# EFFECT OF SALT INDUSTRIES BYPRODUCT ON GROWTH AND YIELD OF SWEET PEPPER IN SOILLESS CULTURE

**FATEMA AKTER**

**DEPARTMENT OF HORTICULTURE**
**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**
**DHAKA-1207**

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**BY**

**FATEMA AKTER**

**Reg. No.: 10-04058**

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**APPROVED BY:**

…………………………………..
**Dr. Md. Jahedur Rahman**
Professor
Department of Horticulture
Sher-e-Bangla Agricultural University
**Supervisor**

…………………………………..
**Prof. Md. Ruhul Amin**
Department of Horticulture
Sher-e-Bangla Agricultural University
**Co-Supervisor**

…………………………………..
**Dr. Tahmina Mostarin**
Chairman
Examination Committee

*Dedicated*

*To*

*My Beloved PARENTS*

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# EFFECT OF SALT INDUSTRIES BYPRODUCT ON GROWTH AND YIELD OF SWEET PEPPER IN SOILLESS CULTURE

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## ABSTRACT

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to determine the effect of salt industries byproduct on growth and yield of sweet pepper. Five concentrations of salt industries byproduct (SIB) are considered as treatments, *viz*. $S_1$ = ¾ strength Rahman and Inden (2012) + 0 $mlL^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 $mlL^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 $mlL^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 $mlL^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 $mlL^{-1}$ SIB. The experiment was conducted in a randomized completely block design with three replications. Different concentration of salt industries by product showed significant variation in most of the parameters. The highest plant height, the maximum number of fruit/plant, individual fruit weight, fruit length, fruit diameter, fruit volume, and yield were found highest in $S_{3.}$ But all the parameters were drastically reduced when $S_5$ treatment was applied. Therefore, $S_3$ treatment can be used for sweet pepper cultivation in soilless culture system in Bangladesh.

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## LIST OF ABBREVIATED TERMS

| | |
|---|---|
| SIB | Salt Industries Byproduct |
| DAT | Days After Transplanting |
| DAS | Days After Sowing |
| EC | Electrical Conductivity |
| LSD | Least Significant Difference |
| SAU | Sher-e-bangla Agricultural University |
| LDW | Leaf Dry Weight |
| SDW | Stem Dry Weight |
| RDW | Root Dry Weight |
| ANOVA | Analysis of Variance |
| BER | Blossom End Rot |
| LSD | Least Significant Difference |
| SAU | Sher-e-bangla Agricultural University |
| Nacl | Sodium chloride |
| $dsm^{-1}$ | Decisiemens |

# CHAPTER I

# INTRODUCTION

# CHAPTER I

# INTRODUCTION

Hydroponics or soilless culture is a technology for growing plants in nutrient solutions (water containing fertilizer) with or without the use of an artificial medium (sand, saw dust, rice husk, khoa etc.) to provide mechanical support. 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 soilless culture in the greenhouse as an alternative to traditional field production for high-value vegetable crops. Hydroponics has proved to be an excellent alternative crop production system (Savvas, 2003). This protected cultivation system can control the growing environment through management of weather factors, amount and composition of nutrient solution and also the growing medium. Therefore, quality of horticultural crops grown through soilless culture improves significantly compared to conventional soil culture pest factors. Nowadays, principle 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.

Sweet pepper (*Capsicum annum* L.) is a flowering plant under the genus Capsicum and belongs to the family Solanaceae. In Bangladesh it is commonly known as capsicum. It is relatively non-pungent with thick flesh and is the world’s second most important vegetable after tomato

(AVRDC, 1989). Tropical South America, especially Brazil is thought to be the original home of pepper (Shoemaker and Teskey, 1995). Capsicum (*Capsicum annum* L.) can be considered a functional food, because it contains many health-promoting phytochemicals such as vitamins A, B, C, E, phenolic compounds, carotenoids, and capsaicin (Bloch and Thomson, 1995). These compounds are reported to have antioxidant, anticarcinogenic, antimutagenic, anti-aging, and antibacterial properties (Chu *et al.*, 2002; Surh, 2002). In addition to their role in defense against human diseases, antioxidants have an important role in plant defense and are produced in response to both biotic and abiotic stresses (Sakihama *et al.*, 2002; Slater *et al.*, 2003).

The nutrient solution is one of the major components for successful hydroponic crop production. The composition of nutrient solutions and the optimization of nutrition in commercial hydroponics can reduce fertilizer costs. Specific formulation of nutrient solution compositions is required for the most horticultural species grown in soilless culture (De Kreij *et al.*, 1999). Moreover, to obtain high yield and good quality in commercial crops grown hydroponically, the nutrient solution supplied to the plants must be specific for the particular crop, the climatic conditions, or hydroponic system used etc.

There is increasing attention being given toward reducing the production cost of agricultural crops. Salt industries byproduct can reduce production cost as it contains many macronutrients, especially calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), and micronutrients. Salt industries byproduct is the effluent of salt industries and cheaper than commercial fertilizers. Salt industries byproduct contains sodium ($Na^{+}$) that may impose mild salinity, but it also contains some silicon (Si) that may minimize the negative effects of salinity. Bradbury and Ahmad (1990) and Liang *et al.*

(1996) reported that Si minimized the adverse effects of salinity. $Ca^{2+}$ plays a key role in plant growth and fruit development and is involved in many biochemical and physiological processes (Saure, 2005). Significant economic losses of horticultural crops have been linked to inadequate $Ca^{2+}$ nutrition (Grattan and Grieve, 1999). Salt industries byproduct can supply adequate $Ca^{2+}$ and other micro nutrients to sweet peppers. Thus, it can reduce fertilizer input and make agricultural practices more sustainable. However, there has been no research on salt industries byproduct application effects on crop production. Therefore, it is desirable to investigate the effects of salt industries byproduct on growth, yield, and quality on crops such as sweet pepper.

Considering the above mentioned facts, the present research work was aimed to study with the following objectives:

- To evaluate the effect of salt industries byproduct on vegetative growth and yield of capsicum,
- To identify the suitable dose of salt industries by product in soilless culture system.

# CHAPTER II

# REVIEW OF LITERATURE

# CHAPTER II

# REVIEW OF LITERATURE

Some of the research findings related to the effect of salt industries byproduct on physiological growth and yield in soilless sweet pepper so far have been reviewed here.

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.

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.

