EFFECT OF ORGANIC MULCH ON GROWTH AND YIELD OF SWEET PEPPER (*Capsicum annuum L*)

BY

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DECLARATION

In exception of references to the works of researchers which have been duly cited, this thesis is the result of my own work produced from research undertaken under supervision.

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DEDICATION

I dedicate this thesis to my wife Mrs. Gifty Opare Addo, my mother Mrs. Patience Foli Addo, my grandfather Mr. Richmond Komla Mawuena Foli and my grandmother Mrs. Monica Yaodem Foli.

ABSTRACT

The high cost and increasing disposal problems associated with polyethylene mulch and greater availability of organic mulches prompted an investigation into the effects of organic mulches on growth and yield of sweet pepper at the University of Ghana Forest and Horticultural Crops Research Centre, Okumaning near Kade. Two field experiments were conducted in the raining season, that is from July, 2012 to December, 2012 and in the dry season from December, 2012 to March, 2013. In both experiments four treatments; dry rice husks (RH), empty palm fruit bunches (EPFB) and cocoa pods husks (CPH) as mulches at the rate of 35t/ha each and a control (bare soil) were evaluated in a randomized complete block design with four replications.

The results indicated that organic mulch application in both rainy and dry seasons significantly influenced soil temperature and suppressed weed growth. Soil moisture content was not significantly influenced by the mulch materials in the rainy season. However, in the dry season soils under mulched plots retained significant amount of soil moisture compared to soils under no mulch treatment.

Organic mulch application in the rainy season did not significantly increase plant height, stem diameter, number of branches, number of leaves, leaf area as well as leaf area index of sweet pepper compared to the control. However, the application of organic mulch compared to the control resulted in increased plant height, canopy size and stem diameter in the dry season. Although weight of fruits per plant, mean fruit weight per plant, total fruit yield, fruit length and fruit width were not significantly increased by the application of organic mulch materials in the rainy season, mulching significantly influenced yield and yield components of sweet pepper in the dry season. Application of rice husk mulch was the most effective treatment in increasing the weight of fruits per plant, total fruit yield and mean fruit weight per plant.

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CHAPTER ONE

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) belongs to the family Solanaceae. It is an important vegetable cum condiment and an active ingredient in cookery. The sweet pepper fruit is rich source of vitamins, especially vitamin A, C and E. It also contains thiamine, vitamin B6, beta carotene, and folic acid. It is grown for green, spices, condiments, sauces and pickles. It also imparts peculiar beauty, taste and flavour to cook the vegetables and other dishes (Tarara, 2000).

Sweet pepper has gained popularity probably due to its additional importance as it also contains a large amount of phytochemicals that have exceptional antioxidant activity, and the production and consumption thereof has increased worldwide. These phytochemicals include chlorogenic acid, zeaxanthin, and coumeric acid. Possibly due to the vitamin C and beta carotene content, green peppers have been shown to be protective against cataracts. They have also been shown to prevent blood clot formation and reduce the risk of heart attacks and strokes probably due to their content of substances such as vitamin C, capsaicin, and flavonoids. Although chilli peppers contain a higher amount of vitamin C, capsaicin, and flavonoids, sweet peppers should still be promoted especially for individuals with elevated cholesterol levels (Murray, 2005).

In Ghana, sweet peppers are grown for both local consumption and export. It is now being cultivated commercially by both small scale and commercial farmers to support the export drive (Norman, 1992).

There is a huge market demand in Ghana for sweet pepper for export; therefore its production needs to be expanded. For instance in 2009, the Millennium Development Authority (MDA) supported some farmer groups in the Kwahu East District of the Eastern Region to produce and sell 5.6 tonnes of sweet pepper at GH¢5,700 to the United Kingdom through Dhillon Farm Limited, a vegetable exporting company located in Accra (ModernGhana.com, 2009)

1.1 Problem Statement

In Ghana and West Africa as a whole, sweet peppers are grown for both local consumption and export. Its production is limited almost entirely to the urban centres (Norman, 1992).

In Ghana, sweet pepper is mainly rain-fed crop, and during the dry season there is some production along river valleys. Most small scale farmers who operate as out growers for export companies grow sweet pepper crops by operating on rain-fed basis. In the dry season, stunted growth, poor fruit set or dropping of flowers and young fruits may occur as a result of dry soils. To meet the high demand of sweet pepper for local consumption, some growers resort to irrigation to take care of irregular rains during the wet seasons, the late minor season and the long dry season occurring between November and March. Moisture supply for the best production of sweet pepper must be uniform during the growing season. It is therefore important for small scale farmers to adopt horticultural practices such as mulching to conserve soil moisture (Norman, 1992) in order to optimise productivity. Mulching is the application of a covering material to the soil surface (Norman, 2004).

The use of polyethylene as a mulch with irrigation is a widespread practice in commercial vegetable production systems. However, polyethylene has some disadvantages such as; difficulty of removal, cost of disposal, increased soil erosion and increased agricultural chemical runoff (Lamont, 1993; Hochmuth, 1998; Brown and Channell- Butcher, 2001; Rice *et al.*, 2001). Disposal of the mulch is increasingly becoming problem and costly to growers and society. Disposal cost in some areas has increased by as much as 30% in one year (Servis, 1992).

Besides the problem associated with its disposal, the cost of polyethylene is also not within the reach of most small-scale producers. An alternative to the use of plastic mulch is the use of organic mulch. Organic mulch systems are recyclable in the soil, reduce production cost and benefit the environment. Surface mulching has been shown to reduce evaporation and decrease salinity hazards (Yang *et al*., 2006). Organic mulch keeps the surface layer wetter and helps to increase root growth (Gajri *et al*., 1994). It has also been found to reduce day time temperature and conserve moisture, increase growth and yield attributes of vegetables (Adetunji, 1990). Organic mulching has been used to obtain good growth and yield in pepper (Aiyelaagbe and Fawusi 1986; Rahman *et al*., 2006).

Organic mulch improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Dilipkumar *et al.*, 1990). Organic mulches reduce soil erosion, and may have advantages of low cost, with no removal requirement (Isenberg and Odland, 1950; Aparbal-Singh *et al*., 1985; Roe *et al*., 1992; Singh, 1992). Organic mulches have also been shown to improve soil quality and stimulate soil microbial communities due to the addition of organic matter (Lalande *et al*., 1998; Ozores-Hampton, 1998; Oslen and Gounder, 2001).

Organic mulches can reduce evaporation of water from the soil surface, suppress weed growth, and restrict leaching of fertilizer nutrients and moderate diurnal and seasonal temperature fluctuations (Janick *et al*., 1986).

A good mulch must be economical, available, easy to handle and must be stable so that it will not easily wash or blow away (Norman, 2004). In Ghana some common materials used for mulching include sawdust, grass straw, grain straw, corncobs and plastic film. Even though these mulch materials are easy to handle and stable when applied, some of them are fed to livestock and used to set fire making them hard to come by and uneconomical.

Although there is some research on the benefits and use of organic mulches as an alternative to polyethylene mulches, there is little or no research about the use of local materials such as empty palm fruit bunches, rice husks and cocoa pods as organic mulches on sweet pepper production in Ghana. There is the need, therefore, to investigate the effect of organic mulches (dry rice husks, dry empty palm fruit bunches and dry cocoa pod husks) as related to the production of green pepper under rain fed conditions in Ghana. The choice of these organic mulch materials is due to their availability, economical, easy to handle and transport and ability to decompose easily.

1.2 Objectives

The study is aimed at ascertaining the effects of organic mulches (cocoa pod husks, empty palm fruit bunches and rice husks) on the growth and yield of sweet pepper. Specifically the experiment is aimed at:

1. Determining changes in soil temperature and moisture under organic mulches.
2. Assessing the ability of weed suppression by various organic mulches in sweet pepper field.
3. Assessing the growth and yield of sweet pepper under organic mulches.

CHAPTER TWO

LITERATURE REVIEW

The literature pertaining to the use of organic mulches (dry cocoa pods, rice husks and empty palm fruit bunch) on growth and yield of sweet pepper is very scarce, so the combined effect of organic mulches on peppers as well as on few of the related crops has been reviewed and presented in this chapter.

2.1 Climatic requirements of sweet pepper

Sweet pepper is a warm-season crop, which grows well under an extended frost-free season, with the capability of producing high yields of exceptional quality. It is easily destroyed by frost and at temperatures between 5 an 15°C, it performs poorly (Bosland and Votava, 1999). The best temperature range for sweet pepper growth is 20-25°C When sweet pepper seed is sown at too low soil temperatures, germination is slow but as temperatures increase to between 24-30°C seedling emergence accelerates (Bosland and Votava, 1999). The best soil temperature for germination is 29°C Low temperatures also reduce the growth of seedling leading to prolonged seedling exposure to insects, diseases, salt or soil crusting, any of which can badly damage or kill the seedlings (Bosland and Votava, 1999). The productivity of many plant species of which sweet pepper is of no exception is adversely affected by high temperatures. Sweet pepper needs optimum day/night temperatures of 25/21°C during flowering. The flowers are aborted and yield is reduced when they are exposed to temperatures as high as 33°C for longer than 120 hours. Pollen becomes non-viable and appears to be deformed, empty and clumped when exposed to high temperatures (>33°C) (Erickson and Markhart, 2002). Temperatures lower than 16°C can lead to fruitless plants (Coertze and Kistner, 1994). When daily air temperature ranges between 18-32°C during fruit set, higher yields are obtained (Bosland and Votava, 1999). Prolonged high relative humidity and temperatures above 35°C reduce fruit set. Normally fruits that are formed during high temperature conditions are deformed. Sweet peppers are also sensitive to sunscald (Coertze and Kistner, 1994). Temperatures above 21°C hasten the development of fruit colour (Bosland and Votava, 1999).

2.2. Soil requirements of sweet pepper

Sweet peppers grow in a wide range of soils, but do well preferably in well-drained, sandy loam or loamy soil with a good water-holding capacity and rich in humus. Soils deeper than 400 mm are needed. Plants can be planted on ridges in shallow soils with a poor drainage capacity (Coertze and Kistner, 1994). Their effective depth of root is between 400-700 mm. Soils with a pH (H_2O) range of between 5.5 and 6.8 is preferable for sweet pepper production. Sweet pepper is fairly sensitive to soil salinity. Soil with 50 percent or more electrical conductivity (EC) of 5 ds m^{-1}can reduce sweet pepper yield. Sweet pepper yield can also be reduced by certain nematode species which damage pepper roots (Bosland and Votava, 1999).

2.3 Use of mulches in vegetable production

Man has come out with technologies since the beginning of civilization to maximize the efficiency of food production. One of these traditional techniques that have been used since 1950' is the utilisation of mulch in commercial vegetable production. When mulch is placed over the soil surface, a favourable soil-water-plant relation is created. The microclimate surrounding the plant and soil is greatly influenced by mulch that is the thermodynamic environment, the moisture, the crop growth and yield. For commercial production of vegetable crops in many regions of the world, the use of mulch has become an important cultural practice to maximize water use efficiency by the plant and to improve the growth.

Organic or inorganic soil mulches influence the crop in many ways. Barrier can be provided by plastic mulches against weeds, moisture loss, nutrient loss, erosion, insect and disease injury while enhancing plant establishment and an earlier crop of higher quality.

Organic mulching improves physical, chemical and biological properties of soil, as it releases nutrients to the soil and ultimately facilitates the growth and yield of crops (Dilipkumar *et al.*, 1990).

Organic Mulching possesses an advantage for increased crop production through its positive effect on the soil environment which enhances crop growth and yield (*Lal et al.*, 1980).

Judicious use of crop residues help to maintain adequate infiltration rates, prevent surface crusting, improve aggregation of soil and modify the transport and retention of water, heat and air in the soil (Agyenim-Boateng and Dennis, 2001). It was also reported that physical, chemical and biological properties of soils are affected by crop residues. According to the authors, when crop residues are applied as surface mulch they influence the soil positively by conserving moisture, improving soil structure thereby enhancing aeration, infiltration and water-holding ability. The authors further stated that mulching also reduce high soil temperature, controls soil erosion by reducing runoff and heavy impact of rain drops and preventing leaching of nutrients, promoting the activities of soil microorganisms as well as reducing weed competition (Agyenim-Boateng and Dennis, 2001).

