cultivars, numbers of harvests (McCraw and Greig, 3; Vavrina and Armbrester, 4; Weston, 10), and were under quite different environments, which makes comparisons among the studies difficult. Perhaps a standardization of the number of harvests for early and total yield is necessary to critically determine the impact of transplant age on pepper production. Considering the HortTechnology October-December 1998 8(4) slower growth habit of pepper compared to tomato, older transplants (i.e., >4 to 6 weeks) may be advised.

2.12 Spacing in Pepper Production

Plant spacing is one of the important aspects for production system of different crops. Optimum plant spacing ensures proper growth and development of plant resulting in maximum yield of crop and economic use of land. Yield of hot pepper has been reported to be dependent on the number of plants accommodated per unit area of land (Duimovic, 1979).

Monirul (2011) used three spacing levels (50×50 cm, 50×40 cm and 50×30 cm) and after the analysis, the results shown that there was significant variation in all the growth and yield components except in per carp thickness. Number of branches per plant, number of leaves per plant, stem girth, number of fruits per plant, days to first harvest, fruit length, individual fruit weight, yield per plant were found to be significantly increased with the increasing of plant spacing but plant height at different stages, number of fruits per plot, days to 50% flowering, fruit breadth, yield per plot and yield per hectare were found to be significantly increased with the decreasing plant spacing.

CHAPTER THREE

3.0MATERIALS AND METHODS

3.1 Experimental site and Location

The experiment was conducted at the multipurpose crop nursery, College of Agriculture, AketenAppiah-Menka University of Skills Training And Entrepreneurial Development of Mampong to investigate the Effect of age of transplant and row spacing on growth and yield of pepper. The site lies at an altitude of 402 m above sea level and occurs within latitude 01.45° north of equator and longitude 1° and 24° west of the Greenwich. Mampong-Ashanti lies at the transitional zone between the forest and northern savannah of Ghana. Mampong-Ashanti lies at 57.6 km of Kumasi on the latitude 01.024° west of the equator and it is 402 m above sea level (Ghana Meteorological Department, 2008). Mampong-Ashanti has a bimodal rainfall pattern with annual rainfall between 1094.4 mm and 1200 mm and monthly mean rainfall of about 91.2 mm. The major rainy season occurs from March to July while minor rainy season occurs from September to November (Ghana Meteorological Department, 2008). Between the two seasons is a short dry spell in August (Meteorological Services Department, Ghana, 2005). Mampong-Ashanti has a daily temperature of about 30.5°C.

3.2 Soil type and vegetation at the experimental site

The soil at the experimental site is derived from the voltarain sandstone of Afram plains. It belongs to the savannah ochrosol class and is characterized by deep sandy loam; free from pebbles. It is well drained and contains moderate organic matter. The soil has a good water holding capacity.

It has been classified by FAO/UNESCO (2008) legend as chromic luvisol and locally as Bediesi series. It is good for tuber, cereal, and legume crops production. The pH ranges from 6.0 to 6.5. The experimental site had been used for the cultivation of various crops such as carrot, tomatoes, maize, cowpea, okra and sweet potato. Grasses such as nut grass (*Cyperusrotundus*), giant star grass (*Cynodonplectostachus*) and guinea grass (*Panicum maximum*) being the most common species.

3.3 Experimental Design, Treatments and Field layout

3.3.1 Experimental Design

The experimental design used for the study was 2 x 3 factorial arranged in Randomized Complete Block Design (RCBD) with three replications. Age of transplants and spacing constituted the factors. The treatment was made up of 2 ages of transplants and 3 row spacing, resulting in 6 treatment combinations.

3.3.2 Treatment combination

The treatment combinations are shown in Table 3.1.

Table 3.1: Treatment combinations

Treatments	**Ages of Transplant**	**RowSpacing**
T1	30 Days After transplanting	40 cm × 30 cm
T2	30 Days After transplanting	50 cm × 30 cm
T3	30 Days After transplanting	60 cm × 30 cm
T4	37 Days After transplanting	40 cm × 30 cm
T5	37 Days After transplanting	50 cm × 30 cm
T6	37 Days After transplanting	60 cm × 30 cm

3.3.3 Field layout

The total field size of 14.4 m x 13 m was demarcated, cleared, lined and pegged. Each experimental plot measured 1.6 m x 3 m (4.8 m^2), 2 m x 3 m (6 m) and 2.4 m x 3 m.

A 1.0 m was left between blocks. Field layout is indicated in figure 3.1.below:

