International Journal of
Agriculture, Environment and Food Sciences

e-ISSN: 2618-5946 https://dergipark.org.tr/jaefs

DOI: https://doi.org/10.31015/2025.2.25 Int. J. Agric. Environ. Food Sci. 2025; 9 (2): 519-528

Enhancing soil health and nitrogen efficiency in cotton (*Gossypium hirsutum* L.) plants through organic and mineral fertilizations in saline and non-saline soils

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Article History
Received: March 25, 2025
Accepted: May 24, 2025
Published Online: June 25, 2025

Article Info
Type: Research Article
Subject: Organic Agriculture

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Available at
https://dergipark.org.tr/jaefs/issue/91914/1664902

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Abstract

Soil salinity significantly influences nitrogen dynamics within the soil matrix. Therefore, monitoring the nitrogen use efficiency (NUE) by plants in saline conditions is imperative. This investigation assesses the impact of mineral and organic fertilizers on nitrogen assimilation and various soil chemical characteristics under both saline and non-saline conditions in cotton (*Gossypium hirsutum* L.) cultivation. The study employed the Candia cotton cultivar along with diammonium phosphate (DAP, 18-46-0), cattle manure, and vermicompost as fertilization strategies. Vermicompost (1.58 dS m^{-1}) and cattle manure (1.49 dS m^{-1}) applications markedly alleviated the adverse effects of salinity by reducing electrical conductivity (EC) in saline soils ($P<0.05$). Organic fertilizers were observed to significantly increase the soil organic carbon (SOC) levels in saline soils compared to mineral fertilizers ($P<0.05$). The maximum plant height in saline conditions was recorded with vermicompost treatment (26.00 cm), while in non-saline environments, the greatest height was observed with cattle manure application (32.33 cm). In saline scenarios, DAP fertilization resulted in elevated nitrogen concentrations in the root (0.94%) and stem (2.03%) tissues over leaf tissues. Organic fertilizers markedly improved the nitrogen content in cotton across all tissue types, under both saline conditions and with both fertilizer categories ($P<0.05$). Additionally, organic amendments decreased the EC levels in saline soils and enhanced soil organic matter content. Contrary to mineral fertilizers, the use of organic amendments positively influenced nitrogen acquisition by cotton in saline conditions.

Keywords: Saline soil, Cotton, Nitrogen dynamics, Organic fertilizers

Cite this article as: Cevheri, C.I., Cun, S., Beyyavas, V., Ramazanoglu, E., Sakin, E., Yilmaz, A. (2025). Enhancing soil health and nitrogen efficiency in cotton (*Gossypium hirsutum* L.) plants through organic and mineral fertilizations in saline and non-saline soils. International Journal of Agriculture, Environment and Food Sciences, 9 (2): 519-528. https://doi.org/10.31015/2025.2.25

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) plays a significant role as a fiber crop, contributing fundamentally to the economies of many countries worldwide (Ahmad et al., 2018; Abbas and Ahmad, 2018; Koukouli and Georgiou, 2018; Rahman et al., 2018). It is also an important oilseed crop (Semizer-cuming et al., 2015) Grown in various geographical regions, cotton production spans approximately 80 countries today (FAO, 2018). Leading producers include China, India, the USA, Pakistan, and Turkey (Jabran et al., 2019). According to the International Cotton Advisory Committee's data for the 2021/2022 production season, the global cotton planting area reached 33.4 million hectares, with production totaling 26.4 million tons. Global cotton consumption was reported at 26.2 million tons (ICAC, 2022).

Like other plants, cotton requires a variety of nutrients for its growth and development, with nitrogen fertilizers being among the most commonly preferred in cotton production (Weir et al., 1996). A deficiency in nitrogen prevents the plant from achieving sufficient vegetative and generative growth (Sutton et al., 2011). Soil salinity is one factor that affects nitrogen uptake in plants (Zhang et al., 2018). The accumulation of salts, especially in the plant root zone, reduces the soil solution's osmotic potential, hindering water uptake by plants (Setia et al., 2013). An increase in soil salinity not only hampers plant growth but also adversely affects the size and activity of soil microbial biomass, as well as the biochemical processes essential for soil organic matter decomposition (Mavi et al., 2012). Soil salinity leads to nitrogen losses in the soil (Reddy and Crohn, 2014; Li et al., 2020). Elevated soil salt concentrations and high humidity conditions result in reduced nitrogen mineralization, with high salinity conditions potentially increasing nitrogen losses in the form of ammonia. Salinity impacts microbial activity in nitrification, the process of converting ammonium to nitrate, thereby reducing the efficiency of this conversion (Zhang et al., 2018).

To ensure sustainability in agricultural production, preserving soil health—the foundation of field agriculture is essential. Soil health encompasses chemical, physical, and biological properties that enable a wide range of functions. The dynamic roles of microorganisms in enhancing soil fertility and productivity hinge on enzyme activity, organic matter decomposition, and nutrient cycling (Antonious et al., 2020). Environmentally friendly applications of animal and plant-based fertilizers notably contribute to soil fertility, thereby increasing sustainable agricultural production (Kılbacak et al., 2021). Among these practices, the application of vermicompost is significant, enriching the soil with organic matter and nutrients, and stands out as a key organic fertilizer (Huang et al., 2013; Emperor and Kumar, 2015). Vermicompost, produced through the digestion of organic matter by earthworms, has been shown to have a greater positive impact on plant growth, soil reclamation, plant health, and the environment compared to traditional compost (Fritz et al., 2012; Bellitürk et al., 2013; Bellitürk et al., 2015).