Ziaf *et al.* (2015) was conducted an experiment to evaluate growth and physiological aspects of bell pepper, under saline stress and exogenous application of proline on the leaves. The experiment was carried out during May and August 2015 in a greenhouse, at the Center of Technology and Natural Resources of the Federal University of Campina Grande (CTRN/UFCG), in the municipality of Campina Grande-PB, Brazil, in the mesoregion of 'Agreste Paraibano', situated at the geographic coordinates of 7°15'18'' S, 35°52'28'' W and mean altitude of 550 m. The treatments were distributed in a randomized block design , in 2 x 4 factorial scheme, with four replicates each consisting of one plant, corresponding to two levels of electrical conductivity of the irrigation water – EC (0.6 and 3.0 dS $m^{-1}$) associated with three proline concentrations through foliar application (10, 20 and 30 mmol $L^{-1}$) and a control treatment without application of proline. Water with ECw of 3.0 dS $m^{-1}$ was prepared using the salts of sodium chloride (NaCl), calcium chloride ($CaCl_2.2H_2O$) and magnesium chloride ($MgCl_2.6H_2O$) in order to have a equivalent proportion of 7:2:1 of Na:Ca:Mg, similar to observed in most water used in irrigation in the northeast region of Brazil (Medeiros *et al.,* 2003). The amount of each salt was determined based on the relationship between ECw and the concentration of salts (10*$mmol_c$ $L^{-1}$ = 1 dS $m^{-1}$).The plant height, stem diameter and number of leaves of bell pepper was reduced ($p<0.05$) by 16.4, 9.3 and 15.4%, respectively (Figure 1A, C and E) under irrigation water salinity of 3.0 dS $m^{-1}$ in comparison to that of 0.6 dS $m^{-1}$ at 50 DAT. Increment in irrigation water salinity increased soil salinity to levels above the threshold of the crop, causing physiological and nutritional alterations in the bell pepper plants, due to toxicity by specific ions; Irrigation with high salinity water (EC=3.0 dS $m^{-1}$) reduce growth, gas exchanges and efficiency of the photosystem bell pepper plants.

Tyson *et al.* (2007) conducted a study to determine the nitrification rate response in a perlite trickling biofilter (root growth medium) exposed to hydroponic nutrient solution, varying $NO_3^-$ 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 $NO_2^-$ to levels near those harmful to plants. 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. Phosphorus is an element which occurs in forms that are strongly dependent on environment pH.

Rubio *et al* .(2002) was carried out an experiment to evaluate the marketable fruit yield of sweet pepper plants (*Capsicum annuum* cv. Orlando) in function of the management of nutrient solution with training system. Plants were grown on coconut coir dust under greenhouse conditions in the southeast of Spain. A randomized block design in split-split plot with four blocks was used to test the effect of the nutrient solution strength (full or half-strength Hoagland nutrient solution), training system (two and three stems per plant) and water salinity (saline and non-saline) on total and marketable yield, fruit quality, and fruit mineral concentration. Salt treatment decreased fruit yield by decreasing the fruit fresh weight but not the number of fruits per plant. Under saline and non-saline conditions, the higher yield of fruits was obtained in plants watered with half-strength Hoagland solution, and grown with three stems per plant. Blossom end rot incidence increased under saline conditions or using full-strength Hoagland solution, but decreased with the combination of half-strength Hoagland solution and three-stem training system. Salt treatment also decreased fruit quality in all the treatments due to a decrease in $PO_2^-$, $SO_4^{2-}$, $Fe^{2+;3+}$, $Cu^{1+;2+}$ and $Mn^{2+}$ concentrations, and fruit shape index. Likewise, plants exposed to salinity and watered with half-strength Hoagland solution and trained with three stems showed a reduction in juice glucose and fructose concentration. Based on these results, an increase of the marketable fruit yield could be obtained under non or moderate saline conditions with the implementation of suitable culture practices.

Another experiment was conducted by Rubio *et al*.(2009 ) to examines the effects of $K^+$ and $Ca^{2+}$ fertilization on sweet pepper production, blossom-end rot (BER) incidence and fruit quality of pepper plants (*Capsicum annuum* L.) grown under moderate saline conditions. Pepper plants were grown in a controlled-environment greenhouse under hydroponic conditions with different nutrient solutions obtained by modifying the Hoagland solution. The experiment consisted on four $K^+$ treatments (0.2, 2, 7 and 14 mM) +30 mM NaCl, and four $Ca^{2+}$ treatments (0.2, 2, 4 and 8 mM) +30 mM NaCl, having in common a control without salt with 7 mM K+/4 mM $Ca^{2+}$. Salinity decreased total fruit yield and marketable fruit yield by 23% and 37%, respectively. The marketable fruit yield reduction by salt treatment was mainly due to the increase in the number of fruit affected by BER. This typical physiopathy of the pepper fruits occurred between 18 and 25 days after anthesis (DAA), when the highest fruit growth rate was reached. Fruit quality parameters were also affected by salt treatment where the fruit pulp thickness and firmness were decreased, and fructose, glucose and myo-inositol fruit concentrations increased with salinity relative to fruits from control treatment. Under saline conditions an increased supply of $K^+$ reduced the fruit fresh weight, the percentage of BER and the marketable yield although promoted the vegetative growth. However, increasing $Ca^{2+}$ concentration in the nutrient solution increased the fruit production, and the marketable yield as consequence of decreasing the percentage of fruit affected with BER. Fruit quality parameters also were affected by the $K^+$ and $Ca^{2+}$ treatments.

An experiment was conducted by Md. Shariful Islam at Central Laboratory in the Sher-e-Bangla Agricultural University, Dhaka; during September 2014 to March 2015 to identify the effect of salt industries by product on growth and yield of lettuce in soilless culture. Three nutrient solutions were considered as treatments, viz. $T_1$ – ½ Rahman and Inden (2012) + 0 ml of salt industries by product (SIB), $T_2$ – ½ Rahman and Inden (2012) + 0.5 ml of SIB, $T_3$ – ½ Rahman and Inden (2012) + 0 ml of SIB. The experiment was conducted in a completely randomized design (CRD). Salt industries by product showed significant variation in most of the parameters. The highest plant height (19.53 cm) was recorded from $T_1$ while the lowest plant height (15.61 cm) was found in $T_3$, number of leaves per plant was maximum (10.61) from $T_1$ whereas minimum (8.80) was recorded $T_3$, higher leaf breadth (11.36 cm) was recorded from $T_1$ which was statistically similar to $T_2$ and lower (9.56 cm) was from $T_3$, higher leaf length (17.61 cm) was found in $T_1$ and lower (13.90 cm) was in $T_3$, the maximum fresh weight (48.81 g/plant) was recorded from $T_1$ which was statistically similar to $T_2$ and minimum (27.94 g/plant) was in $T_1$.In case of ascorbic acid content, the maximum amount of ascorbic acid content (157.61 mg/100g fresh weight) was recorded from $T_3$ and the minimum (127.41 mg/100g fresh weight) was in $T_1$. In case of β-carotene content, the maximum amount of β-carotene content (3207 µg/100g fresh weight) was recorded from $T_3$ and the minimum (3100 µg/100g fresh weight) was in $T_1$. Similar trend also found in other growth analytical parameters (viz. leaf area, leaf area ratio, leaf mass ratio, root weight ratio, net assimilation ratio and relative growth rate), which was the best from $T_1$ but LA, RGR and NAR were statistically similar to that of $T_2$.Meanwhile all the physiological parameters were lowest in $T_3$. Therefore, $T_2$ (½ Rahman and Inden (2012) + 0.5 ml of SIB) can be used to get higher amount of ascorbic acid and β-carotene content with moderate yield.

Investigations were carried by Giuffrida *et al*. (2014) to know the effects of nutrient and sodium chloride (NaCl) salinity on pepper grown in closed soilless culture systems were studied. A control (2 dS $m^{-1}$) and two saline nutrient solutions (2.8 and4 dS $m^{-1}$) differing in the salt sources (fertilizers or NaCl) were studied. Shoot biomass production as well as total and marketable yield were more affected by NaCl than nutrient salinity. Fruit dry matter and total soluble solids increased in both salinity treatments compared to the control. Total phenol content rose slightly (10%) with NaCl salinity, while the concentration of carotenoids was enhanced by 40% with NaCl compared to the control and nutrient salinity. The results showed that the response of pepper to salinity is both osmotic and ion specific, but a more negative effect was recorded under NaCl stress. Moreover, the highest content of antioxidant compounds in NaCl treated fruits may indicate that NaCl caused more stressful conditions than nutrient salinity.

