# PERFORMANCE OF TRIACONTANOL IN CULTIVATION OF TOMATO UNDER SALINE CONDITION

**BY**

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# PERFORMANCE OF TRIACONTANOL IN CULTIVATION OF TOMATO UNDER SALINE CONDITION

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## *CERTIFICATE*

This is to certify that the thesis entitled**, "Performance of triacontanol in cultivation of tomato under saline condition"** submitted to the Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in SOIL SCIENCE** embodies the result of a piece of bona fide research work carried out **FAHIMA AKTAR,** by Registration No**. 18-09307** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma elsewhere in the country or abroad.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

Dated: 20 March, 2022
Place: SAU, Dhaka, Bangladesh

…….....
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Dedicated
To
My Beloved Parents

# LIST OF ABBREVIATIONS

| Abbreviation/ Symbol | Full Words |
|---|---|
| AEZ | Agro-Ecological Zone |
| $Al_2(SO4)_3$ | Aluminum sulphate |
| BARC | Bangladesh Agricultural Research Council |
| ANOVA | Analysis of Variance |
| BARI | Bangladesh Agricultural Research Institute |
| BBS | Bangladesh Bureau of Statistics |
| $Ca^{2+}$ | Calcium |
| $CaSO_4$ | Calcium sulphate |
| $CaCl_2$ | Calcium chloride |
| $Cl^-$ | Chloride |
| CV | Coefficient of Variation |
| DAT | Days After Transplanting |
| $^oC$ | Degree Centigrade |
| dS $m^{-1}$ | Deci siemens per meter |
| EC | Electrical conductivity |
| et al. | And others |
| $Fe^{2+}$ | Iron |
| $Fe_2(SO_4)_3$ | Ferric sulphate |
| FAO | Food and Agriculture Organization |
| $GA_3$ | Gibberellic acid |
| GLC | Gas Liquid Chromatography |
| $H_2SO_4$ | Sulphuric acid |
| IR | Infrared Radiation |
| $K^+$ | Potassium |
| kg $ha^{-1}$ | kilogram per hectare |
| $K_2Cr_2O_7$ | Potassium dichromate |
| LSD | Least Significant Difference |

| | |
|---|---|
| mg $L^{-1}$ | Miligram per litre |
| mM | Mili-molar |
| $Mg^{2+}$ | Magnesium |
| mL | mili-litre |
| NAA | Napthaleneacetic acid |
| Na+ | Sodium |
| $NaHCO_3$ | Sodium bicarbonate |
| NADH | Nicotinade Adenine Dinucliotid Oxidage |
| P | Phosphorus |
| % | Percentage |
| PGPB | Plant growth-promoting bacteria |
| pH | Negative logarithm of hydrogen ion concentration |
| ppm | Parts per million |
| ROS | Reactive Oxygen Species |
| RuBP | Ribulase 1, 5-biphosphate |
| S | Sulphur |
| SM | Solid Matrix |
| SRDI | Soil Resource Development Institute |
| TLC | Thin Layer chromatography |
| TRIA | Triacontanol |
| USDA | United State Department of Agriculture |

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*The author*

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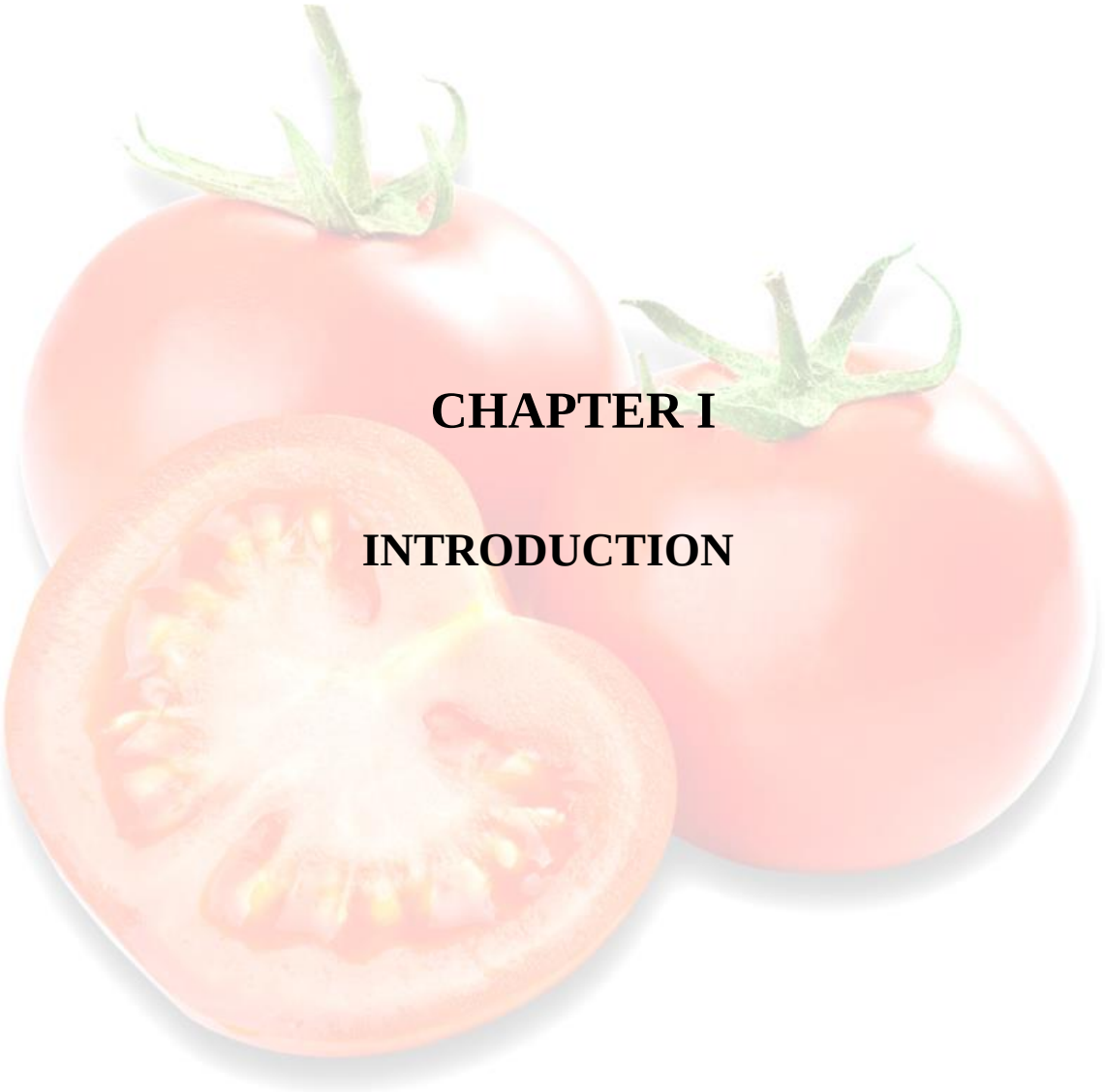
# ABSTRACT

Soil salinity in Bangladesh is a major constraint for crop production. The pot experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University (SAU), Dhaka during November 2019 to March 2020. BARI Tomato-18 was used as a test crop. The two factors experiment was laid out in CRD with three replications. The experiment consisted of two factors: Factor A: NaCl salt concentration (three levels) as S0: Control, S1: 100 mM and S2: 200 mM. Factor B: Triacontanol (four levels) as T0: Control i.e., no triacontanol, T1: 0.5 mg/L triacontanol, T2:1.0 mg/L triacontanol and T3: 2.0 mg/L triacontanol, respectively. The results of this experiment showed that the salt stress reduced the morphological parameters and yield of tomato. The minimum germination percentage (76.7) and shortest seedling (2.07 cm) was found in control treatment and the maximum germination percentage (98.3) and the tallest seedling (3.53 cm) was observed with priming with 2 mg/L of triacontanol .The lowest value of plant height (36.7 cm), leaf length (12.0 cm), leaves per plant (7.67), flowers per cluster (2.33), number of fruits per cluster (1.33), yield per pot (0.16 kg), length of fruit (43 mm) and fruit diameter (17.33 mm), lowest OM (1.30%), lowest phosphorus (14.8 mg/kg) ,lowest sulphur (16.2 mg/kg), were recorded with S2 and the highest values were notice in control. Triacontanol significantly increased the germination percentage, growth contributing characters as well as fruit yield of tomato at all NaCl concentrations. For combined effect, the tallest plant (88.7 cm), highest leaf length (31.4 cm), maximum number of leaves (19.33), highest number of flowers per cluster (10.0), highest number of fruits per cluster (6), highest yield per pot (0.29 kg), highest fruit length (63.3 mm) and highest fruit diameter (38.0 mm), highest organic matter (1.43%), highest available phosphorus (26.8 mg/kg), highest available sulphur (25.1 mg/kg) were produced from S0T3 and the lowest from S2T0. Except electrical conductivity (EC), no other soil parameters (pH, Organic matter, P and S) were significantly influenced by the treatments (NaCl and triacontanol). This result suggests that, triacontanol can help to reduce the deleterious effect of salt stress in tomato.



# CHAPTER I

# INTRODUCTION

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# INTRODUCTION

Among abiotic stresses salinity is a very serious threat to agricultural productivity (Babu *et al.,* 2012). It is reported that 900 million-hectare areas are affected by salinity in the world (Munns and Tester, 2008). Climate change is responsible to increase soil salinity which adversely affects soil fertility and crop productivity. Low precipitation, high surface evaporation, weathering of parental rocks, and human activities such as irrigation with saline or low-quality water (Goudarzi and Pakniyat, 2008) are responsible for increasing soil salinity. The high accumulation of salt in the root zone increases the osmotic pressure in the soil solution that hamper the crop to uptake water causing physiological drought. As a result, crop growth is decreased due to ion toxicity or nutrient imbalance (Babu *et a*l., 2012), oxidative stress (high ROS production) (Abbaspour, 2012), membrane damage (Farkhondeh *et al.,* 2012), disturbed leaf water relations (Carpici *et al.,* 2010), and hormonal imbalance (Babu *et al*., 2012).

In Bangladesh, 2.86 million hectares are coastal area, which cover over 30% of the total crop lands of the country. Among these coastal areas, about 1.056 million ha are affected by varying degrees of soil salinity (SRDI, 2010). The desiccation of the soil that enhances the intensity of salinity of this area. Degree of salinity affects the crops at the critical stages of growth, ultimately yield is reduced. Out of salinity affected cultivable area, very slight (2.0-4.0 dS $m^{-1}$), slight (4.1-8.0 dS $m^{-1}$) and moderate salinity (8.1-12.0 dS $m^{-1}$) affected areas are about 328 (31%), 274 (26%) and 190 (18%) thousand hectares of land (SRDI, 2010).

Rapid seed emergence is important to enhance the quality and quantity in annual crops. The slow germination ability of seeds causes seed borne diseases. Germination is the main step of the plant life cycle, seedling establishment are the expansion of a species in a new environment (Bewley, 1997). Fast and tantamount germination is important for increasing tomato crop quality and

quantity (Zhang *et al*., 2012). Morphological, physiological and biochemical processes are involved in germination that occur in the seed starting with the imbibition phase and culminating with radical emergence from the seed coat (Bewley *et al*., 2013).

Tomato (*Lycopersicon esculentum*) is one of the most important, popular and nutritious vegetable in the world. Tomato contains 94 g water, 0.5 g minerals, 0.8 g fibre, 0.9 g protein, 0.2 g fat and 3.6 g carbohydrate and other elements like 48 mg calcium, 0.4 mg iron, 356 mg carotene, 0.12 mg vitamin B-1, 0.06 mg vitamin B-2 and 27 mg vitamin C in each 100 g edible ripen tomato (BARI, 2010). Tomatoes contain the antioxidant lycopene (the most common form of carotenoid) which markedly reduces the chance of prostate cancer. (Kucuk, 2001). The average yield of tomato in Bangladesh is 13.45 million tons /ha (BBS, 2016).

Priming is a technique which partly hydrates the seed and then re-drying in order to boost up germination process before radical emergence (Dezfuli *et al*., 2008). Seed priming is a procedure in which seeds are soaked in an aerated solution of water; osmotic or nutrients activity starts but radical emergence does not take place. Protein synthesis, amendment of nucleic acid and membranes in the seed germination process that are increased by priming (Fujikura and Karssen, 1995). This process improves germination percentage, germination rate, emergence, and seedlings vigor and plant performance of many crops such as maize, wheat, rice, sunflower and soybean (Salehzade *et al*., 2009).

Under the saline condition, there is a record that priming increase the action of antioxidant compounds and ROS scavenging enzymes (Bailly *et al*.,1998), hence seed priming enhances crop performances. Different seed priming techniques including osmopriming, hydropriming, halopriming, thermopriming and hormone priming are used to improved salinity tolerance in tomato (Tzortzakis, 2009).

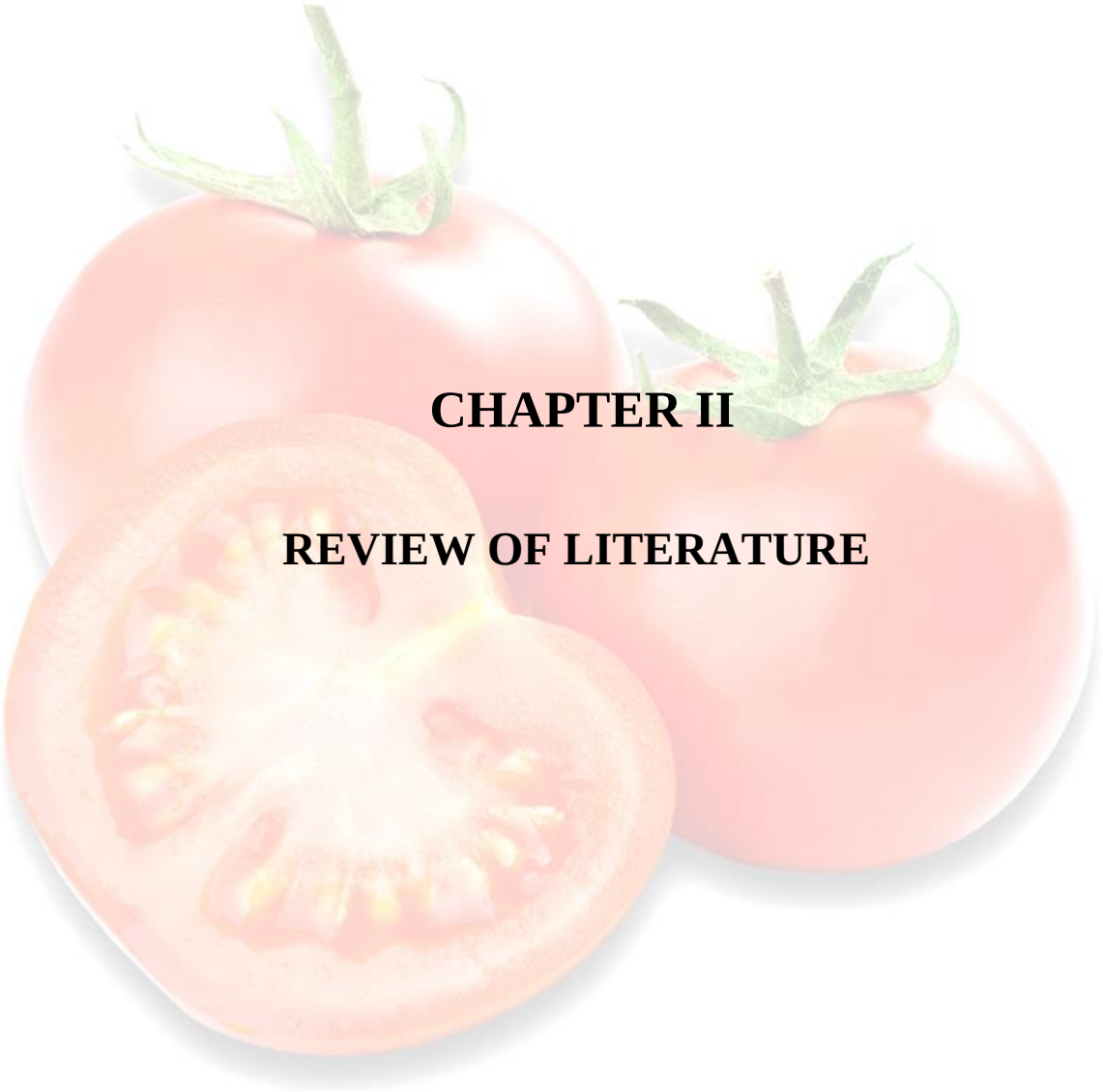
For preventing problematic seed germination, seed priming with natural and/or synthetic compounds is a physiological seed increment method (Gupta *et al.*, 2015). Under abiotic conditions, seed priming assures rapid and uniform germination (Varier *et al.*, 2010). Seed priming could be the simplest and cost-effective way in alleviating salinity problems in field crops (Afzal *et al.*, 2008).

