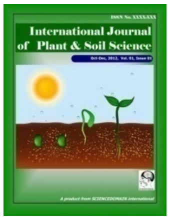

International Journal of Plant & Soil Science
4(3): 241-251, 2015; Article no.IJPSS.2015.024
ISSN: 2320-7035

SCIENCEDOMAIN *international*
www.sciencedomain.org

Influence of Calcium, Potassium and Salicylic Acid Application on Nutrient Ratios and Yield of Turnip and Chard Grown in Saline Soil

R. M. Zewainy[1], S. A. A. EL-Sayed[1] and F. A. Hellal[1*]

[1]Department of Plant Nutrition, National Research Centre, Dokki, Cairo, Egypt.

Authors' contributions

This work was carried out in collaboration between all authors. Authors RMZ, SAAE and FAH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SAAE and FAH managed the analyses of the study. Author FAH managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2015/12019
Editor(s):
(1) Sławomir Borek, Faculty of Biology, Department of Plant Physiology, Adam Mickiewicz University, Poland.
Reviewers:
(1) Christophe Bernard Gandonou, Department of Plant Biology, Faculty of Sciences and Techniques (FAST), University of Abomey-Calavi, Republic of Benin.
(2) Ahmet Ozan Gezerman, Chemical Engineering, Yildiz Technical University & Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=704&id=24&aid=6549

Original Research Article

Received 13th June 2014
Accepted 23rd July 2014
Published 18th October 2014

ABSTRACT

Soil salinity stress is a major problem for enhancing crop production and agricultural sustainability in arid and semiarid regions. In Egypt the area of irrigated land that is salt-affected is 33%. Field experiments was conducted at farmer's field, Koom Oshim, El–Fayoum governorate, Egypt during two successive seasons based on factorial completely randomized block design with three replicate. The research work aimed to study the effect of various levels of calcium (0 and 40kg fed^{-1}), potassium (0, 40 and 80kg fed^{-1}) combined with the foliar application of salicylic acid (0 and 0.05mM) on growth, yield, chlorophyll and nutrient content of Turnip and Chard grown in saline soil. The highest growth and yield parameter represented by root and shoot of Turnip and Chard was obtained with 40kg fed^{-1} applied calcium (Ca) and potassium (K) combined with 0.05mM salicylic acid (SA) as compared with same levels of Ca and K without SA and control treatment. At 40 days of sowing, Chlorophyll a and Chlorophyll b and carotene of Turnip and Chard significantly increased by Ca and K combined with SA application. Sodium (Na) accumulation in root and shoot of both Turnip and Chard decreased due to Ca and K application. K^+, Na^+, Ca^{++}, ratios and selectivity increased in plant shoot due to decrease the Na accumulation in shoot as affected by Ca, K and SA

**Corresponding author: E-mail: hellalaf@yahoo.com;*

application. Results concluded that Turnip and Chard could tolerate the soil salinity and produce higher yield under balanced application of Calcium and potassium combined with salicylic acid.

Keywords: Turnip; chard; sodium; salicylic acid; salinity.

1. INTRODUCTION

Salinity is considered "a significant factor" affecting crop production and agricultural sustainability in arid and semiarid regions of the world, decreasing the value and productivity of the affected land [1]. Soil salinity is one of the most important "abiotic stresses" that reduce growth and agricultural productivity more than many other similar stress factors. The severity of this problem is gradually being aggravated by the build-up of salts in soils through common irrigation practices [2]. Saline soils are abundant in semi-arid and arid regions, where the amount of rainfall is insufficient for substantial leaching [3]. Salinity is a scourge for agriculture, forestry, pasture development and other similar practices [4].

The most common adverse effect of salinity on the crop of *Brassica* is the reduction in plant height, size and yield as well as deterioration of the product quality [5]. The salinity may reduce the crop yield by upsetting water and nutritional balance of plant [6]. Turnip (*Brassica rapa*) is a member of the cruciferous family of vegetables. *Brassica rapa*, commonly known as field mustard or turnip mustard is a plant widely cultivated as a leaf vegetable, a root vegetable and an oilseed. Nutrient supply to plants greatly affects their growth, production and plant constituents. The seed yield, total dry matter and harvested index in some genotypes of *Brassica napus* and *B. juncea* has been found to improve with higher of N [7,8]. Chard (*Beta vulgaris ssp. cicla L.)* is a very nutritive demanding species. The content of mineral elements, total quality and yield are influenced by the amount, frequency and method of fertilization [9]. Swiss chard as a vegetable more tolerant to higher soil salinity as consider by [10].