Fernandez *et al.* (2005) found that tomato begins to suffer inhibited growth and lose yield when nutrient solution EC is above 4 dS $m^{-1}$. Higher salinity negatively affects tomato root, shoot, leaf, yield and water use efficiency, while improves fruit quality. Under salinity condition, tomato root is the first organ exposed to salinity stress, and salinity induced root zone water stress. This may led to less water intake by the root and decreased transportation to the shoot. Consequently, less water is available for normal growth and development

Giuaffrida and Leonardi (2012) was conduct an experiment to verify how the adoption of a reduced strength nutrient solution in a soilless closed system could influence the production and quality of pepper and improve the use efficiency of water and minerals. Two nutrient solutions characterized by the same ion ratio but macronutrient concentration equal to 100% or 60% were adopted. The total yield did not differ between the treatments; however the lower concentration of nutrients determined a significant reduction of incidence of unmarketable fruits (blossom-end rot) and thus a higher marketable production (+15%). Within the fruit quality characteristics the dry matter content and the titratable acidity were significantly higher adopting the full strength nutrient solution.

Azarmi *et al.* (2010) was carried an experiment to study the effect of salinity at different levels on growth, yield and quality of greenhouse tomato (*Lycopersicon esculentum* Mill.) grown in hydroponics culture was evaluated. Salinity treatments were applied at EC of 2.5, 3, 4, 5 and 6 dS $m^{-1}$ by adding NaCl to standard nutrient solution. The results indicated that plant height and leaf number were significantly ($P \leq 0.05$) decreased with increasing salinity. Total leaf area at EC of 6 dS $m^{-1}$ decreased by 29% in comparison to 2.5 dS $m^{-1}$. Chlorophyll content was significantly ($P \leq 0.05$) reduced at EC of above 3 dS $m^{-1}$. Stomatal conductance in nutrient solution with EC of 6 dS $m^{-1}$, reduced by 28.2% compared to 2.5 dS $m^{-1}$. Fruit fresh weight at EC of 6 dS $m^{-1}$ decreased by 29% in comparison to 2.5 dS m-$^{1}$. Total fruit yield reduced by 8.7, 21.7, 36 and 48.9% at EC of 3, 4, 5 and 6 dS $m^{-1}$, respectively, compared with 2.5 dS $m^{-1}$. Total soluble solid was significantly ($P \leq 0.05$) increased at EC of above 3 dS $m^{-1}$. Fruit dry weight at EC of 6 dS $m^{-1}$ increased by 8.7% compared with 2.5 dS $m^{-1}$. Titratable acidity increased by 2.7, 9.9, 20.3 and 28.9% at EC of 3, 4, 5 and 6 dS $m^{-1}$, respectively, compared with 2.5 dS $m^{-1}$. The results of this experiment showed that growth parameters and yield reduced with increasing salinity, but qualitative properties were improved by salinity.

An experiment was carried out by Miceli *et al.* (2001) to evaluate the effect of salt stress on quality and production of lettuce grown in soilless culture. A soilless cultivation was carried out under an unheated greenhouse in plastic containers filled with coconut coir dust. Lettuce plants of two cultivars were grown using a water supply containing four nutrient solutions with different electrical conductivity (1.6, 2.6, 3.6, 4.6 mS $cm^{-1}$). These variations were obtained by adding NaCl to the mother nutrient solution. An increase in salinity of the nutrient solution was associated with a reduction of marketable yield, average plant fresh weigth and leaf number per plant. Salinity influenced also the ratio and content of anions and cations in the plant.

Jones (2007) said that the main advantages of hydroponics over soil culture are more efficient nutrition regulation, availability in regions of the world having non arable land, efficient use of water and fertilizers, no water stress on plants, ease and low cost of sterilization of the medium, no need for weed controlling, ability medium temperature can be maintained optimum by flooding with the nutrient solution, higher density planting, leading to increased yields per acre. As well as improving fruits quality especially for export.

Kim *et al.* (2008) investigated the effects of salinity and nutrients on the growth of red leaf lettuce (*Lactuca sativa* L. cv. Mother-red). A closed plant factory with hydroponic cultures supplemented with sodium salt (NaCl) or seawater was employed for cultivation of lettuce. The fresh weight of lettuce grown in culture with NaCl was dramatically reduced when compared to those grown in standard culture or culture with seawater. The lettuces grown in the culture with NaCl or seawater contained higher amounts of sugar and anthocyanin, and the lettuce plants grown in the culture with seawater accumulated highest levels of photosynthetic pigments, chlorophylls and carotenoids. These results indicate that the addition of some solutes (e.g. NaCl) to the culture medium affect the size of plant as well as the levels of sugars and pigments in the plant, and suggest that the addition of seawater (20%) to the medium is effective to produce lettuces with higher quality and nutritional value

Lucia *et al.* (2003) carried out an research to evaluate the effects of sea water irrigation on the antioxidant properties and qualitative characteristics of tomato. The berries of plants grown with 0, 10 and 20% of sea water, corresponding to conductivity values of 3, 8, 14 mS/cm, respectively, were harvested at two growth stages, green and red-ripe. Increasing water salinity resulted in reduced crop water consumption, plant growth, fruit and crop yield, whereas it caused an increase in fruit quality. Titrable acidity, osmotic pressure and concentration of sodium, sugars and organic acids increased upon irrigation with saline water, whereas K content increased only at 14 mS/cm EC. The antioxidant capability was evaluated by the analysis of reduced/oxidised ratios of the major antioxidants: the reduced pool of ascorbate suggested a favourable response of tomato fruits, and the determinant role of GSH in the behaviour of total glutathione content was pointed out. Finally, the trend of APX activity testified the increased requirement of active oxygen species scavenging under salinisation.

# CHAPTER III

# MATERIALS AND METHODS

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted during the period from September 2015 to March 2016 to study the effect of salt industries byproduct on vegetative growth and yield of capsicum, This chapter includes a brief description of the location of experimental site, materials used for the experiment, design of the experiment, data collection procedure and procedure of data analysis that were used for conducting the experiment**.**

## 3.1. Location

The experiment was conducted in the greenhouse at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experiment was carried out during rabi season. The location of the study site is situated between $23^{0}41^{/}$ N latitude and $90^{o}22^{/}$ E longitude (Anon., 1989). The altitude of the location was 8 m from the sea level (The Meteorological Department of Bangladesh, Agargaon, Dhaka).

## 3.2. Plant materials and others

Sweet pepper cv. 'Wonder Bell' of average fruit weight around 220 g is used in this experiment. Seeds of sweet pepper were collected from Siddique Bazar Seed Market, Dhaka. .The salt industries by product was collected from Nitaigonj, Narayanganj.

