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The Influence of Salt Stress on Yield of Vegetable Cowpea (Vigna unguiculata)

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Abstract

Soil salinity is one of the major imperative environmental factors affecting crop yield in arid and semiarid irrigated areas. This study was conducted in order to evaluate the effect of salinity stress on yield of vegetable cowpea by using Completely Randomized Design (CRD) with four treatments and four replicates. In addition, some soil chemical properties were investigated. Seeds of vegetable cowpea variety Sene were exposed to non-saline (T1), 0.5% saline (T2), 1% saline (T3) and 1.5% saline (T4) treatments in shade house conditions. Results indicated that increasing salinity levels significantly decreased the yield of cowpea and ions concentration in the soil after harvesting. Highest pod yield (2.28 g) were observed in 0% NaCl (control), where no yield was recorded in treatment T4 (1.5% soil salinity).

Keywords: Pod yield, Salinity, Vigna Unguiculata, soil chemical properties.

1. Introduction

Soil salinity affects the agricultural production in a large proportion in the world's territorial areas. Even though the advanced management technologies available today, salinization of millions of hectares of land continues to reduce crop production severely world-wide. A soil is considered saline if the electrical conductivity of its saturation extract (ECe) is above 4 dSm^{-1} (US Salinity Laboratory Staff, 1954). Furthermore, nutrient availability in the soil solution will be reduced by salinity conditions due to the high concentration of sodium and chlorine ions. So that, salinity conditions cause nutrient imbalances and disruptions in plant nutrient. Reduction in biomass, photosynthetic capacity changes in leaf water potential and leaf turgor have been reported to have a cumulative effect attributed to salinity stress (Gamma, 2007). Salinity will destroy soil structure and can cause unsuitable physical properties in the soil.

Cowpea is an important grain legume which is widely grown in arid and semiarid regions of the world (Ehlers and Hall, 1997) and cowpea seed can consist of 25% protein and is low in anti-nutritional factors. Apart from their nutritional value, cowpeas enhancing soil fertility to the soil through symbiotic N2 fixation process. Limited attention has been given to legumes and forages, which are known to have low tolerance to salinity. Therefore this study was initiated to investigate the effect of different NaCl concentrations on yield of vegetable cowpea.

2. Materials and Methods

This study was conducted at soil science laboratory and crop farm during the period May 2015 to July 2015 at Faculty of Agriculture Eastern University, Sri Lanka.

The different amounts of sodium chloride were added to 1 liter of deionized water. Then, the treatments were converted to dSm^{-1} including; distilled water T1 (EC=0dSm^{-1}), T2 (EC=3.5dSm^{-1}), T3 (EC=7dSm^{-1}) and T4 (EC=10.5dSm^{-1}). In addition, the conversion factor from dSm^{-1} to g/L is 1 dSm^{-1} = 0.7 g of sodium chloride per one liter of water was used (Handreck and Black (2002).

Sixteen plastic buckets were taken and filled with 6 kg of NaCl saturated soil. Five seeds of Sene variety of cowpea was sown in five holes of each plastic buckets and then irrigated with non-saline(T1), 0.5% saline(T2), 1% saline (T3) and 1.5% saline solution (T4) until harvesting. One month after planting one plant in each pot was maintained up to harvesting to compare the yield. Fertilizers were applied at the following rates: 195 kg/ha of urea, 280 kg/ha of triple super phosphate and 150 kg/ha of murate of potash and top dressing 125 kg/ha of urea.

2.1. Plant analysis

Plant samples were taken after one month from each replicates for the yield parameter. Pods were harvested after 55 days and pods were weighed using a battery operated electronic balance (5g to 5kg).

2.2. Soil analysis

The soil samples for the analysis were collected from top of each pot separately at the end of experiment. The soils were air dried, sieved and stored for analysis.

Organic carbon was determined by according to the standard method of Walkley-Black (1934). Total Nitrogen in soil was determined by using Kjeldahl method, Black (1965). Available Phosphorus in soil was estimated by vanadomolybdate blue method (Beater, 1949).

2.3. Analysis of results

The obtained data were analyzed statistically such as Analysis of Variance (ANOVA). Duncan Multiple Range Test (DMRT) was used to separate significantly differing treatment means after main effects were found significant at $p < 0.05$ by using SAS application statistical pack.

