EFFECT OF HUMIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO VARIETIES UNDER SALINE CONDITION

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DHAKA-1207

JUNE, 2018

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REGISTRATION No. 11-04380

A Thesis Submitted to

The Department of Horticulture

Sher-e-Bangla Agricultural University, Dhaka-1207

In partial fulfillment of the requirements for thedegree of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE
SEMESTER: JANUARY – JUNE, 2018

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CERTIFICATE

This is to certify that thesis entitled, ***"EFFECT OF HUMIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO VARIETIES UNDER SALINE CONDITION"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in HORTICULTURE****, embodies the result of a piece of bona fide research work carried out by* ***MD. MUKLESUR RAHMAN****, Registration No.* ***11-04380*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2018
Place: Dhaka, Bangladesh

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DEDICATED TO MY BELOVED PARENTS

ACKNOWLEDGEMENTS

*All praise,gratitude and thanks for the omniscient, omnipotent & omnipresent **almighty Allah** who kindly enable to complete his research work successfully and submit the thesis for degree of Masters of Science (MS) in Horticulture.*

*The author feels boundless joy to place a record his sincere sense of thanks and implicit respect to his respectable supervisor, **Prof. Dr. Mohammad Humayun Kabir,** Chairman, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207 and Chairman of the Horticulture Department for his expert guidance, valuable suggestions, unending support, restless cooperation, constructive suggestions and constructive criticism throughout the course of investigation and preparation of this manuscript.*

*The author has profound gratitude to his respected Co-Supervisor,**Prof. Dr. Md. Ismail Hossain** , Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, for giving the required supports & scholastic guidance for enabling successful completion of the thesis work.*

*The author expresses his special thanks to Higher Education Quality Enhancement Project **(HEQEP), CP-3643, World Bank, UGCB** for finance to this research work. The author also thankful to Minister of Science and Technology, The Peoples Republic of Bangladesh for providing him a National Science and Technology (NST) fellowship to conduct his research rightly.*

*The author wishes to acknowledge his heartfull indebtness and profound regards and respect to his beloved parents **Late Khalilur Rahman** and **Saleha Begum**; and honor to best his older brother **Salah Uddin.***

The author wish to express his wholehearted thanks to his well-wishers, lab mates Samar Biswas, Md. Russel Monir, and classmate Nahidul Islam for their keen help as well as heartiest co-operation and encouragement.

The Author

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ABSTRACT

A pot experiment was conducted in the "Field Laboratory of Plant Stress Management" in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from October 2016 to March 2017. The two factors experiment was laid out in Complete Randomized Design with three replications. Factor A is three tomato varieties viz. V_1 = BARI Tomato 8, V_2 = BARI Tomato 14 and V_3 = BINA Tomato 4 and factor B is humic acid treatment viz. H_0 = No humic acid (control), H_1 = 50 ppm soil application+50 ppm foliar spray and H_2 = 100 ppm soil application+100 ppm foliar spray. The total treatment combinations were (3×3) 9 and 8 dS/m salinity maintained for all the pots. The experimental results exhibited that humic acid treatment significantly affected growth, yield and quality parameters of tomato. The highest plant height (80.55 cm), number of fruits per plant (63.22) and fruit yield per plant (3.55 kg) were found from V_2 under 8 dS/m. In case of humic acid, the highest plant height (84.00 cm), number of fruits per plant (63.33) and fruit yield per plant (3.46 kg) were recorded from H_2. Regarding the combined effect, the highest plant height (87.33 cm), number of fruits per plant (75.00) and fruit yield per plant (3.63 kg) were found from V_2H_2 treatment. So the BARI Tomato-14 with 100 ppm soil application+100 ppm foliar spray of humic acid showed better performance for growth, yield and quality of tomato under 8 dS/m saline condition.

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LIST OF ABBREVIATIONS

BARI	= Bangladesh Agricultural Research Institute
CRD	= Completely Randomized Design
DAT	= Day After Transplanting
NaCl	= Sodium Chloride
$C_{187}H_{186}O_{89}N_9S_1$	= Humic Acid
cm	= centimeter
et al.	= and others (at elli)
FRG	= Fertilizer Recommendation Guide
g	= gram
mg	= milligram
LSD	= Least Significant Difference
CV	= Coefficient of Variance
%	= Percent
MoP	= Muriate of Potash
TSP	= Triple Super Phosphate
m	= Meter
hr	= Hour
cm^2	= Square centimeter
ml	= Milliliter

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* L) is mainly grown as Rabi crop in Bangladesh. It is one of the most important fruit vegetables under the Solanaceae Family and widely cultivated crop in Bangladesh. It has been originated in tropical America (Salunkhe *et al*., 1987) which includes Peru, Ecuador, Bolivia areas of Andes (Kallo, 1986). It ranks next to potato and in the world vegetable production and tops the list of canned vegetable (Choudhury, 1979). Tomato is one of the important vegetables in many parts of the world. It is a favourite crop in Indian sub-continent. It is the second largest vegetable grown after potato in Bangladesh. Tomato being a rich source of photochemical such as lycopene, β-carotene, flavonoids, potassium, vitamins E and C, folic acid, which collectively play beneficial role in human health (Rai *et al*., 2009). Tomato is highly nutritious as it contains 94.1% water, 23 calories energy, 1.90 g protein, 1 g calcium, 7 mg magnesium, 1000 IU vitamin A, 31 mg vitamin C, 0.09 mg thiamin, 0.03 mg riboflavin, 0.8 mg niacin per 100 g edible portion (Rashid, *et al.* 1983). The main antioxidant of tomato are carotinoids and vitamin C (Giovanelli, *et al*.,' 1999) The total area under tomato production is about 68366 acres with a production of 388725 tons and a productivity of 5.69 tons/acres (BBS, 2018). The average tomato yield in Bangladesh is 50-90 tons/ha. The yield of tomato in our country is not satisfactory in comparison to its requirement (Aditya *et al*., 1999). In Bangladesh, it is commonly referred as "poor man's orange" and widely grown in almost all over the country. It is mainly grown as Rabi crop in Bangladesh. Depending on yield and consumers preference a number of tomato varieties are being cultivated throughout the country. Winter tomato contributes about 80% of its total production (Anonymous, 1987).

During the lifecycle, tomato crop come across a number of biotic and abiotic stresses which severely limit the production. Among the abiotic stresses, salinity,

drought, temperature, mineral toxicity, U.V radiations are vital for yield constraints. Abiotic factors are considered to be the main cause of yield reduction up to 71% (Hussein *et. al.*, 2006). Salinity is a threat to agriculture all over the world. Salinity is one of the major abiotic stress factor that limit the plant growth as well as fruit yield. It is observed that over 800Mha land is salt-affected in the world. The coastal and offshore area of Bangladesh includes tidal, estuaries and river floodplains in the south along the Bay of Bengal. Tomato is a moderately sensitive to salt stress (Lee, 2006). Salinity imposes stress conditions on crop plants and affect growth and chemical contents and has been shown to limit yield of tomato (Paridam and Das, 2005). Salt stress severely inhibits plant growth for two reasons: first by an osmotic or water-deficit effect of salinity and 2nd by ion-excess effect of NaCl (Abbaspour, 2012). The growth and yield of tomato is reduced in salt affected soils because of the excess uptake of potentially toxic ions (Grattan & Grieve 1999). Soil salinity is characterised by high amounts of Na^{+}, Mg^{2+}, Ca^{2+}, Cl^{-}, HCO_3^{-}, SO_2^{-}, and B ions which have negative effects on the plant growth (Grunes, 2007). The coastal area covers about 20% of the country and over thirty percent of the net cultivable area. It extends inside up to 150 km from the coast. Out of 2.85 million hectares of the coastal and offshore areas about 0.83 million hectares are arable lands, which cover over 30% of the total cultivable lands of Bangladesh. The cultivable areas in coastal districts are affected with varying degrees of soil salinity. Several researchers have shown that tomato is moderately tolerate to salinity during different growth stages (Fernandez *et al*., 1977; Bethke and Drew, 1992; Pascale *et al.*, 2003). But high concentration of salt causes hyper osmotic and ionic stresses which in turn generate secondary stresses such as oxidative stress, ionic imbalance and ultimately cell death. (Rana 1988, Munns 1993). One of the most effective ways to overcome salinity problems is the introduction of salt tolerant to crops or application of various growth regulator chemicals.

Humic acid ($C_{187}H_{186}O_{89}N_9S_1$) is natural acidic organic polymer that can be extracted from humus found in soil, sediment, or aquatic environments. Foliar sprays of these substances under saline condition promote growth, and increases yield and quality in a number of plant species (Brownell *et al*., 1987; Yildirim, 2007; Karakurt *et. al*., 2009). In salt stressed of tomato, soil and foliar application of humic acid also decreases both Na+ and Cl^- levels, reduced electrical conductivity and electrolyte leakage of plant but increases K^+ ion, nitrate, nitrogen and phosphorus; enhanced tomato root and shoot dry weight by allowing nutrients and water to be released to the plant as needed; this was proposed to the key mechanism of humic acid–enhanced salt tolerance in this species (Liang *et. al.,*1999; Dell'Agnola and Nardi, 1987; Nardi *et. al*., 1988; Muscolo *et. al*., 1999; Serenella *et. al*., 2002). Humic acid have been shown to stimulate shoot and root growth and nutrients uptake of vegetable crops under saline condition (Tattini *et. al*., 1990; Padem *et. al.,* 1997; Akinremi *et. al*., 2000; Cimrin and Yilmaz, 2005). Humic acid appeared to be highly effective for better tomato growth, yield, quality by alleviating salinity stress under saline condition. Humic acid has obtained particular attention because of inducing protective effects on plants under salinity. We have to take initiatives to reverse the deleterious effect of NaCl in soil to improve tomato production specially in the saline prone area of Bangladesh. However, considering the situation the experiment was conducted focusing the following objectives-

1. To determine the performance of different tomato varieties under saline condition.
2. To investigate the role of humic acid on growth, physiological parameters, yield and quality of tomato under saline condition.
3. To find out the best combination of humic acid and tomato variety under saline condition.

CHAPTER II

REVIEW OF LITERATURE

Tomato (*Lycopersicon esculentum* L.) is one of the most important vegetables crop in Bangladesh as well as many countries of the world. However, its demand and production is increasing day by day. Every year the land of our country going under saline condition and basically farmers have to face trouble in produce table tomato and for over coming this different doses of humic acid have stimulating effect to increase growth and yield. Also varietal screening was done to evaluate the variety under salinity condition. Therefore, information available regarding humic acid and tomato varieties and other crops has been reviewed and presented in this section.

Abdel Latif *et. al*. (2017) conducted an experiment to evaluate the effect of humic acid (HA) applied at 4.8, 9.6 and 14.4 kg/ha on the growth and productivity of two tomato hybrids Nema 1400 and Platinium 5043 under hot continental climate. HA was applied twice to soil: the first one – three weeks from transplanting and the second one, after one week from the first application, in both seasons. Application of HA during the summer season targeted a great results on tomato plant growth and productivity. HA at 14.4 kg·ha-1 in-creased the vegetative growth of tomatoes (plant height and fresh weight) and flowering parameters (number of flower clusters and flowers per plant) as well as yield characters (fruit number per plant and fruit weight, which resulted in higher early and total yield) in both seasons. HA

Kazemi (2013) was studied the effect of calcium and humic acid foliar application on growth, yield and yield components of tomato plants as a completely randomized experimental design with four replications. These factors included humic acid in 3 levels (5, 10 and 20 ppm) and calcium in 2 levels (5 and 10 mM) spray on tomato. Results indicated that humic acid (20 ppm) and calcium (10 mM) either alone or in combination (20 ppm HA+10 mMCa) increased vegetative and reproductive growth, yield and chlorophyll

content. The application 20 ppm HA+10 mMCa significantly increased the leaves-NK content and dry weight; in the other hand it decreased the incidence of blossom end rot. The TSS, TA, and vitamin C content of tomato fruit had significantly affected by the application of 20 ppm HA+10 mM Ca. Foliar application of 20 ppm HA+10 mMCa resulted in the maximum TSS (6.64 °Brix), TA (3.5 and vitamine C (15.1). In conclusion, application of calcium and humic acid improved the yield contributing factors that resulted in significant increase in tomato fruit yield.

Kazemi (2014) was studied to evaluate the effects of foliar application of humic acid and calcium chloride on vegetative and reproductive growth, yield, and quality of tomato plants as a completely randomized block design with 4 replications, each consisting of 3 pots with each pot containing one plant. Humic acid (15 and 30 ppm) and calcium chloride (10 and 15 mM) solutions were applied as foliar sprays either alone or in combination. Data were recorded for plant height, branches per plant, flowers per cluster, fruits per plant, yield, fruit weight, fruit firmness and total soluble solid content of the fruit. Results showed that humic acid (30ppm) and calcium chloride (15 mM) spray either alone or in combination (30 ppm HA+15 mMCa) affected on vegetative and reproductive growth and chlorophyll content, significantly. Mean comparisons indicated yield, and quality of tomato plants was improved by increasing humic acid and calcium chloride concentration up to 30 ppm and 15 mM. Foliar application of Ca (15 mM) + HA (30 ppm) resulted in the maximum TSS (5.14° Brix), vitamin C (25.14), nitrate reductase activity (6.4), yield (25.36 t ha–1), fruit firmness (3.91 kg cm–2), fruit lycopene content (2.14) and the lowest blossom end rot incidence (5%). In Finally, humic acid and calcium chloride application can be helpful for yield improvement and prevent of decreasing yield.

Farnia and Moradi (2015) conducted an experiment to evaluate the effect of humic acid on quantitative and qualitative characteristics of strawberry (Fragariaananasa cv. 'Aromas'), an experiment was conducted as factorial arrangement in randomized complete block design with three replications in a

commercial hydroponic greenhouse. The rooted daughter plants of 'Aromas' strawberry were planted in pots containing perlite and cocopeat(1:1). Humic acid were sprayed on the plants when they were completely established. Thetreatments consisted of different concentrations of humic acid (Greenhum containing 13% humicacid) (0, 1.5, 3.0 and 4.5 mg l-1). Certain traits were measured including leaf chlorophyll index; the weight, length, width and length/width ratio of the fruits; number of fruit in plant; yield of single plant in a 2months period; malformed fruit percent; total soluble solid percent and fruit firmness. Results indicated that the application of humic acid had positive influence on fruit number, total yield of plant, TSS, fruit firmness and chlorophyll content. Generally, foliar application of humic acid led to the improvement of quantitative and qualitative characteristics of this cultivar of strawberry. Consequently, the application of 1.5-3 mg l-1 humic acid is recommended in hydroponic culturing of strawberry.

Abdel-Monaim *et. al*. (2012) conducted an experiment to study the effect of tomato seedling treated with plant growth promoting rhizobacteria (PGPR) strains viz. Azotobacter sp. (AZM1),Bacillus cereus (BCM8), B. megaterium (BMM5) individually or combined with humic acid were evaluated for controlling wilt disease caused by *Fusarium oxysporum* f. sp. lycopersici, plant growth, fruit quantitative and qualitative (cv. Super Strain-B).Combination treatments of humic acid with PGPR reduced significantly wilt incidence and increased plant height, fresh and dry weights of tomato plants comparing with the application of each of them alone. Plant height, number of branches plant^{-1} quantitative number of fruits plant $^{-1}$, fruit weight plant $^{-1}$, fruit weight, fruit yield plant^{-1}, Number of fruit Kg^{-1} and qualitative degree of fruit's color, fruit diameters, firmness, fruit height, total soluble solids parameters of tomato fruits compared with untreated plants (control) in both growing seasons.

Yildirim, (2007) conducted an experiment to determine the effect of foliar and soil fertilization with humic acid (HA) on quality, growth and yield of tomato under greenhouse conditions in 2004 and 2005. Tomato plants were treated with soil and foliar HA applications at different concentrations (0 ml/l, 10 ml/l

and 20 ml/l). Three weeks after planting HA was sprayed four times during the vegetation period at 10-day intervals. Furthermore, 0, 10 and 20 ml/l HA solutions were applied as a drench to the plant root area four times during the vegetation period at 10-day intervals three weeks after planting. HA treatments had no effect on pH and titratable acidity (TA) of tomato. Total soluble solids (TSS) increased with both foliar and soil HA treatments. Foliar applications of HA led to higher leaf and stem dry matter contents than the control. Both foliar and soil HA treatments positively affected fruit characteristics including fruit diameter, fruit height, mean fruit weight and fruit number per plant. Similarly, HA treatments increased the early yield of tomato compared to control.