## 3.3. Experimental environment

The seeds were sown in the seed bed prepared by the media mixture of coco peat, brick broken and rice husk at the ratio of 6:2:2 (v/v). Two-week-old seedlings were transferred into the 250-mL plastic pots. Eight-week old seedlings were transferred 20-cm apart into the cork-sheet boxes containing media mixtures of coco peat, brick broken and rice husk at the ratio of 6:2:2 (v/v). The 150-cm × 25-cm × 30-cm cork sheet boxes were prepared by cork-sheets. The boxes were filled with the media mixture of coco peat, brick broken and rice husk at the ratio of 6:2:2 (v/v). Six healthy seedlings were transferred in each box. The pH and EC of ≅ 6.0 and ≅ 2.5– 3.5 $dS \cdot m^{-1}$, respectively are maintaining in the nutrient solution.

### 3.4. Experimental Design and treatments

The experiment has conducted in a completely randomized block design with three replications. Five concentrations of SIB are considered as treatments, *viz*.

$S_1$ = ¾ strength Rahman and Inden (2012) + 0 $mlL^{-1}$ SIB,

$S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 $mlL^{-1}$ SIB,

$S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 $mlL^{-1}$ SIB,

$S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 $mlL^{-1}$ SIB and

$S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 $mlL^{-1}$ SIB.

The nutrient compositions of Rahman and Inden (2012) solution were $NO_3$-N, P, K, Ca, Mg, and S of 17.05, 7.86, 8.94, 9.95, 6.0 and 6.0 $meq \cdot L^{-1}$, respectively. The rates of micronutrients were Fe, B, Zn, Cu, Mo and Mn of 3.0, 0.5, 0.1, 0.03, 0.025 and 1.0 $mg \cdot L^{-1}$, respectively for the nutrient solutions.

The components of salt industries byproduct were Phosphorus, Potassium ,Calcium, Magnesium, Sulfur, Iron , Zinc, Boron, Molybdenum, Sodium, and Silicon etc .

All the treatments were started at half strength from the first day of the seedlings when transferred into the boxes. Full strength of the treatments was started from the second week of the experiment. The pH ≅ 6.0 and

EC ≅ 2.5-3.5 $dS \cdot m^{-1}$, respectively were maintained in the nutrient solutions. These solutions were used in different boxes. Treatments were applied from the second week of the transplantation. Nine plants were considered as an experimental unit.

### 3.5. Preparation of nutrient solutions

In this experiment Rahman and Inden (2012) solution was used. ¾ strength Rahman and Inden (2012) was used in this experiment.These nutrient solution are prepared according to their composition. $MgSO_4$, $NH_4H_2PO_4$, $KNO_3$, $Ca(NO_3)_2$ were prepared as macro-nutrient solution and a micro-nutrient stock solution was prepared two nutrient solutions at different concentration were used.

### 3.6. Growing media preparation for seedling rising

The mixture of coco peat, broken bricks (khoa) and ash at the ratio of 50:30:20% (v/v). Coco peat was soaked in a big bowl for 24 hours. It was washed well with water and spread in a polythene sheet for 3 hours. Then they are mixed with khoa and ash properly. This mixer was placed in a styrofoam sheet box for using seedbed.

### 3.7. Seed sowing

The seeds were soaked in water for 24 hours and then wrapped with piece of thin cloth. The socked seed were then spreaded over polythene sheet for 2 hours to dry out the surface water. After that seeds were sown in growing substrate and covered newspaper under room temperature for rising

**Plate 1: Capsicum Seedling in Seedbed**

### 3.8. Transplanting of sweet pepper seedling

Sweet pepper seedlings were transplanted into the main boxes containing nutrient solution after two weeks of emerging. The cup contains the mixture of coco peat, khoa and ash. One healthy lettuce plant from seedbed was selected for each pot. Capsicum plants were transplanted carefully so that roots were not damaged. After transplanting of capsicum plant in the pot light watering was done with sprayer.

**Plate 2: Transplanting of seedlings in pot**

**Plate 3. Flowering stage of capsicum plant**

**Plate 4. Fruiting stage of capsicum plant**

## 3.9. Data collection

Data on the following parameters were recorded from the plants during the experiment. Data were collected from each plant. Each box was regarded as an experimental unit. Data were collected on different growth and yield components. Data is collecting on growth and yield parameters, viz., plant height at different days after planting, fruit length, fruit diameter, fruit volume, number of fruit per plant, individual fruit weight, fruit yield per plant; physiological parameters, viz., leaf area (LA), leaf area ratio (LAR), relative growth rate (RGR), and net assimilation rate (NAR); and antioxidant contents ascorbic acid . Some of the growth and yield contributing parameters have recorded discussed in the results and discussion section, but physiological parameters will be recorded at the end of the experiment and antioxidants will be measured during the experiment.

### 3.9.1 Plant height

Plant height was measured in centimetre (cm) by a meter scale at 30, 60, 90,120, 150 and 180 DAT (days after transplanting) from the point of attachment of growing media up to the tip of the longest leaf.

### 3.9.2. 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.

### 3.9.3. Individual fruit weight

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

### 3.9.4. Individual fruit length

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

### 3.9.5. Individual fruit diameter

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

### 3.9.6. 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.

### 3.9.7. Fresh weight of plant

Plants were collected in labeled plastic bags and bring to the laboratory. Leaves were detached by a sharp knife and fresh weight of the plant was taken by an electric balance at harvest (180 DAT) and data was recorded.

### 3.9.8. Dry weight of plant

After recording fresh weight, the random samples of plants dried for seven days. After drying, plants were weighed. An electric balance was used to record the dry weight of plant.

### 3.9.9 Yield (kg) /plant

Fruits were harvested at the commercial maturity stage of fruit. In each of harvesting, the weights of harvested fruits were recorded using electric balance in the field. The final data was made at the final harvesting using calculator and Microsoft Excel Software. Average results are used for statistical analysis purpose.

**Plate 5. Harvesting stage of capsicum plant**

### 3.9.10. Statistical analysis of data

Data were analyzed by one-way analysis of variance (ANOVA) using MSTATC software and the differences among means were determined using least significant difference (LSD) test.

# CHAPTER IV

# RESULT AND DISCUSSION

# CHAPTER IV

# RESULTS AND DISCUSSION

The research work was accomplished to identify the effect of different treatments on growth, yield and quality of capsicum in soilless culture. Some of the data have been presented and expressed in table(s) and others in figures for case of discussion, comparison and understanding