3. Results & Discussion

3.1. Pod Yield

Pod yield production of cowpea significantly influenced by NaCl treatment and responded differently for different salinity level in Figure 1.

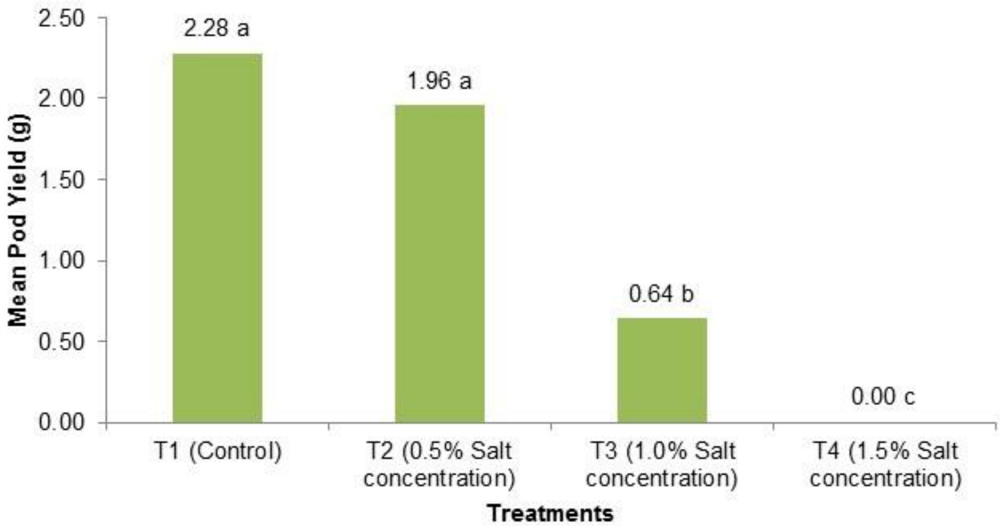

Fig. 1. Effect of different salinity levels on pod yield of vegetable cowpea

There was no significant change in pod yield between the treatments T1 and T2 and the influence was much more pronounced at T3 and T4. Control plants were performed well and produced the highest pod yield (2.28g) than the other treatments that were tested. Whereas, the yield performance of T4 plants were zero. The results (Fig 1) were full agreement with studies in wheat explained that salt stress, imposed while the shoot apex is in vegetative stage, can adversely affect spike development and decrease yields of wheat (Maas and Grieve, 1990).

The action of these salts can go beyond a simple decrease in soil water potential to cellular injury caused by oxidative stress in plants, and these effects together result in reduced productivity. The presence of salts, due to development of osmotic potential, in soil water hinders extraction of water by plant roots in required amount to meet their evapo-transpiration demand even though sufficient quantity of water is present in soil and thereby effects on crop yield.

Decreased fruit weight with increasing salinity was reported by Singh et al. (1988) respectively. The findings of the study elucidate that increment of salinity level in the growth media cause significant reduced in pod yield. Similar results were reported by (Islam et al., 2012) in lentil reported that decrement in the pod yield of lentil as consequence of increasing salinity. This may be due to salinity adversely reduced in leaves per plant, chlorophyll content and leaf water content and high leaf temperature which result in decrement of pod yield of plants (Nasir Khan et al., 2007).

3.2. Effect of different soil salinity levels on Organic Matter, Nitrogen and Phosphorous content of soil

3.2.1. Organic Matter content

Effect of different soil salinity levels on soil organic matter content, presented in the Table 1.

Table 1. Organic Matter content of soil

Treatments	**Mean Organic Matter content (%)**
T1 (control)	1.28 a
T2 (0.5% Salt Concentration)	1.10 ab
T3 (1.0% Salt concentration)	0.97 ab
T4 (1.5% Salt concentration)	0.69 bc

Note. Mean followed by the same letters are not significantly different according to the Duncan Multiple Range test at 5% level

The result of control showed highest mean organic matter content (1.285%) while T4 showed a less amount of soil organic matter content (0.695). T2 and T3 were no significance with control.