Phytohormones have been testified playing a regulatory role in growth, development, reproduction, and survival under biotic and abiotic stress conditions (Sharma *et al.*, 2005). Hormone priming is one of the seed treatment techniques that enhance abiotic stress tolerance through major physiological and biochemical changes inside the seed (Hela et al. 2012). It is a simple, low-cost, and environmentally friendly technique (Shahbaz *et al.*, 2012). Therefore, seed priming could be an effective strategy to improve seed germination and seedling establishment in several horticultural and agronomic crops under saline and non- saline environments (Afzal *et al.*, 2015).

Triacontanol (TRIA) is one kind of plant hormone (Ries *et al.*, 1977) that stimulates plant growth at very low concentration when exogenously applied to various plant species such as chickpea (Singh *et al.*, 1991), groundnut (Verma *et al.*, 2009), and pigeon pea (Pujari *et al.*, 1998). TRIA has been reported to increase water and mineral nutrient uptake (Chen *et al.*, 2003), enhance photosynthesis (Chen *et al.*, 2003), regulate activities of various enzymes (Naeem *et al.*, 2011), and increase the level of various organic compounds (Chen *et al.*, 2003). TRIA application not only increase yield, but also quality characteristics of crops as observed in wheat, tomato, and cotton (Naeem *et al.*, 2009). TRIA generally can stimulate the enzymes which regulate growth (Chen *et al.*, 2002) and metabolic processes in plants (Morre *et al.*, 1991). Under saline conditions, TRIA has been reported to increase the photosynthetic pigments, growth, biomass, and uptake of $Ca^{2+}$ and $K^{+}$ essential mineral contents instead of sodium (Muthuchelian *et al.*, 1996).

Considering the above stated prospective, it is hypothesized that pre-sowing seed treatment with TRIA could mitigate the malicious effects of salinity stress on tomato. Thus, the present study was undertaken with the following objectives:

i. To observe the effect of seed treatment with TRIA on germination, growth and yield of tomato in salt treated soil.
ii. To find out the suitable concentration of triacontanol for a maximum germination and yield of tomato in salt stress condition.



# CHAPTER II

# REVIEW OF LITERATURE

# CHAPTER II
# REVIEW OF LITERATURE

## 2.1. Soil Salinity

James and Jurinak, (1982) defined a saline soil can be a soil which consists of an adequate amount of dissoluble salts which can hamper the growth of crops.

Pessarakli (1994) reported that saline soils can be classified into five types. Firstly, saline soil that occurs due to the effect of electrolytes of sodium salts. This soil can be formed in desert and semi-desert regions. Secondly, alkaline soil which is produced due to the effect of electrolytes of alkaline hydrolysis. This kind of soil is found in all climatic regions. Thirdly, soil which is salt-affected by $CaSO_4$ or $CaCl_2$. It can be formed in arid and semi-arid regions (North America, North Africa, the Middle and Far East, and Australia). Fourthly, saline soil which is induced by magnesium which occurs in desert and semi-desert regions. It can also be formed in semi-humid regions. Finally, acid sulphate soil which is formed as a result of $Al_2(SO_4)_3$ and $Fe_2(SO_4)_3$ accumulation. This soil can occur throughout the world in regions close to seacoast and in tidal marsh areas.

Salama and Hassan, 2011 reported that the mechanisms of growth inhibition as affected by salinity include the osmotic or water deficit effect and specific ion excess effect. The osmotic effect is the decreasing of osmotic potential due to the high accumulation of ions in the solution of growth medium, which reduces the ability of plant to take up water and leads to decreased growth. The ion specific effect is described as the increase of toxic ions (e.g. $Na^+$, $Cl^-$) in the plant tissue with a decrease in beneficial ions (e.g. $K^+$, $Ca^{2+}$), thus decreasing plant growth.

Dhanapackiam and Ilyas (2010) reported that during germination early seedling establishment, plant is more sensitive to salinity.

Sayar *et al*. (2010a, 2010b) and Abari *et al*., (2011) reported that salt affected soils contain enough soluble salts to restrict the growth of, and cause damage to plants through a series of interacting factors such as osmotic potential and ion toxicity.

Munns and Tester (2008) reported that distinguishing between these two types of stress is important to understand the physiological mechanisms for the salinity tolerance of plants.

Munns and Tester (2008) reported that Soil salinity affects plant in two ways: a high percentage of salts in the soil, which makes it harder for roots to extract water (osmotic stress), and high concentrations of toxic salts within the plant (ion toxicity). Salts on the outside of roots have an adverse effect on cell growth and metabolism; however, toxic salts take time to accumulate inside plants before they influence plant functions.

### 2.1.1. Distribution of salt-affected soils

Haidarizadeh and Zarei (2009) estimated that 25% of the whole of the cultivated world's land is affected by salinity and 33% of it is irrigated land.

Moud and Maghsoudi (2008), and Sattar and Javaid (2010) estimated that 19% of the 2.8 billion ha of agricultural land are affected by salinity in the world.

Unlukara *et al.* (2010) reported that about 40,000 ha of agricultural area become unavailable for agricultural production every year because of the increase soil salinity.

Saboora *et al*. (2006) mentioned the salt affected soils are estimated at 3.5 million ha and that most of it is associated with cotton, rice, wheat, and sugarcane and rapeseed cultivation.

### 2.2.1. Effects of salinity on tomato

Leo (1964) reported that high salinity decreased elongation rates of roots and found that compared with the control nutrient solution, tomato root subjected to 1% NaCl solution reduced at 26% of the elongation rate.

Albacete *et al*. (2008) had presented data that tomato (*lycopersicum esculentum* L.) root fresh weight reduced (30%) after three weeks under saline conditions (100 mM NaCl).

Schwarz and Grosch (2003) also reported that fresh and dry mass of tomato root, total root length, number of adventitious roots, tap root, and lateral root decreased with increasing EC of nutrient solution (EC range: 1.5-10 dS $m^{-1}$). The reduction of root growth under salinity stress is caused by root cell growth restriction, root-zone water stress and root disease increase.

Cuartero and Fernandez (1999) reported that tomato grown under salinity condition causes root cell growth restriction, because of low water potential of external medium, interference of the ions or the toxicity of accumulated ions.

Oztekin and Tuzel (2011) reported that average tomato (21 commercially available cultivars) plant height showed 29.03% reduction under 200 mM NaCl treatment when compared with no salinity treatment.

Zhu (2002) had inferred that reduction in shoot growth under saline conditions is possible due to three reasons: (1) salinity reduced photosynthesis, which in turn limits the supply of carbohydrate needed for growth; (2) salinity reduced shoot and roots growth by reducing turgor in expanding tissues resulting from lowered water potential in root growth medium; and (3) salinity disturbs mineral supply, either an excess or deficiency; induced changes in concentrations of specific ions in the growth medium, may have a direct influence on growth.

Azarmi *et al*. (2010) showed that total leaf area of tomato (*Lycopersicon esculentum* Mill.) decreased with increasing salinity (EC range:2.5-6 dS $m^{-1}$).

Kamrani *et al*. (2013) also reported that leaf area at salinities of 40 and 60 mM was decreased in tomato plants. The reasons for inhibition of tomato leaf expansion by salinity stress are due to inhibition of cell division, disturbance of water balance and closure of leaf stomata.

Recently, Shimul *et al*. (2014) also reported that total tomato (var. BARI Tomato 14) leaf chlorophyll content, stomatal resistance and photosynthetic activities are significantly reduced with increasing salinity.

Qaryouti *et al*. (2007) had reported that the total yield of tomato (*Lycopersicon esculentum* M. cv. Durinta F1) is significantly reduced at salinity equal and above 5 dS $m^{-1}$, and a 7.2% yield reduction per unit increase in salinity.

In addition, Magan *et al*. (2008) also reported that tomato (*Lycopersicon esculentum* Mill) total and marketable fresh fruit yield decreased significantly with increasing salinity.

Dalton *et al*. (1997) observed that yield is reduced uniformly with decreasing osmotic potential of the nutrient solution.

Observations of Bustomi *et al*. (2014) indicate that tomato (*Solanum lycopersicum*) yield increased as EC of nutrient solution increased from 0 to 3 dS $m^{-1}$ due to increase of nutrients, while decreased as EC of nutrient solution increased from 3 to 5 dS $m^{-1}$ due to increase of salinity stress.

Adams (1991) as well as Cuartero and Fernandez (1999) also reported that yield reduction in tomato under salinity stress is caused by decrease in mean fruit weight.

Qaryouti *et al*. (2007) also reported that tomato fruit quality parameters (Fruit dry matter %, total soluble solids, and titratable acidity) increased by

increasing salinity up to 5 dS $m^{-1}$ as compared to the control, while fruit firmness decreased with increasing salinity.

Zhang *et al*. (2016) also confirmed that tomato total fruit sugar and total acid content increased with increased salinity; in addition, increased nutrient solution salinity from 0.78 dS $m^{-1}$ to 1.58 dS $m^{-1}$ led to an increase of sugar and acid content to 14.3% and 28%, respectively.

### 2.3. Triacontanol

Chibnall *et al*. (1933) discovered Triacontanol in 1933 which was found in alfalfa (*Medicago sativa*). It is aliphatic alcohol found in bees wax and rice bran wax. Kolattukudy and Walton, 1972 found that Triacontanol in cuticular waxes. It occurs widely in nature as waxy coating on many plants.

#### 2.3.1 Role of TRIA under saline condition

Muthuchelian *et al*. (2003) reported a TRIA mediated increase in root and shoot, leaf density and area, and fresh and dry biomass accumulation of acidic-mist-treated *Erythrina variegata* plants. Their studies suggested that lipophilic TRIA might act on cell membranes to produce adenosine.

Ries and Wert (1992) found that this substance is rapidly translocated throughout the plant causing a cascade of metabolic events and, thus, resulting in significant increases in growth and dry matter of plant.

Muthuchelian *et al.* (2003) reported that application of TRIA increased $14CO_2$ fixation, enzyme activities, synthesis of chl a, chl b, carotenoids, starch, and sugars in *E. variegata* seedlings under flooded and acid mist conditions as well as under salt stressed conditions.

Muthuchelian *et al*. (1996) and Perveen *et al*. (2010) found that the reduction in the contents of chlorophyll and carotenoids as well as that in chlorophyll fluorescence was also improved by TRIA in salt-stressed in *E. variegata* seedlings and *Triticum aestivum* plants.

By means of TRIA application, Krishnan and Kumari (2008) reported a successful amelioration of salt stress in soybean plants in terms of leaf weight ratio, relative water content, chlorophyll pigments, nucleic acids, soluble sugars, and soluble proteins.

Sarwar et al. (2017) tested the efficacy of TRIA at different doses in the alleviation of salt stress in cucumber through seed priming for 12 hours. They found that salt stress altered growth, physiology, and biochemical attributes, restored with 25 and 50 μM Tria priming. However, 50 μM Tria was more effective in improving all attributes under salt stress.

Muthuchelian et al. (1996) grew *E. variegata*, plant seedlings were exposed to Tria (1 mg $kg^{-1}$), the salt-induced changes were found to be ameliorated, which was reflected through increased growth, biomass, and the contents of chlorophyll and carotenoid- I

A recent study, Khanam and Mohammad (2018) studied that triacontanol improved the single photoelectric analysing diode (SPAD) value, net photosynthetic rate, and yield and quality traits in *Mentha piperita* during salt stress conditions.

In salt-challenged maize plants, Perveen *et al*. (2017) studied the effects of exogenous Tria in salt stress amelioration. Salt stress altered the growth attributes in maize, increased free proline and sodium ($Na^+$) ions, relative membrane permeability (RMP), MDA and protein contents, and the activities of POD and CAT enzymes. Spraying of Tria restored the abovementioned parameters and alleviated the saltinduced changes by mediating an augmentation in proline, phenolics, activity of nitrate reductase, and potassium content in shoot.

Perveen *et al*. (2012b) conducted an experiment to study the salt induced variation in nutrient composition, uptake, and use efficiency in wheat plants. Salt stress significantly enhanced the endogenous contents of $Na^+$ and $Cl^-$ ions in

shoot and root, simultaneously decreasing the $K^+$ and $K^+/Na^+$ ratios in both shoot and root cells.

Salt stress also imposes restriction on use efficiency of nutrients in shoot and root ($Na^+$, $K^+$, $Ca^{2+}$, and $Cl^-$). Seed pretreatment with Tria at 10 μM level significantly restored the root nutrient uptake and use efficiency.

Shahbaz *et al*. (2013) conducted an experiment in canola plants, Salt stress imposed reductions in growth, $K^+$ contents, leaf gas exchange traits, and photochemical quenching (qP), while increased leaf GB, proline, and contents of $Na^+$ ions. Plants raised from priming with Tria exhibited an increase in fresh weight of shoots, photosynthetic rate, number of seeds per plant, transpiration rate, ratio of chlorophylls a/b, electron transport rate, qP, $K^+$ contents in root and shoot, GB, and proline under saline conditions.

In *C. sativum*, Karam and Keramat (2017) evaluated the effect of exogenous TRIA under salt stress. Salt stress-induced oxidative damage was nullified by foliar spray of Tria through modulating activities of antioxidant enzymes.

Thus, the available literature clearly helped us to conclude that TRIA is an important PGR, which regulates diverse plant metabolic processes to counter the damages of salt stress.

### 2.4 Seed priming

Umair *et al*. (2012) reported that priming is generally defined as a pre-germination seed treatment method in which the water potential of the seed is decreased to permit imbibition and some chemical alteration to occur but prevents the emergence of the radicle.

Zhao, Zhong, and Zhong (2009) defined priming "as a technique controlling hydration and drying those results in more rapid germination when the seeds are reimbibed".

Tavili *et al*., 2011 reported that seed priming has been effectively confirmed to enhance germination percentage and rate, and emergence percentage and rate mainly in vegetable seeds and small seeded grasses.

Jisha *et al*. (2013) found that Seed priming has been used to improve germination rate and uniformity.

Hussain *et al*. (2015) reported that primed seeds usually have more and uniform germination due to decreased lag time of imbibition, activation of enzyme, enhanced germination metabolism, improved repair processes, and osmotic adjustment.

### 2.4.1 Hormonal priming

Ashraf *et al*., (2001). reported that hormonal priming seeds are treated with different plant growth hormones like $GA_3$, kinetin, NAA and ascorbate etc. This is basically a presoaking treatment which promotes the growth and development of the seedlings.

Perveen *et al*. (2011). reported that reed treatment with TRIA has been reported to increase the activity of a key antioxidant enzyme peroxidase that plays a role in reducing the level of $H_2O_2$ (a reactive oxygen species).

