Effect of Salt Stress on Germination, Growth and Yield of Cowpea (*Vigna unguiculata* L. Walp.)

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Abstract: ***Salt stress is a significant challenge for crop plants in agriculture. It occurs when the concentration of soluble salts in the soil, primarily sodium and chloride ions, reaches levels that are detrimental to plant growth and development. Salt stress has affected cowpea production in many parts of the world. This research work was conducted to evaluate the impact of salt on the germination, growth and yield of cowpeas in Mangalore, India. The experiment was designed with five groups, the control group received only water and the remaining 4 test groups were treated with different concentrations of NaCl (25, 50, 75 and 100mM). Different parameters including germination, growth, Chlorophyll content and yield were tested and compared with control and salt-stress plants. The results showed that the germination of cowpea seeds delayed in salt-stress groups. The salt stress also affected the plant growth, chlorophyll content and seed yield in cowpea plants.***

Keywords: Cowpea, germination, salt-stress, chlorophyll content, yield.

1. Introduction

Cowpea (Vigna unguiculata) is a popular legume crop in India, commonly known as "black-eyed pea." It is widely cultivated and consumed in various parts of the country. Worldwide, 14.5 million hectares of land are used to produce more than 7 million tons of cowpeas each year [1]. 2014]. Cowpea is grown in different regions of India, with a preference for warm and tropical climates. It is often cultivated in states like Uttar Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu, and Karnataka. There are various cowpea varieties cultivated in India, including both green and black-eyed pea varieties. These can differ in terms of size, color, and taste. Cowpeas are a good source of protein, fiber, vitamins, and minerals [2]. The root nodules of cowpea plants fix atmospheric nitrogen improving the fertility of the soil [3] Cowpeas are used in a wide range of Indian dishes and they are considered an essential dietary component in many Indian households. They can be added to curries, salads, and even made into snacks and sweets. Cowpea seeds are used as an astringent, diuretic, and antipyretic and to treat a variety of illnesses [4]. Cowpea is often used in crop rotation to improve soil fertility and reduce the risk of pests and diseases. It is also used as fodder for livestock. Cowpea cultivation provides income and livelihoods to many farmers and it plays a significant role in the country's agriculture sector. Cowpea is a versatile crop with a rich cultural and culinary heritage in India. It serves as an important source of nutrition and income for many people in the country.

Natural salinity and human interferences are the driving factors in transforming arable land into saline, resulting in up to 50% land loss by 2050 [5]. Annual reduction in arable land is by intense usage of saline irrigated water and application of fertilizer. Salinity stress is a wide-spread environmental stress for crop-plants in arid coastal-regions [6]. Sehrawat et al. 2013 [7] showed that mungbean yield reduced drastically by environmental factors like insects, pests, high temperature, pod-shattering along with salinity. Due to the significant economic impact of cowpea on both human and livestock populations worldwide, with particular importance in India, it is essential to understand the salt tolerance of cowpea, particularly when cultivated in Indian subcontinent. Consequently, this study was crafted to assess how salinity affects the germination, growth, and yield of cowpea in the specific context of South India.

2. Materials and Methods

2.1. Saline water treatment: Healthy cowpea seeds were obtained from a local farmer in Mangalore, Karnataka and were kept in the laboratory of University College Mangalore. The seeds were divided into 5 groups with five seeds each. Four salinity levels of 25 mM NaCl (S1), 50 mM NaCl (S2), 75 mM NaCl (S3), and 100 mM NaCl (S4) were prepared by dissolving sodium chloride in tap water used for irrigation. The control treatment (S0) was without sodium chloride.

The experiment was set up as a completely randomized block design with five treatments and three replications. All the pots were filled with a potting soil: a mixture of sandy, loamy, and clay soil. The soil was sun-dried to constant weight, and thereafter, 5kg of soil was measured into earthen pots of 25 cm diameter and 22 cm height. The pots were placed in the screen house at a spacing of 60cm x 30cm, as proposed by Okeleye et al., 1999 [8].

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2.2. Number of Days to Seed Germination: Germination of the cowpea seeds sown in all the experimental pots were subsequently noted, until they were fully germinated. The percentage of the seeds germinated was calculated.

2.3. Crop Growth and Yields: Seed pods were harvested as they matured beginning on Day 80. Pod count and seed counts were taken along with its weight. The plant material was oven-dried at 60°C to obtain dry weight yields of the shoots, mature and immature pods, and seeds.

2.4. Biochemical parameters: The biochemical parameters including chlorophyll, starch, and protein content was tested in the leaves of all the experimental plants treated with or without saline water.

