EFFECTS OF SALINE WATER ON THE GROWTH PERFORMANCE OF CABBAGE (*Brassica oleracea L.*) GROWN IN A HYDROPONIC FLOATING SYSTEM ALONG THE COAST OF NAMIBIA

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ABSTRACT

The use of saline water for vegetable production is being recognised as an innovative dry land agricultural farming approach from the emerging farmers living along the desert coastal areas of Namibia. The absence of fresh water for irrigation has necessitated the use of brackish water for vegetable production which is fast becoming a phenomenon. Selecting salt tolerant vegetable cultivars to be grown using hydroponics as an innovative vegetable farming method could be the alternative solution for promoting agricultural activities and hence improve income generation and food security for the community living within dry land areas. In this study nine hydroponic floating systems were used. The salinity concentrations in water solutions were 0 (control), 5 and 10 parts per thousand (ppt). Measurements for plant height, number of leaves, leaf width and quality [sugar content (Brix %) and fresh weight (g)] were made. This experiment was conducted at Sam Nujoma Marine and Coastal Resources Research Centre (SANUMARC) in a shade net environment. The study evaluated the effects of salinity on the vegetative growth and quality of cabbage (*Brassica oleracea L.*) Copenhagen variety. The results have shown that salinity in the water had significantly reduced the plant height, number of leaves and leaf area of cabbage. However the cabbage quality, based on the sugar content, increased with the increase in water salinity concentrations while quality based on fresh weight recorded a decrease with the increase in water salinity level respectively.

INTRODUCTION

A major obstacle to agricultural productivity world-wide is undoubtedly due to environmental stressful factors including increasing salinity of crop land and irrigation water (Abdelly, Öztürk, Ashraf & Grignon, 2008). Most crops do not fully attain their original genetic potential for growth, development, and yield under salinity stress (Koyro, Geissler, Hussin & Huchzermeyer, 2008). The economic value of most crops declines as salinity levels in their growth medium increase, whereas only a few crops that are salt tolerant can adapt well to these conditions and continue to maintain their economic value. The prolonged use of saline water can severely affect the soil due to salt accumulation in the soil layer, making it difficult for the vegetables to absorb nutrients and water for growth (Öztürk, Waisel, Khan, & Görk, 2006). The utilisation of saline water affects the vegetable's growth in such a way that the yield and the quality of the vegetable are reduced. Therefore, proper plant selection and use of hydroponics can enhance food security in unsuitable soil which has a high salinity level and limited availability of fresh water.

From an ecological point of view the use of a hydroponic innovative farming system is important because it causes no environmental damage or harm to the organisms living in the soil. This can be ascribed to the fact that it is a soilless system where no disturbance to the soil occurs during farming practices. Cabbage (*Brassica oleracea L.*), Copenhagen variety was the object of study as it is a salt-tolerant species with considerable economic importance and well adapted to arid and semi-arid farming conditions. The main objective was to evaluate the effects – if any – saline water has on the vegetative growth and quality of cabbage grown in a hydroponic floating system. The results have shown that there was a negative effect of saline water on the vegetative growth, but a positive effect on quality [sugar content (Brix %)] of cabbage. The research project was undertaken at the Sam Nujoma Marine and Coastal Resources Research Centre (SANUMARC) located at the riverbank of the Omaruru River north of Henties Bay in the Erongo Region.

METHODS

The experiment on cabbage (*Brassica oleracea L.*) Copenhagen variety was undertaken from February to June 2010. Nine hydroponic tables [170 cm (length) x 85 cm (width) x 25 cm (depth)] filled with 236 litres of water solution in three replicates were used. Two types of fertilizers: hygroponic (236 g) and calcium nitrate (188 g) were applied in the water solution per hydroponic table during transplanting. The seedlings were transplanted and subjected to salinity 14 days after sowing. Salinity concentrations in solutions were 0 (control), 5 and 10 parts per thousand (ppt). Spacing between plants was 60 cm x 30 cm with 9 plants planted in each hydroponic system. The seedlings were secured or positioned by passing their stems through a piece of sponge which was placed firmly into the fomolite floating sagex hole with the roots floating in the solutions.