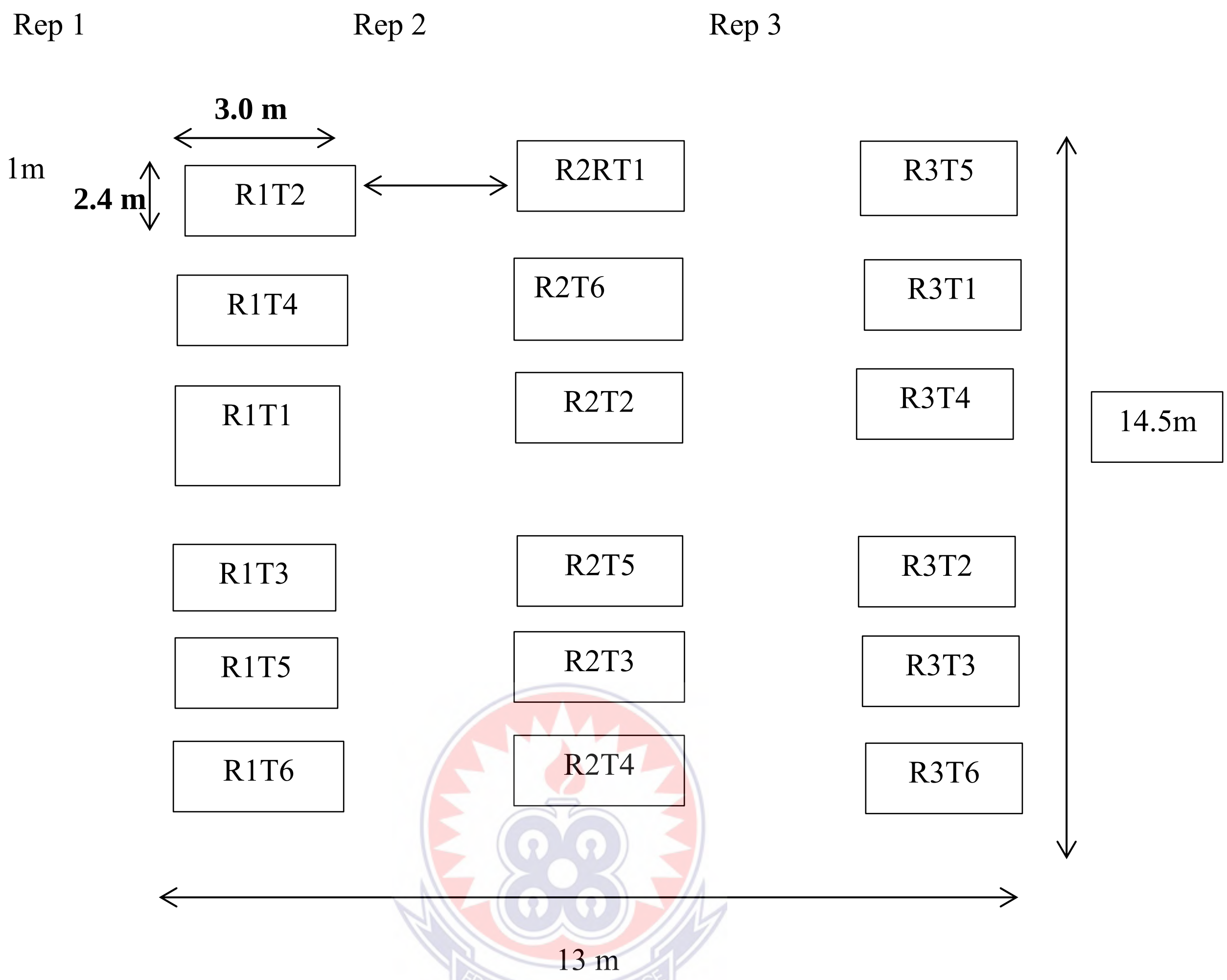

Figure3.1 : Field layout not drawn to scale

3.4 Planting Materials

The planting material to be used for the study was cayenne seed. The seeds were bought from Kyeiwa agro-chemical shop in Mampong. Watering cans used were also attained from the school. Garden tools such as hand fork and trowel, garden fork, garden line, pegs, shovel, hoe etc. were collected from the school garden. The cayenne pepper has high seed viability, fast seedling growth rate and fast seed germination.

3.5Nursery practices

Seedlings were raised on well prepared nursery beds on 24th October, 2020. Dried palm fronds were burnt on top of each bed to keep soil sterilized. The seeds were sown on 24thOctober, 2020, the evening of the same day of bed preparation. After sowing, the beds were watered and covered with palm fronds. A shed made from palm fronds, was erected on top of the beds to provide shade to protect the seedlings from harsh weather conditions after germination. Watering was carried out every other day depending on the climatic conditions. Watering, hand picking of weeds, stirring of the soil to enhance aeration were carried out regularly. Cymethoate super E.C with active ingredient cypermethrin, an organic insecticide at the rate of l mg per liter of water was used to control pests.

3.6 Land preparation and planting

The field was ploughed and harrowed. The field was demarcated, lined and pegged before transplanting. The experimental area measured 14.4 m x 13 m (158.5 m^2). The area was divided into three blocks. Each block was further divided into six plots. Out of the 6 plots, two of the plots each had plot measurement of 1.6 m x 3 m (4.8 m^2), 2 m x 3 m (6 m^2) and 2.4 m x 3 m (7.2 m^2) respectively. A distance of 1 m was left between blocks and in between plots. The planting spacing use on each plot or bed was 40 cm x 30 cm, 50 cm x 30 cm and 60 cm x 30 cm with forty seedlings per bed. Number of seedlings per hill was 1 per hill. A total of 720 seedlings were transplanted.

Factor A: Ages of transplants will be:

a) 30 days old after planting.

b) 37 days old after planting.

Factor B: The different row spacing was:

a) 40 cm x 30 cm.

b) 50 cm x 30 cm.

c) 60 cm x 30 cm

3.7 Agronomic practices

In other to accomplish the aim, the following agronomic practices were executed:

3.7.1 Weed control

Weeds control was done on the beds mainly by hand picking, hoeing and slashing using cutlass. Uprooting of weeds around the plants was done occasionally.

3.7.2 Irrigation

The experimental period experienced rainy, humid, warm and dry spells within the wet season watering was occasionally done using rubber hose and watering can

3.7.3 Fertilizer Application

A complete fertilizer application such as N.P.K. 15:15:15: was carried out about 2 weeks after transplanting at the rate of 12g of fertilizer per plant. The N.P.K fertilizer was applied using the ring method. A circle was drawn round the base of the plant and the fertilizer will be carefully spread in the groove and later covered lightly with soil. The circle was made reasonably far from the stem of the plant to prevent the plant from dying off due to excessive heat production by the fertilizer.

3.7.4 Pests and Diseases Control

Insect pests were control during the experimental period using Cymethoate super E.C and champion fungicide with active ingredient cupric hydroxide at each spraying. A CP15 Knapsack sprayer was used in spraying the pesticides. In the first spraying at one week after transplanting, only Cymethoate super E.C was use, but the rest of the spraying were done combining Cymethoate super E.C and champion fungicide till the end of the experiment.

3.7.5 Harvesting

Harvesting of ripen fruits in all the treatments started about 11 weeks after transplanting and continue at 7 days intervals. Though pepper can stay in the field up to a year or more, harvesting of fruits ended 21 days after transplanting.