Salinity has been found to negatively influence the size and activity of soil microbial biomass and biochemical processes essential for maintenance of soil organic matter (Rietz and Haynes, 2003). Hence, salinity is able to affect the component of soil organic materials (Peinemann et al., 2005). High concentrations of salt in soils constraint crop production and have enormous influence on soil organic matter (SOM) content. Dispersion of aggregates, often with cores containing organic material (Tisdall and Oades, 1982), caused by salinity, also increases the availability of C, resulting in an increase in its accessibility and degradability for the microbial population. This process also contributes to the rate of soil organic matter loss.

3.2.2. Soil Nitrogen and Phosphorus content

The variation in nitrogen and phosphorus content of experimental soil at the end of experiment with respect different soil salinity levels presented in the Table 2.

Table 2. Nitrogen and phosphorous content of soil

Treatments	**Mean Nitrogen (%)**	**Mean Phosphorus(mg/kg)**
T1 (Control)	0.26 a	229.44 a
T2 (0.5% Salt Concentration)	0.23 b	162.43 b
T3 (1.0% Salt Concentration)	0.12 c	59.07 c
T4 (1.5% Salt Concentration)	0.08 d	48.55 c

Note. Mean followed by the same letters are not significantly different according to the Duncan Multiple Range test at 5% level

3.2.3. Nitrogen content of soil

Significant difference was observed in total nitrogen among all treatments. Control soil showed an amount of 0.26 % while T4 recorded lowest amount of nitrogen (0.08 %). This may due to reduced mineralization at high salinity level. Irshad et al. (2005) hypothesized that the observed reduction in N mineralization for agricultural soils was due to salinity inhibition of nitrification occurring in soils. These results are similar to those found when salinity incursion and restored tidal influences effects of denitrification were observed in outdoor mesocosm studies using fresh semi-natural grassland/marsh soils and agricultural soils (Antheunisse et al., 2007). Another study observed potential denitrification was also found to be negatively affected by high salinity in mangrove soil microcosm (Wu et al., 2008). Therefore, denitrification and mineralization process will be affected due to salinity according to Ashraf and Sultana (2000). Therefore, depression of ammonification and nitrification and the overall decrease in net N mineralization with increasing salinity were all evidence of the biological nature of N mineralization in salt-affected soils. Thus, salinity increment results in a decrease in the nutritional quality of plants in soil due to N content reduction.

3.2.4. Phosphorous content of soil

The study results showed that soil salinity had different effects on phosphorous concentration in cowpea (Table 2). Significant difference was observed among treatments while no significant different between T3 and T4. Higher phosphorus availability (229.44) was found in T1 (Control) which was significantly different from other treatments. These results on the basis of slightly higher availability of P in low to moderately saline soils also explain the earlier findings (Maliwal and Paliwal, 1971), where slightly higher uptake of phosphorus was observed in the plants of wheat, barley, maize and bajra (pearl millet) crops grown at low salinity level. However, at higher salinity levels, the uptake of phosphorus by these crop plants was decreased and was negatively correlated with the soil salinity. It is primarily due to low availability of phosphorus in highly saline soils, as has been observed. It appears that at low to moderate salinity levels more phosphorus is dissolved, while at higher levels its solubility is reduced (Howe and Graham, 1957). Salinity affects chemical conditions within the estuary, particularly levels of dissolved oxygen and dissolved inorganic phosphorus in the soil (Levinton, 2001).This may be the reason for low level of phosphorus content at high salinity level.

Kuiper (1984) observed salinity significant increase in sodium and chloride concentrations, while it reduced the accumulation of phosphorus and potassium concentrations in soil.

4. *Conclusion*

Conclusion can be drawn from the test results that the different level of salinity had an adverse effect on yield of vegetable cowpea. The results suggest that cowpea plant is sensitive to NaCl at harvesting stage. The growth inhibitory effect of NaCl was more pronounced in 1.5% NaCl as compared to the control and 0.5% NaCl.

No pod yield was recorded in T4 while control treatment recorded highest yield followed by T2 which was no significant with control.

Different soil salinity levels led to significant decrease in total nitrogen, available phosphorus and organic matter content of soil. The result of control showed highest value for the above soil parameters while T4 showed a less value.

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