Afzal *et al*., (2011) reported that seed treatment is conducted in low water potential solution and incorporation of plant growth hormones for priming significantly improved the seed performance of several crops.

Iqbal and Ashraf (2013) found that plant hormones play a key role in plant physiology and development by generating and transmitting different kinds of signals between and within the cells; the endogenous levels of phytohormones undergo significant changes under abiotic stresses.

Miransari and Smith (2014) reported that seed priming with phytohormones can increase seed germination by activating some enzymes such as amylase and

protease, which hydrolyzed molecules of starch and protein into simple available form for embryo uptake.

### 2.4.2 Seed priming under saline condition

Afzal *et al*., (2012) reported that seed priming is one of the simplest and low-cost strategies to induce salinity tolerance in crops

Ashraf *et al*., (2007) found that seed germination significantly contributes to the establishment of vigorous crop stand.

Afzal *et al*., (2015) reported that seed priming is very effective strategy to improve seed germination and seedling establishment in several horticultural and agronomic crops under saline and nonsaline environments.

Afzal *et al*., (2016). reported that seed priming in aerated solutions trigger metabolic activities which are essential for germination and improves uniformity, germination rate, final germination and stand establishment.

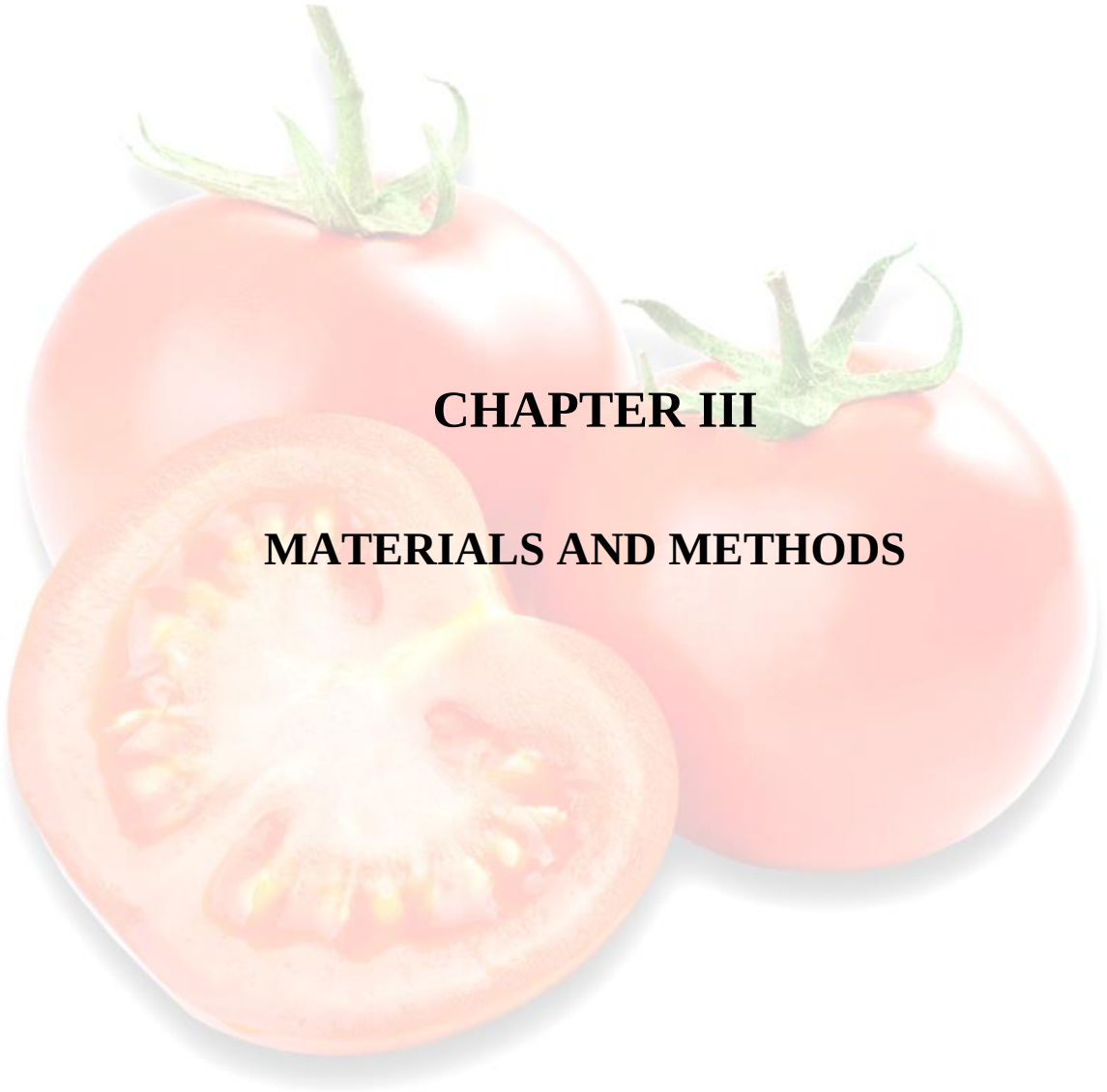
Moosavi *et al*. (2009) reported that pre sowing seed treatments improve the performance of seeds under adverse conditions and environmental stresses such as salinity.

Tavili *et al*. (2011) has been reported that seed priming has recently been applied to overcome the salt stress problem on agricultural land.

Hussain *et al*. (2016b) reported that seed priming is one of the useful physiological approaches that can be used to tolerate adverse abiotic stresses such as drought, salinity, and chilling in various plant species.

Chen and Arora (2011) reported that abiotic stress tolerance assimilated by seed priming is likely reached via two strategies. In the first strategy, seed priming stimulates the pre-germination metabolic processes such as enhancement in the energy metabolism, early mobilization of seed food reserves, elongation of embryo cell, and endosperm weakening, which provide the conversion of quiescent seeds into germinating state and lead to increased germination. In the

second strategy, seed priming imposes biotic stresses on seeds, which represses the protrusion of the radicle but supports stress responses, inducing cross-tolerance to abiotic stresses, activation of enzymes, and osmotic adjustment.



# CHAPTER III

# MATERIALS AND METHODS

# CHAPTER III
# MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, (SAU), Dhaka, under the agro-ecological zone of Modhupur Tract, (AEZ 28) during rabi season of 2019. For better understanding, the site is shown in the Map of AEZ of Bangladesh (Fig. 3.1). This chapter presents a brief description of the soil, crop, experimental design, treatments, cultural operations, collection of soil and plant samples and analytical methods followed in the experiment. This chapter has been divided into a number of sub-heads as described below:

## 3.1 Description of experimental site

### 3.1.1 Soil

The experiment was carried out at Sher-e- Bangla Agricultural University (SAU) farm, Dhaka, during Rabi season of 2019. The farm belongs to the General Soil Types; Deep Red Brown Terrace Soils under Tejgaon Series. The land was above flood level and there was sufficient sunshine during the experimental period. Morphological, physical and chemical characteristics of initial soil are presented in Tables 3.1 and 3.2.

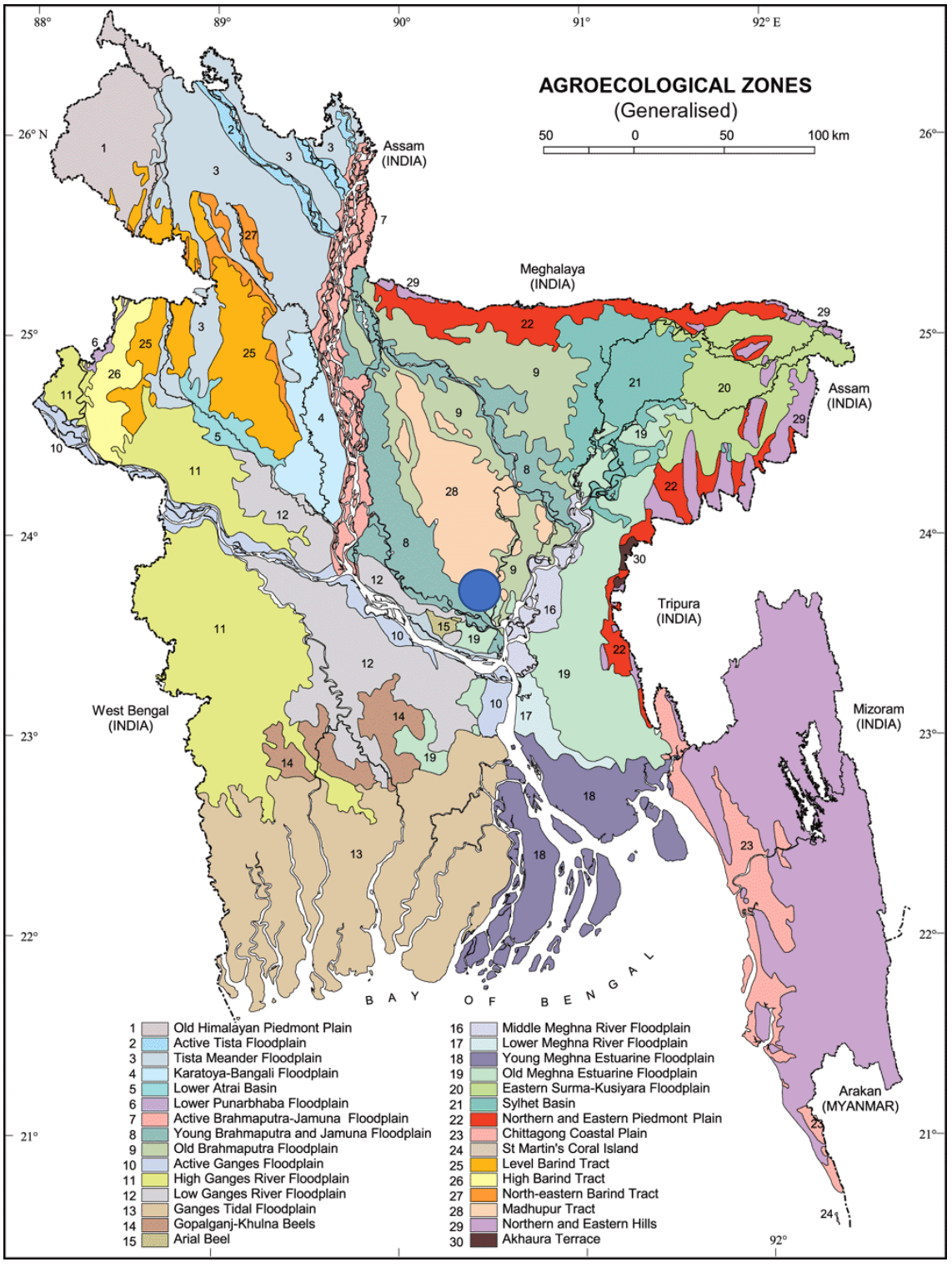



Fig. 3.1. Map showing the experimental site under study

**Table 3.1 Morphological characteristics of experimental field**

| Morphological characteristics | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University (SAU) farm, Dhaka |
| AEZ No. and name | AEZ-28, Modhupur Tract |
| General soil type | Deep Red Brown Terrace Soil |
| Soil Series | Tejgaon |
| Topography | Fairly level |
| Depth of Inundation | Above flood level |
| Drainage condition | Well drained |
| Land type | High land |

**Table 3.2. Physical and chemical characteristics of experimental soil**

| Soil characteristics | Value |
|---|---|
| **A. Physical properties** | |
| Particle size analysis of soil. | |
| % Sand | 18.3 |
| % Silt | 45.5 |
| % Clay | 36.2 |
| Soil texture | Silty Clay loam |
| **B. Chemical properties** | |
| Soil pH | 5.8 |
| Organic carbon (%) | 0.76 |
| Organic matter (%) | 1.31 |
| Electrical conductivity(dS/m) | 3.43 |
| Available P (mg/kg) | 20.0 |
| Available S (mg/kg) | 26.0 |

### 3.1.2 Climate

The experimental area has sub-tropical climate characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The experiment was done during the rabi season. The average temperature and rainfall data during the cropping period are shown in Appendix I.

### 3.1.3 Seeds and variety

BARI Tomato-18, a high yielding variety of tomato (*Lycopersicon esculentum* Mill.) developed by Bangladesh Agricultural Research Institute (BARI), Gazipur, was used as a test crop. Seeds were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur.

### 3.1.4 Raising of seedlings

**Preparation of TRIA solution**

For 0.5,1 and 2 mg/L TRIA solution-

- 0.554, 1.1 and 2.2 mg TRIA 90% was weighted into a micro able safe glass container.
- 0.066, 0.132 and 0.264ml coconut oil instead of polysorbate 20 was added.
- 0.1985, 0.397 and 0.794 ml distilled water was added.
- Microwaves for 30 second and stirred.
- The process was repeated once more.
- 0.2645, 0.529 and 1.058 ml TRIA concentrate was added to 999.74,999.45 & 998.242 ml of distilled water, following by shaking.

**Seed sowing through priming:**

Tomato seeds were soaked in aerated distilled water containing 0.5, 1or 2 mg/L solutions of 95% pure TRIA for 48 h, ratio of seed weight to volume of solution was 1:5 gm/L. Un-treated seeds were considered as a control. Tomato seeds were directly sown in petridis on 18 November, 2019. Complete germination of the

seeds took place with 5 days after seed sowing. No chemical fertilizer was used in the Petridis.

### 3.1.5 Details of treatment

**Salinity levels:**

| Salinity symbol | Salinity Level (mM) |
|---|---|
| **$S_0$** | 0 |
| **$S_1$** | 100 |
| **$S_2$** | 200 |

**Concentration of Triacontanol:**

| Treatments | Concentration (mg/L) |
|---|---|
| **$T_0$** | 0 |
| **$T_1$** | 0.5 |
| **$T_2$** | 1.0 |
| **$T_3$** | 2.0 |

**Treatment's combination:**

i. $S_0T_0$ (0 mM + 0 mg/L)
ii. $S_0T_1$ (0 mM + 0.5 mg/L)
iii. $S_0T_2$ (0 mM + 1.0 mg/L)
iv. $S_0T_3$ (0mM + 2.0 mg/L)
v. $S_1T_0$ (100mM + 0 mg/L)
vi. $S_1T_1$ (100mM + 0.5 mg/L)
vii. $S_1T_2$ (100 mM + 1.0 mg/L)
viii. $S_1T_3$ (100 mM + 2. 0 mg/L)
ix. $S_2T_0$ (200 mM + 0 mg/L)
x. $S_2T_1$ (200 mM +0. 5 mg/L)
xi. $S_2T_2$ (200 mM + 1.0 mg/L)
xii. $S_2T_3$ (200 mM +2.0mg/L)

### 3.1.6. Layout of the experiment

The experiment was laid out in a Completely Randomized Design (CRD) with three replications. The experiment area was divided into three equal blocks. Each block contains by 12 pots where 12 treatment combination were allotted at random. Two plants were placed under each treatment. The total number of pots were 36 (3 × 12). The layout of the experiment is shown in Fig. 2.