This study aimed to evaluate the effects of organic and mineral fertilization strategies on nitrogen uptake and key soil chemical properties in cotton cultivation under saline and non-saline soil conditions.

MATERIAL AND METHOD

Material

The Candia cotton (*Gossypium hirsutum* L.) variety cleaned seeds served as the plant material. Organic fertilizers used in the study were cattle manure (Biofarm Fertilizer) and vermicompost (Ekosolfarm), while the chemical fertilizer employed was diammonium phosphate (DAP 18-46). The fertilizer treatments comprised four different approaches in both saline and non-saline soil types: 2000 kg ha^{-1} of cattle manure, 1500 kg ha^{-1} of vermicompost, 300 kg ha^{-1} of DAP fertilizer, and a control group without fertilizer application. The saline soils for the experiment were sourced from the Bozyazı area in the Harran plain, a region affected by salinity. The chemical properties of the soil types utilized in the experiment are detailed in Table 1.

Table 1. Characteristics of soil used in the experiment.

Soil Type	EC [ds m^{-1}]	pH	Lime [%]	Organic matter [%]
Saline soil	3.40	7.20	26.62	3.74
Non-saline soil	0.88	7.82	10.96	3.03

Method

The study was carried out in May 2019 at the Plant Laboratory of Harran University Şanlıurfa Technical Sciences Vocational School. The Candia cotton variety was cultivated in both non-saline and saline soils. Germination proceeded under laboratory conditions within a temperature-controlled chamber, adhering to the International Seed Testing Association (ISTA) guidelines. A test system was established for both non-saline and saline soils, utilizing seeds as control with three types of fertilizers and a control group. To prevent contamination, surface sterilization of the cotton seeds was performed by initially rinsing them with deionized water, followed by immersion in a 2% sodium hypochlorite solution for 3-5 minutes. Subsequently, the seeds were thoroughly rinsed 2-4 times with sterile distilled water. Additionally, for surface sterilization, the seeds underwent a 30-second soak in 70% ethanol, then a 10-minute immersion in a 10% sodium hypochlorite (NaOCl) solution. Soils were sifted through a 2 mm sieve and filled into 5 kg plastic pots. Surface-sterilized seeds were sown in pots prepared with fertilizers, applied according to manufacturers recommendations. Post-sowing, pots were watered to facilitate germination. Irrigation was adjusted based on plant water requirements, generally occurring twice weekly, using deionized water. The average temperature for plant growth was maintained daily at 27±1°C (30 °C day/26 °C night), with plant illumination set to 14 hours of light and 10 hours of darkness. Both sunlight and fluorescent light served as light sources. Harvesting occurred 12 weeks post-germination.

Soil reaction (pH) and electrical conductivity (EC) were assessed using saturation extract mud (Jackson, 1958). The soil calcium carbonate ($CaCO_3$) content was determined via the Scheibler calcimeter method (Allison and Moodie, 1965). Organic carbon was quantified through the wet oxidation method as developed by Nelson and Sommer (1982). Total soil nitrogen content (Bremner and Mulvaney, 1983), as well as nitrate (NO_3-N), were extracted using a 2M potassium chloride solution and quantified at a wavelength of 410 nm with a spectrophotometer (Cataldo et al., 1975). The nitrogen content in different parts of the cotton plant (root, stem, and leaf) was measured employing the Kjeldahl method (Bremner and Mulvaney, 1983). Plant height was determined by measuring from the soil surface to the apex of the tallest part of the plant.

Statistical analysis

The experiment was laid out according to the split plots divided in random plots. The descriptive statistics of the data were carried out and the mean values were obtained. Variance analyzes were performed using the JMP 13.2 statistical software. The mean values for the treatments were grouped by the Tukey-HSD test.

RESULTS AND DISCUSSION

Result

This study investigated the potential effects of soil salinity on the development of cotton plants and certain soil chemical properties, applying organic and mineral fertilizer sources across two contrasting soil types. Specifically, organic fertilizers (cattle manure and vermicompost) were found to positively contribute to both plant nitrogen uptake and the improvement of some soil chemical properties. The application of organic fertilizers led to a greater reduction in soil electrical conductivity (EC) compared to mineral fertilizers in both soil types, as detailed in Table 2. Particularly in the saline soil type, the application of cattle manure and vermicompost resulted in a more than twofold decrease in EC values relative to the control group. The effects of organic and mineral fertilizers on saline soils were also statistically significant in terms of soil EC values ($P<0.05$). In the non-saline soil type, due to the low EC value of the soil used in the experiment and the absence of salinity issues (as indicated in Table 1), there was no statistically significant variation in soil EC values between organic and mineral fertilizers applied in the non-saline soil type ($P<0.05$), as shown in Figure 1.

