Research Article

# Effect of Organic Acids and *Trichoderma harzianum* in Reducing the Effect of Sodium Chloride on Wheat Growth

**Qasim H.A.Aljboori[1,2]*, A.V. Kurovsky[1], Andrey Babenko[1] and Ekaterina Kornievskaya[1]**

*[1]National Research Tomsk State University, av. Lenine,36,Tomsk , 634050, Russia; [2]University of Al-Qadisiyah ,Iraq.*

**Abstract** | Salinity is an abiotic factor affecting the growth and production of wheat plants, which poses a significant threat to global food security. This study aimed to evaluate the synergy of organic acids (folic acid, salicylic acid, and humic acid), together with *Trichoderma harzianum*, in improving wheat tolerance to sodium chloride concentrations of 0, 100, and 150 mmol/L. The experiment was conducted according to a completely randomized design; wheat seeds were pre-soaked in organic acids to specific levels of humic acid 75%, folic acid 0.2 mmol/L, salicylic acid 1 mmol/L and T. harzianum for 12 hours. Several indicators were evaluated: plant height, root length, and dry weight. The results showed that treatment with organic acids and T. harzianum contributed to a significant improvement in the growth of wheat compared with the control, and treatment with salicylic acid 1mmol/L+ humic acid 75% with T. harzianum gave the best results, as it increased the plant height, root length, and dry weight of wheat growing under the pressure of salt stress. These results confirm the importance of synergism between organic acids and T. harzianum as effective applications in salinity management and improving the sustainability of wheat growth in environments affected by sodium chloride.

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***Correspondence** | Qasim H.A. Aljboori, National Research Tomsk State University, av. Lenine,36,Tomsk, 634050, Russia; **Email:** abdulkadhim.qh@qu.edu.iq
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## Introduction

In the era of climate change, salinity has become a significant global issue that limits the production of economically important crops (Mukhopadhyay *et al.*, 2021). Sodium stress is considered one of the greatest environmental threats to the agricultural sector and the achievement of global food security. It is caused by two simultaneous risk factors: salinity and alkalinity (Ramadan *et al.*, 2022). Salinized soils have become a major concern worldwide (Hossain, 2019). Today, at the global level, salinity is an increasing problem, especially in arid and semi-arid regions, and the continuous use of saline water for irrigation purposes exacerbates this problem. Wheat is one of the most strategic crops, but its yield is repeatedly affected by salt stress and soil salinization worldwide (Quan *et al.*, 2021). Most cereals are generally sensitive to salinity during the vegetative and early reproductive stages (Gerona *et al.*, 2019). To address environmental constraints, recent advances have focused on environmentally friendly materials and techniques to improve seed growth. Seed coating and pelleting are advanced methods that have been used to improve crop growth in the past decade. In addition, modern seed coating techniques improve the resistance to environmental stresses by applying active ingredients such as nutrients, biostimulants, and plant protection agents to seeds (Afzal *et al*., 2020; Feghhenabi *et al*., 2020). pretreatment of seeds with S.A improved seedling growth of wheat under Nacl treatment (Lamlom *et al*., 2023; Talaat *et al*., 2023). Exogenous application of humic acid as a pre-sowing seed treatment significantly increased the biomass of growing maize plants under salt stress (Kaya *et al*., 2018; Lasheen *et al*., 2024). SA improved seedling length and dry weight in stressed barley (Ben Youssef *et al*., 2025; Torun *et al*., 2020; Pirasteh-Anosheh *et al*., 2022). FA is involved in the resistance of barley to salt stress (Kilic *et al*., 2016). In recent years, the use of exogenous plant growth regulators to enhance abiotic stress tolerance in plants has attracted considerable attention. Trichoderma can be utilized as an effective and safe biostimulant, demonstrating the ability to enhance plant growth under saline agricultural conditions. Trichoderma can be considered a useful and sustainable method for improving the growth of salt-sensitive crops (Ding *et al*., 2021, Yusnawan *et al*., 2021). *Trichoderma harzianum* stimulates wheat plant growth under salt stress (Zhao *et al*., 2025). Trichoderma provides plants with nutrients and enhances their tolerance to abiotic stresses, including salinity (Pacheco-Trejo *et al*., 2022). Salt stress negatively affected the physiological characteristics of plants. However, the data revealed that Trichoderma treatments alleviated the stress condition and significantly increased root length and photosynthesis rate (Rawat *et al*., 2012) . Salt stress poses a serious threat to the agricultural environment and agricultural sustainability. Therefore, our study focused on the enhancing role of organic acids, either in combination or alone, with *Trichoderma harzianum*, applied externally to wheat seeds, in reducing the effect of sodium chloride on wheat growth. We hypothesized that the combination of salicylic acid, humic acid, and T. harzianum would synergistically mitigate NaCl-induced stress in wheat seedlings.

