



Salinity Mitigation of Tomato by Application of Chitosan and Organic Manures

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: The present study was designed to assess the role of chitosan and organic manures on tomato plant growth and productivity under saline condition.

Study Design: The experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications.

Place and Duration of Study: The experiment was conducted at farmers' field in the Kolapara thana under Patuakhali district during November 2023 to March 2024.

Methodology: Two-factor experiment with sixteen treatment combinations consisted of four chitosan level viz., control, 250, 500 and 1000 ppm; and four different organic manures (No manure,

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cowdung (10 t/ha), vermicompost (10 t/ha) and, farm yard manure (10 t/ha)). Thirty days old healthy seedlings were transplanted in the experimental plots in the afternoon of 15 December 2023 maintaining a spacing of 60 × 40 cm² between the rows and plants, respectively. The plot size was 1.8 × 1.2 m² with 9 seedlings were planted in each plot. The seedlings were watered after transplanting. After transplanting the seedlings, different intercultural operations were done whenever necessary for better grow and development of the plants.

Results: The study results exhibited that most of the parameters were significantly influenced by the different concentration of chitosan and organic manures. Among the treatment combination, chitosan 500ppm showed the longest plant (119.37 cm), the largest leaves (35.80 cm), the maximum number of flowers per cluster (6.89), the maximum number of fruits per clusters (7.50), the highest fruits weight per plant (4.86 kg) and yield (43.74 t/ha) of tomato in combination with vermicompost (10 t/h) under saline condition.

Conclusion: The present studied results revealed that foliar application of chitosan alone or in combination with manures had positive impact on growth and yield contributing characters of tomato under saline condition.

Keywords: Tomato; salinity; mitigation; chitosan; manures.

1. INTRODUCTION

“Tomato (*Lycopersicon esculentum*) belongs to Solanaceae family mostly grown in almost all region of the world, a good and dependable source of vitamins (A and C), minerals, essential amino acids, lycopene, ascorbic acid, antioxidants, sugars, and dietary fibers” (Li, Wang, Zhang, & Martin, 2018). It is the most consumable and economically attractive crop due to its high yield and short duration. Economically, tomatoes are a significant cash crop for many countries, providing livelihood opportunities for millions of farmers and contributing to national economies. The adaptability of tomatoes to various climatic conditions, from temperate to tropical regions, has made them a global crop (Bhandari, Neupane, & Adhikari, 2021). The demand for organic and sustainably grown tomatoes has also increased due to growing consumer awareness of health and environmental concerns (Sattar et al., 2024). “It is considered as “moderately tolerant” to salinity but exposure to high salt concentrations is known to cause negative effects in most of its cultivars in terms of seed germination, inhibition of growth and reduction of fruit productivity” (Cuartero, Bolarin, Asins, & Moreno, 2006). “Tomato plant exposed to excess salinity at the root zone exhibited leaf growth inhibition and has been attributed to reduced cellular turgor, diminished photosynthetic activity and activation of metabolic signaling between stress perception and adaptation” (Maggio, De Pascale, Angelino, Ruggiero, & Barbieri, 2004). “Globally, salinity is the significant factor that constraints the productivity potential of agricultural land,

especially for vegetable crops. To mitigate soil salinity, plant researcher is applying different techniques such as sub-soiling, mixing sand, seed bed preparation, and salt scraping, as well as modern agronomic practices, hydrophilic polymer, gypsum, sulfur acids, green manuring, humic substance, farm yard manures, irrigation system, and salt-tolerant crops” (Bhowmik, Kibria, Rhaman, Murata, & Hoque, 2021; Zaman et al., 2018). “Appropriate fertilization and foliar application of biostimulants has emerged as a promising approach to mitigate the adverse effects of different abiotic stresses including salinity” (Banerjee, Gantait, Sarkar, & Bhattacharyya, 2018). “Chitosan is a natural, nontoxic, biodegradable and eco-friendly compound with numerous agricultural applications” (Zhang et al., 2021). “It is obtained from crab and shrimp shells by the deacetylation of chitin, considered to improve crop performance” (Alenazi et al., 2024). “Several studies concur that Chitosan application boosted growth, productivity, and stress tolerance, in addition to enhancing plant physio-anatomical pathways within normal or stressful environments. Chitosan plays an important role inside plant body, improves plant defense mechanism against both biotic and abiotic stress by activating several enzymes against many stresses” (Alenazi et al., 2024). “Now a days it is mostly used as biostimulators. Not only different biostimulants, planting techniques are used to control soil salinity but also different organic manures can be used for this purpose. Organic amendments improve physical, chemical and biological properties of soils under saline conditions” (Ud Din et al., 2023). “Organic matter decomposition and plant root action also help

dissolve the calcium compounds found in most soils, thus promoting reclamation of saline soil. Various organic amendments such as farmyard manure, compost, poultry manure and vermin compost can be used for the amelioration of saline soils. Recently, different organic amendments such as the application of vermicompost (VC), vermi-wash (VW), biochar (BC), plant growth promoting rhizobacteria (PGPR), and bio-fertilizers (BF) are being used widely to ameliorate the negative consequences of soil salinity" (Haque et al., 2022; Imran et al., 2022). Therefore, the present study was designed to assess the role of chitosan and organic manures on tomato plant growth and productivity under salt stress condition.

2. MATERIALS AND METHODS

2.1 Planting Materials, Site and Period

Roma VF tomato variety was used as planting material in the present experiment. Seedlings were raised in the farmers seedbed. The experiment was conducted at farmers' field in the Kolapara thana under Patuakhali district during November 2023 to March 2024.

2.2 Treatments and Design of the Study

Two-factor experiment with sixteen treatment combinations consisted of four chitosan level viz., control, 250, 500 and 1000 ppm; and four different levels of organic manures (No manure/100% soil (with only basal dose of fertilizer, cow dung (10 t/ha), vermin compost (10 t/ha) and, farm yard manure (10 t/ha)). The experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications.

2.3 Soil of the Experimental Field

The medium highland with moderate fertility having EC (6.29 ds/m) and pH (4.10) were selected for this experiment. Before transplanting of seedlings, textural class and fertility status of experimental area were analyzed.

2.4 Land Preparation

The soil of the experimental field was first open on 15th November, 2023 in order to get well prepared and good tilth for tomato production. The unit plots were prepared as 15 cm raised beds. twelve pits were made in each plot.