Table 2. Effect of treatments on some soil chemical properties

Soil Type	Treatments	EC [dS m^{-1}]	pH	CaCO3 [%]	Organic matter [%]
Saline soil	Control	3.72	7.80	28.95	2.55
	DAP	3.40	7.20	22.73	2.95
	Cattle manure	1.49	8.10	23.97	4.63
	Vermicompost	1.58	8.10	26.31	4.23
Non-saline soil	Control	1.01	7.80	12.30	3.49
	DAP	1.00	7.50	12.14	2.55
	Cattle manure	0.88	7.70	11.52	3.56
	Vermicompost	0.77	7.70	9.34	2.55

The application of both mineral and organic fertilizers in the contrasting soil types did not lead to any alterations in the pH values of the soils, as demonstrated in Table 2 and Figure 1. In the saline soil type, compared to the control group, the use of both mineral and organic fertilizers was associated with a reduction in the soil $CaCO_3$ content, as detailed in Table 2. This reduction was statistically significant ($P<0.05$), as illustrated in Figure 1. While no statistically significant difference was observed in the $CaCO_3$ content within the non-saline soil type, the application of vermicompost was notably associated with a partial decrease in the $CaCO_3$ content of the soils, as indicated in Table 2.

In the saline soil type, organic fertilizer applications significantly increased the soil organic carbon content (Table 2), and the changes induced by the applications in soil organic carbon content were also statistically significant ($P<0.05$). However, in the non-saline soil type, it was observed that the organic fertilizer sources applied to the soil had values closer to the control group. Organic fertilizers, containing high levels of carbon in their structure, are seen to be particularly effective in improving the properties of problematic soils such as saline soil. In the experiment terminated with the harvest of the cotton plant, the remaining total nitrogen and nitrate concentrations in the soil were determined.

In the conducted experiment, soils treated with both organic and mineral fertilizers exhibited lower nitrogen content compared to the control group soils across both soil types, as detailed in Table 3. Within the saline soil type, the application of cattle manure resulted in the lowest nitrogen content, with diammonium phosphate (DAP) and vermicompost applications following in ascending order of nitrogen content, respectively, as shown in Table 3.

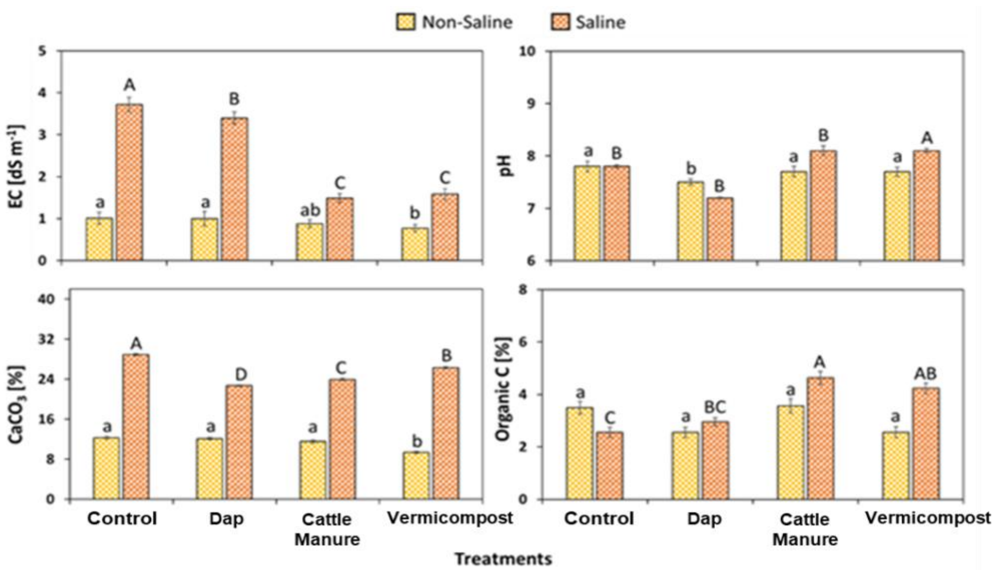

Figure 1. The effect of organic and mineral fertilizer application on certain soil chemical properties

Table 3. Soil total nitrogen and nitrate concentration.

Soil Type	treatments	Soil Nitrogen Concentration [mg N kg]	Soil Nitrate Concentration [mg N kg]
Saline soil	Control	1806	127.58
	DAP	1132	4.04
	Cattle manure	698	0.72
	Vermicompost	1181	11.17
Non-saline soil	Control	2015	2.61
	DAP	610	18.96
	Cattle manure	781	7.18
	Vermicompost	699	11.55

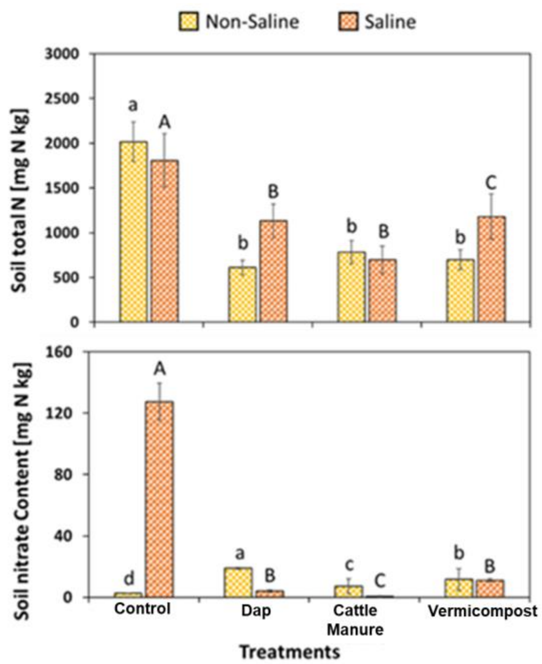

Figure 2. The effect of organic and mineral fertilizer application on soil nitrogen and nitrate content.

