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Innovative Approaches to Enhancing Food Security: Saline Water Kitchen Gardening

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Abstract:
Food security, a critical global concern, hinges on our ability to sustainably produce nutritious food in the face of mounting challenges such as climate change, water scarcity, and soil degradation. This study investigates how saline water affects the initial growth and adaptability of vegetable crops in a Kitchen Gardening Model designed for saline environments. Chili peppers demonstrated the highest germination rate at 90%, followed by tomatoes at 85%, and eggplants at 82%, while okra had the lowest rate at 75%. Adaptability of seedlings varied with salinity levels; the initial irrigation with a TDS of 700 resulted in 81% adaptation, while the fourth irrigation with 2250 TDS had 65% adaptation. Chili peppers exhibited the highest overall adaptability at 76%, followed by tomatoes at 74% and eggplants at 72%, with okra having the lowest adaptability at 9%. Plant height ranged from a maximum of 32 cm (okra) to a minimum of 23 cm (tomatoes). The number of leaves per plant correlated with genetics and increased salinity, with a maximum of 10 leaves (tomatoes) and a minimum of 4 leaves (chili peppers). This research highlights the importance of managing water quality and selecting suitable crops for sustainable food production in saline-prone areas.

Keywords: Kitchen Gardening Model, Saline agriculture, Adaptability, Sustainable food production.

INTRODUCTION

Food security is a global necessity that necessitates creative solutions to produce wholesome food in a sustainable manner in the face of escalating difficulties such soil degradation, water scarcity, and climate change (FAO, 2020). A rising number of people are challenging conventional agricultural paradigms, especially in arid and semi-arid countries where soil salinity and water scarcity typically work together to limit agricultural production (Hanjra & Qureshi, 2010). Creative solutions are not only needed in these situations, but also essential. Using the potential of saline water to cultivate a wide variety of crops and ultimately increase food security is one such option known as "Saline Water Kitchen Gardening," which goes beyond the confines of conventional farming. The accessibility and sustainability of kitchen gardening, sometimes referred to as home or backyard gardening, has long been praised. It increases local food production and lessens reliance on centralized agricultural systems by enabling people and communities to grow a range of fruits, vegetables, and herbs just outside their door (Kumar et al., 2018). This strategy has great potential to supply households with wholesome, fresh vegetables while also encouraging dietary diversification and self-sufficiency. However, the lack of freshwater and the predominance of saline or alkaline soil conditions pose severe obstacles to conventional agriculture in dry and semi-arid regions (Munns & Tester, 2008). Fortunately, there has been a growing chance to turn these constraints into opportunities in a time of scientific and technical progress (Rengasamy, 2010). Due to its high salt content, saline water has long been thought to be harmful to plant growth, preventing the uptake of nutrients, the absorption of water, and the general health of crops (Rengasamy, 2006). However, there is a growing chance to turn these constraints into opportunities in a time of scientific and technical progress. Additionally, self-sufficiency and dietary diversity are encouraged by kitchen gardening, which enhances food security (Biradar and Ananda, 2020). This study focuses on the largely unexplored field of saline water kitchen gardening in an effort to determine how it might be used to alleviate issues with food security in arid and semi-arid areas. In order to shed light on an innovative strategy that has the potential to change food production in difficult conditions, this research investigates the effects of saline water on crop growth and develops customized models for kitchen gardening. The creative use of salt water in kitchen gardening techniques offers a ray of hope amidst the overwhelming issues of our day, such as population expansion and shifting climatic patterns. It holds the potential to improve food security, strengthen community bonds, and revolutionize the agricultural industry.

MATERIAL AND METHOD

The research was carried out at the Arid Zone Research Centre (PARC) adopting a specific model of a kitchen garden. The garden model, which is about 20 feet wide and 40 feet long, was made prior to the start of my internship. It had four equal portions, with planting furrows in each for seedlings. The garden was kept uniform in terms of plant-to-plant spacing, and these furrows functioned as places where the seedlings could be transplanted. In order to gather data for the study, a variety of crops were cultivated, including tomatoes (Solanum Lycopersicon), chili peppers (Capsicum spp.), eggplants (Solanum melongina), and okra (Abelmoschus esculentus). All of these crops were grown in salty water.

Selection and Preparation of Plants

The experiment involved the careful selection of seeds for tomatoes, chili peppers, eggplants, and okra. These seeds were sourced from reputable suppliers and underwent an initial assessment of their tolerance to salinity to ensure consistent seed quality. Healthy and uniform seedlings were subsequently transplanted into the greenhouse beds.

Transplantation and Plant Spacing

Before transplanting, the field received thorough watering. The seedlings were then transferred to the primary planting area on the same day to maintain uniform observations and facilitate data collection. Data collected for various treatment groups were tabulated and graphically presented. Plant-to-plant spacing was maintained at specific intervals: 80 cm for tomato plants, 40 cm for chili peppers, and 30 cm for eggplants.