2.5 Transplanting of Seedlings

Disease free and uniform size 30 days old seedlings were transplanted in the experimental plots in the afternoon of 15 December 2023 maintaining a spacing of 60 × 40 cm² between the rows and plants, respectively. The plot size was 1.8 × 1.2 m² with 9 seedlings were planted in each plot. The seedlings were watered after transplanting. Shading was provided using banana leaf sheath for three days to protect seedlings from direct sunlight. After transplanting the seedlings, different intercultural operations were done whenever necessary for better grow and development of the plants.

2.6 Data Collection

Five plants were selected randomly from each plot for data collection. Data on the following parameters were recorded from the sample plants during the course of experiment.

Plant height (cm): Plant height was measured by using cm scale. The plant height was taken in centimeter from ground level to the tip of the longest stem of the plant at 45, 60, 75 and 90 days after transplanting (DAT).

Length of largest leaves (cm): The length of largest leaves was measured in cm with a cm scale as the vertical distance from one side to another side of the five largest leaves at 45, 60, 75 and 90 DAT.

Number of flower clusters per plant: Total number of flower clusters was measured by counting and the mean value was expressed as number for data analysis.

Number of flowers per cluster: Total number of flowers was divided by the total number of clusters to get flower number per cluster.

Number of fruits per cluster: Total number of fruits per cluster was calculated and the mean value was expressed as number for data analysis.

Weight of fruits per plant: Mature fruits were collected different times and weighted. Total weight was counted and expressed as weight of fruits per plant in kilogram (kg).

Fruit yield per hectare: Total yield of each plot will be measured and then it was converted into ton per hectare.

2.7 Statistical analysis

The data collected from the experimental plots were statistically analyzed by using SPSS data analysis software. Mean data was analyzed statistically and carried out to analysis of variance (ANOVA) for “F” variance test. The significance of difference among the means was evaluated by Tukey’s test at 5% level of probability (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

3.1 Plant Height

Highly significant variation was observed among different concentration of chitosan in case of plant height at different days after transplanting (Fig. 1). The tallest plant (82.08, 91.15, 102.05 and 114.23 cm) was recorded from 500 ppm chitosan treatment followed by 1000 ppm chitosan (58.00, 68.40, 78.67 and 90.85 cm) at 45, 60, 75 and 90 DAT, respectively. In contrast, the shortest plant (49.14, 59.11, 67.45 and 81.21 cm) was noted from control treatment at 45, 60, 75 and 90 DAT, respectively. Similar findings

were reported by Ullah et al. (Ullah et al., 2020), they noted that chitosan application increased salinity tolerance of tomato plant and enhanced plant height mainly due to its growth promoting activity. In another study demonstrated that foliar spraying of different concentration of oligo chitosan increased the plant height of tomato (N. Sultana, Zakir, Parvin, Sharmin, & Seal, 2019).

Different manures had an impact on the plant’s height and significant differences was observed at different days after transplanting (Fig. 2). Among all treatments, vermin compost exhibited tallest plant (71.99, 81.48, 92.46 and 104.72 cm) followed by farm yard manure (67.84, 77.30, 87.34 and 99.03 cm) at 45, 60, 75 and 90 DAT, respectively. On the other hand, the smallest plant (55.31, 65.61, 75.90 and 88.09 cm) was noted from control treatment at 45, 60, 75 and 90 DAT, respectively. Similar results were reported by Yupeng et al. (Yupeng et al., 2020), that organic manures reduced the salinity and sodicity stress of crops. In this experiment, the discrepancy in plant height may be due to the leaching out the salt ions from the tomato plants root zone by vermicompost.

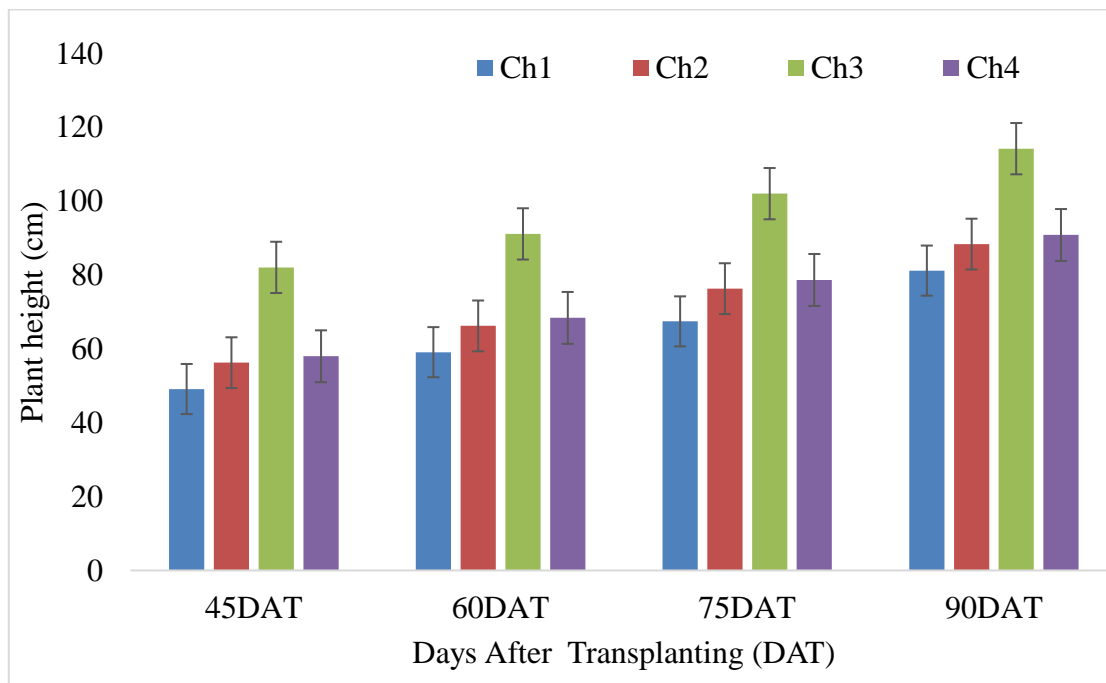


Fig.1.Effect of different concentrations of chitosan on plant height of tomato. Here, vertical bars represent standard error. Ch₁=Control; Ch₂=250 ppm chitosan; Ch₃= 500 ppm chitosan and Ch₄= 1000 ppm chitosan