In response to salinity stress, endogenous Na concentration increased in the various *Brassica* genotypes whereas K concentration decreased. Calcium (Ca) and K ameliorate the adverse effects of salinity on plants [11,12]. Salinity impairs the uptake up Ca by plants, possibly by displacing it from the cell membrane or in some way affecting membrane function [13]. All plants discriminate to some extent between Na and K as claimed by [14]. Na can be substituted for K for uptake and it is believed that similar mechanisms of uptake may operate for both ions [15]. High levels of K in young expanding tissue are associated with salt tolerance in many plant species [16,17].

Salicylic acid (SA) has been considered as a signal molecule [18] that may promote the generation of reactive oxygen species during salt stress thus playing an important role in stress tolerance [19]. Several developmental, physiological and biochemical functions of exogenously-applied salicylic acid in plants have been reported, e.g, enhancing the drought and salt stress resistance of plants [20,21] The exogenous application of SA mitigated the adverse effects of salinity on maize plants by osmotic regulation which is possibly mediated by increased production of sugar as well as proline [22].

The objectives of the present study were to investigate the effect of salinity stress on growth, yield and the nutrient contents and ratios of the root and shoots through application of Ca, K combined with SA in order to obtain higher yield of Turnip and Chard grown under saline soil condition.

2. MATERIALS AND METHODS

Field experiments were conducted at farmer's field, Koom Oshim El–Fayoum governorate, Egypt during two winter season of (2013/2014) to assess role of Ca, K in combination with salicylic acid (SA) for increasing salt tolerance by two potential vegetable crops viz. Turnip (*Brassica rapa* L.) and Chard (*Beta vulgaris* sp. cicla L.) were used in the experiment. Some physical and chemical properties of a representative soil sample used in the experimental soil were determined before cultivation according to [23] and presented in (Table 1).

The recommended dose of phosphorus fertilizer applied as Mono ammonium phosphate (46% P_2O_5 and 16% N) at a rate of 100kg fed^{-1} (fed=0.42ha) during preparation of the experiment. Nitrogen fertilizer in the form of urea (46%N) at the rate of 80kg N fed^{-1} was added in two equal doses. The first one was applied after thinning and the other one 25 days later.

Potassium fertilizer in the form of potassium sulphate (48%K_2O) at different rates of 0, 40 and 80kg K_2O fed^{-1} in addition of soil applications of calcium as: 0, 40kg Ca fed^{-1} as calcium nitrate applied during seedling stage. Foliar application of salicylic acid as: 0 and 0.05mM was done at 25 and 50 day of sowing. The experiment irrigated with fresh water 0.23dS m^{-1} Electrical conductivity.

The experimental design was factorial-completely randomized block design, with three replicates including the following treatments: T1: Control (without Ca and K), T2: 40Kg K_2O fed^{-1}, T3: 80Kg K_2O fed^{-1}, T4: 40Kg CaO fed^{-1}, T5: 40Kg CaO fed^{-1} + 40Kg K_2O fed^{-1}, T6: 40Kg CaO fed^{-1} + 80Kg K_2O fed^{-1}, T7: T1+0.05mM Salicylic Acid (SA), T8: T2+0.05mM SA, T9: T3+0.05mM SA, T10: T4+0.05mM SA, T11: T5+0.05mM SA, T12: T6+0.05mM SA.

All agriculture practices were done according to plant needs. Plants were harvested on 5 and 10 February in 1st and 2nd season respectively. The plant samples were collected from each treatment randomly at 30 days after sowing and at harvest. Fresh and dry biomass of shoot and root was recorded. The chlorophyll a, b and carotene were estimated in the fresh leaves as described by [24].

Minerals content as nitrogen, phosphorus, potassium, calcium and sodium in shoots and roots were estimated in the plant digest according to the method described by [25].

