Original Article

Responses of Nitrobenzene on Growth and Yield Attributes in Okra to Salinity Stress

Md. Sheikh Shadi Haque[1], Faizur Rahman[1], Mollah Naimuzzaman[1], Fatima Jannat[1], Md. Mahmud[2]*

[1]College of Agricultural Sciences, IUBAT-International University of Business Agriculture and Technology, Dhaka-1230, Bangladesh
[2]Nabib Nagar Gov't Primary School, Godkhali -7420, Jashore, Bangladesh

Citation Md. Sheikh Shadi Haque, Faizur Rahman, Mollah Naimuzzaman, Fatima Jannat, Md. Mahmud. Responses of Nitrobenzene on Growth and Yield Attributes in Okra to Salinity Stress, Journal of Agricultural Sciences and Engineering, 2024, 6(1), 49-59

https://doi.org/10.48309/JASE.2024.425212.1041

ARTICLE INFO

Received: 2023-12-10

Accepted: 2024-02-19

Checked for Plagiarism: Yes.

Checked for Language Editor: Yes.

Editor who approved publication: Editorial board

***Corresponding Author:**
Md. Mahmud
(hasan.mahmud.edu@gmail.com)

Keywords:
Okra, Nitrobenzene, Salinity, Biostimulant, Salt stress.

ABSTRACT

Among the abiotic stress, salinity is conceived as a detrimental environmental stress that impairs crop production worldwide. The pot experiment was conducted at the Agricultural research field of the IUBAT, Dhaka during the period from January to April 2022 to assess the impacts of different concentrations of salt on the growth and yield of okra. The experiment followed a completely randomized design with three replications. The growth and yield components exhibited significant variations across different treatment groups. This study reveals the intricate dynamics of plant growth, mortality, leaf number, flowering, fruit set, and fruit yield in response to a range of nitrobenzene and salinity treatments during different developmental stages. Notably, the control group (T0) demonstrated remarkable resilience, particularly in later stages, compared to that of other treatments. Nitrobenzene treatments initially showed growth-promoting potential, but this effect diminished over time, while salinity consistently hindered growth. Interestingly, the combined effect of nitrobenzene and salinity treatments revealed complex interactions, suggesting tailored strategies to optimize crop productivity. In addition, the timing of flowering and fruit setting proved to be sensitive to these treatments, highlighting the intricate relationships between salinity and nitrobenzene. The highest plant height (14.91 cm), and the maximum leaf length (10.08 cm) were observed in the T0 (Control) treatment. The T10 Salinity (100 mM) + Nitrobenzene (20%) treatment exhibited the highest fruit number, with a count of 14, while the T2 (Nitrobenzene 25%) and T9 Salinity (50mM) + Nitrobenzene (30%) treatments had the lowest fruit number, with only 1 fruit each. The maximum fruit length was observed in the T0 (Control) and T13 Salinity (150mM) + Nitrobenzene (20%) treatments during the first stage of harvesting, measuring 7.2 cm and 7.26 cm, respectively, while the T13 Salinity (150 mM) + Nitrobenzene (20%) treatment exhibited the highest yield of okra (91 g). The results obtained from the present study provide valuable insights into the morphological responses of Okra plants, paving the way for innovative approaches to crop management and optimizing yield under challenging environmental conditions.

Introduction

Salinity stress poses a widespread environmental obstacle that significantly impacts the productivity of crops and holds extensive implications for global agriculture [1]. Okra (*Abelmoschus esculentus*), a warm-season vegetable of considerable economic and nutritional importance, is not exempt from the detrimental consequences of increased soil salinity [2]. This occurrence, which involves the accumulation of soluble salts in the root zone, initiates a chain of physiological disturbances in okra plants such as disrupted ion balance, reduced water availability, impaired nutrient absorption, and compromised photosynthetic efficiency. Consequently, salinity stress often results in hindered germination, stunted growth, and reduced yields [3]. As agricultural lands worldwide grapple with the escalating issue of salinization, comprehending the intricate mechanisms and consequences of salinity stress on okra becomes a necessity for sustainable crop management and food security. Salt stress, among these stressors, poses particularly difficult obstacles to agricultural productivity, often surpassing the detrimental effects of other non-living stresses such as heat, cold, and drought [4]. Okra, known for its culinary and nutritional value, is not immune to the challenges posed by salt stress. As a warm-season vegetable, it thrives in tropical, subtropical, and warm temperate regions worldwide, offering various edible parts including leaves, buds, flowers, pods, stems, and seeds [5]. These components provide a rich source of carbohydrates, fats, vitamins, and essential minerals, contributing to the crop's multifaceted nature with numerous culinary and dietary applications [6]. Moreover, research indicates that okra offers a range of health benefits, such as cholesterol reduction and potential cancer prevention through bile acid-binding. In addition, okra seeds have been found to possess properties that are beneficial for regulating blood glucose levels and improving lipid profiles in diabetic conditions [7]. However, the successful cultivation of this versatile crop faces significant challenges when confronted with soil salinity. The expansion of salt-affected areas is a growing concern, particularly in coastal regions where a considerable portion of irrigated land struggles with severe salinity issues [8]. High concentrations of salt in the soil lead to a series of adverse effects on plant growth, ultimately affecting cellular function and overall crop yield. These effects result in changes to ion balance, water potential, mineral uptake, and photosynthetic efficiency, while the presence of toxic ions such as Na^+ and Cl^- compounds the problem by hindering the absorption of essential ions like K^+, Ca^{2+}, and Mn^{2+} [1].