3.8 Data collection and Analysis

3.8.1 Data collection

3.8.2Plant height

Plant height was recorded on the four sampled plants from each plot using a meter rule. The measurements were taken from the soil level to the highest point of the stem apex every two weeks for ten weeks and the mean was recorded.

3.8.3Number of branches

Total number of branches was counted from the four sampled plants from each plot every two weeks for ten weeks and the mean was calculated and recorded.

3.8.4Number of leaves per plant

Total number of leaves on the four sampled plants from each treatment plot was counted every two weeks for ten weeks and the mean was recorded.

3.8.5Days to 50% flowering and fruiting

These was recorded as the number of days after transplanting to 50% flower opening and 50% fruiting on the four sampled plants.

3.8.6Number of fruits per plant and plot

These were recorded after the fruits harvested from the four tagged, plants was counted from each treatment plot. Number of fruits per plot was recorded after the fruit were harvested from the whole population of plants, including the four sampled plants, were counted from each treatment plot every two weeks for ten weeks and the mean recorded.

3.8.7Fruit weight per plant and plot

Fruit weight per plant was determined by weighing harvested produce from the four sampled plants for each plot using electronic balance. Fruit weight per plot was also determined by weighing harvested produce from the whole population of plants from each plot using electronic balance every two weeks for ten weeks and the mean were recorded.

3.8.8Canopy width

Plant canopy width was recorded on the four sampled plants from each plot using long meter rule. The measurements were taken from one end of the canopy to the longest end point of the canopy, every two weeks for ten weeks and the mean was recorded.

3.8.9 Percentage plant establishment

This was done once, three weeks after transplanting to determine the number of plant which were able to establish after transplanting. Two selected middle rows numbering eight were counted leaving the border plants.

3.8.10Number of plants harvested

This was done by counting plants that had established ripe fruits, ready to be harvested and every weak within three weeks.

3.8.11 Fruit length

In determining this, five sampled fruits from each plot will be used. Their lengths were taken by stretching a thread from the pedicle of the fruits to the tip of the bottom. The thread were then stretch on a rule and the length determined. The length of the thread on the rule determined the length of the fruit and this was done every week within three weeks.

3.8.12Fruit diameter

In determining this, five sampled fruits from each plot were used as well. Their diameters were taken by using a veneer caliper to measure the largest part of the fruit. The readings recorded from the caliper determine diameter of the fruit and this was done every week within three weeks.

3.8.13Number of rotten fruits

Rotten fruits, among good ones, were removed and counted as well and this was done every week within three weeks.

3.8.14 Disease assessment

Diseased fruits, among good ones were removed and counted as well. This was also done every week within three weeks.

3.9 Statistical Analysis

The data collection in this study was subjected to statistical analysis. The analysis of variance (ANOVA) was carried out using Genstat statistical package (2007) version of 9.2. Significant differences between treatment means were delineated by Least Significance Difference (LSD) test at 5% level of probability.

CHAPTER FOUR

4.0RESULTS

4.1Phenology

4.1.1Days to 50% Flowering

Days to 50% flowering were recorded and the mean values determined throughout the days of records. After the analysis, there was no significant (P≥ 0.05) difference in the mean values of days to 50% flowering for 30 days after planting (DAP). Shortest day to 50% flowering was however recorded as 64.2 days and 70.2 days in transplanting ages and spacing respectively in the individual effect (Table 4.1). In the interactive effect, there was no significant (P≥ 0.05) difference in the mean values recorded though the earliest was recorded as 62.7 days in 30 DAP x 50cm x 30cm (Table 4.1).

Table 4.1: Individual and Interactive Influence of Transplanting Ages and Different Spacing Regime to 50% Flowering

Treatment	Days to 50% Flowering
Transplanting Age	
30 DAP	64.22^b
37 DAP	78.11^a
LSD (0.05)	3.90
Planting Space	
40cm x 30cm	70.17^a
50cm x 30cm	70.83^a
60cm x 30cm	72.50^a
LSD (0.05)	4.77
*Transplanting Age * Spacing*	
37 DAP * 50 cm x 30 cm	79.00^a
37 DAP * 60 cm x 30 cm	78.33^a
37 DAP *40 cm x 30 cm	77.00^a
30 DAP *60 cm x 30 cm	66.67^b
30 DAP *40 cm x 30 cm	63.67^b
30 DAP *50 cm x 30 cm	62.67^b
LSD (0.05)	6.75
CV (%)	5.21

Means bearing different superscripts in the same column for each treatment were significantly different (P<0.05), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

4.1.2 Days to 50% fruiting

There was no significant ($P \geq 0.05$) difference in 50% fruiting in the individual effect of transplanting ages and different spacing in days to 50%fruiting. The earliest was recorded in 30 DAP (105 days) and 37 DAP recorded the late mean value (124 days). There was no significant ($p \leq 0.05$) difference for the interaction between transplanting age × different spacing too, 30 DAP x 50cm x 30cm had an early 50% fruiting (98 days) which was immediately followed by 30 DAP x 40 cm x 30 cm which also recorded (100 days), but the most delayed were 37 DAP x 50 cm x 30 cm and 37 DAP x 60 cm x 30 cm which recorded 125 days and 125 days respectively.

