HYDROPNIC CAPSICUM AS INFLUENCED BY ALTERNATIVE ADDITION OF COWDUNG SLURRY AND ELECTRICAL CONDUCTIVITY OF NUTRIENT SOLUTION

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CERTIFICATE

This is to certify that the thesis entitled ***"HYDROPONIC CAPSICUM AS INFLUENCED BY ALTERNATIVE ADDITON OF COW DUNG SLURRY AND ELECTRICAL CONDUCIVITY of NUTRIENT SOLUTION"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.) in HORTICULTURE,*** *embodies the results of a piece of bona fide research work carried out by* ***SHYAMOLY AKHTER,*** *Registration. No.* ***17-08185*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.*

I further certify that any help or sources of information received during the course of this investigation has duly been acknowledged.

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DEDICATED
TO
MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Cow dung slurry and electrical conductivity (EC) of the nutrient solution are the most important factors for producing high quality fruit of capsicum in hydroponic system. Therefore, the present research work was aimed to identify suitable cow dung slurry in capsicum and optimum level of EC in the nutrient solution for capsicum production in hydroponic system. Treatments considered two factors, viz., four types of cow dung slurry (C_1: 100ml cow dung slurry; C_2: 200 ml cow dung slurry; C_3: 300 ml cow dung slurry and C_4: 400 ml cow dung slurry) and four different electrical conductivity (E_1: 2.5ds/m; E_2: 3.0 ds/m; E_3: 3.5 ds/m and E_4: 4.0 ds/m). The experiment was conducted in a randomized completely block design with three replications. Data were collected on growth and yield contributing characters; yield per plant and physiological traits in fruits. In case of cow dung slurry application the highest plant height (89.6cm), number of fruit per plant (8.1), individual fruit weight (111.13gm), fruit yield (861.88gm/plant), fruit length (10.65cm), fruit diameter (6.0cm), fruit volume (143.78cc) in C_4 but statistically similar results were found in case of growth and yield in C_3 while the lowest in C_1. In case of EC value of nutrient solution the highest plant height (95.43cm), number of fruit per plant (10.25), individual fruit weight (139.38gm), fruit yield (1123.6gm/plant), fruit length (11.5cm), fruit diameter (7.1cm), fruit volume (184.12cc) in E_2 but statistically similar results were found in case of growth and yield in E_4 while the lowest in E_1. In case of physiological traits viz. leaf area, leaf mass ratio, net assimilation ratio and relative growth rate were found highest in C_4 while the lowest in C_1 and considering different EC values highest was in E_2 and lowest was in E_1. The highest result was recorded from the treatment combination C_4E_2 and the lowest was from C_1E_1. Therefore, it can be concluded that 400 ml of cow dung slurry and 3.0 ds/m EC of nutrient solution can be used for producing higher yield and quality of capsicum in hydroponic system.

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LIST OF ABBREVIATED TERMS

DAT = Day after transplanting

DAF = Day after flowering

DAS = Day after sowing

SAU = Sher-e-Bangla Agricultural University

EC = Electrical Conductivity

LA = Leaf Area

LAR = Leaf Area Ratio

LDW = Leaf Dry Weight

LMR = Leaf Mass Ratio

RDW = Root Dry Weight

RWR = Root Weight Ratio

df = degree of freedom

ANOVA = Analysis of Variance

FW = Fresh Weight

TSS = Total soluble solid

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Government is giving the highest priority in agriculture to feed the increasing population of Bangladesh, especially in agricultural research to ensure food and nutritional security of the people. In respect to the food security, balance nutrition and income generation; the importance of hydroponics for horticultural crops comes first within the agriculture sector of Bangladesh under changing climate. Cultivable land is decreasing day by day and Bangladesh is adversely encompassed by seasonality of crops and environmental stresses. In recent years agriculture is under threats of climatic changes. Climate change is a crucial problem in our agriculture. There must be some alternatives technologies to overcome these threats. Hydroponics can be one of the good alternative technologies to mitigate the effect of climate change on crops. Hydroponic crop production has significantly increased in recent years worldwide is the growing of plants in a soilless medium or an aquatic based environment. Hydroponic grower uses mineral nutrient solutions to feed the plants in water without soil. Soilless culture is the modern cultivation system of plants that use either inert organic or inorganic substrate through nutrient solution nourishment. Possibly it is the most intensive culture system utilizing all the resources efficiently for maximizing yield of crops and the most intense form of agricultural enterprises for commercial production of greenhouse vegetables. Several studies suggested that soilless culture in the greenhouse as an alternative to traditional field production for high value vegetables crops. This protected cultivation system can control the growing environment through management of weather factors, and composition of nutrient solution and also the growing medium (Santamaria et al., 1996). Therefore, quality of horticultural crops grown through soilless culture improves significantly compared to conventional soil culture.

Furthermore, hydroponic production increases crop quality and productivity, which results in higher competitiveness and economic incomes (Savvas, 2003). Hydroponics culture is becoming increasingly popular all over the world (Avidan, 2000). It provides an instant as well as long term solution to the problem of inability of a household to produce its own vegetables under urban settings. But the main problem of hydroponic is the higher cost for nutrient solution and other components. The cost of nutrient solution can be cut by using different alternative addition with standard solution.

Cow dung slurry is one of the most important alternative addition in hydroponic system, which can mitigate the cost of nutrient solution. In our country cow dung is very available therefore it can be effortlessly used in crop production. The composition and effectiveness of cow dung slurry as a source of plant nutrients depends on several factors including type of ration fed, housing system, method of cow dung collection, storage and handling. Research has shown that cow dung application increased soil N, P, K, Ca, Mg and Na. However, heavy or excessive application of cow dung increased leaching of NO3-N, P and Mg. Cow dung slurry is reported to be effective in increasing the yields of cereals, legumes, oilseeds, vegetables and pastures, and in increasing plant nutrient concentration, especially N, P and K. The beneficial effect of organic manure in crop production has been demonstrated by many workers (Joshi *et al.*, 1994; Batsai *et al.*, 1979; Singh *et al.*, 1970 and Subhan, 1991). The efficient use of cow dung slurry can be a hydroponically and economically viable management practice for sustainable crop production in our country.

Electrical conductivity (EC) of nutrient solution is one of the most important factors which affect the success of the hydroponic systems. Water deficits affect plant growth and development through a reduction in leaf water potential (Awang et al. 1993a), and by reducing photosynthesis (Xu et al. 1994) because of the closure of stomata (Longuenesse & Leonardi 1994). Plant water uptake can be limited by high electrical conductivity (EC) of the nutrient solution (Ehert & Ho 1986a) as a result of an increase in osmotic potential of the solution and to specific ion effects (Sanchez & Silvertooth 1996) especially when evapotranspiration is high (Awang et al. 1993a), thus reducing plant growth. This osmotic stress, because of high EC, results in reduced yield and improvement in fruit quality of tomatoes in terms of increased dry matter (DM) content, titratable acidity, and sugar concentration (Adams 1991). Although high EC reduced total fresh and dry weights of tomato fruit and shoot it did not affect DM partitioning (Ehert & Ho 1986b). In cucumber plants high EC affected both the yield and DM partitioning in favour of the shoots (Ho & Adams 1994). Few reports are available on the effects of EC on the growth and development of greenhouse-grown capsicum *(Capsicum annuum* L.) and they are contradictory. The present research examined the effects of EC on the growth of capsicum plants and assimilate distribution and on fruit quality and physiological attributes of fruit maturity.

Capsicum or sweet pepper is one of the most important vegetable crops and it contains high amount of vitamin C, A, and E, and many antioxidants (Rahman et al., 2012). Capsicum (*Capsicum annuum* L.) is one of the most important vegetable crop belonging to the family solanaceae. The demand of capsicum is increasing day by day both in local and export market. Capsicums are green at the immature stage and it turns red, gold, purple, orange when sugar content increases at the ripen stage. Colored peppers tend to be sweeter than green peppers. The most notable feature of peppers is flavor, which can be sweet, mild or strongly pungent. The fruit contain capsaicinoids which is responsible for the pungency. Capsaicin and dihydrocapsaicin, the two major capsaicinoids, are responsible for up to 90% of the total pungency of pepper fruits. Capsaicinoids are currently used in the food industry, for medical purposes as pharmaceuticals, and in defensive sprays.

The level of carotene, like lycopene, is nine times higher in red pepper The sweetness of capsicums is due to their natural sugars (green capsicums have less sugar than red capsicums). Red peppers have twice the vitamin C content than green peppers. Red bell peppers are a great source of vitamin B6 and folate. Both these vitamins and minerals can help prevent anemia. Red bell peppers are high in vitamin A, which helps to support healthy eyesight, especially night vision. (University of the District of Columbia, Center for Nutrition, Diet and Health, 2013.) In Bangladesh, a lot of people are suffering from malnutrition. Therefore, capsicum or capsicum can reduce some degree of malnutrition.

Growing capsicum in the field involves extensive labor and a high cost of agrochemicals to assure good yield and quality. Cultivation of plant without soil gives more production in less time, allows to growing plant more densely with balanced supply of air water and nutrient where the products are more resistant to diseases and natural or biological control can be easily employed to it. Moreover, soil born pests and diseases can be easily eliminated easily through the soil less cultivation. Troublesome weeds can be avoided by this cultivation (Munoz *et al.* 2010). Soilless growing is becoming an attractive option because of the unpredictable problems of soil due to fluctuating temperatures, moisture holding capacity, obtainability of nutrients, salinity, root aeration, undesirable microbial activities and nematode, disease and pest to overcome these problems with soilless.

Again hydroponics culture is becoming increasingly popular all over the world (Avidan, 2000). It provides an instant as well as long-term solution to the problem of inability of a household to produce its own vegetables under urban settings. Hydroponic is suitable for coastal and hoar area. Despite the considerable advantages of commercial hydroponics, there are still some disadvantages, which restrict the further expansion of soilless cultivation. Nowadays, principal disadvantages of hydroponics relative to conventional open-field agriculture are the high costs of capital and energy inputs and the high degree of management skills required for successful production. In hydroponics, cow dung slurry and electrical conductivity is very important factor.

Therefore, it is needed to identify a suitable, adequate cow dung slurry as an alternative to nutrient solution and electrical conductivity for simple and low cost hydroponic capsicum in Bangladesh.

Objectives of the Study:

- To prepare a simple and cost effective nutrient solution for producing higher yield and high quality of vegetables, like capsicum in Bangladesh.
- To investigate the use of cow dung slurry as alternative liquid fertilizer sources for reducing some degree of solution cost.
- To determine a suitable EC value of nutrient solution for capsicum production

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Capsicum is a popular, common and important vegetable crop which is commercially cultivated in our country. many research works have been done in different parts of the world on growth and yield of capsicum. But very few studies on the growth and yield of capsicum in hydroponic system have been carried out in our country. Therefore, the research work so far done in Bangladesh is not adequate and conclusive. Nowadays, a wide variety of capsicum and leafy vegetables can be successfully grown in hydroponic systems. An appropriate nutrient solution is necessary to produce a high quality crop.

Some of the research findings relevant to the growth and yield of hydroponic capsicum as influenced by alternative addition of cow dung slurry and electrical conductivity have been reviewed here.

Samarakoon*et al*. (2006) reported that the EC values for hydroponic systems range from 1.5 to 2.5 ds m-1. Higher EC hinders nutrient uptake by increasing osmotic pressure, whereas lower EC may severely affect plant health and yield.

Steiner (1996) reported that extended use of the same nutrient solution may result in accumulation of toxic quantities of micro elements such as zinc and copper from metals in the plumbing system, fertilizer impurities, or from the water itself.

Hell *et al.* (2013) reported that the temperature of the nutrient solution influenced the behavior of capsicum changing the electrical conductivity (EC). They found that the increased in EC did not reduce capsicum productivity when the maximum temperature of the nutrient solution was limited at 26^{O}C. They also found that cooling of the nutrient solution provided greater accumulation of biomass and higher water content in plants, increasing the productivity of hydroponic capsicum in the tropics.

Resh (2012) reported that Hydroponics is a method of growing plants using mineral nutrient solutions in water without soil. It is a technology designed for arid countries like Namibia, where it is advantageous over soil based vegetable production in that it conserves water avoids soil-borne diseases, makes vegetable production possible even in areas with poor soil fertility and generally enhances vegetable production and quality.

Liang et al., (2014) reported that traditionally, organic nutrient solution for hydroponics has not been feasible, despite the similarities in plant growth when either conventional or organic fertilizer is applied on soil. It was not until the early 1990s when liquid organic nutrient solutions for hydroponics were introduced. Challenges with these liquid nutrient solutions emerged, such as organic fertilizer being unsuitable to plant growth because nitrogen in organic sources is predominantly organic, hence unusable by plants. The forms of nitrogen absorbed by plants are nitrate and ammonium. Therefore, the nitrogen in manure requires to be mineralised prior to use by plants hydroponically.

Several studies including Garland et al (1993) and Shinohara et al (2011) have since demonstrated that using microorganisms to degrade organic nitrogen in organic sources such as manure results in nitrates and ammonium production which in turn are used for plant production.

Recently, there have been successful hydroponic production of tomato and other vegetables using organic nutrient solutions processed by microorganisms. Chinta et al (2015) found that using organic nutrient solution made from corn steep liquor not only made successful Lactuca sativa (lettuce) production, but also reduced root rotting.

Fujiwara et al (2012) found the same effect of reducing root rotting was also observed in tomato plants when organic nutrient solution was used. Furthermore, plant wilting was also reduced in this case. Chinta et al (2015) found that using organic nutrient solution made from corn steep liquor provided resistance to air-borne disease in vegetables.

Zotarelli et al., 2009 found total plant dry biomass in tomato has been established when using fertilizers such as pig manure and synthetic fertilisers. Furthermore, it has been proposed that a nutrient-specific analysis, considering the biology of each mineral nutrient rather than grouping plant resources as a whole, is more appropriate than general models in understanding plant responses to nutrient availability. Nutrient use efficiency has, however, not been established with goat manure using plants like tomato.

Shinohara et al (2011) found that using organic nutrient solutions made from fish-based fertiliser or corn steep liquor hydroponically, produced tomato yield similar to those produced from conventional nutrient solutions. From the same organic nutrient solutions, Shinohara et al (2011) further established that when Lactuca sativa (lettuce) was grown, the organic system produced significantly greater and fresh Lactuca sativa (lettuce) head weight than in the conventional system.

Kreij (1989) reported little effect of EC (1.4-6.0 mS cm"1) on the yields of 'Bruisma Wonder' capsicum, whereas Uffelen & Bakker (1989) obtained yield reductions with an increase in EC levels over a similar range with 'Delphin'. The present research examined the effects of EC on the growth of capsicum plants and assimilate distribution and on fruit quality and physiological attributes of fruit maturity.

Ziaf *et al.* (2009) was conducted an experiment to know the effects of different concentrations of NaCl on growth and physiological traits of hot pepper. The experiment was laid out according to completely randomized design with three replications. The concentration of NaCl was (2 [control], 4, and 6 dS m-1). They conclude that root and shoot length, dry matter contents, relative growth rate, leaf area, specific leaf area and leaf area ratio were significantly reduced by higher salinity levels (6 dS m-1). Nonetheless, all the aforementioned attributes improved at 4 dS m-1 compared with control (2 dS m-1).

Hansen (1978) indicated that the addition of plant nutrients to hydroponic systems may be performed according to the plant nutrient requirement. Application of nutrients may be performed according to analyses of a specific crop stage that may describe the consumption of the various typical nutrients of the particular crop or by means of analyses of the total plant needs quantitatively adjusted to the rate of growth and the amounts of water supplied.