As a response to this challenge, the nitrobenzene application, a plant growth regulator derived from seaweeds, has garnered increasing attention as a potential solution to mitigate the adverse effects of salinity stress on okra plants [9]. Nitrobenzene has demonstrated exceptional efficacy in enhancing the process of flowering, increasing yields, and improving the uptake of nutrients in a wide range of crops [10]. The compound operates in synergy with plant growth regulators, augmenting the process of flowering, reducing the shedding of flowers, enhancing the efficiency of nutrient use, and stimulating vegetative growth [11]. Its influence extends to the biochemical pathways within plants, facilitating the uptake of necessary nutrients from the soil and promoting profuse flowering, while also improving the sensory qualities and shelf life of the produce [12]. As a result, it emerges as a promising tool for addressing the significant challenges posed by soil salinity in the cultivation of okra. This study embarks on a comprehensive exploration of the effects of nitrobenzene on the growth characteristics of okra when exposed to salinity stress, with the overarching objective of providing profound insights into strategies that can enhance the resilience and productivity of okra in saline environments. Despite the considerable volume of research dedicated to elucidating plant responses to salt stress, there remains a relatively limited amount of knowledge about the salt tolerance strategies of okra. In Asian regions, select studies have investigated the salt tolerance of specific okra genotypes, examining various indicators of growth parameters. Others have delved into the physiological adaptations of Asian okra genotypes to saline conditions [13,14]. These studies have provided valuable insights into the responses of okra to salinity stress. However, a comprehensive understanding of the plant's strategies for salt tolerance is still unfolding.

Moreover, the noteworthy aspect of nitrobenzene lies in its capacity to augment yields. Research has

demonstrated that the application of four sprays of nitrobenzene at specific growth stages throughout the crop cycle can result in yield enhancements of up to 40% [11]. This substantial amplification in productivity has bestowed upon nitrobenzene a valuable status in contemporary agriculture, particularly in the cultivation of vegetable crops and flowering plants where yield and quality assume utmost significance. Given the potential advantages of nitrobenzene in ameliorating crop performance, it becomes imperative to evaluate its influence on okra under the additional burden of salinity. This study endeavor embarks upon an exhaustive exploration of the effects of nitrobenzene on the growth characteristics of okra in the presence of salinity stress. By examining the impact of nitrobenzene application at diverse growth stages and concentrations, this study endeavors to elucidate its effectiveness in mitigating the challenges posed by soil salinity, with the ultimate aim of enhancing okra's resilience and productivity in saline environments. This study delves into the intricate interplay between the application of nitrobenzene and salt stress on okra, with a specific focus on growth characteristics. The overarching objective is to provide a comprehensive understanding of how nitrobenzene can potentially serve as a valuable instrument in overcoming the obstacles imposed by salinity stress in the cultivation of okra. The outcomes of this study hold the potential to inform agricultural practices by offering pragmatic strategies for optimizing okra production in regions where soil salinity represents a prevalent and persistent challenge.

Materials and methods

The experiment was carried out at the IUBAT agricultural research field. Geographically, IUBAT is positioned at a latitude of 23°53'17.80"N and a longitude of 90°23'25.98"E, approximately 9 meters above the average sea level. IUBAT lies under the Agro-ecological Zone - Madhupur Tract (AEZ 28), and it has a wet tropical climate having an average yearly temperature of 29.96 °C (85.93 °F), 9.9 inches of rainfall per year, and 65.8% mean yearly humidity [15]. The experiment was laid out in a Completely randomized design (CRD) under a factorial arrangement with three replications. Earthen pots were used, and each pot was filled with 5 kg of soil. The pot size was 20 cm in height, 30 cm diameter in top, and 20 cm diameter in bottom. During soil preparation, a dose of Urea 1 g/pot, TSP 0.7 g/pot, and MOP 0.3 g/pot were applied according to BARI recommended dose of fertilizer. Okra (*Abelmoschus esculentus* L.) BARI Dheros 2 variety was used for this study. Seeds of okra were sowed directly into the growth medium. Eight seeds per pot were sown but after 15 days of germination, the plants were thinned out to four. The experiment was carried out with three replications. Afterwards, the salt treatment was initiated. Sodium chloride was dissolved in distilled water to obtain a final concentration of 0 (Control), 50,100, and 150 mM and then these solutions of different NaCl concentrations were applied to create the salinity while the dose was applied in three installments. To prevent the plants from osmotic shock, the NaCl concentrations were imposed in 25 mM increments every day until final concentrations were reached after three days intervals [16].

Irrigation along with a saline solution was applied to the selected treatments according to the needs of the plants by regularly observing the wetness extent of the media. The data was recorded on various parameters such as morphological parameters like Plant height, Leaf area, and Number of leaves per plant. Phonological parameters like the number of flower buds and fruits. Yield parameters like Fruit length, Fruit diameter, Fruit weight, Fruit yield per plant, and Fruit yield per pot. The collected data were analyzed with the help of a computer package program Statistix 10 and means were separated using the LSD test.