## Materials and Methods

A laboratory experiment was conducted at Al-Qadisiyah University, Iraq, under a completely randomized design during the years 2024-2025 to study the effect of organic acids (Humic acid 75% German humin Tech Company, Folic acid 0.2 mmol/l, and Salicylic acid1mmol/l) alone and in combination with the bioactive agent *T. harzianum* on the growth plant height, root length, dry weight of wheat cultivar Iba99 under different salinity levels of sodium chloride (0, 100, and 150 mmol/L). Wheat seeds were immersed in the acids F.A, S.A, F. A+S.A, H.A+T.h , F.A +H.A+T.h and S.A +H.A +T.h as the control treatment distilled water for 12 hours. The seeds were washed with distilled water and dried with filter paper. The seeds were germinated in sterile Petri dishes containing filter paper, and the dishes were placed in an incubator at 25°C for 48 hours. Homogenized wheat seedlings were transferred from the plates to plastic pots at a rate of four seedlings per pot, with three replicates in a controlled greenhouse environment, with an average temperature of 25 ± 2°C, a relative humidity of 70%, and a light/dark period of 8/16 h. They were irrigated with distilled water and saline solutions according to the following treatments Nacl at concentrations of 0, 100, and 150 mmol/l Nacl Concentration was gradually increased to prevent osmotic shock. The plant height, root length, and dry weight were measured after 55 days, and statistical analysis of variance (ANOVA) was performed using SPSS. The experimental data were analyzed using CRD, Means were compared using the least significant difference (L.S.D) test at a probability level of 5%.

## Results and Discussion

The results show that as sodium chloride concentration increased, plant height gradually decreased, indicating that salt stress negatively impacts wheat plants. The decrease in the growth height of the wheat plant under salt pressure may be due to osmotic stress and the influence of sodium chloride ions, which affect the physiological and biochemical processes related to the wheat growth. The average plant height was 17.09 and 13.21 cm, respectively, at concentrations of 100 and 150 mmol/l, compared to the mean of 27.00 cm in the control group. However, seed dipping treatments with organic acids (F.A, S.A and H.A+ *T. harzianum*) showed a clear difference in their ability to mitigate the effect of sodium chloride on wheat growth. This is attributed to the role of organic acids with the bioactive factor *T. harzianum*, which stimulates the production of plant growth hormones, which play a key role in cell elongation and plant height. Salicylic acid enhances cell growth-regulating pathways and contributes to mitigating the effects of salinity stress. S.A+ H.A+ *T.harzianum* treatments were the most effective, values mean of 26.08 cm/plant compared to the control group values of 19.19 cm/plant, indicating its ability to improve wheat growth under salinity stress. These results are Compatible with the researcher's findings (Ben Youssef *et al*., 2025; Torun *et al*., 2020; Pirasteh-Anosheh *et al*., 2022), which show that organic acids enhanced plant length in stressed barley. This suggests that these three components combine positively to improve plant development under salty circumstances.

**Table 1:** *Effect of organic acids and T.harzianum on plant height of wheat cm/plant growing under the pressure of salt stress.*

| Treatments | Nacl mmol/l | | | Means |
|---|---|---|---|---|
| | 0 | 100 | 150 | |
| Control | 27.27 | 17.09 | 13.21 | 19.19 |
| H.A+T.h | 34.14 | 24.75 | 15.33 | 24.74 |
| F.A | 31.61 | 20.05 | 14.23 | 21.96 |
| S.A | 32.44 | 22.02 | 14.49 | 22.98 |
| F.A+S.A | 33.31 | 22.84 | 14.81 | 23.65 |
| S.A+H.A+T.h | 35.91 | 26.35 | 15.98 | 26.08 |
| F.A+H.A+T.h | 34.98 | 25.53 | 15.21 | 25.24 |
| L.S.D = 0.74 | | | | |

**Table 2:** *Shows the effect of organic acid and T.harzianum on the root length of wheat in cm/plant growing under salt stress*

| Treatments | Nacl mmol/l | | | Means |
|---|---|---|---|---|
| | 0 | 100 | 150 | |
| Control | 6.4 | 4.21 | 2.37 | 4.32 |
| H.A+T.h | 8.19 | 5.50 | 3.45 | 5.77 |
| F.A | 7.36 | 4.91 | 2.63 | 4.96 |
| S.A | 7.61 | 5.18 | 2.92 | 5.23 |
| F.A+S.A | 7.89 | 5.25 | 3.17 | 5.49 |
| S.A+H.A+T.h | 8.92 | 5.98 | 3.96 | 6.28 |
| F.A+H.A+T.h | 8.53 | 5.72 | 3.74 | 6.00 |