Table 4.2: Individual and Interactive Influence of Transplanting Age and Spacing Regime on 50% Fruiting

Treatment	Days to 50% Fruiting
Transplanting Age	
30 DAP	105.33[b]
37 DAP	124.33[a]
LSD (0.05)	3.03
Planting Space	
40 cm x 30 cm	110.50[b]
50 cm x 30 cm	112.33[b]
60 cm x 30 cm	121.67[a]
LSD (0.05)	3.70
*Transplanting Age * Spacing*	
37 DAP * 50 cm x 30 cm	125.00[a]
37 DAP * 60 cm x 30 cm	125.00[a]
37 DAP *40 cm x 30 cm	123.00[ab]
30 DAP *60 cm x 30 cm	118.33[b]
30 DAP *40 cm x 30 cm	99.67c
30 DAP *50 cm x 30 cm	98.00c
LSD (0.05)	5.24
CV (%)	2.51

Means bearing different superscripts in the same column for each treatment were significantly different (P<0.05), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

4.1.3 Days to Maturity

The records indicates that treatments had no significant ($p \geq 0.05$) difference in the individual treatment of transplanting age and different spacing in days to maturity and in their interaction too. Considering the individual treatment, 30 DAP matured early (134 days) and 37 DAPwas late in maturing with mean value of (137 days) (Table 4.3).

And considering the interactive effect too, 30 DAP * 40 cm x 30 cm matured earlier with a mean value of 133 days followed by 30 DAP * 50 cm x 30 cm which also recorded 134 days. Those that were transplanted in 37 days recorded the late maturity in an indirectly proportional to the different planting space.

Table 4.3: Individual and Interactive Influence of Transplanting Age and Spacing Regime on Maturity

Treatment	Maturity
Transplanting Age	
30 DAP	134.22[b]
37 DAP	137.33[a]
LSD (0.05)	2.7
Planting Space	
40cm x 30cm	136.33[a]
60cm x 30cm	135.83[a]
50cm x 30cm	135.17[a]
LSD (0.05)	3.3
*Transplanting Age * Spacing*	
37 DAP * 50 cm x 30 cm	136.67[a]
37 DAP * 60 cm x 30 cm	135.33[ab]
37 DAP *40 cm x 30 cm	140.00[a]
30 DAP *60 cm x 30 cm	136.33[ab]
30 DAP *40 cm x 30 cm	132.67[b]
30 DAP *50 cm x 30 cm	133.67[b]
LSD (0.05)	4.7
CV (%)	1.9

Means bearing different superscripts in the same column for each treatment were significantly different (P<0.05), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

4.1.4Percentage Plant Establishment

There was no significant ($p \geq 0.05$) difference between transplanting age and different spacing in the individual treatments and in their interaction in percentage plant establishment (Table 4.4). In the individual treatment, 37 DAP produced 90%plant establishment and differed significantly from 30 DAP which recorded 94%, 60 cm x 30 cm also differed significantly from 40 cm x 30 cm with the mean values of 90% and 94% respectively. In the interaction between Transplanting Ages and Spacing, the least was recorded as 86.7% in 37 DAP * 60 cm x 30 cm and the highest percentage plant establishment was recorded as 95% in both 37 DAP *40 cm x 30 cm and 30 DAP *50 cm x 30 cm (Table 4.4).

Table 4.4: Individual and Interactive Influence of Transplanting Ages and Different Spacing Regime on Percentage Plant Establishment.

Treatment	Percentage Plant Establishment (%)
Transplanting Age	
30 DAP	93.89[a]
37 DAP	90.00[a]
LSD (0.05)	5.56
Planting Space	
40cm x 30cm	94.17[a]
50cm x 30cm	91.67[a]
60cm x 30cm	90.00[a]
LSD (0.05)	6.81
*Transplanting Age * Spacing*	
37 DAP * 50 cm x 30 cm	88.33[a]
37 DAP * 60 cm x 30 cm	86.67[a]
37 DAP *40 cm x 30 cm	95.00[a]
30 DAP *60 cm x 30 cm	93.33[a]
30 DAP *40 cm x 30 cm	93.33[a]
30 DAP *50 cm x 30 cm	95.00[a]
LSD (0.05)	9.63
CV (%)	5.76

Means bearing different superscripts in the same column for each treatment were significantly different (P<0.05), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

4.2 Vegetative Growth

4.2.1Number of Leaves per plant

There was no significant ($p \geq 0.05$) difference between transplanting age in number of leaves per plant from 30 DAT to 86 DAT (Table 4.5). However, a 30 DAP differed significantly on 58 DAT but recovered for the rest of the recordings. No significant ($p \geq 0.05$) difference existed between the different plant spacing in number of leaves per plant from 30 DAT to 86 DAT but a change was observed on the 86 DAT where 50cm x 30cm recorded the highest number of leaves (17) then 60cm x 30cm and 40cm x 30cm recorded the moderate and lowest number of leaves respectively. In the interaction between Transplanting Age and Spacing, there was no significant ($p \geq 0.05$) difference observed throughout. But 37 DAP* 50 cm x 30 cm recorded all the highest number of leaves from the 58 DAT to 86 DAT but 37 DAP *40 cm x 30 cm recorded the lowest on 86 DAT.

Table 4.5: Individual and Interactive Effect of Transplanting Age and Spacing Regime on Number of Leaves of Plant on 30 DAT, 44 DAT, 58 DAT, 72 DAT and 86 DAT

Treatment	30 DAT	44 DAT	58 DAT	72 DAT	86 DAT
Transplanting Age					
30 DAP	5.56^{a}	6.22^{a}	7.00^{b}	11.33^{a}	15.89^{a}
37 DAP	4.67^{a}	6.11^{a}	10.89^{a}	13.44^{a}	13.44^{a}
LSD (0.05)	1.61	1.03	2.06	2.95	2.62
Planting Space					
40cm x 30cm	5.33^{a}	6.00^{a}	8.50^{a}	13.17^{a}	12.67^{b}
50cm x 30cm	5.33^{a}	6.67^{a}	8.83^{a}	13.17^{a}	16.83^{a}
60cm x 30cm	4.67^{a}	5.83^{a}	9.50^{a}	10.83^{a}	14.50^{ab}
LSD (0.05)	1.97	1.26	2.52	3.61	3.22
*Transplanting Age * Spacing*					
37 DAP * 50 cm x 30 cm	4.67^{a}	7.00^{a}	12.00^{a}	16.33^{a}	17.67^{a}
37 DAP * 60 cm x 30 cm	3.33^{a}	5.33^{a}	11.67^{a}	10.00^{b}	13.00^{bc}
37 DAP *40 cm x 30 cm	$4,67^{a}$	6.00^{a}	9.00^{ab}	12.33^{ab}	9.67^{c}
30 DAP *60 cm x 30 cm	6.00^{a}	6.33^{a}	7.33^{b}	10.00^{b}	16.00^{ab}
30 DAP *40 cm x 30 cm	4.67^{a}	6.00^{a}	8.00^{b}	14.00^{ab}	15.67^{ab}
30 DAP *50 cm x 30 cm	6.00^{a}	7.00^{a}	5.67^{b}	10.00^{b}	16.00^{ab}
LSD (0.05)	2.80	2.06	3.57	5.10	4.55
CV (%)	30.03	15.94	21.95	22.67	17.07