Coic and Steiner (1973) studied that the composition and concentration of the nutrient solution are dependent on culture system, crop development stage, and environmental conditions.

Dyśko*et al.* (2008) studied that in the root zone this element can be found as PO_4^{3-}, HPO_4^{2-}, and H_2PO_4- ions; the last two ions are the main forms of P taken by plants. On inert substrates, the largest amount of P available in a nutrient solution is presented when its pH is slightly acidic (pH 5). In alkaline and highly acidic solutions the concentration of P decreases in a significant way.

Salisbury and Ross (1992) reported that currently 17 elements are considered essential for most plants, these are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, copper, zinc, manganese, molybdenum, boron, chlorine and nickel which must be present in nutrient solution in case of growing Lettuce.

Voors et al (2016) reported that first, adoption of hydroponics technology is practical to local farmers in that it uses simplified local resources such as cow dung manure, goat manures which are abundantly available in the Erongo region as inputs. In contrast to the already failed adoption of hydroponics based on the non-accessible costly resources that come along with the use of hydroponics based on conventional hydroponic fertilizers. Therefore, in the second instance, access to finance for local farmers to participate in hydroponic vegetable production is another handicap for most cannot afford to sustain hydroponic operations based on the current costs associated with conventional hydroponics. In the third instances, with the abundance of organic sources of nutrients such as goat, cattle and chicken manures in the Erongo region, local community members i.e. those raring goats can form social network groups where they could encourage those within their circles to upscale the local organic hydroponic solution for vegetable production in contrast to the conventional hydroponic nutrient solution which according to the locals is to be afforded by only certain members of society with financial abilities.

Al-Kanani *et al*. (1992) reported that use of sphagnum peat moss reduced NH3 losses by 75%. In general, losses of P and K are minimal (5–15%) except from open-lot or lagoon handling systems where 40–50% of P can be lost to runoff and leaching. The rate, time and method of manure application depends on numerous factors including climatic conditions, growing substrates, type of crop and rate of mineralization of nutrients. Maximum nutrient benefit from cow dung manure is obtained when it is incorporated immediately after land application to minimize the loss of nutrients.

Beauchamp (1983) determined that during a growing season, approximately 20% of the organic N will be mineralized and become available, and that 25% of ammoniacal N will be volatilized resulting in a net availability of about 50% applied N for crop growth.

Mowa (2015) found that when goat manure was used hydroponically after processing in compost piles, Beta vulgaris subspecies cicla var. flavescens (spinach) production was made possible through production was less than conventional hydroponics.

Sutton *et al*. 1978 reported that the housing system, method of manure collection, storage and handling can affect the composition of manure. Generally 50% of N in the cow dung slurry is present in the ammonium N form and the remaining 50% is present in organic N form. The organic N consists of microbial N, labile organic N and stable organic N.

Osman et al.2009 repoted that the use of mineral fertilisers for agriculture is relatively expensive worldwide and particularly in Africa (Sanchez, 2002). Yet nutrition required for food production (quality and quantity) remains a priority for food security in general, and for vegetables value chains in particular. Farmers therefore, use little or no commercial fertilisers for fear of high cost (Mowa, 2015). Therefore, the current trend depending on expensive fertilisers has failed to achieve the benefit of increased production from use of available critical macro and micro nutrients as a means of increasing the value addition of specialised production for the horticultural market.The goal in retrospect is to search for alternative means for specialised horticultural production.

Vanderholm (1975) summarized research indicating NH4+-N losses of 10–99% from manure depending on the type of storage and system of treatment. The least loss was from aerated storage and the highest loss was from feed-lot surfaces and anaerobic lagoons.

Sutton *et al.* 1976 reported that cow dung slurry must be applied uniformly to minimize localized salt concentration, especially Na which can reduce germination and crop yields. Knifing the manure into the soil is recommended when there are severe odour problems, but this procedure also reduces rate that manure can be applied. Vanderholm (1975) reported 5, 15 and 30–90% losses of NH3-N from manure with ploughing down, discing and surface applied systems, respectively. Hoff *et al.* (1981) reported 0–2.5% NH3-N losses with the injection method of liquid hog manure compared with 10–16% from surface broadcast.

Beauchamp *et al.* 1982 reported that applying manure close to the planting date will maximize nutrient availability to the crop, especially in areas of high rainfall (Alberta Agriculture 1984; Sutton *et al.* 1984*a*). However, reduced germination and seedling growth could occur if planting is done immediately after heavy manure application because of salt accumulation. Thus, even though fall–winter application may cause 25–30% loss of N from manure, a longer field duration will allow soil micro-organisms to decompose the manure and make the nutrient more available to spring seeded crops. In temperate climates, early spring application of manure may not be possible since it may be frozen in the pit, particularly when stored in open lagoons. To obtain the most efficient use of manure, the rate of application should be such that the amount of available nutrients is equal to the amount required by the crop. This creates a problem, since the N in manure is present in organic and ammonium forms, and in the first year of application only 45% of the manure Nis mineralized. Larson (1991) reported that it takes about 5 years to mineralize 80% of the N from manure. On the other hand, almost all the P and K present in manure are available at the time of application.

Tyson *et al.* (2007) in a study to determine the nitrification rate response in a perlite trickling biofilter (root growth medium) exposed to hydroponic nutrient solution, varying NO3-concentrations and two pH levels (6.5 and 8.5), founded that nitrification was significantly impacted by water pH. The increased ammonia oxidation rate (1.75) compared to nitrite oxidation rate (1.3) at pH 8.5 resulted in accumulation of NO2− to levels near those harmful to plants (observed peak of 4.2 mg L-1 NO2−). The potential for increased levels of un-ionized ammonia, which reduced plant nutrient uptake from micronutrient precipitation, are additional problems associated with pH 8.5.

Marschner (1995) concluded that an important feature of the nutrient solutions is that they must contain the ions in solution and in chemical forms that can be absorbed by plants, so in hydroponic systems the plant productivity is closely related with to nutrient uptake and the pH regulation.

Bergquist *et al.* (2007) reported that with the exception of carbon (C) and oxygen (O), which are supplied from the atmosphere, the essential elements are obtained from the growth medium. Other elements such as sodium, silicon, vanadium, selenium, cobalt, aluminium and iodine among others, are considered beneficial because some of them can stimulate the growth, or can compensate the toxic effects of other elements, or may replace essential nutrients in a less specific role. The most basic nutrient solutions consider in its composition only nitrogen, phosphorus, potassium, calcium, magnesium and sulphur and they are supplemented with micronutrients. The nutrient composition determines electrical conductivity and osmotic potential of the solution.

Garceäs-Claver *et al.* (2006) produced capsicum in stationary (trough) culture of hydroponics successfully under tropical greenhouse conditions (38.5^{o}C). A solution concentration of 0.5 g/L of Albert’s solution(havinganECofl.4dS/m) with renewal at 2weeks intervals could be identified as the best fertigation strategy under hot and humid conditions. Increasing solution concentrations above that level upto 2dS/m increased the plant uptake of N, P, K and Ca but, without a significant increase in leaf growth and yield.

Dufour and Guéri (2005) reported that when a nutrient solution is applied continuously, plants can uptake ions at very low concentrations. So, it has been reported than a high proportion of the nutrients are not used by plants or their uptake does not impact the production. It was determined that in anthurium, 60% of nutrients are lost in the leachate.

Fanasca*et al.*(2006) reported that Iron, copper, zinc, boron, and manganese, become unavailable at pH higher than 6.5 in nutrient solution of Hydroponic system.

Voogt (2002) studied that in closed systems of hydroponic nutrient solution, the loss of nutrients from the root environment is brought to a minimum.

De Rijck and Schrevens (1999) reported that each nutrient on capsicum shows differential responses to changes in pH of the nutrient solution as described below. In the nutrient solution, NH_3 only forms a complex with H^+. For a pH range between 2 and7, NH_3^+ is completely present as NH_4^+. Increasing the pH above 7 the concentration ofNH_4^+ decreases, while the concentration of NH_3^+ augments.

Epstein (1994) reported that Silicon application in hydroponic systems has been reported beneficial on growth, yield, and also disease resistance of some crops.

Evans *et al* (1977) reported that swine manure application resulted in similar or higher crop and pasture yields than inorganic fertilizers. However, due to limited availability of N from manure at the time of application the rate of manure was higher than inorganic fertilizers.

Miller & MacKenzie (1978) reported lower corn grain yield and lower plant N recovery in the first year of manure application compared with inorganic fertilizer. However, because of the slow release of N from manures, residual N recovery from manure was twice that from inorganic fertilizer.

Chase *et al*. (1991) reported that, in Iowa in a study involving various application rates of liquid manure, the highest economic return (U.S. $379 ha-1) was from lands treated with manure applied at 2000 U.S. gallons ha-1 (7570 l ha-1) compared to commercial fertilizer (U.S. $337 ha-1) at the recommended rate for the region and crop. They concluded that with increasing cost of fertilizer, the profitability of swine manure as a nutrient source will increase. Long-term studies with swine manure often do not show consistent annual crop yield responses to applied manure because annual variations in weather generally produces significant treatment´year interactions. Differences as high as 3500 kg dry matter ha-1 were reported between normal weather and dry weather and years when droughty soil conditions stressed corn plants during pollination (Sutton *et al*. 1984*b*). Inconsistent or non-significant responses of forage yield to increasing rate of applied swine manure were attributed to winter injury, low rainfall, soil heterogeneity or disease infestation (Burns *et al*. 1985, 1987, 1990).

De Rijck and Schrevens (1998a) studied that the pH is a parameter that measures the acidity or alkalinity of a solution. This value indicates the relationship between the concentration of free ions H^+ and OH^- present in a solution and ranges between 0 and 14. Changing the pH of a nutrient solution affects its composition, elemental speciation and bioavailability. The term "speciation" indicates the distribution of elements among their various chemical and physical forms like: free ions, soluble complexes, chelates, ion pairs, solid and gaseous phases and different oxidation states.

De Rijck and Schrevens (1998b) conveyed that the pH is a parameter that measures the acidity or alkalinity of a solution. This value indicates the relationship between the concentration of free ions H^+ and OH^- present in a solution and ranges between 0 and 14 exchanges the pH of a nutrient solution affects its composition, elemental speciation and bioavailability. The term "speciation" indicates the allocation of elements among their various chemical and physical forms like: free ions, soluble complexes, chelates, ion pairs, solid and gaseous phases and different oxidation states.

Zeiger (1998) studied that an essential elements of nutrient solution for hydroponic capsicum have physiological role and its absence prevents the complete plant life cycle.

McRijck *et al.* (1998) conducted an experiment on capsicum (*Capsicum annuum*L.) under three nutrient solution nitrate contents which represented a range of adequate and inadequate environments. Larger, faster-growing plants should have a larger demand for nitrate and hence larger uptake rates than smaller, environmentally stressed plants. Results showed higher sustained levels of nitrate uptake by larger plants. Neither the severity of stress under which a plant was grown nor the plant sizes were the sole determinants of maximum potential uptake behavior, however. Increased light level was related to an increased ability to transport nitrate on a short-term basis. Increased light level was associated with increased maximum nitrate uptake rates. The effects of environmental light and nitrate levels on nitrate uptake were incorporated into a power relationship where the maximum uptake velocity was determined in relation to the shoot growth rate.

Steiner (1966) reported that a nutrient solution for hydroponic systems is an aqueous solution containing mainly inorganic ions from soluble salts of essential elements for higher plants. Eventually, some organic compounds such as iron chelates may be present.

Noto (1993) reported that in soilless crops, the substrate replaces the soil because the natural soil is often poorly suited to cultivation due to chemical (reaction, nutrient availability, etc.), physical (density, structure, water retention, etc.), or biological (presence of pathogens, exhaustion, etc.) limitations, or because in this way it controls plant growth better.

Winsor and Adams (1987) reported that the total concentration of solutes in the nutrient solution is characterized by the electrical conductivity (EC, dsm^{-1}). Usually EC in commercial tomato production is in the range 2±5 dsm^{-1}. Too low a concentration causes mineral deficiency and restricts plant growth.

Verdonck *et al* (1982) reported that the use of different organic and inorganic substrates allows the plants the best nutrient uptake and sufficient growth and development to optimize water and oxygen holding.

Materska *et al.* (2005) reported that there was no significant difference on root dry mass among treatments because it did not show any specific tendency of either increasing or decreasing with increasing nutrient solution concentration. However, there was contrasting results between fresh mass and leaf dry mass whereby fresh mass was decreasing with an increase in nutrient concentration while leaf dry mass was increasing with increasing nutrient concentration. This could be attributed to the fact that plants grown at 1 mS/cm had more water content whereas plants grown a higher EC level (4 mS/cm) had less water content but more dry matter content. The chlorophyll content was not significantly different among the different treatments, however, the highest chlorophyll content was recorded in treatments 2 and 3 while treatments 1 and 4 had equal amount of chlorophyll. This indicate that there was very little nutrients (nutrient deficiency) in the lower EC (1 mS/cm) while high salt content resulted in low chlorophyll content in the higher EC levels (4 mS/cm). Nitrogen significantly increased with increasing nutrient solution concentration. Phosphorus is good for root development but there was conflicting relationship between the P content in the leaves and the dry root mass which could not be explained. Calcium (Ca) decreased with increasing the EC level while magnesium (Mg) remained constant, but both were slightly lower than the recommended range. However, potassium(K) was below the recommended range although it did not affect capsicum quality/taste.

Voogt (2002) studied that in closed systems of hydroponic nutrient solution, the loss of nutrients from the root environment is brought to aminimum.

Voogt (2002) indicates that the nutrient solution composition must reflect the uptake ratios of individual elements by the crop and as the demand between species differs, the basic composition of a nutrient solution is specific for each crop. It must also be taken into account that the uptake differs between elements and the system used. For instance, in open-systems with free drainage, much of the nutrient solution is lost by leachate.

Sarro *et al.* (2007) found decreasing fresh shoot mass with increasing nutrient solution concentration in hydroponic system.

Chen *et al.* (1997) found that the growth of capsicum was significantly increased when the NO_3 concentration of the solution was reduced below the highest concentration being used by a local commercial hydroponic grower.

Marschner (1995) reported that an important feature of the nutrient solutions is that they must contain the ions in solution and in chemical forms that can be absorbed by plants, so in hydroponic systems the plant productivity is closely related with to nutrient uptake and the pH regulation.

Steiner (1998) reported that a nutrient solution for hydroponic systems is an aqueous solution containing mainly inorganic ions from soluble salts of essential elements for higher plants. Eventually, some organic compounds such as iron chelates may be present.

Chapter III

Materials & Methods

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted in the semi-net house at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh during september 2017 to march 2018. The location of the study site is situated in 23º 74$^{/}$ N latitude and 90º 35$^{/}$ E longitude. The altitude of the location was 8 m from the sea level (The Meteorological Department of Bangladesh, Agargaon, Dhaka).

3.2 Plant and other materials

The seeds of capsicum cv. California Wonder,Tokyo and Red Army were used in the experiment. The seeds were kept in a sealed packet, collected from Siddik Bazar, Gulistan, Dhaka. The styrofoam, cocopeat, plastic pot, plastic tray, wood, polythene sheet etc were collected from Town Hall, Mohammadpur, Dhaka. Experimental chemicals were bought from Tikatolli, Dhaka.

3.3 Experimental Design and treatments

The experiment was conducted in a completely randomized design (CRD) with three replications. Two factors were considered as treatments denoted as C (Cow dung slurry) and E (Electrical Conductivity) of nutrient solution.