Hochmuth *et al* (2001), reported that the main objectives of mulching are weed control, conservation of soil moisture and modification of temperature. Mulching effectively manipulates crop growing environment leading to increased yield and improved product quality by suppressing weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content (Opara-Nadi, 1993; Hochmuth *et al.*, 2001; Awodoyin and Ogunyemi, 2005).

Nowadays mulching by either organic or inorganic materials are being utilised to protect plants from root borne diseases and for conservation of water. Organic mulches such as sawdust, dry grass, maize cobs, water hyacinth, rice and wheat straw have enhanced vegetative growth and yield through improving water content of soil, heat energy and addition of some organic nitrogen and other minerals to improve nutrient status of the soil (Yang *et al*., 2006). Vegetative growth as well as increased yield of vegetables are enhanced by mulching through improvement in the soil environment (Yang *et al*., 2006).

2.4 Types of mulches

Lal (1987), defined mulching as the application of a layer of dissimilar material, separating the soil surface from the atmosphere. According to Wild (1988), mulches are organic or inorganic materials spread on the surface of the soil to protect it from the full force of the sun, raindrops and wind which may otherwise induce surface crusting, freezing and evaporation of the bare soil. Mulching is the application of covering layer of material to the soil surface (Norman, 1992). Stigter (1984), stated that materials used by traditional farmers include; leaves, dried or fresh banana leaves, grass, straw, maize stalk, crop residues, ash, animal dung and household rubbish. Traditional farmers use organic mulch materials such as cereal straw and stalk, crop debris, sawdust, leaves, grass, maize stover, weeds, manure, Spanish moss, and various water plants. In modern or commercial agriculture, inorganic mulches used include aluminium foil, asphalt, paper, glass wool, petroleum mulch and various polythene mulches such as black or transparent polythene sheets (Thurston, 1997). The main types of mulches are organic materials obtained from plant and animal residues and inorganic materials which are usually synthetic in nature.

2.5 Effect of organic mulches on soil moisture.

According to Rajput and Singh (1970), straw mulch conserved higher soil moisture compared with bare soil. There has been significant rise in the average available soil moisture stored in the soil by mulching with wheat residue in comparison to bare soil (Black, 1973). Koni (1983), reported of better soil moisture conservation with the application of sorghum stubbles, cotton stubbles and maize stubbles as mulch in pepper than the bare soil. Mulch protects the soil from direct rays of the sun which would cause evaporation of moisture from the soil surface and cause drying of the soil profile. This leads to improved and higher soil moisture.

According to Dilipkumar *et al.* (1990), mulching reduces soil water evaporation. Thus, it enhances more retention of soil moisture. Moisture retention of soil has been shown to be improved by the application of organic mulches. Mintah (1998), reported of higher soil moisture content on *Mucuna pruriens* mulched plot in comparison with no mulch plot. Several studies conducted by (Fraedrich and Ham, 1982; Unger, 1995; Schonbeck and Evanylo, 1998; Agele *et al.*, 2000) have shown that mulching with organic materials conserved soil moisture and consequently increased crop production. Moisture contents of soils under organic mulches - grass straw, rice straw, rice husk and sawdust were higher than those in the control (Nkansah *et. al.*, 2003).

Ghosh *et al.* (2006), studied the growth and yield response of groundnut under wheat straw mulch and bare soil and reported that there was higher moisture content in wheat straw mulch plot than bare soil under field condition. Organic mulches helped to maintain soil moisture content longer than bare soil. Mulching conserves water by reducing evaporation and mitigates negative effects of water stress on plant growth and yield under semi-arid conditions. Mulching conserves moisture contents which in turn results in increase in the plant growth. (Nasir *et al.*, 2011).

2.5.1 Effect of organic mulches on soil temperature

Mulching aids in the control of temperature fluctuations (Dilipkumar *et al.*, 1990). Mintah (1998), observed that *Mucuna pruriens* mulched plots had lower soil temperature compared to that of no mulch plots. Agele *et al.* (2000), studied the effect of tillage and mulching on the performance of post-rainy season tomato in the humid, south of Nigeria. He reported that mulching resulted in reduced soil temperature that led to increased yield. Several studies conducted by (Ashworth and Harrison, 1983; and Agele *et al*., 2000) have also shown that mulching with organic materials regulates soil temperatures and consequently increase crop production. Organic mulches - grass straw, rice straw, rice husk and sawdust were more effective in reducing soil temperature compared to the control (Nkansah *et al.*, 2003). Gandhi and Bains (2006), reported that mulches moderate hydrothermal regime of the soil and modify the microclimate by modifying soil temperature. (Norman *et al.*, 2011) found that dry *Panicum maximum* grass and sawdust mulches reduced soil temperature.

2.5.2 Effect of organic mulches on weed control.

According to Dilipkumar *et al.* (1990), organic mulching reduces weed infestation and enhances growth and yield of crops. Increase in yield as a result of reduced crop-weed competition due to weed suppression by organic mulching has been reported by several workers (Roe *et al*., 1993; Unger, 1995; Hendrickson, 1997; Schonbeck and Evanylo, 1998). Mintah (1998), also reported that *Mucuna pruriens* mulched plots recorded the lowest weed population than the no mulch plots. According to Nkansah *et al.* (2003), grass straw, rice straw, rice husk and saw dust mulches significantly reduced fresh weed weight. They also stated that grass straw mulch significantly reduced fresh weed weight while the highest fresh weed weight was observed in the control. According to Norman *et al* (2011), dry grass and sawdust mulches suppressed weed growth significantly.

2.5.3: Effect of organic mulches on plant growth.

2.5.3.1 Leaf area

Mintah (1998), reported that no mulch plots recorded the lowest leaf area compared to *Mucuna pruriens* mulched plots. Norman *et al.* (2002), studied the effect of grass mulch on the growth and yield of sweet corn in Ghana and reported that grass mulch increased leaf area of sweet corn. Acording to Ojeniyi *et al.* (2007), Cocoa husk increased leaf area of tomato compared to the control.

Venkanna (2008), observed increase in chilli leaf area and leaf area index under glyricidia mulch and crop residue mulch over no mulch treatment. In an experiment to determine the growth and yield response of okra to different organic manures, it was observed that leaf area was significantly influenced compared to the control (Abd El-Kader *et al*., 2010). According to Iftikhar *et al.* (2011), organic mulch materials maintain soil moisture and raise soil temperature and consequently resulted in increased leaf area.

2.5.3.2 Number of leaves per plant

Lantana leaves and grass mulches maintained higher number of leaves as compared to unmulched treatments of capsicum (Thakur *et al.,* 2000). Leaf number of sweet corn increased by the application of dry grass mulch (Norman *et al.*, 2002). Mulching increased the number of lettuce leaves per plant than no mulch (Moniruzzaman, 2006). Tomato plants grown in pots mulched with wild sunflower leaves recorded the highest number of leaves per plant over those grown in unmulched pots (Liasu and Abdul, 2007). In an experiment to determine the growth and yield response of okra to different organic manures, it was observed that number of leaves per plant was significantly higher under mulched treatments compared to the control (Abd El-Kader *et al*., 2010).

The greater number of leaves per chilli plant was recorded in rice straw mulch followed by wheat straw mulch and sugarcane bagasse mulch. Control plants recorded the lowest number of leaves per plant, (Iftikhar *et al*., 2011). Dauda (2011), also reported that grass mulch recorded the highest number of pepper leaves at 10 weeks after plating compared to the control. Iftikhar *et al.* (2011), also observed that in a pot experiment, chilli plants grown in rice straw mulch produced the maximum number of leaves followed by wheat straw mulch and sugarcane bagasse mulch. The minimum number of leaves was recorded by the control (no mulch). Dry grass mulch plants recorded the highest okro leaf number compared to the control plants (Norman *et al*., 2011).

2.5.3.3 Number of branches

In his experiment to study the effect of Lantana leaves and grass mulches on growth and yield of capsicum, Thakur *et al.* (2000), reported that Lantana leaves and grass mulches maintained higher number of branches as compared to unmulched treatments. Gandhi and Bains (2006), reported of higher number of tomato plants branches under straw mulch as compared to no mulch. Number of branches of chilli recorded at different stages of crop growth was significantly higher with application of glyricidia mulch and crop residue mulch over no mulch. Cocoa husk increased number of branches of tomato plant compared to the control (Ojeniyi *et al*., 2007).

(Venkanna, 2008). In an experiment to determine the growth and yield response of okra to different organic manures, branch number was influenced significantly by mulching (Abd El-Kader *et al*., 2010). Dauda (2011), reported of no significant effect on the number of branches per pepper plant by Grass mulch compared to the control. Dry grass mulch produced higher number of branches in okro than control (Norman *et al*., 2011).

2.5.3.4 Plant height

Thakur *et al.* (2000), reported of higher plant height of capsicum under Lantana leaves and grass mulches compared to unmulched treatments. Norman *et al.* (2002), reported that grass mulch increased sweet corn height. According to Nkansah *et al.* (2003), organic mulches increased tomato plant height than the control. Lettuce plant height was significantly increased by mulching more than control (no mulch), (Moniruzzaman, 2006). According to Awodoyin *et al.* (2007), the highest plant height of tomato was recorded under wood chips and grass mulches over the control (unmulched). Liasu and Abdul (2007), observed higher plant height of tomato plants in pots mulched with wild sunflower leaves compared to those in unmulched pots. Acording to Ojeniyi *et al.* (2007), cocoa husk increased tomato plant height compared to the control. Significantly higher plant height was recorded in chilli with the application of Glyricidia loppings used as mulch over no mulch control plots. But, it was at par with application of Crop residue mulch (grasses/plant materials/weeds) (Venkanna, 2008).

In an experiment to determine the growth and yield response of okra to different organic manures, it was observed that there was significant influence of chicken manure and plant residues on plant height compared to control (Abd El-Kader *et al*., 2010). According to Iftikhar *et al.* (2011), mulch material had significant effect on plant height. The highest chilli plant height was noted in rice straw mulch followed by sugarcane bagasse mulch and wheat straw mulch. The lowest plant height was recorded in control plants. Pepper plant height was significantly higher on grass mulch plots compared to the control (Dauda, 2011). High vegetative growth was observed in grass and sawdust mulches. Okro plants on grass mulched plots recorded significant height than the control plants at fruit set (Norman *et al*., 2011). Sawdust mulch increased hot pepper plant height more than the control (Norman *et al.*, 2011).

2.5.3.5 Canopy width

Capsicum plants grown on plots mulched with Lantana leaves and grass mulches maintained higher canopy width compared to plants on unmulched plots (Thakur *et al.*, 2000). Mulching have also been found to increase canopy width of lettuce plant compared with unmulched plants (Moniruzzaman, 2006). Increased hot pepper canopy size was observed on sawdust mulch compared to the control (no mulch) (Norman *et al*., 2011).

2.5.3.6 Stem diameter

Lantana leaves and grass mulches maintained higher stem diameter as compared to unmulched treatments of capsicum (Thakur *et al.,* 2000). Grass mulched plots produced higher stem diameter of sweet corn than control plots (Norman *et al.*, 2002). Grass mulch recorded the highest stem girth of tomato plant compared to control (unmulch) plot

(Awodoyin *et al*., 2007). Okro stem diameter was increased by applying plant residues and chicken manure compared to the control (Abd El-Kader *et al*., 2010).

2.5.3.7 Plant dry matter

Norman *et al.* (2002), stated that grass mulch increased sweet corn leaf dry matter more than control. Mulching produced maximum dry weight of lettuce plant than no mulch (Moniruzzaman, 2006). Application of glyricidia mulch recorded higher dry matter production as compared to no mulch and further crop residue mulch (Venkanna, 2008). Norman *et al.* (2011), also reported of maximum dry upper plant biomass of okro plants by dry grass mulch compared to the control plants.

2.5.4 Effect of organic mulches on flowering and harvesting

2.5.4.1 Number of days to flower

According to Ravindrkumar and Shrivastav (1998), organic mulches enhanced early flowering in tomato crop over control. Norman *et al.* (2002), reported of early teaselling of sweet corn under grass mulch compared to bare soil. Mulch material reduced number of days to flower. It took minimum days for chilli plants to flower in wheat straw mulch followed by plants in rice straw mulch and plants in sugarcane bagasse mulch. Control plants took maximum days to flower (Iftikhar *et al*., 2011).