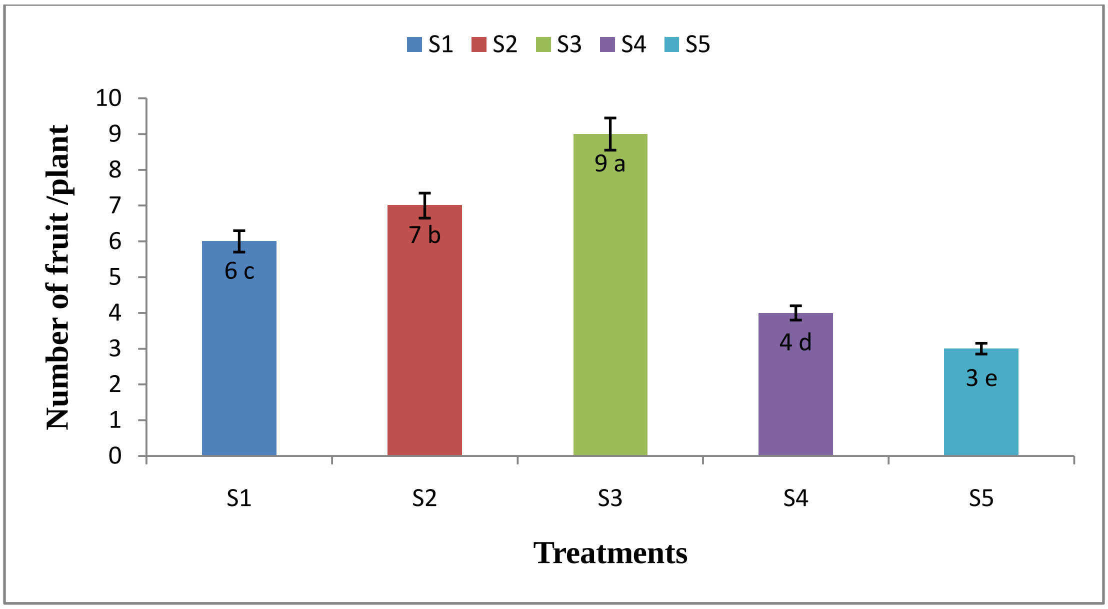
**4.1. Plant height:** Plant heights at different days after planting (DAT) of sweet pepper were significantly affected by different SIB concentrations. The highest plant heights at 30 DAT, 60 DAT, 90 DAT, 120 DAT, 150 and 180 DAT were found in the $S_3$ ( ¾ strength Rahman and Inden (2012) + 0.5 $mlL^{-1}$ SIB) treatment (Table 1). Meanwhile, the lowest plant heights were found in $S_5$ (¾ strength Rahman and Inden (2012) + 1.0 $mlL^{-1}$ SIB) treatment (Table 1). This result revealed that the greater plant height was found in the $S_3$ treatment compared to others. However, the mechanism for improvement of plant height due to application of $S_3$ treatments not clear, but the positive impact of SIB is due to the presence of rather high amounts of $Ca^{2+}$ and Si, which might have contributed to reduce $Na^+$ absorption sites. Bradbury and Ahmad (1990) and Liang *et al.* (1996) reported that Si minimized the effects of salinity in *Prosopis juliflora* and barley, respectively. Calcium sulfate counteracted the toxic effect of NaCl, resulting in greater plant height and leaf number of salt treated Leucaena leucocephala plant (Hansen and Munns, 1988). Salt industries byproduct (SIB) contains a higher amount of $Ca^{2+}$ which may able to counteract the toxic effects of Na+ when applied at the rate of 1.0 $mlL^{-1}$.

**Table 1. Effect of salt industries byproduct on plant height (cm)**

| Treatments | Plant height (cm) at different days after transplanting(DAT) | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAT | 60 DAT | 90 DAT | 120 DAT | 150 DAT | 180 DAT |
| $S_1$ | 41 c | 60 c | 74 c | 86 c | 91 c | 98 c |
| $S_2$ | 47 b | 66 b | 79 b | 90 b | 96 b | 101 b |
| $S_3$ | 53 a | 75 a | 84 a | 95 a | 102 a | 112 a |
| $S_4$ | 37 d | 55 d | 65 d | 80 d | 87 d | 92 d |
| $S_5$ | 33 e | 50 e | 60 e | 76 e | 81 e | 86 e |
| CV % | 9.01 | 4.48 | 6.42 | 3.9 | 5.79 | 6.7 |
| LSD (0.05) | 1.12 | 4.41 | 4.2 | 2.1 | 2.92 | 3.4 |

[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 $mlL^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 $mlL^{-1}$ SIB, $S_3$ = ¾ strengthRahman and Inden (2012) + 0.5 ml $L^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 $mlL^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 $mlL^{-1}$ SIB]

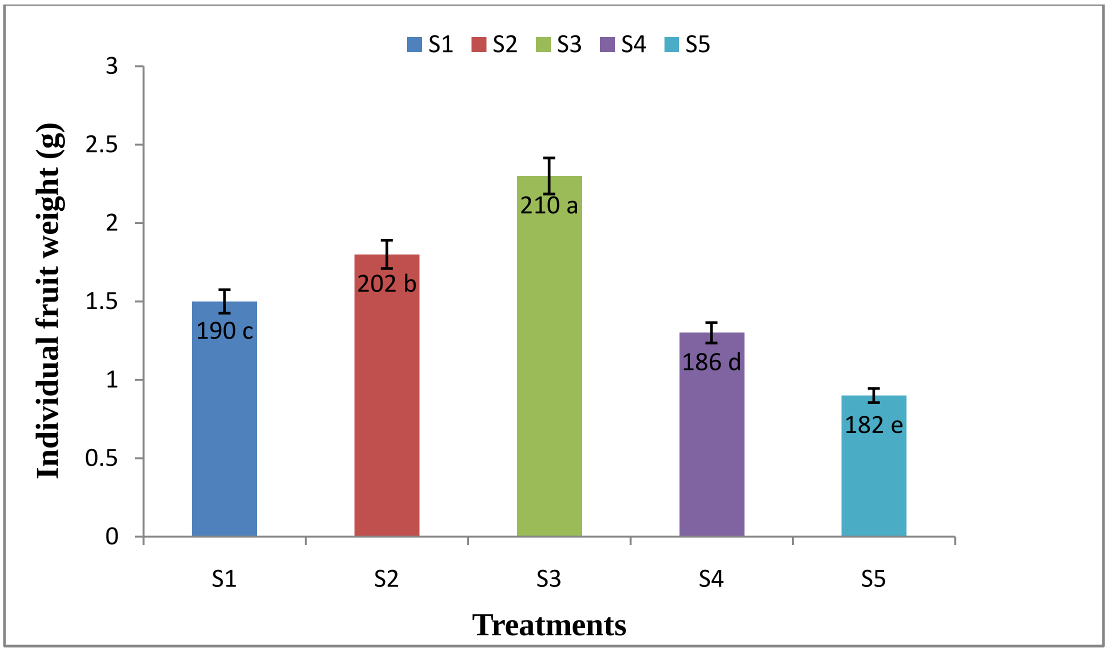
**4.2. Number of fruit per plant:** Significant variation was observed among $S_1$, $S_2$, $S_3$, $S_4$ and $S_5$ treatments in terms of number of fruits per plant (Figure 1). The maximum number of fruit per plant (9.0) was found in $S_3$ treatment whereas the lowest value (3.0) was found in $S_5$ treatment (Figure 1). The plants required optimum nutrient combination for proper growth and development. $S_3$ treatment provide $Ca^{2+}$ which decrease % (BER) on the contrary $S_5$ treatment contain more $Ca^{2+}$ than $S_3$ treatment which causes osmotic stress , resulting higher (%)BER. Water stress and osmotic stress reduce $Ca^{2+}$ transport particularly to the distal end region of sweet pepper fruit, where BER develops (Marcelis and Ho, 1999; Silber et al., 2005). Due to lower % (BER) higher number of fruit found in $S_3$ treatment.