In the saline soil, the application of organic and mineral fertilizers did not result in any statistically significant differences ($P < 0.05$) in the soil nitrogen content remaining after harvest, as illustrated in Figure 2. Conversely, in the non-saline soil, the nitrogen content post-harvest was significantly lower for both organic and mineral fertilizer treatments compared to the control group, as detailed in Table 2. Additionally, no statistically significant difference was observed between the organic and mineral fertilizer treatments in the non-saline soil, as shown in Figure 2. Intriguingly, the control group in the saline soil, which received no fertilizer application, exhibited higher residual nitrate content after harvest compared to treated soils, as indicated in Table 3. For both mineral and organic fertilizer applications, soil nitrate levels were markedly lower than those in the control group, with this difference being statistically significant, as depicted in Figure 2. Despite the reduced soil nitrate contents post-harvest in the non-saline soil, the differences between treatments were statistically significant ($P < 0.05$), as shown in Figure 2.

Plant height, a critical agronomic parameter, demonstrated varied responses across the different soil types and fertilizer treatments. In the non-saline soil, the highest plant height (32.33 cm) was observed in the cattle manure treatment, whereas the lowest plant height (24.33 cm) occurred in the DAP-treated soil. In the saline soil, the highest plant height was noted in the vermicompost treatment (26.00 cm), with the lowest height recorded in the control group. Statistically significant differences in plant height were observed across both mineral and organic fertilizer applications in both soil types, as evidenced in Figure 3.

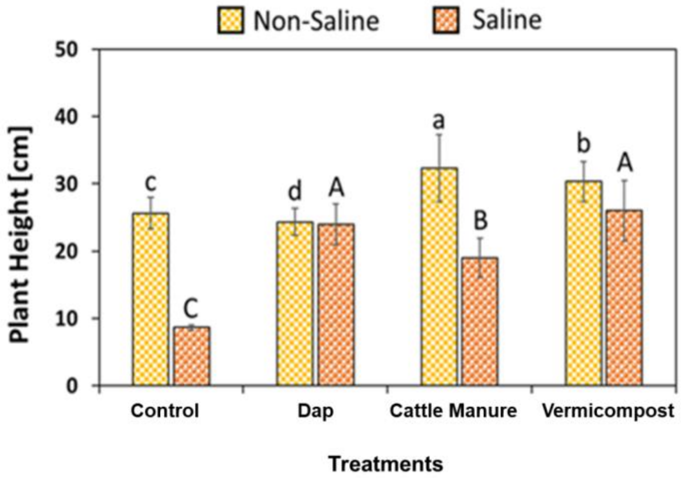

Figure 3. The effect of treatments on plant height.

Total nitrogen analysis was performed on various parts of the cotton plants (roots, stems, and leaves) to assess the nitrogen absorption from the soil during the trial period. In the saline soil, the nitrogen content in the roots and the stem and leaf tissues of cotton plants grown in the control soil exhibited very low levels. This suggests that the presence of salt in the environment may have significantly impeded physiological development, as evidenced by the notably low levels of nitrogen in the cotton plants from the control group (Table 4), coupled with their reduced height relative to other treatments. Notably, in saline soils, the application of diammonium phosphate (DAP) resulted in lower nitrogen content across the roots, stems, and leaves of the plant compared to the applications of the two organic fertilizers. Overall, in the saline soil type, organic fertilizers had a more pronounced effect on the plant nitrogen uptake than mineral fertilizer applications, as demonstrated in Figure 4.

Table 4. Effects of organic and mineral fertilizers on nitrogen uptake in cotton plants

Soil Type	Fertilizer treatment	Root [%]	Stem [%]	Leaf [%]
Saline soil	Control	0.10	0.10	0.10
	DAP	0.94	2.03	0.05
	Cattle manure	1.43	2.78	1.32
	Vermicompost	1.81	3.36	1.49
Non-saline soil	Control	3.05	3.73	1.47
	DAP	3.62	4.48	0.20
	Cattle manure	2.65	0.28	0.09
	Vermicompost	1.84	1.97	1.63

The analysis of nitrogen content in the roots, stems, and leaves of cotton plants grown in control group soil revealed uniform nitrogen levels across all three plant parts. This uniformity, coupled with the observed reduced plant height compared to other treatments, suggests that the presence of salt in the environment may have hindered the plant ability to thrive. In treatments with organic fertilizers, the nitrogen content was predominantly higher in the stem part of the plant, indicating a differential uptake and allocation pattern. Conversely, in the DAP (diammonium phosphate) treatment, nitrogen content was lower in the leaves but higher in the stems, pointing to a specific influence of mineral fertilizer on nitrogen distribution within the plant.

In the context of non-saline soil, DAP application was associated with significantly higher nitrogen content in both the root and stem parts of the plant, while the nitrogen content in the leaves was comparatively lower. The vermicompost treatment stood out, showing a more balanced nitrogen distribution across all three parts of the plant, as indicated in Table 4. The challenging conditions created by soil salinity significantly impair the plant nitrogen uptake from the soil. However, this study found that the adverse effects of salinity on nitrogen absorption could be substantially mitigated through the application of organic fertilizers. Organic fertilizers have been observed to enhance plant nitrogen content more effectively than mineral fertilizers, underscoring their potential to improve nutrient uptake in saline conditions.