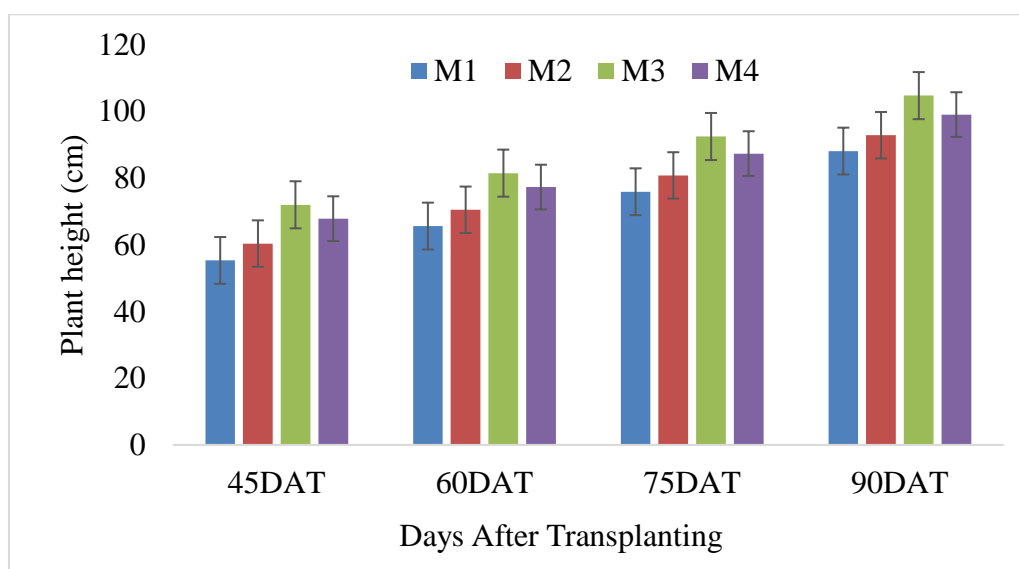


Fig. 2. Effect of different organic manures on plant height of tomato. Here, vertical bars represent standard error. M₁= No manure/ 100% soil (with only basal dose of fertilizer); M₂=cow dung (10 t/ha); M₃= vermin compost (10 t/ha) and M₄= farm yard manure (10 t/ha).

Table 1. Interaction effect of chitosan and organic manures treatment on plant height of tomato

Treatments	Plant height (cm)			
	45DAT	60 DAT	75 DAT	90DAT
Ch ₁ M ₁	47.75	58.33	69.05	81.11
Ch ₁ M ₂	52.19	62.99	73.35	85.29
Ch ₁ M ₃	78.35	87.81	98.07	110.32
Ch ₁ M ₄	58.27	67.33	77.34	88.12
Ch ₂ M ₁	50.59	60.77	70.92	83.09
Ch ₂ M ₂	54.39	63.88	73.88	85.92
Ch ₂ M ₃	61.67	72.62	82.73	94.71
Ch ₂ M ₄	58.41	67.64	77.77	89.84
Ch ₃ M ₁	73.33	83.69	93.93	106.18
Ch ₃ M ₂	84.63	94.30	104.60	116.81
Ch ₃ M ₃	86.98	94.92	107.22	119.37
Ch ₃ M ₄	83.40	92.69	102.45	114.57
Ch ₄ M ₁	49.56	59.67	69.73	81.97
Ch ₄ M ₂	50.22	60.80	71.34	83.37
Ch ₄ M ₃	60.95	71.58	81.81	94.47
Ch ₄ M ₄	71.28	81.56	91.81	103.60
Level of significance	**	**	**	**
CV (%)	12.80	10.79	9.41	8.19

Here, **= Significant at 1% level of probability; DAT= Days After Transplanting; CV= Coefficient of variance; Ch₁=Control; Ch₂=250 ppm chitosan; Ch₃= 500 ppm chitosan and Ch₄= 1000 ppm chitosan; M₁= No manure/ 100% soil (with only basal dose of fertilizer); M₂=cow dung (10 t/ha); M₃= vermin compost (10 t/ha) and M₄= farm yard manure (10 t/ha)

The interaction effect of chitosan and organic manures treatment showed significant variations in respect of plant height at different days after transplanting (Table 1). The maximum plant height (86.98, 94.92, 107.22 and 119.37 cm) was noted from Ch₃M₃ followed by Ch₃M₂ (84.63,

94.30, 104.60 and 116.81 cm) and Ch₃M₄ (83.40, 92.69, 102.45 and 114.57 cm) at 45, 60, 75 and 90 DAT, respectively. In contrast, the minimum plant height was recorded from Ch₁M₁ (47.75, 58.33, 69.05 and 81.11 cm) at 45, 60, 75 and 90 DAT, respectively. The tallest plants were

observed in Ch3M3 than other treatment combination. Chitosan with vermicompost treatment provides better soil health as it is rich in essential nutrients. Its facilitates better root growth which helps in increasing plant height under saline stress. Vermicompost is rich in macro and micronutrients and beneficial soil microbes which improves plant growth (Nasrin, Khanom, & Hossain, 2019). These results are in line with those obtained by Bakhom et al.(Bakhom, Sadak, & Badr, 2020), who found that the maximum growth characteristics and photosynthetic pigments in sunflower plants were noted by the interaction effect in plants treated with chitosan concentration (50 mg L⁻¹) below salinity level (4000 mg L⁻¹).

3.2 Length of Largest Leaves

Different concentration of chitosan had significant effect on length of largest leaf at different DAT (Fig.3). The largest leaves (24.51, 28.67, 31.59 and 34.05 cm) was recorded from 500 ppm chitosan treatment followed by 1000 ppm chitosan (21.47, 25.60, 28.50 and 30.96 cm) at 45, 60, 75 and 90 DAT, respectively. In contrast, the smallest leaves (18.77, 22.82, 25.73 and 28.26 cm) was recorded from control treatment at 45, 60, 75 and 90 DAT, respectively.

Significant differences were observed among different manures in respect of length of largest

leaves at different days after transplanting (Fig. 4). Among the tested manures, vermin compost showed largest leaves (23.29, 27.42, 30.33 and 32.86 cm) followed by farm yard manure (21.64, 25.77, 28.67 and 31.14 cm) at 45, 60, 75 and 90 DAT, respectively. On the other hand, the smallest leaves (19.05, 23.12, 26.03 and 28.50 cm) was noted from control treatment at 45, 60, 75 and 90 DAT, respectively. Chitosan not only stimulates the cell division and elongation but it also helps to improve plant immunity system and improved plant growth and yield. Previous study demonstrated that chitosan foliar spray increased the leaf area and leaf length of vegetables crops (Kazimi & Saxena, 2023). The findings of the present study noted that different concentration of chitosan foliar spray significantly increased the leaf length which supports previous studied results.