[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 mL. $L^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 ml $L^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 $mlL^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 $mlL^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 $mlL^{-1}$ SIB]

**Figure 1. Effect of salt industries byproduct on number of fruits/plant**

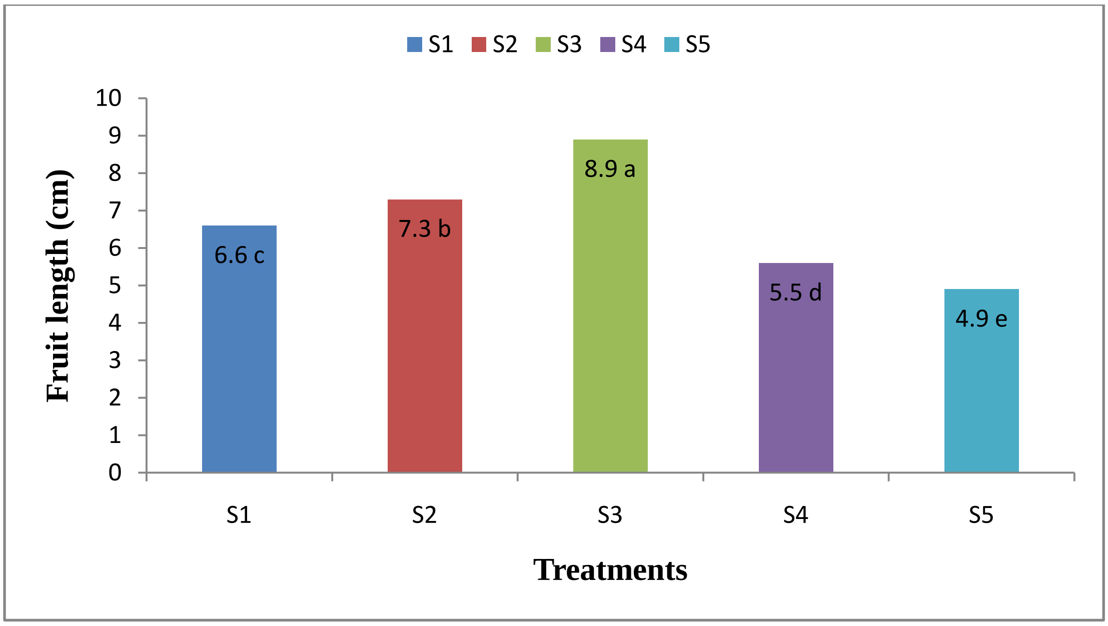
**4.3. Individual fruit weight:** Individual fruit weight of capsicum varied significantly by different SIB concentrations. Result revealed that topmost result (210g) was recorded from $S_3$ treatment where as $S_5$ treatment was scored as the lowest (182g) at final harvest (Figure 2). This might be because of proper supply of nutrient in the plants. Shinohara *et al.* (2005) stated that sweet pepper 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, $S_3$ can supply proper amount in available forms of nutrients to the plants resulting higher fruit weight.




[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 mlL$^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 ml L$^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 ml L$^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 ml L$^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 mlL$^{-1}$ SIB]

**Figure 2. Effect of salt industries byproduct on individual fruit weight (g)**

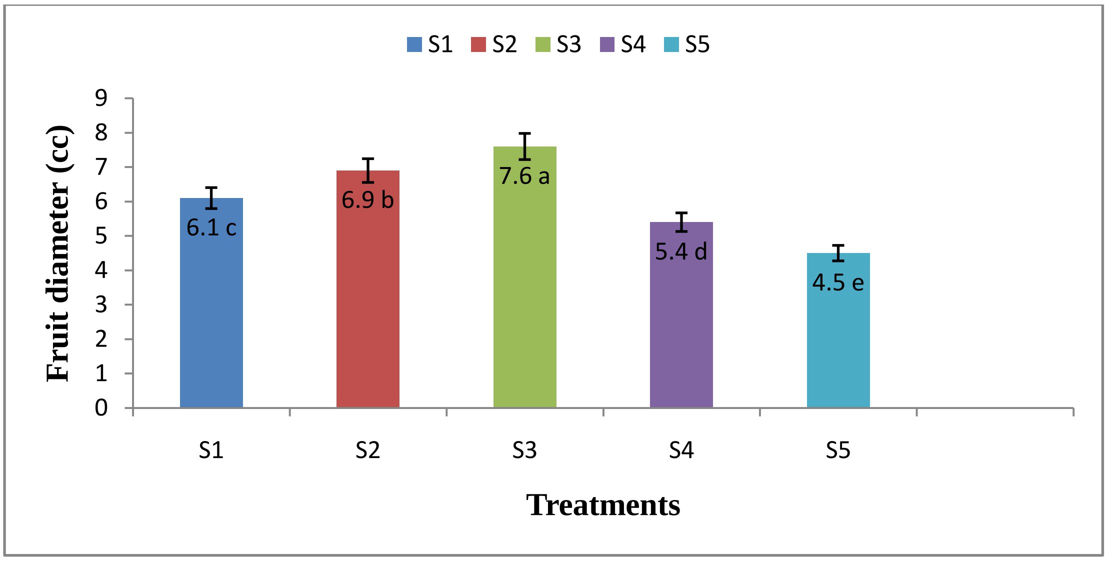
**4.4. Fruit length** : The maximum fruit length of capsicum (8.90) was found in $S_3$ ( ¾ strength Rahman and Inden (2012) + 0.5 mlL$^{-1}$ SIB) treatment ((Figure3). Meanwhile, the lowest value (4.90) was found in $S_5$ (¾ strength Rahman and Inden (2012) + 1.0 mlL$^{-1}$ SIB) treatment. Similar findings on pepper plants were reported by Navarro *et al.* (2002).




[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 mL. $L^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 mL. $L^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 mL. $L^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 mL. $L^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 mL. $L^{-1}$ SIB]

**Figure 3. Effect of salt industries byproduct on fruit length (cm)**

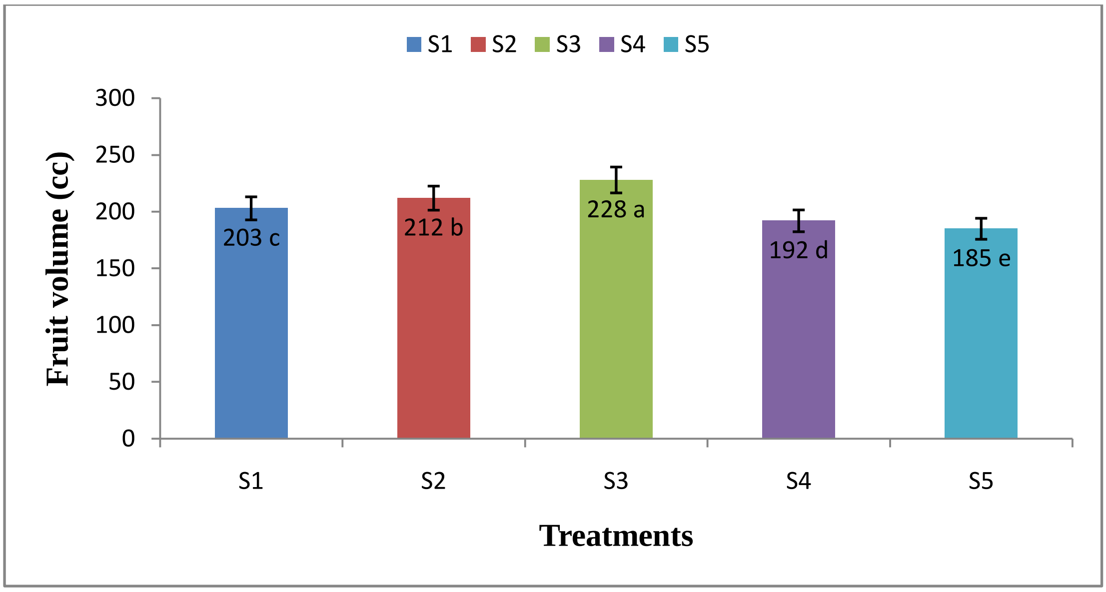
**4.5. Fruit diameter :** Fruit diameter of capsicum exposed statistically significant inequality for the application of salt industries byproducts. The maximum fruit diameter (7.6 cm) was recorded from $S_3$ ( ¾ Rahman and Inden (2012) + 0.5ml of SIB) treatment and the minimum fruit diameter (4.5cm) was obtained from $S_5$ (¾Rahman and Inden (2012) + 1.0ml of SIB) treatment (Figure 4). Similar findings on pepper plants were reported by Navarro *et al*., (2002).