The measurements for plant height (cm) and leaf width (cm) were made and the number of leaves was counted at an interval of 7 days after transplanting, when plants had achieved steady growth stability. The quality variables

[sugar content (Brix %) and fresh weight (g)] were measured at harvest, 75 days after transplanting. The sugar content to determine the quality of the cabbage was measured using a refractometer. Analysis of variance (ANOVA) was applied to the data using MS-Excel Statistical software to determine the effect of salinity on growth and quality of cabbage. Therefore in this study all statistical decisions were made at the 95 % probability level ($P \leq 0,05$).

RESULTS

Results from the experiment showed that the plant height (Figure 1A) and leaf width (Figure 1B) for cabbage of the control group increased significantly ($P \leq 0,05$) from 14 to 35 and 49 days after transplanting compared to the plant heights and width for cabbage that were grown in 5 and 10 ppt saline water solution. The analysis of the growth rate showed that plants that were subjected to 5 and 10 ppt saline water solution could on average only grow 1,78 cm to 2,79 cm per week while the growth rate for plants from the control group was on average 4,18 cm as shown in Figure 1C. The number of leaves decreased significantly ($P \leq 0,05$) as salinity in the water solution increased (Figure 1D). The result on the quality of cabbage plants that were subjected to a salinity level of 10 ppt scored a significantly higher sugar content (Brix %) than the control group (Figure 2A); but grew a smaller head on average, resulting in significantly lower fresh weights when compared to the control group as shown in Figure 2B.

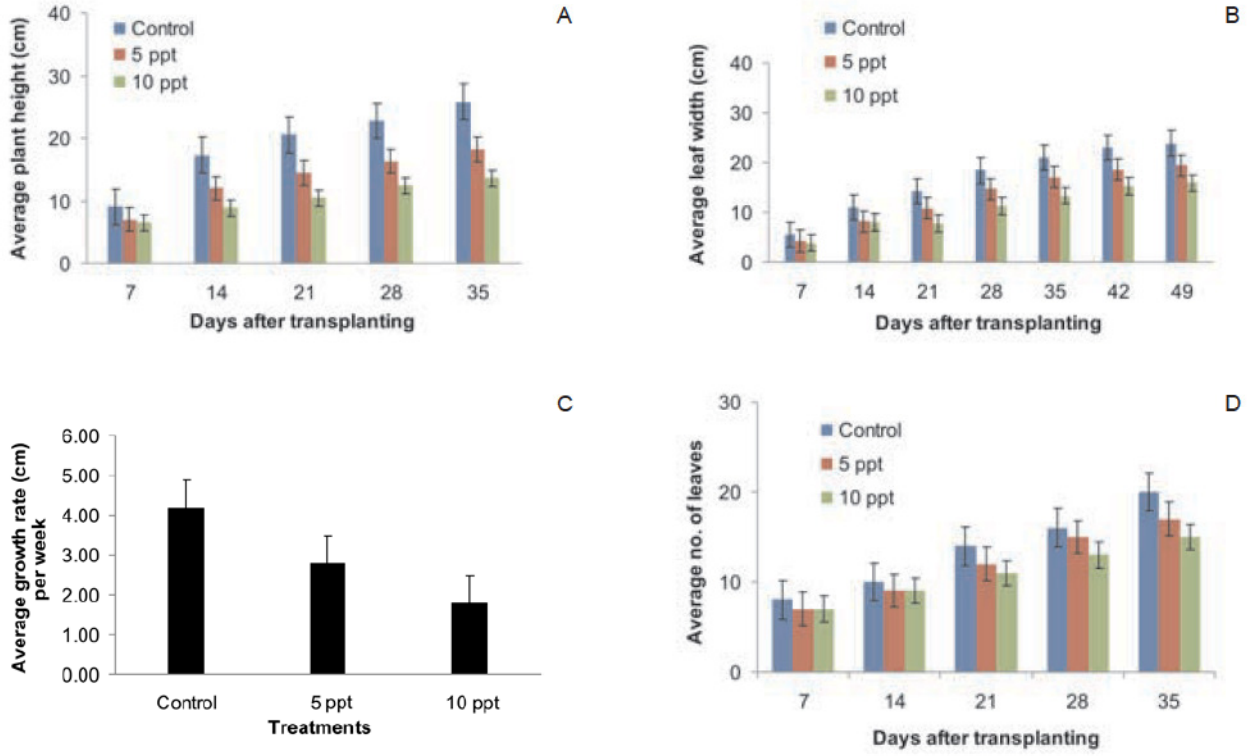

Figure 1. Mean plant height (A); leaf width (B); growth rate per week (C) and number of leaves (D) of three replicates for cabbage in different salinity treatments.