Aman and Rab (2013)was conducted an experiment to study the response of tomato to nitrogen levels with or without Humic acid on yield and yield components of tomato `Advanta-1209` sown at New Developmental Farm (Horticulture section),The University of Agriculture, Peshawar Pakistan, during summer 2011. The experiment was laid out in Randomized Complete Block Design with spilt plot arrangements having three replications. The experiment involved two factors, Humic acid (0 and 5 kg ha-1) allotted to main plot and nitrogen (0, 25, 50, 75, 100, 125 and 150 kg ha-1) kept in sub plots. . The results showed that leaf length (cm), plant height (cm), fruit weight (g), and yield (t ha-1) were significantly affected, whereas survival percentage and blossom end rot to fruits were not significantly affected by Humic acid and nitrogen levels and interaction of both. High leaf length (6.43 cm), plant height (82.92 cm), fruit weight (75.27 gm) and yield (28.49 t ha-1) were produced by Humic acid applied at the rate of 5 kg ha-1and maximum leaf length (6.88 cm), plant height (89.16 cm), fruit weight (78.82 gm) and yield (32.43 t ha-1) were recorded by nitrogen applied at the rate of 125 kg ha-1. From this study it can be concluded that tomato plants should be treated with fertilizers, Humic acid and nitrogen at the rate of 5 kg and 125 kg ha-1 respectively to obtain maximum and quality yield.

Asri *et. al.* (2015) observed that humic acid was sprayed on soil at the rate of 0, 40, 80, 120, 160 and 200 Lha-1 soil along with uniform dose of nitrogen-

phosphorus-potassium (NPK) (180-60-210 kg ha-1) was applied through drip irrigation. The humic acid applications caused a significant increase of yield. Titretable acidity, fruit weight and fruit diameter showed increase by ascending humic acid levels. Results showed that N, P, K, Ca, Zn and Mn concentration of leaves was increased by humic acid, especially 80 L ha-1 humic acid level provided the most important progress in the first year. In the second year, N, P, K, Fe and Mn concentration of leaves was positive changed by humic acid and high levels of humic acid caused decline. Therefore, mid-levels (80 and 120 L ha-1) were found more effective.

The experiment was carried out in the private vegetable farm, Somail , Duhok government , during autumn growing season 2015, The aim of the experiment was to study the effect of humic acid on growth and yield of three cultivars of summer squash (*Cucurbi ta pepo*L.). The experiment was a split plot design within three replicates, in this study, three concentrations of humic acid were used (0, 25 and 59 mg/litter), and three cultivars of summer squash which were (Alexandria F1, Khatoon F1 and Ardendo174 F1). The data was recorded on: fresh and dry weight /plant, number of male, female flowers, sex ratio, length, diameter, weight of fruit , number of fruit/plant and total yield/hectare. The results showed that the concentration at 50 mg/ litter of humic acid gave a significant increase in fresh, dry weight /plant , fruit length, number of fruits /plant and total yield, the cultivar Ardendo 174 F1 gave a significant increase in most traits except the sex ratio and fruit diameter, and the interaction between the 50mlg/l liter of humic acid and cultivar Ardendo 174 F1 gave a significant increase in fresh, dry weight /plant , female flower /plant , number of fruit /plant and total yield/hectare. The results showed that there was higher positive phenotypic correlation coefficient between the total yield /hectare, fruit weight with most traits (Kamal B. E., 2017).

A field experiment was conducted in 2007-2008 winter season to study the effect of humic(HA) and amino acids (AA) and their interactions on growth, chemical composition, chlorophyll content and chocolate spot and rust diseases of faba bean plants. All morphological (plant height, no of branches and leaves

plant-1) and yield components (no of pods/plant and weight of 100 seed) as well as macronutrients content (N, P, K in seeds and straw) and chlorophyll content significantly increased by the application of HA (2000 ppm) interacted with AA (2000 ppm). On the other hand, number of seedspod-1 did not significant effected. The maximum reduction of disease severity of chocolate spot at 55 days from planting was recorded with the interaction between HA at1000 ppm + AA at 1000 ppm then HA at 1000 ppm, while, at 75 days the maximum reduction in both disease severity and disease incidence occurred by AA at 3000 ppm followed by the treatment of HA at 1000 ppm. HA at 3000 ppm followed by the interaction between HA 1000 and AA 1000 ppm then the treatment with HA 2000 ppm were the most effective in reducing rust disease severity of faba bean plant. The study under these application recommended using HA and AA as foliar application to improve growth and mineral content as well as decreasing the damage of chocolate spot and rust diseases of faba bean, in addition the advantages as environmental safety and coast effective (El-Ghamry *et al.*2009).

Humic acids are heterogeneous, which include in the same macromolecule, hydrophilic acidic functional groups and hydrophobic groups. A distinction on the effects of HAs should be made between indirect and direct effects on plants growth. Under water stress, foliar fertilization with humic molecules increased leaf water retention and the photosynthetic and antioxidant metabolism. Several studies showed that humic acid increase root length, root number and root branching. Stimulation of root growth is generally more apparent than shoot growth (Fahramand *et al*., 2014).

Karakurt *et. al*., (2009) studied that Pepper plants were treated with soil and foliar HA applications at various concentrations (0 ml/l, 10 ml/l, 20 ml/l, 30 ml/l, and 40 ml/l). Starting four weeks after planting HA was applied via spraying and/or drenching to the plant root area three times during the growth period at 15-day intervals. HA treatments had no significant effect on fruit firmness, fruit length, or diameter. Total and reducing sugar contents significantly increased in response to both foliar and soil HA treatments.

Moreover, HA application significantly influenced total chlorophyll content and this effect was mainly on chlorophyll b content. Foliar 20 ml/l and soil 20 ml/l HA application resulted in the highest total chlorophyll content. Foliar and soil HA applications also led to significantly higher mean fruit weight, and early and total yield than for control. The study demonstrates that both soil and foliar HA treatment might successfully be used to obtain higher fruit yield and can significantly enhance fruit quality in organically grown pepper.

Khaled (2011) conducted an experiment to study the effects were investigated of salinity, foliar and soil applications of humic substances on the growth and mineral nutrients uptake of Corn and the comparison was carried out of the soil and foliar applications of humic acid treatments at different NaCl Sodium chloride. The application doses of solid humus were 0, 2 and 4 g/kg and those of liquid humic acids were 0, 0.1 and 0.2%. Salinity negatively affected the growth of corn; it also decreased the dry weight and the uptake of nutrient elements except for Na and Mn. Soil application of humus increased the N uptake of corn while foliar application of humic acids increased the uptake of P, K, Mg, Na, Cu and Zn. Although the effect of interaction between salt and soil humus application was found statistically significant, the interaction effect between salt and foliar humic acids treatment was not found significant. Under salt stress, the first doses of both soil and foliar application of humic substances increased the uptake of nutrients.

Moraditochaee (2012) studied the effects of humic acid foliar spraying and nitrogen fertilizer management on yield and yield components of peanut (Arachishypogaea L.). An experiment in factorial format based on randomized complete block design with three replications, during 2011 year in Astaneh Ashrafiyeh (north of Iran) was conducted. Factors of experiment includes two levels of foliar humic acid spraying (H1: 0 (control) and H2: 40 mg/l) and four levels of nitrogen fertilizer levels consist of (n1: 0 (control), n2: 25 kg/ha, n3: 50 kg/ha, n4: 75 kg/ha pure nitrogen from source of urea). Inmaturity time, seed yield, straw yield, biological yield and harvest index were measured. Effects of humic acid foliar spraying and nitrogen management on all traits

were significant at 1% probability level. Interaction effect of humic acid and nitrogen management on seed yield, straw yield and harvest index showed significant differences at 5% probability level.

An experiment was conducted in siltyclay loam soil at the Research Farm of NWFP Agricultural University Peshawar during 2003 to evaluate the influence of different levels of HA applied by different methods on the yield and yield components of maize (Zea mays. L. Kissan). HA at the rate of 200 and 300 g ha -1 were applied by three different methods i.e. soil mixing (broadcast), band placement and soil spray along with basal dose of NPK as 120, 90 and 60 kg ha-1,respectively, replicated four times in RCB design. The addition of 200 gha-1 HA applied as soil spray caused significant (P less than 0.05)increases of 28 % in grain yield (4508 kg ha- 1), 23 % in total dry matter yield (10793 kg ha-1) and 25 % in total cobs weight (5509 kg ha-1) as compared to control (added no HA). Number of grains per cob, 1000-grainweight, stover yield and number of cobs ha-1 increased non-significantlywith different levels of HA applied by different methods. Soil organicmatter was slightly increased while a decreasing trend was recorded in soil pH values. Soil P concentration improved significantly (P less than 0.05) by the addition of 200 and 300 g ha-1 HA applied as broadcast whereas plant P accumulation was not significantly increased over control. Soil N concentration and plant N accumulation significantly (P lessthan 0.05) increased over control (Sarir *et. al*., 2005).

Ferrara and Brunetti (2010) was applied HA to increase productivity and quality of Superior seedless table grape and toachieve this aim an experiment was conducted on 11 years old Superior seedless grapevine grown in a private vineyard at Belbees, Sharkia governorate, Egypt in 2014 and 2015. Four treatment were carried out control without HA fertilization, T_1 fertilization once by HA first February; (T_2) fertilization twice with HA first and mid-February and (T_3) fertilization four times with a HA first and mid-February, first and mid-March. Productivity indicators such as hypothetic yield, bunch weight, bunch diameter, bunch length, number of berries per bunch and qualitative indicators such as size and weight of juice, total soluble solids

(TSS), total acidity, and TSS/acid ratio were measured. All productivity parameters indicated a significant increase in vines fertilized by HA compared with control vines in both 2014 and 2015.

Ayas and Gulser (2005) conducted an experiment to determine the effects of sulphe and humic acid on yield component and nutrient content on spinach. Different doses of sulpher (0, 125, 250 and 375 gm^{-2}) and humic acid (0, 10, 20 and 30 gm^{-2}) were incorporated into soil. The application of humic acid increased total yield of spinach and did not affect K, Ca and Mg content in plants statistically.

Ahmad *et. al*. (2011) conducted an experiment to compare the growth and yield of five promising cut rose (*Rosa hybrid* L.) cultivars in twoproduction systems viz. greenhouse and field under agro-ecological conditions of Faisalabad, Pakistan on all the plant growth parameters. Among cultivars, Rosy Cheeks and Whisky Mac had vigorous vegetative growth while Amalia and Anjlique produced higher flower yield of best quality than other cultivars compared in the study. Therefore, Amalia and Anjlique are preferred cultivars for commercial production than Rosy Cheeks, Whisky Mac and Kardinal.

An experiment was conducted to evaluate the comparative performance of 11 tomato cultivars in the Northern Areas of Pakistan during 2003. It was found that all parameters showed significant differences among the various cultivars under the trial. Maximum days to first picking (96.40) were recordedin cultivar Local round followed by Shalkot (95.25 days) while Rio grande gave the earliest fruit maturity (82.40 days). Cultivar Local round also showed maximum plant height (110.50 cm), number of branches per plant (10.77) and fruits per plant (98.30) followed by Shalkot, Nagina and Peto-mech-II with 58.47, 51.33 and 46.15 fruits per plant, respectively. The lowest number of fruits per plant (29.47) was found in Nemadina. Cultivar Shalkot attained maximum fruit weight per plant (3.03 kg), fresh fruit yield (68.36 t ha^{-1}) and dry fruit yield (4.49 t ha^{-1}) while cultivar Local round gave the lowest fruit weight per plant (0.83 kg), fresh fruit yield (20.30 t ha^{-1}) and dry fruit (1.01 t ha^{-1})yield (Fayaz et al., 2007).

Investigation were undertaken to study "Evaluation of various cultivars for quality and yield of tomato (*Lycopersicon esculentum* Mill.) under agro climatic condition of Peshawar" an experiment was conducted at Agriculture Research Institute Tarnab (ARI) Peshawar during 2013-14. The experiment was laid out in Randomized Complete Block Design (RCBD) with having three replications. Roma, Money Maker, Super Stone, Super Classic and Bambino cultivars of tomato was evaluated during experiment. The parameters selected under study i.e. Plant height (cm), number of branches plant-1, average fruits weight (g), number of fruits plant-1, yield (t/ha), TSS, Ascorbic Acid (mg/100g) and Acidity (%). All the parameters were found significantly different among various cultivars. The results shows that maximum plant height(137.37 cm), number of branches plant-1 (4.71) and number of fruits plant-1 (137.47) was recorded in Cv. Money Maker, whereas maximum average fruit weight (80.78g), Ascorbic Acid (16.53mg/100g) and yield (23.31 T ha-1) was noted in Cv. Roma. (Gabal, 1985).

Hossain (2001)conducted an experiment was carried out at the field laboratory of Horticulture Department, BAU during the winter season from October 2013 to March 2014 with a view to evaluate fruit and seed production potentiality of tomato genotypes. Eight tomato genotypes namely C-11, C-21, C41, C-51, C-71, FP-5,WP-10 and HT-025 were used for this study. A remarkable variation was observed among the tomato genotypes at the seedling stage of hypocotyls color, stem length, root length and number of leaves at 1 st inflorescences of seedlings etc. The genotype C-41 produced the highest number of fruits (48.00 plant-1) but its corresponding individual fruit weight was the lowest (34.33 g). The lowest number of fruits plant-1 was harvested from the line WP-10 (22.33 plant-1), and it had the highest individual fruit weight (66.67 g). Significant variation was observed in weight of fruit plant-1. The highest fruit yield plant-1 was recorded from the genotype HT-025 (2.02 kgplant^{-1}) and the lowest was recorded from the line FP-5 (1.17 kgplant^{-1}). Corresponding hectare-1 fruit yield was the highest in HT-025 (68.68 tones) followed by the line C11 (68.0 tones). The highest number of seedsfruit^{-1} was counted from the genotype C-51

(85.42) very closely followed by C-11 (81.67). The genotype C-41 produced the lowest number of seeds (49.28 fruit^{-1}) identical to that of C-21 (51.72). The genotype HT-025 had the highest 1000-seed weight (2.90 g) which was identical to that of C-41 (2.80 g). The lowest 1000-seed weight was recorded from WP-10 (2.20 g). Seed yield plant^{-1} was varied from 3.64 g to 9.41 g. Among the genotypes, C-11 produced the maximum amount of seeds (319.94 kg ha^{-1}) and lowest seed production recorded from WP-10 (123.76 kg ha^{-1}).

Mehraj et al. (2014)conducted an experiment at Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to assess the response of foliar application of GA_3 with different concentrations to cherry tomato plants. The assessment expressed that the foliar application of 200-ppm gibberellic acid solution provided maximum number of leaves (16.7), the tallest plant (70.0 cm), early flower bud initiation (13.0 days), early flowering (16.0 days) and early fruiting (20.3 days); utmost fruit diameter (25.9 mm) and number of fruits (105.0 fruits) per plant; maximum single fruit weight (11.1 g) and total fruit weight (1.2 kg) per plant, whereas the control was the lowest.

An experiment was conducted at Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period March to October 2016 to evaluate the growth and yield characteristic of eight brinjal varieties (V1, Green Round, V2, Bankim Purple Long, V3, DebjhuriHajari, V4, Black Magic, V5, Muktojhuri, V6, Green Express, V7, Black Boy, V8, Tal Begun). The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. Significant variations were found within the varieties. The highest plant height (60.7 cm), number of branches plant^{-1} (8.3), number of leaves plant^{-1} (77.0), maximum individual leaf area (200.0 cm^2) number of flowers plant^{-1} (41.0), largest fruit size (185.7 cm^2), and maximum fruit yield (47.1 t ha^{-1}) were observed in variety Green Express (V6), giving it superiority over all other varieties (Rahul *et. al*., 2017).

Uddin *et. al*. (2017) studied the potentiality of trichoderma as consistent plant growth stimulators of strawberry at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during January 2015 to April 2015.Four

concentrations of trichoderma, viz. T_0, control; T_1, 100 g/m^2; T_2, 200 g/m^2 and T_3, 300 g/m^2 were applied in randomized completely block design with four replications. Number of runner, number of stolon, chlorophyll percentage, plant survival percentage (%), number of fruits/plant, fruit length (mm) , fruit diameter (mm), fruit weight (g), total fruit weight (g/plant) were showed significant variation among all treatments. Results showed that the highest fruit yield/plant found in T_1 (702.9.0 g), whereas minimum (220.05g) from T_2. Rate of survival ability of strawberry plants observed the highest (79.5) in T_1 (100 g/m^2) and the lowest (42.7) was in control.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the winter season. It was a pot experiment on Tomato varieties under saline condition to identify the growth, yield & quality of tomato imposing different humic acid treatment. In this chapter the interpretation of different materials used and the methodology followed during the experimental period are explained below:

3.1 Experimental Location

The research was conducted in the "Field Laboratory of Plant Stress Management" at Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka-1207 during the Rabi (winter) season from mid October 2016 to February 2017. The experimental field is located at 23°77′ N latitude and 90°37′ E longitudes at a height of 8.5 meters above the sea level.