2.5.4.2 Number of days to fruit set

Vos and Sumarni (1997), observed quick plant growth and early fruiting in hot pepper with straw mulching compared to control. Organic mulches enhanced early fruit set in tomato over the control (Ravindrkumar and Shrivastav, 1998). Sweet corn plants under grass mulch reached early silking than those on control plots (Norman *et al.*, 2002).

2.5.4.3 Number of days to first fruit harvest

According to Ravindrkumar and Shrivastav (1998), organic mulches reduced number of days to harvest in tomato crop. Sweet corn plants under grass mulch also reached harvesting earlier than those on control plots (Norman *et al.*, 2002). In their studies on the effect of mulching on growth and yield of chilli, Iftikhar (2011) observed that the mulch materials (rice straw, wheat straw and sugarcane bagasse) reduced the number of days to first harvest of chilli. It took the minimum number of days to first harvesting in rice straw mulch followed by wheat straw mulch plants and sugarcane bagasse respectively. Control plants recorded the maximum numbers of days for first harvest (Iftikhar *et al*., 2011).

2.5.5: Effect of organic mulches on plant yield

2.5.5.1 Mean fruit weight

Vos and Sumarni (1997), observed increased fruit weight of hot pepper with straw mulching compared to control. According to Gandhi and Bains (2006), tomato plants under straw mulch recorded higher fruit weight as compared to no mulch. Fruit weight of chilli was significantly higher with the application of glyricidia mulch followed by crop residue mulch at the same quantity as compared to no mulch (Venkanna, 2008). (Iftikhar *et al.* (2011), observed that Sugarcane bagasse, rice straw, and wheat straw mulches significantly influenced chilli fruit weight. Sugarcane bagasse mulch recorded the highest fruit weight followed by rice straw, wheat straw and control in that order. Plant residues and chicken manure significantly influenced okro fresh fruit weight compared to the control (Abd El-Kader *et al.,* 2010). Dry grass mulch recorded higher mean fruit weight of okro than the control (Norman *et al*., 2011). Sawdust mulch recorded the maximum mean fruit weight of pepper than the control (Norman *et al*., 2011).

2.5.5.2 Fruits weight per plant

Both grass mulched plots and bare soil in summer and winter produced no significant difference on growth and yield parameters of bell pepper, but bell pepper grown on grass mulch plots produced higher total number of weight of fruits than those on bare soil (Manuel *et al*., 2000). According to Norman *et al*. (2002), there were increased fresh ear weights of sweet corn from plants under grass mulch compared to those from control plants. Cocoa husk increased tomato fruits weight per plant compared to the control (Ojeniyi *et al.,* 2007). The total fresh weight of sweet pepper fruit per plant during an experiment revealed that grassed mulched recorded the highest value compared to the control (unmulched) which had the lowest value (Dauda, 2011). Dry grass mulch produced higher fruits weight of okro per plant than the control (Norman *et al*., 2011). Sawdust mulch recorded the maximum weight of pepper fruits per plant than the control (Norman *et al*., 2011).

2.5.5.3 Number of fruit per plant

Chakraborthy and Sadhu (1994**),** observed increased number of tomato fruit with water hyacinth mulch more than rice straw mulch. Bell pepper grown on grass mulch plots produced higher total number of fruits than those on bare soil both in summer and winter (Manuel *et al*., 2000). Norman *et al.* (2002), reported of higher number of sweet corn ear by the application of grass mulch compared to control. Organic mulches had the highest tomato fruit number per plant than the control. Rice husk mulch recorded the highest fruit number per plant over rice straw, grass straw and sawdust mulches (Nkansah *et al*., 2003). Grass mulch recorded the highest number of fruits per tomato plant followed by wood chip mulch in comparison to control (Awodoyin *et al*., 2007). The number of fruits produced during the first week of fruit production was highest in tomato plants in pots mulched with wild sunflower leaves while plants in unmulched pots had the lowest number of fuits per plant (Liasu and Abdul, 2007). Acording to Ojeniyi *et al* (2007), Cocoa husk increased number of tomato fruits compared to the control.

The number of chilli fruits per plant differed significantly with glyricidia mulch and with crop residue mulch compared to no mulch (Venkanna, 2008). The use of mulch material influenced the number of chilli fruits per plant. The highest fruit number per plant was recorded in sugarcane bagasse mulch followed by rice straw mulch and wheat straw mulch. Control recorded the lowest fruit number per plant (Iftikhar *et al*., 2011). The highest mean number of sweet pepper fruits per plant was observed on grass mulch plots over the control. (Dauda, 2011). Higher number of okro fruits per plant was recorded in plants on grass mulch than those on the control (Norman *et al*., 2011).

2.5.5.4 Yield per hectare

Okra production increased significantly under straw mulch followed by saw dust mulch over control (Batra *et al.*, 1985). The application of straw mulch increased tomato and okra yield over control (Gupta and Gupta., 1987). *According to* Dilipkumar *et al.* (1990), under rain fed situations mulching increased the yield over no mulching. Tomato yields were higher in organic mulched plots than the control. Gollifer (1993), reported that application of organic mulch resulted in increased chilli dry fruits yield compared to control. Organic mulch had the highest fruit yield of bell pepper over control (Rose *et al.*, 1994, Hassan *et al.*, 1994). Significant higher yield of tomato was reported under hairy vetch mulch than bare soil (Aref *et al.,* 1996). Vos and Sumarni (1997), observed increased yield of hot pepper with straw mulching compared to control.

Lantana leaves and grass mulches maintained higher growth and yield parameters in capsicum as compared to unmulched treatments, yield levels increased in lantana leaves and grass mulched plants over unmulched plants (Thakur *et al*., 2000). Norman *et al.* (2002), reported that grass mulch increased total ear yield of sweet corn more than control. Rice husk mulch had significantly higher yield than the control (Nkansah *et al*., 2003). Gandhi and Bains (2006), found out that tomato plant under straw mulch recorded higher fruit yield as compared to no mulch. Significantly higher fresh yield of lettuce was recorded from mulch treated plot than that from control (Moniruzzaman, 2006). According to Awodoyin *et al.* (2007), wood-chips mulch recorded the highest fruit yield of tomato followed by grass mulch compared to the control (unmulched) plots. The application of glyricidia loppings as mulch recorded significantly higher dry fruit yield of chilli as compared to no mulch treatment. (Venkanna, 2008).

Cover crops and the application of organic mulches increased tomato yield more than control (Qingren *et al*., 2008). Plant residues and chicken manure recorded the highest green fruit yield of okra compared to the control (Abd El-Kader *et al*., 2010). Grasse mulch plots recorded the highest yield of sweet pepper per hectare over the control (unmulched) (Dauda, 2011). The average cucumber and Bitter gourd production under mulch condition was significantly higher compared to values obtained in control treatments. (Nasir *et al*., 2011). Higher total okro fruit yield was observed in plants on grass mulch than those on the control (Norman et al., 2011). The highest total fruit yield of hot pepper was produced by sawdust mulch than the control *(Norman et al., 2011).* Bare soil plots resulted in lowest yield of tomato but this was not significantly different from yields obtained from mulched plots (Osei-Bonsu and Asibuo, 2013).

2.5.6 Effect of organic mulches on fruit quality

2.5.6.1 Fruit length

Sugarcane bagasse mulch recorded the maximum chilli fruit length. This was followed by wheat straw mulch and rice straw mulch. No mulch material recorded the lowest fruit length (Iftikhar *et al*., 2011). Grass mulch recorded the same length of pepper fruit compared to the control (Dauda, 2011). Dry grass mulch recorded higher mean fruit length of okro than the control (Norman *et al*., 2011). Sawdust mulch produced the highest mean fruit length of hot pepper compared to the control (Norman *et al*., 2011).

2.5.6.2 Fruit width

The application of mulch material influenced chilli fruit width. Iftikhar et al., (2011) found that sugarcane bagasse mulch recorded the highest fruit width followed by rice straw mulch and wheat straw mulch while control produced the lowest fruit width. Mulching materials had significant influence on fruit width of pepper. The highest mean fruits diameter was recorded on the grassed mulched plots over the control (unmulched) (Dauda, 2011).

Mean fruit diameter of okro was not significantly affected by dry grass mulch, sawdust mulch and the control (no mulch), (Norman *et al*., 2011). Maximum mean fruit diameter of hot pepper was recorded by sawdust mulch compared to the control (Norman *et al*., 2011).

2.5.7 Effect of organic mulches on net return

According to Sutagundi (2000), treatment receiving straw mulch resulted in significantly higher net return compared to the control.

CHAPTER THREE

MATERIALS AND METHODS

The present investigation was carried out at the University of Ghana Forest and Horticultural Crops Research Centre (FOHCREC), Kade from July, 2012 to March, 2013 with the objective of understanding the effect of organic mulches on growth and yield attributes of sweet pepper. The details of materials used and methods adopted during the course of investigation are outlined in this chapter.

3.1 Experimental site

The centre is at Okumaning near Kade (latitude 6º 09 and 6º 06 N and longitude 0º 55 and 0º 49 W and 135.9 m above sea level). It is located in the semi-deciduous forest agro-ecological zone of Ghana in the Kwaebibrim District of the Estern Region. The soils of the experimental site are well drained. They are classified as the forest Ochrosol Great Soil by the Ghanaian soil classification system (Brammer, 1962; Owusu-Benoah *et al*., 2000) and are generally classified as Acrisols (Offin series) in the FAO-UNESCO Revised Legend (FAO, 1998). The study site is characterized by a bi-modal rainfall pattern with peaks in June and October and a short dry spell in August while the major dry season stretches from December to February. The climatic conditions during the experimental period are presented in Table 3.1.

Table 3.1: Climatic data during the experimental period

Month	Total monthly rainfall (mm)	Temperature (˚C)	
		Mean monthly (maximum)	Mean monthly (minimum)
July 2012	150.9	29.3	21.7
August 2012	21.6	28.8	21.3
September 2012	131.5	31.1	22.0
October 2012	218.8	31.6	21.9
November 2012	110.3	32.5	21.1
December 2012	32.8	32.2	21.6
January 2013	0.1	33.7	20.4
February 2013	45.2	35.2	22.4
March 2013	228.5	34.1	22.3

Source: University of Ghana
Forest and Horticultural
Crops Research Centre
(FOHCREC), Kade.

3.2 Soil characteristics of the experimental site

Soil samples were collected from the field before layout of the experiment for the determination of the soil properties. The soil samples collected from 0 to 30cm depth were dried under shade and were pounded with wooden pestle in a mortar to pass through 2 mm sieve. The composite soil was used for analysis. The initial soil chemical and physical properties from the experimental site are presented in Table 3.2

Table 3.2 Initial soil chemical and physical properties from the experimental site

Ph	OC %	N %	P mg/kg	K cmol /kg	Na cmol /kg	Ca cmol /kg	Mg cmol /kg	CEC cmol /kg	% Sand	% Silt	% Clay
5.1	2.79	0.21	7.84	0.15	0.13	4.0	3.6	18.2	48.88	26.12	25.0

3.3 Experimental details

The experiment was conducted for two seasons, the first one commenced in July, 2012 and ended in December, 2012 while the second one started in December, 2012 and ended in March, 2013. Both experiments were conducted in a randomised complete block design with four replicates. The treatments evaluated included dry cocoa pod husks, empty palm fruit bunches, rice husks, all as mulches at the rate of 35t/ ha each and a control (bare soil). Each plot measured 3.6m x 8.1m. Each treatment consisted of five rows of ten plants each per plot (50 plants / plot). The sweet pepper cultivar planted in this experiment was Yolo Wonder.

3.4 Cultural practices

3.4.1 Land preparation

The site which was previously cropped to maize was prepared for planting by clearing with cutlasses in June, 2012. Four weeks later, the field was sprayed with (Sunphosate (Glyphosate) herbicide at a rate of 900 g a.i per hectare). At two weeks after spraying, stumps and debris were removed from the experimental area. These were followed by lining and pegging of the area into blocks and plots. Both blocks and plots were separated by 1 m buffer.