Results showed that a gradual increase in salinity concentrations led to a decrease in root length due to the increased sensitivity of the roots of the wheat plant to sodium chloride concentrations which leads to inhibition of root growth in saline environments (Dissanayake *et al*., 2022). However, treatment of wheat seeds with organic acids (F.A, H.A and S.A) resulted in significant differences in root length, values of 5.77, 4.96, 5.23, 5.49, and 6.00 cm/plant compared to the control group. Previous studies have shown that application of folic acid alleviates the negative effects of salt stress, increased root growth and improved plant growth (Kilic *et al*., 2016). The treatment of salicylic acid+ humic acid with *T. harzianum* significantly increased root length compared to the other treatments, with the mean root length in this treatment value 6.28 cm/plant, compared to a value of 4.32 cm/plant in the control treatment. This improvement is attributed to the stimulatory role of humic and salicylic acids and *T. harzianum* in promoting root cell division and elongation, as well as the improved nutrient uptake due to the activity of *T. harzianum* in the root zone, indicating a positive interactive effect between these three components in improving rooting under saline conditions. These results are consistent with the findings of (Lamlom et al., 2023; Kaya *et al*., 2018; Lasheen *et al*., 2024). pointed out that dipping seeds in humic acid and salicylic acid under saline conditions helps stimulate root growth.

**Table 3:** *Effect of organic acids with T.harzianum on dry weight g/ plant of Wheat cm/plant growing under salt stress*

| Treatments | Nacl/mmol | | | Means |
|---|---|---|---|---|
| | 0 | 100 | 150 | |
| Control | 0.26 | 0.18 | 0.13 | 0.19 |
| H.A+T.h | 0.31 | 0.22 | 0.16 | 0.23 |
| F.A | 0.27 | 0.20 | 0.14 | 0.20 |
| S.A | 0.28 | 0.21 | 0.14 | 0.21 |
| F.A+S.A | 0.29 | 0.21 | 0.15 | 0.22 |
| S.A+H.A+T.h | 0.34 | 0.24 | 0.17 | 0.25 |
| F.A+H.A+T.h | 0.32 | 0.23 | 0.17 | 0.24 |
| L.S.D = 0.008 | | | | |

The results showed a decrease in the dry weight of wheat plants grown in saline environments due to the toxic effect of sodium chloride ions Sodium chloride caused a decrease in the dry weight of the wheat plant, and these results are consistent with previous studies (Mohamed *et al*., 2020). The dry weight decreased from 0.26 at control group to 0.18 and 0.13 g/plant at sodium chloride concentrations of 100 and 150 mmol/l. The results indicated that seed coating with organic acids (F.A, S.A and H.A+*T.harzianum*) resulted in significant differences in the means dry weight of wheat plants values of 0.23, 0.20, 0.21, 0.22, 0.25, and 0.24 g/plant compared to the control group of 0.19 g/plant. The combination of organic acids also better results. Humic acid can alleviate various stressors by increasing dry biomass weight and stimulating plant growth (Kaya *et al*., 2018). The results indicated that the treatment (S.A+H. A+*T. harzianum*) was superior to all other treatments, resulting in an increase in dry weight value of 0.25 g/plant. This is attributed to the role of organic acids in enhancing metabolism and biosynthesis and the role of *T.harzianum* as well as enzymes and hormonal compounds that stimulate plant growth in saline environments. These results are consistent with the findings of the researcher (Ben Youssef *et al*., 2025; Torun *et al*., 2020; Pirasteh-Anosheh *et al*., 2022). indicating that organic acids increased plant length and dry weight in stressed barley. This indicates a positive interactive effect between these three components in improving plant growth under saline conditions.

## Conclusions and Recommendations

Salt stress is one of the most important abiotic factors that hinder wheat growth, and salinity reduces seedling growth. The study results showed that organic acids, mixed with *T.harzianum*, contributed to alleviating salt stress in wheat. It was found that stressed seedlings, obtained from seeds prepared with salicylic acid 1mmol/L+ humic acid 75% with T. harzianum, were more tolerant to NaCl than unprepared seeds. The results support the hypothesis that the use of multiple biotic and organic treatments could represent an effective integrated approach to mitigate the effects of salt stress on wheat growth. The improvement in the studied traits indicates that these treatments enhanced the adaptive capacity of plants in different saline environments. Based on the study's results, we suggest adopting the seed dipping technique with the compound salicylic acid +humic acid+ *T.harzianum* as a primary treatment to enhance wheat tolerance to salt stress in deteriorating environments. We also recommend conducting further field studies under various agricultural conditions and over extended growth periods.

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## Novelty Statement

This study showed that the combined effects of organic acids and the bio-factor *T.harzianum* significantly reduced the effect of sodium chloride on wheat growth under salt stress conditions.

## Authors' Contribution

**Qasim H.A.Aljboori:** Planned the experiment and wrote the manuscript.
**A.V. Kurovsky:** Planned the experiment and analyzed the data.
**Andrey Babenko:** Developed the general idea of the experiment.
**Ekaterina Kornievskaya:** Planned the experiment in microbiological aspects.
**Conflict of interest**: The authors have declared no conflict of interest.

*Generative AI or AI assisted technology statement*
The authors declare that they did not use AI.

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The authors have no conflict of interest.

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