Factor - A: Four different types of cow dung slurry

$C_{1:}$ Cow dung slurry 100 ml
C_2: Cow dung slurry 200 ml
C_3: Cow dung slurry 300 ml
C_4: Cow dung slurry 400 ml

Factor - B: Four different electrical conductivity of nutrient solution (Rahman and Inden solution)

E_1: 2.5.ds/m
E_2: 3.0 ds/m
E_3: 3.5 ds/m
$E_{4:}$ 4.0 ds/m

3.4 Collection of cow dung:

Cow dung was collected from SAU animal farm in the, where the manure was stored for few days in an open storage. Cow dung was chosen because it is abundantly available due to dominance of small stock farming in our country.

3.5 Preparation of cow dung slurry:

The manure was homogenized, air-dried for 1 week at 30°C, ground and sieved (< 2 mm) before use. Then cow dung will be aerobic treated by bacteria house and aeration for 21 days. After that it was filtered and used as fertilizer additives. Then it was given to the plant after 3 days interval.

3.6 Experimental environment

Eight different wooden boxes (180cm × 25cm × 25cm) were prepared for culturing the plants. Polythene sheet was placed in the inner side of box so that the nutrient solution could not pass through the wooden box. Boxes were filled with different substrates mixture according to the treatments. For seedling growing, plastic tray filled with media mixture of coco peat, brick broken and rice husk at the ratio of 6:2:2 (v/v) were used. Two-week-old seedlings were transferred into the 250 mL plastic pots. The experiment was conducted in a polythene shade house under intensive care. The room was kept clean and tidy during the time of the experiment. The crop was cultivating and it continued until March 2019.

3.7 Growing media preparation

The mixture of coco peat, broken bricks (khoa) and rice husk at the ratio of 50:30:20% (v/v). Coconut coir was soaked in a big bowl for 24 hours. Then they are mixed with khoa and rice husk properly. This mixer was placed in a styrofoam sheet box for using seedbed.

3.8 Seed sowing

The seeds were soaked in water for 24 hours and then wrapped with piece of thin cloth. The socked seed were then spread over polythene sheet for 2 hours to dry out the surface water. After that seeds were shown in plastic tray and covered with newspaper under room temperature for rising (Plate 1).

3.9 Transplanting of capsicum seedling

Two weeks old capsicum seedling s were transferred to plastic pot contains the mixture of coco peat, khoa and ash. Regular water and ½ strength of Rahman and Inden (2012) solution were given. After four weeks these seedlings were transplanted to the main box (plate 2). The plants were transplanted carefully so that roots were not damaged. After transplanting of capsicum plant in the box light watering was done with sprayer. that roots were not damaged. After transplanting of capsicum plant in the box light watering was done with sprayer.

Plate 1: Growing capsicum seedling in plastic tray

Plate 2: Transplanting of capsicum seedling   Plate 3: Watering of transplanted seedling

3.10 Intercultural operations

3.10.1 Pruning

Three weeks after transplanting, the crown flower and the flower on the first node of each stem were removed, allowing plants to develop an adequate vegetative frame before fruit set. Starting four weeks after transplanting, plants are trained with “V” trellis system. In the “V” trellis system, the lateral shoot (the smaller shoot of the pair that bifurcated on a node) were pruned when they reached 3-4cm long.

3.10.2 Weeding

No weeding was done in the experiment.

3.10.3 Insect management

Capsicum plants were grown in controlled environment. So, no insecticides were applied in the experiment.

*

3.10.4 Diseases management

Capsicum plants were grown in controlled environment in hydroponic system and all nutrients required for plant were supplied artificially to the plants. The growing environment was clean and no disease attacked to the plants.

3.11 Harvesting

The crop was harvested after 75, 120 and 180 DAT. Harvesting of the crop was done according to treatment.

3.12 Data collection

Data on physicochemical properties of growing media mixtures were collected before transplanting capsicum seedling described below. Different data on the growth and physiological traits were recorded during the experiment. Data were collected from each plant described below.

3.13 Electrical Conductivity

EC values for all media before planting were determined by EC meter.

3.14 Plant growth and yield parameter

3.14.1 Plant height

Plant height was measured in centimeter (cm) by a meter scale at 0, 30, 60, 90, 120, 150 and180 DAT (days after transplanting) from the point of attachment of growing media up to the tip of the longest leaf.

3.14.2 Number of fruits per plant

Number of fruits per plant were counted at 75 (First harvesting), 120 (Second harvesting) and 180 (Third harvesting) DAT. All the fruits of each plant were counted separately. Only the smallest young fruits at the growing point of the plant were excluded from the counting and the average number was recorded.

3.14.3 Individual fruit weight

The individual fruit weights were measured by electric balance at department of horticulture, Sher-e-Bangla Agricultural University, Dhaka 1207.

3.14.4 Individual fruit length

The individual fruit length was measured during harvesting with the help of a large scale in centimeter unit.

3.14.5 Individual fruit diameter

The individual fruit breadth was measured during harvesting with the help of a large scale in centimeter unit.

3.14.6 Individual fruit volume

The individual fruit volume was measured during harvesting with the help of a 500ml beaker in centimeter cube (cc) unit. Another name of cc unit is ml.

3.14.7 Dry weight of 100gm fruit

100gm fruit was collected from each treatment, the fruit was sliced by knife and dried at sun for 2 days separately, after that these was transferred to oven of central laboratory, Sher-e-Bangla Agricultural University. It was collected and weighted by electric balance after 72 hours.

3.14.8 Fresh weight of stem, leaf and root

One plant was uprooted from each treatment at 180 DAT. Leaf was detached from the stem and root was cut at the junction of stem and root. Root was washed by tap water to remove media and sun dried to remove attaching water. All these three part of plant was weighted by electric balance.

3.14.9 Dry weight of stem, leaf and root

Stem, leaf and root was dried by sun for 2 days separately, after that these was transferred to oven of central laboratory, Sher-e-Bangla Agricultural University It was collected and weighted by electric balance after 72 hours.

3.14.10 Dry matter content of plant (%)

From the random samples of plants weighing then sun dried for seven days. After drying, plants were weighed. An electric balance was used to record the dry weight of plant and it was calculated on percentage basis. The percentage of dry matter of plant was calculated by the following formula.

$$\%\ \text{Dry matter of plant} = \frac{\text{Dry weight of plant}}{100\ \text{Fresh weight of plant}} \times$$

3.15 Growth parameter analysis

Growth parameters (dry weights of stem, leaf and root), and different physiological parameters [Leaf area (LA), leaf area ratio (LAR), leaf mass ratio (LMR), root weight ratio

(RWR), relative growth rate (RGR), and net assimilation rate (NAR)] were determined in the experiments. The parameters were measured as described below:

Where, LAR = leaf area ratio, LA = Leaf area (cm^2), PDW = plant dry weight (g).

Where, LMR = leaf mass ratio, LDW = leaf dry weight (g).

Where, RWR = root weight ratio, RDW = root dry weight (g).

3.16 Statistical analysis of data

The data in respect of yield and yield contributing characters were statistically analyzed to find out the statistical significance for the experimental results statistic 10. The means for all the treatments were calculated and analyses of variance for all the characters were performed by F test.

Chapter IV

Results and Discussions

RESULTS AND DISCUSSION

The results of the experiment conducted under semi greenhouse conditions were presented in table 1 to table 12 and figure 1 to figure 18. The experiment was conducted to study the growth and yield of hydroponic capsicum as influenced by organic substrates. The results were presented and discussed under the following sub heading.

4. Vegetative growth and yield parameters

4.1.1 Plant height

Significant increment in plant height were found at 0, 30, 60, 90, 120, 150 and 180 DAT due to the cow dung slurry application (Table 1). At 0 DAT, the tallest plant (17.25cm) was found in C_4 and the lowest (13.87cm) was found in C_1. At 30 DAT, the tallest plant (43.3cm) was found in C_4 and the lowest (32.03cm) was found in C_1. At 60 DAT, the tallest plant (63.7cm) was found in C_4 and the lowest (51.0cm) was found in C_1. At 90 DAT, the tallest plant (66.3cm) was found in C_4 and the lowest (54.2cm) was found in C_1. At 120 DAT, the tallest plant (76.5cm) was found in C_4 and the lowest (66.8cm) was found in C_1. At 150 DAT, the tallest plant (82.1cm) was found in C_4 and the lowest 75.9cm) was found in C_1. At 180 DAT, the tallest plant (89.6cm) was found in C_4 and the lowest (80.4cm) was found in C_1. The results revealed that the maximum plant heights at all dates were found in plants grown in treatment C_4 (400 ml cow dung slurry) which was statistically similar to that of 300 ml cow dung slurry application coconut coir (C_3). It was revealed that with the increase of cow dung slurry plant height increased following an increasing trend. Cow dung slurry might have positive role on the increase of nitrogen. Nitrogen from slow release of cow dung slurry might have encouraged more vegetative growth and development of the plant at later stage of growth.

Salam (2001) showed that nitrogen enhances the protein synthesis, which allows plant to grow faster, rate of metabolism, cell division, cell elongation and thereby stimulated apical growth.

Melton and Default (1991) found that plant height increased as the level of nitrogen was increased (Table.1). Scientists have reported that different levels of organic manure significantly increased plant height (Yadav RD and Malik CVS 2005).

Plant height was significantly influenced by different electrical conductivity levels at different growth stage at different DAT (Table 1). Result revealed that at 0 DAT, the highest plant heights (15.75cm) was recorded from the level of E_2 in which the value of electrical conductivity is 3.0ds/m and the lowest (12.93cm) was found in E_1 in which the EC value is 2.5 ds/m. At 30 DAT, the highest plant heights (38.5cm) was recorded from the level of E_2 and the lowest (29.5cm) was found in E_1. At 60 DAT, the tallest plant (58.3cm) was found in E_2 and the lowest (29.5 cm) was found in E_1. At 90DAT, the tallest plants (60.1cm) were found in E_2 and the lowest (51.1 cm) was found in E_1. At 120 DAT, the tallest plants (72.9cm) were found in E_2 and the lowest (60.5 cm) were found in E_1. At 150 DAT, the tallest plants (87.6cm) were found in E_2 and the lowest (71.1cm) were found in E_1**.** At 180DAT, the tallest plants (95.3cm) were found in E_2 and the lowest (80.3cm) was found inE_1. The plant height of capsicum grown in different EC level increased in advancement of maturity. These might be due to different EC values. The plant water uptake was increased in 3.0 ds/m EC value which plays a positive role in plant growth. On the other hand in 2.5 ds/m EC value restricted roots from water absorption and ultimately caused water stress. This was forced stress on the plants which resulted into reduction of vegetative characters at higher concentration and vice versa. The water deficit caused numerous changes in physiological and biological process of the plant (Klamkows ki and Waldemar Treder, 2006).

In case of combined effect of cow dung slurry and electrical conductivity, the insignificant variation was found at 0 DAT, whereas the significant variations were found at 30,60,90,120,150 and 180 DAT (Table 2). The highest plants at all dates were found in C_4E_2 the lowest were found in C_1E_1.

Table:1 Main effect of cow dung slurry and electrical conductivity on plant height at different days after transplanting.

Treatment	Plant height at different days after transplanting (DAT) (cm)						
	0 DAT	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
Cowdung (C)							
C_1	13.87 b	32.037b	51.000b	54.250b	66.875b	75.938d	84.438d
C_2	11.85 c	31.450b	55.125b	57.625b	68.438b	77.938c	86.438c
C_3	14.00 b	32.025b	52.750b	56.000b	70.625b	79.438b	87.938b
C_4	17.25 a	43.313a	63.750a	66.375a	76.500a	82.063a	89.625a
Electrical conductivity (E)							
E_1	12.93 b	33.763b	55.875ab	51.125a	60.437ab	71.125d	80.375d
E_2	15.75 a	37.000a	58.375a	60.625a	72.938a	87.688a	95.438a
E_3	14.18 b	29.500c	52.250b	53.625b	66.438b	75.625c	83.813c
E_4	14.10 b	38.563a	56.125ab	59.875a	72.625a	80.938b	88.813b
Level of significance (P)							
C	0.012	<0.001	0.0140	0.0423	0.0091	<0.001	<0.001
E	<0.001	<0.001	0.006	0.0010	0.0128	<0.001	<0.001

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

Table 2. Interaction effects of cow dung slurry and electrical conductivity on plant height at different days after transplanting.

Treatment	Plant height at different days after transplanting (DAT) (cm)						
	0 DAT	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
C_1E_1	13.250cfg	32.150d	61.000b	46.500e	59.500d	67.000k	78.00l
C_2E_1	11.500fgh	31.300d	51.500bcdf	56.000ce	65.000cd	71.000j	80.00kl
C_3E_1	13.500cfg	35.60bc	60.000bc	62.000cd	71.750bc	72.750ij	81.25jk
C_4E_1	13.500cdg	36.00bc	51.000bcdf	57.500cd	72.500bc	73.750hi	82.25ijk
C_1E_2	11.000gh	32.50cd	50.00cdef	52.50de	69.00bcd	83.75cd	82.50ij
C_2E_2	9.750h	28.500d	56.000bcde	57.00cde	66.500cd	85.25bc	83.75hi
C_3E_2	16.750b	32.50cd	46.000ef	51.500de	66.250cd	87.000b	84.00gi
C_4E_2	25.500a	54.500a	81.500a	81.500a	90.000a	94.750a	101.00a
C_1E_3	15.00bcde	31.000d	44.500f	65.000bc	72.500bc	74.500hi	86.25fg
C_2E_3	12.75defh	29.000d	58.00bcd	60.500cd	72.750bc	75.500h	88.50ef
C_3E_3	13.500cfg	29.250d	56.000bcde	55.500ce	69.500bd	76.25gh	90.25de
C_4E_3	15.500bcd	28.750d	50.500cdef	52.000de	64.000cd	76.25gh	90.25de
C_1E_4	16.250bc	32.50cd	48.500def	53.000de	66.500cd	78.50fg	91.00d
C_2E_4	13.400cdg	37.000b	55.000bcde	57.00cde	69.50bcd	80.000ef	93.50c
C_3E_4	12.25efgh	30.750d	49.000def	55.00cde	75.000bc	81.75de	96.25b
C_4E_4	14.50bcdf	54.000a	72.000a	74.500ab	79.500ab	83.50cd	85.00gh
Level of significance (P)							
C × E	<0.001	<0.001	0.002	.0011	0.0190	0.0020	0.00

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

4.1.2 Flowering of plant

Flowering of capsicum were significantly affected by cow dung slurry application (Table 3). First flower was appeared in C_4 at 34.8 DAT which was statistically similar to that of C_3 treatment. On the other hand last flower was appeared in C_1 at 36.7DAT. This was because proper management of cow dung slurry increases nitrogen that enhances the protein synthesis, which allows plant to grow faster, rate of metabolism, cell division, cell elongation and thereby stimulated apical growth.

The different E.C levels of the nutrient solution have shown significant effect on various vegetative and growth characters of the capsicum. Flowering of capsicum were significantly affected by different levels of EC (Table 3). First flower was appeared in E_2 in which the EC level is 3.0ds/m because of increased leaf water potential, leaf area and the consequent increment in photosynthesis. On the otherhand E_1 showed last flowering in which the EC level is 2.5ds/m. Therefore, the last flowering in plants grown under high EC levels is probably the result of reduced leaf water potential, leaf area, and the consequent reduction in photosynthesis.

Significant influence was noted on flowering influenced by combined effect of cow dung slurry and electrical conductivity. First flowering was recorded from the treatment combination C_4E_2 and the last flowering were found in C_1E_1.