3. Results and Discussion

3.1 Number of Days to Seed Germination

The control plants without saline water treatment showed early germination at 3 days. Whereas, increasing salinity led to a gradual delay in the germination of seeds. Highest delay of 6 days showed in the seeds treated with 40mM salt water (Figure 1). Inhibition or delay in seed germination at higher salinity is may be due to the combined effects of hyperosmotic potential and specific ion toxicity [9]. Our results are in accordance with the studies conducted by Krishnamurthy et al., 2007 [10], where, they have shown that the seed germination and emergence of radicle was restricted at higher salinity due to the osmotic stress which have negative impact on the growth of seeds.

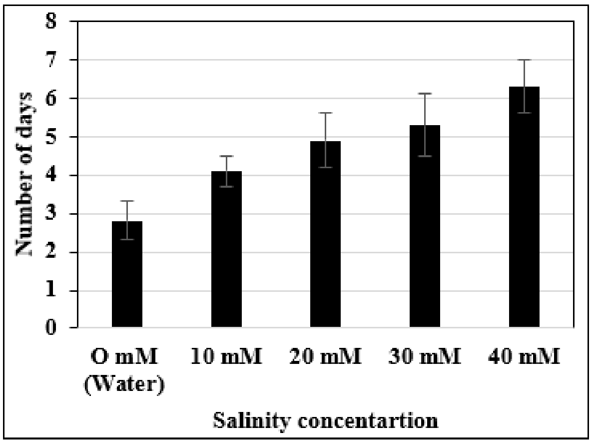

Figure 1: Effect of salinity on seed germination days

3.2 Percentage of Seed Germination

The control plants, which did not undergo saline water treatment, exhibited a higher percentage of seed germination, with 78% of seeds successfully germinated. However, as salinity levels increased, the percentage of germinated seeds decreased: 52% for 10mM, 42% for 20mM, 33% for 30mM, and 35% for 40mM (Figure 2). A significant difference in seed germination percentages was observed among the different treatment groups. Similar reduction in the percentage of germination under salt stress was reported by Ndifon. 2013 [11]. Experiments on rice showed that with the increase in salinity the percentage of seed germination also decreased [12].

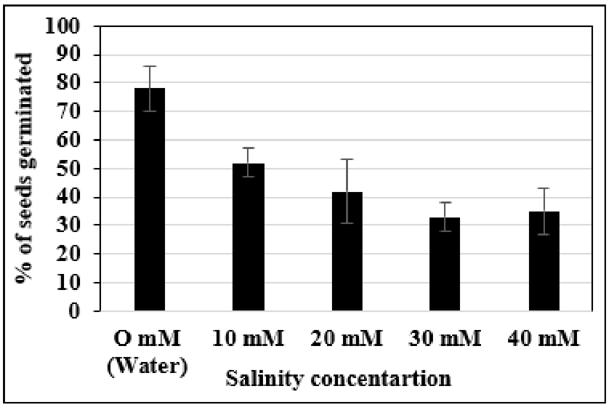

Figure 2: Effect of salinity on percentage of seed germination

3.3 Effect of Salinity on flowering and pod formation

In the control plants the flowering and pod formation took place at 21st and 34th day respectively. The flowering was delayed by 5 days in 10mM saline water treated group and further there was a steady increase in delay of flowering as the salinity increased (Figure 3). Pod formation was also delayed in saline water treated plants compared to normal water. Our results are similar to Samineni et al., 2011 [13], where they have shown the delayed flowering and pod formation in 40mM treated chickpea plants. Higher salinity led to dropping of flowers and reduced the yield and quality of the seeds.

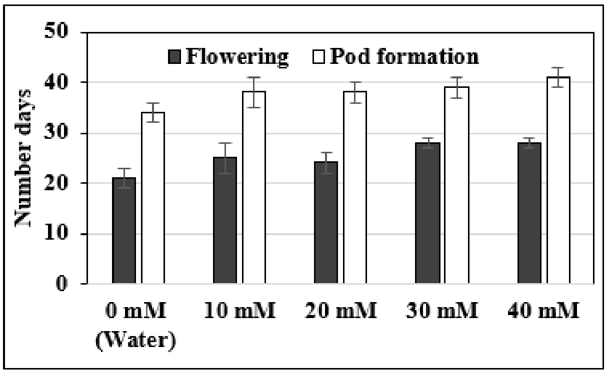

Figure 3: Effect of salinity on flowering and pod formation

3.4 Effect of Salinity on the Yield of Cowpea

There were 22 pods per plant and 16 seeds per pod in the plants that were not treated with normal water. Figure 4 shows that the increased salinity declined the number of pods per plant and number of seeds per pod. Similar results were observed in paddy crop by Hasanuzzaman et al., 2012 [14], where the crops grown under saline condition suffer from the nutrient disorder, toxicity and high osmotic stress which led to the decrease in the crop productivity. They have also shown that the filled spikelet per panicle of rice decreased with increasing salinity and so the fertility of the spikelet. Similarly, Alan et al., 2004 and Taffouo et al., 2004 [15], [16] reported that hyper-saline condition in roots, affects the growth and yield of important crops by water and nutritional imbalance.