[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 $mlL^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 $mlL^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 $mlL^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 $mlL^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 ml $L^{-1}$ SIB]

**Figure 4. Effect of salt industries byproduct on fruit diameter (cm)**

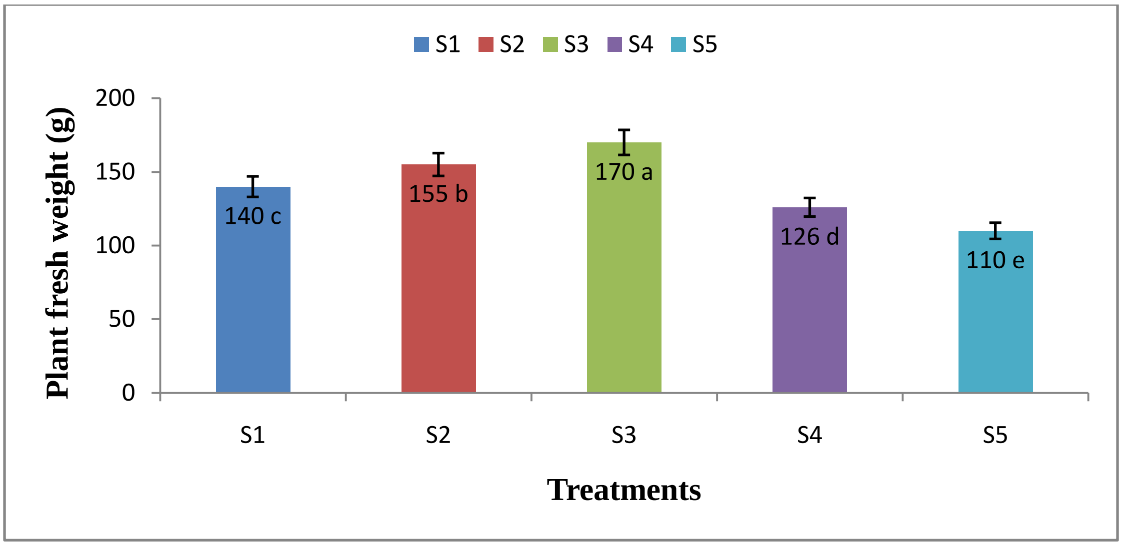
**4.6. Fruit volume:** Significant difference was not found in fruit diameter due to the application of different strength nutrient solutions with salt industries by product. The highest fruit volume (228 cc) was recrded from $S_3$ ( ¾ Rahman and Inden (2012) + 0.5ml of SIB) treatment. Meanwhile, the lowest fruit volume (185cc) was obtained from $S_5$ (¾Rahman and Inden (2012) + 1.0ml of SIB) (Figure 5). Salinity reduces total yield by a fruit size reduction (Chartzoulakis and Klapaki, 2000).




[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 mL$^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 mlL$^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 mlL$^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 mlL$^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 mlL$^{-1}$ SIB]

**Figure 5. Effect of salt industries byproduct on fruit volume (cc)**

**4.7. Plant fresh weight:** The maximum plant fresh weight (170 g) was recorded from of $S_3$ ( ¾ Rahman and Inden (2012) + 0.5ml of SIB) treatment while, the minimum plant fresh weight (110g) was found from $S_5$(¾Rahman and Inden (2012) + 1.0ml of SIB) treatment(Figure 7). Kaya, *et al.* (2009) reported that increased salinity decreased fresh weight. In treatment $S_5$ salinity increased resulting decreased fresh weight.




[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 ml $L^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 $mlL^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 $mlL^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 $mlL^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 $mlL^{-1}$ SIB]

**Figure 6. Effect of salt industries byproduct on plant fresh weight (g)**

## 4.8. Plant dry weight

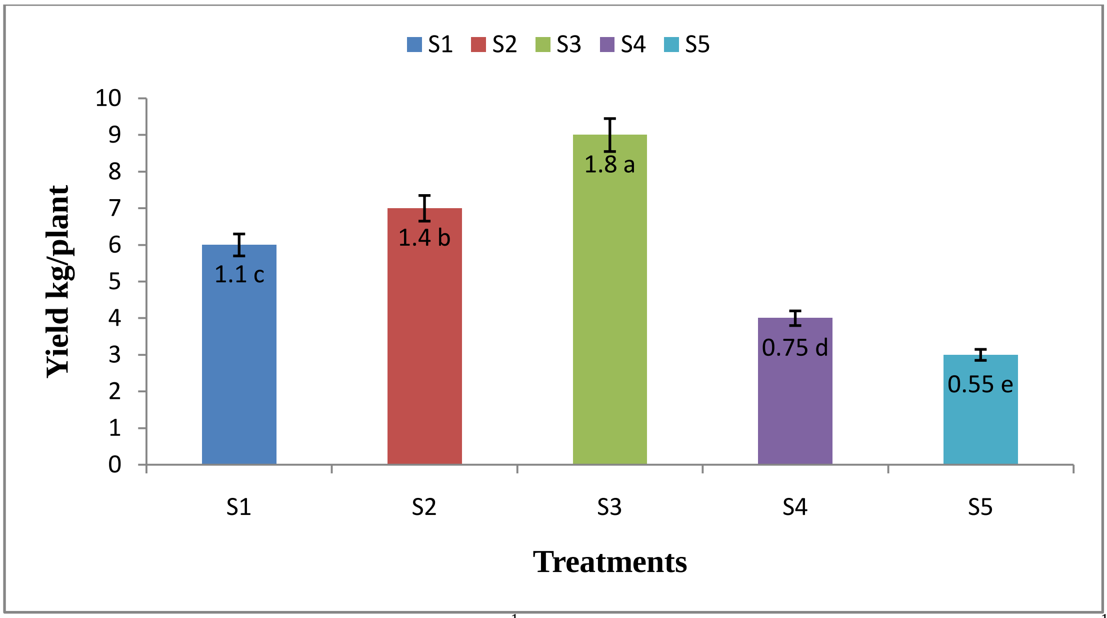
Plant dry weights of capsicum were varied significantly by three treatments (Table 2). The highest dry weights of leaf stem and root was found in $S_3$ treatment. Meanwhile, dry weights of plants drastically decreased at $S_5$. This might be due to proper supply of nutrient solution to the plants. $S_2$ treatment containing higher $Ca^{2+}$ which contributed to higher dry weights. On the contrary, $S_5$ treatment contain highest amount of $Ca^{2+}$ compared to other treatments, but it have salinity stress resulting lower dry weight. Epstein and Bloom (2005) reported that $Ca^{2+}$ increased the root dry weight and calcium content in plant tissues. The present findings consisted with the other findings.