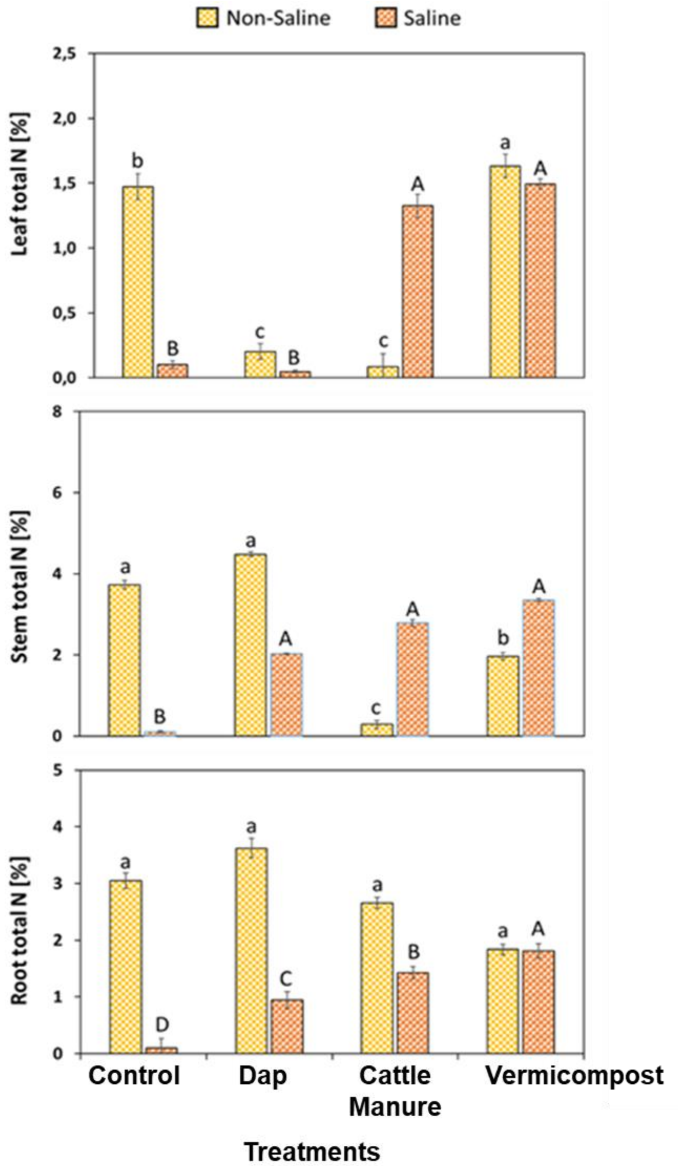

Figure 4. Nitrogen content in cotton plant root, stem, and leaf tissues

The examination of the impact of various treatments on the nitrogen uptake in cotton plants, as depicted in Figure 4, reveals that in non-saline soil conditions, the nitrogen absorption by the plant roots, stems, and leaves was comparable between the control group and the DAP (diammonium phosphate) fertilizer treatment. This observation underscores the primary aim of the study, which was to explore the effects of salinity on plant development. The conclusion of the experiment upon achieving the requisite plant measurement parameters in saline soils may have obscured the potential distinctions in treatment effects within the non-saline soil category.

The utilization of pots as the medium for conducting this experiment was a limiting factor for extending its duration. A longer experimental period might have highlighted more pronounced differences, with expectations pointing towards the control group exhibiting the lowest nitrogen content.

In non-saline soil, the DAP application was observed to result in the highest nitrogen content across the entire plant. Among the organic fertilizers, vermicompost was identified as more efficacious than cattle manure in enhancing nitrogen uptake. In conditions of saline soil, applications of organic fertilizers markedly improved the nitrogen uptake in cotton plants, with vermicompost standing out as the most advantageous for nitrogen absorption in such environments.