Results and Discussion

Plant height (cm)

This study investigated the impacts of different treatments on the growth of plants at various stages of development (15 DAS, 30 DAS, 45 DAS, and 60 DAS). The treatments consisted of different combinations of Nitrobenzene (20%, 25%, and 30%) and Salinity (50 mM, 100 mM, and 150 mM), with the control group labeled as T0. The numerical values indicate significant variations in plant growth across treatments and stages. At 15 DAS, T13 Salinity (150 mM) + Nitrobenzene (20%) demonstrated the highest

growth (2.5833), which was significantly different from most other treatments, including the control (T0). T4 (Salinity 50 mM) also displayed noteworthy growth. As the plants progressed to 30 DAS, T13 Salinity (150 mM) + Nitrobenzene (20%) remained the most favorable treatment, showing a high growth value of 5.50. Similarly, T4 Salinity (50 mM) maintained its growth performance. However, in the later stages (45 DAS and 60 DAS), the control group (T0) exhibited exceptional growth, surpassing most other treatments and highlighting its resilience to environmental stresses. Interestingly, several combinations involving Salinity T5 Salinity (100 mM) to T15 Salinity (150 mM) + Nitrobenzene (30%) experienced significant reductions in growth, particularly at the 60 DAS stage. This comprehensive analysis emphasizes the intricate interplay between Nitrobenzene, Salinity, and plant growth at different developmental stages. Importantly, while some treatments initially promoted growth, the control group eventually outperformed them in the later stages. These findings provide valuable insights into how plants respond to environmental stressors and the potential benefits of specific treatments, shedding light on strategies for optimizing crop growth and yield in challenging conditions. The use of common letters to represent homogeneous groups confirms the statistical significance of these findings.

Table 1. Effect of nitrobenzene and salinity on plant height (cm) of okra plants

Treatment	15 DAS	30 DAS	45 DAS	60 DAS
T0	2.0083 ^{BCDE}	5.1250 ^{ABC}	14.667 ^{A}	14.917 ^{A}
T1	2.1667 ^{ABCDE}	4.6000 ^{ABCDE}	9.0000 ^{BCD}	10.083 ^{BC}
T2	2.5000 ^{AB}	4.5833 ^{ABCDE}	3.8333 ^{F}	4.9167 ^{E}
T3	1.8083 ^{DE}	3.5833 ^{F}	7.4167 ^{DE}	7.9583 ^{BCDE}
T4	2.1333 ^{ABCDE}	4.7500 ^{ABCD}	7.5000 ^{DE}	6.4167 ^{DE}
T5	2.3083 ^{ABCD}	4.9583 ^{ABCD}	7.1667 ^{DE}	5.4167 ^{DE}
T6	2.1250 ^{ABCDE}	4.6250 ^{ABCDE}	7.8333 ^{CDE}	8.5833 ^{BCD}
T7	2.0083 ^{BCDE}	4.1250 ^{DEF}	7.5833 ^{DE}	8.1667 ^{BCDE}
T8	2.0250 ^{BCDE}	4.1667 ^{DEF}	6.5833 ^{DEF}	7.1667 ^{CDE}
T9	1.7833 ^{E}	3.4583 ^{F}	6.0833 ^{EF}	6.3333 ^{DE}
T10	1.9000 ^{CDE}	3.7500 ^{EF}	10.417 ^{BC}	11.333 ^{B}
T11	2.1833 ^{ABCDE}	4.0417 ^{DEF}	7.4167 ^{DE}	8.2500 ^{BCDE}
T12	2.3333 ^{ABC}	4.5417 ^{BCDE}	8.0000 ^{CDE}	7.9167 ^{BCDE}
T13	2.5833 ^{A}	5.5000 ^{A}	11.333 ^{B}	10.917 ^{B}
T14	2.1667 ^{ABCDE}	4.2500 ^{CDEF}	7.7500 ^{CDE}	8.5000 ^{BCD}
T15	2.5000 ^{AB}	5.3333 ^{AB}	6.3333 ^{DEF}	6.4167 ^{DE}

DAS= Days after sowing, T0 Control, T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), T4 Salinity (50 mM), T5 Salinity (100 mM), T6 Salinity (150 mM), T7 Salinity (50 mM) + Nitrobenzene (20%), T8 Salinity (50 mM) + Nitrobenzene (25%), T9 Salinity (50mM) + Nitrobenzene (30%), T10 Salinity (100 mM) + Nitrobenzene (20%), T11 Salinity (100 mM) + Nitrobenzene (25%), T12 Salinity (100 mM) + Nitrobenzene (30%), T13 Salinity (150 mM) + Nitrobenzene (20%), T14 Salinity (150 mM) + Nitrobenzene (25%), and T15 Salinity (150 mM) + Nitrobenzene (30%)

Leaf number

This research endeavor sought to examine the influence of different interventions, such as Nitrobenzene (20%, 25%, and 30%) and Salinity (50 mM, 100 mM, and 150 mM), on the development of BARI Dheros 2 at varying growth stages (15 DAS, 30 DAS, 45 DAS, and 60 DAS), with the control group denoted as T0 (Control). The numerical data reveals noteworthy variations in leaf number across the treatments and developmental phases. During the initial stage (15 DAS), T0 (Control) and T1 (Nitrobenzene 20%) showcased the highest growth values of 2.3333 and 2.2500, respectively, with no significant disparity between them. However, as the plants progressed to 30 DAS, T0 (Control) maintained its growth while T1(Nitrobenzene 20%) experienced a decline. In addition, T2 (Nitrobenzene 25%) demonstrated a substantial reduction in growth. At 45 DAS, T0 (Control) sustained its advantage, but T1(Nitrobenzene 20%) and T2 (Nitrobenzene 25%) manifested a significant decrease in growth. Interestingly, T3 (Nitrobenzene 30%) exhibited a growth recovery compared to earlier stages. In the final stage (60 DAS), T0 (Control) continued to