4.1.3 Fruiting of plant

Fruiting of capsicum were significantly affected by cow dung slurry application (Table 3). First fruit was appeared in C_4 at 15.87 DAT which was statistically similar to that of C_3 treatment. On the other hand last fruit was appeared in C_1 at 17.37 DAT. This was because proper management of cow dung slurry increases nitrogen that enhances the protein synthesis, which allows plant to grow faster, rate of metabolism, cell division, cell elongation and thereby stimulated apical growth.

The different E.C levels of the nutrient solution have shown significant effect on various vegetative and growth characters of the capsicum. Fruiting of capsicum were significantly affected by different levels of EC (Table 3). First fruit was appeared in E_2 in which the EC level is 3.0ds/m because of increased leaf water potential, leaf area and the consequent increment in photosynthesis. On the otherhand E_1 showed last fruiting in which the EC level is 2.5ds/m. Therefore, the last fruiting in plants grown under high EC levels is probably the result of reduced leaf water potential, leaf area, and the consequent reduction in photosynthesis.

Significant influence was noted on fruiting influenced by combined effect of cow dung slurry and electrical conductivity. First fruiting was recorded from the treatment combination C_4E_2 and the last flowering were found in C_1E_1.

Table 3. Main effect of cow dung slurry and electrical conductivity on first flowering and first fruiting in capsicum.

Treatment	First Flowering (DAT)	First Fruiting (DAF)
Cowdung (C)		
C_1	36.750a	17.375a
C_2	35.625bc	16.250c
C_3	36.000ab	16.750b
C_4	34.875c	15.875c
Electrical conductivity (E)		
E_1	41.500a	19.375a
E_2	31.750d	13.500d
E_3	33.875c	15.750c
E_4	36.125b	17.625b
Level of significance (P)		
C	0.0030	<0.001
E	<0.001	<0.001

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

Table 4. Interaction effects of cow dung slurry and electrical conductivity on 1st flowering and fruiting days after transplanting in capsicum.

Treatment	First Flowering (DAT)	First Fruiting (DAF)
C_1E_1	43.500g	20.000a
C_2E_1	32.000fg	13.500j
C_3E_1	32.000fg	13.500j
C_4E_1	32.500f	14.500i
C_1E_2	40.000b	19.000bc
C_2E_2	41.000b	19.000bc
C_3E_2	41.500b	19.500ab
C_4E_2	30.500a	12.500g
C_1E_3	33.000ef	15.000hi
C_2E_3	33.500ef	15.500gh
C_3E_3	34.500de	16.000fg
C_4E_3	34.500de	16.500ef
C_1E_4	36.000cd	17.000e
C_2E_4	36.000cd	17.000e
C_3E_4	36.000cd	18.000d
C_4E_4	36.500c	18.500cd
Level of significance (P)		
C × E	0.0415	0.0052

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

4.1.4 Fruit length

Fruit length of capsicum were significantly affected by cow dung slurry application (Table 5). The highest fruit length was found in C_4 (10.62cm) which was statistically similar to that of C_3 (10.18cm) treatment. This might be due to more vegetative growth and development of the plant at later stage of growth and for that reason increasing dose of cow dung increased fruit length. The positive effects of cow dung slurry were seen in the elevation of nutrient availability (as indicated by higher EC) and wettability. On the other hand C_1(9.75cm) and C_2 (9.87cm) showed lowest fruit length because of inferior vegetative growth which was described earlier.

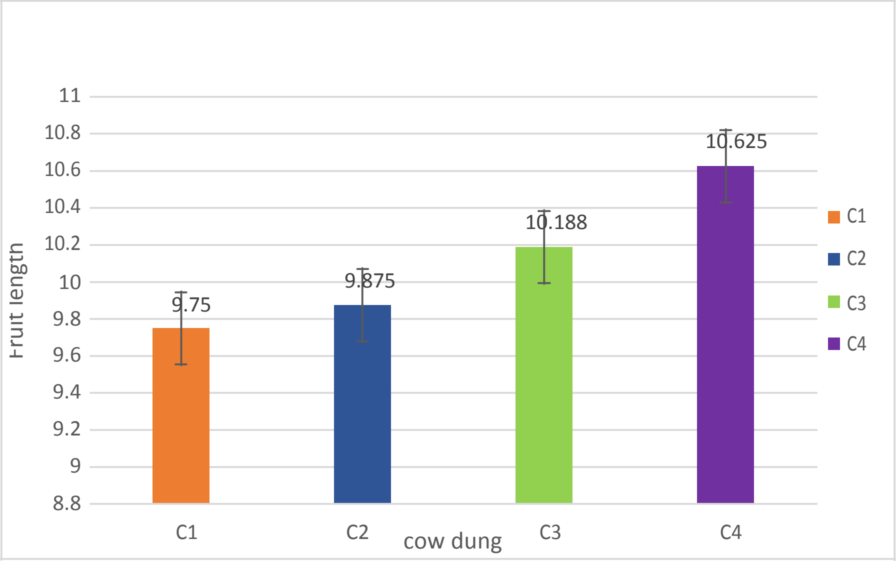

Figure 1. Effect of cow dung slurry on fruit length (cm)

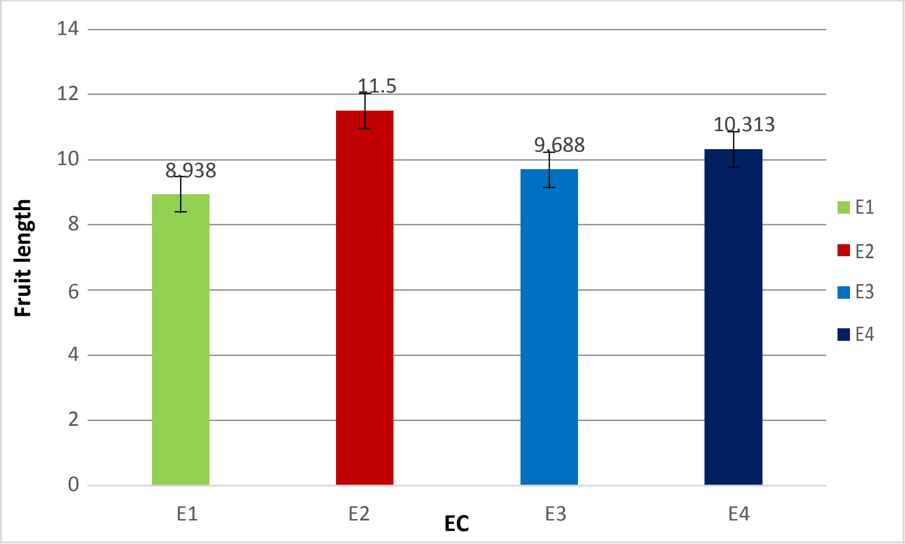

Figure 2. Effect of electrical conductivity on fruit length (cm)

Fruit length of capsicum were significantly affected by different levels of EC (Table 5). The highest fruit length was found in E_2 (11.5cm) which was statistically similar to that of E_4 (10.3cm). On the otherhand E_1 (8.9cm) and E_3 (9.6cm) showed lowest fruit length. The fruit quality was directly related to the E.C level which is confirming to research work of Caruso *et.al* (2011). The length of the fruits harvested from the plants grown in EC level 3.0 was better than 2.5, 3.5 and 4.0 EC levels respectively. Because at 3.0 EC levels, capsicum fruits had high firmness possibly because of higher calcium (Ca) content. It increased the TSS content of capsicum fruit. The increase TSS may be a result of increased fruit breadth.

Significant influence was noted on fruit length influenced by combined effect of cow dung slurry and electrical conductivity. The highest fruit length (12.5cm) was recorded from the treatment combination C_4E_2 and the lowest (8.5cm) were found in C_1E_1.

4.1.5 Fruit breadth

Fruit breadth of capsicum were significantly affected by cow dung slurry application (Table 5). The highest fruit breadth was found in C_4 (6.5cm) which was statistically similar to that of C_3 (6.1cm) treatment. This might be due to more vegetative growth and development of the plant at faster stage of growth and for that reason increasing dose of cow dung increased fruit breadth. On the otherhand C_1 (5.6cm) and C_2 (5. 9cm) showed lowest fruit breadth because of inferior vegetative growth which was described earlier. Nassar (1986) reported the breadth of individual fruit was increased with the increasing nitrogen levels.

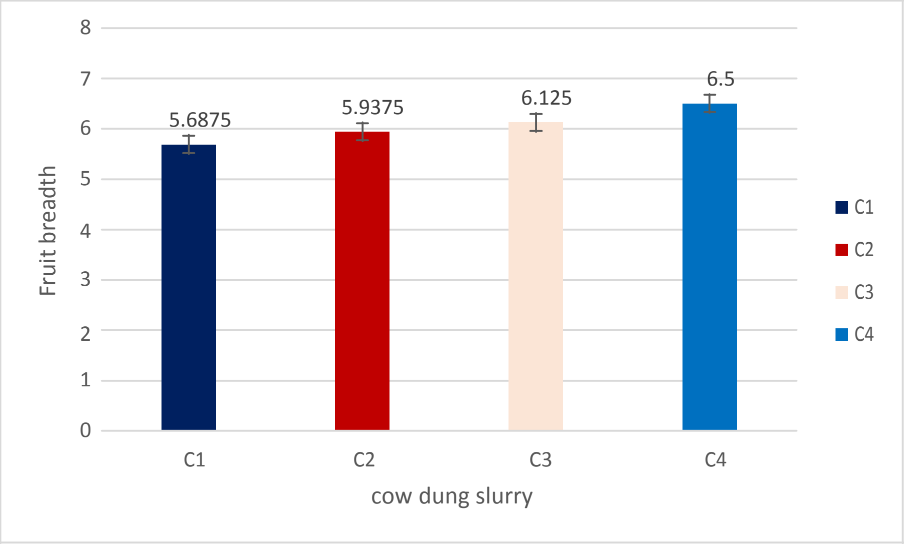

Figure 3. Effect of cow dung slurry on fruit breadth (cm)

Fruit breadth of capsicum were significantly affected by different levels of EC (Table 5). The highest fruit breadth was found in E_2 (7.06cm) at 3.0 EC level which was statistically similar to that of E_4 (6.3cm) at 4.0 EC level. On the otherhand E_1 (4.9cm) at 2.5 EC level and E_3 (5.9cm) at 2.5 EC level showed lowest fruit breadth. The fruit quality was directly related to the E.C level which is confirming to research work of Caruso *et.al* (2011). The breadth of the fruits harvested from the plants grown in EC level 3.0 was better than 2.5, 3.5 and 4.0 EC levels respectively. Because at 3.0 EC levels, capsicum fruits had high firmness possibly because of higher calcium (Ca) content. It increased the TSS content of capsicum fruit. The increase TSS may be a result of increased fruit breadth.

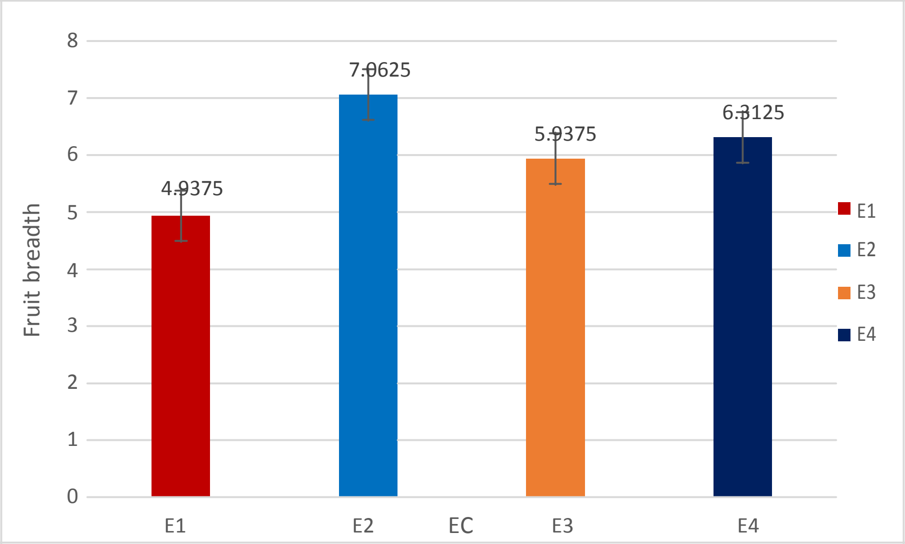

Figure 4. Effect of electrical conductivity on fruit breadth (cm)

Significant influence was noted on fruit breadth influenced by combined effect of cow dung slurry and electrical conductivity. The highest fruit breadth (7.5cm) was recorded from the treatment combination C_4E_2 and the lowest (4cm) were found in C_1E_1.

4.1.6 Fruit diameter

Fruit diameter of capsicum were significantly affected by different cow dung slurry application (Table 5). The highest fruit diameter was found in C_4 (6cm) which was statistically similar to that of C_3 (5.5cm). This was because proper management of cow dung slurry increases nitrogen that enhances the protein synthesis, which allows plant to grow faster, rate of metabolism, cell division, cell elongation and thereby stimulated vegetative growth. On the otherhand C_1 (5.01cm) and C_2 (5.2cm) showed lowest fruit diameter because of inferior vegetative growth.

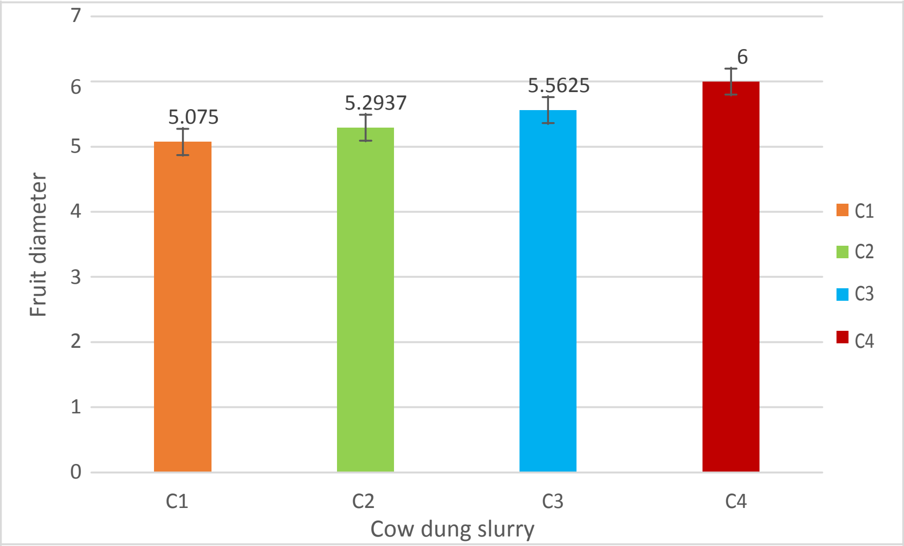

Figure 5. Effect of cow dung slurry on fruit diameter (cm)

Fruit diameter of capsicum were significantly affected by different levels of EC . The highest fruit diameter was found in E_2 (7.12cm) at 3.0 EC level which was statistically similar to that of E_4 (6.03cm) at 4.0 EC level. On the otherhand E_1 (3.8cm) at 2.5 EC level and E_3(4.9cm) at 3.5 EC level showed lowest fruit diameter. Because at 3.0 EC levels, capsicum fruits had high firmness possibly because of higher calcium (Ca) content. It increased the TSS content of capsicum fruit. The increase TSS is result of increased fruit diameter.