3.4.2 Raising of nursery

The nursery area was cleared with cutlass and sprayed with pesticide (Cidym super) at the rate of 35 mls per 15 l of water. A nursery box of 2.5m length, 1.5m width and 20cm height was filled with carbonated rice husk. A shed was erected over the nursery box.

3.4.3 Sowing of seeds and after care

Seeds of sweet pepper, variety- Yolo Wonder purchased from Agrimat, Madina – Accra were sown on 9 July 2012 for the first planting and on 5 November 2012 for the second planting in drills of 10cm apart in seed box and watered. Rain was alternated with watering in the evening hours up to the time of transplanting. Seedlings were fertigated with 20g of NPK dissolved in 2 litres of water weekly. As a preventive measure against pests- grasshoppers and crickets, seedlings were sprayed with Cidym Super fortnightly.

3.4.4 Transplanting

Sweet pepper seedlings of 6 weeks old were transplanted out on the field on 20 August 2012 for the first planting and on 11 December 2012 for the second planting at a spacing of 90cm x 90cm. One week later, the mulch materials were applied as indicated above.

3.4.5 Application of manures and fertilizers

The plants were side-dressed with N.P.K. (15:15:15) fertilizer at the rate of 300kg /ha in two splits; one-half at two weeks after transplanting and another one-half two weeks later. The plants were side-dressed again with sulphate of ammonia at the rate of 250kg /ha at flowering, that is about 5 weeks after planting.

3.4.6 Irrigation

The plants were irrigated uniformly at an interval of 3 days depending upon the soil and climate conditions so as to maintain adequate moisture in root zone in open field conditions. The irrigation was done using watering cans.

3.4.7 Crop protection measures

Weeds were controlled by hand picking at 3 weeks interval. Grasshoppers, crickets, termites, beetles and ants were controlled as and when necessary using Cydim Super at the rate of 35 ml per 15 l of water fortnightly to reduce pest damage.

3.5 Data collection

The data was collected on the following parameters; plant height, number of leaves per plant, leaf area, number of branches per plant, stem diameter, canopy size, dry weight of upper plant biomass, days to first flowering, days to 50% flowering, days to first fruit harvest and days to 50% fruit harvest. Others were number and weight of fruits per plant, mean fruit weight, fruit length, fruit width, marketable and non marketable fruits, days to final fruit harvest, cropping period, soil temperature, soil moisture content, weed biomass, assessment of insects and capsicum chlorosis disease. Leaf area index was calculated and economic analysis was done.

3.5.1 Growth parameters

Five randomly selected plants were tagged in each treatment plot for recording growth parameters and the mean of the observations on these 5 plants was computed and recorded.

3.5.1.1 Plant height

The height of the plants was measured in centimetres from the ground level to the tip of the main shoot at 50% flowering. A ruler was used to measure the height.

3.5.1.2 Stem diameter

The diameter of the main stem of the plant was measured in millimetres at 2 cm above the ground level with the help of vernier caliper at 50% flowering.

3.5.1.3 Number of branches per plant

At 50% flowering, the number of branches on each tagged plant was counted and mean number of branches per plant was recorded.

3.5.1.4 Number of leaves per plant

The number of leaves born by each tagged plant was counted at 50% flowering. Mean number of leaves per plant was calculated and recorded.

3.5.1.5 Leaf area per plant

Leaf area was measured at 4 WAT by disc method and was expressed in (cm^2). 20 leaf discs of known size were taken through a cork borer from randomly selected leaves of five plants, which were uprooted to record by dry matter accumulation from each experimental plot. Weight (g) and area of the discs (cm^2) were determined and leaf area per plant was computed.

3.5.1.6 Leaf area index (LAI)

LAI was worked out by dividing the leaf area by land area. Land area was determined from the planting distance, that is 90cm × 90cm.

3.5.1.7 Dry matter production and its accumulation in different plant parts

Electric oven dry weight (drying at 70ºC for 72 hrs. to a constant weight) of different parts were recorded by partitioning of whole plant into stem and leaves at 4 WAT. The sum of mean dry weight of all the plant parts represented the total dry matter per plant (g). Dry matter per hectare was also computed and expressed in Kg/ha.

3.5.1.8 Plant canopy

The plant canopy was measured from North to South and East to West directions at 50 percent flowering by the use of a centimetre rule. The values were added up and average was striked to represent plant spread.

3.5.1.9 Days to 50 per cent flowering

The number of days taken from the date of planting to flower opening of 50 per cent of the tagged plants (plants on the plot except the border plants) were counted and recorded.

3.5.1.10 Days to first fruit set

Numbers of days taken from the date of planting to the appearance of first fruit were counted and recorded as days taken to fruit set.

3.5.1.11 Days to 50 per cent fruit set

The number of days taken from the date of planting to the fruit set of 50 percent of the tagged plants (plants on the plot except the border plants) were counted and recorded.

3.5.1.12 Days to final fruit harvest

The number of days taken from the date of first fruit harvest to the harvest of last fruit. The data was taken on the record plants.

3.5.2 Yield parameters

The five tagged plants used for recording growth parameters were also used for recording the yield parameters. The following data were recorded.

3.5.2.1 Number of fruits per plant

The total number of fruits harvested from five tagged plants were counted from all the pickings and average was computed and recorded as number of fruits per plant.

3.5.2.2 Fruits weight per plant

The fresh fruit weights of fruits harvested from five tagged plants for 7 times from each experimental plot were summed up and average was computed and recorded as fruits weight per plant. The weight was taken by using electronic balance.

3.5.2.3 Weight of fruits per hectare

The weight of fruits per plot was used to compute the weight of fruits per hectare and expressed in Kg/ha.

3.5.2.4 Fruit length

The lengths of fruits harvested from five tagged plants for seven times from each experimental plot were summed up and average was computed and recorded in centimetres as fruit length per plant. The length was recorded from the pedicel end of the fruits to the proximal end of the fruit using a cm rule.

3.5.2.5 Fruit width

Recorded breadths of fruits used for recording the length were totalled and average was calculated and recorded in centimetres as fruit width. Vernier calliper was used to measure the breadth at the point of maximum breadth.

3.5.2.6 Marketable and unmarketable fruits

Sweet pepper fruits harvested from five tagged plants for 7 times were sorted into marketable and unmarketable, counted and weighed. Fruits damaged by insect and or disease were grouped as unmarketable. Mean number and weight of marketable and unmarketable fruits were calculated from the total number and weight of marketable and unmarketable fruits.

3.5.3 Soil parameters

3.5.3.1 Soil moisture content

Soil moisture content at a depth of 0-20cm was assessed five times at weekly interval (4, 5, 6, 7 and 8 WAP during the afternoons at 1:00 pm. 100g of fresh soil sample per each experimental plot was taken and air dried for 4 weeks. The dry weight was taken and percentage soil moisture content was computed and expressed in percent.

3.5.3.2 Soil temperature

A soil thermometer was used to assess soil temperature at a depth of between 5 to 10 cm five times at weekly interval (4, 5, 6, 7 and 8 WAP) during the afternoon at 1:00 pm. Three readings were taken randomly per experimental plot and the mean calculated and expressed in degree Celsius.

3.5.4 Weed parameter

3.5.4.1 Weed biomass

The prevalent weeds on the site included *Cyperus rotundus, Euphorbia heterophylla, Chromolaena odorata,Commelina benghalensis* and *Calopogonium mucunoides*.

Weight of fresh weeds taken from randomly thrown quadrat of 50cm^2 (three times) on each experimental plot before weed control at 4 WAP was recorded in grams. Average weight of weed biomass was calculated and divided by the area of the quadrat and expressed in gram per square centimetre (g/cm^2). The weed biomass was weighed using an electric weighing scale.

3.5. 5 Disease assessment

3.5.5.1 Assessment of severity of Capsicum chlorosis disease (CaCD)

During the course of work, observation of foliar symptoms and the presence of thrips on some plots were made. Record plants were assessed for the severity of suspected Capsicum Chlorosis Disease (CaCD) which is caused by Capsicum Chlorosis Virus (CaCV) believed to have been transmitted by the thrips. Symptoms observed include; Yellowing (chlorosis) of leaf margins and areas between veins on younger leaves, curling of leaves, plants stunted, fruit distorted with dark spots and scarring. Disease severity was assessed using an arbitrary scale of 0 – 4 (Table 3.3). Each record plant was assessed for the severity of CaCD starting from 5 weeks after transplanting and repeated for 3 consecutive times at 2 weeks interval. Mean disease severity was calculated for each treatment. Whenever present, fruits were observed for the presence of symptoms stated above.

Table 3.3: severity rating for CaCD

Scale	Description
0	No symptom
1	Mild deformation and curling of leaves
2	Moderate deformation and curling of leaves
3	Severe deformation and curling of leaves
4	Very severe deformation and curling of leaves

3.5.6 Economic analysis

Financial analysis was carried out to evaluate the profitability of green pepper under the various mulch types. Involved in the analysis are; total revenue (TR) and cost of production (TC) per hectare from which net revenue was determined. The net revenue (NR) from the investment was given by NR = TR – TC. Return on investment (ROI) was also calculated as ROI = NR/TC × 100.

3.6 Data analysis

Data on growth and reproductive parameters, soil temperature and moisture content and weed biomass were analysed using Analysis of Variance (ANOVA) for randomised complete block design. Least significance difference (LSD) at P = 0.05 was used to compare the means. However, excel was used to analyse data on disease assessment.

CHAPTER FOUR

RESULTS

The findings and results of the effect of organic mulches (rice husk, empty palm fruit bunch and cocoa pod husk) on soil temperature, soil moisture, weed biomass, growth and yield of sweet pepper are presented in this chapter.

4.1 Effect of organic mulch on vegetative growth of sweet pepper at 50% flowering.

The effect of organic mulch on vegetative growth parameters of sweet pepper in the rainy season is shown in Table 4.1. The mean plant height, leaf and branch number, canopy size and stem diameter were not significantly influenced by mulching. Also there were no significant differences in leaf area and leaf area index among the treatments.

In the dry season, plants on mulched plots grew significantly taller than the plants on the control plots at 50% flowering (Table 4.2). Plants from the mulch treatments recorded significantly higher canopy size than plants from the control although there were no significant differences in canopy size among the different mulch materials. Significant differences were also observed in stem diameter between the mulch treatments and the control. Leaf and branch number were not significantly influenced by any of the four treatments.

Table 4.1: Effect of organic mulch on vegetative growth parameters of sweet pepper at 50% flowering in the rainy season

Mulch type	Number of days to 50% flowering	Plant height (cm)	Leaf number	Number of branches	Canopy size (cm)	Stem diameter (mm)	leaf area (cm^2)	leaf area index
Rice husk	39.0	18.75	55.0	7.0	23.90	8.2	256.0	0.0317
Palm fruit bunches	39.0	18.75	47.0	6.0	22.07	8.50	285.0	0.0352
Cocoa pod husk	37.0	17.25	42.0	6.0	23.60	8.00	279.0	0.0345
Control	37.0	19.75	48.0	7.0	28.79	8.25	251.0	0.0310
LSD (5%)	0.857	NS	NS	NS	NS	NS	NS	NS

Table 4.2: Effect of organic mulch on vegetative growth parameters of sweet pepper at 50% flowering in the dry season

Mulch type	Number of days to 50% flowering	Plant height (cm)	Leaf number	Number of branches	Canopy size (cm)	Stem diameter (mm)
Rice husk	36.0	25.25	68.0	11.0	37.08	7.47
Palm fruit bunches	37.0	24.75	63.0	11.0	35.10	7.47
Cocoa pod husk	36.0	24.25	72.0	11.0	35.98	7.40
Control	36.0	20.00	45.0	8.0	25.90	5.40
LSD (5%)	NS	3.90	NS	NS	4.59	1.53

4.2 Mean and total dry shoot biomass

There were no significant differences in above-ground mean and total dry plant biomass among the different treatments in the rainy season (Table 4.3). Empty palm fruit bunch mulch however recorded the highest mean dry shoot biomass compared to other mulch types. The highest total dry shoot biomass was produced by cocoa pod husk mulch while rice husk mulch recorded the lowest.

Also, there was no significant difference in above-ground mean and total dry plant biomass between the different treatments in the dry season (Table 4.4), but rice husk mulch produced the highest mean and total dry shoot biomass among other mulch types while control recorded the lowest.