outperform other treatments, with a growth value of 4.0833, while most treatments displayed diminished growth in comparison to previous stages. Notably, treatments involving Salinity T4 Salinity (50mM) to T15 Salinity (150mM) + Nitrobenzene (30%) generally demonstrated reduced growth, particularly at the 60 DAS stage. This comprehensive analysis underscores the intricate relationship between Nitrobenzene, Salinity, and leaf number at various developmental stages. While Nitrobenzene initially exhibited potential in promoting growth, its efficacy diminished over time. In contrast, Salinity treatments consistently impeded plant growth. These findings offer valuable insights into the dynamic nature of plant responses to environmental stressors and chemical interventions. The utilization of common letters to denote homogeneous groups validates the statistical significance of these findings and their implications for optimizing crop growth under challenging conditions.

Table 2. Effect of nitrobenzene and salinity on leaf number per okra plants

Treatment	15 DAS	30 DAS	45 DAS	60 DAS
T0	2.3333 ^{A}	5.1667 ^{A}	5.0833 ^{A}	4.0833 ^{ABC}
T1	2.2500 ^{A}	3.3333 ^{BCDE}	4.2500 ^{AB}	3.5833 ^{BCD}
T2	1.5833 ^{C}	3.0000 ^{BCDE}	1.5833 ^{G}	2.0833 ^{DE}
T3	2.0000 ^{ABC}	3.5000 ^{BCD}	4.1667 ^{ABC}	4.4167 ^{AB}
T4	1.5833 ^{C}	2.5000 ^{E}	4.1667 ^{ABC}	3.3333 ^{BCDE}
T5	1.6667 ^{C}	2.7500 ^{CDE}	3.1667 ^{BCDEF}	2.0000 ^{DE}
T6	2.1667 ^{AB}	3.5000 ^{BCD}	3.4167 ^{BCDE}	5.3333 ^{A}
T7	1.7500 ^{BC}	2.8333 ^{CDE}	3.6667 ^{BCDE}	4.3333 ^{ABC}
T8	2.3333 ^{A}	3.6667 ^{BC}	2.8333 ^{DEF}	2.7500 ^{CDE}
T9	1.9167 ^{ABC}	3.2500 ^{BCDE}	2.6667 ^{EFG}	3.7500 ^{ABC}
T10	2.1667 ^{AB}	3.8333 ^{B}	4.0000 ^{ABCD}	3.8333 ^{ABC}
T11	1.7500 ^{BC}	2.5833 ^{DE}	3.5000 ^{BCDE}	3.5000 ^{BCDE}
T12	2.0000 ^{ABC}	3.5000 ^{BCD}	3.0000 ^{CDEF}	3.3333 ^{BCDE}
T13	1.9167 ^{ABC}	3.5833 ^{BC}	3.7500 ^{BCDE}	3.0833 ^{BCDE}
T14	1.7500 ^{BC}	2.9167 ^{BCDE}	3.4167 ^{BCDE}	3.3333 ^{BCDE}
T15	1.6667 ^{C}	3.5000 ^{BCD}	2.0833 ^{FG}	1.9167 ^{E}

DAS= Days after sowing, T0 Control, T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), T4 Salinity (50 mM), T5 Salinity (100 mM), T6 Salinity (150 mM), T7 Salinity (50 mM) + Nitrobenzene (20%), T8 Salinity (50 mM) + Nitrobenzene (25%), T9 Salinity (50 mM) + Nitrobenzene (30%), T10 Salinity (100 mM) + Nitrobenzene (20%), T11 Salinity (100 mM) + Nitrobenzene (25%), T12 Salinity (100 mM) + Nitrobenzene (30%), T13 Salinity (150 mM) + Nitrobenzene (20%), T14 Salinity (150mM) + Nitrobenzene (25%), and T15 Salinity (150 mM) + Nitrobenzene (30%)

Leaf length (cm)

This investigation examined the impacts of different treatments, such as Nitrobenzene (20%, 25%, and 30%) and Salinity (50 mM, 100 mM, and 150 mM), on the growth of BARI Dheros 2 at different developmental stages (15 DAS, 30 DAS, 45 DAS, and 60 DAS), with the control group represented as T0. The results demonstrate significant variations in plant growth across treatments and developmental stages. During the initial stage (15 DAS), T0 (Control) exhibited the highest growth value of 3.3333, followed by T13 (Salinity 150 mM + Nitrobenzene 20%) at 3.55, which did not significantly differ from T0 (Control). In contrast, T2 (Nitrobenzene 25%) displayed the lowest growth at this stage. As the plants progressed to 30 DAS, T0 (Control) maintained its lead, with a growth value of 9.3750, followed closely by T1 (Nitrobenzene 20%) at 5.2833. The Salinity treatments T4 Salinity (50mM), T5 Salinity (100 mM), and T6 Salinity (150 mM) exhibited lower growth compared to T0. At 45 DAS, T0 again demonstrated the highest growth, followed by T1 Nitrobenzene (20%). Interestingly, T7 (Salinity 50 mM + Nitrobenzene 20%) showed substantial growth at this stage, indicating a potential interaction between Salinity and Nitrobenzene. In the final stage (60 DAS), T0 (Control) and T13 Salinity (150mM) + Nitrobenzene (20%) maintained their growth superiority, while T10 (Salinity 100 mM+ Nitrobenzene 20%) displayed significant growth, becoming the third highest treatment. The results

suggest that Nitrobenzene treatments initially showed promise in promoting growth but gradually lost their effectiveness, while Salinity treatments generally hindered growth. Notably, combinations of Salinity and Nitrobenzene, particularly T7 Salinity (50 mM) + Nitrobenzene (20%) and T10 Salinity (100 mM) + Nitrobenzene (20%) exhibited unique growth patterns, indicating potential interactions that warrant further investigation. The use of common letters to denote homogeneous groups confirms the statistical significance of these findings, highlighting the complexity of plant responses to environmental stressors and chemical treatments.