Vermicompost is one of the excellent organic fertilizers, which has a good physical structure, abundant mineral elements which have positive effect on plant growth and development. In the present study we observed that vermicompost application in the saline soil mitigate salinity effect and enhance plant growth by increasing the leaf area and leaf size. The plant growth promoting effect of vermicompost is mainly due to the remediation of salty soil's physical, chemical, and biological properties (Goswami et al., 2017; Shen et al., 2022).

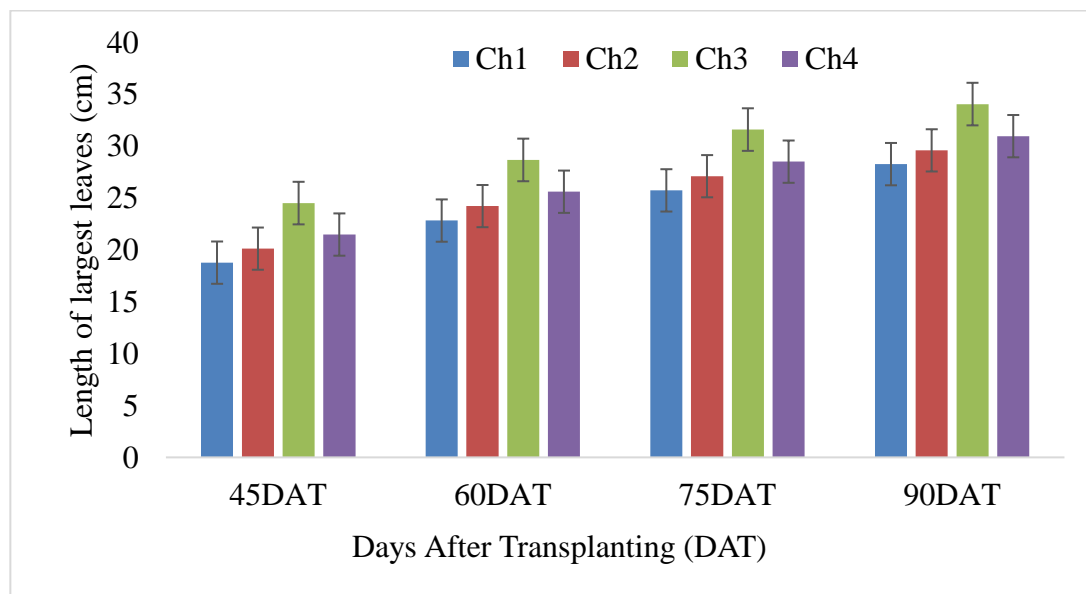


Fig. 3. Effect of different concentrations of chitosan on length of the largest leaves of tomato. Here, vertical bars represent standard error. Ch₁=Control; Ch₂=250 ppm chitosan; Ch₃= 500 ppm chitosan and Ch₄= 1000 ppm chitosan

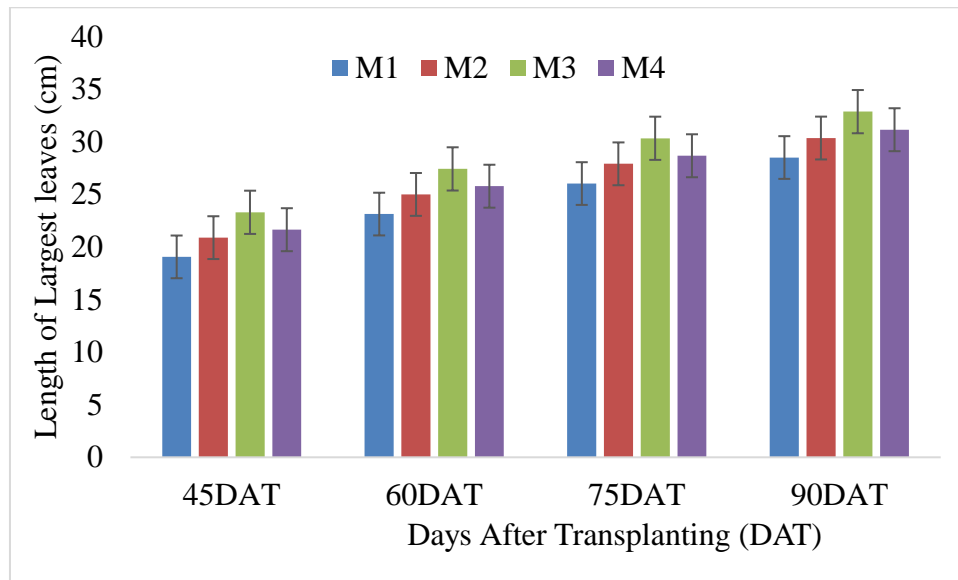


Fig. 4. Effect of different organic manures on length of the largest leaves of tomato. Here, vertical bars represent standard error. M₁= No manure/ 100% soil (with only basal dose of fertilizer); M₂=cow dung (10 t/ha); M₃= vermin compost (10 t/ha) and M₄= farm yard manure (10 t/ha)

Table 2. Interaction effect of chitosan and organic manures treatment on length of the largest leaves of tomato

Treatments	Length of largest leaves (cm)			
	45DAT	60 DAT	75 DAT	90DAT
Ch ₁ M ₁	16.75	20.73	23.68	26.15
Ch ₁ M ₂	17.96	22.03	24.93	27.36
Ch ₁ M ₃	20.96	24.99	27.89	30.59
Ch ₁ M ₄	19.41	23.54	26.44	28.96
Ch ₂ M ₁	18.15	22.23	25.09	27.61
Ch ₂ M ₂	20.42	24.56	27.45	29.97
Ch ₂ M ₃	22.67	26.75	29.64	32.13
Ch ₂ M ₄	19.23	23.33	26.22	28.65
Ch ₃ M ₁	23.39	27.50	30.39	32.83
Ch ₃ M ₂	24.86	28.95	31.88	34.30
Ch ₃ M ₃	26.06	30.31	33.29	35.80
Ch ₃ M ₄	23.73	27.91	30.82	33.28
Ch ₄ M ₁	17.92	22.05	24.95	27.42
Ch ₄ M ₂	20.30	24.43	27.34	29.78
Ch ₄ M ₃	23.49	27.62	30.51	32.93
Ch ₄ M ₄	24.19	28.32	31.21	33.70
Level of significance	**	**	**	**
CV (%)	8.54	7.19	6.44	6.02