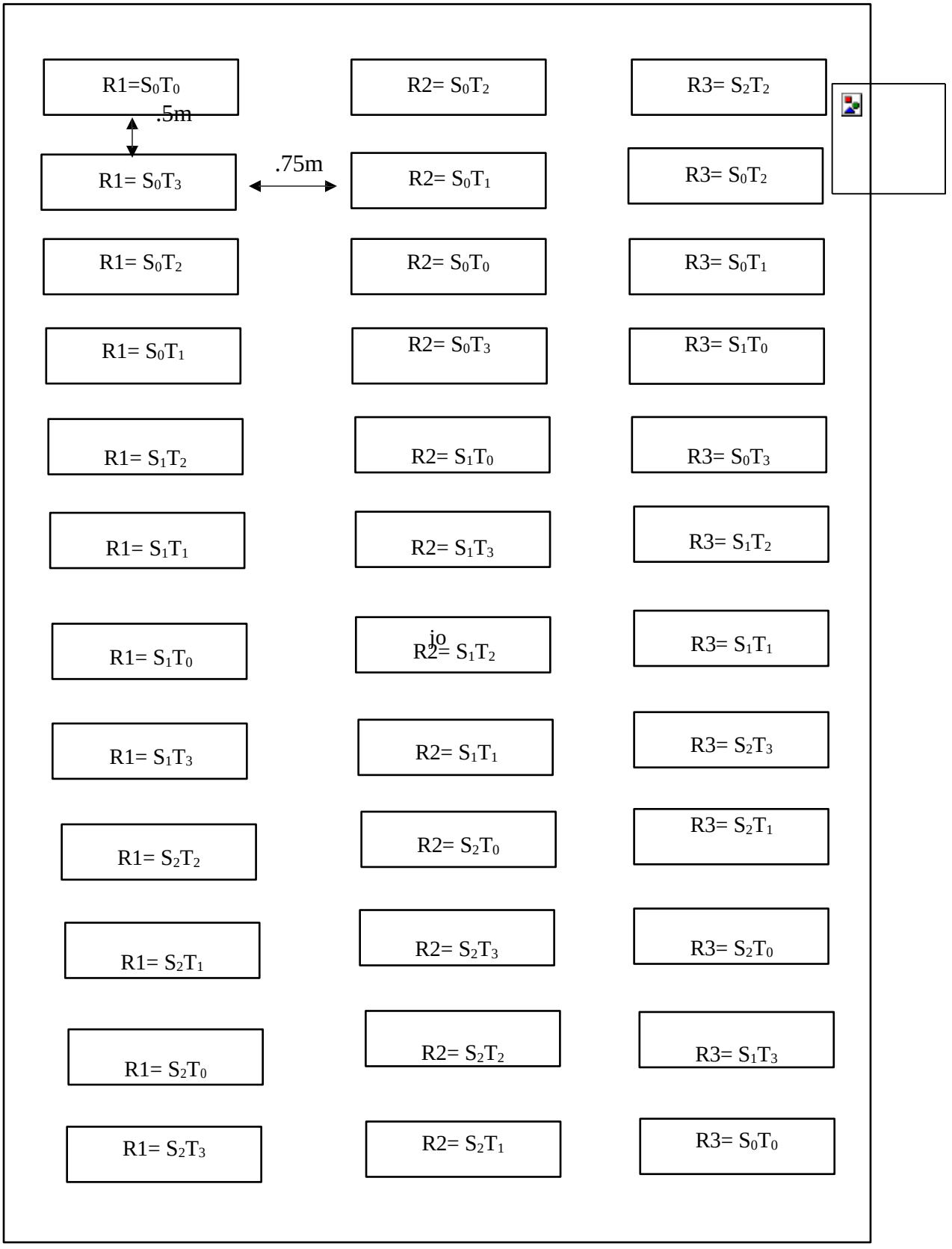



Fig.3.2: Layout of the experiment

### 3.1.7 Collection and processing of soil sample

A bulk volume of soil was collected from the experimental to a depth of 0-15 cm from the surface. The soil was air dried, ground and passed through a 2-mm sieve and stored in a clean, dry plastic container for analysis.

### 3.1.8 Preparation of the pot

The experimental pots were first filled with soil on 8 November, 2019. Potted soil was brought into desirable fine tilth by hand mixing. The stubble and weeds were removed from the soil. The final pot preparation was done on 13 November. Cowdung was mixed with soil at the time of final pot preparation.

### 3.1.9 Application of fertilizers

The P, K, S, Zn and B fertilizer were applied according to Fertilizer Recommendation Guide (FRG, 2018) through Triple Super Phosphate (TSP), Muriate of Potash (MP), Gypsum, Zinc sulphate and boric acid respectively. TSP, Gypsum, Zinc sulphate and boric acid were applied in full during final pot preparation. Urea and muriate of potash (MP) were applied in two equal instalments at 15 and 35 days after transplanting around the plants followed by irrigation.

**Table 3.3. Fertilizer application for the experimental field**

| Fertilizers | Dose/ ha | Application (%) | | |
|---|---|---|---|---|
| | | Basal | 15 DAT | 35 DAT |
| **Urea** | 120 kg | -- | 50 | 50 |
| **TSP** | 36 kg | 100 | -- | -- |
| **MoP** | 80 kg | -- | 50 | 50 |
| **Gypsum** | 15 kg | 100 | -- | -- |
| **Zinc sulphate** | 2.0 kg | 100 | -- | -- |
| **Boric acid** | 0.6 kg | 100 | -- | -- |

### 3.1.10 Transplanting of seedlings

Healthy and uniform sized 10 days old seedlings were taken separately from the petridish and were transplanted in the experimental pot on 26 November, 2019.Two seedlings were planted per pot with a sufficient spaces between the pots, separately. The Petridis was watered before uprooting the seedlings so as to minimize the damage of the roots. This operation was carried out during late afternoon. The seedlings were watered after transplanting.

### 3.1.11 Application of NaCl

5.85 g salt was mixed with 1 L water for 100 mM and 11.7 g salt was mixed with 1L water for 200mM saline water. Saline water application was started on 8 January, 2020. As per the treatment, the required amount of NaCl was added to pot by irrigation. The application of saline water was continued until flowering.

### 3.1.12 Intercultural operation

After raising seedlings, various intercultural operations such as weeding, earthing up, irrigation, pest and disease control etc. were accomplished irrespectived of the treatments for better growth and development of the tomato seedlings.

- **Weeding**

Hand weeding was done as when necessary to keep the pots free from weeds.

- **Earthing up**

Earthing up was done at 20 and 40 days after transplanting on the basement of plant by taking the soil from the boundary side of pots by hand.

- **Irrigation**

Light watering was given by a watering cane in each pot with equal amount as necessary in the afternoon.

- **Pest management**

The crop was infested with cutworm, leaf hopper and others which was controlled successfully by spraying Rivcot and neem extract.

### 3.1.13 Harvesting

Tomato Fruits were harvested at 3-day intervals during early ripening stage when they attained slightly red color. The maturity of the crop was determined on the basis of red coloring of fruits. Harvesting was started from 15 March, 2020 and completed by 8 April 2020.

**3.2. Data collection:** Data were collected from plant of each unit pot.

**3.2.1. Germination percentage (%):** Germination percentage was counted from petridish by following way-

GP= Seed germinated/total seeds ×100

**3.2.2. Seedling height (cm):** The seedling plant height was measured during transplantation from the ground level to the top of the sample by a cm scale.

**3.2.3. Plant height (cm):** The plant height was measured from plant of each unit pot from the ground level to the top of the sample by a cm scale.

**3.2.4. Leaf length (cm):** Leaf length was measured from petiole to leaf apex through a cm scale.

**3.2.5. Number of leaves per plant:** The number of leaves per plant was counted from plant of each unit pot and recorded.

**3.2.6. 1st flowering time (DAT):** Days required for transplanting to initiation of flowering was recoded from the date of transplanting to the initiation of flowering.

**3.2.7. 1st fruiting time (DAT):** Days required for transplanting to initiation of fruiting was recoded from the date of transplanting to the initiation of fruiting.

**3.2.8. Number of flowers per cluster:** The number of flowers per cluster was counted from plants of each unit pot and recorded.

**3.2.9. Number of fruits per cluster:** The number of fruits per cluster was counted from plant of each unit pot and the number of flowers per cluster was recorded.

**3.2.10. Fruit yield (kg):** Yield of tomato was measured as the whole fruit per pot harvested in different time intervals and was expressed in kilogram.

**3.2.11. Diameter length & width (mm):** The length and width of fruit was recorded with slide calipers from the neck of the bottom and one side to another side respectively from five selected marketable fruits and their average was taken and expressed in mm.

### 3.3 Post harvest soil sampling

After harvest of crop soil samples were collected from each pot. Soil samples was air-dried, crushed and passed through a 2 mm (10 mesh) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil. The soil samples were analyzed by the following standard methods as follows:

### 3.3.1 Organic carbon (%)

Organic carbon in soil was determined by Walkley and Black's (1934) wet oxidation method. The underlying principle is to oxidize the organic carbon with an excess of 1 N $K_2Cr_2O_7$ in presence of conc. $H_2SO_4$ and to titrate the residual $K_2Cr_2O_7$ solution with 1 N $FeSO_4$ solution.

### 3.3.2 Soil organic matter

Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724. The result was expressed in percentage.

% organic matter = % organic carbon × 1.724

### 3.3.3 Soil pH

The pH of the soil was determined with the help of a glass electrode pH meter using soil: water ratio 1:2.5 (Jackson, 1973).

### 3.3.4) Electrical conductivity (EC)

Electrical conductivity was determined with the help of a conductivity meter following Jackson (1973)

Electrical conductivity of soil = observed EC of soil × K

### 3.3.5 Available sulphur

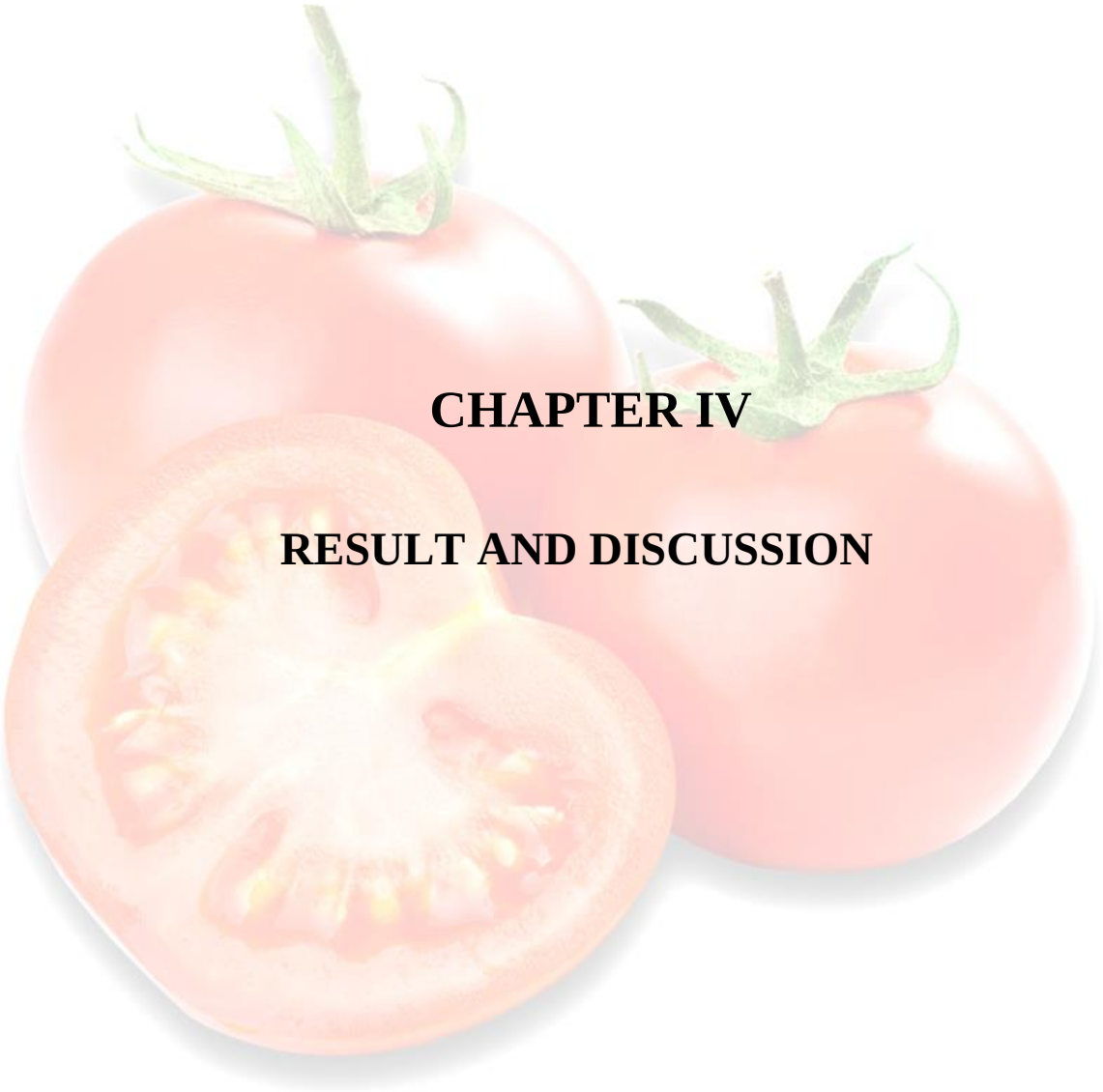
Available sulphur in soil was determined by extracting the soil samples with 0.15 % $CaCl_2$ solution (Page *et al.,* 1982). The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

### 3.3.6 Available phosphorous

Available phosphorus was extracted from soil by shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 (Olsen *et al*., 1954). The phosphorus in the extract was then determined by developing blue color using Ascorbic acid. The absorbance of the ascorbic acid blue color was measured at 660 nm wave length by spectrophotometer and available P was calculated with the help of a standard curve.

## 3.4 Statistical analysis

Statistical package program 'Statistic 10' was used for analysis of the experimental data. Duncan's Multiple Range Test (DMRT) was done for comparison of means (Gomez and Gomez, 1983).



# CHAPTER IV

# RESULT AND DISCUSSION

# CHAPTER IV

# RESULTS AND DISCUSSION

This Chapter comprises the experimental results along with discussions. Data on germination and plant height during transplanting through seed priming with triacontanol are recorded in Table 4.1. Individual and combined effects of salinity and Triacontanol on different growth and yield parameter are shown in Tables 4.2-4.7. The results have been presented in the table and graphs and possible interpretations given under the following headings:

## 4.1 Effects of triacontanol on seed germination and seedling height of tomato

### 4.1.1 Germination percentage of seed

Priming with triacontanol, gave the excellent performance in terms of improvement in germination percentage (Table 4.1). The maximum germination percentage (98.3) was observed by priming with 2.0 mg/L Triacontanol respectively and least germination percentage (76.7) was found in control treatment. Overall, seed priming with Triacontanol improved germination percentage in a tested genotype (Table 4.1). Un- treated and hydro-primed seeds failed to emerge potentially and resulted in minimum germination (Table 4.1).

### 4.1.2 Seedling height (Before application of saline water)

Seedling Plant height of tomato was significantly increased by priming with different concentration of triacontanol (Table 4.1). The tallest seedling (3.53 cm) was produced by priming with 2mg/L of triacontanol and shortest seedling (2.07 cm) was found in control treatment (Table 4.1). It was observed that tomato seedling height increased gradually with the increment of triacontanol concentration. This might be due to higher triacontanol concentration that progressively enhanced the vegetative growth of the plant. Un-treated and hydro-primed condition decreased plant height (Table 4.1).

**Table 4.1 Effects of Triacontanol on % germination and seedling height (cm) of tomato**

| Treatments | % Germination | Seedling height (cm) |
|---|---|---|
| $T_0$ | 76.7 c | 2.07 d |
| $T_1$ | 86.7 b | 2.53 c |
| $T_2$ | 91.7 ab | 3.00 b |
| $T_3$ | 98.3 a | 3.53 a |
| **CV** | **4.32** | **8.80** |
| **LSD (0.05)** | **7.2** | **0.46** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

**T0 =0 mg/L; T1 =0.5 mg/L; T2 =1.0 mg/L; T3 =2.0 mg/L**

## 4.2 Effects of salinity and triacontanol on growth and yield of tomato

### 4.2.1 Plant height (At flowering stage)

Plant height of tomato varied significantly for different levels of salt stress. The tallest plant (60.00 cm) was recorded from $S_0$ (control) and the shortest plant (36.67 cm) was observed from $S_2$ which was statistically similar (42 cm) to $S_1$ (Table 4.2). Data revealed that the salt stress reduced the morphological parameters such as plant height of tomato. Plant salt tolerance means the inherent ability of the plant to withstand the effects of high salt concentration in the rhizosphere. Tomato is one of the world's most important and widespread crops with adverse effects of salinity, growth is affected (Bradbury and Ahmad, 1990; Liang *et al*., 1996). Luo *et al*. (2013) reported that under the salt stress of NaCl, the increase of NaCl concentration had stronger inhibitory effect on tomato growth. Agong *et al*. (2003) found that significant genotypic and/or salt treatment effects were registered on plant height of tomato plant.