3.2 Properties of soil that used in pot

Soil was collected from Dhaleshwari river bank, Hemayetpur, Savar which was alluvial in nature. The main features of the soil of my experiment were examined. The soil texture was sandy clay loam. The soil P^H was 6.1 and electrical conductivity (EC) 2.0 dS/m. (Appendix I)

3.3 Weather and Climatic conditions

The experimental site is located in the sub-tropical monsoon climate belt and it is characterized by heavy rainfall during the months of April to September and exiguous rainfall during the remainder of the year. The crop was grown in Rabi season when the day length (sunshine period) is ranged from 9.5-11.5 hours/ day. Temperature during the growing season ranged between 14.25°C and 33.45° C with normally 55.20 - 89.70 % humidity in the air.

3.4 Planting materials

3.4.1 Tomato Variety

Three tomato varieties viz. V_1-BARI Tomato 8, V_2-BARI Tomato 14, V_3-BINA Tomato 4 were used as the planting materials.

The seeds of the experimental varieties were collected from "Horticultural Biotechnology and stress management Laboratory", M.A. Wajed Miah Research Centre, SAU. The seeds were disease free, vigorous, well ripen and free from other crop seeds and inert substances.

3.4.2 Chemicals

Sodium Chloride (NaCl) and humic acid ($C_{187}H_{186}O_{89}N_9S_1$) were used for experimental material.

3.5 Preparation of soil and filling of pots

A total of 81 plastic pots were prepared with 9.5 kg well air dried soil. The size of the pot was 30 cm top diameter with a height of 25 cm. Thus, the surface area of an individual pot was 706.5sq. cm. Plant parts, plant residues, inert substances, different types of insects and pests were dispelled from soil by sieving. Collected soil was dried under the sun. The dry soil was thoroughly mixed with well rotten cow dung and fertilizers before filling the pots. The pots were placed in the net house.

3.6 Experimental design

The soil salinity level was fixed to 8 dS/m for all the pots. The experiment was set up in a two factor completely randomized design (CRD) with three replications. Thus 81 experimental pots were placed in "Field Laboratory of Plant Stress Management." The salinity in irrigation water was developed by providing required amounts of NaCl salt in irrigation water as per the procedure of BARI.

3.7 Experimental Treatments

The experiment consisted of two factors. These are:

Factor A: Tomato Variety

V_1 = BARI Tomato 8

V_2 = BARI Tomato 14

V_3 = BINA Tomato 4

Factor B:

Humic Acid

H_0 = No Humic Acid (Control)

H_1 = 50 ppm soil+50 ppm foliar spray

H_2 = 100 ppm soil+ 100 ppm foliar spray

3.8 Soil salinity level

Average salinity level 8 dS/m was maintained in all the pots. For keeping up soil salinity, 80 millimoles of NaCl containing water was applied in the soil.

3.9 Determination of salinity treatments

First application of salt water in the soil was applied 30 days after seedling transplanting. After first application, the rest t two application of salt water was applied in 15 days interim. The developed irrigation water salinity and pot soil were measured by using an EC (electrical conductivity) meter (HANNA HI 993310, Direct Salinity Meter). which is expressed in dS/m.

3.10 Preparation of salt solution Humic acid solution

Saline water was synthesized by using Emplura Sodium Chloride. 4.68 g of salt was dissolved in 1-liter tap water to prepare the salt solution. The salinity level of the salt solution was 8 dS/m. 50 mg humic acid in 1L water and 100 mg in 1L makes 50 ppm and 100 ppm humic acid solution respectively.

3.11 Application of saline water to plant

Saline water was applied to the plant as irrigation. 500 ml of well-prepared saline water was supplied to every pot.

3.12 Application of fertilizer in the pot

The required amount of fertilizers (N,P,K,S,Zn,B) and manure (cow dung @ 10 t/ha) was estimated on the basis of initial soil test result following Fertilizer Recommendation Guide (BARC, 2012). As per such recommendation urea 28g, triple super phosphate (TSP) 12g, murate of potash (MP) 6.64 g and 400 g cowdung per pot was applied. One third of urea and entire amount of cow dung, TSP, MoP were mixed with the soil in each pot before sowing.

3.13 Sowing the seeds

The seeds of three tomato varieties were sown on the October 2016 by hand in three different seed bed to raise the seedling. Proper care was taken for the growth & development of healthy seedlings.

3.14 Transplanting the seedling

Healthy & vigorous 25 days old tomato seedlings were uprooted carefully from the seed beds. The seedlings were watered before uprooting so as to reduce damage of roots. Two seedlings were transplanted to each experimental pot in the afternoon during the November 2016. Mild irrigation was given immediately after transplanting by using water can. One weal seedling was uprooted leaving one healthy seedling in each pot after seedling establishment.

3.15 Intercultural operations

Proper intercultural operations were done for better growth and development of tomato plants in pots. Necessary weeding and mulching were accomplished as and when necessary to keep the crop free from weeds, better soil aeration and to break the soil crust.

Staking

At pre-flowering stage, the juvenile plants were stalked with bamboo sticks to keep them erect and to protect from damage caused by storm and strong wind. The plants were tied by plastic ropes to the stems with bamboo slices which are hung above them.

Weeding

The experimental pots were kept under careful observation. Weeding was done on when it necessary.

Irrigation

Immediately after transplanting, light irrigation to the individual pot was provided to overcome water deficit. After establishment of seedlings, each pot

was watered in alternate days to keep the soil moist for normal growth and development of the plants. During pre-flowering stage, irrigation was done with saline water as per treatments twice at 45 and 60 DAS. Thereafter, no irrigation was given. However, water was sprayed over the foliage at regular intervals up to 85 DAS.

3.16 Plant protection measures

Plant protection measures were done whenever it was necessary.

Insect pests

As a control measure against as the insect pest Malathion 57 EC was applied @ 2 ml/l. To prevent plants from fungal infection, Autobac 20WP was applied @ $2g1L^{1}$ at the early stage of tomato (Hossain, 2001).

Diseases

Autobac 20WP was applied @ 2 g/l at the early stage against late blight of tomato (Hossain, 2001).

3.17 Harvesting the fruits

Fruits were harvested during early ripening stage when they attained yellow to red color. Harvesting was started on 10 February 2017 and completed by 30 March, 2017.

3.18 Parameter Studied:

Data on the following parameters were recorded:

3.18.1Measurement of morphological characters

1. Plant height (cm)
2. Number of leaves/Plant
3. Number of branches/Plant
4. Leaf area (cm^2)
5. Length of internode (cm)
6. Stem diameter(cm)

3.18.2Measurement of yield and yield contributing characters

1. Number of flower cluster/plant
2. Number of fruits/plant
3. Individual fruit weight (g)
4. Fruit length (cm)
5. Fruit diameter (cm)
6. Total fruit yield/plant (g)

3.18.3Measurements of Quality parameters

1. Chlorophyll content (SPAD value)
2. Vitamin C content (mg)
3. Carotenoid content (mg)
4. TSS (Total soluble solids)

Measurement of morphological Characters

Plant height (cm)

Plant heights were measured in centimeter (cm) from the ground level to the tip of the longest stem at final harvest.

Number of branches per plant

The branch number of individual plants was counted and the average number of branch per plant was calculated.

Number of leaves per plant

The leaf number of individual plants was counted and the average number of leaves per plant was calculated.

Length of internode

The length of internodes of individual plants were measured at the 60 days after transplanting. A meter scale used for estimating the length of internodes and expressed in centimeter (cm). Average data was used for statistical analysis.

Leaf area (cm^2)

Leaf area was measured with leaf area meter (Model–CI-202, CID. Inc. USA) and expressed in cm^2. Sample leaves were collected with a sharp knife from the middle and upper portion of plant and submitted in the device.

Stem diameter (cm)

The stem diameter of individual plant was measured at the 60 days after transplanting. A slide calipers used for estimating the stem diameter and expressed in centimeter (cm).

Measurement of yield contributing characters

Number of flower cluster/plant

The number of flower cluster of individual plant was recorded and the average number of clusters was recorded.

Number of fruits cluster/plant

The number of fruit cluster of individual plant was recorded and the average number of clusters was recorded.

Number of fruits per plant

The number of fruits of individual plant was recorded and the average number of fruits was recorded.

Individual fruits weight (g)

The fresh weight of individual fruits of from individual plant was recorded by an electric balance and the mean value was calculated.

Fruit length (cm)

Fruit length was measured in centimeter (cm) after harvest of matured tomato fruit.

Fruit diameter (cm)

Fruit diameter was measured in centimeter (cm) after harvest of matured tomato fruit.

Fruit yield/plant

The average fruits weight of in individual plant was recorded by an electric balance and then the fruit yield was calculated.

Measurement of growth and fruit quality parameters

Chlorophyll contents (SPAD value)

Leaf chlorophyll content as SPAD values were measured from the tender fully-expanded leaf in the third position from the tip by a portable chlorophyll meter (SPAD-502, Konica Minolta, Japan). The SPAD-502 chlorophyll meter can mesure total chlorophyll amounts in the leaves of a variety of species with a higher degree of accuracy and is a nondeleterious method. SPAD was recorded at flowering stage and 30 days after flowering.

Measurement of Vitamin-C

Oxidation Reduction Titration method was used for determination of vitamin-c in ripen tomato juice. Extract of tomato fruit juice was used for determination of Vitamin-C content in per 100g of tomato sample. It has expressed as mg Vitamin-C per 100gm of tomato. Tomato juice was prepared by blender and the volume was made with meta phosphoric acid up to 100 ml. 5 ml of standard L-ascorbic solution was taken in a conical flask. Then it was titrated with 2, 6 dichlorophenol indophenol taken in a burette. The end point was reached when the pink color lasts 10 seconds. Similarly, 5 ml of tomato juice was titrated with dye. It was measured in "Horticultural Biotechnology and Stress Management Laboratory," M.A.Wajed Miah Research Centre, SAU.

Calculation:

$$= \frac{\textbf{0.5 × mean value of unknown solution reading ×100}}{\textbf{Mean value of known solution reading ×5}}$$ %mg of L-ascorbic acid

Determination of Carotenoid Content

For determination of carotenoid, 0.1g of ripen fruit sample was collected from each tomato variety and ground with 1g of Calcium Carbonate ($CaCO_3$). Total of 25 mL of 80% acetone was added to the power and mixed evenly. The mixture was filtered by Whatman No. 1 filter paper and filtrate was collected to determine carotenoid (Harborne, 1973). The absorbance was measured at 440nm by using SP-UV 500DB Series UV-Vis Spectrophotometer to determine carotenoid content and calculated by using following this equation:

$$\text{Carotenoid Content}(\mu g/g) = \frac{A \times V(mL) \times 10^4}{A_{1cm}^{1\%} \times P(g)}$$

Measurement of total soluble solids (TSS)

Brix refractometer (Model RHB 32 ATC) was used to measure TSS. One tomato sample was collected from each of the treatment. Tomato samples were cut with the sharp knife and inside was squeeze with the needle for sample juice. A drop of tomato fruit juice was placed on the transparent glass and it was covered by the upper glass. Brix refractometer was directly showed the TSS as percentage.

Analysis of data

The data in respect of growth, yield contributing characters and growth & fruit quality parameters were statistically analyzed to find out the statistical significance of the experimental results. The means for all the treatments were calculated and the analyses of variance for all the characters were performed by F test. The analyses were done following the software SPSS. The significance of the difference among the means was evaluated by the Least Significant Difference Test (LSD) at 5% level of probability.

CHAPTER IV
RESULTS AND DISCUSSION

The mean data recorded on plant height, number of branches per plant, number of leaves, diameter of the stem, length of internode, number of flower clusters, number of flower per plant, number of fruits per plant, fruit diameter, fruit length, fruit weight, fruit yield per plant and growth and fruit quality parameters were analyzed as per the Completely Randomized Design (CRD) adopted and mean squares are presented in appendix and an overview of tomato growth performance and yield data are presented in different tables and graphs. The perusal of analysis of variance indicated that the treatments were significant for most of the parameters studied and that the humic acid treatments had significant effect on all the parameters under saline condition.

4.1 Plant height

The plant height is one of the most important factors which affect the growth and yield of tomato. Plant height is severely reduced under saline condition. humic acid has beneficial effect on plant height under saline condition.

The data on plant height of tomato plant as influenced by different level of humic acid treatments was presented in the Table 1 and Fig. 1 & 2.

Significant variation in the plant height was seen at 30 DAT, 60 DAT and 90 DAT among different varieties and humic acid treatments under saline condition. (Appendix II). Significant variation was observed by the varietal effect on plant height of tomato (Fig. 1. & Appendix II). BARI tomato 14 showed highest plant height (53.00 cm at 30 DAT, 75.22 cm at 60 DAT and 80.55 cm at 90 DAT respectively) under saline condition. Lowest plant height (41.88 cm at 30 DAT, 57.55 cm at 60 DAT and 72.22 cm at 90 DAT respectively) was recorded in BINA tomato 4 (Fig. 1).

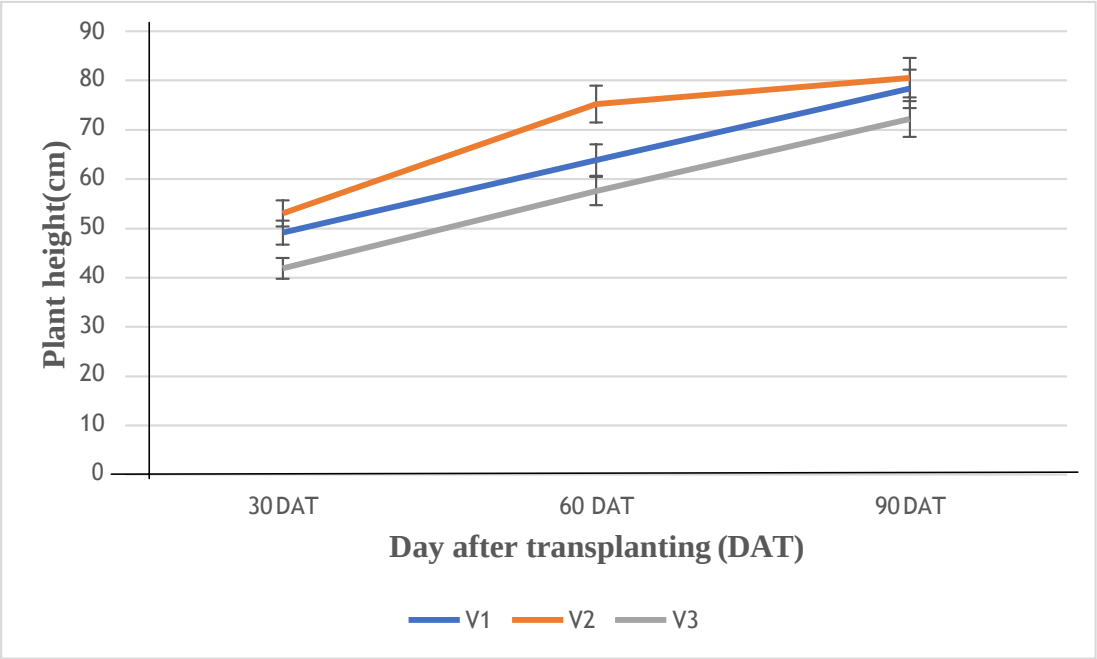

Fig. 1. Effect of different varieties on plant height under saline condition.
(V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

As influenced by different humic acid treatments a mean plant height(cm) has shown in the (Fig. 2.) at 30 DAT, 60 DAT and 90 DAT. It was highest (53.11 cm, 71.66 cm, and 84.00 cm at 30 DAT. 60 DAT & 90 DAT respectively) from H_2 (100ppm soil+100ppm foliar spray) treatment and lowest plant height (45.88 cm at 30 DAT, 60.66 cm at 60 DAT and 69.66 cm at 90 DAT respectively) was recorded from control under saline condition (Fig. 2).

The Combined effect of varieties and humic acid treatments showed significant variation on plant height. The experiment findings observed the variation among all the treatments (Table 1 & Appendix II). The highest plant height (57.66 cm, 71.00 cm and 87.33 cm at 30 DAT, 60 DAT and 90 DAT respectively) was recorded from V_2H_2 which is statistically similar with V_1H_2, V_2H_1 and the lowest plant height (38.33 cm, 52.66 cm and 64.33 cm at 30 DAT, 60 DAT and 90 DAT respectively) was achieved from V_3H_0 which was statistically similar with V_3H_1 , V_3H_2 , V_1H_0 and V_2H_0.