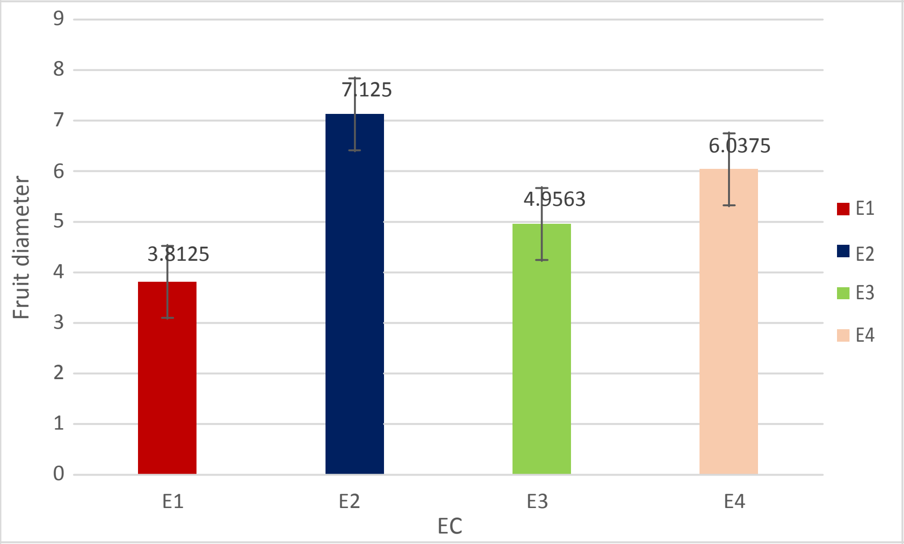

Figure 6. Effect of electrical conductivity on fruit diameter (cm)

Significant influence was noted on fruit diameter influenced by combined effect of cow dung slurry and electrical conductivity. The highest fruit diameter (cm) was recorded from the treatment combination C_4E_2 the lowest were found in C_1E_1.

4.1.7 Fruit pericarp

Fruit pericarp of capsicum were significantly affected by different cow dung slurry application (Table 5). The highest fruit pericarp was found in C_4 (4.8) which was statistically similar to that of C_3 (). This was because proper management of cow dung slurry increases nitrogen that enhances the protein synthesis, which allows plant to grow faster, rate of metabolism, cell division, cell elongation and thereby stimulated apical growth. On the otherhand C_1 (4.00) and C_2 (4.31) showed lowest fruit pericarp because of inferior cell division and vegetative growth.

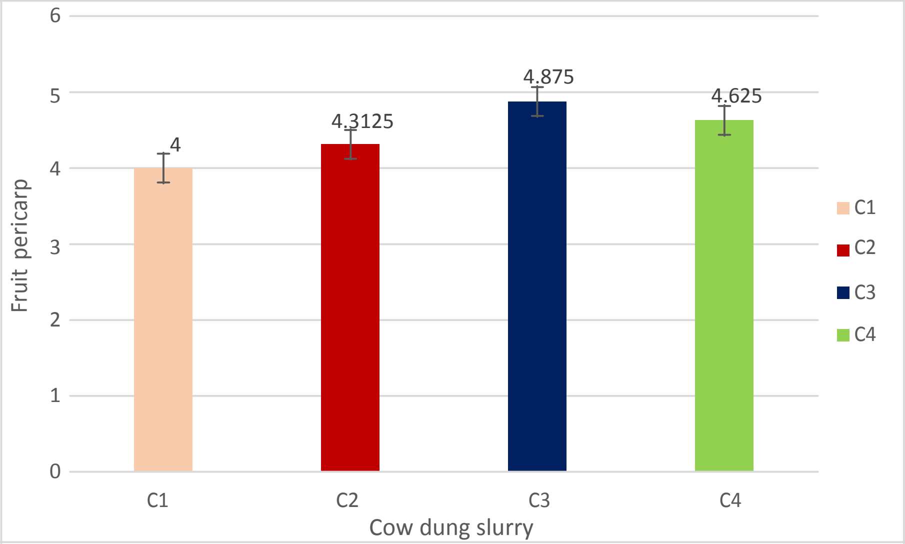

Figure 7. Effect of cow dung slurry on fruit pericarp (cm)

Fruit pericarp of capsicum were significantly affected by different levels of EC (Table 5). The highest fruit pericarp was found in E_2 (5.56) at 3.0 EC level which was statistically similar to that of E_4 (5.06) at 4.0 EC level. Because at 3.0 EC levels, capsicum fruits had high firmness possibly because of higher calcium (Ca) content. It increased the TSS content of capsicum fruit. The increase TSS is result of increased fruit pericarp. On the otherhand E_1 (3.31) at 2.5 EC level and E_3 (3.87) at 3.5 EC level showed lowest fruit pericarp. Because at 2.5 and 3.5 EC levels, capsicum fruits had low firmness and TSS content possibly because of lower calcium (Ca) content.

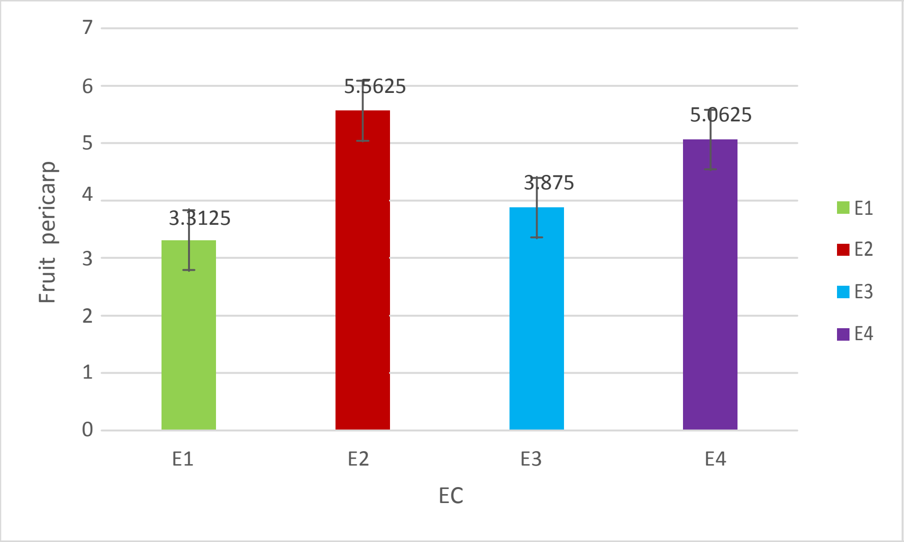

Figure 8. Effect of electrical conductivity on fruit pericarp

Significant influence was noted on fruit pericarp influenced by combined effect of cow dung slurry and electrical conductivity. The highest fruit pericarp (6.5) was recorded from the treatment combination C_4E_2 the lowest (3.00) were found in C_1E_1.

4.1.8 Fruit volume

Fruit volumes of capsicum were significantly affected by different cow dung slurry application (Table 5). The highest fruit volume was found in C_4 (143.7cc) which was statistically similar to that of C_3 (139.1cc). This was because proper management of cow dung slurry increases nitrogen that enhances the protein synthesis, which allows plant to grow faster, rate of metabolism, cell division, cell elongation and thereby stimulated vegetative growth. On the otherhand C_1 (127.8cc) and C_2 (133.6cc) showed lowest fruit volume because of inferior cell division and vegetative growth.

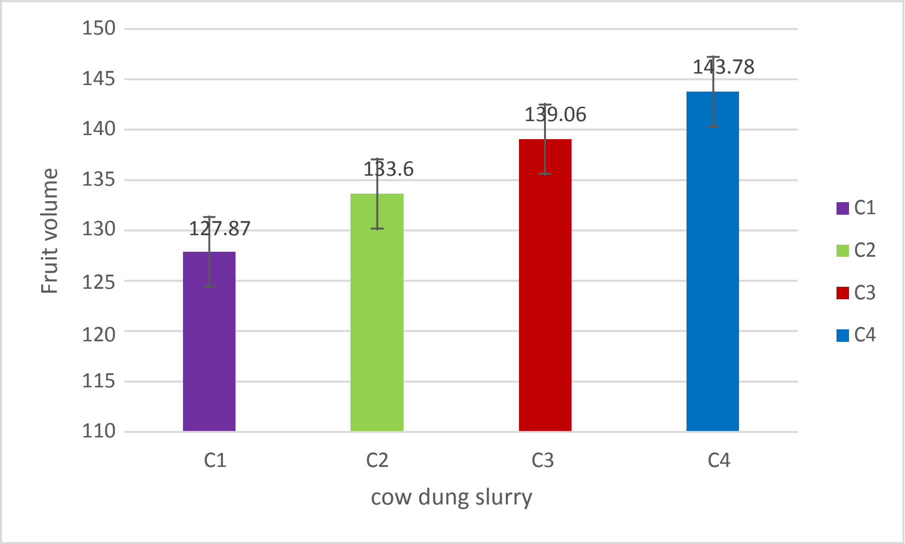

Figure 9. Effect of cow dung slurry on fruit volume (cc)

Fruit volume of capsicum were significantly affected by different levels of EC (Table 5). The highest fruit volume was found in E_2 (184.1cc) at 3.0 EC level which was statistically similar to that of E_4 (138.6cc) at 4.0 EC level. Because at 3.0 EC levels, capsicum fruits had high firmness possibly because of higher calcium (Ca) content. It increased the TSS content of capsicum fruit. The increase TSS is result of increased fruit pericarp. On the otherhand E_1 (104.6cc) at 2.5 EC level and E_3 (116.8cc) at 3.5 showed lowest fruit volume. Because at 2.5 and 3.5 EC levels, capsicum fruits had low firmness and TSS content possibly because of lower calcium (Ca) content.

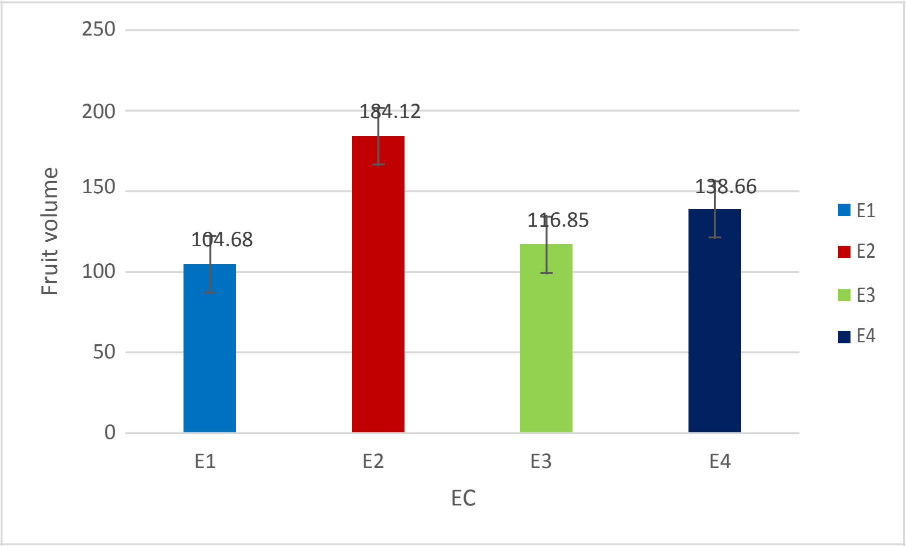

Figure 10. Effect of electrical conductivity on fruit volume(cc)

Significant influence was noted on fruit volume influenced by combined effect of cow dung slurry and electrical conductivity. The highest fruit volume (196.00cc) was recorded from the treatment combination C_4E_2 the lowest (98.00cc) were found in C_1E_1

Table 5: Interaction effect of cow dung slurry and electrical conductivity on fruit length, fruit breadth, fruit pericarp, fruit diameter, fruit volume in capsicum.

Treatment	Fruit length (cm)	Fruit breadth (cm)	Fruit diameter (cm)	Fruit volume (cc)	Fruit Pericarp
C_1E_1	8.500h	4.0000f	3.4500k	98.00i	3.0000e
C_2E_1	9.000gh	4.7500e	3.7000jk	103.00hi	3.0000e
C_3E_1	9.000gh	5.2500d	3.8000jk	108.70ghi	4.0000cde
C_4E_1	9.250fgh	5.7500c	4.3000ijk	109.00ghi	3.2500e
C_1E_2	11.000bc	5.7500c	6.5500bcd	176.00b	5.0000abc
C_2E_2	11.000bc	7.0000a	6.7500bc	181.00b	5.2500ab
C_3E_2	11.500b	7.0000a	7.2000ab	183.50ab	6.0000a
C_4E_2	12.500a	7.0000a	8.0000a	196.00a	6.0000a
C_1E_3	9.500fg	7.0000a	4.5500hij	111.00fghi	3.5000de
C_2E_3	9.500fg	7.2500a	4.8750ghi	114.90efgh	4.0000cde
C_3E_3	9.750efg	6.0000bc	5.0500fghi	118.50efg	4.0000cde
C_4E_3	10.000def	6.0000bc	5.3500efgh	123.00def	4.0000cde
C_1E_4	10.000def	6.0000bc	5.7500defg	126.50de	4.5000bcd
C_2E_4	10.000def	6.0000bc	5.8500cdef	135.50cd	5.0000abc
C_3E_4	10.500cde	6.0000bc	6.2000cde	145.55c	5.5000ab
C_4E_4	10.750bcd	6.2500b	6.3500bcd	147.10c	5.2500ab
Level of significance (P)					
C × E	0.0057	0.0039	0.0093	0.0087	0.0093

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

4.2 Number of fruit per plant:

Number of fruit of capsicum varied significantly by different treatment of cow dung slurry. Result revealed that topmost result (8.12) was recorded from C4 treatment where as C1 treatment was scored as the lowest (6.6) at final harvest (Figure 11). This might be because of proper supply of nutrient in the plants. In the present study, C_4 can supply proper amount in available forms of nutrients to the plants resulting maximum fruit number. It has been observed that fruit per plant increased gradually with the increasing rate of cow dung slurry. The increasing doses of cow dung slurry increased the number of fruits per plant.

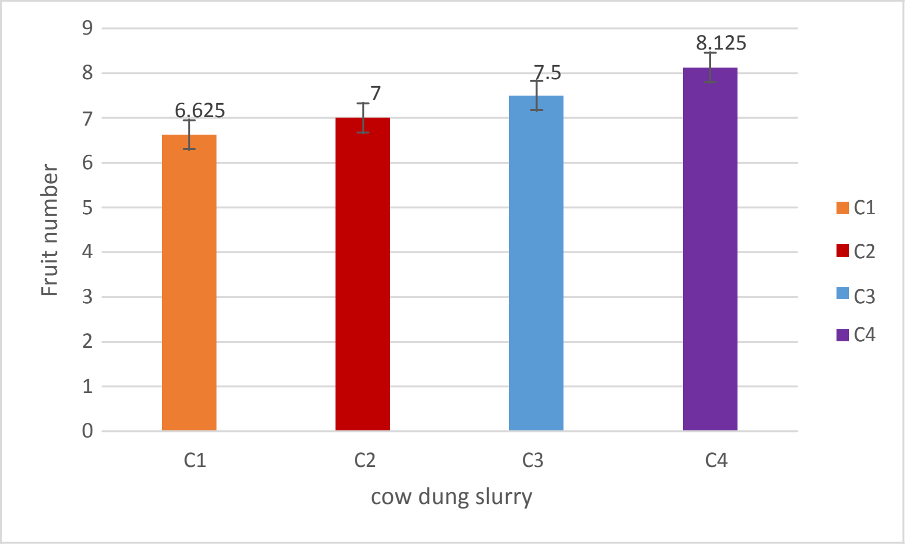

Figure 11. Effect of cow dung slurry on fruit number.