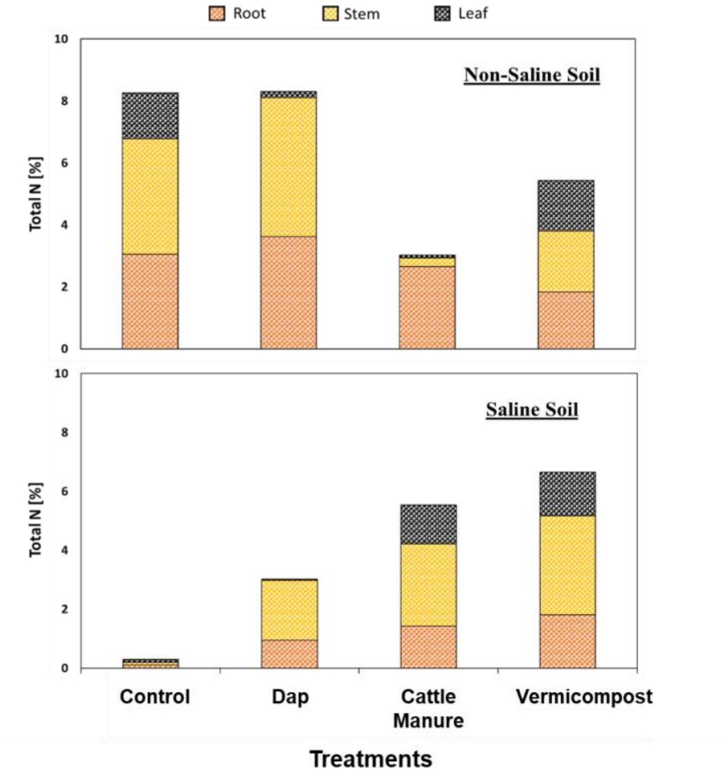

Figure 5. Nitrogen distribution in various parts of the cotton plant

Cattle manure and materials such as vermicompost, owing to their high carbon content, significantly enhance the levels of soil organic matter and biological activity in the soils to which they are applied (Deng et al., 2017). An increase in soil organic matter levels is pivotal for the rapid amelioration of saline soils, particularly those characterized by poor aeration and microbial activity (Makkar et al., 2017). Soil salinity profoundly influences nitrogen dynamics in the soil, affecting processes such as mineralization, nitrification, and denitrification (Zeng et al., 2013). This influence directly impedes nitrogen uptake, a critical nutrient for plants, thereby substantially reducing crop yields (Han et al., 2015). In saline soil types, the elevated soil nitrate content post-harvest can be attributed to the intensified competition between chloride ions (Cl^-) and nitrate ions (NO_3^-) due to the increased salt concentration, which obstructs the plants absorption of nitrate (Mengel and Kirkby, 2001). Nitrogen plays a crucial role in metabolic processes that enhance plant photosynthetic efficiency through the synthesis of chlorophyll and certain enzymes (Wen et al., 2019). The presence of salt disrupts the protein bond between chlorophyll and chloroplasts, leading to a rapid decline in the photosynthetic activity of plants (Jia et al., 2020).

Several factors contribute to the diminished development of plants in saline soil compared to those in non-saline soil types. These include the impediment to the plants access to water and nutrients caused by soil salinity, the formation of small capillary roots during early developmental stages, which in turn restricts growth and hinders the synthesis of enzymes involved in photosynthesis. The growth of cotton seeds in saline conditions may significantly slow or even result in plant mortality (Gouia et al., 1994). The lower nitrogen content observed in the roots of plants grown in saline soils, as opposed to other plant parts, may be due to the dynamic distribution of salt which interferes with irrigation and root water uptake (Malash et al., 2008). It has been documented that cotton plants accumulate nitrogen absorbed from the soil in their roots and stems, while the leaves exhibit lower nitrogen content. These observations align with the findings of our study (Chen et al., 2010). Ma et al. (2021) observed that salt application during early stages reduced nutrient and water uptake through the roots of sunflower plants. However, the roots were not significantly affected by salt applied during periods of increased plant growth, which was attributed to the absence of a rapid decrease in photosynthetic activity due to growing and expanding leaf area.

The dissolution of organic fertilizers in the soil releases humic substances, which enhance the availability of certain nutrients that plants are deficient in under saline conditions (Lakhdar et al., 2009). Notably, the application of vermicompost significantly improves nitrogen uptake in plants. Akhzari et al. (2016) reported that vermicompost application substantially increases plant nitrogen content, positively affecting plant growth parameters. The use of mineral fertilizers in saline conditions may further increase soil salinity. This is because mineral fertilizers inherently contain salts, and their excessive use in saline soils can exacerbate plant damage (Liu et al., 2019).

CONCLUSION

The application of both mineral and organic fertilizers to saline and non-saline soil types significantly influences soil chemical properties and the nitrogen uptake in cotton plants. Specifically, the application of organic fertilizers in saline soil types has been shown to reduce soil electrical conductivity (EC) values, thereby mitigating the adverse effects of salinity on plant growth. This reduction in EC values in saline soils contributes to enhanced plant development and more efficient utilization of nitrogen from the soil. It is commonly expected that plants grown under saline conditions tend to accumulate absorbed nitrogen predominantly in their roots and stems. A pivotal finding of our study is that the application of organic fertilizers to cotton plants cultivated in saline soils prevents the excessive accumulation of nitrogen in both the root and stem parts. Furthermore, the analysis of nitrogen content in leaf tissues reveals that organic fertilizer applications bolster nitrogen uptake by plants in saline conditions. In the specific soil conditions examined in this study, the utilization of 200 kg ha^{-1} of cattle manure and 150 kg ha^{-1} of vermicompost significantly improves various chemical properties of saline soils, as well as the nitrogen uptake and overall development of cotton plants.

Compliance with Ethical Standards

Peer-review

Externally peer-reviewed.

Declaration of Interests

The authors have no conflict of interest to declare.

Author contribution

The responsible author evaluated the analysis and results of the experiment and wrote the article. Other researchers collaborated on studies such as setting up the trial, supplying materials, statistical evaluation, and editing the article.

REFERENCES

Abbas, Q. & Ahmad, S. (2018). Effect of Different Sowing Times and Cultivars on Cotton Fiber Quality under Stable Cotton-Wheat Cropping System in Southern Punjab, Pakistan. Pakistan Journal of Life & Social Sciences, 16(2).