Means bearing different superscripts in the same column for each treatment were significantly different (P<0.05), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

4.2.2 Plant height

Results from (Table 4.6) indicate that there was no significant ($P \geq 0.05$) difference between transplanting age in plant height from 30 DAT to 86 DAT. No record differed from each other.

There was no significant ($P \leq 0.05$) difference between different plant spacing in plant height from 30 DAP to 86 DAT although 40cm × 30 cm was tallest from 58 to 86 and at 30 DAT in plant height during the cropping season than 60cm × 30 cm which had the shortest plant height.

There was no significant ($P \geq 0.05$) difference between transplanting age × different plant spacing interaction in plant height across the growing period from 58 DAT to 86 DAT and at 30 DAT and differed significantly from the other treatment at 44 DAT(Table 4.5).

Table 4.6: Individual and Interactive Effect of Transplanting Age and Spacing Regime on Plant Height on 30 DAT, 44 DAT, 58 DAT, 72 DAT and 86 DAT

Treatment	30 DAT	44 DAT	58 DAT	72 DAT	86 DAT
Transplanting Age					
30 DAP	8.43[a]	18.98[a]	26.04[a]	29.43[a]	30.49[a]
37 DAP	8.84[a]	17.34[a]	25.94[a]	29.78[a]	30.69[a]
LSD (0.05)	4.23	2.60	5.09	5.29	5.16
Planting Space					
40cm x 30cm	8.01[a]	17.80[a]	27.52[a]	29.92[a]	31.37[a]
50cm x 30cm	7.56[a]	18.05[a]	26.08[a]	29.72[a]	31.22[a]
60cm x 30cm	10.35[a]	18.63[a]	24.38[a]	29.18[a]	29.18[a]
LSD (0.05)	5.18	3.19	6.22	6.47	6.32
*Transplanting Age * Spacing*					
37 DAP * 50 cm x 30 cm	6.63[a]	14.73[b]	24.90[a]	28.13[a]	29.43[a]
37 DAP * 60 cm x 30 cm	13.00[a]	19.57[a]	25.13[a]	31.53[a]	30.67[a]
37 DAP *40 cm x 30 cm	6.90[a]	17.73[ab]	27.80[a]	29.67[a]	31.97[a]
30 DAP *60 cm x 30 cm	7.70[a]	17.70[ab]	23.63[a]	26.83[a]	27.70[a]
30 DAP *40 cm x 30 cm	9.11[a]	17.87[ab]	27.23[a]	30.17[a]	30.77[a]
30 DAP *50 cm x 30 cm	8.47[a]	21.37[a]	27.27[a]	31.30[a]	33.00[a]
LSD (0.05)	7.33	4.5	8.81	9.15	8.94
CV (%)	46.64	13.66	18.63	17.00	16.06

Means bearing different superscripts in the same column for each treatment were significantly different (P<0.05), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

4.2.3 Number of branches

There was no significant (p ≥ 0.05) difference between transplanting age in number of branches from 44 DAT to 86 DAT (Table 4.7). 30 DAP recorded the highest number of branches throughout and 37 DAP differed significantly in number of branches (Table 4.7).There was no significant (P ≥ 0.05) difference between plant spacing in number of branches although the highest was recorded on 50 cm x 30 cm as 8 branches on 86 DAT (Table 4.7).

There was no significant (P ≥ 0.05) difference in transplanting age × different plant spacing interaction in number of branches from 58 to 72 DAT and at 30 DAT (Table 4.7). 60 cm × 30 cm differed significantly from other treatment in number of branches 72 DAT to 86 DAT and at 30 DAT (Table 4.7). 40 cm × 30 and 50 cm × 30 cm produced the same number of branches at 58 DAT.

Table 4.7: Individual and Interactive Effect of Transplanting Age and Spacing Regime on Number of Branches on 30 DAT, 44 DAT, 58 DAT, 72 DAT and 86 DAT

Treatment	44 DAT	58 DAT	72 DAT	86 DAT
Transplanting Age				
30 DAP	2.11^{a}	3.67^{a}	5.11^{a}	7.33^{a}
37 DAP	1.89^{a}	2.78^{b}	3.33^{b}	6.78^{a}
LSD (0.05)	0.66	0.66	1.43	2.38
Planting Space				
40cm x 30cm	2.33^{a}	3.33^{a}	4.00^{a}	6.50^{a}
50cm x 30cm	1.67^{a}	3.33^{a}	4.17^{a}	7.67^{a}
60cm x 30cm	2.00^{a}	3.00^{a}	4.50^{a}	7.00^{a}
LSD (0.05)	0.81	0.80	1.75	2.91
*Transplanting Age * Spacing*				
37 DAP * 50 cm x 30 cm	1.33^{a}	2.67^{b}	3.33^{a}	7.00^{a}
37 DAP * 60 cm x 30 cm	2.00^{a}	2.67^{b}	3.33^{a}	6.00^{a}
37 DAP *40 cm x 30 cm	2.33^{a}	3.00^{ab}	3.33^{a}	7.33^{a}
30 DAP *60 cm x 30 cm	2.00^{a}	3.33^{ab}	5.67^{a}	6.00^{a}
30 DAP *40 cm x 30 cm	2.33^{a}	3.67^{ab}	4.67^{a}	7.33^{a}
30 DAP *50 cm x 30 cm	2.00^{a}	5.00^{a}	5.00^{a}	8.33^{a}
LSD (0.05)	1.15	1.13	2.38^{a}	4.11
CV (%)	31.62	19.35	32.26	32.08