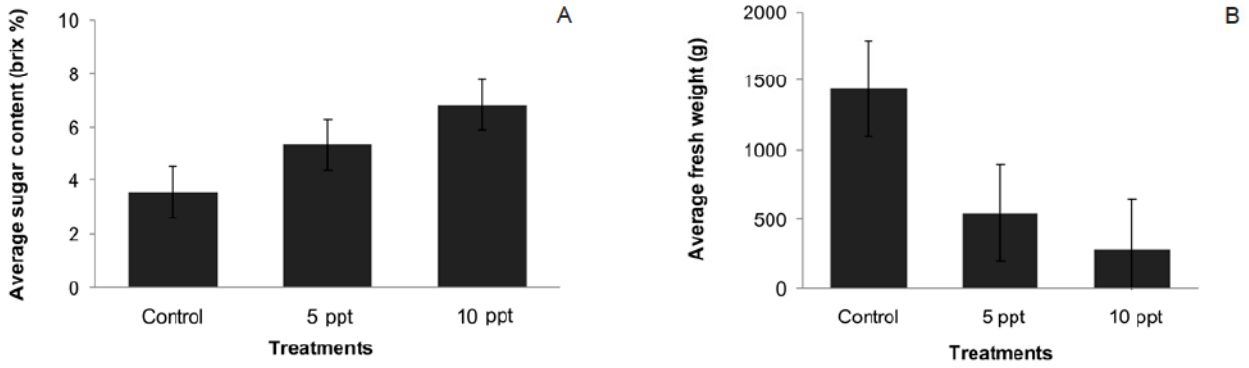

Figure 2. The significant difference in (A) quality and (B) fresh weight of cabbage when treated with water of different salinities.

DISCUSSION

Salinity had a negative effect on the plant height of cabbage as it reduced height with the increase in salinity level in the water solution (Figure 1A). This result is supported by those of Jamil, Rehman & Rha (2007) in which they observed a reduction of plant growth for cabbage. The initial effect of salinity at cellular level is due to osmotic effects in which shoots are reduced, resulting in smaller leaves and shorter plant stature (Andriolo, Da Luz, Witter, Godoi, Barros & Bortolotto, 2005). The reduction in plant growth under saline water could be as a result of the interference of sodium and chloride salts on the metabolism in the leaves (Turan, Elkarim, Taban & Taban, 2009). The results showed that there was a reduction in the leaf area as the salinity level increased (Figure 1B). Similar results were observed by Jamil *et al.* (2007) when they investigated cabbage and sugar beet at different salinity levels and they also observed that salt stress reduced the leaf area by shortening the width of the leaf for cabbage.

A smaller leaf area lowers the ability of the plant to capture light and thereby affects the process of photosynthesis and which ultimately affect leaf biomass production (Izzo, Incerti & Bertolla, 2008). In this study, when the salinity level increased, the establishment of the plant leaves decreased as salinity retards the plant growth (Figure 1D). Salinity induced effects on quality (sugar content) since plants that were subjected to 5 and 10 ppt had better quality when compared to plants from the control group, while salinity induced a negative effect on quality based on fresh weight because the plants that were subjected to 5 and 10 ppt saline water had the lowest average fresh weight compared to plants in the control group. Similar results were observed by Abdelly *et al.* (2008) in tomato where they concluded in their study that seawater at a concentration of up to 20 % used for berry growth significantly reduced plant growth in terms of yield, but improved berry quality.

CONCLUSION

The results showed that salinity stress induced a negative effect for the vegetative growth of cabbage since there was a decrease in plant height and size of head with the increase in the salinity level. The number of leaves and leaf area reduced significantly, and affected the process of photosynthesis hence the whole plant growth was affected. Despite this phenomenon, the quality of the cabbage based on sugar content (Brix %) increased with the increase in salinity, while the fresh weight decreased significantly. It can be concluded that saline water can be utilised for the production of cabbage (Copenhagen variety) along the desert coastal areas while using a hydroponic floating system. The results have shown that it can adapt successfully with a moderate tolerance to salinity, even though it reduces the size of the cabbage head but can still achieve high quality value. Therefore price maximisation or leverage can be achieved for pricing of cabbage based on quality (sugar content) and hence also stimulate the preference by consumers for smaller cabbage which could be used during the preparation of meals.

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