Statistically significant variation was recorded for different concentration of triacontanol on plant height of tomato (Table 4.3). Data revealed that the tallest plant (80.67 cm) was found in $T_3$ (2 mg/L TRIA), the shortest plant (59.00cm) was recorded from $T_0$ (control, no TRIA). Shahbaz *et al*. (2013) found that Triacontanol (TRIA) is an effective plant growth regulator which can significantly enhance plant growth.

Combined effect of different levels of salt stress and Triacontanol showed significant differences on plant height of tomato. The tallest plant (88.67 cm) was found from $S_0T_3$ (0 mM + 2 mg/L triacontanol) treatment combination, while the shortest (31.0 cm) was found from $S_2T_0$ (200mM + control, TRIA) treatment combination (Table 4.4).

### 4.2.2 Leaf length

Length of tomato leaf varied significantly for different levels of salt stress under the present trial (Table 4.2). The highest length of leaf (19.20 cm) was recorded

from $S_0$. On the other hand, the lowest length (11.97 cm) was recorded from $S_2$ which was followed (15.30 cm) by $S_1$ (Table 4.2).

Different concentrations of triacontanol showed significant differences on length of tomato leaf (Table 4.3). The highest length of leaf (25.37 cm) was attained from $T_3$ which was closely followed (20.47 cm) by $T_2$, whereas the lowest length (18.03 cm) was recorded from $T_0$ (Table 4.3).

Combined effect of different levels of salt stress and triacontanol showed significant differences on length of leaf (Table 4.4). The highest length of leaf (31.40cm) was recorded from $S_0T_3$ treatment combination, again the lowest length (17.70 cm) was observed from $S_2T_0$ treatment combination (Table 4.4) which was statistically similar (17.77 cm) to $S_2T_3$.

### 4.2.3 Number of leaves per plant

Statistically significant variation was recorded for number of leaves per plant of tomato due to different levels of salt stress under the present trial (Table 4.2). The maximum number of leaves per plant (16.33) was observed from S0 which was statistically similar (13.33) to $S_1$ while the minimum number (7.67) was found from $S_2$.

Different concentration of triacontanol varied significantly on number of leaves per plant of tomato (Appendix 3). Data revealed that, the maximum number of leaves per plant (27.67) was obtained from $T_3$ whereas the minimum number (14.67) was found from $T_0$ which was statistically similar (16.33) to $T_1$.

Combined effect of different levels of salt stress and triacontanol showed significant differences on number of leaves (Table 4.4). The maximum number of leaves (19.33) was recorded from $S_0T_3$ treatment combination, again the minimum number of leaves (10.00) was observed from $S_2T_0$ treatment combination (Table 4.4).

### 4.2.4 1st flowering time (DAT)

Days from transplanting to 1st flowering of tomato varied significantly due to different levels of salt stress under the present trial. The minimum days from transplanting to 1st flowering (61.67) was found from $S_0$. On the other hand, the maximum days (81.67) was attained from $S_2$ (Table 4.2). Murshed *et al*. (2014) reported that the response of antioxidant systems of tomato fruits to oxidative stress induced by salt stress treatments was different depending on the fruit development stage.

Significant differences in first flowering date from transplanting were recorded due to different concentration of triacontanol (Appendix 3). The minimum days from transplanting to 1st flowering (50.67) was recorded from $T_3$ which was closely followed (56.33) by $T_2$ and the maximum days (66.67) was found from $T_0$ (Table 4.3) which was statistically similar (65.33) with $T_1$.

Different levels of salt stress and triacontanol varied significantly due to their combined effect in terms of days from transplanting to 1st flowering (Appendix 4). The minimum days from transplanting to 1st flowering (52.33) was observed from $S_0T_3$ treatment combination, whereas the maximum days (80.00) was found from $S_2T_0$ treatment combination (Table 4.4 and fig. 4.3).

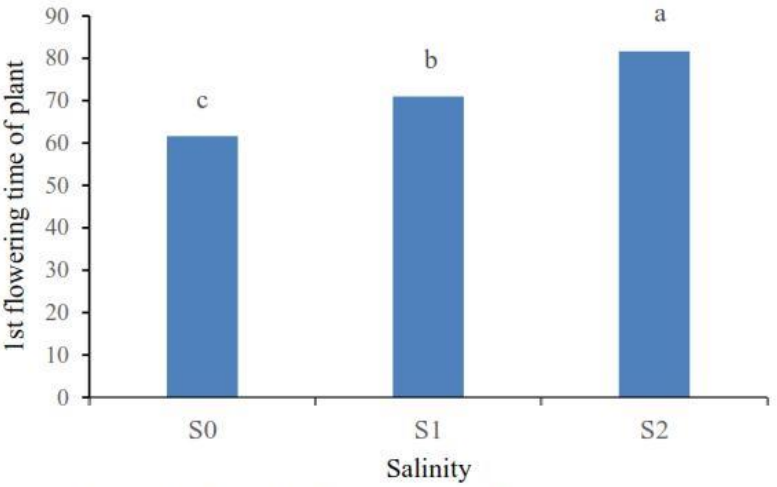



Fig 4.1: Effects of salt stress on 1st flowering time of plant

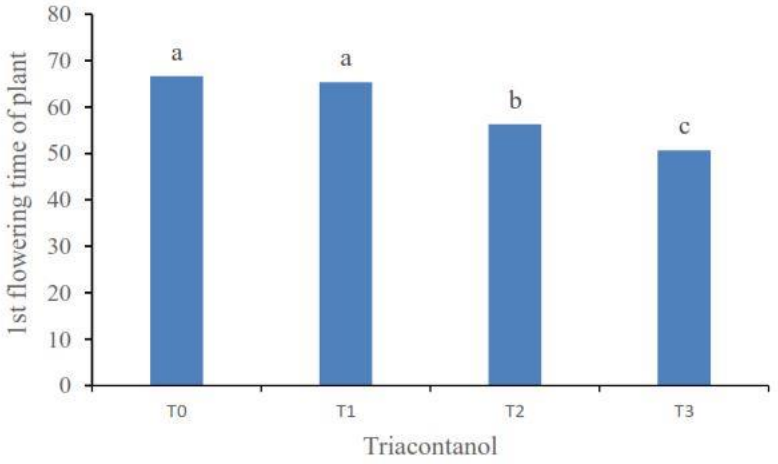



Fig 4.2: Effects of triacontanol on 1st flowering time of plant

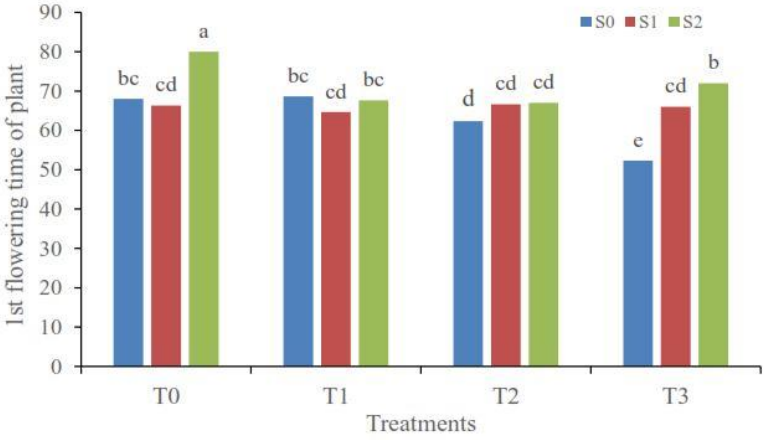



Fig 4.3. Effects of salt stress and triacontanol on 1st flowering time of plant

### 4.2.5 1st fruiting time (DAT)

Days from transplanting to 1st fruiting of tomato varied significantly due to different levels of salt stress under the present trial. The minimum days from transplanting to 1st fruiting (69.67) was found from $S_0$. On the other hand, the maximum days (89.00) was attained from $S_2$ (Table 4.2).

Significant differences in first fruiting date from transplanting were recorded due to application of different concentration of triacontanol (Appendix 3). The minimum days from transplanting to 1st fruiting (55.00) was recorded from $T_3$ which was closely followed (62.33) by $T_2$ and the maximum days (72.67) was found from $T_0$ (Table 4.3) which was statistically similar (70.00) with $T_1$.

Different levels of salt stress and triacontanol varied significantly due to their combined effect in terms of days from transplanting to 1st fruiting. The minimum days from transplanting to 1st fruiting (57.67) was observed from $S_0T_3$ treatment combination, whereas the maximum days (86.67) was found from $S_2T_0$ treatment combination (Table 4.4).

### 4.2.6 Number of flowers per cluster

Number of flowers per cluster was significantly influenced by the application of saline water up to higher level (Table 4.2). The highest number of flowers per cluster (5.67) was recorded from $S_0$ which was statistically similar (4.67) to $S_1$. On the other hand, the lowest number (2.33) was recorded from $S_2$ (Table 4.2). Luo *et al.* (2013) reported that salt stress of NaCl, stronger inhibitory effect on tomato growth.

Number of flowers per cluster progressively increased with increasing concentration of triacontanol up to a certain level (Table 4.3). The highest number of flowers per cluster (10.33) was found from $T_3$. The lowest number of flowers per cluster (5.33) was observed in $T_0$. It is evident from the results that the application of triacontanol up to 2mg/L increased number of flowers per

cluster. Combined effect of different levels of salt stress and triacontanol showed significant differences on number of flowers per cluster (Table 4.4). The highest number of flowers per cluster (9.67) was found in $S_0T_3$ treatment. The treatment combination $S_2T_0$ gave the lowest number of flowers per cluster (3.00).

**Table 4.2 Effects of salinity level on growth and yield attributes of tomato**

| Treatments | Plant height (cm) | Leaf length (cm) | No of leaves per/ plant | 1st flowering time (DAT) | 1st fruiting time (DAT) | No. of flowers / cluster | No. of fruits/ cluster |
|---|---|---|---|---|---|---|---|
| $S_0$ | 60.00 a | 19.20 a | 16.33 a | 61.67 c | 69.67 c | 5.67 a | 2.67 a |
| $S_1$ | 42.00 b | 15.30 b | 13.33 a | 71.00 b | 78.67 b | 4.67 a | 2.33 ab |
| $S_2$ | 36.67 b | 11.97 c | 7.67 b | 81.67 a | 89.00 a | 2.33 b | 1.33 b |
| **CV** | **7.63** | **7.49** | **13.12** | **3.00** | **3.15** | **19.34** | **27.35** |
| **LSD (0.05)** | **7.05** | **2.32** | **3.26** | **4.26** | **4.98** | **1.63** | **1.15** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

**$S_0$=0 mM; $S_1$=100 mM; $S_2$=200 mM**

**Table 4.3 Effects of Triacontanol on the growth and yield attributes of tomato**

| Treatments | Plant height (cm) | Leaf length (cm) | No. of leaves per plant | 1st flowering time (DAT) | 1st fruiting time (DAT) | No. of flowers/ cluster | No. of fruits/ cluster |
|---|---|---|---|---|---|---|---|
| $T_0$ | 59.00 c | 18.03 c | 14.67 c | 66.67 a | 72.67 a | 5.33 c | 2.33 b |
| $T_1$ | 68.67 b | 19.30 bc | 16.33 c | 65.33 a | 70.00 a | 6.67 bc | 5.00 a |
| $T_2$ | 72.00 b | 20.47 b | 20.00 b | 56.33 b | 62.33 b | 8.33 ab | 6.67 a |
| $T_3$ | 80.67 a | 25.37 a | 27.67 a | 50.67 c | 55.00 c | 10.33 a | 7.33 a |
| **CV** | **4.01** | **3.57** | **9.51** | **4.13** | **4.12** | **17.66** | **26.52** |
| **LSD (0.05)** | **5.30** | **1.40** | **3.52** | **4.64** | **5.04** | **2.55** | **2.66** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

**$T_0$= 0 mg/L; $T_1$= 0.5 mg/L; $T_2$=1.0 mg/L;$T_3$=2.0 mg/L**

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**Table 4.4 Combined effects of triacontanol and salinity level on the growth and yield attributes of tomato**

| Treatments | Plant height (cm) | Leaf length (cm) | No. of Leaves per plant | 1st flowering time (DAT) | 1st fruiting time (DAT) | No. of flowers/ cluster | No. of fruits/ cluster |
|---|---|---|---|---|---|---|---|
| $S_0T_0$ | 65.33 b-e | 25.50 a-d | 16.00 a-c | 68.00 bc | 76.33 b-d | 5.67 bc | 2.33 cd |
| $S_0T_1$ | 74.33 bc | 26.37 a-c | 18.00 ab | 68.67 bc | 79.67 bc | 5.00 b-d | 2.33 cd |
| $S_0T_2$ | 75.33 b | 27.33 a-c | 16.00 a-c | 62.33 d | 68.67 e | 6.33 b | 3.33 b |
| $S_0T_3$ | 88.67 a | 31.40 a | 19.33 a | 52.33 e | 57.67 f | 9.67 a | 6.00 a |
| $S_1T_0$ | 56.33 d-g | 23.53 a-d | 13.67 b-d | 66.33 cd | 76.33 b-d | 4.33 c-e | 2.33 cd |
| $S_1T_1$ | 69.00 b-d | 27.90 ab | 15.00 a-b | 64.67 cd | 73.67 c-e | 5.00 b-d | 3.00 bc |
| $S_1T_2$ | 54.67 e-g | 25.07 a-d | 15.67 a-c | 66.67 cd | 75.33 b-d | 5.67 bc | 3.00 bc |
| $S_1T_3$ | 61.33 c-f | 25.02 a-d | 14.67 bc | 66.00 cd | 71.67 de | 5.33 b-d | 3.00 bc |
| $S_2T_0$ | 31.00 i | 17.70 d | 10.00 d | 80.00 a | 86.67 a | 3.00 e | 1.33 e |
| $S_2T_1$ | 46.00 gh | 21.80 b-d | 14.00 b-d | 67.67 bc | 77.33 b-d | 4.67 cd | 2.33 cd |
| $S_2T_2$ | 41.33 hi | 19.43 cd | 12.00 cd | 67.00 cd | 76.00 b-d | 5.33 b-d | 1.67 de |
| $S_2T_3$ | 50.00 f-h | 17.77 d | 13.00 cd | 72.00 b | 80.67 ab | 4.00 de | 2.67 bc |
| **CV** | **13.17** | **20.37** | **18.26** | **4.41** | **4.82** | **16.83** | **19.90** |
| **LSD (0.05)** | **13.19** | **8.27** | **4.55** | **4.97** | **6.09** | **1.51** | **0.93** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

**$S_0$=0 mM** **$T_0$= 0 mg/L**
**$S_1$=100 mM** **$T_1$= 0.5 mg/L**
**$S_2$=200 mM** **$T_2$=1.0 mg/L**
**$T_3$=2.0 mg/L**

### 4.2.7 Number of fruits per cluster

There were significant differences among the different levels of Salinity (Table 4.2). The highest number of fruits per cluster (2.67) was recorded from $S_0$. On the other hand, the lowest number (1.33) was recorded from $S_2$ (Table 4.2).