Means bearing different superscripts in the same column for each treatment were significantly different (P<0.05), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

4.2.3Canopy Width (cm)

Except at 44 DAT to 72 DAT where there were difference existed between the transplanting ages (Table 4.8). There was no significant ($p \geq 0.05$) difference between different planting space in canopy width across the entire cropping period except at 72 DAT which differed from the others. There was no significant ($p \geq 0.05$) difference between transplanting age in canopy width from 30 DAT and 86 DAT significantly in canopy width.

Result from (Table 4.8) indicates that there was a significant ($P \geq 0.05$) difference between transplanting age and different plant spacing interaction in canopy width.35 transplanted using 50 cm × 30 cm produced significantly higher canopy width than 40 cm × 30 cm and 60 cm × 30 cm which produced least canopy width from 44 DAT to 86 DAT (Table 4.8).

Table 4.8: Individual and Interactive Effect of Transplanting Age and Spacing Regime on Canopy Width on 30 DAT, 44 DAT, 58 DAT, 72 DAT and 86 DAT

Treatment	30 DAT	44 DAT	58 DAT	72 DAT	86 DAT
Transplanting Age					
30 DAP	10.50[a]	15.56[b]	22.34[b]	23.81[b]	34.72[a]
37 DAP	10.33[a]	26.89[a]	36.33[a]	46.78[a]	49.80[a]
LSD (0.05)	1.37	7.81	9.15	8.80	15.83
Planting Space					
40cm x 30cm	9.167[b]	19.87[a]	26.62[a]	35.73[a]	43.76[a]
50cm x 30cm	10.68[ab]	19.60[a]	26.97[a]	31.48[a]	36.23[a]
60cm x 30cm	11.40[a]	24.20[a]	34.43[a]	38.67[a]	46.80[a]
LSD (0.05)	1.68	9.56	11.20	10.78	16.38
*Transplanting Age * Spacing*					
37 DAP * 50 cm x 30 cm	11.00[a]	29.00[a]	36.33[a]	43.00[a]	46.00[a]
37 DAP * 60 cm x 30 cm	12.33[a]	25.67[ab]	38.67[a]	52.67[a]	49.33[a]
37 DAP *40 cm x 30 cm	7.67[b]	26.00[ab]	34.00[ab]	44.67[a]	54.08[a]
30 DAP *60 cm x 30 cm	10.47[a]	22.73[abc]	30.20[abc]	24.67[b]	44.27[a]
30 DAP *40 cm x 30 cm	10.67[a]	13.73[bc]	19.23[bc]	26.80[a]	33.43[a]
30 DAP *50 cm x 30 cm	10.37[a]	10.20[c]	17.60[c]	19.97[b]	26.47[a]
LSD (0.05)	2.37	9.14	15.84	15.24	23.17
CV (%)	12.53	35.02	29.68	23.74	29.12

Means bearing different superscripts in the same column for each treatment were significantly different (P<0.05), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

4.3 Yield and Yield Components

4.3.1 Number of plants harvested

Result from (Table 4.9) indicates that there was no significant ($P \geq 0.05$) difference between transplanting age and different plant spacing. Approximately both 30 DAP and 37 recorded the same number of plants harvested with the mean of 17.

There was no significant ($P \leq 0.05$) difference between transplanting age × different plant spacing interaction in number of plants harvested.(Table 4.9). All interactions recorded a mean value of 17 harvested.

4.3.2 Number of fruit per plant

There was no significant ($P \geq 0.05$) difference between transplanting age, different plant spacing and transplanting age × different plant spacing interaction in number of fruit per plant (Table 4.9).However, 30 DAP recorded the highest number of fruit per plant (31) while37 DAP obtained the least mean value (30) in number of fruit per plant (Table 4.9).

Different plant spacing 50 cm × 30 cm produced significantly higher number of fruit per plant (40) than 40 cm × 30 cm (31) followed by 60 cm × 30 cm (20) (Table 4.9).

4.3.3 Fruit weight per plot (kg)

From (Table 4.9) there was no significant ($p \geq 0.05$) difference between transplanting age and different plant spacing in fruit weight per plot. 30 DAP was not significant in fruit weight per plot as compared to 37 DAP (Table 4.9).

There was no significant ($p \leq 0.05$) difference between plant spacing, transplanting age × different plant spacing interaction in fruit weight per plot. 30 DAP * 40 cm × 30 cm produced significantly heavier (358.7 g) fruit weight per plot than other treatments (Table 4.9).

4.3.4Number of rotten fruit per plot

Results in (Table 4.9) shows that there was no significant ($P \geq 0.05$) difference between transplanting age and different plant spacing and their interaction in number of rotten fruit per plot although 37 DAP, 60 cm × 30 and 37 DAP * 40 cm x 30 cm in transplanting age, plant spacing and their interaction respectively had the highest number of rotten fruit per plot and the least with 25 DAT and 40 cm × 30 cm(Table 4.9).

4.3.5 Fruit diameter (cm)

Table 4.9 shows that there was no significant ($P \leq 0.05$) difference between transplanting age, different spacing and transplanting age × different spacing interaction in fruit diameter. Plant which were transplanted 30 DAP and 37 DAP produced approximately the same fruit diameter and recorded as 4.1 cm. 60 cm × 30 cm plant spacing produced significantly higher (4.5 cm) fruit diameter than other planting space (Table 4.9) and40 cm × 30 cm produced the lowest (3.75) fruit diameter.