*Here, **= Significant at 1% level of probability; DAT= Days After Transplanting; CV= Coefficient of variance; Ch₁=Control; Ch₂=250 ppm chitosan; Ch₃= 500 ppm chitosan and Ch₄= 1000 ppm chitosan; M₁= No manure/ 100% soil (with only basal dose of fertilizer); M₂=cow dung (10 t/ha); M₃= vermin compost (10 t/ha) and M₄= farm yard manure (10 t/ha).*

The interaction effect of chitosan and organic manures treatment exhibited significant variations in case of length of largest leaves at different days after transplanting (Table 2). The

largest leaves (26.06, 30.31, 33.29 and 35.80 cm) was noted from Ch₃M₃ followed by Ch₃M₂ (24.86, 28.95, 31.88 and 34.30 cm) and Ch₄M₄ (24.19, 28.32, 31.21 and 33.70 cm) at 45, 60, 75

and 90 DAT, respectively. In contrast, the smallest leaves were noted from Ch₁M₁ (16.75, 20.73, 23.68 and 26.15 cm) at 45, 60, 75 and 90 DAT, respectively. Chitosan with vermicompost treatment provides better soil health as it is rich in essential nutrients. Chitosan plays a major protective function against salinity stress and promote uptake of nutrient; which may be a reason for the increase in leaf length.

3.3 Number of Flower Clusters Per Plant

Highly significant variation was noted among different concentration of chitosan in case of number of flower clusters per plant in different days after transplanting (Table 3). The highest number (13.64) of flower cluster per plant was observed in chitosan 500ppm treatment followed by chitosan 1000ppm (11.93) and chitosan 250ppm (10.92), while the minimum number of flower cluster (7.05) was noted from control treatment. Results revealed that different concentration of foliar application of chitosan on tomato plant had positive effect to increase the number of flower clusters per plant. Similar result was also reported by previous researchers and they stated that foliar spraying of oligo-chitosan with different concentrations had positive effect on number of flower clusters per plant of tomato (Mondal, Puteh, & Dafader, 2016; S. Sultana, Islam, Khatun, Hassain, & Huque, 2017).

Different manures had an impact on the number of flower clusters per plant and significant differences was observed at different days after transplanting (Table 3). Among all manures, vermicompost exhibited highest number of flower clusters per plant (12.49) followed by farm yard manure (11.35). On the other hand, the minimum number of flower cluster per plant (9.05) was noted from control treatment. This might be because application of different organic manures releases both macro and micro nutrients and beneficial soil microbes like N-fixing bacteria which enhances growth and development of the plant. Similar findings were reported by Grimme (Grimme, 2006) and they noted that the highest number of tomato flower clusters per plant was observed by the application of 100% well decomposed cowdung and vermicompost.

The interaction effect of chitosan and organic manures treatment exhibited significant variations in case of number flower cluster per plant at different days after transplanting (Table 4). The highest number of flowers per cluster (16.13) was noted from the combination of

chitosan 500ppm and vermicompost followed by chitosan 500ppm and farm yard manure (13.43). In contrast, the minimum number of flower cluster per plant (4.59) was counted from control treatment. Chitosan with vermicompost treatment provides better soil health as it is rich in essential nutrients. Chitosan plays a major protective function against salinity stress and promote uptake of nutrient; which may be a reason for the increase in number of flower cluster per plant.

3.4 Number of Flowers Per Cluster

Significant variation was found among different concentration of chitosan in case of number of flowers per cluster in different days after transplanting (Table 3). The maximum number (6.45) of flowers per cluster was observed in chitosan 500ppm treatment followed by chitosan 250ppm (5.79) and chitosan 1000ppm (5.76), while the minimum number of flowers per cluster (4.65) was noted from control treatment. Results showed that foliar application of chitosan on tomato plant had positive effect to increase the number of flowers per clusters. Similar findings was also reported by previous researchers and they demonstrated that foliar application of oligo-chitosan increased the number of flowers per cluster in tomato plants (Mondal et al., 2016; S. Sultana et al., 2017).

Application of manures in saline soil had positive impact on the number of flowers per cluster and significant differences was observed among different manures (Table 3). Among all manures, vermicompost exhibited the highest number of flowers per cluster (6.12) followed by farm yard manure (5.80). On the other hand, the lowest number of flowers per cluster (5.20) was counted from control treatment. This might be because application of different organic manures releases both macro and micro nutrients and beneficial soil microbes like N-fixing bacteria which enhances growth and development of the plant. Similar findings were reported by Grimme (Grimme, 2006) and they noted that the highest number of tomato flowers per cluster was observed by the application of 100% well decomposed cowdung and vermicompost.

The interaction effect of chitosan and organic manures treatment showed significant variations in case of number of flowers per cluster at different days after transplanting (Table 4). The highest number of flowers per cluster (6.89) was noted from the combination of chitosan 500ppm and vermicompost followed by chitosan 500ppm

and farm yard manure (6.51). In contrast, the minimum number of flower cluster per plant (3.95) was counted from control treatment. Chitosan with vermicompost treatment provides better soil health as it is rich in essential

nutrients. Chitosan plays a major protective function against salinity stress and promote uptake of nutrient; which may be a reason for the increase in number of flowers per cluster in tomato plant.

Table 3. Effect of chitosan and manures on the number of clusters per plant, number of flowers per cluster, number of fruits per cluster, weight of fruits per plant and yield of tomato

Treatments	No. flower clusters per plant	No. of flowers per cluster	No. of fruits per cluster	Weight of fruits per plant (kg)	Yield (t/ha)
Ch ₁	7.05	4.65	4.70	2.82	25.38
Ch ₂	10.92	5.79	6.11	3.85	34.65
Ch ₃	13.64	6.45	6.76	4.08	36.72
Ch ₄	11.93	5.76	6.11	3.62	32.58
Level of significance	**	**	**	**	**
CV (%)	6.07	1.25	1.73	1.2	1.26
M ₁	9.05	5.20	5.26	3.03	27.27
M ₂	10.65	5.54	5.83	3.58	32.22
M ₃	12.49	6.12	6.54	4.20	37.8
M ₄	11.35	5.80	6.05	3.56	32.04
Level of significance	**	**	**	**	**
CV (%)	6.07	1.25	1.73	1.2	1.26