Table 4.3: Effect of organic mulch on vegetative growth (mean and total dry shoot biomass) of sweet pepper at 3 WAT in the rainy season

Mulch Type	Mean dry shoot biomass/plant (g)	Total shoot biomass (Kg/ha)
Rice husk	0.27	3.37
Palm fruit bunches	0.35	4.37
Cocoa pod husk	0.33	4.10
Control	0.25	3.12
LSD (5%)	NS	NS

Table 4.4: Effect of organic mulch on vegetative growth (mean and total dry shoot biomass) of sweet pepper at harvest in the dry season

Mulch Type	Mean dry shoot biomass/plant (g)	Total dry shoot biomass (Kg/ha)
Rice husk	17.7	219.0
Palm fruit bunches	11.1	137.0
Cocoa pod husk	13.5	167.0
Control	6.9	85.0
LSD (5%)	NS	NS

4.3 Phenology

Table 4.5 indicates the effect of organic mulch on the number of days to 50% flowering of sweet pepper in the rainy and dry seasons. The type of mulch material significantly affected the number of days to flowering in the rainy season. Plants from the rice husk mulch and palm fruit bunch mulch plots significantly took the longest time to reach 50% flowering while plants from the control and the cocoa pod husk plots took the shortest time to reach 50% flowering.

In the dry season, days to 50% flowering was not significantly influenced by any of the four treatments however, plants from rice husk and cocoa pod mulches and the control took the shortest time to reach 50% flowering while plants from the empty palm fruit bunch mulch took the longest time to reach 50% flowering.

Table 4.5: Effect of organic mulch on the number of days to 50% flowering of sweet pepper in the rainy and dry seasons

Mulch Type	Number of days to 50% flowering in the rainy season	Number of days to 50% flowering in the dry season
Rice husk	39.0	36.0
Palm fruit bunches	39.0	37.0
Cocoa pod husk	37.0	36.0
Control	37.0	36.0
LSD (5%)	0.857	NS

4.4 Fruit set

Table 4.6 shows data on the number of days to first and 50% fruit set of sweet pepper in the dry season. There were no significant differences in the number of days to first and 50% fruit set among the treatments.

Table 4.6: Effect of organic mulch on number of days to first and 50% fruit set of sweet pepper in the dry season

Mulch type	*Number of days to first fruit set*	*Number of days to 50 % fruit set*
Rice husk	37	48
Palm fruit bunches	37	51
Cocoa pod husk	37	53
Control	36	49
LSD (5%)	NS	NS

4.5 Days to final fruit harvest and cropping period

There was no significant difference in the number of days to final fruit harvest among the treatments in the dry season (Table 4.7). Period of harvest of sweet pepper was also not significantly influenced by any of the treatments (Table 4.7).

Table 4.7: Effect of organic mulch on the number of days to final fruit harvest and period of harvest of sweet pepper in the dry season

Mulch type	days to final fruit harvest	period of harvest
Rice husk	86.0	38.0
Palm fruit bunches	89.0	37.0
Cocoa pod husk	87.0	35.5
Control	93.0	40.0
LSD (5%)	NS	NS

4.6 Yield and yield components.

Table 4.8, indicates the effect of organic mulch on the fruit yield and yield components of sweet pepper in the rainy season. Number of fruits per plant, yield per plant, total yield, mean fruit weight, length and diameter were not significantly influenced by any of the four treatments.

The effect of organic mulch on yield and yield components of sweet pepper in the dry season is shown in table 4.9. The mulch treatments produced significantly higher weight of fruits per plant, total fruit yield and mean fruit weight than the control plants. For instance, dry rice husks, empty palm fruit bunches and cocoa pods mulches increased weight of fruits per plant over the control plots by 334%, 200% and 189.9% respectively. Fruit number per plant, mean fruit length and mean fruit diameter were not significantly influenced by any of the four treatments. Rice husk mulch produced significantly higher weight of fruits per plant than palm fruit bunch mulch and cocoa pod husk mulches. Empty palm fruit bunch mulch recorded no significant increase in fruits weight per plant over cocoa pod husk mulch. Furthermore, there were no significant increases in total fruit yield and mean fruit weight among the mulch treatments.

Table 4.8: Effect of organic mulch on yield and yield components of sweet pepper in the rainy season

Mulch type	Fruit number per plant	Weight of fruits per plant(g)	Total fruits yield (t/ha)	Mean fruit weight (g)	Fruit length (cm)	Fruit width (cm)
Rice husk	1.35	30.8	0.38	13.5	5.06	5.09
Palm fruit bunches	1.45	28.3	0.349	11.0	4.68	5.28
Cocoa pod husk	1.20	26.5	0.327	13.1	4.61	4.44
Control	1.45	36.9	0.456	13.8	6.72	5.75
LSD (5%)	NS	NS	NS	NS	NS	NS

Table 4.9: Effect of organic mulch on the yield and yield components of sweet pepper in the dry season

Mulch type	*Fruit number per plant*	*Weight of fruits per plant(g)*	*Total fruits yield (t/ha)*	*Mean fruit weight (g)*	*Fruit length (cm)*	*Fruit width (cm*
Rice husk	5.0	159.3	1.97	27.9	3.96	4.06
Palm fruit bunches	4.0	110.1	1.40	21.9	3.68	3.57
Cocoa pod husk	4.0	106.0	1.31	23.9	4.01	3.75
Control	3.0	36.7	0.45	12.5	3.10	3.02
LSD (5%)	NS	47.02	705.59	6.84	NS	NS

4.7 Mean number and weight of marketable and unmarketable fruits

Table 4.10 shows data on mean number and weight of marketable and unmarketable fruits of sweet pepper in the rainy season. Data in Table 4.10 indicates that there were no significant differences in mean number of marketable fruits among the treatments. Similarly, the mean number of unmarketable fruits were not significantly influenced by any of the treatments.The mulched plots produced significantly higher mean weight of marketable fruits compared to the control. For instance, dry rice husk, empty palm fruit bunch and cocoa pod mulches enhanced mean weight of marketable fruits over the control by 176%, 72% and -19% respectively. Rice husk mulch recorded significant increase in mean weight of marketable fruits over empty palm fruit bunch and cocoa pods husk mulches but there was no significant increase in mean weight of marketable fruits among palm fruit bunch and cocoa pods husk mulches. However, none of the treatments significantly influenced the mean weight of unmarketable fruits.

Table 4.11 indicates the effect of organic mulch on mean number and weight of marketable and unmarketable fruits of sweet pepper in the dry season. There were significant increases in mean number and weight of marketable fruits between the mulched plots and the control. For instance, dry rice husks, empty palm fruit bunches and cocoa pods increased marketable fruits yield per plant over the control plots by 1394%, 791% and 703% respectively. Rice husk mulch recorded significant increase in mean number of marketable fruits over cocoa pod husk mulch but showed no significant increase in mean number of marketable fruits over empty palm fruit bunch mulch. There was no significant increases in the mean number of marketable fruits among empty palm fruit bunch and cocoa pod husk mulches. Rice husk recorded significant increase in mean weight of marketable fruits over empty palm fruit bunch and cocoa pod husk. There was no significant difference in mean weight of marketable fruit between the empty palm fruit mulch and cocoa pod husk mulch. There were no significant differences in the mean number and weight of unmarketable fruits between the mulched plots and the control.

Table 4.10: Effect of organic mulch on mean number and weight of marketable fruits and mean number and weight of unmarketable fruits of sweet pepper in the rainy season

Mulch Type	Mean number of marketable Fruits/plant	Mean number of unmarketable fruit/plant	Mean weight of marketable fruits/plant (g)	Mean weight of unmarketable fruits/plant(g)
Rice husk	1	0	35.6	11.4
Palm fruit bunches	1	1	22.2	13.1
Cocoa pod	0	1	10.5	8.8
Control	1	1	12.9	10.7
LSD (5%)	NS	NS	12.26	NS

Table 4.11: Effect of organic mulch on mean number and weight of marketable fruits and mean number and weight of unmarketable fruits of sweet pepper in the dry season

Mulch Type	Mean number of marketable Fruits/plant	Mean number of unmarketable fruits/plant	Mean weight of marketable fruit/plant (g)	Mean weight of unmarketable fruits/plant (g)
Rice husk	4.35	0.50	147.90	33.70
Palm fruit bunches	3.20	1.10	88.20	16.10
Cocoa pod husk	2.50	1.50	79.50	23.40
Control	0.45	2.20	9.90	26.80
LSD(5%)	1.63	NS	54.89	NS

4.8 Soil moisture content

The effect of organic mulch on soil moisture content in the rainy season is shown in Table 4.12. There was no significant difference in soil moisture content among the different treatments. Cocoa pod husk however, recorded the highest amount of soil moisture followed by empty palm fruit bunch and rice husk.

In the dry season soils under mulch treatments retained significantly higher amount of soil moisture compared to soils under no-mulch treatment. Cocoa pod mulches recorded significantly higher amount of soil moisture than that of the empty palm fruit bunches. There was no significant difference in soil moisture content between rice husk and empty palm fruit bunch mulch (Table 4.13).

4.9 Effect of organic mulch on soil temperature

Dry rice husk, empty palm fruit bunch and cocoa husk mulches significantly reduced soil temperature compared to the control (no mulch) in both the rainy and dry seasons. However, no significant differences in soil temperature were found among the mulch treatments (Tables 4.12 and 4.13).

4.10 Weed biomass

Table 4.12 indicates the effect of organic mulch on fresh weed biomass in the rainy season. Mulch materials significantly suppressed weed growth. However, no significant differences were observed in weed growth among the mulch treatments. The prevalent weeds in the control plots were: *Cyperus rotundus, Euphorbia heterophylla, Chromolaena odorata,Commelina benghalensis* and *Calopogonium mucunoides* while *Euphorbia heterophylla , Commelina benghalensis and Chromolaena odorata* were weed species encountered in the rice husk, empty palm fruit bunch and cocoa pod husk mulched plots.

Table 4.13 shows the effect of organic mulch on fresh weed biomass in the dry season. Weed growth was significantly suppressed by mulch treatments. The table shows that rice husk mulch recorded the lowest fresh weed weight followed by empty palm fruit bunch and cocoa pod husk mulches. The highest fresh weed weight was observed in the control plot. The prevalent weeds in both the control and mulched plots were similar to those observed in the first season.

Table 4.12: Effect of organic mulch on soil moisture content, temperature, and fresh weed biomass in the rainy season

Mulch Type	Soil temperature (^0C)	Soil moisture content (%)	Weed biomass (g/m^2)
Rice husk	30.67	24.42	710
Palm fruit bunches	30.38	25.03	860
Cocoa pod husk	30.73	25.29	700
Control	32.87	21.70	3100
LSD (5%)	0.61	NS	1.44

Table 4.13: Effect of organic mulch on soil moisture content, temperature, and fresh weed biomass in the dry season

Mulch Type	Soil temperature (^0C)	Soil moisture content (%)	Weed biomass (g/m^2)
Rice husk	27.82	13.97	1.5
Palm fruit bunches	28.27	13.03	1.9
Cocoa pod husk	28.38	15.31	2.3
Control	32.41	7.68	3.0
LSD (5%)	0.76	2.250	0.69

4.11 Disease assessment

No scoring was done on incidence of Capsicum chlorosis disease in the rainy season. However, critical observation indicated that the disease was more severe in cocoa pod husk followed by empty palm fruit bunch, rice husk and control.

In the dry season the mulch treatments recorded high incidence of Capsicum chlorosis disease compared to the control. The disease was severe in the cocoa pod husk treatment while the rice husk and empty palm fruit bunch recorded moderately severe incidence (Table 4.14).

Table 4.14: Effect of organic mulch on severity of Capsicum chlorosis disease on sweet pepper in dry season

Mulch Type	Mean ± SE
Rice husk	2.2 ± 0.28
Palm fruit bunch	2.1 ± 0.35
Cocoa pod husk	2.8 ± 0.20
Control	1.8 ± 0.35

Plate 1 Plant infected with CaCD

Plate 2 Fruits from infected plants

4.12 Correlations among some soil and growth and yield parameters of sweet pepper

Spearman's rank correlation was used to establish relationships among some soil parameters and among some soil parameters and growth and yield traits of green pepper in the rainy season (Table 4.15).