Table 4.9: Individual and Interactive Effect of Transplanting Age and Spacing Regime on Yield and Yield Components

Treatment	Number of Plants Harvested	Number of Fruits Per Plant	Fruit Weight Per Plot (g)	Number of Rotten Fruits	Fruit Diameter
Transplanting Age					
30 DAP	16.89^{a}	30.67^{a}	334.89^{a}	7.00_{a}	4.12^{a}
37 DAP	16.78^{a}	29.22^{a}	284.56^{a}	8.44^{a}	4.11^{a}
LSD (0.05)	1.55	12.79	136.31	3.96	1.27
Planting Space					
40 cm x 30 cm	16.67^{a}	30.50^{ab}	355.33^{a}	7.50^{a}	3.75^{a}
50 cm x 30 cm	17.00^{a}	39.50^{a}	298.17^{a}	7.67^{a}	4.07^{a}
60 cm x 30 cm	16.83^{a}	19.83^{b}	275.67^{a}	8.00^{a}	4.53^{a}
LSD (0.05)	1.90	15.67	166.95	4.87	1.56
*Transplanting Age * Spacing*					
37 DAP * 50 cm x 30 cm	17.00^{a}	43.00^{a}	275.67^{a}	7.67^{a}	4.17^{a}
37 DAP * 60 cm x 30 cm	16.33^{a}	18.67^{b}	226.00^{a}	8.33^{a}	4.00^{a}
37 DAP * 40 cm x 30 cm	17.00^{a}	26.00^{ab}	352.00^{a}	9.33^{a}	4.17^{a}
30 DAP * 60 cm x 30 cm	17.33^{a}	21.00^{ab}	325.33^{a}	7.67^{a}	5.07^{a}
30 DAP * 40 cm x 30 cm	16.33^{a}	35.00^{ab}	358.67^{a}	5.67^{a}	3.33^{a}
30 DAP * 50 cm x 30 cm	17.00^{a}	36.00^{ab}	320.67^{a}	7.67^{a}	3.97^{a}
LSD (0.05)	2.68	22.15	236.10	6.89	2.20
CV (%)	8.74	40.65	41.90	49.01	29.40

Means bearing different superscripts in the same column for each treatment were significantly different ($P<0.05$), NS= Not Significant LSD= Least significant difference CV = coefficient of variation

CHAPTER FIVE

5.0 DISCUSSION

5.1 Phenology of Pepper as influenced by transplanting age and different plant spacing

The non-significant difference in transplanting age in days to 50% flowering and 50% fruiting might be that transplanting age and the different planting space did not affect the 50% flowering and fruiting. Uarrota (2010) stated that flower formation and fruit set in plants are dependent on the interaction of many complex processes which are influenced by genetic and environment factors. This could be due to the fact that both the 30 DAP and 37 DAP were transplanted during a suitable environmental conditions and that favoured phenological development of the pepper. AVRDC (1990) also reported that fruiting delays when night temperatures were greater than 24^0C or daily temperatures exceeded 32^0C for longer period, so this could be the fact that the pepper has suitable conditions in line with AVRDC(Asian vegetable research and development center) (1990). This is in agreement with Hills (2014) and Lithourgidis *et al.* (2011) who reported that pepper started flowering from two months after planting and fruit should be ready for harvest a month time. And again, could be probably early flowering from 25 DAT resulted in early fruiting which might have limited vegetative growth period resulting in fewer branches, hence lower yield compared to the four weeks old transplant.

5.2 Vegetative Growth of pepper as influenced by transplanting age and different plant spacing.

There was no significant (P ≥ 0.05) difference between transplanting age 30 DAP and 37 DAP in plant height from 58 DAT to 86 DAT and at 30 DAT except at 44 DAT where significant difference exist. This could be due to variation in transplant age during the cropping seasons. This is in agreement with the findings of Ibrahim *et al.*(2013) that transplanting of plant at younger age was better in performance, especially in height than those transplanted later. Plant height however, was not significantly affected by age of transplant and different plant spacing interaction from 58 to 86 DAT during cropping season. The 30 DAP transplants differed significantly from 37 DAP and at 44 DAT in plant height during cropping period might be that in younger seedlings there was less stored food needed for vegetative extension while the older transplants switched over to reproductive phase earlier and had little time for establishment. Again, the results of this findings agrees with the results of Jovicich *et al.* (2004) who stated that growth parameters of pepper were significantly increased at earlier sowing dates. The length of seedlings at transplanting increased with increase in seedling age. Increased plant height in older transplants might also be attributed to higher biomass, especially the well developed and established root system which resulted into more uptakes of water and nutrients from the soil leading to better cellular elongation. Similar trends have also been reported by (He *et al.*, 2012).

There was no significant (p ≥ 0.05) difference between transplanting age, different spacing and transplanting age × different interaction in percentage plant establishment and this might be due to the differences in crop response to transplanting age, soil nutrient and moisture. This may enhance seedling with initial vigorous seedling growth, proper plant establishment and subsequently early flowering. This agrees with Yemane *et al.* (2013) and (Zhang *et al.*, 2014) that establishment of plant depends on the interaction of genetic makeup and environment.

The non- significant ($p \geq 0.05$) difference between transplanting age in number of leaves per plant from 30 DAT to 86 DAT. 30 DAP produced the highest number of leave than 35 DAP might be due differences in plant morphology and its response to high temperature tolerance experienced during the later stage of plant development. The higher number of leaves produced by plant spacing 50 cm × 30 cm from 30DAP to 86 DAT except at 72 DAT could be the fact that when inter row spacing increase, the number of branches per plants per unit area becomes less. This contradicts with the findings of Waktola *et al.*, (2014) that plants develop fewer branches at narrower plant spacing.