**Table 2. Effect of salt industries byproduct on plant dry weight**

| Treatments | Plant dry weight (g/plant) | | |
|---|---|---|---|
| | Leaf | Stem | Root |
| $S_1$ | 7.98 c | 10.1 c | 5.2 c |
| $S_2$ | 9.2 b | 12.3 b | 6.1 b |
| $S_3$ | 10.5 a | 15.2 a | 8.5 a |
| $S_4$ | 6.2 d | 8.5 d | 4.2 d |
| $S_5$ | 5.3 e | 6.9 e | 3.4 e |
| CV % | 5.8 | 7.1 | 6.4 |
| LSD (0.05) | 0.7 | 1.1 | 0.73 |

[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 $mlL^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 ml. $L^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 $mlL^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 $mlL^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 ml $L^{-1}$ SIB]

**4.13.** ***Yield:*** Marketable yield was affected by SIB concentrations (Figure 12). The highest yield(2.3 kg/plant) was found in $S_2$ ( ¾ Rahman and Inden (2012) + 0.5ml SIB) treatment while, lowest yield (0.90 kg/plant) was found in $S_5$(¾ Rahman and Inden (2012) + 1.0ml of SIB) treatment. This might be due to higher number of fruit by application of $S_3$. Furthermore, SIB contains Si that might have a positive effect on fruit yield in sweet pepper. Stamatakis *et al.* (2003) found a positive effect of Si addition to the nutrient solution under saline condition in tomato fruit yield. Alexander and Clough (1998) also observed that marketable yield of pepper increased due to increased $Ca^{2+}$, mainly because of decrease in BER-affected fruits.




[$S_1$ = ¾ strength Rahman and Inden (2012) + 0 ml $L^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 $mlL^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 $mlL^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 $mlL^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 $mlL^{-1}$ SIB]

**Figure 7. Effect of salt industries byproduct on yield (kg/ plant)**

# CHAPTER V

# SUMMARY AND CONCLUSIONS

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh to determine the effect of salt industries byproduct (SIB) on growth and yield of capsicum. Five levels of salt industries byproduct (SIB) concentrations were used in this experiment. Five concentrations of SIB are considered as treatments, *viz*. $S_1$ = ¾ strength Rahman and Inden (2012) + 0 mlL$^{-1}$ SIB, $S_2$ = ¾ strength Rahman and Inden (2012) + 0.25 mlL$^{-1}$ SIB, $S_3$ = ¾ strength Rahman and Inden (2012) + 0.5 ml L$^{-1}$ SIB, $S_4$ = ¾ strength Rahman and Inden (2012) + 0.75 mlL$^{-1}$ SIB and $S_5$ = ¾ strength Rahman and Inden (2012) + 1.0 mlL$^{-1}$ SIB. The experiment will be conducted as randomized completely block design with three replications. Salt industries by product showed significant variation in most of the parameters.

The highest plant height (53 cm, 75 cm, 84 cm, 95 cm, 102 and 112 cm) was observed from $S_3$, at 30, 60, 90, 120, 150 and 180 DAT. The maximum number of fruit per plant (9) was observed from $S_3$ whereas minimum (3) was recorded $S_5$, higher individual fruit weight (210g) was recorded from $S_3$ and lower (182 g) was from $S_5$, higher fruit length length (8.90 cm) was found in $S_3$ and lower (4.90 cm) was in $S_5$, the maximum fruit diameter (7.6 cm) was observed from $S_3$ whereas minimum (4.5 cm) was recorded $S_5$, higher fruit volume (228 cc) was recorded from $S_3$ and lower (185) was from $S_5$,the maximum fresh weight (170 g/plant) was recorded from $S_3$ and minimum (110 g/plant) was in $S_5$, the maximum dry weight [(leaf, stem and root(10.5, 15.2 and

8.5 g/plant respectively)] was recorded from $S_3$ and minimum [(leaf, stem and root (5.3, 6.9 and 3.4 g/plant respectively)] (16.8 g/plant) was in $S_5$. Maximum yield (1.8 kg/plant) was observed from $S_3$ whereas minimum (0.55 kg/plant) was recorded $S_5$. Considering the findings of the experiment, it may be concluded that: $S_3$ (¾ Rahman and Inden (2012) + 0.5 ml of SIB) was very effective for growth and development of capsicum and cost of production can be minimize

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## APPENDICES

**Appendix I**. Analysis of variances of the data on plant height (cm) at different days after transplanting (DAT) of capsicum

| Degrees of Freedom (df) | Mean Square for plant height (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAT | 60 DAT | 90 DAT | 120 DAT | 150 DAT | 180 DAT |
| 4 | 193.00** | 819.00** | 1161.0** | 446.33** | 513.00** | 608 |
| 6 | 14.67 | 10.33 | 16.33 | 1.66 | 3.5 | 5.1 |

**: Significant at 0.01 level of probability*: Significant at 0.05 level of probability

**Appendix II**. Analysis of variances of the data on number of fruit/plant, individual fruit weight(g), fruit length (cm), fruit diameter (cm) and fruit volume (cc) of capsicum plant

| Source of variation | Degrees of Freedom (df) | Mean square for different attributes of capsicum | | | | |
|---|---|---|---|---|---|---|
| | | number of fruit/plant | individual fruit weight(g) | fruit length (cm | fruit diameter (cm) | fruit volume (cc) |
| Treatment | 4 | 0.030* | 0.494** | 1.146** | 2.131** | 2.567** |
| Error | 6 | 0.016 | 0.023 | 0.026 | 0.043 | 0.048 |

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

**Appendix III**. Analysis of variances of the data on dry weight (g) of capsicum

| Source of variation | Degrees of Freedom (df) | Mean square for dry weight (g) | | |
|---|---|---|---|---|
| | | Leaf dry weight(g) | Stem dry weight | Root dry weight(g) |
| Treatment | 4 | 13.56** | 41.43** | 17.28** |
| Error | 6 | 0.23 | 0.53 | 0.21 |

*: Significant at 0.05 level of probability; **: Significant at 0.01 level of probability

**Appendix IV.** Analysis of variances of the data on plant fresh weight (g), ascorbic acid content and yield (kg/plant) of capsicum Analysis of variances of the data on leaf area ($cm^2$) at different days after transplanting (DAT) of Capsicum

| Source of variation | Degrees of Freedom (df) | Mean square for different attributes of capsicum | |
|---|---|---|---|
| | | plant fresh weight (g) | yield (kg/plant) |
| Treatment | 2 | 282.52** | 0.48** |
| Error | 6 | 39.36 | 0.02 |

*: Significant at 0.05 level of probability, **: Significant at 0.01 level of probability