Here, **= Significant at 1% level of probability; DAT= Days After Transplanting; CV= Coefficient of variance; Ch₁=Control; Ch₂=250 ppm chitosan; Ch₃= 500 ppm chitosan and Ch₄= 1000 ppm chitosan; M₁= No manure/ 100% soil (with only basal dose of fertilizer); M₂=cow dung (10 t/ha); M₃= vermin compost (10 t/ha) and M₄= farm yard manure (10 t/ha)

Table 4. Interaction effect of chitosan and organic manures treatment on number of flower clusters per plant, number of flowers per cluster, number of fruits per cluster, weight of fruit per plant and yield of tomato

Treatments	Flower clusters per plant	No. of flowers per cluster	No. of fruits per cluster	Weight of fruits per plant	Yield (t/ha)
Ch ₁ M ₁	4.59	3.95	3.61	2.26	20.34
Ch ₁ M ₂	6.66	4.10	4.09	2.86	25.74
Ch ₁ M ₃	8.17	5.35	5.68	3.18	28.62
Ch ₁ M ₄	8.79	5.20	5.43	3.01	27.09
Ch ₂ M ₁	9.30	5.55	5.89	3.11	27.99
Ch ₂ M ₂	11.71	5.87	6.22	4.10	36.90
Ch ₂ M ₃	12.04	6.13	6.50	4.61	41.49
Ch ₂ M ₄	10.65	5.62	5.81	3.57	32.13
Ch ₃ M ₁	12.07	6.01	6.01	3.45	31.05
Ch ₃ M ₂	12.92	6.39	6.87	3.89	35.01
Ch ₃ M ₃	16.13	6.89	7.50	4.86	43.74
Ch ₃ M ₄	13.43	6.51	6.68	4.15	37.35
Ch ₄ M ₁	10.25	5.30	5.54	3.32	29.88
Ch ₄ M ₂	11.32	5.80	6.16	3.49	31.41
Ch ₄ M ₃	13.61	6.11	6.51	4.17	37.53
Ch ₄ M ₄	12.53	5.85	6.26	3.52	31.68
Level of significance	**	**	**	**	**
CV (%)	14.21	7.16	9.81	12.55	15.63

Here, **= Significant at 1% level of probability; DAT= Days After Transplanting; CV= Coefficient of variance; Ch₁=Control; Ch₂=250 ppm chitosan; Ch₃= 500 ppm chitosan and Ch₄= 1000 ppm chitosan; M₁= No manure/ 100% soil (with only basal dose of fertilizer); M₂=cow dung (10 t/ha); M₃= vermin compost (10 t/ha) and M₄= farm yard manure (10 t/ha)

3.5 Number of Fruits Per Cluster

Highly significant variation was noted among different concentration of chitosan in case of number of fruits per cluster in tomato plants (Table 3). The highest number (6.76) of fruits per cluster was observed in chitosan 500ppm treatment followed by chitosan 1000ppm (6.11) and chitosan 250ppm (6.11), while the minimum number of fruits per cluster (4.70) was recorded from control treatment. Results demonstrated that different concentration of foliar application of chitosan on tomato plant had positive effect to enhance the number of fruits per cluster. Similar result was also reported by previous researchers and they stated that foliar spraying of oligo-chitosan with different concentrations had positive effect on number of fruits per cluster of tomato (Mondal et al., 2016; S. Sultana et al., 2017).

Different manures had positive impact on the number of fruits per cluster and significant variation was noted among different manures applied in the saline soil (Table 3). Among all applied manures, vermicompost exhibited the highest number of fruits per plant (6.54) followed by farm yard manure (6.05). On the other hand, the lowest number of fruits per cluster (5.26) was counted from control treatment. This might be due to the application of different organic manures which releases both macro and micro nutrients and beneficial soil microbes like N-fixing bacteria that promotes flowering and fruiting of plants. Similar findings were reported by Grimme (Grimme, 2006) and they noted that the highest number of tomato fruits per cluster was noted with the application of 100% well decomposed cowdung and vermicompost.

The interaction effect of chitosan and organic manures treatment exhibited significant variations in case of number fruits per cluster in saline soil conditions (Table 4). The highest number of fruits per cluster (7.50) was noted from the combination of chitosan 500ppm and vermicompost followed by chitosan 500ppm and farm yard manure (6.68). In contrast, the minimum number of fruits per cluster (3.61) was counted from control treatment. Chitosan with vermicompost treatment provides better soil health as it is rich in essential nutrients. Chitosan plays a major protective function against salinity stress and promote uptake of nutrient; which may be a reason for the increase in number of flower cluster per plant.

3.6 Weight of Fruits Per Plant

Chitosan had positive impact on weight of tomato fruit per plant. Significant variation was observed in respect of different concentration of chitosan foliar spray on weight of fruit per plant of tomato in saline condition (Table 3). The maximum fruit weight per plant (4.08 kg) was counted from 500ppm chitosan followed by 250 ppm chitosan (3.85 kg) whereas the minimum weight of fruit (2.82 kg) was recorded from without chitosan treatment. Foliar application of chitosan stimulated weight of fruits per plant in tomato which might be due to chitosan that increased the photosynthetic pigments and biochemical activities in plant. Our results are in line with Rahman et al. (Rahman et al., 2018) who reported that application of chitosan increased the weight of strawberry fruits. Tomato plants were treated with chitosan exhibited high phenolic compound, production of phytoalexins and improvement in fruit weight (Sathiyabama, Akila, & Charles, 2014).

Significant variation was noted among different manures applied in saline soil in respect of weight of tomato fruits per plant (Table 3). Among applied all manures, vermicompost exhibited the highest weight of fruits per plant (4.20 kg) followed by farm yard manure (3.58 kg). On the other hand, the lowest weight of fruits per plant (3.03 kg) was recorded from control treatment. Saha et al. (Saha, Kabir, Mondal, & Mannan, 2019) supported the result of present findings, they noticed application of different manures helps to create good soil environment which promotes proper growth and development of plants, finally the plants produced higher number and weight of fruits per plant.

The interaction effect of chitosan and organic manures treatment showed significant different in respect of weight of fruits per plant in saline soil conditions (Table 4). The maximum weight of fruits per plant (4.86 kg) was counted from the combination of chitosan 500ppm and vermicompost followed by chitosan 250ppm and vermicompost (4.61 kg). In contrast, the minimum weight of fruits per plant (2.26) was noted from control treatment.