There was no significant ($p \geq 0.05$) difference between transplanting age in number of branches from 58 DAT to 72 DAT. The highest number of branches recorded by 30 DAT might be that more dry matter accumulated for vegetative growth to produced branches, while 37 DAP has matured and might have little limited vegetative growth due to limited dry matter available. 30 DAP grew faster, the ability to compete for space and growth factors such as sunlight, temperature, etc. these growth factors.60 cm × 30 cm plant spacing differed significantly from other treatment in number of branches might be due to wider spacing which allows the plant to explore available nutrients and water for photosynthesis. This is in agreement with Yang *et al.* (2015)who reported that wider spacing could be more feeding zone that encourage lateral growth resulting in the production of more branches and leaves per plant and also Ravanappa *et al.* (2012) who reported that the lowest plant density treatment obtained from the wider plant spacing produced the highest number of branches per plant.

There was no significant ($p \geq 0.05$) difference between transplanting age in canopy width at 30 DAP and 86 DAT. 37 DAP transplants produced the widest canopy width from 30 DAT to 86 DAT across the cropping period. This might be due that transplanting age used differs in plant morphology. The 50 cm × 30 cm produced significantly higher canopy width than 40 cm × 30 cm and 60 cm × 30 cm from 30 DAT to 86 DAT cropping season .This might be due to differences in plant morphology and plant spacing. Plants with increased canopy width tend to have higher photosynthetic potential (Qian *et al.*, 2014).The 40 × 30 cm and 60 × 30 cm plant spacing had the lowest canopy width for cropping periods. This might be due to differences in plant spacing and its effect on plant structure. Plant density can affect canopy formation, light conversion efficiency and duration of vegetative growth. Therefore, optimizing plant spacing, which could be defined by number of plants per unit area and the arrangement of plants on the ground, is a pre-requisite for obtaining higher biomass hence canopy width.

5.3 Yield and yield components of pepper as transplanting age and different plant spacing

There was no significant difference between transplanting age and different plant spacing in number of plants harvested during cropping seasons.

There was no significant ($P \geq 0.05$) difference between transplanting age × different plant spacing interaction in number of plants harvested. This might be due to the fact that different plant spacing used had no effect on number of plant harvested. The highest number of plants harvested was recorded as 17 plants while the least mean recorded as 16 plants. This might be due that plant was able to establish well in root system seedlings which were capable of causing enhanced water absorption and translocation along with nutrients from the rhizosphere. This agrees with the findings of Wang *et al.* (2017).that seedlings transplants with sufficient roots and number of true leaves might be responsible for absorbing soil water and manufacturing a sizable amount of photosynthesis required to establish vigorous plant and complete its life cycle more comfortably.

The non-significant ($P \geq 0.05$) difference between transplanting age, different plant spacing and transplanting age × different plant spacing interaction in number of fruit per plant might be due to young seedlings transplanted. This agrees with the findings of Dagnoko *et al.* (2013) who reported of highest number of fruits from younger transplants. Contrary to this (Miao *et al.,* 2011).found more fruits from older transplants. 37 DAP recorded the highest number of fruit per plant (31.6) while30 DAP obtained the least mean value (30.7) in number of fruit per plant. This might be due to the fact that in younger seedlings there was less storage of food needed for vegetative extension, whereas, older transplants were mature enough and limit vegetative extension. Moreover, middle aged seedlings on account, extended lateral branches produced maximum number of fruits per plant than younger or older ones. This is in conformity with the findings of (Zhong *et al.*, 2013) that middle aged transplants produced higher number of fruits per plant than the younger or older transplants. The highest number of fruits per plant by middle aged transplants was also reported by (Li *et al.*, 2013).in tomato. Different plant spacing had no significant effect on number of fruits per plant in both cropping seasons although differences exist between treatment means.

The plant spacing 50 cm × 30 cm produced significantly higher number of fruit per plant than 60 cm × 30 cm, 40 x 30 cm might be due to better vegetative growth in terms of plant height, number of leaves per plant and number of branches in both cropping seasons.

Plant which were transplanted 30 DAP produced higher fruit diameter than other treatments (37 DAP) which the least recorded in fruit diameter. This might be due to differences in transplanting age of seedlings. This is not in line with (Manna *et al.,* 2013) that pepper transplants of 6 to 8 weeks (older transplants) have a yield advantage for early fruit size.

60 cm × 30 cm plant spacing produced higher (4.20)fruit diameter than other treatments. The 30 DAP differed from 37 DAP in fruit diameter during growing season. The widest fruit diameter in 30 DAP might be attributed to high or enhanced biomass, accumulation of resources and improved water relationship in the plants. This heightened meristematic activities that favored the enlargement of fruit. This agrees with the findings of Yang *et al.,* 2015).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The result revealed that:

- Seedling transplanted 37 DAP on 50 cm × 30 cm performed better in days 50% flowering, days 50% fruiting, number of fruits per plant.
- 50 cm × 30 cm produced significantly higher number of branches per plant than other treatments for the entire growing period.
- Pepper seedling transplanted at 30 DAP was earliest to mature (134days) while 37 DAP lagged in maturity (137days).
- The interaction of 37 DAP and 60 cm × 30 cm produced significantly taller plants from 30 to 86 DAT than other interactions(40 cm × 30 cm and 50 cm × 30 cm) and all the interactions of 30 DAP.
- Seedling transplanted at 37 DAP on 40 cm × 30 cm produced the highest number of rotten fruit.
- 37 DAP interactions produced wider canopy width than the 30 DAP interactions.

6.2Recommendations

From the results the following recommendations were made:

- Farmers are encouraged not to grow pepper by using 37 days old of transplant on 40 cm × 30 cm in other to limit or reduce number of rotten fruits.
- It is recommended that pepper growers should transplant seedlings at 60 cm × 30 cm for optimum plant establishment and for number of branches for higher yield.

- To produce more leaves per plant farmers are encouraged to transplant seedling at 30 days old on 50 cm × 30 cm from 30 to 86 DAT.
- Pepper farmers are to transplant seedling 30 DAP for early days to maturity.
- The work should be repeated, if possible, on farmer's field to ensure that the result is validated and to facilitate the transfer of technology.

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