Table 3. Effect of nitrobenzene and salinity on leaf length (cm) of okra plants

Treatment	15 DAS	30 DAS	45 DAS	60 DAS
T0	3.3333 ^{AB}	9.3750 ^{A}	9.7083 ^{A}	10.083 ^{AB}
T1	2.5500 ^{BCD}	5.2833 ^{BC}	5.6333 ^{BCD}	7.0833 ^{BCDE}
T2	1.7250 ^{DEF}	2.8667 ^{F}	3.0000 ^{E}	3.2500 ^{F}
T3	2.1000 ^{CDEF}	4.1583 ^{CDEF}	4.7917 ^{CDE}	6.1250 ^{DEF}
T4	1.7000 ^{EF}	3.0000 ^{F}	3.9167 ^{CDE}	6.5833 ^{DE}
T5	1.6333 ^{F}	3.3417 ^{EF}	3.1667 ^{E}	4.3333 ^{EF}
T6	2.4667 ^{CDE}	5.1250 ^{BCD}	4.5833 ^{CDE}	6.5000 ^{DE}
T7	1.8667 ^{CDEF}	3.9167 ^{CDEF}	5.8917 ^{BC}	9.7500 ^{ABC}
T8	1.6500 ^{EF}	2.9917 ^{F}	3.6167 ^{DE}	5.0833 ^{EF}
T9	1.9250 ^{CDEF}	3.4583 ^{DEF}	3.6000 ^{DE}	4.6667 ^{EF}
T10	3.3333 ^{AB}	5.9417 ^{B}	7.5000 ^{B}	11.500 ^{A}
T11	1.9833 ^{CDEF}	3.6500 ^{CDEF}	4.8333 ^{CDE}	6.8333 ^{CDE}
T12	1.8750 ^{CDEF}	3.3750 ^{EF}	3.9000 ^{CDE}	5.9167 ^{DEF}
T13	3.5500 ^{A}	6.2500 ^{B}	7.1250 ^{B}	8.4167 ^{ABCD}
T14	2.6667 ^{BC}	4.7667 ^{BCDE}	4.7917 ^{CDE}	6.0833 ^{DEF}
T15	1.6750 ^{EF}	3.5833 ^{CDEF}	4.0417 ^{CDE}	4.8333 ^{EF}

DAS= Days after sowing, T0 Control, T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), T4 Salinity (50 mM), T5 Salinity (100 mM), T6 Salinity (150 mM), T7 Salinity (50 mM) + Nitrobenzene (20%), T8 Salinity (50 mM) + Nitrobenzene (25%), T9 Salinity (50 mM) + Nitrobenzene (30%), T10 Salinity (100 mM) + Nitrobenzene (20%), T11 Salinity (100 mM) + Nitrobenzene (25%), T12 Salinity (100 mM) + Nitrobenzene (30%), T13 Salinity (150mM) + Nitrobenzene (20%), T14 Salinity (150 mM) + Nitrobenzene (25%), and T15 Salinity (150 mM) + Nitrobenzene (30%)

Leaf width (cm)

This study examined the effects of different treatments, specifically Nitrobenzene (20%, 25%, and 30%) and Salinity (50 mM, 100 mM, and 150 mM), on the growth of BARI Dheros 2 at different stages of development (15 DAS, 30 DAS, 45 DAS, and 60 DAS), with the control group denoted as T0. The outcomes demonstrate noteworthy variations in plant growth across treatments and developmental stages. During the initial stage (15 DAS), T0 (Control) exhibited the highest growth value of 3.0750, significantly exceeding all other treatments. Among the treatments, T13 (Salinity 150 mM + Nitrobenzene 20%) displayed the highest growth, although it did not reach the level of T0 (Control). T2 (Nitrobenzene 25%) demonstrated the lowest growth at this stage. As the plants progressed to 30 DAS, T0 maintained its growth superiority with a value of 7.5167, followed by T1 (Nitrobenzene 20%) at 4.2417. The Salinity treatments T4 Salinity (50 mM), T5 Salinity (100 mM), and T6 Salinity (150 mM) continued to exhibit lower growth compared to T0 (Control). At 45 DAS, T0 (Control) again displayed the highest growth, with a value of 6.8917, closely followed by T1. Interestingly, T7 (Salinity 50 mM + Nitrobenzene 20%) showed substantial growth at this stage, suggesting a potential interactive effect between Salinity and Nitrobenzene. In the final stage (60 DAS), T0 (Control) and T13 Salinity (150mM) + Nitrobenzene (20%) remained among the top treatments in terms of growth, while T10 (Salinity 100 mM + Nitrobenzene 20%) exhibited significant growth, becoming the third-highest treatment. The results indicate that Nitrobenzene treatments initially showed promise in promoting growth, but gradually lost their efficacy over time. In contrast, Salinity treatments generally impeded growth, with some exceptions, particularly when combined with Nitrobenzene. These interactions

suggest a complex relationship between environmental stressors and chemical treatments that require further investigation. The use of common letters to denote homogeneous groups confirms the statistical significance of these findings, highlighting the intricate nature of plant responses to varying conditions and treatments.