The effect of triacontanol on the number of fruits per cluster was found positive and significant (Table 4.3). Number of fruits per cluster gradually increased with increasing concentration of triacontanol up to higher level. The highest number of fruits per cluster (7.33) was found from $T_3$ which was closely followed (5.00 and 6.67) by $T_1$ and $T_2$ and they were statistically similar, whereas the lowest number (2.33) was found from $T_0$ (Table 4.3).

The treatment combinations of salinity and triacontanol on number of fruits per cluster were significant (Table 4.4). The highest number of fruits per cluster (6.00) was obtained in $S_0T_3$ treatment combination. The lowest number of fruits per cluster (1.33) was produced by $S_2T_0$ treatment combination (Table 4.4 and Fig. 4.6).

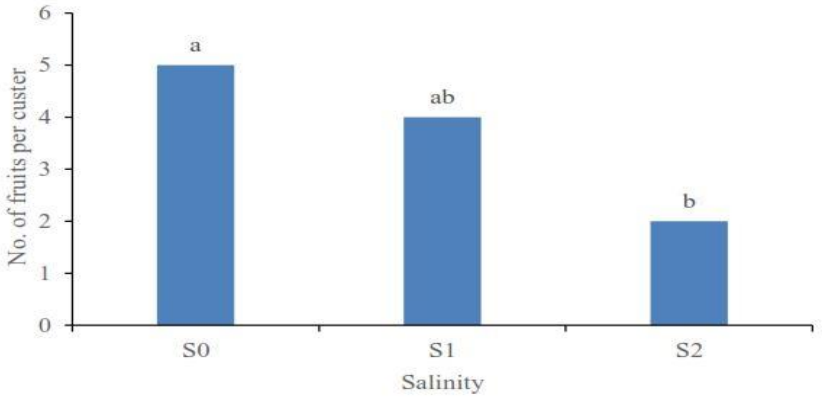



Fig 4.4: Effects of salt stress on number of fruits per cluster of plant

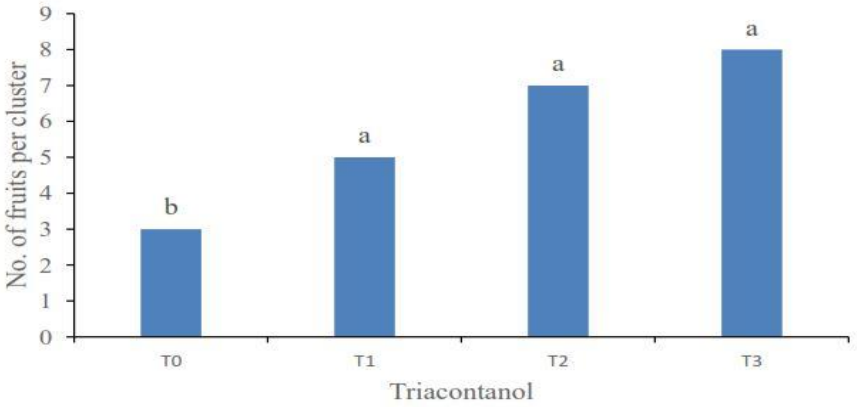



Fig 4.5: Effects of Triacontanol on number of fruits per cluster of plant

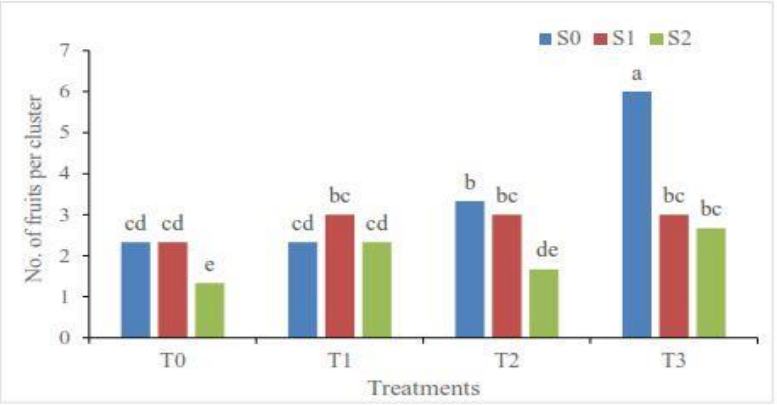



Fig 4.6. Combined effects of salt stress and triacontanol on number of fruits per cluster of plant

### 4.2.8 Fruit yield (kg /pot)

Fruit yield was significantly decreased with increasing levels of salinity up to a higher level. The highest yield per pot (0.22 kg) was recorded from $S_0$ which was closely followed (0.20kg) by $S_1$ while the lowest yield (0.16 kg) was found from $S_2$ (Table 4.5 and Fig. 4.7). Most crops tolerate salinity up to a threshold level, above which yields decrease as salinity increases (Maas, 1986). Tomato yield were subjected to 75 and 150 mM NaCl stress in order to study the effect of salt stress on its antioxidant response and stress indicators by Slathia and Choudhary (2013).

The effect of triacontanol on fruit yield was found positive and significant (Table 6 & Appendix 3). The highest yield per pot (0.25 kg) was recorded from $T_3$ which was closely followed (0.21 and 0.22 kg) by $T_1$ and $T_2$ that were statistically similar, whereas the lowest yield (0.19 kg) was observed from $T_0$ (Table 4.6). Triacontanol increased the yield of tomato.

Yield per plant varied significantly due to the combined effect of different levels of salt stress and triacontanol (Appendix 4). The highest yield per pot (0.29 kg) was recorded from $S_0T_3$ treatment combination and the lowest yield (0.13 kg) was observed from $S_2T_0$ treatment combination (Table 4.7).

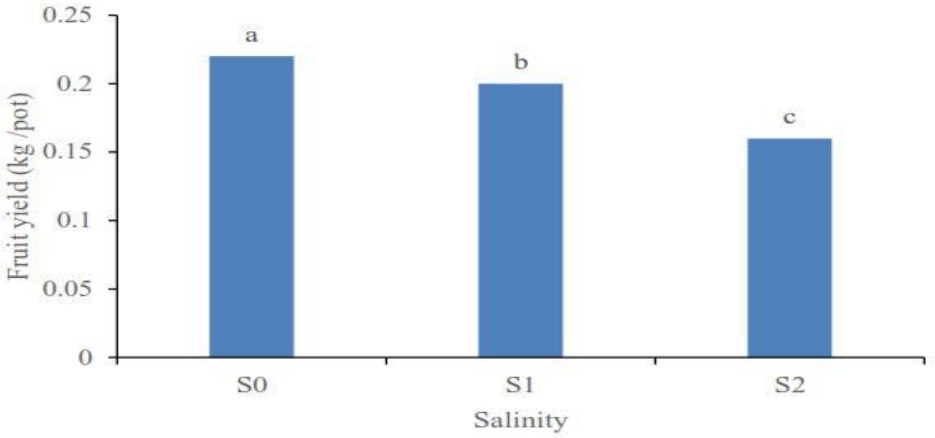



Fig 4.7. Effects of Salinity on fruit yield of kg/pot

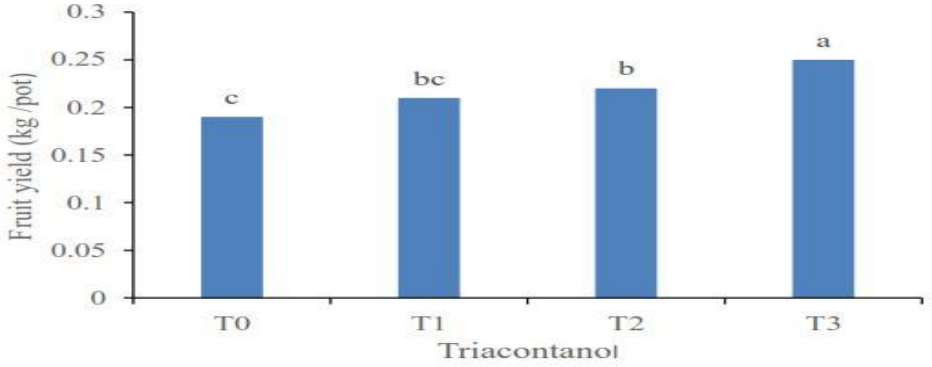



Fig 4.8: Effects of Triacontanol on fruit yield of kg/pot

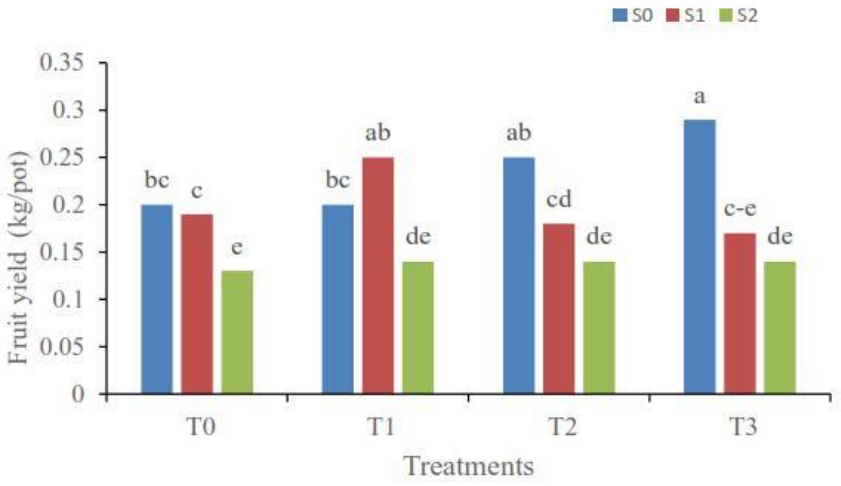



Fig 4.9. Combined effects of salt stress and triacontanol on fruit yield (kg/pot)

### 4.2.9 Fruit length

Length of fruit of tomato varied significantly for different levels of salt stress under the present trial. The highest length of fruit (56.33 mm) was recorded from $S_0$ which was statistically similar (51.00 mm) with $S_1$. On the other hand, the lowest length (43.00 mm) was recorded from $S_2$.

Different concentration of triacontanol showed significant differences on length of fruit of tomato (Appendix 4). The highest length of fruit (67.00mm) was attained from $T_3$ whereas the lowest length (56.33 mm) was recorded from $T_0$ (Table 4.6) which was statistically similar (59.33 mm) with $T_1$.

Combined effect of different levels of salt stress and triacontanol showed significant differences on length of fruit (Appendix 4). The highest length of fruit (63.33mm) was recorded from $S_0T_3$ treatment combination, again the lowest length (46.00mm) was observed from $S_2T_0$ treatment combination (Table 4.7).

### 4.2.10 Fruit diameter

Different levels of salt stress varied significantly for diameter of fruit of tomato. The highest diameter of fruit (30.67mm) was recorded from $S_0$ which was closely followed (24.97mm) with S1 while the lowest diameter (17.33mm) was found from $S_2$ (Table 4.5). Posada and Rodriguez (2009) reported that fruits of salt-stressed plants had reduced diameter.

Statistically significant variation was recorded due to different concentration of triacontanol on diameter of fruit of tomato (Appendix 3). Data revealed that the highest diameter of fruit (36.37mm) was recorded from $T_3$, whereas the lowest diameter (31.00mm) was found from $T_0$ (Table 4.6).

Diameter of fruit varied significantly due to the combined effect of different levels of salt stress and triacontanol. The highest diameter of fruit (38.00 mm) was recorded from $S_0T_3$ treatment combination and the lowest diameter (26.00 mm) was observed from $S_2T_0$ treatment combination (Table 4.7).

**Table 4.5 Effects of Salinity level on yield and yield attributes of tomato**

| Treatments | Fruit yield (kg/ pot) | Fruit length (mm) | Fruit diameter(mm) |
|---|---|---|---|
| $S_0$ | 0.22 a | 56.33 a | 30.67 a |
| $S_1$ | 0.20 b | 51.00 a | 24.97 b |
| $S_2$ | 0.16 c | 43.00 b | 17.33 c |
| **CV** | **4.10** | **6.13** | **9.11** |
| **LSD (0.05)** | **0.02** | **6.14** | **4.43** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

**$S_0$=0 mM; $S_1$=100 mM; $S_2$=200 mM**

**Table 4.6 Effects of Triacontanol on yield and yield attributes of tomato**

| Treatments | Fruit yield (kg/ pot) | Fruit length (mm) | Fruit diameter(mm) |
|---|---|---|---|
| $T_0$ | 0.19 c | 56.33 c | 31.00 c |
| $T_1$ | 0.21 b | 59.33 c | 32.43 bc |
| $T_2$ | 0.22 b | 63.00 b | 33.67 b |
| $T_3$ | 0.25 a | 67.00 a | 36.37 a |
| **CV** | **5.34** | **3.12** | **3.11** |
| **LSD (0.05)** | **0.02** | **3.60** | **1.95** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

**$T_0$=0 mg/L; $T_1$=0.5 mg/L; $T_2$=1.0 mg/L; $T_3$=2.0 mg/L**

**Table 4.7 Combined effects of triacontanol and salinity level on yield and yield attributes of tomato**

| Treatments | Fruit yield (kg/ pot) | Fruit length (mm) | Fruit diameter (mm) |
|---|---|---|---|
| $S_0T_0$ | 0.20 bc | 54.67 b | 33.87 bc |
| $S_0T_1$ | 0.20 bc | 52.67 bc | 34.23 bc |
| $S_0T_2$ | 0.25 ab | 55.67 b | 34.70 b |
| $S_0T_3$ | 0.29 | 63.33 a | 38.00 a |
| $S_1T_0$ | 0.19 | 50.67 bc | 33.67 bc |
| $S_1T_1$ | 0.25 ab | 53.00 b | 31.60 cd |
| $S_1T_2$ | 0.18 cd | 53.00 b | 31.93 b-d |
| $S_1T_3$ | 0.17 c-e | 56.00 b | 32.25 bc |
| $S_2T_0$ | 0.13 | 46.00 c | 26.00 f |
| $S_2T_1$ | 0.14 de | 53.00 b | 32.28 bc |
| $S_2T_2$ | 0.14 de | 51.23 bc | 28.03 ef |
| $S_2T_3$ | 0.14 de | 52.37 bc | 29.30 de |
| **CV** | **15.7** | **7.53** | **5.24** |
| **LSD (0.05)** | **0.0** | **6.79** | **2.84** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

**$S_0$=0 mM $T_0$=0 mg/L**
**$S_1$=100 mM $T_1$=0.5 mg/L**
**$S_2$=200 mM $T_2$=1.0mg/L**
**$T_3$=2.0mg/L**

## 4.3 Post harvest soil properties

### 4.3.1 Soil pH

The Variation of pH value was statistically non-significant due to different level of salinity (Table 4.8). The maximum and minimum pH value in post-harvest soil (5.95) and (5.75) was recorded at $S_2$ and $S_0$ treatment respectively.

Different concentration of triacontanol had no significant variation on soil pH (Table 4.9). The highest and lowest pH value (6.01) and (5.80) was found at $T_3$ and $T_0$ treatment respectively.

Statistically non-significant variation was recorded in terms of post-harvested soil pH due to the effect of different treatments (Table 4.10). The highest soil pH value (5.90) was recorded from $S_2T_0$ treatment and the lowest soil pH value (5.70) was found from S0T3treatment.

### 4.3.2 Organic matter

Different level of salinity had no significant variation on amount of organic matter in post-harvest soil (Table 4.8). The maximum (1.33%) and minimum (1.30%) amount of OM was recorded at $S_0$ and $S_2$ treatment respectively.

Different concentration of triacontanol had no significant variation on amount of organic matter in post-harvest soil (Table 4.9). The maximum (1.41%) and minimum (1.34%) amount of OM was recorded at $T_3$ and $T_0$ treatment respectively.