3.7 Fruit Yield

Significant variation was noted among different concentration of chitosan in respect of yield of tomato (Table 3). The maximum yield (36.72

t/ha) was observed in chitosan 500ppm treatment followed by chitosan 250ppm (34.65 t/ha) and chitosan 1000ppm (32.58 t/ha), while the minimum yield (4.70 t/ha) was recorded from control treatment. Results revealed that different concentration of foliar application of chitosan on tomato plant had positive effect to increase the yield of tomato. This result is similar with the research works done by Sultana *et al.* (Sultana *et al.*, 2017) and Mondal *et al.* (Mondal *et al.*, 2016), they noted that foliar spraying of oligo-chitosan with different concentrations increased the yield of tomato.

Due to varying quantities of organic manures, there was a significant variance in yield per hectare of tomato in the saline soil (Table 3). Among all applied manures, vermicompost exhibited the maximum yield (37.8 t/ha) followed by cowdung (32.22 t/ha). On the other hand, the minimum yield (27.27 t/ha) was recorded from control treatment. This might be because of different organic manures which go through mineralization and retain essential nutrients for proper growth and development. This is related to physiological changes inside the plant and contributes to an increase in the number of fruits per plant and, ultimately the overall yield of tomato (Farid *et al.*, 2023). Similar results were demonstrated by Bose *et al.* (Bose *et al.* 2014) and Rahman *et al.* (Rahman *et al.* 2013), they recorded higher yield of cabbage and potato in case of organic manures treatment compared to control.

The interaction effect of chitosan and organic manures treatment exhibited significant variations in case of number fruits per cluster in saline soil conditions (Table 4). The highest number of fruits per cluster (7.50) was noted from the combination of chitosan 500ppm and vermicompost followed by chitosan 500ppm and farm yard manure (6.68). In contrast, the minimum number of fruits per cluster (3.61) was counted from control treatment. Chitosan with vermicompost treatment provides better soil health as it is rich in essential nutrients. Chitosan plays a major protective function against salinity stress and promote uptake of nutrient; which may be a reason for the increase in number and weight of fruits and ultimately yield of fruit. Kamal *et al.*, (2024) reported that manure-biochar composition mitigate the antagonistic effect of salt stress as a result increased plant growth and yield of tomato.

4. CONCLUSION

This study highlights the importance of foliar spray of different chitosan concentration and manures. Applying proper chitosan concentrations and manures could effectively improve the growth and yield of tomato plants by improving the different morphological aspects and yield contributing characters. From the above results it can be concluded that among the different concentration used in the present study, chitosan 500ppm had superior performance in respect of plant height, leaf length, flower per cluster, fruit weight and yield of tomato. Among the different manures, vermicompost (10 t/ha) exhibited the highest performance in respect of growth and yield of tomato. The present studied results revealed that foliar application of chitosan alone or in combination with manures has significant effect on growth and yield contributing characters of tomato. So, before final recommendation, foliar application of chitosan concentration and manures dose, further study is needed in different years and agro-ecological zones of Bangladesh.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Alenazi, M. M., El-Ebidy, A. M., El-Shehaby, O. A., Seleiman, M. F., Aldhuwaib, K. J., & Abdel-Aziz, H. M. (2024). Chitosan and chitosan nanoparticles differentially alleviate salinity stress in *Phaseolus vulgaris* L. plants. *Plants*, 13(3), 398.
<https://doi.org/10.3390/plants13030398>

- Bakhoum, G. S., Sadak, M. S., & Badr, E. A. E. M. (2020). Mitigation of adverse effects of salinity stress on sunflower plant (*Helianthus annuus* L.) by exogenous application of chitosan. *Bulletin of the National Research Centre*, 44, 1-11. <https://doi.org/10.1186/s42269-020-00343-7>
- Banerjee, J., Gantait, S., Sarkar, S., & Bhattacharyya, P. K. (2018). Transgenic research on tomato: problems, strategies, and achievements. *Biotechnologies of Crop Improvement, Transgenic Approaches*, 287-334. http://dx.doi.org/10.1007/978-3-319-90650-8_12
- Bhandari, R., Neupane, N., & Adhikari, D. P. (2021). Climatic change and its impact on tomato (*Lycopersicon esculentum* L.) production in plain area of Nepal. *Environmental Challenges*, 4, 100129. <https://doi.org/10.1016/j.envc.2021.100129>
- Bhowmik, U., Kibria, M. G., Rhaman, M. S., Murata, Y., & Hoque, M. A. (2021). Screening of rice genotypes for salt tolerance by physiological and biochemical characters. *Plant Science Today*, 8(3), 467-472. <https://doi.org/10.14719/pst.2021.8.3.1098>
- Bose, S. K., Howlader, P., Khan, A. B. M. M. M., Mallik, M. R & Kayosar, M.N. (2014). Growth and Yield of Cabbage as Influenced by Different Sources of Plant Nutrients. *Journal of Bangladesh society for agricultural science and technology*, 11 (1& 2): 141-144.
- Cuartero, J., Bolarin, M., Asins, M., & Moreno, V. (2006). Increasing salt tolerance in the tomato. *Journal of experimental botany*, 57(5), 1045-1058. <https://doi.org/10.1093/jxb/erj102>
- Farid, M. N., Kobir, M. S., Obaidullah, A. J. M., Haque, M. E., Islam, M. R., & Mondal, M. F. (2023). Effects of different manures and fertilizers on growth and yield of tomato. *Asian Journal of Crop*, 8(01), 299-307.
- Goswami, L., Nath, A., Sutradhar, S., Bhattacharya, S. S., Kalamdhad, A., Vellingiri, K., & Kim, K.-H. (2017). Application of drum compost and vermicompost to improve soil health, growth, and yield parameters for tomato and cabbage plants. *Journal of Environmental Management*, 200, 243-252. <https://doi.org/10.1016/j.jenvman.2017.05.073>
- Grimme, S. (2006). Semiempirical GGA-type density functional constructed with a long-range dispersion correction. *Journal of computational chemistry*, 27(15), 1787-1799. <https://doi.org/10.1002/jcc.20495>
- Haque, S., Mondal, M., Hassan, M., Islam, M., Hoque, M., Ahamed, S., & Bir, M. (2022). Effects of Organic Manures on Growth and Yield of Cabbage. *Journal of agriculture, food and environment*, 3(2): 45-49. <http://doi.org/10.47440/JAFE.2022.3209>
- Imran, M., Akhtar, M. J., Arshad, S. F., Ashfaq, M., Gulzar, M. Z., Ahmad, H. S., Haq, T. U. (2022). Improving Growth and Yield of Sunflower with Integrated Use of Compost and PGPR (*Variovorax Paradoxus*) with Different Levels of N-Chemical Fertilizer. *Journal of Bioresource Management*, 9(2), 4.
- Kamal, M. Z., Sarker, U., Roy, S. K., Alam, M. S., Azam, M. G., Miah, M. Y., Hossain, N., Ercisli, S., Alamri, S. (2024). Manure-biochar compost mitigates the soil salinity stress in tomato plants by modulating the osmoregulatory mechanism, photosynthetic pigments, and ionic homeostasis. *Scientific Reports*, 14(1) :21929. <https://www.nature.com/articles/s41598-024-73093-5>
- Kazimi, R., & Saxena, D. (2023). Significance of chitosan foliar spraying on the growth and yield of vegetable crop under protected cultivation: a review. *Plant Science Today*, 10(3), 140-148. <https://doi.org/10.14719/pst.2204>
- Li, Y., Wang, H., Zhang, Y., & Martin, C. (2018). Can the world's favorite fruit, tomato, provide an effective biosynthetic chassis for high-value metabolites? *Plant Cell Reports*, 37, 1443-1450. <https://doi.org/10.1007/s00299-018-2283-8>
- Maggio, A., De Pascale, S., Angelino, G., Ruggiero, C., & Barbieri, G. (2004). Physiological response of tomato to saline irrigation in long-term salinized soils. *European Journal of Agronomy*, 21(2), 149-159. [http://dx.doi.org/10.1016/S1161-0301\(03\)00092-3](http://dx.doi.org/10.1016/S1161-0301(03)00092-3)
- Mondal, M., Puteh, A. B., & Dafader, N. C. (2016). Foliar application of chitosan