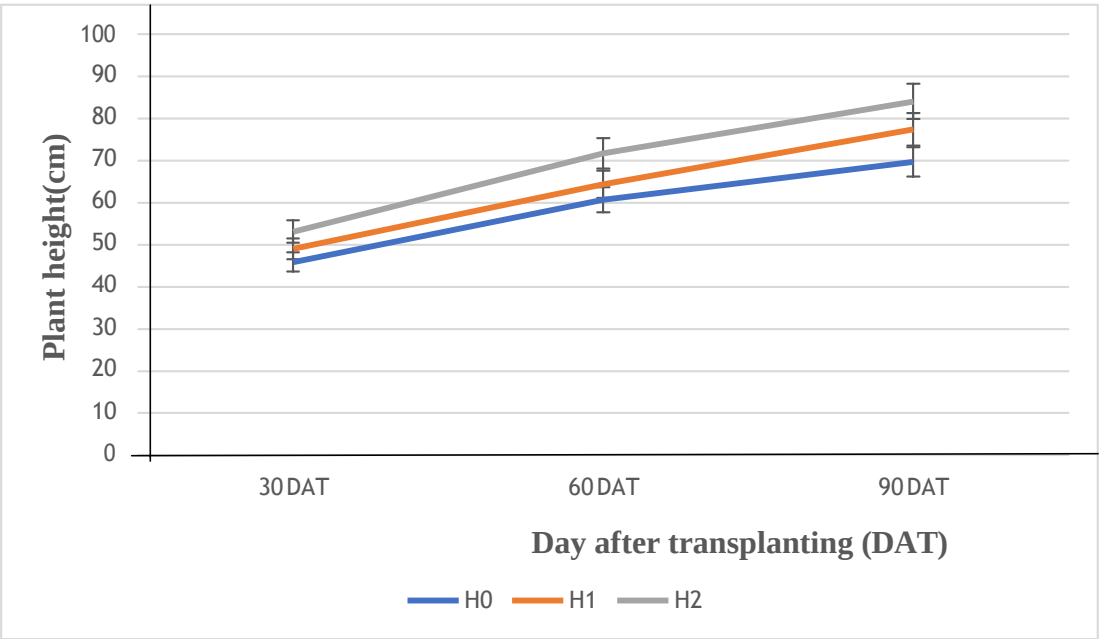

Fig. 2. Effect of different humic acid treatments on plant height under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

The expanded plant tallness impacted by humic acid treatment in the present experiment may be because of fast cell division in meristematic locale, number of cells and increment in cell prolongation because of duplication of different pieces of the plant tissue, auxin digestion, cell divider versatility and porousness of cell layer, expanding photosynthates, cell augmentation and quick cell extension because of increase of different pieces of the plant tissue, auxin digestion, cell divider pliancy and penetrability of cell film, expanding photosynthates, cell broadening and fast cell lengthening. A logically expanded upgrade with humic acid treatment was additionally revealed by Rahid, (2004). Further, Nodi and Arnoldim (1988) revealed that height could be because of overwhelming and mono hereditarily acquired characteristic. Henceforth, a positive relationship among yield and plant stature can be watched (Asi *et al*., 2015).

Table 1: Combined effect of different varieties of tomato and humic acid treatments on plant height under saline condition.

Combination	Plant Height (cm)		
	30 DAT	60 DAT	90 DAT
V_1H_0	40.33 bc	62.00 bc	76.66 b
V_1H_1	52.33 ab	64.00 b	78.66 ab
V_1H_2	55.66 ab	69.66 ab	84.33 ab
V_2H_0	48.00 bc	57.33 c	68.00 bc
V_2H_1	53.33 ab	63.33 b	79.66 ab
V_2H_2	57.66 a	71.00 a	87.33 a
V_3H_0	38.33 c	52.66 d	64.33 c
V_3H_1	41.33 bc	55.66 cd	72.00 bc
V_3H_2	46.00 bc	64.33 b	80.33 ab
LSD(0.05)	2.16	4.35	5.23
CV%	5.34	5.56	9/12

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. [DAT- Days After Transplanting, V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4, H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray]

4.2 Number of branches per plant

A significant effect of varieties under salinity stress was found on the number of branches per plant of tomato (Fig. 3 and Appendix III). The highest number of branches per plant (6.44) was found from V_2 and the lowest value (5.55) was recorded from V_3 which was statistically similar with V_1(2.33).

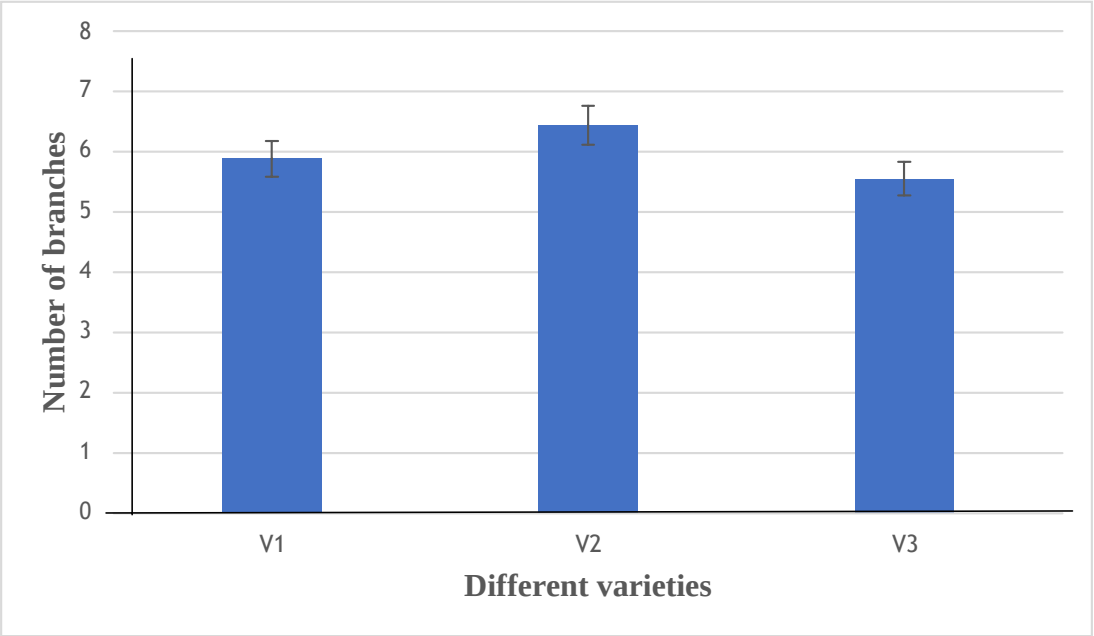

Fig. 3. Effect of different varieties on Number of branches under saline condition. (V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

Number of branches per plant of tomato was significantly affected by the different humic acid treatment under saline condition. (Fig. 4 and Appendix III). The highest number of branches p e r plant (7.88) was found from H_2. The lowest value (4.00) was recorded from H_0.

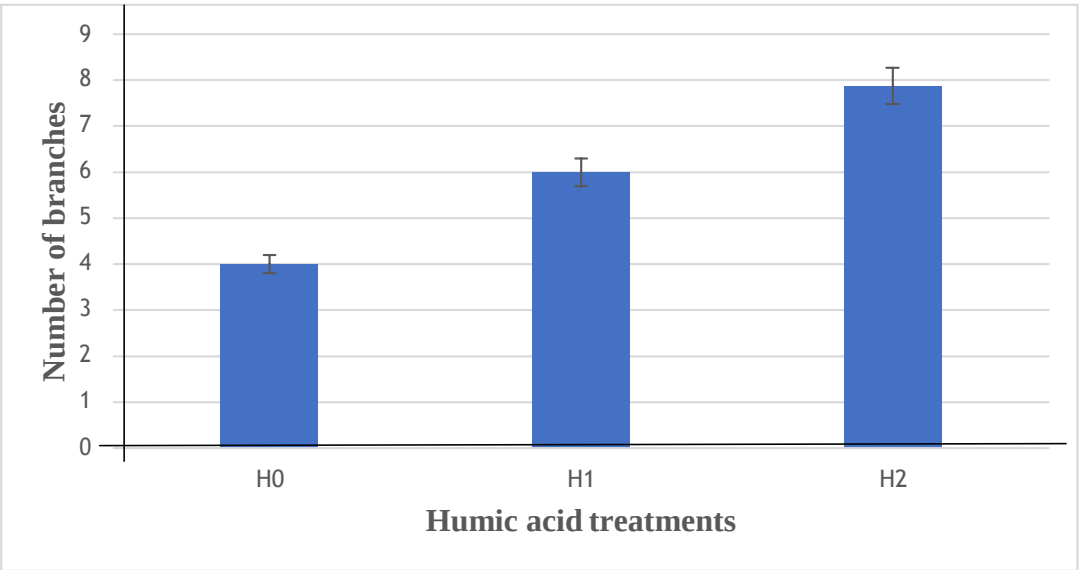

Fig. 4. Effect of different humic acid treatments on number of branches per plant under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

The Combined effect of humic acid and variety on number of branches per plant of tomato showed a significant effect. (Table 2 and Appendix III). The highest number of branches p e r plant (8.33) was found from V_2H_2. The lowest value (3.66) was found from V_1H_0. The positive impact of humic acid in improving the beneficial branches and there by expanded yield. The conceivable explanation behind this expansion could be because of a positive connection among's yield and number of essential branches per plant as revealed by Tattni *et al.* (1990) and Ahmed *et al.*(2011) or may be because of physiological improvement in the speed and consistency of seedling foundation and number of branches due to osmo-molding (Abdel Latif *et al*., 2012).

4.3 Number of leaves per plant

The leaf number is the significant character for plant development and advancement as leaf is the fundamental photosynthetic organ which has direct connection to yield of the plant.

A significant effect of variety on the number of leaves per plant of tomato was observed (Figure 5 and Appendix III). The highest number of leaves per plant (38.88) was found from V_2 and the lowest value (35.44) from V_3 which was statistically similar with V_1 (35.88)

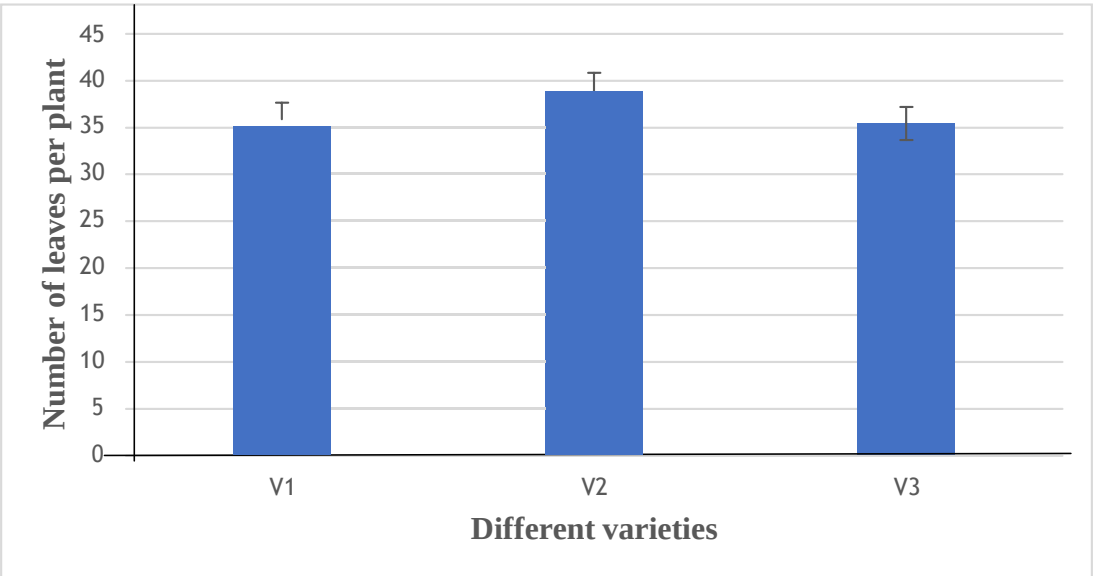

Fig. 5. Effect of different varieties on Number of leaves per plant under saline condition. (V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

The results of this experiment showed that different humic acid treatment have significant effect on number of leaves per plant of tomato. (Figure 6 and Appendix III). Maximum numbers of leaves per plant (41.44) was found from H_2 and minimum (32.11) from H_0. The finding agreed with the results of Shreedebi (2014), Number of leaves of tomato has positive relation to the humic acid.

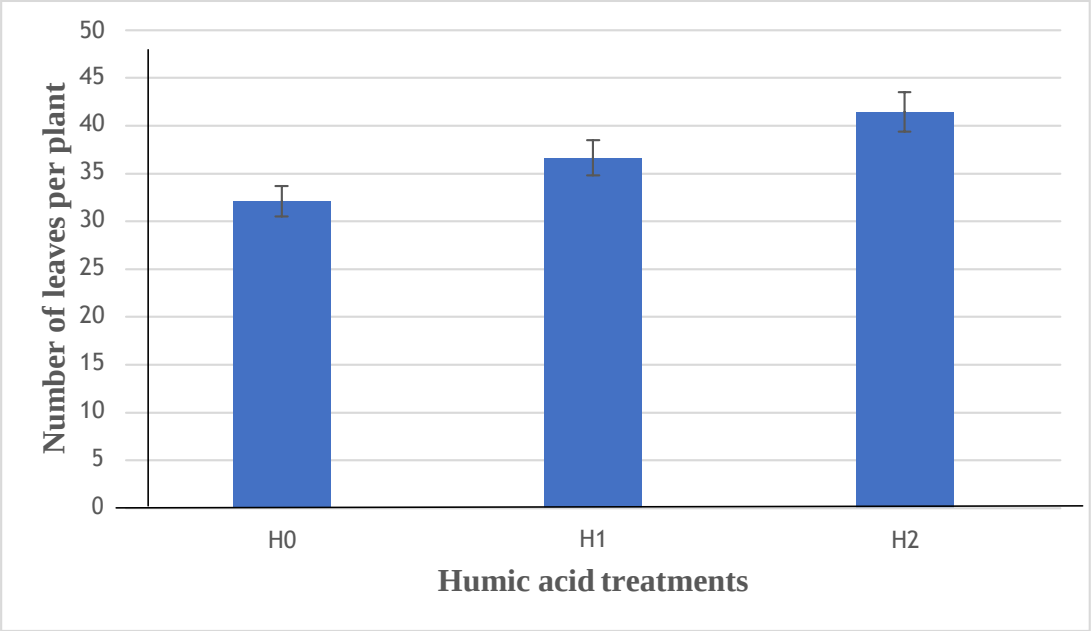

Fig. 6. Effect of different humic acid treatments on number of leaves per plant under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

The combined effect of humic acid and variety on the number of leaves per plant was significant. (Table 2 and Appendix III). The highest number of leaves pe r plant (45.00) was found from V_2H_2 and the lowest value (31.00) was observed from V_1H_0 which was statistically similar with V_3H_0 (32.00) and V_2H_0 (33.33)

4.4 Leaf area

Different varieties varied significantly on leaf area of tomato at flowering stage and 30 days after flowering (Appendix III). At flowering stage, the maximum leaf area (309.25 cm^2) was obtained from V_2 whereas the minimum leaf area (181.65 cm^2) was found from V_3. (Fig. 7).

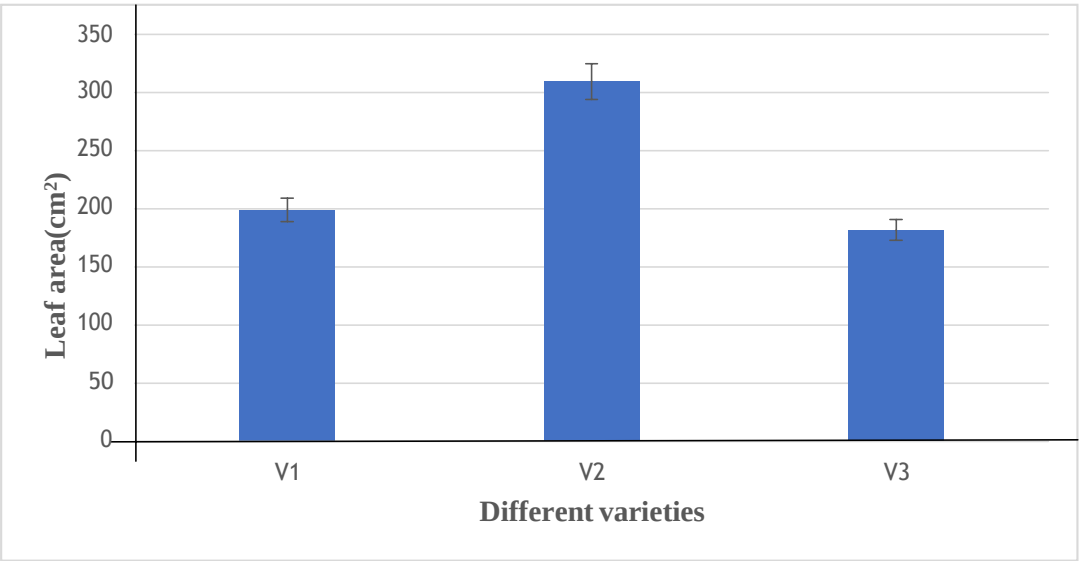

Fig 7. Effect of different varieties on Leaf area under saline condition.
(V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

Statistically significant difference was noted for leaf area due to humic acid treatment at 30 days after flowering (Appendix III). At flowering stage, the highest leaf area (262.11 cm^2) was recorded from H_2 while the lowest leaf area (198.56 cm^2) was found from H_0 (Fig. 8). Humic acid treatment effects were registered on leaf area of tomato.