Organic matter content in post-harvest soil showed statistically non-significant differences due to the effects of different treatments (Table 4.10). The highest organic matter (1.43%) was found from $S_0T_3$ treatment and the lowest organic matte (1.31%) was observed from $S_2T_0$ treatment.

**Table 4.8. Effects of salinity on soil pH, organic matter, electrical conductivity, sulphur & phosphorus.**

| Treatments | Soil pH | Organic matter (%) | Electrical conductivity (dS/m) | Available P (mg/kg) | Available S (mg/kg) |
|---|---|---|---|---|---|
| **$S_0$** | 5.75 | 1.33 | 3.44 c | 26.7 a | 25.05 a |
| **$S_1$** | 5.90 | 1.33 | 6.43 b | 20.02 b | 22.40 ab |
| **$S_2$** | 5.95 | 1.30 | 8.10 a | 14.75 c | 16.15 b |
| **CV** | **14.27** | **13.12** | **10.51** | **3.94** | **16.34** |
| **LSD (0.05)** | **1.67** | **0.34** | **1.25** | **1.61** | **6.92** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

**$S_0$=0 mM; $S_1$=100 mM; $S_2$=200 mM**

**Table 4.9. Effects of triacontanol on soil pH, organic matter, electrical conductivity, sulphur & phosphorus.**

| Treatments | Soil pH | Organic matter (%) | Electrical conductivity (dS/m) | Available P (mg/kg) | Available S (mg/kg) |
|---|---|---|---|---|---|
| **$T_0$** | 5.80 | 1.34 | 3.71 | 14.70 d | 16.15 c |
| **$T_1$** | 5.90 | 1.35 | 3.63 | 16.80 c | 20.22 b |
| **$T_2$** | 5.96 | 1.38 | 3.43 | 20.22 b | 22.40 b |
| **$T_3$** | 6.01 | 1.41 | 3.41 | 27.20 a | 26.05 a |
| **CV** | **8.45** | **13.87** | **10.16** | **4.18** | **7.19** |
| **LSD (0.05)** | **0.94** | **0.35** | **0.67** | **1.55** | **2.87** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

**$T_0$=0 mg/L; $T_1$=0.5 mg/L; $T_2$=1.0 mg/L; $T_3$=2.0 mg/L**

### 4.3.3 Electrical conductivity

Different level of salinity had significant variation on electrical conductivity in post-harvest soil (Table 4.8). The maximum (8.10 dS/m) and minimum (3.44 dS/m) electrical conductivity was recorded at S2and $S_0$ treatment respectively.

Different concentration of triacontanol had significant variation on electrical conductivity in post-harvest soil (Table 4.9). The maximum (3.71 dS/m) and minimum (3.41 dS/m) electrical conductivity was recorded at $T_0$ and $T_3$ treatment respectively.

Statistically significant variation was recorded in terms of post-harvested soil electrical conductivity due to the effect of different treatments (Table 4.10). The highest soil electrical conductivity (8.10 dS/m) was recorded from $S_2T_0$ which was statistically similar to $S_2T_1$, $S_2T_2$ and $S_2T_3$ treatment and the lowest electrical conductivity (3.43 dS/m) was found from $S_0T_3$ treatment was statistically similar to $S_0T_0$, $S_0T_1$ and $S_0T_2$.

### 4.3.4 Available phosphorus

The variation of phosphorus concentration was statistically significant by the application of different level of salinity (Table4.8). The highest amount of phosphorus (26.70 mg/kg) was found at $S_0$ treatment. The lowest amount of phosphorus (14.75 mg/kg) was found at $S_2$.

Different concentration of triacontanol application had significant variation on phosphorus concentration in post-harvest soil (Table 4.9). Highest concentration of phosphorus (27.20 mg/kg) was recorded at $T_3$ treatment and lowest (14.70 mg/kg) was recorded at $T_0$.

Available phosphorus in post-harvest soil showed statistically significant variation due to the effect of different treatments (Table 4.10). The highest available phosphorus (26.80 mg/kg) was recorded from $S_0T_3$ treatment which was statistically similar to $S_0T_0$, $S_1T_2$ and the lowest available phosphorus (14.75 mg/kg) was found from $S_2T_0$ treatment.

### 4.3.5 Available sulphur

The variation of Sulphur concentration was statistically significant by the application of different level salinity (Table 4.8). The highest amount of Sulphur (25.05 mg/kg) was found at $S_0$ treatment. The lowest amount of Sulphur (16.15 mg/kg) was found at $S_2$ treatment.

Different concentration of triacontanol application had significant variation on Sulphur concentration in post-harvest soil (Table 4.9). Highest concentration of S (26.05 mg/kg) was recorded at $T_3$ treatment and lowest (16.15 mg/kg) was recorded at $T_0$.

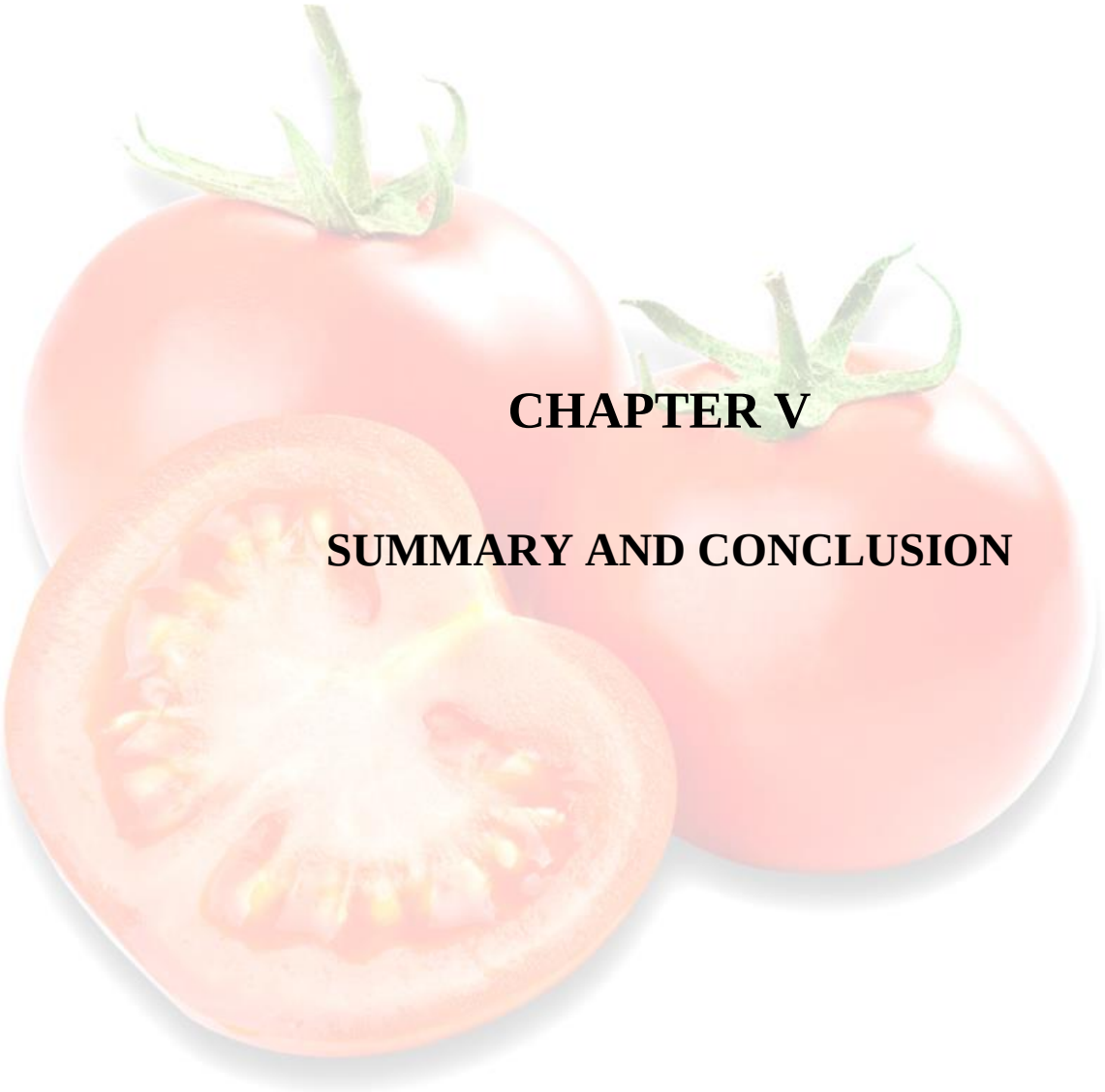
Available Sulphur in post-harvest soil showed statistically significant variation due to the effect of different treatments (Table 4.10). The highest available Sulphur (25.05 mg/kg) was recorded from $S_0T_3$ treatment which was statistically similar to $S_0T_0$, $S_1T_2$, $S_2T_2$, $S_2T_2$, $S_2T_3$ treatment and the lowest available Sulphur (16.00 mg/kg) was found from $S_2T_0$ treatment.

**Table 4.10. Combined effects of salinity and triacontanol on soil pH, organic matter, electrical conductivity, sulphur & phosphorus.**

| Treatments | Soil pH | Organic matter (%) | Electrical conductivity (dS/m) | Available P (mg/kg) | Available S (mg/kg) |
|---|---|---|---|---|---|
| $S_0T_0$ | 5.80 | 1.32 | 3.43 c | 26.75 a | 25.08 a |
| $S_0T_1$ | 5.70 | 1.33 | 3.63 c | 16.62 d | 18.05 cd |
| $S_0T_2$ | 5.80 | 1.32 | 3.71 c | 24.62 ab | 20.06 bc |
| $S_0T_3$ | 5.70 | 1.43 | 3.43 c | 26.80 a | 25.05 a |
| $S_1T_0$ | 5.90 | 1.33 | 6.42 b | 20.01 c | 22.40 ab |
| $S_1T_1$ | 5.80 | 1.32 | 5.60 b | 20.05 c | 20.06 bc |
| $S_1T_2$ | 5.90 | 1.33 | 6.28 b | 26.75 a | 24.23 a |
| $S_1T_3$ | 5.80 | 1.31 | 6.03 b | 24.02 b | 19.39 c |
| $S_2T_0$ | 5.90 | 1.31 | 8.10 a | 14.75 d | 16.00 d |
| $S_2T_1$ | 5.80 | 1.32 | 7.52 a | 19.98 c | 20.06 bc |
| $S_2T_2$ | 5.80 | 1.33 | 8.14 a | 25.05 ab | 25.08 a |
| $S_2T_3$ | 5.90 | 1.32 | 8.04 a | 20.01 c | 24.23 a |
| **CV** | **26.04** | **6.97** | **10.14** | **5.87** | **7.56** |
| **LSD (0.05)** | **NS** | **NS** | **1.02** | **2.18** | **2.76** |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

**$S_0$=0 mM $T_0$=0 mg/L**
**$S_1$=100 mM $T_1$=0.5 mg/L**
**$S_2$=200 mM $T_2$=1.0mg/L**
**$T_3$=2.0mg/L**



# CHAPTER V

# SUMMARY AND CONCLUSION

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# SUMMARY AND CONCLUSION

The experiment was conducted at the Research Farm of Sher-e- Bangla Agricultural University (SAU), Dhaka during the period from November 2019 to March 2020 to study the effects of salt stress in tomato with priming through triacontanol. BARI Tomato-18 was used as a test crop. It was a pot culture experiment. The experiment consisted of two factors: Factor A: NaCl salt concentration (three levels) as $S_0$: Control, $S_1$: 100mM and $S_2$: 200mM. Factor B: Triacontanol (four levels) as $T_0$: Control i.e., no TRIA, $T_1$: 0.5 mg/L TRIA, $T_2$:1.0mg/L TRIA and $T_3$: 2.0 mg/L TRIA. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield parameter were recorded and statistically significant variation was found for different levels of salt stress and triacontanol and their combined effect.

Application of salinity and triacontanol at different levels influenced plant characters. The effect of triacontanol on growth and yield was found positive.

The maximum germination percentage (98.3) was revealed from $T_3$ by priming with 2.0 mg/L Tria respectively and least germination percentage (76.7) was found in control treatment. The tallest plant (3.53 cm) was produced in $T_3$ by priming with 2mg/L of triacontanol and shortest plant (2.07 cm) was found in control treatment.

Plant height gradually decreased with increasing levels of salinity up to higher level. The tallest plant (60.0 cm) was recorded from $S_0$ (control) and the shortest plant (36.7 cm) was observed from $S_2$. Plant height of tomato was significantly increased by different concentration of triacontanol. Data revealed that the tallest plant (80.7 cm) was found in $T_3$ (2mg/L TRIA), the shortest plant (59.0 cm) was recorded in $T_0$ (control, no TRIA). The tallest plant (88.7 cm) was found in $S_0T_3$ (0 mM + 2mg/L triacontanol) treatment combination, while the shortest

plant (31.0cm) was found in $S_2T_0$ (200mM + control, TRIA) treatment condition.

Salinity had effect on the leaf length. The highest length of leaf (19.2 cm) was recorded from $S_0$. On the other hand, the lowest length (12.0 cm) was recorded from $S_2$. The highest length of leaf (25.4 cm) was attained from $T_3$ whereas the lowest length (18.0 cm) was observed with $T_0$. The highest length of leaf (31.40cm) was recorded with $S_0T_3$ treatment combination, again the lowest length (17.7 cm) was noted in $S_2T_0$ treatment combination.

Number of leaves gradually decreased due to salinity up to higher level. The maximum number of leaves per plant (16.3) was observed in $S_0$ while the minimum number (7.67) was found from $S_2$. Different concentrations of triacontanol increased the number of leaves. The maximum number of leaves per plant (27.7) was obtained in $T_3$ whereas the minimum number (14.67) was found in $T_0$. The maximum number of leaves (19.33) was recorded with $S_0T_3$ treatment combination, again the minimum number of leaves (10.00) was noted in $S_2T_0$ treatment combination.

The minimum time (days) from transplanting to 1st flowering (62) was in $S_0$. On the other hand, the maximum days (82) was attained in $S_2$. The minimum days from transplanting to 1st flowering (51) was recorded with $T_3$ and the maximum days (67) was found in $T_0$. The minimum days from transplanting to 1st flowering (52.33) was observed in $S_0T_3$ treatment combination, whereas the maximum days (80) was found in $S_2T_0$ treatment combination.

The minimum days from transplanting to 1st fruiting (70) was found in $S_0$. On the other hand, the maximum days (89) was attained in $S_2$. The minimum days from transplanting to 1st fruiting (55) was recorded with $T_3$ and the maximum days (73) was found in $T_0$. The minimum days from transplanting to 1st fruiting (58) was observed in $S_0T_3$ treatment combination, whereas the maximum days (87) was noted in $S_2T_0$ treatment combination.

Salinity had an adverse effect on number of flowers per cluster. The highest number of flowers per cluster (6) was recorded in $S_0$. On the other hand, the lowest number (2) was observed in $S_2$. The effect of triacontanol on the number of flowers per cluster was influenced significantly. The highest number of flowers per cluster (10) was found in $T_3$ and the lowest number of flowers per cluster (5) was observed in $T_0$. The highest number of flowers per cluster (10) was found in $S_0T_3$ treatment and the treatment combination $S_2T_0$ gave the lowest number of flowers per cluster (3).

The number of fruits per cluster gradually decreased with increasing levels of salinity up to higher level. The highest number of fruits per cluster (3) was recorded from $S_0$, on the other hand, the lowest number (1.33) was observed in $S_2$. The number of fruits per cluster gradually increased with increasing levels of triacontanol up to a certain level. The highest number of fruits per cluster (7) was found in $T_3$ whereas the lowest number (2) was found in $T_0$. The highest fruits per cluster (6) was obtained in $S_0T_3$ treatment combination and the lowest number of fruits per cluster (1) was noted in $S_2T_0$ treatment combination.