Fruit number of capsicum were significantly affected by different levels of EC (Table 5). The maximum fruit number was found in E_2 (10.2) which was statistically similar to that of E_4 (7.7). Because 3.0 EC levels increase the vegetative as well as reproductive yields of the crop. This is associated with a increment in the uptake of water, leaf water content, and a increment in the photosynthetic capacity of the crop. On the otherhand E_1 (4.8) and E_3 (6.3) showed lowest fruit number because of water deficit condition which causes lower leaf water content and photosynthetic capacity. Similar results were also reported by Saied at all (2005)

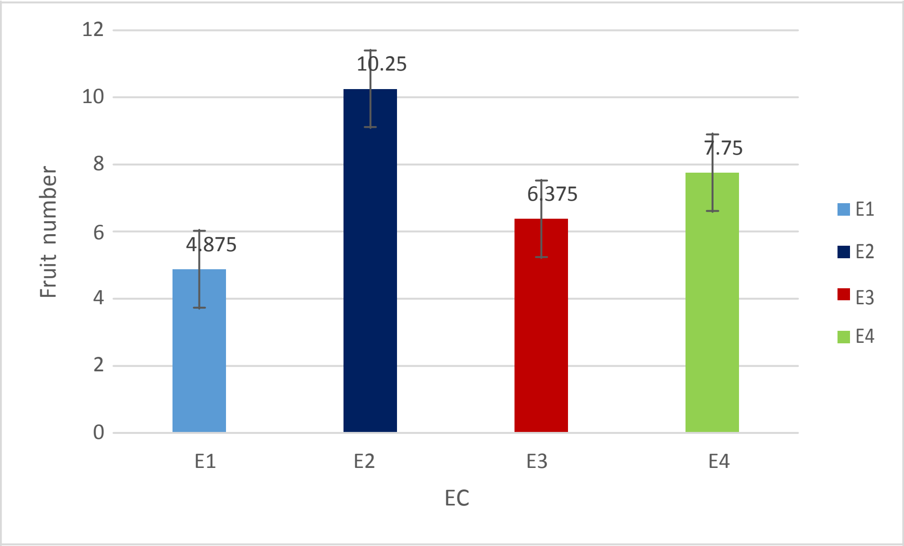

Figure 12. Effect of electrical conductivity on fruit number (gm)

Significant influence was noted on fruit number influenced by combined effect of cow dung slurry and electrical conductivity. The highest fruit number (12) was recorded from the treatment combination C_4E_2 the lowest (4) were found in C_1E_1.

4.3. Individual fruit weight:

Individual fruit weight of capsicum varied significantly by different treatment of cow dung slurry. Result revealed that topmost result (111.13gm) was recorded from C_4 treatment whereas C_1 treatment was scored as the lowest (93.25gm) at final harvest (Figure 13). This might be because of proper supply of nutrient in the plants. Shinohara *et al.* (2005) stated that capsicum growth was affected by different strength of nutrient solutions. The present finding was consisted with the findings of Shinohara *et al.* (2005). In the present study, C4 can supply proper amount in available forms of nutrients to the plants resulting higher fruit weight.

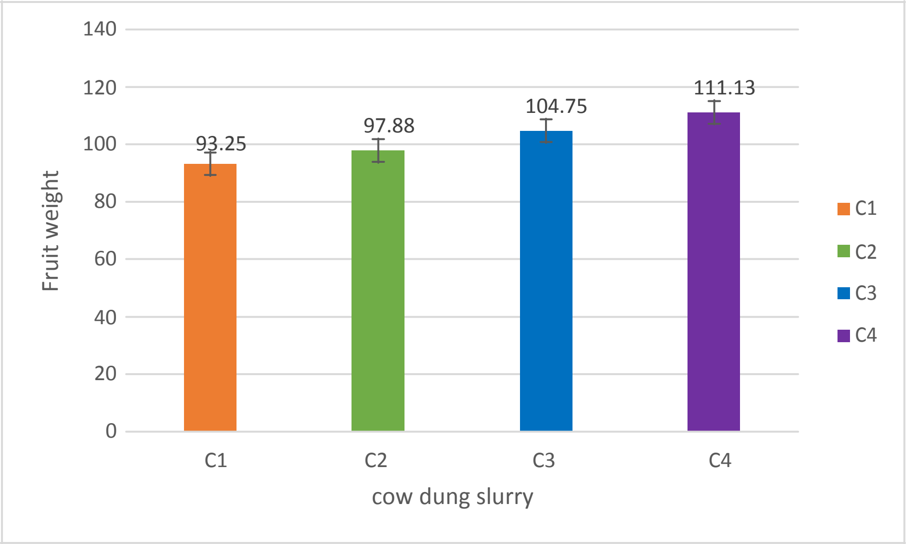

Figure 13. Effect of cow dung slurry on fruit weight (gm)

Fruit weight of capsicum were significantly affected by different levels of EC. The highest fruit weight was found in E_2 (139.38gm) which was statistically similar to that of E_4 (109.25gm). On the otherhand E_1 (65.63gm) and E_3(92.75) showed lowest fruit weight. The fruit quality was the directly related to the E.C level which is confirming to research work of Caruso *et.al*(2011).The weight of the fruits harvested from the plants grown in EC level 3.0 was better than 2.5, 3.5 and 4.0 EC levels respectively. The average number of marketable fruits per plant and average fruit weight of the capsicum was significantly affected by the EC levels. The EC level of 3.0 was proved to be the best in recording more number of fruits and weight of the fruits than EC level of 2.5, 3.5 and 4.0. Both the characters are yield contributing characters and have positive effect in increasing the fruit yield and marketable fruits. It also indicated that although the total number of fruits per plant was statistically same the bigger size fruits were produced on the plants grown in EC 3.0 than other two concentrations of EC.

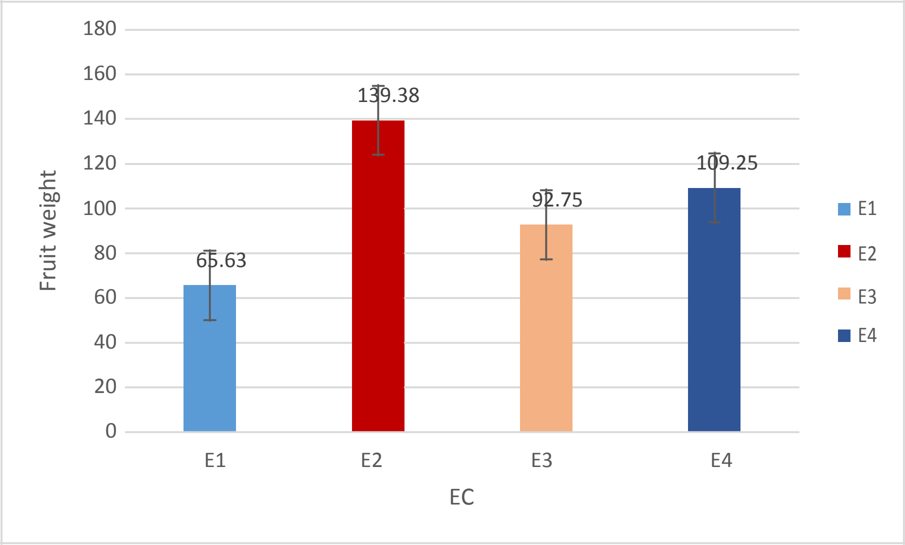

Figure 14. Effect of electrical conductivity on fruit weight(gm)

Significant influence was noted on fruit weight influenced by combined effect of cow dung slurry and electrical conductivity. The highest fruit weight (142.50gm) was recorded from the treatment combination C_4E_2 the lowest (54.50) were found in C_1E_1.

4.4 Dry weight of 100g fruit

Dry weight of 100g fruit of capsicum were significantly affected by different cow dung slurry application (Table 5). The highest dry weight was found in C_4 (8.6gm) which was statistically similar to that of C_3 (8.2gm). This might be because of proper supply of nutrient in the plants. Which increases the cell division and vegetative growth. On the otherhand C_1 (7.5gm) and C_2 (7.8gm) showed lowest dry weight of fruit because of inferior vegetative growth.

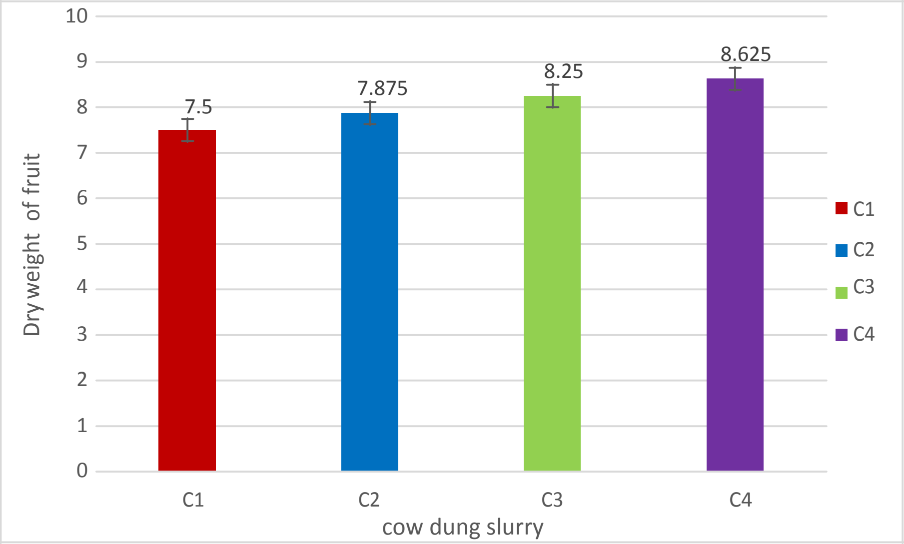

Figure 15. Effect of cow dung slurry on dry weight of fruit (gm)

Dry weight of 100g fruit of capsicum were significantly affected by different levels of EC (Table 5). The highest fruit dry weight was found in E_2 (10.1gm) which was statistically similar to that of E_4 (8.6gm). This might be due to proper uptake of water by plant. On the otherhand E_1 (6.1gm) and E_3(7.3gm) showed lowest fruit dry weight.

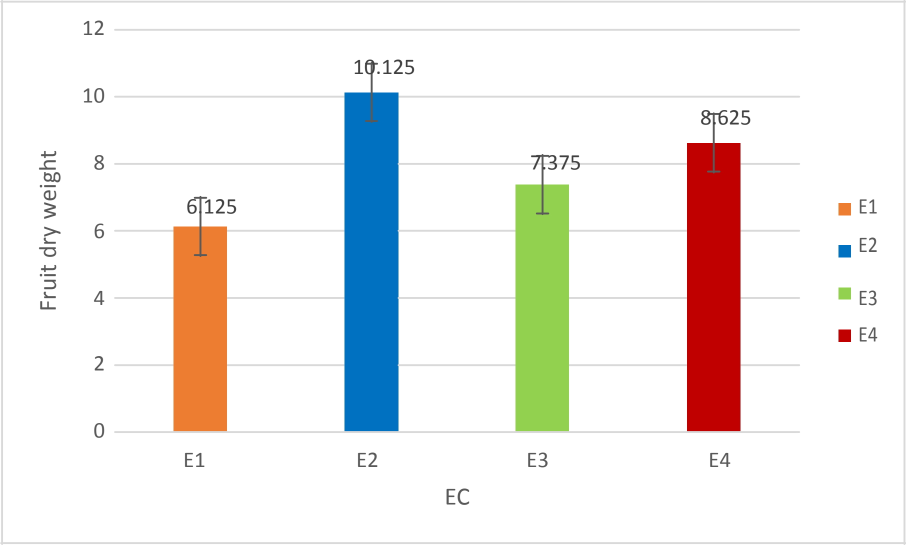

Figure 16. Effect of electrical conductivity on fruit dry weight(gm)

Significant influence was noted on dry weight of fruit influenced by combined effect of cow dung slurry and electrical conductivity. The highest dry weight of fruit (11gm) was recorded from the treatment combination C_4E_2 the lowest (5.5) were found in C_1E_1.

Table 6: Interaction effect of cow dung slurry and electrical on fruit number, fruit weight and dry weight of fruit.

Treatment	Fruit number	Fruit weight (gm)	Dry weightof fruit (gm)
C_1E_1	4.000h	54.50i	5.500i
C_2E_1	4.500h	63.00hi	6.000hi
C_3E_1	5.500g	71.00ghi	6.500gh
ssC_4E_1	5.500g	74.00fghi	6.500gh
C_1E_2	9.000cd	130.50abc	9.000c
C_2E_2	9.500c	130.50abc	10.000b
C_3E_2	10.500b	142.50ab	10.500ab
C_4E_2	12.000a	154.00a	11.000a
C_1E_3	6.000fg	88.00efgh	7.000fg
C_2E_3	6.500f	91.00efg	7.000fg
C_3E_3	6.500f	93.00defg	7.500ef
C_4E_3	6.500f	99.00def	8.000de
C_1E_4	7.500e	100.00def	8.500cd
C_2E_4	7.500e	107.00cde	8.500cd
C_3E_4	7.500e	112.50cde	8.500cd
C_4E_4	8.500d	117.50bcd	9.000c
P=C×E	.0043	0.0099	0.0213

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

4.5 Leaf fresh weight:

Leaf fresh weight of capsicum at 180 DAT varied significantly by different treatment of cow dung slurry. Result revealed that topmost result (59.8gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (50.6gm) after final harvest. This might be because of proper supply of nutrient in the plants. In the present study, C4 can supply proper amount in available forms of nutrients to the plants resulting highest leaf fresh weight.

Leaf fresh weight of capsicum were significantly affected by different levels of EC (Table 9). The highest fruit volume was found in E_2 (72.1gm) at 3.0 EC level which was statistically similar to that of E_4 (61.7gm). Because the chlorophyll content of the leaves were increased with respect to their age from initial stage to maturity, and maximum leaf chlorophyll content was observed in the leaves of plants grown in high E.C (3.0) the similar results were found by Romero-Aranda *et al*., (2001) the chlorophyll content per leaf increased with the salinity in the tomatoes. This results higher leaf fresh weight. On the otherhand E_1 (37.5gm) and E_3 (49.5gm) showed lowest leaf dry weight because of lower leaf chlorophyll content. The similar trends were also reported by Romero-Aranda, R., Soria, T., Cuartero, J., (2001.)

Significant influence was noted on leaf fresh weight influenced by combined effect of cow dung slurry and electrical conductivity. The highest leaf fresh weight (77.7gm) was recorded from the treatment combination C_4E_2 the lowest (31.9gm) were found in C_1E_1.

4.6 Stem fresh weight:

Stem fresh weight of capsicum at 180 DAT varied significantly by different treatment of cow dung slurry. Result revealed that topmost result (66.3gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (56.3gm) after final harvest. This might be because of proper supply of nutrient in the plants. In the present study, C4 can supply proper amount in available forms of nutrients to the plants resulting highest leaf fresh weight.

Stem fresh weight of capsicum were significantly affected by different levels of EC (Table 7). The highest stem fresh weight was found in E_2 (82.5gm) which was statistically similar to that of E_4 (69.1gm). Because the plant water uptake was increased in 3.0 ds/m EC value which plays a positive role in plant growth On the otherhand E_1 (38.1gm) and E_3(54.1gm) showed lowest stem fresh weight. This might be due to water deficit condition of plant.

Significant influence was noted on stem fresh weight influenced by combined effect of cow dung slurry and electrical conductivity. The highest stem fresh weight (89.03gm) was recorded from the treatment combination C_4E_2 the lowest (34.7gm) were found in C_1E_1.