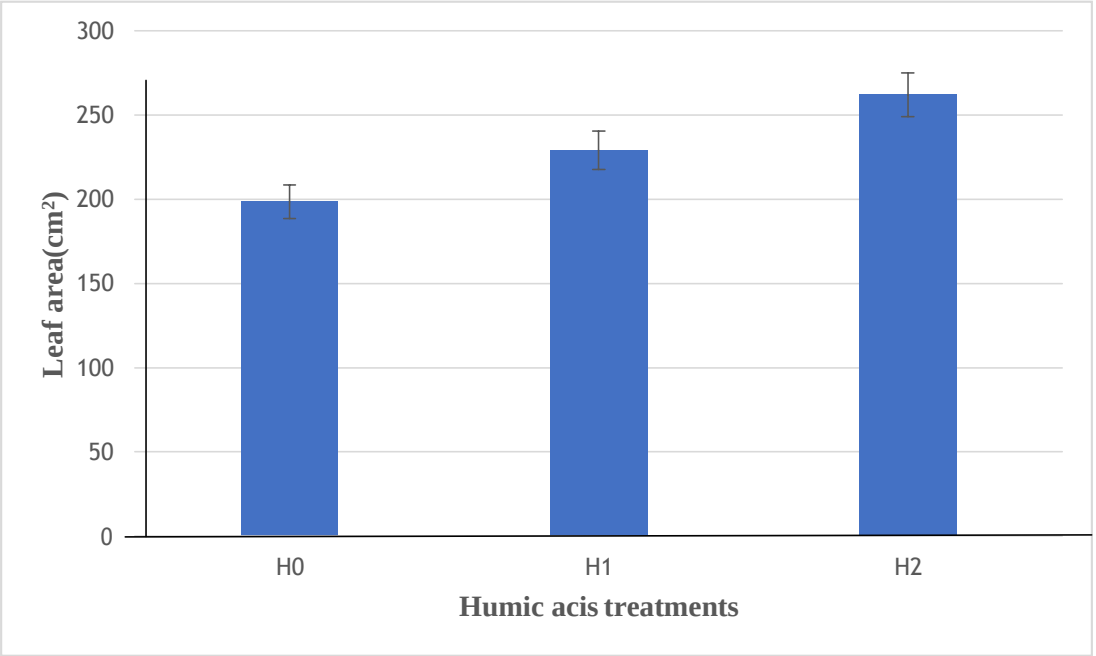

Fig. 8. Effect of different humic acid treatments on leaf area under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

Leaf area of tomato showed significant differences due to combined effect of different humic acid treatment and variety at flowering stage and 30 days after flowering (Appendix III). At flowering stage, the maximum leaf area (364.11 cm^2) was obtained from V_2H_2 treatment combination and the minimum (162.95 cm^2) from V_3H_0 treatment combination which was significantly similar to V_1H_0 (172.44 cm^2) and V_3H_1 (187.13) (Table 2).

4.5 Diameter of the stem

The diameter of the stem per plant was showed at 60 DAT among different varieties and humic acid treatments under salt stress was nonsignificant (Appendix III). Influence of variety on the diameter of the stem per plant was also observed (Fig. 9). V_2 showed the highest value (.83 cm). V_3 showed lowest value (.70 cm) which was statistically similar to V_1 (0.73 cm).

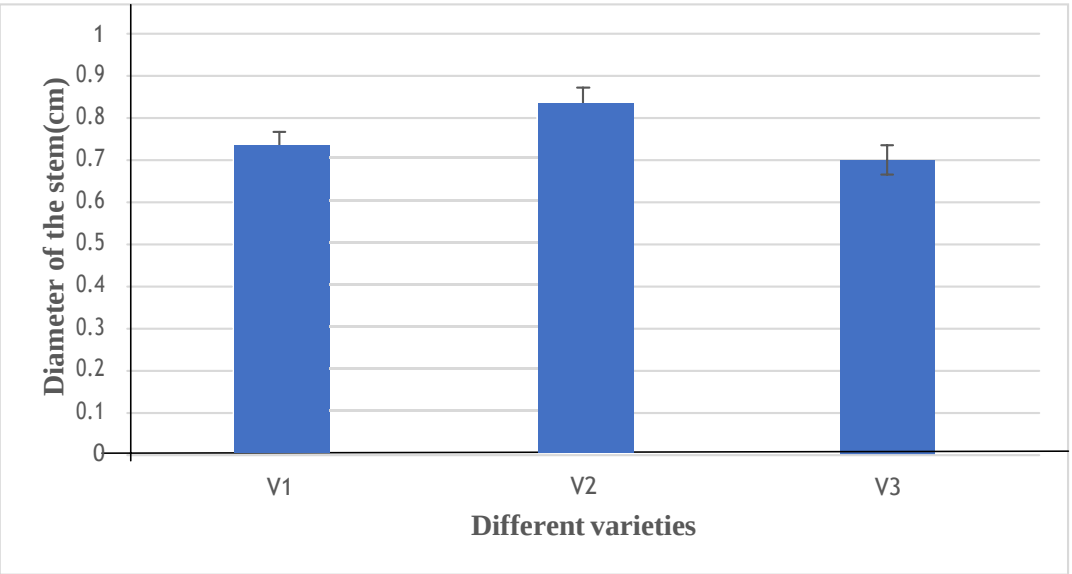

Fig. 9. Effect of different varieties on diameter of the stem under saline condition.(V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

As influenced by different humic acid treatments a mean diameter of the stem per plant (cm) has shown in the (Table 4. Appendix VI) at 60 DAT. It was highest (0.89 cm) in the NaCl humic acid (50mM) treatment with at 60 DAT. Lowest diameter of the stem per plant (0.48 cm) was recorded in control at 60 DAT under saline condition.

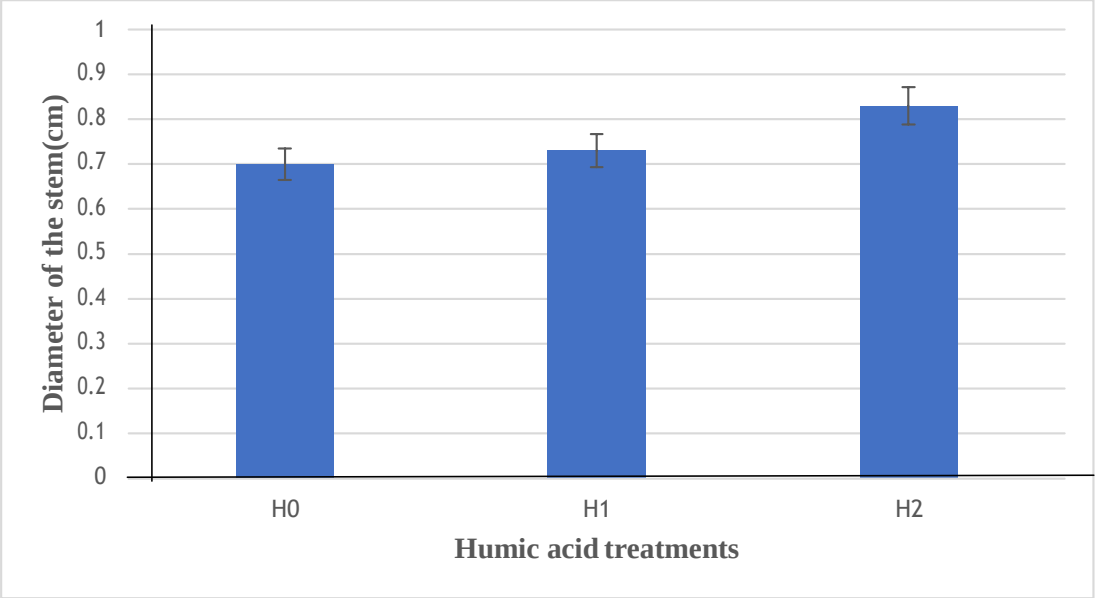

Fig. 10. Effect of different humic acid treatments on diameter of the stem under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

The Combined effect of humic acid and variety noticed nonsignificant difference on diameter of the stem per plant. The experiment results noticed the variation among all treatments (Table 2 & Appendix III). The highest diameter of the stem per plant .90 cm at 60 DAT was recorded from V_2H_2 where the lowest of diameter of the stem .60 cm at 60 DAT was achieved from V_3H_0 which was statically similar with V_1H_0 (60).

Table 2: Combined effect of different varieties of tomato and different humic acid treatments on plant growth parameters under saline condition.

Combination	Number of leaves per plant	Number of branches per plant	Leaf area (cm^2)	Diameter of the stem (cm)	Internode length per plant (cm)
V_1H_0	31.00 d	3.66 d	172.44 ef	0.60 d	3.66 d
V_1H_1	36.00 bc	6.00 bc	196.75 de	0.70 c	5.00 bc
V_1H_2	40.66 b	8.00 a	227.37 cd	0.80 b	6.33 b
V_2H_0	33.33 cd	4.33 c	260.28 bc	0.70 c	6.00 b
V_2H_1	38.33 b	6.66 bc	303.37 b	0.80 b	8.00 ab
V_2H_2	45.00 a	8.33 a	364.11 a	0.90 a	10.33 a
V_3H_0	32.00 d	4.00 c	162.95 f	0.60 d	3.33 d
V_3H_1	35.66 c	5.33 cd	187.13 ef	0.70 c	4.00 cd
V_3H_2	38.66 b	7.33 ab	194.87 de	0.80 b	6.33 b
LSD(0.05)	3.23	1.45	7.46	0.05	1.78
CV%	4.34	2.67	12.79	1.09	2.98

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. [DAT- Days After Transplanting, V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4, H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray]

4.6 Length of internode

Significant variation in the length of internode per plant was observed at 60 DAT among different varieties and humic acid under salt stress (Appendix III). Influence of variety on the length of internode per plant was also observed (Fig. 11). V_2 observed the highest value (8.11 cm) and lowest value found from V_3 (4.55 cm) which was statistically similar with V_1 (5.00 cm).

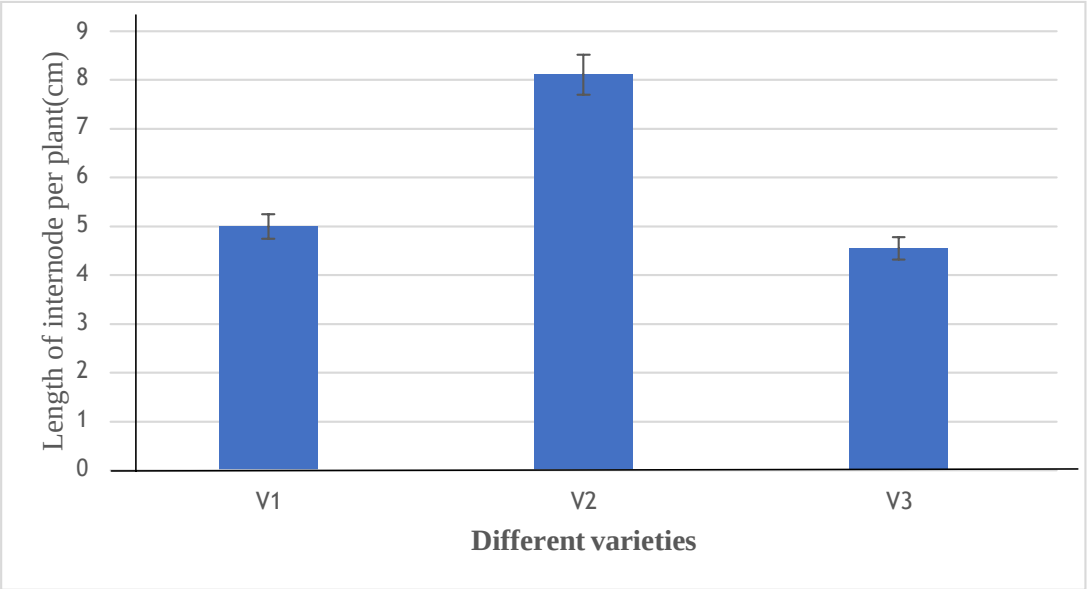

Fig 11. Effect of different varieties on the length of internode per plant under saline condition. (V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

As influenced by different humic acid treatments a mean length of internode per plant (cm) has shown in the (Fig. 12. Appendix III) at 60 DAT. It was highest in H_2 treatment with 7.66 cm at 60 DAT. Lowest length of internode per plant was recorded in control i.e., 4.33 cm at 60 DAT under salt stress.

The Combined effect of humic acid and variety showed significant variation on length of internode per plant. The experiment results noticed the variation among all treatments (Table 2 & Appendix III). The highest length of internode per plant 10.33 cm at 60 DAT was recorded from V_2H_2 which was statistically similar with V_2H_1 (8.00cm) where the lowest length of internode (3.33 cm) at 60 DAT was achieved from V_3H_0 which was statically similar with V_1H_0 (3.66 cm).

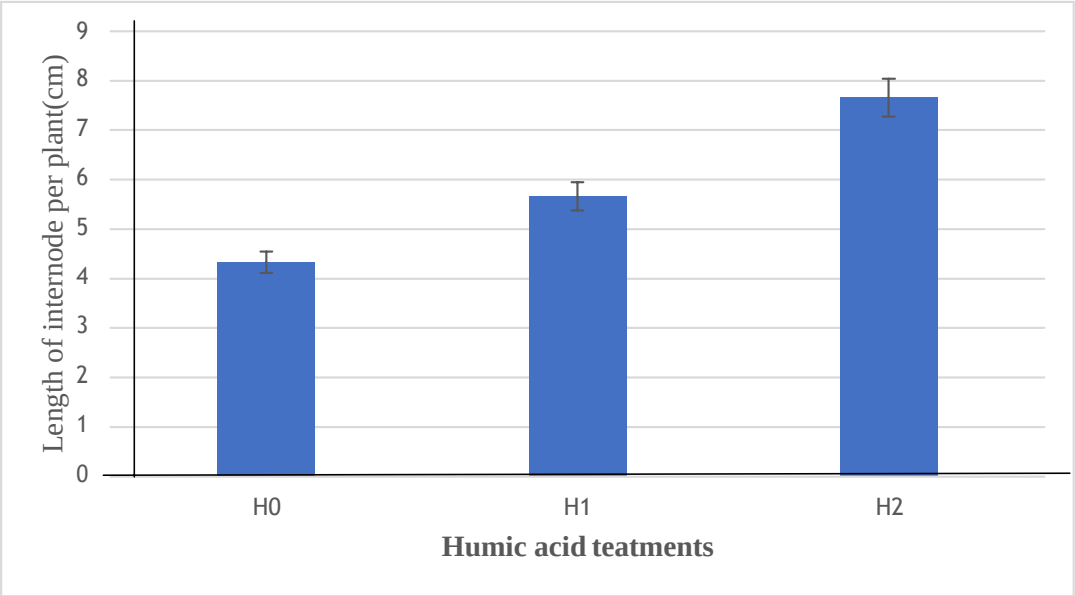

Fig. 12. Effect of different humic acid treatments on the length of internode per plant under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

4.7 Number of flower cluster per plant

Different varieties showed significant differences on number of flower cluster per plant of tomato (Appendix IV). The highest number of flower cluster per plant (16.00) was recorded from V_2 and lowest result found from (13.44) V_3 (Table 3).

Different humic acid treatments under salt stress significantly in terms of number of flower cluster per plant of tomato (Appendix IV). Data revealed that the highest number of flower cluster per plant (16.88) was found from H_2 while the lowest number (13.11) was recorded from H_0 (Table 4).

Combined effect of different humic acid treatments and variety showed significant differences on number of flower cluster per plant (Appendix IV). The highest number of flower cluster per plant (18.66) was observed from V_2H_2 treatment combination, while the lowest number (12.00) was attained from V_3H_0 treatment combination which was statistically similar with V_1H_0 (13.33),V_1H_1 (14.66), V_2H_0 (14.00) and V_3H_1 (13.33)(Table 5).