Ahmad, S., Iqbal, M., Muhammad, T., Mehmood, A., Ahmad, S. & Hasanuzzaman, M (2018). Cotton productivity enhanced through transplanting and early sowing. Acta Scientiarum. Biological Sciences, 40, 1-7. https://doi.org/10.4025/actascibiolsci.v40i1.34610

Akhzari, D., Pessarakli, M. & Khedmati, M. (2016). Effects of vermicompost and salinity stress on growth and physiological traits of (*Medicago rigidula* L.). Journal of Plant Nutrition, 39(14), 2106-2114. https://doi.org/10.1080/01904167.2016.1193609

Allison, L.E. & Moodie, C.D. (1965). Carbonate. Methods of soil analysis: part 2 chemical and microbiological properties, 9, 1379-1396. https://doi.org/10.2134/agronmonogr9.2.c40

Antonious, G.F., Turley, E.T. & Dawood, M.H. (2020). Monitoring soil enzymes activity before and after animal manure application. Agriculture, 10(5), 166. https://doi.org/10.3390/agriculture10050166

Belliturk, K., Shrestha, P. & Görres, J.H. (2015). The importance of phytoremediation of heavy metal contaminated soil using vermicompost for sustainable agriculture. J Rice Res, 3(2), 6-e114. http://dx.doi.org/10.4172/2375-4338.1000e114

Bellitürk, K., Aslan, S. & Eker, M. (2013). Ekosistem mühendisleri diye adlandırılan toprak solucanlarından elde edilen vermikompostun bitkisel üretim açısından önemi. Hasad Aylık Tarım Dergisi, 29(340), 84-87.

Bremner, J.M. & Mulvaney, C. (1983). Nitrogen—total. Methods soil analysis: part 2 chemical microbiological properties. 9: 595–624.

Cataldo, D.A., Maroon, M., Schrader, L.E. & Youngs, V.L. (1975). Rapid colorimetric determination of nitrate in plant tissue by nitration of salicylic acid. Communications in Soil Science and Plant Analysis, 6(1), 71-80. https://doi.org/10.1080/00103627509366547

Chen, W., Hou, Z., Wu, L., Liang, Y. & Wei, C. (2010). Effects of salinity and nitrogen on cotton growth in arid environment. Plant and Soil, 326, 61-73. https://doi.org/10.1007/s11104-008-9881-0

Deng, X., Wu, C., Li, Q. & Li, W. (2017). Effect of vermicompost on soil enzyme activity of coastal saline soil in water spinach plantation. In 2017 6th international conference on energy, environment and sustainable development (ICEESD 2017) (pp. 419-422). Atlantis Press. https://doi.org/10.2991/iceesd-17.2017.79

Emperor, G.N. & Kumar, K. (2015). Microbial population and activity on vermicompost of *Eudrilus eugeniae* and *Eisenia fetida* in different concentrations of tea waste with cow dung and kitchen waste mixture.

FAO (2018). FAOSTAT. Food and Agriculture Organization of the United Nations. Available online: http://www.fao.org/faostat/en/#data/QC/visualize. Accessed: 04.10.2018.

Fritz, J.I., Franke-Whittle, I.H., Haindl, S., Insam, H. & Braun, R. (2012). Microbiological community analysis of vermicompost tea and its influence on the growth of vegetables and cereals. Canadian Journal of Microbiology, 58(7), 836-847. https://doi.org/10.1139/w2012-06

Gouia, H., Ghorbal, M.H. & Touraine, B. (1994). Effects of NaCl on flows of N and mineral ions and on NO3-reduction rate within whole plants of salt-sensitive bean and salt-tolerant cotton. Plant Physiology, 105(4), 1409-1418. https://doi.org/10.1104/pp.105.4.1409

Han, J., Shi, J., Zeng, L., Xu, J. & Wu, L. (2015). Effects of nitrogen fertilization on the acidity and salinity of greenhouse soils. Environmental Science and Pollution Research, 22, 2976-2986. https://doi.org/10.1007/s11356-014-3542-z

Huang K, Li F, Wei Y, Chen X, Fu X (2013). Changes of bacterial and fungal community compositions during vermicomposting of vegetable wastes by *Eisenia foetida*. Bioresource Technology, 150, 235-241. https://doi.org/10.1016/j.biortech.2013.10.006

ICAC (2022). International Cotton Advisory Committee. Cotton Update May 19, 2022.

Jabran, K., Ul-Allah, S., Chauhan, B.S. & Bakhsh, A. (2019). An introduction to global production trends and uses, history and evolution, and genetic and biotechnological improvements in cotton. Cotton Production, 1-22. https://doi.org/10.1002/9781119385523.ch1

Jackson, M. L. (1958). Soil Chemical Analysis. Englewood Cliffs, NJ: Prentice- Hall. Inc

Jia, K., Yan, C., Yan, H. & Gao, J. (2020). Physiological responses of turnip (*Brassica rapa* L. subsp. rapa) seedlings to salt stress. HortScience, 55(10), 1567-1574. https://doi.org/10.21273/HORTSCI15187-20

Kılbacak, H., Bellitürk, K. & Çelik, A. (2021). Bitkisel ve hayvansal atıklardan vermikompost üretilmesi: yeşil badem kabuğu ve koyun gübresi karışımı örneği. Akademik Perspektiften Tarıma Bakış. İKSAD Yayınevi. Ankara.