Table 4. Effect of nitrobenzene and salinity on leaf width (cm) of okra plants

Treatment	15 DAS	30 DAS	45 DAS	60 DAS
T0	3.0750 A	7.5167 A	6.8917 A	6.8333 AB
T1	2.3083 BCD	4.2417 BC	4.2417 BCD	5.0833 BCDEF
T2	1.4833 EF	2.6917 DE	2.5000 EF	2.3333 H
T3	2.0833 BCDE	3.6333 BCDE	3.7833 BCDE	5.2500 ABCDE
T4	1.4083 F	2.9917 CDE	3.3333 CDEF	4.7500 BCDEFG
T5	1.6500 EF	3.2333 CDE	1.9667 F	2.9167 FGH
T6	1.9750 CDEF	4.0083 BCD	3.8333 BCDE	4.5833 CDEFG
T7	1.4500 EF	2.5000 E	4.1833 BCD	6.3333 ABC
T8	1.9167 DEF	2.5750 E	2.7583 DEF	3.9167 DEFGH
T9	1.6667 EF	2.6083 E	2.4167 EF	2.8333 GH
T10	2.5833 ABC	4.8167 B	5.0000 B	7.3333 A
T11	1.8750 DEF	2.8167 DE	3.2667 DEF	4.5000 CDEFGH
T12	1.6667 EF	2.9750 CDE	2.6917 DEF	3.4167 EFGH
T13	2.7167 AB	4.8667 B	4.9167 BC	5.7500 ABCD
T14	1.8917 DEF	3.6000 BCDE	3.2500 DEF	4.0833 DEFGH
T15	1.5500 EF	2.8417 DE	2.6500 DEF	3.2500 EFGH

DAS= Days after sowing, T0 Control, T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), T4 Salinity (50 mM), T5 Salinity (100 mM), T6 Salinity (150 mM), T7 Salinity (50 mM) + Nitrobenzene (20%), T8 Salinity (50 mM) + Nitrobenzene (25%), T9 Salinity (50 mM) + Nitrobenzene (30%), T10 Salinity (100 mM) + Nitrobenzene (20%), T11 Salinity (100 mM) + Nitrobenzene (25%), T12 Salinity (100 mM) + Nitrobenzene (30%), T13 Salinity (150 mM) + Nitrobenzene (20%), T14 Salinity (150 mM) + Nitrobenzene (25%), and T15 Salinity (150 mM) + Nitrobenzene (30%)

Responses of Nitrobenzene in okra for days to first flower and days to fruit setting as affected by salinity stress

The findings presented in this study demonstrate a nuanced interplay between different treatments and their respective impacts on the flowering and fruit-setting processes in the plant under investigation. The control group (T0) displayed an average duration of 33.33 days for the onset of flowering and 36.34 days for the initiation of fruit set. When exposed to varying concentrations of Nitrobenzene (20%, 25%, and 30%) and Salinity (50 mM, 100 mM, and 150 mM), it was observed that Nitrobenzene treatments did not significantly alter the timing of flowering or fruit set compared to the control. In contrast, the introduction of salinity stress (50,100, and 150 mM) in isolation T4 Salinity (50 mM), T5 Salinity (100 mM), and T6 Salinity (150 mM) resulted in a delayed response in flowering and fruit set, with a noticeable increase in the duration required. Interestingly, when combinations of salinity and Nitrobenzene were applied T7 Salinity (50 mM) + Nitrobenzene (20%) to T15 Salinity (150 mM) + Nitrobenzene (30%), intricate patterns emerged. The interaction between these factors exhibited complex and, in some cases, synergistic effects. For example, the combination of Salinity (50 mM) and Nitrobenzene (20%) (T7) as well as the combination of Salinity (100 mM) and Nitrobenzene (25%) (T11) both prolonged the time required for the onset of flowering and fruit set, indicating a cumulative impact. In contrast, the combination of Salinity (150 mM) and Nitrobenzene (20%) (T13) resulted in a less pronounced delay compared to T6 Salinity (150 mM) alone. These findings highlight the necessity for a more comprehensive understanding of the intricate relationships between salinity and Nitrobenzene treatments concerning the flowering and fruit-setting processes, emphasizing the significance of considering multiple variables in agricultural management strategies.