- improved morphophysiological attributes and yield in summer tomato (*Solanum lycopersicum*). *Pakistan Journal of Agricultural Sciences*, 53(2). <http://dx.doi.org/10.21162/PAKJAS/16.2011>
- Nasrin, A., Khanom, S., & Hossain, S. A. (2019). Effects of vermicompost and compost on soil properties and growth and yield of Kalmi (*Ipomoea aquatica* Forsk.) in mixed soil. *Dhaka University Journal of Biological Sciences*, 28(1), 121-129. <http://dx.doi.org/10.3329/dujbs.v28i1.46491>
- Rahman, M. S., Ali, M., Bose, S. K., Robbani, M & Suem, M. A.(2013). Effect of tuber sizes and coddung on the growth and yield of potato. *Journal of Bangladesh society for agricultural science and technology*,10 (1&2): 175-179.
- Rahman, M., Mukta, J. A., Sabir, A. A., Gupta, D. R., Mohi-Ud-Din, M., Hasanuzzaman, M., & Islam, M. T. (2018). Chitosan biopolymer promotes yield and stimulates accumulation of antioxidants in strawberry fruit. *PloS one*, 13(9), e0203769. <https://doi.org/10.1371/journal.pone.0203769>
- Saha, K., Kabir, M. Y., Mondal, C., & Mannan, M. A. (2019). Growth and yield of tomato as affected by organic and inorganic fertilizers. *Journal of the Bangladesh Agricultural University*, 17(4), 500-506. <http://dx.doi.org/10.3329/jbau.v17i4.44618>
- Sathiyabama, M., Akila, G., & Charles, R. E. (2014). Chitosan-induced defence responses in tomato plants against early blight disease caused by *Alternaria solani* (Ellis and Martin) Sorauer. *Archives of Phytopathology and Plant Protection*, 47(16), 1963-1973. <http://dx.doi.org/10.1080/03235408.2013.858423>
- Sattar, S., Iqbal, A., Parveen, A., Fatima, E., Samdani, A., Fatima, H., & Shahzad, M. (2024). Tomatoes Unveiled: A Comprehensive Exploration from Cultivation to Culinary and Nutritional Significance. *Qeios*. <https://doi.org/10.32388/CP4Z4W>
- Shen, Z., Yu, Z., Xu, L., Zhao, Y., Yi, S., Shen, C., & Gu, C. (2022). Effects of vermicompost application on growth and heavy metal uptake of barley grown in mudflat salt-affected soils. *Agronomy*, 12(5), 1007. <https://doi.org/10.3390/agronomy12051007>
- Sultana, N., Zakir, H., Parvin, M., Sharmin, S., & Seal, H. (2019). Effect of chitosan coating on physiological responses and nutritional qualities of tomato fruits during postharvest storage. *Asian Journal of Advances in Agricultural Research*, 10(2), 1-11. <http://dx.doi.org/10.9734/ajaar/2019/v10i230027>
- Sultana, S., Islam, M., Khatun, M. A., Hassain, M. A., & Huque, R. (2017). Effect of foliar application of oligo-chitosan on growth, yield and quality of tomato and eggplant. *Asian Journal of Agricultural Research*, 11(2), 36-42. <https://doi.org/10.3923/ajar.2017.36.42>
- Ud Din, M. M., Khan, M. I., Azam, M., Ali, M. H., Qadri, R., Naveed, M., & Nasir, A. (2023). Effect of biochar and compost addition on mitigating salinity stress and improving fruit quality of tomato. *Agronomy*, 13(9), 2197. <https://www.mdpi.com/2073-4395/13/9/2197#>
- Ullah, N., Basit, A., Ahmad, I., Ullah, I., Shah, S. T., Mohamed, H. I., & Javed, S. (2020). Mitigation the adverse effect of salinity stress on the performance of the tomato crop by exogenous application of chitosan. *Bulletin of the National Research Centre*, 44, 1-11. <https://doi.org/10.1186/s42269-020-00435-4>
- Yupeng, J., Chunye, L., Peiyi, Z., Xiuping, L., Qiang, Z., Yujie, L., & Xiao, Y. (2020). Salinized soil improvement by planting 5 plant species in Hetao irrigation area. *Soils and Crops*, 9(2), 114-125.
- Zaman, M., Shahid, S. A., Heng, L., Shahid, S. A., Zaman, M., & Heng, L. (2018). Introduction to soil salinity, sodicity and diagnostics techniques. *Guideline for salinity assessment, mitigation and adaptation using nuclear and related techniques*, 1-42. http://dx.doi.org/10.1007/978-3-319-96190-3_1

Zhang, G., Wang, Y., Wu, K., Zhang, Q., Feng, Y., Miao, Y., & Yan, Z. (2021). Exogenous application of chitosan alleviate salinity stress in lettuce (*Lactuca sativa* L.). *Horticulturae*, 7(10), 342.
<http://dx.doi.org/10.3390/horticulturae7100342>

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