Saline Water Treatment

To replicate the conditions of kitchen gardening using saline water, the plants were subjected to saline water irrigation. Different levels of saline water treatments, each with varying salinity concentrations, were administered. In the nursery, normal, non-saline water was used for seedling irrigation. However, after transplantation, the seedlings received four irrigations with water of different salinity levels. The first irrigation, with a total dissolved salts (TDS) of 700, was conducted immediately after planting. The second irrigation, with a TDS of 800, took place three days after transplanting. The third irrigation, with a TDS of 2250, occurred after one week, and the fourth irrigation, also with a TDS of 2250, was carried out after ten days.

Intercultural Activities

Weeding and hoeing for inter-cultivation were performed manually seven days after transplanting the seedlings.

Data Collection

Germination Percentage:

The germination percentage (%) was determined by counting the number of successfully sprouted seedlings and expressing it as a percentage of the total seeds sown.

Plant Height:

Plant height was measured from the base of the stem to the tip of the main shoot, and these measurements were recorded in centimeters (cm) at regular intervals throughout the experiment.

Number of Leaves:

The number of leaves per plant was counted, and this count was used to calculate the average number of leaves in each treatment group.

DATA ANALYSIS

The data collected for germination percentage, plant height, number of leaves, and other variables were subjected to analysis using Statistix 8.1 computer software, and visual representations and diagrams were created using MS Excel.

RESULT AND DISCUSSION

Germination Percentage

In this experiment, the highest germination rate was recorded in chilies at 90%, followed by tomatoes at 85%, and Brinjal at 82%. Conversely, the lowest seed germination rate was recorded for okra at 75% (Fig. 1). Germination is a complex physiological process that sets in motion a series of biological and biochemical reactions leading to seedling development (Poudel et al., 2019; MEI and Song, 2008). During the initial stages of germination, a phase known as imbibition, seeds rapidly absorb water, resulting in the expansion and softening of the seed coat, particularly at optimal temperatures (FU et al., 2021; Koornneef et al., 1994). The variations in germination rates observed in our study may be attributed to genetic factors and the overall seed viability of different vegetable seeds (Fig. 1). Koornneef et al. (1994) and Bewley et al. (2005) have previously reported that these differences activate inner physiological processes within the seeds, subsequently initiating seed respiration.

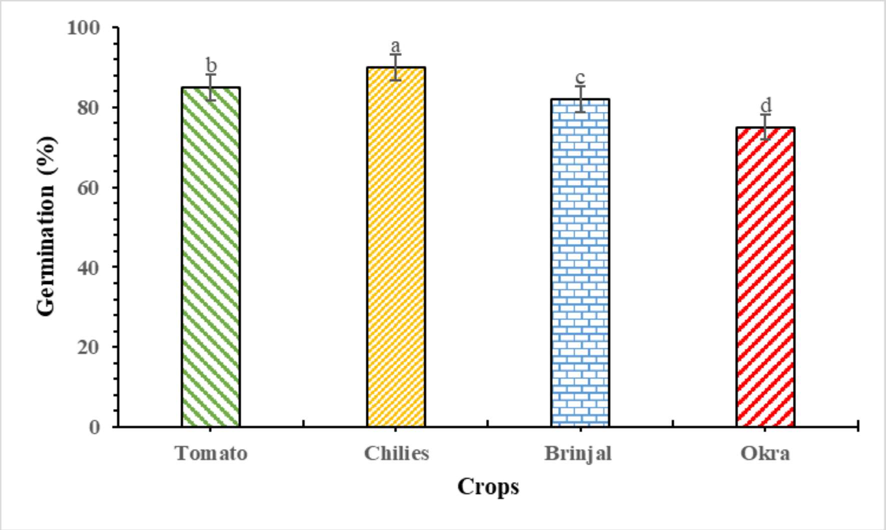

Fig. 1: Seed germination percentage (%) of various crops grown in nursery.

The different lower-case letter shows the difference between various crops on germination percentage.

Adoptions of Seedling (%)

In our investigation, we found that the adaptation of plants after transplanting was notably influenced by shifts in water salinity, transitioning from lower to higher Total Dissolved Solids (TDS) levels, as outlined in Table 1. Across all the tested vegetable seedlings, the most successful adaptation, standing at 81%, occurred following the initial irrigation with a TDS of 700. This was followed by a 78% adaptation rate after the second irrigation with a TDS of 800, and a 69% adaptation rate following the fourth irrigation with a TDS of 2250. In contrast, the lowest adaptation rate, at 65%, was observed after the fourth irrigation with a TDS of 2250 (see Table 1). Regarding specific vegetables, chili peppers exhibited the highest average adaptation rate at 76%, followed by tomatoes at 74% and eggplants at 72%. On the other hand, okra displayed the lowest adaptation rate at 9% (refer to Table 1). These findings suggest that heightened salinity levels can diminish the adaptability of various vegetables when exposed to higher salinity levels of water during the early seedling stage. However, as plants progress through their growth stages, they tend to enhance their stress tolerance potential, leading to improved adaptation. This aligns with the observations made by Pangapanga-Phiri and Mungatana (2021) and Gallardo et al. (2001), who noted that abiotic stress, soil conditions, and environmental factors may reduce seed germination percentages while promoting adaptation to induced stress.

Table 1: Percentage of seedling adaptation in different vegetable varieties as influenced by the number of irrigations with rising salinity levels.