Koukouli, P. & Georgiou, P. (2018). Evaluation of climate change impacts on cotton yield using Cropsyst and regression models. Journal: Journal of Advances in Agriculture, 8(01). https://doi.org/10.24297/jaa.v8i1.7779

Lakhdar, A., Rabhi, M., Ghnaya, T., Montemurro, F. & Jedidi, N., Abdelly, C. (2009). Effectiveness of compost use in salt-affected soil. Journal of Hazardous Materials, *171*(1-3), 29-37. https://doi.org/10.1016/j.jhazmat.2009.05.132

Li, Y., Xu, J., Liu, S., Qi, Z., Wang, H., Wei, Q. & Hameed, F. (2020). Salinity-induced concomitant increases in soil ammonia volatilization and nitrous oxide emission. Geoderma, 361, 114053. https://doi.org/10.1016/j.geoderma.2019.114053

Liu, M., Wang, C., Wang, F. & Xie, Y. (2019). Maize (*Zea mays*) growth and nutrient uptake following integrated improvement of vermicompost and humic acid fertilizer on coastal saline soil. Applied Soil Ecology, 142, 147-154. https://doi.org/10.1016/j.apsoil.2019.04.024

Ma, T., Zeng, W., Lei, G., Wu, J. & Huang, J. (2021). Predicting the rooting depth, dynamic root distribution and the yield of sunflower under different soil salinity and nitrogen applications. Industrial Crops and Products, 170, 113749. https://doi.org/10.1016/j.indcrop.2021.113749

Makkar, C., Singh, J. & Parkashi, C. (2017). Vermicompost leachate reduces some negative effects of salt stress in pomegranate. Int. J. Recycl. Org. Waste Agric. 6, 255–263. https://doi.org/10.1007/s4009.3 017-0168-4.

Malash, N.M., Ali, FA., Fatahalla, M.A., Khatab, E.A., Hatem, M.K. & Tawfic, S. (2008). Response of tomato to irrigation with saline water applied by different irrigation methods and water management strategies. International J of Plant Production, 2(2), 101-116. http://gau.ac.ir/journals/ijpp/showpdf.php?id=267

Mavi, M.S., Marschner, P., Chittleborough, D.J., Cox, J.W. & Sanderman, J. (2012). Salinity and sodicity affect soil respiration and dissolved organic matter dynamics differentially in soils varying in texture. Soil Biology and Biochemistry, *45*, 8-13. https://doi.org/10.1016/j.soilbio.2011.10.003

Mengel, K. & Kirkby, E.A. (2001). Principles of plant nutrition, Kluwer Academic Publishers, Netherlands, 849.

Nelson, D.W. & Sommers, L.E. (1982). Total Carbon, Organic Carbon, and Organic Matter. In: A.L. Page (Ed.), Methods of Soil Analysis: Part 2, Chemical and Microbiological Properties, 9.2.2, Second Edition, Wisconsin American Society of Agronomy Inc., USA, pp. 539 579. https://doi.org/10.2134/agronmonogr9.2.2ed.c29

Rahman, M.H., Ahmad, A., Wang, X., Wajid, A., Nasim, W., Hussain, M. & Hoogenboom, G. (2018). Multi-model projections of future climate and climate change impacts uncertainty assessment for cotton production in Pakistan. Agricultural and Forest Meteorology, 253, 94-113. https://doi.org/10.1016/j.agrformet.2018.02.008

Reddy, N. & Crohn, D.M. (2014). Effects of soil salinity and carbon availability from organic amendments on nitrous oxide emissions. Geoderma, 235, 363- 371. https://doi.org/10.1016/j.geoderma.2014.07.022

Semizer-cumıng, D., Altan, F., Akdemır, H., Tosun, M., Gurel, A., & Tanyolac, B. (2015). QTL analysis of fiber color and fiber quality in naturally green colored cotton (*Gossypium hirsutum* L.). *Turkish Journal of Field Crops*, *20*(1), 49-58. https://doi.org/10.17557/.94527

Setia, R., Gottschalk, P., Smith, P., Marschner, P., Baldock, J., Setia, D. & Smith J (2013). Soil salinity decreases global soil organic carbon stocks. Science of the Total Environment, 465, 267-272. https://doi.org/10.1016/j.scitotenv.2012.08.028

Sutton, M.A., Howard, C.M., Erisman, J.W., Billen, G., Bleeker, A., Grennfelt, P. & Grizzetti B (2011). *The European nitrogen assessment: sources, effects and policy perspectives*. Cambridge university press.

Weir, B.L., Kerby, T.A., Hake, K.D., Roberts, B.A. & Zelinski, L.J. (1996). Cotton fertility. Cotton Production Manual. Beltwide Cotton Production Research Conferences, 9-12 January 1996, University of California, CA, U.S.A, 210- 227.

Wen, B., Li, C., Fu, X., Li, D., Li, L., Chen, X. & Gao, D. (2019). Effects of nitrate deficiency on nitrate assimilation and chlorophyll synthesis of detached apple leaves. Plant Physiology and Biochemistry, 142, 363-371. https://doi.org/10.1016/j.plaphy.2019.07.007

Zeng, W.Z., Xu, C., Wu, J.W., Huang, J.S. & Ma, T. (2013). Effect of salinity on soil respiration and nitrogen dynamics. Ecological Chemistry and Engineering S, 20(3), 519-530.

Zhang, L., Song, L., Wang, B., Shao, H., Zhang, L. & Qin, X. (2018). Coeffects of salinity and moisture on CO2 and N2O emissions of laboratoryincubated salt-affected soils from different vegetation types. Geoderma, 332: 109-120. https://doi.org/10.1016/j.geoderma.2018.06.025