Number of days to 50% flowering exhibited a strong negative association with soil temperature (-0.386**) and a significant negative relationship with weed biomass (-0.237*). It also showed a significant positive association with number of leaves at 50% flowering (0.266*). Number of branches at 50% flowering showed a strong significant positive relationships with number of leaves at 50% flowering (0.755**) and plant height at 50% flowering (0.627**). It also had a significant positive associations with yield per plant (0.303*), number of fruits per plant (0.251*), fruit length (0.249*) and fruit weight (0.286*). A strong significant positive relationship was established between area of canopy at 50% flowering and soil temperature (0.690**). Area of canopy at 50% flowering also had a significant positive association with weed biomass (0.299*) while it established a significant negative associations with soil moisture content (-0.511*) and plant height at 50% flowering (-0.259*).

Dry shoot weight per plant had a strong significant positive association with soil temperature (0.402**) and a significant positive associations with yield per plant (0.243*), number of fruits per plant (0.240*), fruit length (0.237*) and fruit weight (0.262*).There were highly significant positive relationships between fruit length and yield per plant (0.796**) and fruit length and number of fruits per plant (0.974**). Fruit length also showed a significant positive relationship with number of leaves at 50% flowering (0.268*). Number of fruits per plant exhibited highly significant positive link with yield per plant (0.984**) and a significant positive relationship with number of leaves at 50% flowering (0.236*). Plant height at 50% flowering showed a strong significant positive link with yield per plant (0.957**) while it had a significant positive association with number of leaves at 50% flowering (0.233*). A highly significant negative association was found between number of leaves at 50% flowering and soil temperature (-0.513**). Also number of leaves at 50% flowering had a significant positive relationships with soil moisture content (0.224*) and stem diameter at 50%

flowering (0.301*). Leaf area at 3WAT established a significant positive associations with yield per plant (0.270*) and stem diameter at 50% flowering (0.461*). A significant negative link was established between soil moisture content and soil temperature (-0.272*) while a strong significant positive relationship was found between soil temperature and weed biomass (0.556**).

Relationships were established among some soil parameters and among some soil parameters and growth and yield traits of green pepper in the dry season by the use of Spearman's rank correlation (Table 4.16).

Number of days to 50% flowering established highly significant positive associations with stem diameter at 50% flowering (0.581**), dry shoot weight per plant at harvest (0.478**) and plant height at 50% flowering (0.681**). It also had significant positive relationships with yield per plant (0.332*), number of leaves at 50% flowering (0.348*), number of fruits per plant (0.297*), fruit length (0.293*) and fruit weight (0.280*) while it showed significant negative associations with weed biomass (-0.308*) and soil temperature at depth of 5 to 10cm (-0.236*). Number of branches at 50% flowering had strong significant positive associations with soil moisture content at depth of 0 to 20cm (0.494**), stem diameter at 50% flowering (0.723**), dry shoot weight at harvest per plant (0.507**), number of leaves at 50% flowering (0.658**), plant height at 50% flowering (0.818**) and area of canopy at 50% flowering (0.408**) while it established a strong significant negative relationship with soil temperature at depth of 5 to 10cm (-0.461**). It also had significant positive associations with yield per plant (0.343*), number of fruits per plant (0.292*), fruit length (0.295*) and fruit width (0.284*). Area of canopy at 50% flowering established highly significant positive links with yield per plant (0.338**), soil moisture content at depth of 0 to 20cm (0.771**), stem diameter at 50% flowering (0.603**), dry shoot weight per plant at harvest (0.526**), number of leaves at 50% flowering (0.730**) and plant height at 50% flowering (0.617**) while it had strong significant negative relationships with weed biomass (-0.579**) and soil temperature at depth of 5 to 10cm (-0.455**).

A highly significant positive associations were established between fruit length and yield per plant (0.969**), fruit length and dry shoot weight per plant at harvest (0.421**) and fruit length and number of fruits per plant (0.937**). A significant positive relationships were also found between fruit length and stem diameter at 50% flowering (0.376*), fruit length and number of leaves at 50% flowering (0.271*) and fruit length and plant height at 50% flowering (0.364*) while fruit length had significant negative links with weed biomass (-0.355*) and soil temperature at depth of 5 to 10cm (-0.271*). A strong significant positive association was found between number of fruits per plant and yield per plant (0.883**). Number of fruits per plant had significant positive relationships with stem diameter at 50% flowering (0.317*), dry shoot weight per plant at harvest (0.350*), number of leaves at 50% flowering (0.225*) and plant height at 50% flowering (0.346*) while it established significant negative associations with weed biomass (-0.279*) and soil temperature at 5 to 10cm (-0.230*).

Dry shoot weight per plant at harvest indicated strong significant positive relationships with yield per plant (0.510**), soil moisture content at depth of 0 to 20cm (0.488**) and stem diameter at 50% flowering (0.521**) while it had highly significant negative associations with weed biomass (-0.524**) and soil temperature at depth of 5 to 10cm (-0.391**). A significant positive link was established between soil moisture content at depth of 0 to 20cm and yield per plant (0.250*) and a significant negative association was found between soil moisture content at depth of 0 to 20cm and weed biomass (-0.315*). Soil temperature at depth of 5 to 10cm had highly significant positive relationships with weed biomass (0.484**) and a significant negative association with yield per plant (-0.333)

15: Matrix of correlation (r) among some soil and growth and yield parameters of green pepper in the raining season

	#DTFPF	#BrFPF	ACFPF	DSWt/P	FrtW	FrtL	#Frt/p	PHFPF	#LFPF	SDFPF	SMCont	STemp	WB	YKg/P
#DTFPF														
#BrFPF	0.209													
ACFPF	-0.071	-0.047												
DSWt/P	0.006	-0.101	-0.072											
FrtW	-0.037	0.286*	0.010	0.262*										
FrtL	-0.081	0.249*	0.022	0.237*	-0.076									
#Frt/p	-0.048	0.251*	-0.012	0.240*	0.002	0.974**								
PHFPF	0.128	0.627**	-0.259*	-0.105	0.024	0.127	1.000							
#LFPF	0.266*	0.755**	0.213	0.069	-0.058	0.268*	0.236*	0.233*						
SDFPF	0.132	0.154	0.089	0.000	0.032	-0.131	-0.156	-0.142	0.301*					
SMCont	0.153	0.115	-0.511*	-0.183	-0.005	0.095	0.061	0.118	0.224*	0.064				
STemp	-0.386**	-0.107	0.690**	0.402**	-0.114	0.114	0.158	0.123	-0.513**	-0.143	-0.272*			
WB	-0.237*	-0.015	0.299*	0.211	-0.110	0.149	0.167	0.136	-0.180	0.078	-0.198	-0.556**		
YKg/P	-0.069	0.303*	0.026	0.243*	-0.097	0.976**	0.984**	0.957**	0.116	0.075	-0.166	0.090	0.142	

* Significant at 5%, ** Significant at 1%,

Legend:

#DTFPF: Number of days to 50% flowering
#BrFPF: Number of branches at 50% flowering
ACFPF: Area of canopy at 50% flowering
DSWt/P: Dry shoot weight per plant
FrtW: Fruit weight
FrtL: Fruit length
#Frts/p: Number of fruits per plant
PHFPF: Plant height at 50% flowering
#LFPF: Number of leaves at 50% flowering
SDFPF: Stem diameter at 50% flowering:
SMCont: Soil moisture content
STemp: Soil temperature
WB: Weed biomass
YKg/P: Yield per plant

Table 16: Matrix of correlation (r) among some soil and growth and yield parameters of green pepper in the dry season

	#DTFPF	#BrFPF	ACFPF	FrtW	FrtL	#Frt/p	PHFPF	#LFPF	DSWt/P	SDFPF	SMCont	STemp	WB	YKg/P
#DTFPF														
#BrFPF	0.714**													
ACFPF	0.066	0.408**												
FrtW	0.280*	0.284*	0.314*											
FrtL	0.293*	0.295*	0.330*	0.963**										
#Frt/p	0.297*	0.292*	0.283*	0.963**	0.937**									
PHFPF	0.681**	0.818**	0.617**	0.363*	0.364*	0.346*								
#LFPF	0.348*	0.658**	0.730**	0.244*	0.271*	0.225*	0.774**							
DSWt/P	0.478**	0.507**	0.526**	0.409**	0.421**	0.350*	0.597**	0.365*						
SDFPF	0.581**	0.723**	0.603**	0.345*	0.376*	0.317*	0.925**	0.802**	0.521**					
SMCont	0.041	0.494**	0.771**	0.199	0.200	0.191	0.424**	0.517**	0.488**	0.330*				
STemp	-0.236*	-0.461**	-0.455**	-0.275*	-0.271*	-0.230*	-0.461**	-0.392**	-0.391**	-0.503*	-0.565			
WB	-0.308*	-0.236*	-0.579**	-0.319*	-0.355*	-0.279*	-0.499**	-0.376*	-0.524**	-0.605**	-0.315*	0.484**		
YKg/P	0.332*	0.343*	0.388**	0.943**	0.969**	0.883**	0.442**	0.326*	0.510**	0.445**	0.250*	-0.333*	-0.393**	

* Significant at 5%, ** Significant at 1%,

Legend:

#DTFPF: Number of days to 50% flowering
#BrFPF: Number of branches at 50% flowering
ACFPF: Area of canopy at 50% flowering
FrtW: Fruit weight
FrtL: Fruit length
#Frts/p: Number of fruits per plant
PHFPF: Plant height at 50% flowering
#LFPF: Number of leaves at 50% flowering
DSWt/P: Dry shoot weight per plant
SDFPF: Stem diameter at 50% flowering
SMCont: Soil moisture content
STemp: Soil temperature
WB: Weed biomass
YKg/P: Yield per plant
plant

4.13 Economic analysis of using organic mulches (rice husk, empty palm fruit bunch and cocoa pod husk) and bare soil for sweet pepper production

Table 4.17 shows the economic analysis of using organic mulches (rice husk, empty palm fruit bunch and cocoa pod husk) and bare soil for green pepper production in the rainy season. The production cost for green pepper is also presented in appendix 1. When the pepper was sold in the city the control treatment produced the highest net revenue of GHC 217 and return on investment of 8.6%. Rice husk application produced negative net revenue of (GHC 1764) and return on investment of (43.6%) followed by empty palm fruit bunch application (GHC 3085) and (59.6%). Cocoa pod husk application had the least net revenue of (GHC 3811) and return on investment of (66.0%).

When the farmer received half of the retail price in the city as the farm gate price without transporting the pepper to the city, control treatment had net revenue of (GHC 970) and return on investment of (41.5%). This was followed by rice husk application (GHC 2753) and (70.1%), empty palm fruit bunch application (GHC 3993) and (79.2%) and cocoa pod husk application (GHC 4662) and (82.6 %), (Table 18).

4.14 Economic analysis of using organic mulches (rice husk, empty palm fruit bunch and cocoa pod husk) and bare soil for sweet pepper production

Table 17 shows the economic analysis of using organic mulches (rice husk, empty palm fruit bunch and cocoa pod husk) and bare soil for green pepper production in the major season. The production cost for green pepper is also presented in appendix 1. The control treatment produced the highest net revenue of GHC 217 and return on investment of 8.6%. Rice husk application produced negative net revenue of (GHC 1764) and return on investment of (43.6%) followed by empty palm fruit bunch application (GHC 3085) and (59.6%). Cocoa pod husk application had the least net revenue of (GHC 3811) and return on investment of (66.0%).

When the farmer received half of the retail price in the city as the farm gate price without transporting the pepper to the city, control treatment had net revenue of (GHC 970) and return on investment of (41.5%). This was followed by rice husk application (GHC 2753) and (70.1%), empty palm fruit bunch application (GHC 3993) and (79.2%) and cocoa pod husk application (GHC 4662) and (82.6 %), (Table 18).