Table 3. Effect of different varieties of tomato on yield related parameters under saline condition.

Variety	Number of flower cluster per plant	Number of flowers per plant	Number of fruits per plant
V_1	14.00 b	60.66 b	48.11 b
V_2	16.00 a	73.77 a	63.22 a
V_3	13.44 c	52.33 c	42.66 c
LSD(0.05)	1.57	4.23	3.89
CV%	2.89	8.90	7.14

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4

4.8 Number of flowers per plant

Number of fruits per plant of tomato showed statistically significant difference due to different varieties (Appendix IV). The highest number of fruits per plant (73.77) was recorded from V_2 and the lowest number (52.33) was recorded from V_3. (Table 3).

Significant variation was recorded in terms of number of fruits per plant of tomato due to different humic acid treatment under salt stress (Appendix IV).The highest number of fruits per plant (74.44) was recorded from H_2 whereas the lowest number (48.88) was found from H_0 (Table 4).

Combined effect of different humic acid treatments and varieties observed significant variation on number of fruits per plant (Appendix IV). The highest number of fruits per plant (84.66) was observed from V_2H_2 treatment combination, whereas the lowest number (40.00) was attained from V_3H_0 treatment combination which was statistically similar to V_1P_0 (44.00) (Table 5). Similarly, significant positive association of this trait with yield was reported by Asri *et al.*(2015).

Table 4. Effect of different humic acid acid treatments on yield related parameters of tomato under saline condition.

Humic Acid treatment	Number of flower cluster per plant	Number of flowers per plant	Number of fruits per plant
H_0	13.11 c	48.88 c	38.88 c
H_1	14.44 b	63.44 b	51.77 b
H_2	16.88 a	74.44 a	63.33 a
LSD(0.05)	1.67	5.90	6.78
CV%	2.13	7.34	12.89

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. [H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray]

4.9 Number of fruits per plant

Number of fruits per plant of tomato showed statistically significant difference due to different varieties (Appendix IV). The highest number of fruits per plant (63.22) was recorded from V_2 and the lowest number (42.66) was recorded from V_3. (Table 3).

Significant variation was recorded in terms of number of fruits per plant of tomato due to different humic acid treatment under salt stress (Appendix IV). The highest number of fruits per plant (63.33) was recorded from H_2 whereas the lowest number (38.88) was found from H_0 (Table 4).

Combined effect of different humic acid treatment and varieties noted significant variation on number of fruits per plant (Appendix IV). The highest number of fruits per plant (75.00) was observed from V_2H_2 treatment combination, whereas the lowest number (31.33) was obtained from V_3H_0 treatment combination which was statistically similar to V_1H_0 (33.33) (Table 5). Similarly, significant positive association of this trait with yield was reported by Nandapuri *et al.* (1973) and Ahmed *et al*. (1988).

Table 5. Combined effect of different varieties of tomato and different humic acid treatments on yield related parameters under saline condition.

Combination	Number of flower cluster per plant	Number of flowers per plant	Number of fruits per plant
V_1H_0	13.33 d	74.00 e	33.33 ef
V_1H_1	14.66 cd	92.00 c	49.00 d
V_1H_2	17.00 ab	106.00 b	62.00 b
V_2H_0	14.00 cd	92.66 c	52.00 cd
V_2H_1	14.33 bc	104.00 b	62.66 b
V_2H_2	18.66 a	124.66 a	75.00 a
V_3H_0	12.00 d	70.00 e	31.33 f
V_3H_1	13.33 cd	84.33 d	43.66 de
V_3H_2	14.00 bc	92.66 c	53.00 c
LSD(0.05)	1.45	5.36	4.32
CV%	2.89	9.46	9.67

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. [V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4, H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray]

4.10 Individual fruit weight

Different varieties under salt stress showed significant differences on individual fruit weight of tomato (Appendix V). The highest individual fruit weight (55.44 g) was attained from V_2 whereas the individual fruit weight (44.55 g) was recorded from V_3 which was statistically similar with V_1(46.11) (Table 6).

The individual fruit weight of tomato had a significant influence due to the humic acid treatment (Appendix V). The maximum individual fruit weight (54.00 g) was recorded from H_2. On the other hand, the minimum individual fruit weight (44.00 g) was recorded from H_0 (Table 7).

Combined effect of different humic acid and varieties under saline condition showed significant differences on individual fruit weight of tomato (Appendix V). The highest individual fruit weight (61.66 g) was recorded from V_2H_2.

again lowest individual fruit weight (41.00 g) was observed from V_3H_0 treatment combination which was statistically similar to V_3H_1 (44.00 g), V_1H_0 (41.00 g) and V_2H_0 (42.00 g) (Table 8). In tomato, the number and mean weight of the fruit are the main components of yield. Similarly, significant positive association of this trait with yield was reported by Nandapuri *et al*. (1973) and Ahmed *et al*.(1988).

Table 6. Effect of different varieties of tomato on yield related parameters under saline condition.

Variety	Individual fruit weight	Fruit diameter(cm)	Fruit length (cm)	Total fruit weight per plant (kg)
V_1	46.11 b	3.41 b	3.48 b	2.25 b
V_2	55.44 a	4.12 a	4.24 a	3.55 a
V_3	44.55 b	3.18 b	3.55 b	1.92 c
LSD(0.05)	3.67	1.23	1.56	1.07
CV%	7.24	2.89	3.76	2.08

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4

4.11 Diameter of fruit

Statistically significant variation was recorded due to different varieties under saline condition on diameter of fruit of tomato (Appendix V). Data revealed that the highest diameter of fruit (4.12 cm) was recorded from V_2 whereas the lowest diameter (3.18 cm) was found from V_3 followed by V_1 (3.41) (Table 6).

Different humic acid treatment under salt stress varied significantly for diameter of fruit of tomato (Appendix V). The highest diameter of fruit (4.03 cm) was recorded from H_2 while the lowest diameter (3.13 cm) was found from H_0 followed by H_1 (3.55).(Table 7)

Diameter of fruit showed significant differences due to combined effect of different humic acid treatment and different varieties under salt stress (Appendix V). The highest diameter of fruit (4.56 cm) was observed from V_2H_2 treatment combination whereas the lowest diameter (2.56 cm) was recorded from V_3P_0 treatment combination which was statistically similar to V_2P_0 (2.83 cm) (Table 8). Significant positive correlation for fruit weight and with equatorial and polar diameter both at genotypic and phenotypic level is always acceptable as confirmed by Gonalez (1985). Srivatsava and Sachan (1973) reported that in tomato, the fruit number per plant and the maximum positive direct effect on yield followed by fruit diameter.

Table 7. Effect of different humic acid treatments on yield related parameters of tomato under saline condition.

Humic Acid treatment	Individual fruit weight	Fruit diameter(cm)	Fruit length (cm)	Total fruit weight per plant (kg)
H_0	44.00 c	3.13 b	3.21 b	1.75 c
H_1	48.11 b	3.55 b	3.72 b	2.52 b
H_2	54.00 a	4.03 a	4.35 a	3.46 a
LSD(0.05)	2.78	1.32	1.32	1.01
CV%	3.14	2.56	2.90	2.56

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. [H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray]

4.12 Length of fruit

Different varieties under salt stress showed significant differences on length of fruit of tomato (Appendix V). The highest length of fruit (4.24 cm) was attained from V_2 whereas the lowest length (3.48 cm) was recorded from V_1 followed by V_3 (3.48) (Table 6).

Length of fruit of tomato varied significantly for different humic acid treatment under salt stress (Appendix V). The highest length of fruit (4.35

cm) was recorded from H_2. On the other hand, the lowest length (3.21 cm) was recorded from H_0 followed by H_1(3.72) (Table 7).

Combined effect of different humic acid and varieties under salt stress showed significant differences on length of fruit (Appendix V). The highest length of fruit (4.96 cm) was recorded from V_2H_2 treatment combination which is statistically similar with V_2H_1(4.10) and V_3H_2 (4.20), again the lowest length (2.93 cm) was observed from V_3H_0 treatment combination followed by V_1H_0 (3.03)(Table 8).

4.13 Fruit yield per plant

Different tomato varieties showed significant differences on yieldper plant of tomato (Appendix V). The highest yield per plant (3.55 kg) was recorded from V_2 whereas the lowest yield (1.93 kg) was observed from V_3 (Table 6).

Different humic acid treatment varied significantly in terms of yield per plant of tomato under salt stress (Appendix V). The highest yield per plant (3.46 kg) was recorded from H_2 while the lowest yield (1.75 kg) was found from H_0 (Table 7).

Yield per plant varied significantly due to the combined effect of different humic acid treatment and different tomato varieties under salt stress (Appendix V). The highest yield per plant (4.64 kg) was recorded from V_2H_2 treatment combination and the lowest yield (1.28 kg) was observed from V_3H_0 treatment combination which is statistically similar with V_1H_0(1.37 kg)), and V_3H_1(1.91 kg) (Table 8).

Table 8. Combined effect of different varieties of tomato and different humic acid treatments on yield related parameters under saline condition.

Combination	Individual fruit weight	Fruit diameter (cm)	Fruit length (cm)	Total fruit weight per plant (kg)
V_1H_0	41.00 e	3.00 c	3.03 cd	1.37 e
V_1H_1	45.66 cd	3.43 bc	3.53 c	2.23 cd
V_1H_2	51.66 bc	3.80 b	3.90 bc	3.16 bc
V_2H_0	42.00 e	2.83 d	3.66 c	2.59 cd
V_2H_1	54.66 b	3.96 b	4.10 ab	3.41 b
V_2H_2	61.66 a	4.56 a	4.96 a	3.64 a
V_3H_0	41.00 e	2.56 d	2.93 d	1.28 e
V_3H_1	44.00 de	3.26 bc	3.53 bc	1.91 de
V_3H_2	48.66 cd	3.73 b	4.20 ab	2.57 cd
LSD(0.05)	5.36	1.01	1.78	0.45
CV%	9.17	2.98	2.96	1.99

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. [DAT- Days After Transplanting, V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4, H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray]

4.14 SPAD Value (Chlorophyll content)

SPAD values of tomato at flowering stage varied significantly due to different tomato varieties under salt stress (Appendix VI). At flowering stage, the highest SPAD value (45.23) was found from V_2 while the lowest SPAD value (35.70) was recorded from V_3. (Fig. 13).

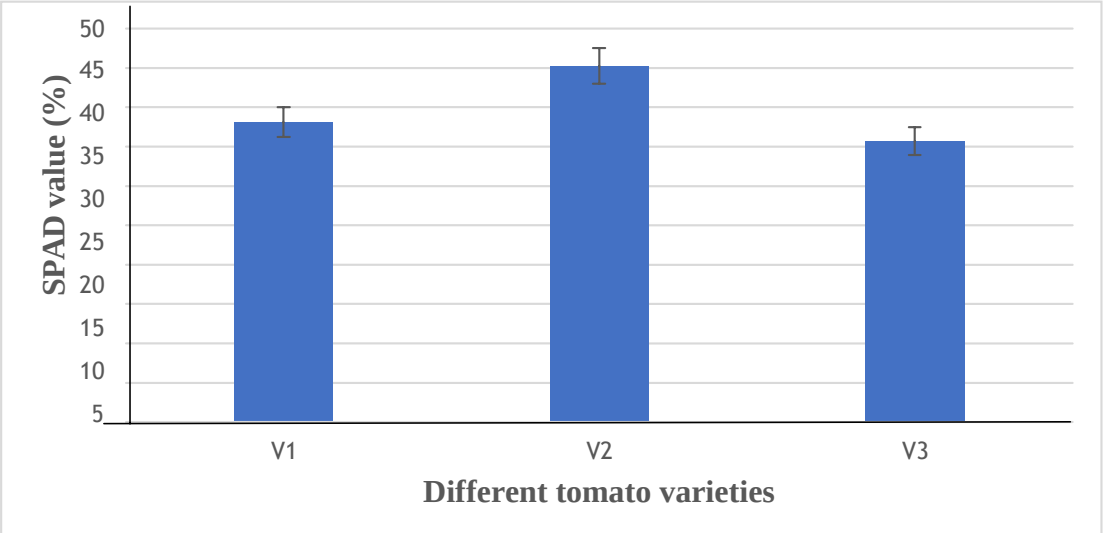

Fig. 13. Effect of different varieties on SPAD value of tomato leaf under saline condition.(V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

Significant variation was observed for SPAD values of tomato plant due to different humic acid treatment under salt stress (Appendix VI). At flowering stage, the highest SPAD values (44.33) was obtained from H_2 whereas the lowest SPAD values (35.62) was found from H_0 (Fig. 14).

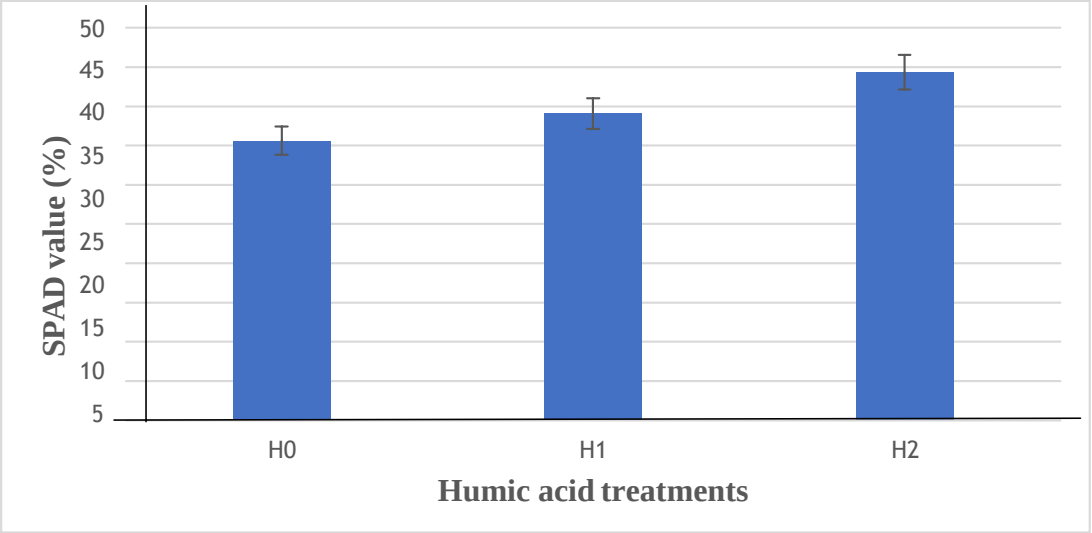

Fig. 14. Effect of different humic acid treatments on SPAD value of tomato leaf under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

Combined effect of different humic acid treatment and different tomato variety showed significant differences in terms of SPAD value of tomato leaf at flowering stage under salt stress (Appendix VI). At flowering stage, the found from V_3H_0.

highest SPAD value (51.20) was observed from V_2H_2 treatment combination and the lowest SPAD values (32.80) from V_2P_3 treatment combination. (Table 9). The outcomes were in concurrence with results announced by Hajer et al., (2006), that chlorophyll substance diminished with expanding water saltiness and humic corrosive will in general shield plants from harm brought about by saltiness. Ashraf and Bhatti (2000) and Al-Sobhi *et al.*, (2005) detailed comparable outcomes that salt pressure diminished chlorophyll content because of its antagonistic impacts on film strength.

Table 9. Combined effect of different varieties of tomato and different humic acid treatments on quality parameters of tomato under saline condition.

Combination	Chlorophyll content of leaves (%)	Vitamin-C (mg per 100gm)	Total soluble solid(brix%)	Carotenoid (mg per 100g)	Lycopene (mg per 100g)
V_1H_0	34.00 d	13.96 c	4.00 cd	3.49 bc	4.14 de
V_1H_1	38.03 cd	16.13 bc	4.50 c	3.78 bc	5.19 cd
V_1H_2	42.33 bc	19.92 b	5.50 bc	4.88 b	6.18 bc
V_2H_0	40.06 bc	17.79 bc	4.66 c	3.35 bc	5.41 cd
V_2H_1	44.43 b	19.52 b	6.00 b	4.83 b	7.04 b
V_2H_2	51.20 a	23.71 a	7.50 a	6.19 a	9.00 a
V_3H_0	32.80 e	10.36 e	3.66 d	3.04 d	3.84 e
V_3H_1	34.83 d	11.87 cd	4.00 cd	3.33 bc	4.61 de
V_3H_2	39.46 cd	17.08 bc	5.33 bc	4.32 b	5.77 cd
LSD(0.05)	4.58	2.98	1.35	1.90	1.03
CV%	8.98	4.63	2.85	2.76	2.93

In a column means similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly. [V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4, H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar

4. 15 Vitamin C content

Vitamin C content in ripen tomato varied significantly with the different tomato varieties under saline condition (Appendix VI). The highest value of Vitamin C content in ripen fruit was found from V_2 (20.34 mg/100g) and lowest from V_3 (13.10 mg/100g). (Fig.15).