Adoption percentage of Seedling (%)					
Treatments	**1st irrigation (700 TDS)**	**2nd irrigation (800 TDS)**	**3rd irrigation (2250 TDS)**	**4th irrigation (2250 TDS)**	**Average**
Tomato	82	79	70	65	**74**
Chilies	85	81	73	68	**77**
Brinjal	80	78	67	64	**72**
Okra	75	74	65	63	**69**
Average	**81**	**78**	**69**	**65**	

The terms "1st," "2nd," "3rd," and "4th" irrigation refer to the sequence and timing of applying irrigation water with different levels of salinity stress, while "TDS" stands for Total Dissolved Salts.

Plant Height (cm)

Plant height exhibited significant variations due to different saline water treatments at various irrigation times. Generally, the tallest plants, reaching 32 cm, were observed following the first irrigation with 700 TDS. This was followed by a height of 30 cm after the second irrigation with 800 TDS and 27 cm following the third irrigation with 2250 TDS, occurring seven days after transplanting. The shortest plants, with a height of 27 cm, were reported after the fourth irrigation with 2250 TDS, conducted ten days after transplanting (see Table 2). Across all the tested vegetable seedlings, plant height ranged from highest to lowest, with okra at 32 cm, chili peppers at 30 cm, eggplants at 29 cm, and tomatoes at 23 cm (refer to Table 2). These findings align with previous research indicating that, among various vegetables, tomatoes exhibit a moderate sensitivity to salinity. De la Peña and Hughes (2007) noted that salt stress has three main effects, leading to reduced water potential, ion imbalances, and toxicity. Similarly, Parida and Das (2005) reported that salt stress affects several crucial processes, including germination, germination rate, root and shoot dry weights, and the Na+/K+ ratio in both roots and shoots. Furthermore, these findings suggest that the growth and development of seedlings were adversely impacted by an excessive salt content in the irrigation water when applied beyond a certain threshold, leading to a deceleration in the accumulation of dry matter in the seedlings.

Table 2: Plant Height (in centimeters) of different vegetable varieties in response to varying numbers of irrigations with increasing salinity levels.

Plant height (cm)					
Treatments	**1st irrigation (700 TDS)**	**2nd irrigation (800 TDS)**	**3rd irrigation (2250 TDS)**	**4th irrigation (2250 TDS)**	**Average**
Tomato	28	26	20	19	**23**
Chilies	33	31	29	28	**30**
Brinjal	32	30	28	26	**29**
Okra	35	32	30	29	**32**
Average	**32**	**30**	**27**	**26**	

The designations "1st," "2nd," "3rd," and "4th" irrigation refer to the specific irrigation events and timing when water with different salinity levels was applied, and "TDS" stands for Total Dissolved Salts.

Number of Leaves

The count of leaves per plant consistently followed a particular pattern throughout this research. The greatest number of leaves per plant (9) was observed in the 1st irrigation (700 TDS) and the 2nd irrigation (800 TDS), followed by 7 leaves per plant with the 3rd irrigation (2250 TDS), administered seven days after transplanting. In contrast, the fewest leaves per plant (5.5) were documented after the 4th irrigation (TDS 2250), which took place ten days after transplanting (see Table 3). Regarding specific vegetables, tomatoes exhibited the highest leaf count (10), while chili peppers displayed the lowest leaf count (refer to Table 3). In this investigation, the noticeable increase in the number of leaves per plant across various vegetable varieties might be attributed to their distinct genetic and morphological characteristics. Conversely, the decrease in the number of leaves per plant, observed with increased irrigation and salinity, may be attributed to the excessive salt content affecting the physiological attributes of the vegetables. This impact not only contributed to leaf senescence but also influenced other morphological features of the vegetables under study.

Table 3: Number of leaves per plant (per plant-1) in different vegetables in response to varying numbers of irrigations with increasing salinity levels.

Number of leaves plant^{-1}					
Treatments	**1st irrigation (700 TDS)**	**2nd irrigation (800 TDS)**	**3rd irrigation (2250 TDS)**	**4th irrigation (2250 TDS)**	**Average**
Tomato	10	13	9	7	10
Chilies	5	5	4	3	4
Brinjal	11	10	9	7	9
Okra	9	7	6	5	7
Average	9	9	7	6	

The designations "1st," "2nd," "3rd," and "4th" irrigation refer to the specific irrigation events and timing when water with different salinity levels was applied, and "TDS" stands for Total Dissolved Salts.

CONCLUSION

The study was conducted to explore the impact of saline water on the initial development and acclimatization of various essential vegetables cultivated within a Kitchen Gardening Model specially designed for thriving in saline water environments. The findings revealed that seed germination percentage plays a crucial role as it influences post-transplant growth in the field. However, the growth rate is significantly altered by the water's salinity level. In our research, plant height, measured in centimeters, was notably affected by the saline water treatment. Likewise, the adjustment of seedlings to field conditions and the number of leaves per plant were influenced by the salinity level of the irrigation water applied. In general, the 1% saline treatment resulted in taller plants for all plant types, indicating that lower salinity levels can promote plant growth under certain circumstances.

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