Table 4.17: Estimated cost of production, gross revenue and return on investment of sweet pepper grown under different organic mulches when the vegetable was retailed in the city in the rainy season

Mulch type	Economic yield (kg/ha)	Price per kilo (GHC)	Total revenue (GHC)	Production cost			Total cost (GHC)	Net revenue (GHC)	Return on investment (%)
				Input	Labour	Transportation			
Control	456	6.0	2736	834	1474	211	2519	217	8.6
RH (35t/ha)	380	6.0	2280	1388	2395	261	4044	-1764	-43.6
PFB(35t/ha)	349	6.0	2094	1526	3364	289	5179	-3085	-59.6
CPH(35t/ha)	327	6.0	1962	1807	3686	280	5773	-3811	-66.0

Table 4.18: Estimated cost of production, gross revenue and return on investment of sweet pepper grown under different organic mulches when the vegetable was sold at the farm gate in the rainy season

Mulch type	Economic yield (kg/ha)	Price per kilo (GHC)	Total revenue (GHC)	Production cost			Total cost (GHC)	Net revenue (GHC)	Return on investment (%)
				Input	Labour	Transportation			
Control	**456**	**3.0**	**1368**	**834**	**1474**	**30**	**2338**	**-970**	**-41.5**
RH (35t/ha)	**380**	**3.0**	**1140**	**1388**	**2395**	**110**	**3893**	**-2753**	**-70.7**
PFB(35t/ha)	**349**	**3.0**	**1047**	**1526**	**3364**	**150**	**5040**	**-3993**	**79.2**
CPH(35t/ha)	**327**	**3.0**	**981**	**1807**	**3686**	**150**	**5643**	**-4662**	**-82.6**

Table 4.19 shows the economic analysis of using organic mulches (rice husk, empty palm fruit bunch and cocoa pod husk) and bare soil for sweet pepper production during the dry season. The production cost for sweet pepper is also presented in appendix 2. When the pepper was sold in the city rice husk application produced the highest net revenue of GHC 7587.74 and return on investment of 180.10% followed by the application of empty palm fruit bunch GHC 3059.38 and 57.50% and cocoa pod husk application GHC 1950.98 and 33.06%. Control treatment had the least net revenue of GHC 200.76 and return on investment of 7.98%.

When the farmer receives half of the retail price in the city as the farm gate price without transporting the pepper to the city, rice husk application again produced the highest net revenue of GHC 1937.37 and return on investment of 48.89%. Empty palm fruit bunch application had net revenue of (GHC 910.81) and return on investment of (17.86%). Even though control treatment produced higher net revenue of (GHC 978.12) than cocoa pod husk application (GHC 1775.51), the return on investment for cocoa pod husk application which was (31.14%) was relatively higher than that of the control treatment which had a return on investment of (41.85%), (Table 4.20).

The low yield realised as the result of the outbreak of Capsicum Chlorosis Disease during the production period and the high transportation cost of sweet pepper to the city accounted for the low net revenue and return on investment recorded when the sweet pepper was sold in the city.

Table 4.19: Estimated cost of production, gross revenue and return on investment of sweet pepper grown under different organic mulches when the vegetable was retailed in the city in the dry season

Mulch type	Economic yield (kg/ha)	Price per kilo (GHC)	Total revenue (GHC)	Production cost			Total cost (GHC)	Net revenue (GHs)	Return on investment (%)
				Input	Labour	Transportation			
Control	452.96	6.0	2717.76	834.0	1473	210	2517	200.76	7.98
RH (35t/ha)	1966.79	6.0	11800.74	1388	2465	360	4213	7587.74	180.10
PFB(35t/ha)	1396.73	6.0	8380.38	1526	3425	370	5321	3059.38	57.50
CPH(35t/ha)	1308.83	6.0	7852.98	1807	3745	350	5902	1950.98	33.06

Table 4.20: Estimated cost of production gross revenue and return on investment of sweet pepper grown under different organic mulches when the vegetable was sold at the farm gate in the dry season

Mulch type	Economic yield (kg/ha)	Price per kilo (GHs)	Total revenue (GHs)	Production cost			Total cost (GHs)	Net revenue (GHs)	Return on investment (%)
				Input	Labour	Transportation			
Control	452.96	**3.0**	1358.88	834.0	1473	30.0	2337.0	-978.12	-41.85
RH (35t/ha)	1966.79	**3.0**	5900.37	1388	2465	110	3963.0	1937.37	48.89
PFB(35t/ha)	1396.73	**3.0**	4190.19	1526	3425	150	5101.0	-910.81	-17.86
CPH(35t/ha)	1308.83	**3.0**	3926.49	1807	3745	150	5702.0	-1775.51	-31.14

CHAPTER FIVE

DISCUSSION

5.1 Effect of organic mulch on soil temperature and moisture content

The low soil temperature recorded by the organic mulches in both rainy and dry seasons may be explained by prevention of direct contact of solar radiation with the soil by the organic mulches. This result is in agreement with those reported by Ashworth and Harrison (1983), Gupta and Gupta (1993), Mintah (1998), Agele *et al.* (2000), Nkansah *et al.* (2003) and Norman *et al.* (2011), who indicated that organic mulches were more effective in reducing soil temperature compared to the control.

However, High soil moisture content observed under the mulches in both the rainy and dry seasons was as a result of adequate soil cover provided by the mulch materials. This prevented contact between the soil and dry air, which reduced water loss into the atmosphere through evaporation. Also, mulches reduce impact of raindrops and splash, thereby preventing soil compaction, reducing surface run-off and increasing water infiltration. All these combined to increase the soil moisture content and reduce moisture depletion. Similar results have been reported by Agele *et al.* (2000), Nkansah *et al.* (2003), Ghosh *et al.* (2006) and Nasir *et al.* (2011).

5.2 Effect of organic mulch on Weed biomass

Smothering of weeds due to provision of soil cover by the organic mulches to cut off or lower light to weeds and their seeds in the soil by the mulch types might have accounted for efficient reduction in weed growth in both rainy and dry seasons. Also the mulch types acted as an obstacle to weed growth. Suppressed weed growth as a result of organic mulching have also been documented by Mintah (1998), Nkansah *et al.* (2003) and Norman *et al.* (2011).

5.3 Growth and Yield

The outbreak of disease suspected to be Capsicum chlorosis disease (*CaCD*) caused by Capsicum chlorosis Virus (*CaCV*) transmitted by thrips (Torkpo 2012, Personal communication) on the pepper plants affected plant height, stem diameter, number of branches, number of leaves, leaf area and leaf area index components of the crop among the treatments in the rainy season. McMichael *et al.* (2002), reported that the virus causes a serious disease in sweet pepper. However, in the dry season (December-March) better results in terms of stem diameter, number of branches, number of leaves, leaf area and leaf area index components were obtained with the mulch treatments than the control due to improved soil moisture conservation, reduced soil temperature, reduced weed infestation and nutrient availability as a result of reduced leaching of nutrients.

In the rainy season, the better performance of plants in the control plots in terms of plant height and canopy size than plants in the mulched plot was an indication that the mulch materials served as a favourable environment (provided wet condition and hide out) for the presence, survival, multiplication and attack of the virus (causative organism) and thrips (vector) on the plants. Slightly high soil temperature recorded by the control plot may also be attributed to the better performance of plants on it. High rainfall of (633.1mm) over the period of July-November, 2012 in the wetter rainy season and low temperature of (21.6˚C) over the same period also favoured the activities of the virus and thrips. Enhanced growth of vegetative components of sweet pepper by the mulched treatments in the relatively drier minor season could be attributed to the fact that mulching provides favourable conditions for growth and development of the plant by providing improved soil moisture conservation, reduced soil temperature, reduced weed infestation and nutrient availability as a result of reduced leaching of nutrients. This is shown in the strong positive correlation of area of canopy and soil moisture content (0.771**) and strong positive correlation of number of branches with soil moisture content (r= 0.494**) for the dry season. These results of increased vegetative growth components by organic mulching obtained confirm those of Vos and Sumarni (1997), Manuel *et al.* (2000), Thakur *et al.* (2000), Norman *et al.* (2002), Nkansah *et al.* (2003), Gandhi and Bains (2006), Moniruzzaman (2006), Awodoyin (2007), Ojeniyi *et al.* (2007), (Venkanna (2008), Iftikhar *et al.* (2011), Dauda (2011), and Norman *et al.* (2011). However, organic mulch did not have significant effect on branch number per plant of sweet pepper in both the rainy and dry seasons. This result is in agreement with Dauda (2011).

Also, higher dry matter yield was produced by plants from the organic mulch treatments than those from the control treatments in both the rainy and dry seasons. Similar findings have been reported by several workers (Norman *et al.*, 2002, Moniruzzaman, 2006, Venkanna, 2008 and Norman *et al.*, 2011). The fact that mulching provides favourable conditions for growth enhancement through improved soil moisture conservation, reduced soil temperature, reduced weed infestation and nutrient availability as a result of reduced leaching of nutrients is supported by the correlation studies for both the rainy and dry seasons. This is indicated by positive correlation between canopy width and weed biomass (r= 0.299*) for the rainy season, strong positive correlation between canopy width and soil moisture content (0.771**) for the dry season, strong positive correlation between dry shoot weight per plant and soil temperature (r=0.402**) for the rainy season and strong positive correlation of number of branches with soil moisture content (r= 0.494**) for the dry season. The studies also indicated positive correlation between number of leaves and soil moisture content (r=0.224*) for the rainy season.

Furthermore, the shorter time taken by plants from the control plots to reach 50% flowering in the rainy season is not in support of the findings of Ravinderkumar and Shrivastav (1998), Norman *et al.* (2002), and Iftikhar *et al.* (2011), who reported that organic mulches enhanced early flowering in vegetables. Delayed 50% flowering by plants from mulched plots could be explained by the fact that the mulch materials extended the vegetative growth period of the crop by providing high soil moisture content, reduced soil temperature, reduced weed infestation and availability of more nutrients that might have resulted in over production of photo assimilate that encouraged more vegetative growth at the expense of reproductive growth. Also, high soil temperature perhaps had positive influence on biochemical activities in the bare soil to influence nutrient availability leading to the fertility of the soil.

Even though in the dry season there was no significant difference between the mulch materials and the control in terms of days to final fruit harvest and period of harvest, plants from the control plots recorded the longest period in both instances. Mulching prolonged the vegetative growth period of the crop duration, hence delayed flowering and fruiting and this in turn shortened the duration of fruiting and harvest. Low soil temperature and high incidence of the disease might have also contributed to the shortest period of final fruit harvest and cropping recorded by plants from the mulch treatments.

In addition, the outbreak of disease suspected to be Capsicum chlorosis disease caused by capsicum chlorosis virus transmitted by thrips (Torkpo 2012, Personal communication) on the pepper plants was more severe in the rainy season than in the dry season. This affected the number of fruits per plant, weight of fruits per plant, mean fruit weight per plant, total fruit yield, fruit length and fruit width of the treatments. However, Better performance in terms of number of fruits per plant, weight of fruits per plant and mean fruit weight per plant were obtained in the rainy season and enhanced performance in terms of number of fruits per plant, weight of fruits per plant, total fruit yield, mean fruit weight per plant, fruit length and fruit width components of sweet pepper were also recorded by the mulch treatments compared to the control in the dry season.

The fact that mulching provides favourable conditions for growth and development by providing improved soil moisture conservation, reduced soil temperature, reduced weed infestation, nutrient availability as a result of reduced leaching of nutrients might have contributed to the increased yield and yield components. Furthermore, increased number of branches, number of leaves, leaf area and leaf area index that might have increased photosynthesis might have contributed to the observed increased yield and yield components in the dry season.

The correlation studies conducted supported the results by indicating strong positive correlation of area of canopy with soil moisture content (0.771**) and strong positive correlation of number of branches with soil moisture content (r = 0.494**) second planting Strong positive associations was also observed between the number of branches and the number of leaves (r = 0.658**) for dry season.

The results of increased yield and yield components obtained by the application of organic mulches confirmed the findings of Vos and Sumarni (1997), Manuel *et al.* (2000), Norman *et al.* (2002), Thakur *et al.* (2000), Nkansah *et al.* (2003), Gandhi and Bains (2006), Moniruzzaman (2006), Awodoyin (2007), Ojeniyi *et al.* (2007),Venkanna (2008), Dauda (2011), Iftikhar *et al.* (2011), and Norman *et al.* (2011).

On the other hand, The increased total fruit yield, fruit length and fruit width of sweet pepper recorded by the control in the rainy season contradicts the findings of Vos and Sumarni (1997), Manuel *et al.* (2000), Thakur *et al.* (2000), Norman *et al.* (2002), Nkansah *et al.* (2003), Gandhi and Bains (2006), Moniruzzaman (2006), Awodoyin (2007), (Venkanna (2008), Iftikhar *et al.* (2011), Dauda (2011), and Norman *et al.* (2011) who reported of increased yield and yield components of vegetables by the application of organic mulches.