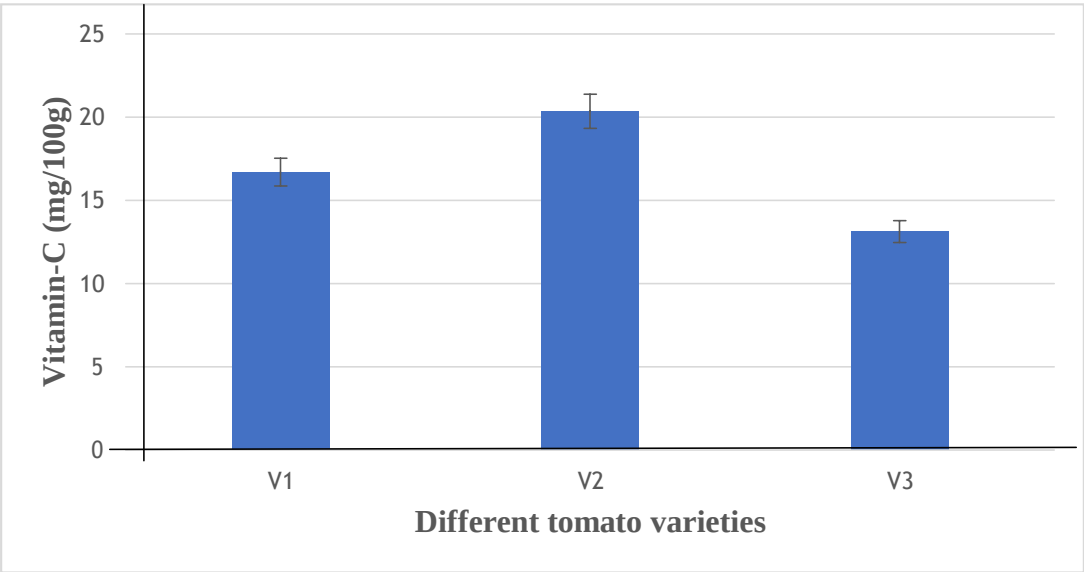

Fig. 15. Effect of different varieties on Vitamin C content of ripen tomato under saline condition.(V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

It was observed from the result of present experiment that different humic acid treatment significantly varied the vitamin-c in ripen tomato fruit under saline condition (Appendix VI). The maximum Vitamin C content (20.23 mg/100g) was found from H_2 while the minimum content of Vitamin C (14.04 mg/100g) was achieved from H_0 . (Fig. 16)

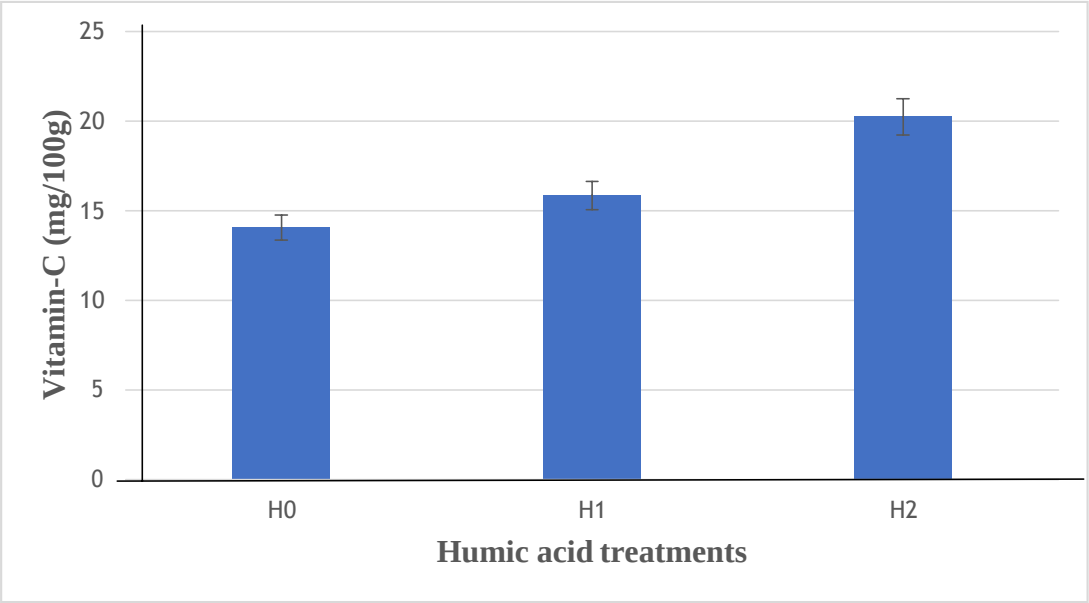

Fig. 16. Effect of different humic acid treatments on Vitamin-C content of ripen tomato under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

Combined effect of the humic acid treatment and different tomato varieties under saline condition varied significantly for the content of Vitamin-C of ripen tomato fruit (Appendix VI). The maximum amount of Vitamin-C content (23.71 mg/100g) was attained from V_2H_2 whereas the minimum amount of Vitamin-C content (10.36 mg/100g) was found from V_3H_0 (Table 9).

4.16 Total soluble solids

Total soluble solid (TSS) in tomato fruit varied significantly with the different variety (Appendix VI). It was noticed that highest TSS (6.05 %) was found from V_2 under saline condition and the lowest TSS (4.33 %) from V_3 which was statistically similar to V_1 (4.66 %). (Fig. 17)

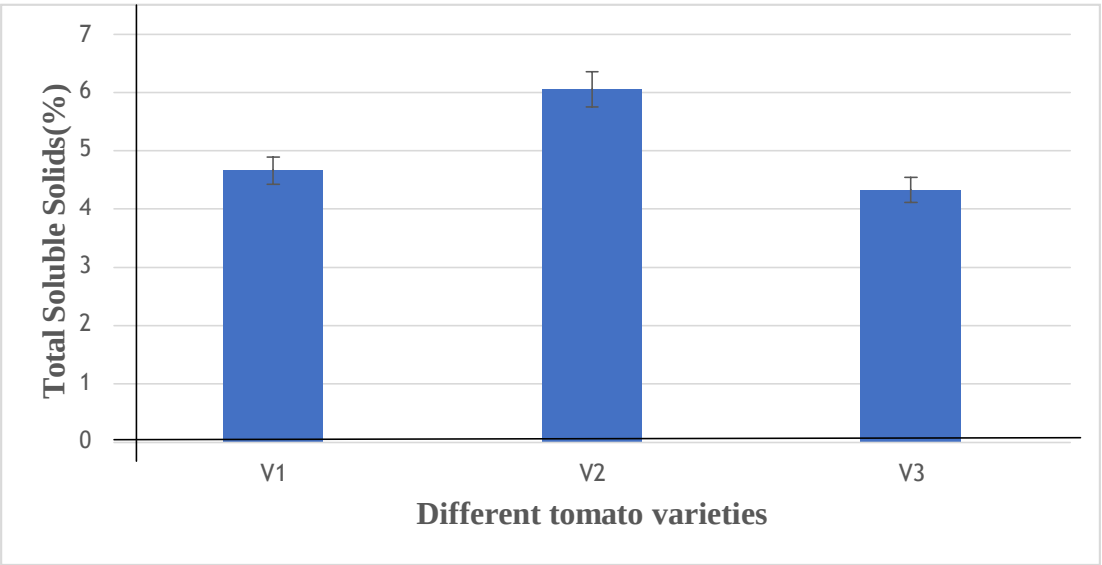

Fig. 17. Effect of different varieties on total soluble solids of ripen tomato under saline condition.(V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

Humic acid treatment had significant differences in total soluble solids under salt stress condition (Appendix VI). Soluble solids in ripen tomato fruit increased with humic acid treatment. The data showed the changes in soluble solids content at different humic acid treatment. Maximum soluble solids was found (6.82 %) from H_2 and lowest value was found (4.11 %) from control (H_0). (Fig. 18).

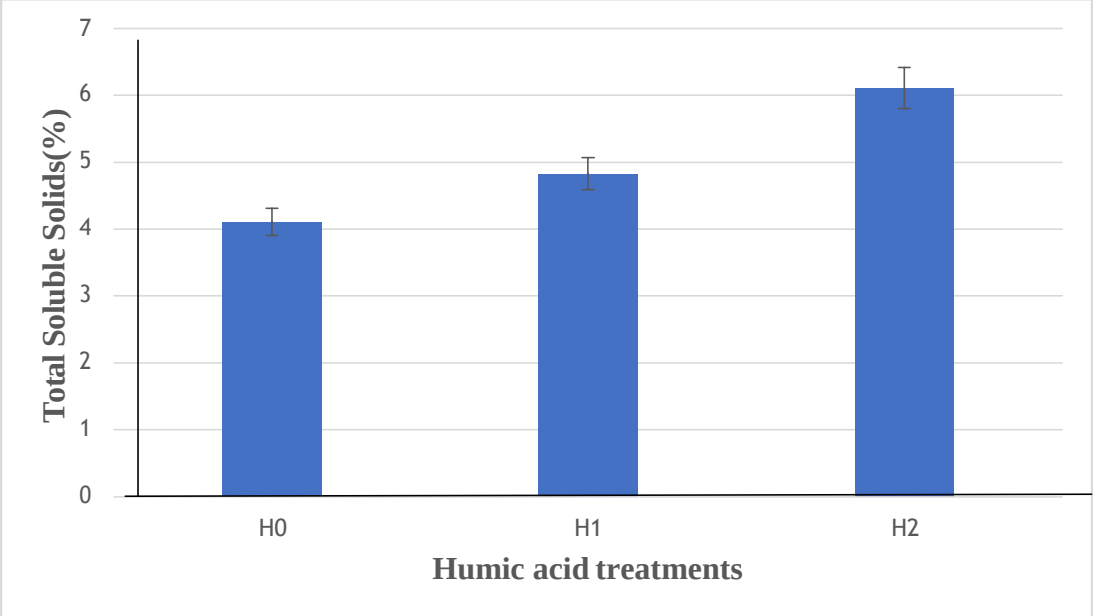

Fig. 18. Effect of different humic acid treatments on total soluble solids of ripen tomato under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

Combined effect of different humic acid treatments and different tomato varieties varied nonsignificant on TSS of ripen tomato fruit under salt stress (Appendix VI). It was noticed that highest value of TSS (7.50%) was found from V_2H_2 while the lowest value of TSS (3.66 %) from V_3H_0 which was statistically similar to V_3H_1 (4.00 %) and V_1H_0 (4.00 %) (Table 9). Balibrea et al (2000) detailed that expansion altogether soluble solids was basically in sensitive cultivars while tolerant stayed unaltered.

4.17 Carotenoid Content

Significant effect of different tomato varieties on carotenoid content observed in ripen tomato fruit under salt stress. (Appendix VI). The highest value of carotenoid content (5.12 mg/100g) was found from V_2 and lowest value (3.56 mg/100g) was recorded from V_3 (Fig.19)

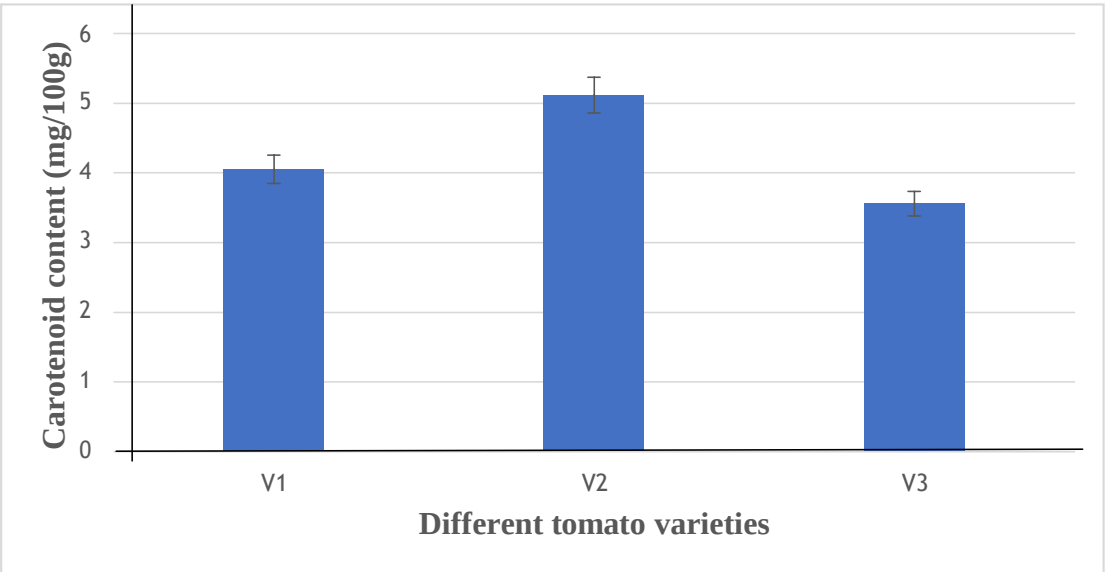

Fig. 19. Effect of different varieties on carotenoid content of ripen tomato under saline condition. (V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

Significant effect of humic acid treatments on carotenoid content showed in ripen tomato fruit under salt stress. (Appendix VI). The highest value of carotenoid content (5.13 mg/100g) was found from H_2 and lowest value (3.62 mg/100g) was recorded from H_0 (Fig. 20)

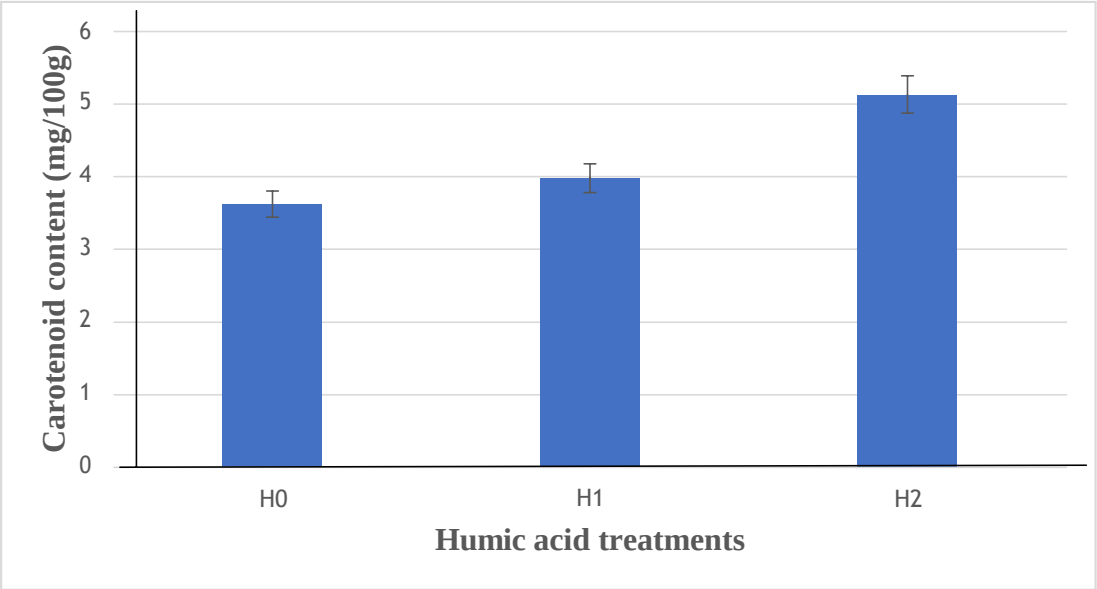

Fig. 20. Effect of different humic acid treatments on carotenoid content of ripen tomato under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray).

The Combined effect between different humic acid treatment and different tomato varieties on carotenoid content of tomato plant was statistically significant (Table 9 and Appendix VI). The highest carotenoid content (6.19 mg/100g) was found from V_2H_2. The lowest value (3.04 mg/100g) was found from V_3H_0.

4.18 Lycopene Content

Significant effect of different tomato varieties on lycopene content observed in ripen tomato fruit under salt stress. (Appendix VI). The highest value of lycopene content (7.14 mg/100g) was found from V_2 and lowest value (4.74 mg/100g) was recorded from V_3.

Significant effect of different humic acid treatments on lycopene content observed in ripen tomato fruit under salt stress. (Appendix VI). The highest value of lycopene content (6.98 mg/100g) was found from H_2 and lowest value (4.46 mg/100g) was recorded from H_0.