4.7 Root fresh weight:

Root fresh weight of capsicum at 180 DAT varied significantly by different treatment of cow dung slurry. Result revealed that topmost result (30.4gm) was recorded from C_3 treatment where as C_1 treatment was scored as the lowest (27.3gm) after final harvest. This might be because of proper supply of nutrient in the plants. In the present study, C4 can supply proper amount in available forms of nutrients to the plants resulting highest root fresh weight.

Root fresh weight of capsicum were significantly affected by different levels of EC (Table 9). The highest root fresh weight was found in E_2 (32.4gm) which was statistically similar to that of E_1 (27.4gm). Because the plant water uptake was increased in 3.0 ds/m EC value which plays a positive role in plant growth. On the otherhand E_3 (27.3gm) and E_4 (27.4gm) showed lowest root fresh weight. This might be due to water deficit condition of plant.

Significant influence was noted on root fresh weight influenced by combined effect of cow dung slurry and electrical conductivity. The highest root fresh weight (33.1gm) was recorded from the treatment combination C_4E_2 the lowest (25.4gm) were found in C_1E_1.

Table 7: Main effect of cow dung slurry and electrical conductivity on dry weights of plants

Treatment	**Fresh weight/plant (g)**		
	Leaf	**Stem**	**Root**
Cowdung (C)			
C_1	50.648c	56.391c	27.349
C_2	53.794bc	59.058bc	28.476
C_3	56.594ab	62.766ab	30.474
C_4	59.811a	66.359a	29.884
Electrical conductivity (E)			
E_1	37.500d	38.714d	28.908
E_2	72.104a	82.556a	32.449
E_3	49.521c	54.176c	27.343
E_4	61.721b	69.128b	27.484
Level of significance (P)			
C	0.0003	<0.001	NS
E	<0.001	<0.001	NS

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

Table 8: Interaction effect of cow dung slurry and electrical conductivity on fresh weights of plants

Treatment	Fresh weight/plant (g)		
	Leaf	Stem	Root
C_1E_1	31.950l	34.755k	25.440
C_2E_1	35.960kl	37.325k	28.040
C_3E_1	39.365jk	39.665jk	31.835
C_4E_1	42.725ijk	43.110ijk	30.315
C_1E_2	67.485bcd	77.060bcd	30.210
C_2E_2	69.885bc	78.485abc	32.875
C_3E_2	73.340ab	85.645ab	33.590
C_4E_2	77.705a	89.035a	33.120
C_1E_3	45.275hij	49.565hij	25.630
C_2E_3	48.545ghi	52.825hi	26.945
C_3E_3	50.680gh	54.640gh	29.240
C_4E_3	53.585fg	59.675fgh	28.115
C_1E_4	57.880ef	64.185efg	26.045
C_2E_4	60.785de	67.595def	27.230
C_3E_4	62.990de	71.115cde	28.545
C_4E_4	65.230cd	73.615cde	27.555
Level of significance (P)			
C × E	0.0099	0.0065	NS

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

4.8 Leaf dry weight:

Leaf dry weight of capsicum at 180 DAT varied significantly by different treatment of cow dung slurry. Result revealed that topmost result (11.1gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (8.5gm) after final harvest. This might be because of proper supply of nutrient in the plants. In the present study, C4 can supply proper amount in available forms of nutrients to the plants resulting highest leaf dry weight.

Leaf dry weight of capsicum were significantly affected by different levels of EC. The highest fruit volume was found in E_2 (14.1gm) which was statistically similar to that of E_4 (10.6gm). Because the plant water uptake was increased in 3.0 ds/m EC value which plays a positive role in plant growth. On the otherhand E_1 (5.9gm) and E_3 (8.7gm) showed lowest leaf dry weight because of water deficit condition.

Significant influence was noted on leaf dry weight influenced by combined effect of cow dung slurry and electrical conductivity. The highest leaf dry weight (16.5gm) was recorded from the treatment combination C_4E_2 the lowest (4.2gm) were found in C_1E_1.

4.9 Stem dry weight:

Stem dry weight of capsicum at 180 DAT varied significantly by different treatment of cow dung slurry. Result revealed that topmost result (11.9gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (8.9gm) after final harvest. This might be because of proper supply of nutrient in the plants. In the present study, C4 can supply proper amount in available forms of nutrients to the plants resulting highest stem dry weight.

Stem dry weight of capsicum were significantly affected by different levels of EC. The highest stem dry weight was found in E_2 (16.2gm) which was statistically similar to that of E_4 (12.09gm). Because the plant water uptake was increased in 3.0 ds/m EC value which plays a positive role in plant growth. On the otherhand E_1 (5.1gm) and E_3(8.2gm) showed lowest stem dry weight. This might be due to water deficit condition of plant.

Significant influence was noted on stem dry weight influenced by combined effect of cow dung slurry and electrical conductivity. The highest stem dry weight (18.7gm) was recorded from the treatment combination C_4E_2 the lowest (3.7gm) were found in C_1E_1.

4.10 Root dry weight:

Root dry weight of capsicum at 180 DAT varied significantly by different treatment of cow dung slurry. Result revealed that topmost result (4.5gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (3.3gm) after final harvest. This might be because of proper supply of nutrient in the plants. In the present study, C4 can supply proper amount in available forms of nutrients to the plants resulting highest root dry weight.

Root dry weight of capsicum were significantly affected by different levels of EC. The highest root fresh weight was found in E_2 (5.9gm) which was statistically similar to that of E_4 (4.02gm). Because the plant water uptake was increased in 3.0 ds/m EC value which plays a positive role in plant growth. On the otherhand E_1 (2.3gm) and E_3(3.3gm) showed lowest root dry weight. This might be due to water deficit condition of plant. Similar results were reported by Bisko (2010).

Significant influence was noted on root dry weight influenced by combined effect of cow dung slurry and electrical conductivity. The highest root dry weight (7.2gm) was recorded from the treatment combination C_4E_2 the lowest (1.8gm) were found in C_1E_1.

Table 9: Main effect of cow dung slurry and electrical conductivity on plant dry weights of capsicum.

Treatment	Dry weight/plant (g)				
	Leaf	Stem	Root	Fruit	Plant
Cowdung (C)					
C_1	8.556	8.923c	3.3525d	7.5000c	20.838
C_2	9.298	9.926bc	3.6700c	7.8750bc	24.409
C_3	10.381	10.973ab	4.0825b	8.2500ab	26.386
C_4	11.166	11.930a	4.5075a	8.6250a	25.095
SE (±)					
Electrical conductivity (E)					
E_1	5.908	5.190d	2.3362d	6.125d	23.459ab
E_2	14.106	16.200a	5.9488a	10.125a	19.008b
E_3	8.788	8.265c	3.3012c	7.375c	31.724a
E_4	10.600	12.096b	4.0262b	8.625 b	22.538ab
SE (±)					
Level of significance (P)					
C	<0.001	<0.001	<0.001	0.0069	<0.001
E	<0.001	0.007	<0.001	0.0064	<0.001

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

Table 10: Interaction effect of cow dung slurry and electrical conductivity on dry weights of plants

Treatment	Dry weight/plant (g)				
	Leaf	Stem	Root	Fruit	Plant
C_1E_1	4.240l	3.725k	1.8400l	5.500i	19.795abc
C_2E_1	5.445kl	5.320jk	2.1950kl	6.000hi	23.840abc
C_3E_1	6.365jk	5.495ijk	2.5000jk	6.500gh	22.645abc
C_4E_1	7.580ij	6.220hij	2.8100ij	6.500gh	27.555abc
C_1E_2	12.095cd	14.010c	4.8950cd	9.000c	14.345bc
C_2E_2	12.675c	15.175bc	5.3050c	10.000b	15.715bc
C_3E_2	15.155 b	16.895ab	6.3050b	10.500ab	21.215abc
C_4E_2	16.500a	18.720a	7.2900a	11.000a	24.755abc
C_1E_3	7.925i	7.005hij	3.0550hij	7.000fg	27.150abc
C_2E_3	8.375hi	7.820ghi	3.2550hi	7.000fg	31.050ab
C_3E_3	9.335gh	8.510fgh	3.3900ghi	7.500ef	32.400ab
C_4E_3	9.515fgh	9.725efg	3.5050gh	8.000de	36.295a
C_1E_4	9.965efg	10.950def	3.6200fgh	8.500cd	22.060abc
C_2E_4	10.670ef	11.390de	3.9250efg	8.500cd	27.030abc
C_3E_4	10.695ef	12.990cd	4.1350ef	8.500cd	29.285abc
C_4E_4	11.070de	13.055cd	4.4250de	9.000c	11.775c
Level of significance (P)					
C × E	0.0237	0.0082	0.0089	0.0213	<0.001

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

4.11 Yield:

Marketable yield was affected by cow dung slurry and electrical conductivity. The highest yield (861.8 g/plant) was found in C_4 (400 ml cow dung slurry) treatment while, lowest yield (639.2 g/plant) was found in C_1 (100 ml cow dung slurry) treatment. This might be due to higher number of fruit by application of C_4. Furthermore, cow dung slurry increases the nitrogen level that might have a positive effect on fruit yield in capsicum. Stamatakis *et al.* (2003) found a positive effect of nitrogen addition to the nutrient solution under saline condition in tomato fruit yield. Doss ***et al*** (1981) reported that average yields from the lower nitrogen rate were greater than the higher nitrogen rate in the two driest years and were similar or higher from the higher nitrogen rate in year of more average rainfall.

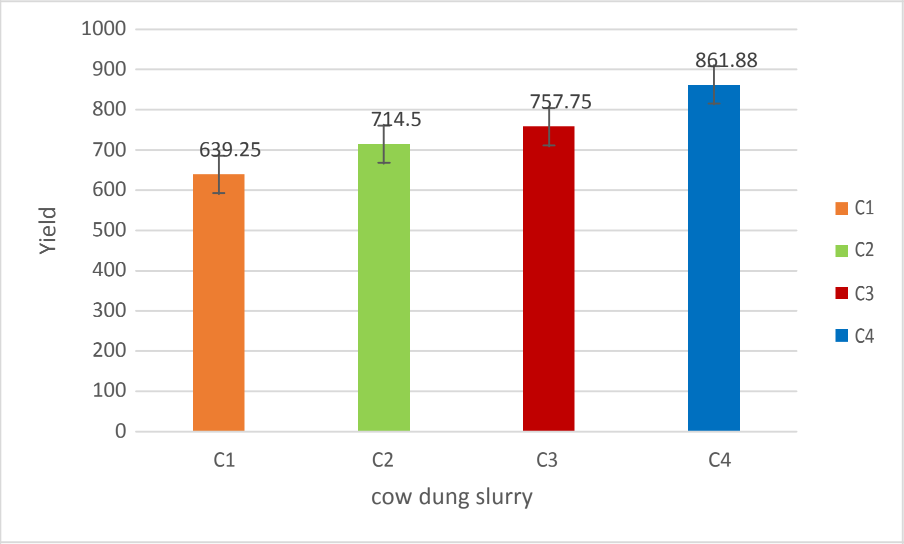

Figure 17. Effect of cow dung slurry on yield per plant in capsicum.

The yield contributing characters of the capsicum has significance due to different EC levels. The yield of any crop is the most economic and qualitative aspect and is of paramount importance. Marketable yield of capsicum was significantly affected by different levels of EC (Table 5). The highest yield was found in E_2 (1123.6gm) at 3.0 EC level which was statistically similar to that of E_4 (810.3gm) at 4.0 EC level. Because the plant water uptake was increased in 3.0 ds/m EC value which plays a positive role in plant growth. On the otherhand E_1 (388.9gm) at 2.5 EC level and E_3(650.6gm) at 3.5 EC level showed lowest yield. Because at 2.5 EC level as the plant face stress conditions which ultimately affected the yield of the plant.

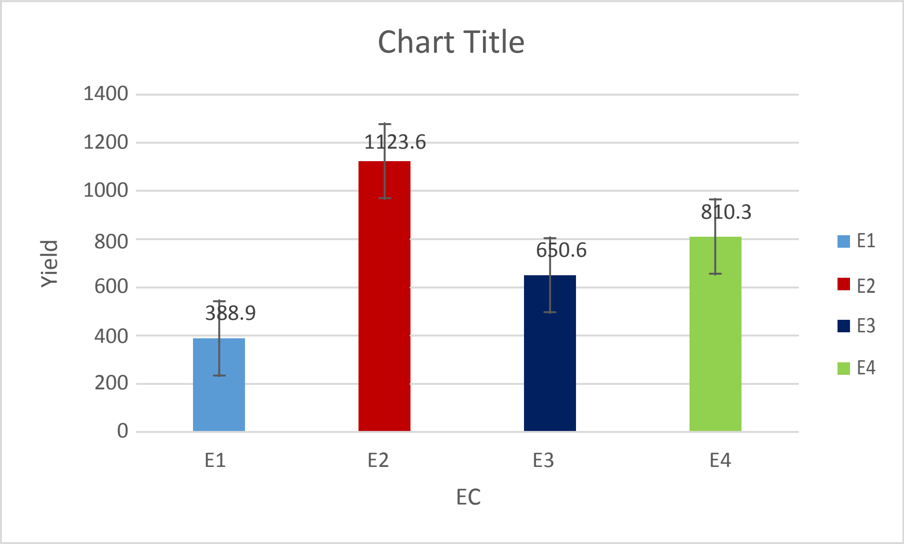

Figure 18. Effect of electrical conductivity on yield per plant in capsicum.

Significant influence was noted on yield influenced by combined effect of cow dung slurry and electrical conductivity. The highest yield (1385.5gm) was recorded from the treatment combination C_4E_2 the lowest (292.01gm) were found in C_1E_1.

4.12 Physiological growth traits

The physiological growth parameters of capsicum plants were significantly influenced by different cow dung slurry application (Table 11). In case of leaf area (LA), the higher leaf area (LA) was found in the plants grown in 400 ml cow dung slurry (C_4) and the lower was found in 100 ml cow dung slurry (C_1). Leaf area is an important determinant of light interception and consequently of transpiration, photosynthesis and plant productivity (Dufour, L. and Guérin, V. (2005). In case of Leaf Mass Ratio (LMR), the higher Leaf Mass Ratio (LMR) was found in C_4 and the lower was found in C_1. Higher LMR is one of the important criteria for producing higher metabolites. Prieto *et al.* (2007) reported that increased LMR gave the plants an increased ability to intercept light. In case of Leaf Area Ratio (LAR), the lower Leaf Area Ratio (LAR) was found in C_4 while the higher was found in C_1. Lower LAR is one of the important criteria for producing higher metabolites. Decreased LAR was found by Starck (1983) in tomato, which agreed with our findings. In case of Root Weight Ratio (RWR), the lower RWR was found in C_4 while the higher was found in C_1. Lower RWR is one of the important criteria for producing higher metabolites. Decreased RWR was found by Starck (1983) in tomato, which agreed with our findings.

The physiological growth parameters of capsicum plants were significantly influenced by different electrical conductivity of nutrient solution (Table 9). In case of leaf area (LA), the higher leaf area (LA) was found in E_2 in which the EC value is 3.0 ds/m and the lower was found in E_1 in which the EC value is 2.5ds/m. In case of Leaf Mass Ratio (LMR), the higher Leaf Mass Ratio (LMR) was found in E_2 and the lower was found in E_1. Higher LMR is one of the important criteria for producing higher metabolites. In case of Leaf Area Ratio (LAR), the lower Leaf Area Ratio (LAR) was found in E_2 while the higher was found in E_1. Lower LAR is one of the important criteria for producing higher metabolites. Decreased LAR was found by Starck (1983) in tomato, which agreed with our findings. In case of Root Weight Ratio (RWR), the lower RWR was found in E_2 while the higher was found in E_1. Lower RWR is one of the important criteria for producing higher metabolites.