The observed increased in yield and yield components on the control plots in the rainy season was an indication that the mulch materials served as a favourable environment (provided wet condition and hide out) for the presence, survival, multiplication and attack of the virus (causative organism) and thrips (vector) on the plants. The better performance of plants in the control also may be due to soil temperature which perhaps had positive influence on biochemical activities in the bare soil to influence nutrient availability leading to the fertility of the soil. High rainfall of (633.1mm) over the period of July-November, 2012 during the rainy season and low temperature of (21.6˚C) over the same period also favoured the activities of the virus and thrips.

5.4 Capsicum Chlorosis disease assessment

The outbreak of disease suspected to be Capsicum Chlorosis disease (CaCD) (Torkpo 2012, Personal communication) was severe in the rainy season than in the dry season. The mulched plots recorded higher incidence of the disease than the control because the mulch materials served as a favourable environment (provide wet condition and hide out) for the presence, survival and transmission of the virus (causative organism of capsicum chlorosis disease) by pests especially thrips (suspected vector). High rainfall of (633.1mm) over the period of July-November, 2012 in the rainy season and low temperature of (21.6˚C) over the same period also favoured the development and destruction of the virus.

5.5 Profitability of the different types of organic mulches and bare soil on sweet pepper production

In the rainy season, all the mulch treatments gave negative return on investment when the sweet pepper was sold at the farm gate. When it was sold in the city only the control treatment gave a positive return on investment.

In the dry season, all the treatments recorded a positive return on investment when the sweet pepper was sold in the city with the rice husk recording the highest return on investment. However, when the pepper was sold at the farm gate it was only the rice husk treatment that gave a positive return on investment. The lowest cost of production and the highest economic yield and for that matter revenue produced by rice husk mulch contributed to the highest return on investment recorded by rice husk mulch. The lowest cost of production associated with the rice husk mulch is due to the fact that the rice husk was not purchased and was readily accessible unlike the cocoa pod husk which was sold and was not easily accessible. The outbreak of Capsicum chlorosis disease during the course of production was severe on the mulched plots particularly during the rainy season (July-November) and had led to reduction in economic yield, net revenue and return on investment recorded by the mulched plots. The positive return on investment recorded during the rainy season by the control was as a result of low incidence of the disease which led to higher economic yield, a pre requisite to high return on investment.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The experimental results have indicated that soil temperature and weed suppression were significantly influenced by mulching both in rainy and dry seasons. In the rainy season soil moisture content was not significantly influenced by the mulch materials. However, soils under mulched plots retained significant amount of soil moisture compared to soils under no mulch treatment in the dry season. The mulch materials did not have significant effect on the growth and yield of the sweet pepper during the rainy season. This could be attributed to an outbreak of Capsicum chlorosis disease in the field. The disease negatively affected the vegetative components of the crop. Meanwhile, in the dry season mulching significantly affected growth and yield of the pepper. Improved soil moisture conservation, reduced soil temperature, reduced weed infestation and nutrient availability as a result of reduced leaching of nutrients provided by mulching might have contributed to the increased growth and yield of the pepper.

6.2 Recommendation

In the semi-deciduous agro-ecological zone of Ghana, moisture is not a limiting factor to the production of sweet pepper in the rainy season but rather may limit the production of the vegetable in the dry season. Farmers who grow or may grow sweet pepper on small scale should be encouraged to adopt the practice of mulching during the dry season. For the production and marketing of sweet pepper for higher return on investment, the adoption of the application of organic mulches especially rice husk mulch during the dry season is recommended. The type of organic mulch to use may be dependent on factors such as cost, availability and production scale.

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APPENDICES

Appendix 1: Catalogue of production cost (GHC) in sweet pepper grown under different organic mulches in the raining season

Items Inputs	control	RH (35t ha^{-1})	PFB (35t ha^{-1})	CPH (35t ha^{-1})
Seeds	107	107	107	107
Sacks	_	350	385	380
Chemical				
i. Herbicides	109	109	109	109
ii. Insecticides	82	82	82	82
iii. Fertilizers				
a NPK	268	268	268	268
b S/A	268	268	268	268
Mulch materials	_	_	_	286
Rubber sheets	_	204	307	307
Sub - total (A)	**834**	**1388**	**1526**	**1807**
Labor				
Land preparation				
i. Weeding	125	125	125	125
ii. Herbicide application	60	60	60	60
Stumping and collection of stumps	200	200	200	200
Lining and pegging	63	63	63	63
Transplanting	250	250	250	250
Filling of sacks with mulch materials and loading into truck	_	857	1715	2143
Application of mulch materials	_	150	180	160
Weeding	270	210	302	224
Application of chemicals				
i. NPK	120	120	120	120
ii. S/A	120	120	120	120
iii. Insecticide	110	110	110	110
Harvesting	156	130	119	111
Sub – total (B)	**1474**	**2395**	**3364**	**3686**
Transportation				
Mulch materials	_	80	120	120
NPK	15	15	15	15
S/A	15	15	15	15
Fresh fruits to the market	181	151	139	130
Sub – total (C)	**211**	**261**	**289**	**280**
Total cost (A+B+C)	**2519**	**4044**	**5179**	**5773**

Appendix 2: Catalogue of production cost (GHC) in sweet pepper grown under different organic mulches in the dry season

Items	control	RH (35t ha^{-1})	PFB (35t ha^{-1})	CPH (35t ha^{-1})
Inputs				
Seeds	107	107	107	107
Sacks	_	350	385	380
Chemical				
iv. Herbicides	109	109	109	109
v. Insecticides	82	82	82	82
vi. Fertilizers				
a NPK	268	268	268	268
b S/A	268	268	268	268
Mulch materials	_	_	_	286
Rubber sheets	_	204	307	307
Sub - total (A)	**834**	**1388**	**1526**	**1807**
Labor				
Land preparation				
iii. Weeding	125	125	125	125
iv. Herbicide application	60	60	60	60
Stumping and collection of stumps	200	200	200	200
Lining and pegging	63	63	63	63
Transplanting	250	250	250	250
Filling of sacks with mulch materials and loading into truck	_	857	1715	2143
Application of mulch materials	_	150	180	160
Weeding	270	210	302	224
Application of chemicals				
iv. NPK	120	120	120	120
v. S/A	120	120	120	120
vi. Insecticide	110	110	110	110
Harvesting	155	200	180	170
Sub – total (B)	**1473**	**2465**	**3425**	**3745**
Transportation				
Mulch materials	_	80	120	120
NPK	15	15	15	15
S/A	15	15	15	15
Fresh fruits to the market	180	250	220	200
Sub – total (C)	**210**	**360**	**370**	**350**
Total cost (A+B+C)	**2517**	**4213**	**5321**	**5902**

Analysis of variance (ANOVA) for raining season

Appendix 3: Soil temperature

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.4027	0.1342	0.94	
TREATMENT	3	15.8613	5.2871	36.86	<.001
Residual	9	1.2908	0.1434		
Total	15	17.5548			

Appendix 4: Soil moisture content

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	4.063	1.354	0.16	
BLOCK.*Units* stratum					
TREATMENT	3	32.465	10.822	1.26	0.345
Residual	9	77.304	8.589		
Total	15	113.833			

Appendix 5: Weed_biomass_

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	2.8827	0.9609	1.19	
BLOCK.*Units* stratum					
TREATMENT	3	16.5316	5.5105	6.82	0.011
Residual	9	7.2709	0.8079		
Total	15	26.6851			

Appendix 6: Days to 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	3.1875	1.0625	3.73	
BLOCK.*Units* stratum					
TREATMENT	3	23.1875	7.7292	27.15	<.001
Residual	9	2.5625	0.2847		
Total	15	28.9375			

Appendix 7: Mean plant height at 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	7.250	2.417	0.84	
BLOCK.*Units* stratum					
TREATMENT	3	12.750	4.250	1.49	0.283
Residual	9	25.750	2.861		
Total	15	45.750			

Appendix 8: Mean number of leaves at 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	614.69	204.90	4.91	
BLOCK.*Units* stratum					
TREATMENT	3	334.69	111.56	2.67	0.111
Residual	9	375.56	41.73		
Total	15	1324.94			

Appendix 9: Mean number of branches at 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	14.000	4.667	2.71	
BLOCK.*Units* stratum					
TREATMENT	3	4.500	1.500	0.87	0.491
Residual	9	15.500	1.722		
Total	15	34.000			

Appendix 10: Mean stem diameter at 50% flower

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.035000	0.011667	2.10	
BLOCK.*Units* stratum					
TREATMENT	3	0.005000	0.001667	0.30	0.825
Residual	9	0.050000	0.005556		
Total	15	0.090000			

Appendix 11: Leaf area

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	215110.	71703.	4.95	
block.*Units* stratum					
Treatment	3	17395.	5798.	0.40	0.753
Residual	73	1057112.	14481.		
Total	79	1289617.			

Appendix 12: Number of fruits per plant

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	25.337	8.446	3.24	
block.*Units* stratum					
Treatment	3	0.838	0.279	0.11	0.956
Residual	73	190.312	2.607		
Total	79	216.487			

Appendix 13: Mean fruit weight per plant

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	3234.7	1078.2	7.60	
block.*Units* stratum					
Treatment	3	92.4	30.8	0.22	0.884
Residual	73	10358.1	141.9		
Total	79	13685.2			

Analysis of variance (ANOVA) for dry season

Appendix 14: Soil temperature

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.9603	0.3201	1.42	
TREATMENT	3	55.0531	18.3510	81.44	<.001
Residual	9	2.0281	0.2253		

Total 15 58.0415

Appendix 15: Soil moisture content

Variate: Soil moisture content

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	9.803	3.268	1.65	
BLOCK.*Units* stratum					
TREATMENT	3	134.260	44.753	22.61	<.001
Residual	9	17.810	1.979		
Total	15	161.874			

Appendix 16: Weed biomass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	1.1116	0.3705	1.98	
block.*Units* stratum					
Treatment	3	4.9255	1.6418	8.76	0.005
Residual	9	1.6859	0.1873		
Total	15	7.7229			

Appendix 17: Days to 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	70.250	23.417	4.28	
Treatment	3	8.250	2.750	0.50	0.690
Residual	9	49.250	5.472		
Total	15	127.750			

Appendix 18: Mean plant height at 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	36.688	12.229	2.05	
Treatment	3	69.688	23.229	3.90	0.049
Residual	9	53.562	5.951		
Total	15	159.938			

Appendix 19: Mean number of leaves at 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	1216.2	405.4	1.05	
Treatment	3	1718.2	572.8	1.48	0.284
Residual	9	3473.2	385.9		
Total	15	6407.8			

Appendix 20: Mean number of branches at 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	42.75	14.25	1.08	
Treatment	3	24.75	8.25	0.63	0.615
Residual	9	118.25	13.14		
Total	15	185.75			

Appendix 21: Canopy size at 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	17.228	5.743	0.70	
Treatment	3	316.902	105.634	12.83	0.001
Residual	9	74.087	8.232		
Total	15	408.217			

Appendix 22: Mean stem diameter at 50% flowering

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	0.042325	0.014108	1.55	
Treatment	3	0.126225	0.042075	4.63	0.032
Residual	9	0.081825	0.009092		
Total	15	0.250375			

Appendix 23: Number of fruits per plant

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	33.038	11.013	1.49	
Treatment	3	55.237	18.412	2.49	0.067
Residual	73	539.212	7.386		
Total	79	627.487			

Appendix 24: Mean fruit weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	988.0	329.3	2.80	
Treatment	3	2555.3	851.8	7.24	<.001
Residual	73	8588.7	117.7		
Total	79	12132.1			

Appendix 25: Mean fruit length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	13.064	4.355	1.98	
Treatment	3	10.338	3.446	1.57	0.205
Residual	73	160.708	2.201		
Total	79	184.110			

Appendix 26 : Mean fruit diameter

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	3	6.382	2.127	1.24	
Treatment	3	11.388	3.796	2.21	0.094
Residual	73	125.518	1.719		
Total	79	143.288			