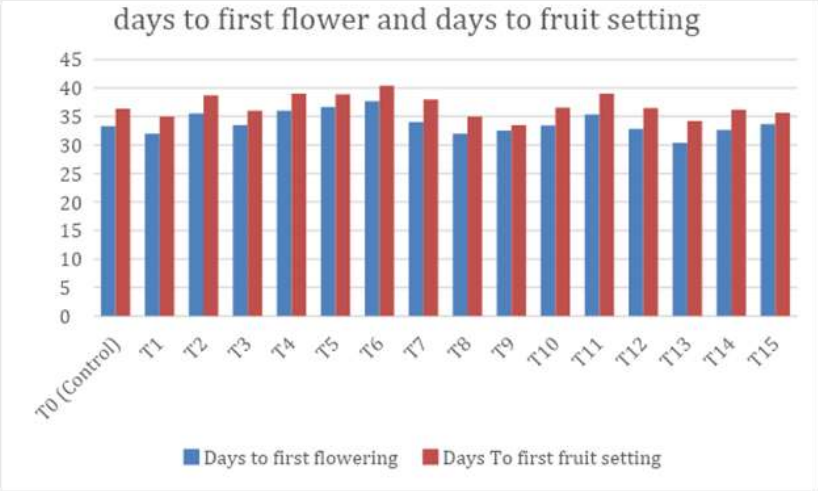

Figure 1. Days to first flower and days to fruit setting

DAS= Days after sowing, T0 Control, T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), T4 Salinity (50 mM), T5 Salinity (100 mM), T6 Salinity (150 mM), T7 Salinity (50 mM) + Nitrobenzene (20%), T8 Salinity (50 mM) + Nitrobenzene (25%), T9 Salinity (50 mM) + Nitrobenzene (30%), T10 Salinity (100 mM) + Nitrobenzene (20%), T11 Salinity (100 mM) + Nitrobenzene (25%), T12 Salinity (100 mM) + Nitrobenzene (30%), T13 Salinity (150 mM) + Nitrobenzene (20%), T14 Salinity (150 mM) + Nitrobenzene (25%), and T15 Salinity (150 mM) + Nitrobenzene (30%)

The % of Death plant (okra) at different salinity stress application

The outcomes of this experiment demonstrate a diverse and intricate reaction of plant death to different treatments, providing insight into the interplay between Nitrobenzene and Salinity levels. In the control group (T0), a mere 8.33% of plants succumbed to death, indicating a relatively low baseline mortality rate. Nitrobenzene treatments alone at various concentrations of T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), and T4 Salinity (50 mM) generally did not have a significant impact on plant mortality, with T3 showing no deaths, suggesting a potential aspect of safety associated with Nitrobenzene at certain levels. In contrast, Salinity treatments alone T4 Salinity (50 mM), T5 Salinity (100 mM), and T6 Salinity (150 mM) resulted in notable increases in plant death, with T5 and T6 leading to a striking 41.66% mortality rate, highlighting the detrimental effect of high salinity on plant well-being. When Nitrobenzene and Salinity were combined T7 Salinity (50 mM) + Nitrobenzene (20%) to T15 Salinity (150 mM) + Nitrobenzene (30%) complex interactions emerged. Salinity (50 mM) + Nitrobenzene (20%) (T7) and Salinity (150 mM) + Nitrobenzene (25%) (T14) both displayed an increased death rate compared to their respective individual treatments, suggesting potential synergistic effects. In contrast, Salinity (100 mM) + Nitrobenzene (20%) (T10) and Salinity (100 mM) + Nitrobenzene (30%) (T12) exhibited relatively lower mortality rates, indicating potential mitigation of the harmful effects of salinity by Nitrobenzene under specific conditions.

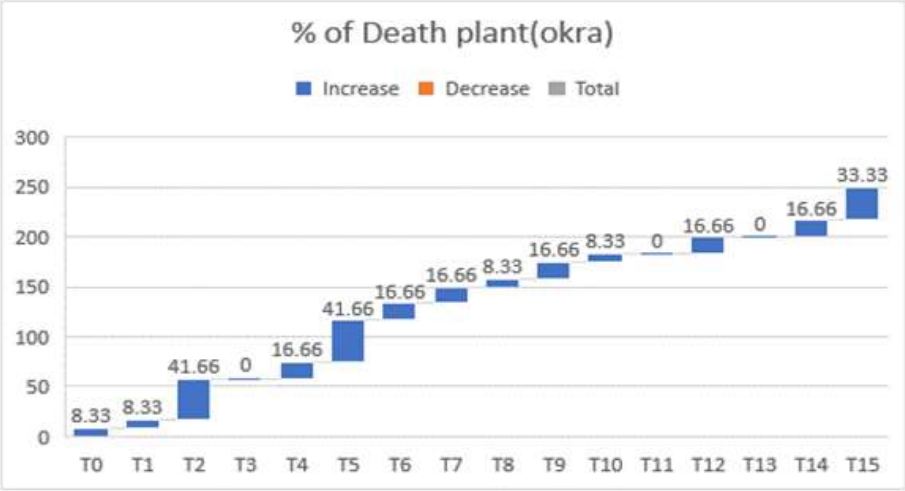

Figure 2. The percent of death plant (okra)
DAS= Days after sowing, T0 Control, T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), T4 Salinity (50 mM), T5 Salinity (100 mM), T6 Salinity (150 mM), T7 Salinity (50 mM) + Nitrobenzene (20%), T8 Salinity (50 mM) + Nitrobenzene (25%), T9 Salinity (50 mM) + Nitrobenzene (30%), T10 Salinity (100 mM) + Nitrobenzene (20%), T11 Salinity (100 mM) + Nitrobenzene (25%), T12 Salinity (100 mM) + Nitrobenzene (30%), T13 Salinity (150 mM) + Nitrobenzene (20%), T14 Salinity (150 mM) + Nitrobenzene (25%), and T15 Salinity (150 mM) + Nitrobenzene (30%)

Responses of nitrobenzene in fruit yield characteristics of okra grown under different Salinity stress applications