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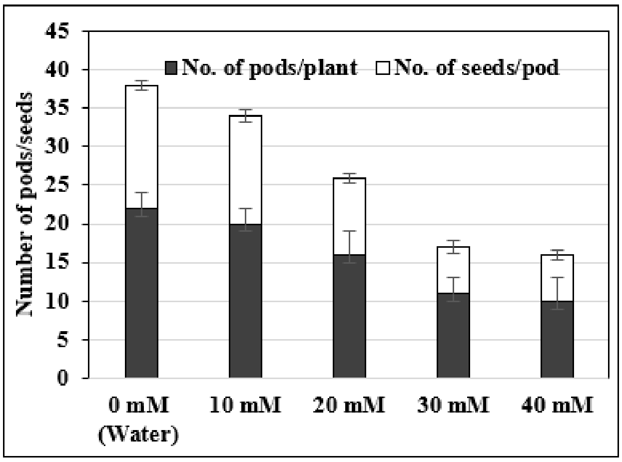

Figure 4: Effect of salinity on the yield of cowpea

3.5 Biochemical parameters

The biochemical parameters including chlorophyll, starch, and protein content, exhibited a decreasing trend with the increased salinity. The increased concentration of salt appears to induce a reduction in the pigment content of cowpea, specifically leading to a significant decrease in chlorophyll levels. The plants treated with normal water showed 17mg/g total chlorophyll whereas 48% decrease in total chlorophyll was observed in 40mM salt treated groups (Figure 5). Zhang et al. 2017 [17] showed that nitrogen, which is the key element in the process of photosynthesis is affected by salinity. The leaves of the plants grown in saline environment are pale green in color and had lesser chlorophyll in comparison to that grown in control condition. In another study on Portulaca oleracea L., low salt concentrations were found to result in increased concentrations of both chlorophyll a and b, whereas high salt concentrations led to decreases in both chlorophyll pigment concentrations [18].

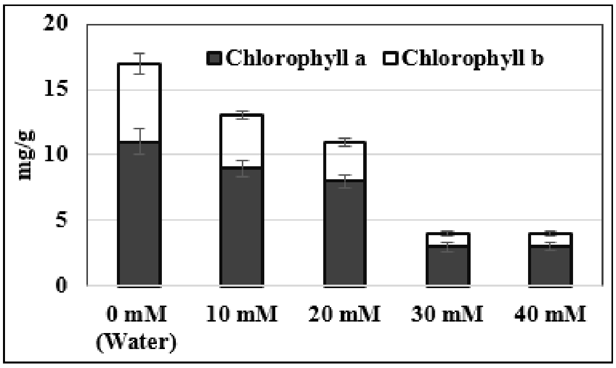

Figure 5: Effect of salinity on the Chlorophyll pigments

The results showed 35% protein and 37% starch content was reduced in 40mM salt treated group compared to the control group (Figure 6). Salinity has negative impact on the activity of enzyme [19], DNA, RNA, synthesis of protein and also mitosis. Increased level of salinity decreases the protein content and dry weight of leaves and roots. Our results are in accordance with the findings of Amirjani, 2011 [20] where, the decrease in the chlorophyll a and b content of rice plants grown at higher concentration of salt, while the total, reducing and non –reducing sugar content increased in the roots. The decline in protein and starch content at higher concentrations of salinity could be attributed to the osmotic pressure caused by the sat concentration that altered the physiology of the plant cells.

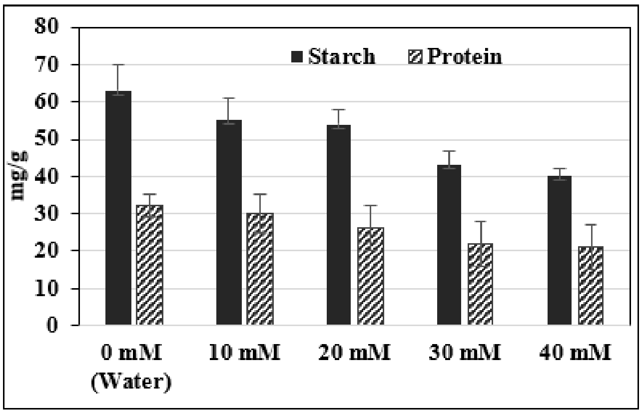

Figure 6: Effect of salinity on the starch and protein

4. Conclusions

The main focus of the study is to understand the effect of different concentration of salinity on cowpea growth and yield. Though the results showed a steady decrease in all the tested parameters with the increased salinity, the plants survived and showed growth and yield. This study is an attempt to show that the popular crop cowpea can be grown in low saline regions along with other crops as a mixed cropping.

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