Significant influence was noted on leaf area (LA) influenced by combined effect of cow dung slurry and electrical conductivity. The highest leaf area was recorded from the treatment combination C_4E_2 the lowest was found in C_1E_1. The higher Leaf Mass Ratio (LMR) was found in C_4E_2 and the lower was found in C_1E_1. Higher LMR is one of the important criteria for producing higher metabolites.

In case of Leaf Area Ratio (LAR), the lower Leaf Area Ratio (LAR) was found in C_4E_2 while the higher was found in C_1E_1. Lower LAR is one of the important criteria for producing higher metabolites. Decreased LAR was found by Starck (1983) in tomato, which agreed with our findings. In case of Root Weight Ratio (RWR), the lower RWR was found in C_4E_2 while the higher was found in C_1E_1. Lower RWR is one of the important criteria for producing higher metabolites.

Table 11: Main effect of cow dung slurry and electrical conductivity on physiological growth parameters of capsicum

Treatment	Growth parameters			
	LA (cm^2)	LMR ($g\ g^{-1}$)	LAR ($cm^2\ g^{-1}$)	RWR ($g\ g^{-1}$)
Cowdung (C)				
C_1	563.11b	0.4058c	32.536a	.01691a
C_2	568.49b	0.4127bc	26.934b	0.1609bc
C_3	575.97a	0.4193ab	29.109b	0.1649ab
C_4	579.84a	0.4261a	24.554c	0.1558d
Electrical conductivity (E)				
E_1	543.86d	0.3821d	44.239a	0.1851a
E_2	602.70a	0.4548a	17.630d	0.1453d
E_3	561.95c	0.4011c	22.081c	0.1536c
E_4	578.91b	0.4259b	29.183b	0.1666b
Level of significance (P)				
C	<0.001	<0.001	<0.001	<0.001
E	<0.001	0.0044	<0.001	0.015

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

Table 12: Interaction effect of cow dung slurry and electrical conductivity on physiological growth parameters of capsicum

Treatment	LA (cm^2)	LMR ($g\ g^{-1}$)	LAR ($cm^2\ g^{-1}$)	RWR ($g\ g^{-1}$)
C_1E_1	533.35k	0.3720i	53.610a	0.2000a
C_2E_1	543.34jk	0.3810hi	17.700jk	0.1440ij
C_3E_1	547.43ij	0.3850hi	18.235ijk	0.1470hij
C_4E_1	551.32hij	0.3905ghi	20.130hij	0.1495ghij
C_1E_2	590.45bc	0.4375cd	37.785c	0.1720cd
C_2E_2	595.59b	0.4455bc	40.610bc	0.1810bc
C_3E_2	610.95a	0.4645ab	44.950b	0.1875b
C_4E_2	613.82a	0.4715a	14.455k	0.1405j
C_1E_3	556.00ghij	0.3930gh	20.385hij	0.1505ghij
C_2E_3	559.32ghi	0.4005fgh	21.875ghij	0.1520ghij
C_3E_3	564.00fgh	0.4010fgh	22.395ghi	0.1555fghi
C_4E_3	568.51fg	0.4100efg	23.670fgh	0.1565fgh
C_1E_4	572.67ef	0.4205def	25.590fg	0.1600efg
C_2E_4	575.73def	0.4240de	27.550ef	0.1665def
C_3E_4	581.51cde	0.4265cde	30.855de	0.1695cde
C_4E_4	585.73bcd	0.4325cd	32.735d	0.1705cde
Level of significance (P)				
C × E	.0081	0.0077	0.0398	0.0367

P represents the level of significance of one-way ANOVA. C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m)

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the polythene shade house at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh during September 2018 to March 2019 to determine the effect of cow dung slurry and electrical conductivity (EC) of the nutrient solution in hydroponic capsicum. Treatments considered two factors, viz., four types of cow dung slurry (C_1: 100ml; C_2: 200ml; C_3: 300 ml and C_4: 400 ml) and four different electrical conductivity (E_1: 2.5ds/m; E_2: 3.0 ds/m; E_3: 3.5 ds/m and E_4: 4.0 ds/m). The experiment was conducted in a randomized completely block design with two replications. Cow dung slurry showed significant variation in most of the parameters. The summary was described here.

In case of growth parameters of capsicum, tallest plant (89.6cm) was recorded from plant grown in C_4 while the shortest plant height (84.4cm) was recorded from C_1, in case of fruit length, highest fruit length (10.6 cm) was recorded from the plant grown in C_4 which was statistically similar to that of C_3 (10.18cm) and lowest fruit length (9.75cm) recorded from the plant grown in C_1, in case of fruit diameter, higher fruit diameter (7.6cm) was recorded from plant grown in C_4 which was statistically similar to that of C_3 (6.9cm) and lower fruit diameter (5.4cm) recorded from plant grown in C_1, in case of fruit volume, higher fruit volume (143.7cc) was recorded from plant grown in C_4 which was statistically similar to that of C_3 (139.1cc) and lower fruit volume (127.8cc) recorded from plant grown in C_1, in case of number of fruit per plant, the maximum (8.12) number of fruit per plant was recorded from plant grown in C_4 which was statistically similar to that of C_3 (7.5) while the minimum number of fruit/plant (6.6) was recorded plant grown in C_1, in case of individual fruit weight, the highest (111.13gm) individual fruit weight was recorded from plant grown in C_4 which was statistically similar to that of C_3 (104.75gm) while the lowest individual fruit weight (93.25gm) was recorded plant grown in C_1, in case of dry weight of 100g fresh weight of capsicum, the higher fruit dry weight was found in C_4 (8.6g) which was statistically similar to that of C_3 (8.2g) and the lowest fruit dry weight was found in C_1 (7.5g), in case of leaf fresh weight at 180 DAT, that topmost result (59.8gm) was recorded from C4 treatment where as

C1 treatment was scored as the lowest (50.6gm) after final harvest, the highest stem fresh weight (66.3gm) was recorded from C_4 treatment where as C1 treatment was scored as the lowest (56.3gm) after final harvest. topmost result (66.3gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (56.3gm), the highest root fresh weight (30.4gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (27.3gm), in case of leaf dry weight at 180 DAT the topmost result (11.1gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (8.5gm) after final harvest, in case of stem dry weight 180 DAT the highest stem dry weight (11.9gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (8.9gm), in case of root dry weight at 180 DAT the highest root dry weight (4.5gm) was recorded from C4 treatment where as C1 treatment was scored as the lowest (3.3gm).

Different physiological parameters; viz. in case of leaf area (LA), the higher leaf area (LA) was found in the plants grown in C_4 and the lower was found in C_1, in case of Leaf Mass Ratio (LMR), the higher Leaf Mass Ratio (LMR) was found in C_4 and the lower was found in C_1, in case of Leaf Area Ratio (LAR), the lower Leaf Area Ratio (LAR) was found in C_2 while the higher was found in C_1, in case of Root Weight Ratio (RWR), the lower Root Weight Ratio (RWR) was found in C_4 while the higher was found in C_1. Best result was found from plant grown in C_4 followed by C_3. That means, 400 ml cow dung slurry gave highest yield and 100 ml cow dung slurry based gave lowest yield.

Results showed that different EC value of lettuce had significant effect on growth and yield of lettuce. In case of growth parameters of capsicum, tallest plant (95.4cm) was recorded from plant grown in E_2 while the shortest plant height (80.3cm) was recorded from E_1, in case of fruit length, highest fruit length (11.5cm) was recorded from the plant grown in E_2 and lowest fruit length (8.9cm) recorded from the plant grown in E_1, in case of fruit diameter, higher fruit diameter (7.1cm) was recorded from plant grown in E_2 lower fruit diameter (3.8cm) recorded from plant grown in E_1, in case of fruit volume, higher fruit volume (184.1cc) was recorded from plant grown in E_2 and lower fruit volume (104.6cc) recorded from plant grown in E_1, in case of number of fruit per plant, the maximum (10.2) number of fruit per plant was recorded from plant grown in E_2 swhile the minimum number of fruit/plant (4.8) was recorded plant grown in E_1, in case of individual fruit weight, the highest (139.3gm) individual fruit weight was recorded from plant grown in E_2 while the lowest individual fruit weight (65.63gm) was recorded plant grown in E_1, in case of dry weight of 100g fresh weight of capsicum, the higher fruit dry weight was found in E_2 (10.12g) and the lowest fruit dry weight was found in E_1 (6.12g), in case of leaf fresh weight at 180 DAT, that topmost result (72.1gm) was recorded from E_2 treatment where as E_1 treatment was scored as the lowest (37.5gm) after final harvest, the highest stem fresh weight (82.5gm) was recorded from E_2 treatment where as E_1 treatment was scored as the lowest

(38.7gm) after final harvest, the highest root fresh weight (32.4gm) was recorded from E_2 treatment where as E_1 treatment was scored as the lowest (28.9gm), in case of leaf dry weight at 180 DAT the topmost result (14.1gm) was recorded from E_2 treatment where as E_1 treatment was scored as the lowest (5.9gm) after final harvest, in case of stem dry weight 180 DAT the highest stem dry weight (16.2gm) was recorded from E_2 treatment where as E_1 treatment was scored as the lowest (5.1gm), in case of root dry weight at 180 DAT the highest root dry weight (10.1gm) was recorded from E_2 treatment where as E_1 treatment was scored as the lowest (2.3gm).

Different physiological parameters; viz. in case of leaf area (LA), the higher leaf area (LA) was found in the plants grown in E_2 and the lower was found in E_1, in case of Leaf Mass Ratio (LMR), the higher Leaf Mass Ratio (LMR) was found in E_2 and the lower was found in E_1, in case of Leaf Area Ratio (LAR), the lower Leaf Area Ratio (LAR) was found in E_2 while the higher was found in E_1, in case of Root Weight Ratio (RWR), the lower Root Weight Ratio (RWR) was found in E_2 while the higher was found in E_1. Best result was found from plant grown in E_2 followed by E_4. That means, EC value of 3ds/m gave highest yield and EC value of 2.5 ds/m gave lowest yield.

Interaction effect of cow dung slurry and electrical conductivity also significantly affected on physiological growth as well as yield of hydroponic capsicum. The maximum yield and almost all parameters were found in C_4E_2 and minimum were found in C_1E_1 that means 400 ml cow dung slurry with 3.0ds/m EC value gave highest yield and 100 ml cow dung slurry with 2.5ds/m EC value gave lowest yield.

CONCLUSIONS

According to the findings of the present experiment, the following conclusions were drawn.

1. The cow dung slurry as an alternative to nutrient solution through C_4 treatment (400 ml cow dung slurry) showed maximum yield and growth parameters of hydroponic capsicum compared to other treatment.
2. Higher fruit yield and other vegetative growth parameters and physiological traits of capsicum were found in E_2 treatment in which the EC value is 3.0 ds/m compared to other studied treatments.
3. The treatment combination of 400 ml cow dung slurry with 3.0 ds/m EC value C_4E_2 performed the best results in terms of yield and physiological growth parameters compared to other treatment combination.

Therefore, it can be concluded that 400ml cow dung slurry as an alternative to nutrient solution with 3.0 ds/m electrical conductivity had very positive effect on growth and yield of simple and low cost hydroponic capsicum.

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Appendices

APPENDICES

Appendix I. Analysis of variances of plant height at different days after transplanting of capsicum

Sources of variation	Degrees of freedom (df)	Means squares for Pant height at different days after transplanting (DAT) (cm)						
		0 DAT	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
Cow dung slurry(C)	3	39.901	263.952	255.781	232.208	142.299	53.281	38.945
EC (E)	3	10.663	128.340	51.365	87.458	71.779	406.760	342.612
C × E	9	24.708	84.842	208.587	155.208	93.918	7.677	4.591
Error	15	31.319	2.087	24.231	25.058	28.108	1.398	1.224
Level of significance (*P*)								
C		<.001	<0.001	<0.001	0.001	0.0128	<0.001	<0.001
E		0.0124	<0.001	0.0140	0.0423	.0091	<0.001	<0.001
C × E		0.999	<0.001	<0.001	0.0011	0.0190	0.002	<0.001

C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, E_4 = 4ds/m).

Appendix II: Analysis of variances of fruit parameters of capsicum

Sources of variation	Degrees of freedom (df)	Means squares for fruit parameters				
		Fruit length	Fruit diameter	Fruit volume	Fruit fresh weight	Dry weight of 100 gm fruit
Cow dung slurry(C)	3	1.216	3.885	377.55	491.08	1.8750
EC (E)	3	9.403	25.685	9789.4	7621.08	23.458
C × E	9	0.125	0.599	19.61	216.50	0.2083
Error	15	0.145	0.398	42.59	152.70	0.133
Level of significance (*P*)						
C	<0.001	<0.001		<0.001	0.0531	<0.001
E	0.0017	<0.001		0.001	<0.001	<0.001
C × E	0.005	<0.023		<0.008	0.009	0.0213

C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, $E_{4\,=}$ 4ds/m).

Appendix III : Analysis of variances for fresh weight of plants of capsicum

Sources of variation	Degrees of freedom (df)	Means squares for fresh weight 0f plant		
		Leaf fresh weight	Stem fresh weight	Root fresh weight
Cow dung slurry(C)	3	122.42	151.38	15.455
EC (E)	3	1796.80	2863.78	45.174
C × E	9	1.30	2.99	3.753
Error	15	10.19	24.75	61.127
Level of significance (*P*)				
C	<0.001	<0.001	NS	
E	0.0017	0.0063	NS	
C × E	0.005	0.0065	NS	

C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, $E_{4\ =}$ 4ds/m).

Appendix IV: Analysis of variances of dry weight of plant of capsicum

<table>
<tr><th rowspan="2">Sources of variation</th><th rowspan="2">Degrees of freedom (df)</th><th colspan="3">Means squares for dry weight 0f plant</th></tr>
<tr><th>Leaf dry weight</th><th>Stem dry weight</th><th>Root dry weight</th></tr>
<tr><td>Cow dung slurry(C)</td><td>3</td><td>10.650</td><td>13.521</td><td>2.0133</td></tr>
<tr><td>EC (E)</td><td>3</td><td>94.267</td><td>181.90</td><td>18.712</td></tr>
<tr><td>C × E</td><td>9</td><td>1.184</td><td>0.716</td><td>0.312</td></tr>
<tr><td>Error</td><td>15</td><td>0.374</td><td>1.333</td><td>0.078</td></tr>
<tr><td colspan="5">Level of significance (*P*)</td></tr>
<tr><td>C</td><td><0.001</td><td colspan="2"><0.001</td><td><0.001</td></tr>
<tr><td>E</td><td><0.001</td><td colspan="2"><0.001</td><td><0.001</td></tr>
<tr><td>C × E</td><td>0.0237</td><td colspan="2">0.0089</td><td>0.008</td></tr>
</table>

C = Cow dung slurry (C_1 = 100ml, C_2 = 200ml, C_3 = 300 ml, and C_4= 400 ml). E = Electrical conductivity (E_1 = 2.5 ds/m, E_2 = 3 ds/m, and E_3 = 3.5 ds/m, $E_{4\,=}$ 4ds/m).

Plate 04: Capsicum plants in shade house

Plate 05: Flowering stage of Capsicum.

Plate 06: First fruiting stage of Capsicum.

Plate 07: Fruiting stage of Capsicum.

Plate 08: Fruiting stage of Capsicum.

Plate 09: Fruit ripening stage of Capsicum.

Plate 10: Evenly riped fruit of Capsicum.

Plate 11: Harvesting of Capsicum.

Plate 12: Harvesting of Capsicum.