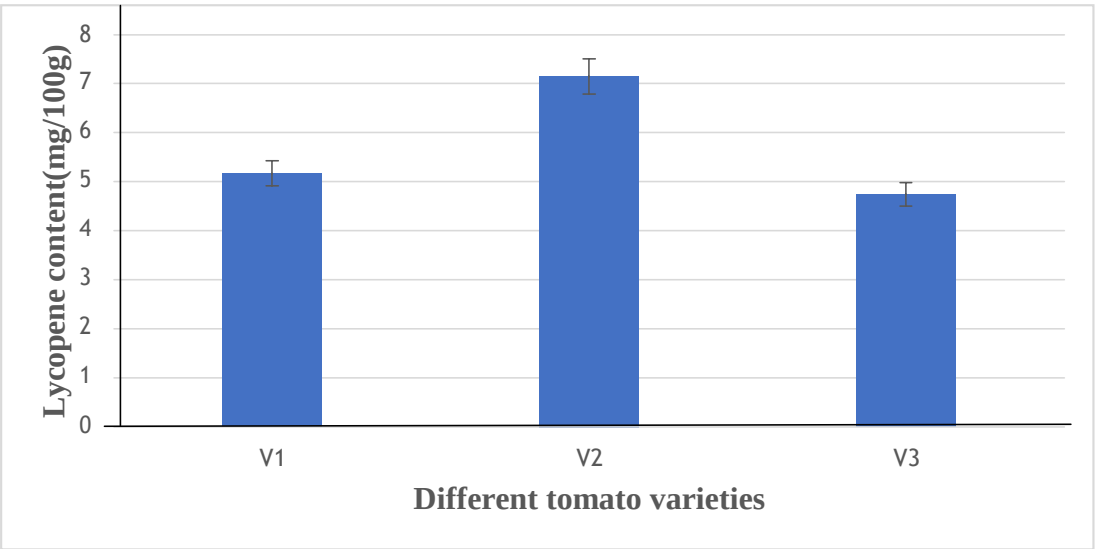

Fig. 21. Effect of different varieties on lycopene content of ripen tomato under saline condition. (V_1=BARI tomato 8, V_2= BARI tomato 14, V_3= BINA tomato 4)

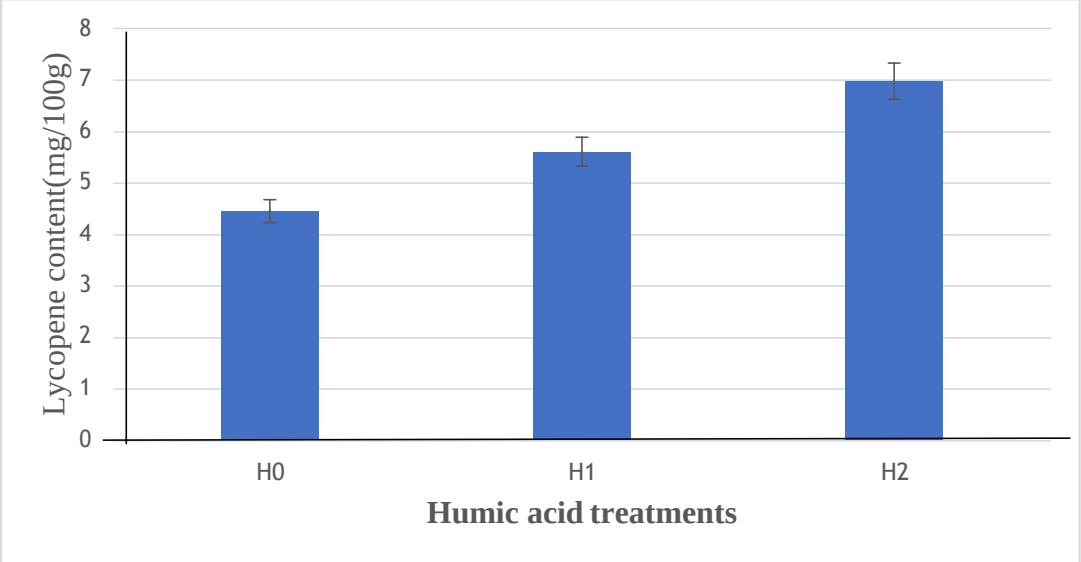

Fig. 22. Effect of different humic acid treatments on lycopene content of ripen tomato under saline condition. (H_0= Control, H_1=50ppm soil+50ppm foliar spray, H_2= 100ppm soil+100ppm foliar spray)

The Combined effect between d i ffe r e n t humic acid treatment and different tomato varieties on lycopene content of tomato plant was statistically significant (Table 9 and Appendix VI). The highest lycopene content (9.00 mg/100g) was found from V_2H_2. The lowest value (3.84 mg/100g) was

spray]

CHAPTER V

SUMMARY AND CONCLUSION

The research was conducted in the "Field Laboratory of plant stress Management" in the Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from mid October 2016 to April 2017 to find out performance of tomato influenced by Humic Acid treatment under saline condition. The experiment was laid out in two factors Complete Randomized Design (CRD) with three replications. Humic acid treatments were H_0= Non Humic acid (Control), H_1= 50 ppm soil application + 50 ppm foliar spray, H_2= 100ppm soil application + 100ppm foliar spray and three tomato varieties were V_1= BAARI Tomato 8, V_2= BARI Tomato-14, V_3= BINA Tomato 4. For conducting the research work, 8 dS/m fixed salinity was maintained for all the pots. Data on different growth parameters, yield contributing characters quality parameters of tomato were recorded. The collected data were statistically analyzed for evaluation of the treatment effect. A significant variation among the treatments was found while different humic treatments and different tomato varieties were applied in different combinations.

There are significant differences among the influence of different humic treatments in case of almost all the parameters. In this experiment, tomato plants were subjected to salinity by applying saline water at three different days in the life cycle of tomato plant to keep the soil in saline condition. Plant grown from non-humic acid (control treatment) showed the minimum height more or less over the growth period whereas the highest height was recorded from the plant grown from humic acid treatments. At 30, 60 and 90 DAT, the highest plant height (53.11, 71.66, 84.00 cm) was recorded under humic acid (H_2) treatment whereas the lowest height (45.88, 66.66 and 69.66cm) at 30, 60 and 90 DAT respectively) in control (H_0) treatment. The maximum number of leaves per plant (41.66) was recorded from humic acid (H_2) treatment whereas the lowest (32.11) was recorded from control (H_0) treatment. Maximum number of branches per plant (7.88) was noticed from humic acid (H_2)

treatment, whereas the lowest (4.00) in control (H_0) treatment. The highest internode length (7.66 cm) was recorded from humic acid (H_2) treatment whereas the lowest (4.33 cm) was recorded under H_0 treatment. The maximum leaf area per plant (262.11 cm^2) was observed from H_2 treatment whereas the lowest (198.56 cm^2) was found from H_0 treatment. Number of flower cluster per plant (16.88) was found from H_0 while the lowest number (13.11) was recorded from H_0 treatment. The maximum number of fruits per plant (63.33) was recorded from H_2 treatment whereas the lowest number (38.88) was found from H_0 treatment. The highest length of fruit (4.35 cm) was recorded from H_2. On the other hand, the lowest length (3.21 cm) was recorded from H_0. The highest diameter of fruit (4.03 cm) was recorded from H_2 while the lowest diameter (3.13 cm) was found from H_0. The maximum amount of yield per plant (3.46 kg) was recorded from H_2 while the minimum yield (1.75 kg) was found from H_0. At flowering stage, the highest SPAD values (44.33) was obtained from H_2 whereas the lowest SPAD values (35.62) was found from H_0. The maximum Vitamin-C content (20.23 mg/100 g) was found from H_2 while the minimum content of Vitamin-C (14.04 mg/100 g) was achieved from H_0 . The carotenoid content of tomato in ripen fruit of tomato was highest in H_2 (5.13 mg/100g) whereas the lowest carotenoid content observed in H_0 (3.62 mg/100g). Among the different humic acid treatment maximum amount of soluble solids was found (6.11%) at 100ppm humic acid and lowest value was found (4.11%) from control.

In this present research, significant variation was observed by the varietal effect under 8 dS/m fixed salinity level on different tomato parameters. Highest plant height (53.00 cm at 30 DAT, 75.22 cm at 60 DAT and 80.55 cm at 90 DAT) was noticed in BARI Tomato 14. Lowest plant height (41.88 cm at 30 DAT, 57.55 cm at 60 DAT and 72.22 cm at 90 DAT) was recorded in BINA Tomato 4. The highest number of leaves per plant (38.88) was seen from V_2 and the lowest value (35.44) from V_3. At 90 DAT, the highest number of branches per plant (6.44) was found from V_2 and the lowest value (5.55) was recorded from V_3. At flowering stage, the maximum leaf area (309.25 cm^2) was obtained from

V_2 whereas the minimum leaf area (181.65 cm^2) was found from V_3. The highest number of flower cluster per plant (16.00) was recorded from V_2. The highest number of fruits per plant (63.22) was recorded from V_2 and the lowest number (42.66) was recorded from V_3. The highest length of fruit (4.24cm) was attained from V_2 whereas the lowest length (3.48 cm) was recorded from V_1. The highest diameter of fruit (4.12 cm) was recorded from V_2 whereas the lowest diameter (3.18 cm) was found from V_3. The highest yield per plant (3.55 kg) was recorded from V_2 whereas the lowest yield (1.92 kg) was observed from V_3. At flowering stage, the highest chlorophyll content (45.23%) was found from V_2 whereas the lowest chlorophyll content (35.70%) was recorded from V_3. The maximum value of Vitamin-C content in ripen fruit was found from V_2 (20.34 mg/100 g) and lowest from V_3 (13.10 mg/100 g). It was found that highest TSS (6.05 %) was found from V_2 and the lowest TSS (4.33 % from V_3. The maximum value of carotenoid content (5.12 mg/100 g) was found from V_2 and minimum value (3.56 mg/100 g) was recorded from V_3.

The Combined of humic acid treatments and different tomato varieties influenced almost all the parameters. The highest plant height (57.66 cm, 71.00 cm and 87.33 cm at 30 DAT, 60 DAT and 90 DAT respectively) was recorded from V2H2 where the lowest plant height (38.33 cm, 52.66 cm and 64.33 cm at 30 DAT, 60 DAT and 90 DAT respectively) was achieved from V_3H_0 which was statically similar with V_2H_0 and V_3H_0. At 90 DAT, the highest number of leaves per plant (45.00) was found from V_2H_2 and the lowest value (31.00) was found from V1H0. The highest number of branches per plant (8.33) was observed from V2H2. The lowest value (3.66) was found from V_1H_0, which was also statistically similar (4.33, 4.00, and 5.33) to V_2H_0, V_3H_0, and V_3H_1. The highest length of internode per plant (10.33 cm) was recorded from V_2H_2 where the lowest length of internode (3.33 cm) was achieved from V_3H_0 which was statically similar with V_1H_0, and V_3H_1. The maximum leaf area (364.11cm^2) was attained from V_2H_2 treatment combination and the minimum (162.95cm^2) from V_3H_0 treatment combination which was statistically similar to V_1H_0 (172.44 cm^2). The maximum number of flower cluster per plant (18.66) was observed from V_2H_2 while the lowest number (12.00) was attained

from V_3H_0. The highest number of fruits per plant (75.00) was observed from V_2H_2 and the lowest number (31.33) was obtained from V_3H_0 which was statistically alike to (33.33) V_1H_0. The highest length of fruit (4.96 cm) was recorded from V_2H_2 again the lowest fruit length (2.93 cm) was observed from V3H0. The highest diameter of fruit (4.56 cm) was observed from V_2H_2 and the lowest diameter (2.93 cm) was recorded from V_3H_0. The highest yield per plant (3.64 kg) was recorded from V_2H_2 and the lowest yield (1.28 kg) was observed from V3H0. The maximum amount of chlorophyll content (51.20%) was observed from V_2H_2 and the minimum values (32.80%) from V_3H_0. The maximum value of Vitamin-C content (23.71 mg/100g) was attained from V_2H_2 whereas the minimum value (10.36 mg/100g) was found from V_3H_0. The highest carotenoid content (6.19 mg/100 g) was found from V_2H_2. The lowest value (3.04 mg/100g) was found from V_3H_0. It was found that highest TSS (7.50%) was found from V_2H_2 while the lowest value of TSS (3.36 %) from V_3H_0. The maximum amount of lycopene (9.00) was estimated from (V_2H_2) while minimum amount (3.84) was found at (V_3H_0).

Conclusions

It may be concluded that most of the parameters of tomato under saline condition exposed positive rapport with humic acid. Among the humic acid treatments, 100ppm showed the best result than other treatments. BARI tomato-14 showed the maximum performance in growth, fruit yield and quality parameters under saline condition. So tomato growers can cultivate tomato with humic acid treatment under saline condition for tomato production.

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APPENDICES

Appendix I. Physical and chemical characteristics of the initial soil.

Characteristics	Value
%Sand	57
%Silt	23
%clay	20
Texture class	Sandy-clay loam
pH	6.2
Organic matter (%)	0.78
Total N (%)	0.003
Available P (ppm)	20.00
Exchangeable K (me/100g soil)	0.10
Available S (ppm)	45
Salinity (ds/m)	2

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Appendix II: Analysis of variance (mean square) of the data for plant height of tomato at different days after transplanting (DAT) as influenced by different varieties and Humic acid treatment saline condition.

Source of variation	Degrees of freedom(df)	Mean square of plant height at		
		30 DAT	60 DAT	90 DAT
Variety (A)	2	374.11*	721.00*	167.59*
Humic acid (B)	2	236.22*	564.66*	926.74*
Combined (A×B)	4	1009.33*	2038.66*	1376.29*
Error	12	70.167	334.833	64.500

* Significant of 5% level of probability; ** significant of 1% level of probability

NS= Not significant at $p<0.05$

Appendix III: Analysis of variance (mean square) of the data growth parameters of tomato at different days after transplanting (DAT) as influenced by different varieties and Humic acid treatment under saline condition.

Source of variation	Degrees of freedom (df)	Mean square of				
		Number of branches per plant	Number of leaves per plant	Leaf area (cm^2)	Diameter of the stem (cm)	Length of internodes (cm)
Variety (A)	2	1.81*	31.53*	410.88*	.043NS	33.77*
Humic acid (B)	2	34.03*	196.03*	903.47*	.04 NS	25.33*
Combined (A×B)	4	9.12*	59.481*	134.38*	.023NS	15.16*
Error	12	36.482	93.75	120.11	0.52	12.08

* Significant of 5% level of probability; ** significant of 1% level of probability

NS= Not significant at $p<0.05$

Appendix IV: Analysis of variance (mean square) of the data for plant yield parameters of tomato as influenced by different varieties and Humic acid treatment under saline condition.

Source of variation	Degrees of freedom (df)	Mean square of		
		Number of flower clusters per plant	Number of flowers per plant	Number of fruits per plant
Variety (A)	2	14.96*	1051.85*	1020.78
Humic acid (B)	2	33.07*	1478.96*	1345.78*
Combined (A×B)	4	12.33*	645.35*	597.67*
Error	12	4.11	365.17	376.11

* Significant of 5% level of probability; ** significant of 1% level of probability

NS= Not significant at $p<0.05$

Appendix V: Analysis of variance (mean square) of the data for yield contributing parameters of tomato as influenced by different varieties and Humic acid treatment under saline condition.

Source of variation	Degrees of freedom (df)	Mean square of			
		Weight of Individual fruit	Fruit diameter (cm)	Fruit length (cm)	Total fruit weight per plant (kg)
Variety (A)	2	312.14*	2.19*	1.55*	6.60*
Humic acid (B)	2	227.37*	1.85*	2.98*	6.63*
Combined (A×B)	4	136.53*	1.08NS	1.15NS	3.33*
Error	12	164.11	0.09	0.14	6.61

* Significant of 5% level of probability; ** significant of 1% level of probability

NS= Not significant at p<0.05

Appendix VI: Analysis of variance (mean square) of the data for quality parameters of tomato as influenced by different varieties and Humic acid treatment under saline condition.

Source of variation	Degrees of freedom (df)	Mean square of				
		SPAD value (%)	Vitamin-C (mg per 100gm)	Total soluble solid (brix%)	Carotenoid (mg per 100g)	Lycopene (mg/g)
Variety (A)	2	220.99*	117.82*	7.59*	5.70*	14.84*
Humic acid (B)	2	173.04*	91.40*	9.23*	5.57*	14.31*
Combined (A×B)	4	100.62*	52.536*	4.40*	2.85*	7.64*
Error	12	21.95	20.61	0.38	0.11	0.10

* Significant of 5% level of probability; ** significant of 1% level of probability

NS= Not significant at p<0.05