Yield of tomato gradually decreased due to obtaining salinity up to higher level. The highest yield per pot (0.22 kg) was recorded from $S_0$ while the lowest yield (0.16 kg) was found from $S_2$. Yield of tomato progressively increased by triacontanol up to higher level. The highest yield per pot (0.25 kg) was recorded in $T_3$ whereas the lowest yield (0.19 kg) was observed in $T_0$. The highest yield per pot (0.29 kg) was recorded with $S_0T_3$ treatment combination and the lowest yield (0.13 kg) was observed in $S_2T_0$ treatment combination.

The highest length of fruit (56.3mm) was recorded in $S_0$. On the other hand, the lowest length (43 mm) was recorded in $S_2$. The highest length of fruit (67 mm) was attained in $T_3$ whereas the lowest length (56.3 mm) was recorded in $T_0$. The highest length of fruit (63.3 mm) was observed in $S_0T_3$ treatment combination, again the lowest length (46 mm) was observed in $S_2T_0$ treatment combination.

The highest diameter of fruit (30.7 mm) was recorded with $S_0$ while the lowest diameter (17.3 mm) was found in $S_2$. The highest diameter of fruit (36.37mm) was observed with $T_3$, whereas the lowest diameter (31 mm) was noted in $T_0$. The highest diameter of fruit (38 mm) was observed in $S_0T_3$ treatment combination and the lowest yield (26 mm) was observed in $S_2T_0$ treatment combination.

The maximum and minimum pH value in post-harvest soil (5.95) and (5.75) was recorded in $S_2$ and $S_0$ treatments, respectively. The highest and lowest pH values (6.01) and (5.80) was found in $T_3$ and $T_0$ treatment respectively. The highest soil pH value (5.90) was recorded with $S_2T_0$ treatment and the lowest soil pH value (5.70) was found in $S_0T_3$ treatment.

The maximum (1.33%) and minimum (1.30%) amount of OM was recorded with $S_0$ and $S_2$ treatments, respectively. The maximum (1.41%) and minimum (1.34%) amount of OM was recorded in $T_3$ and $T_0$ treatments, respectively. The highest organic matter (1.43%) was found from $S_0T_3$ treatment and the lowest organic matte (1.31%) was observed in $S_2T_0$ treatment.

The maximum (8.10 dS/m) and minimum (3.44 dS/m) electrical conductivity was recorded in $S_2$ and $S_0$ treatments, respectively. The maximum (3.71 dS/m) and minimum (3.41 dS/m) electrical conductivity was noted in $T_0$ and $T_3$ treatments respectively.The highest soil electrical conductivity (8.10 dS/m) was observed in $S_2T_0$ and the lowest electrical conductivity (3.41 dS/m) was found in $S_0T_3$ treatment.

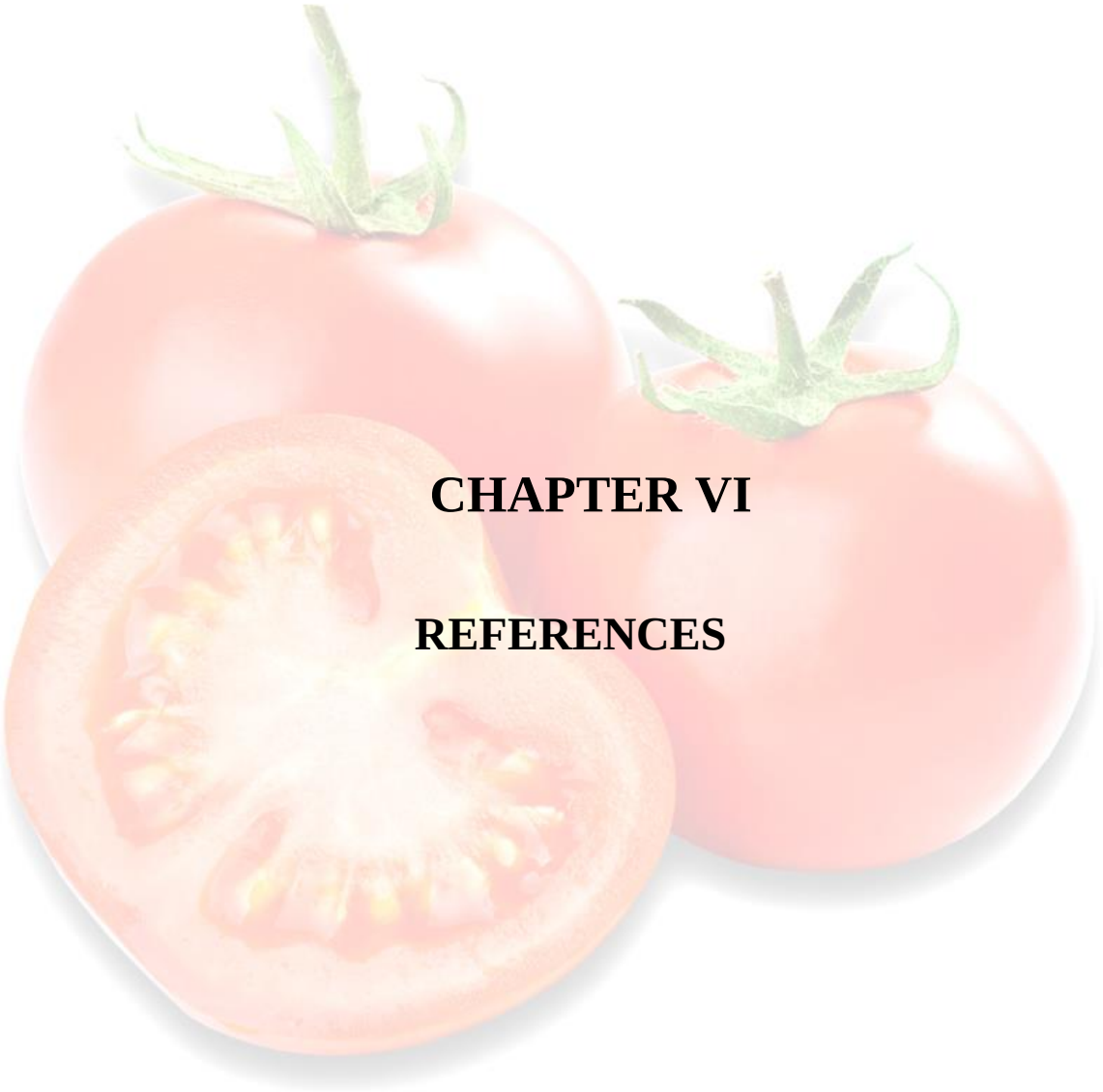
The highest amount of phosphorus (26 mg/kg) was found in $S_0$ treatment and the lowest amount of phosphorus (14.8 mg/kg) was found in $S_2$. The highest concentration of P (27.2 mg/kg) was recorded in $T_3$ treatment and the lowest (14.7 ppm) was noted in $T_0$.The highest available P (26.8 mg/kg) was found in $S_0T_3$ treatment which was statistically similar to $S_0T_0$ and $S_1T_2$ and the lowest available P (14.8 mg/kg) was found in $S_2T_0$ treatment. The highest amount of sulphur (25.1 mg/kg) was found in $S_0$ treatment. The lowest amount of sulphur (16.2 mg/kg) was found in $S_2$ treatment.

The highest concentration of S (26.1 mg/kg) was observed in $T_3$ treatment and the lowest (16.2 mg/kg) was recorded in $T_0$. The highest available S (25.1 mg/kg) was observed in $S_0T_3$ treatment and the lowest available S (16 ppm) was found in $S_2T_0$ treatment.

Overall results revealed that the combination of $S_1T_2$ (100Mm NaCl + 1.0 mg/L triacontanol) was most suitable in consideration of yield contributing characters and yield, and application of triacontanol reduced salt stress condition to a considerable extent.

From the present study, the following conclusion is drawn –

- Priming with triacontanol enhanced growth, yield and yield attributes of tomato.
- Individual effect of triacontanol on growth and yield of tomato was found positive and significant.
- Application of triacontanol 2.00 mg/L gave the highest yield of tomato.
- Such study is needed in coastal zones (AEZ 13) of Bangladesh for regional compliance and other performance.



# CHAPTER VI

# REFERENCES

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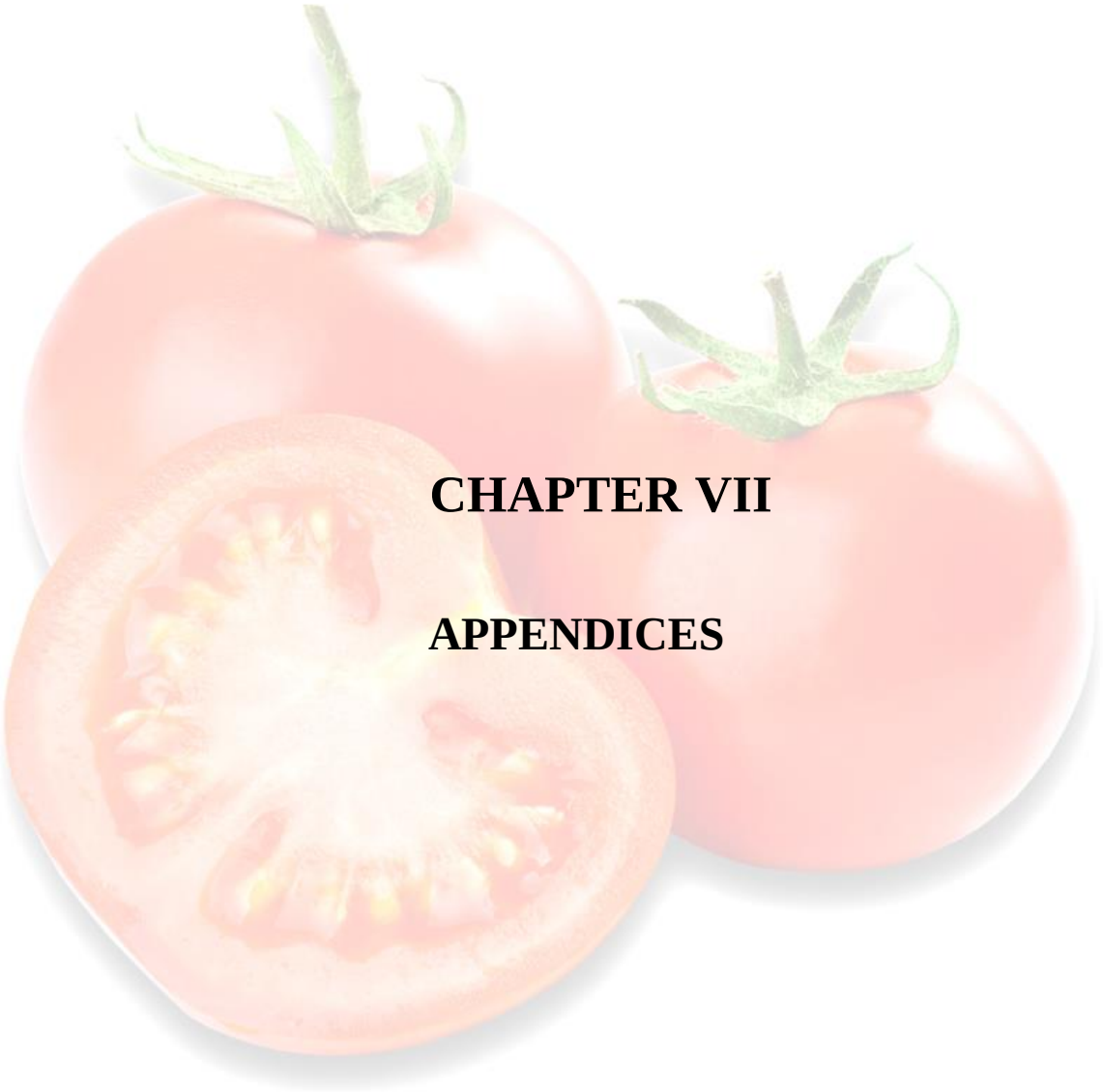

# CHAPTER VII

# APPENDICES

# CHAPTER VII

# APPENDICES

**Appendix 1. Monthly records of meteorological observation at the period of experiment (November, 2019 to March, 2020).**

| Month | Temperature($^0$C) (mean) | Humidity (%) | Precipitation (mm) |
|---|---|---|---|
| November | 24.9 | 74 | 37.0 |
| December | 19.3 | 74 | 5.0 |
| January | 18.5 | 76 | 21.0 |
| February | 21.6 | 59 | 1.0 |
| March | 26.4 | 57 | 30.0 |

**Source**: Bangladesh Metrological Department (Climate division), Agargaon, Dhaka-1207.

**Appendix 2. Analysis of variance of the data on Effect of Triacontanol of % Germination and Seedling height (cm) of tomato.**

| Source | DF | Mean square of Triacontanol effect | |
|---|---|---|---|
| | | Germination | Seedling height (cm) |
| **Replication** | 2 | 14.58 | 0.10 |
| **Treatments** | 3 | 250.00** | 1.19** |
| **Error** | 6 | 14.58 | 0.05 |

** Significant at 0.01 level of probability

**Appendix 3. Analysis of variance of the data on effect of salinity and triacontanol level on growth and yield attributes of**

**tomato**

| Source | DF | Mean square of salinity effect level on growth and yield attributes of tomato | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant Height (cm) | 1st Flowering Date (DAT) | 1st Fruiting Date (DAT) | No. of flowers/ cluster | No. of fruits/ cluster | Leaf Length (cm) | Leaf No. | Yield | Fruits Length | Fruits Width |
| **Replication** | 2 | 7.44 | 5.44 | 5.78 | 0.44 | 0.78 | 3.03 | 4.11 | 1.08 | 11.44 | 14.45 |
| **Treatments** | 2 | 448.44** | 300.44** | 280.78** | 8.78* | 1.44* | 39.32** | 58.11** | 3.00** | 135.11** | 134.27** |
| **Error** | 4 | 14.94 | 4.11 | 6.44 | 0.78 | 0.11 | 0.50 | 1.19 | 4.17 | 8.44 | 0.14 |
| | | | | | | | | | | | |
| | | Mean square of triacontanol effect level on growth and yield attributes of tomato | | | | | | | | | |
| **Replication** | 2 | 5.58 | 1.75 | 2.25 | 2.58 | 5.58 | 1.25 | 4.03 | 2.10 | 1.00 | 2.96 |
| **Treatments** | 3 | 240.53** | 173.19** | 190.89** | 14.00* | 14.89** | 30.87** | 10.22** | 2.43** | 80.08** | 15.56** |
| **Error** | 6 | 8.69 | 7.53 | 8.81 | 1.58 | 0.81 | 0.32 | 3.31 | 1.10 | 2.33 | 0.45 |

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

**Appendix 4. Analysis of variance of the data on combined effect of salinity and triacontanol level on growth and yieldattributes of tomato**

| Source | DF | Mean square of combined effect of salinity and triacontanol level on growth and yield attributes of tomato | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant Height (cm) | 1st Flowering Date (DAT) | 1st Fruiting Date (DAT) | No. of flowers/ cluster | No. of fruits/ cluster | Leaf Length (cm) | Leaf No. | Yield | Fruits Length | Fruits Width |
| **Replication** | 2 | 114.53 | 11.86 | 7.75 | 1.33 | 0.53 | 137.41 | 8.78 | 5.42 | 17.53 | 0.94 |
| **Treatments** | 11 | 790.14** | 120.45** | 150.97** | 7.88** | 4.08** | 59.12** | 19.23* | 7.72** | 49.40* | 30.98** |
| **Error** | 22 | 56.45 | 8.40 | 13.54 | 0.76 | 0.29 | 15.12 | 7.14 | 9.22 | 16.10 | 3.01 |

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

## Appendix 5. Some research pictural view