The experimental results on fruit yield over two harvests reveal intricate interactions between Nitrobenzene and Salinity treatments, providing valuable insights into their combined effects on plant productivity. In the control group (T0), a modest first harvest resulted in 0.083 fruits per plant and 4 grams of fruit yield, while the second harvest showed improved results with 0.75 fruits per plant and 57 grams of fruit yield, indicating the potential for subsequent yield improvement. Nitrobenzene treatments T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), and T4 Salinity (50mM) demonstrated varying impacts, with T1 Nitrobenzene (20%) showing enhanced the first and the second harvests compared to the control, suggesting the potential benefits of Nitrobenzene at a certain concentration. In contrast, T2 Nitrobenzene (25%) and T3 Nitrobenzene (30%) exhibited no fruit production in the first harvest, indicating potential inhibitory effects at higher concentrations. Salinity treatments alone T4 Salinity (50 mM), T5 Salinity (100 mM), and T6 Salinity (150 mM) severely restricted fruit production in both harvests, highlighting the adverse impact of salinity on fruit yield. When Nitrobenzene and Salinity were combined T7 Salinity (50 mM) + Nitrobenzene (20%) to T15 Salinity (150 mM) + Nitrobenzene (30%), diverse responses were observed. Salinity (50 mM) + Nitrobenzene (20%) (T7) demonstrated a slight improvement over salinity treatment alone, while Salinity (100 mM) + Nitrobenzene (20%) (T10) showed a substantial increase in fruit yield, suggesting a potential ameliorative effect of Nitrobenzene on salinity-induced limitations. While some combinations, like Salinity (150 mM) + Nitrobenzene (25%) (T14), exhibited reduced fruit yield compared to their treatments, emphasizing the importance of careful consideration of treatment combinations.

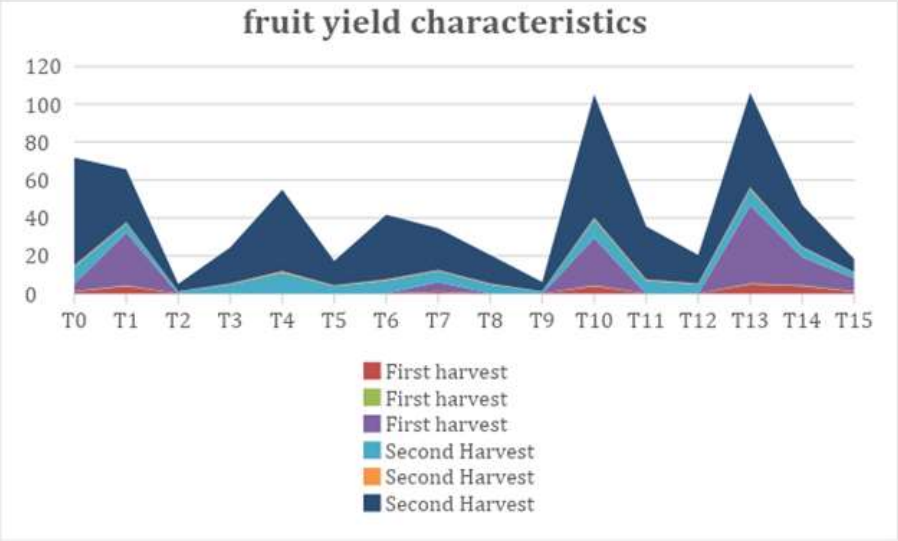

Figure 3. Fruit yield characteristics
DAS= Days after sowing, T0 Control, T1 Nitrobenzene (20%), T2 Nitrobenzene (25%), T3 Nitrobenzene (30%), T4 Salinity (50 mM), T5 Salinity (100 mM), T6 Salinity (150 mM), T7 Salinity (50 mM) + Nitrobenzene (20%), T8 Salinity (50 mM) + Nitrobenzene (25%), T9 Salinity (50 mM) + Nitrobenzene (30%), T10 Salinity (100 mM) + Nitrobenzene (20%), T11 Salinity (100 mM) + Nitrobenzene (25%), T12 Salinity (100 mM) + Nitrobenzene (30%), T13 Salinity (150 mM) + Nitrobenzene (20%), T14 Salinity (150 mM) + Nitrobenzene (25%), and T15 Salinity (150 mM) + Nitrobenzene (30%)

Conclusion

To sum up, this comprehensive study has provided valuable insights into the complex interactions between Nitrobenzene and Salinity treatments and their impact on the growth, mortality, flowering, and fruit-setting processes of BARI Dheros 2 plants at various developmental stages. Nitrobenzene treatments, particularly at specific concentrations, initially showed promise in promoting growth and mitigating the adverse effects of Salinity stress, suggesting their potential utility in crop management strategies. However, these positive effects diminished over time. In contrast, Salinity treatments consistently hindered growth and increased plant mortality, underscoring the challenges posed by high salinity conditions. Notably, the combination of Salinity and Nitrobenzene treatments resulted in intricate and sometimes synergistic responses, further highlighting the need for tailored strategies to optimize crop productivity under varying environmental conditions. The exceptional resilience of the control group (T0) in later developmental stages raises intriguing questions about the plant's ability to adapt and recover from stressors. Overall, this study contributes to our understanding of how plants respond to environmental stressors and chemical interventions, paving the way for more informed and effective agricultural practices in the face of challenging conditions. Further research into the underlying mechanisms of these responses is warranted to refine and tailor treatment strategies for sustainable crop management.

Orcid

Md. Sheikh Shadi Haque
https://orcid.org/0009-0001-9275-7670
Md. Mahmud
https://orcid.org/0000-0002-1487-2876

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