The ability of the plants to maintain tissue K+ concentration in saline conditions is indicated as the K+ selectivity. It is defined as the ratio of K^+ / (K^+ + Na^+) in the tissue divided by the ratio of K^+ / (K^+ + Na^+) in the external medium [16].

2.1 Statistical Analysis

The obtained data (the means of two growing seasons) were statistically analyzed for two successive seasons. For comparing the means, the Least Significance Difference (LSD at 5%) test was used according to the procedure outlined by [26].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The growth characters of Turnip and Chard plants at 40 day as affected by different levels of Ca and K fertilization combined with salicylic acid (SA) are presented in (Table 2).

Regarding root fresh weight, it could be easily noticed that the applied Ca and K fertilizers had the capacity to increase root fresh weight significantly as compared with control. The chemical fertilization by Ca and K at higher level of 40kg fed^{-1} Ca + 80kg fed^{-1} K expressed as T6) exhibited the most promising effect on root fresh weight followed by level (40kg fed^{-1} Ca + 40kg fed^{-1} K expressed as T5) where the increment values was 56 and 47% for Turnip and 50 and 36% for Chard over the control treatment, respectively.

The roots characters of Turnip and Chard plants were improved significantly by the combination of salicylic acid with various levels of calcium and potassium fertilizers. The highest increment values of root fresh weight were 78% for Turnip and 85% for Chard observed with 40kg fed^{-1} Ca + 40kg fed^{-1} K + 0.05mM SA expressed as T11 over the control treatment, respectively.

Table 1. Initial physical and chemical soil properties of the experimental soil site

Particle size distribution (%)			Texture class	pH (1: 2.5)	EC (dS m^{-1}) Soil paste	Organic Matter (%)	$CaCO_3$ (%)
Sand	Silt	Clay					
72.5	4.82	23.22	Loamy sand	7.32	10.25	1.20	3.12
Soluble cations (me L^{-1})				**Soluble anions (me L^{-1})**			
Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
10.44	1.68	9.02	2.90	0.00	1.27	11.97	9.81
Available macronutrients (mg Kg^{-1})				**Available micronutrients (ppm)**			
N	P		K	Fe	Zn	Mn	Cu
26.10	2.11		74	1.02	0.79	2.46	0.08

Fresh weights of shoot were significantly increased in Turnip and Chard plants due to utilization of both Ca and K fertilization. The maximum increment for fresh and dry shoot weights of Turnip and Chard were recorded with 40kg fed^{-1} Ca + 40kg fed^{-1} K combined with 0.05mM SA (T11) which reached to 64% for Turnip and 87% for Chard over the control treatment, followed by the highest mineral fertilizers of 40kg fed^{-1} Ca + 80kg fed^{-1} K combined with 0.05mM SA (T12), respectively.

Based on the previous finding, one can conclude that the applied level of 40kg fed^{-1} Ca + 40kg fed^{-1} K combined with salicylic acid was sufficient to obtain the highest growth parameters or biomass represented by shoots and roots.

The improvement effects of the applied Ca and K fertilizer on growth characters may be due to the important role of calcium and potassium in increasing activity of growing apex via increasing cell formation and elongation. Also, calcium plays an essential role in processes that preserve the structural and functional integrity of plant membranes, stabilize cell wall structures, regulate ion transport and selectivity and control ion-exchange behavior as well as cell wall enzyme activities [27,3]. In this respect, Maintenance of adequate levels of K is essential for plant survival in saline habitats. Potassium is the most prominent inorganic plant solute, and as such makes a major contribution to the low osmotic potential in the stele of the roots that is a prerequisite for turgor-pressure-driven solute transport in the xylem and the water balance of plants [3].

The beneficial stimulation effect of salicylic acid on growth characters of turnip and chard plants may be explained by, Salicylic acid, a phenolic compound, plays a vital role in the plant response to adverse environmental conditions such as salt and osmotic stresses [19]. In maize, the application of 0.1mM SA to plants under saline conditions enhanced their growth and development [28].

3.2 Yield Parameters

Data presented in (Table 3) illustrated that, at harvest the levels of Ca and K fertilizers increased fresh root yield by 39, 42% for Turnip and 40, 49% for Chard expressed as T5 and T6 treatments compared with control treatment, respectively.

In contrast the application of salicylic acid combined with Ca and K application was better for increasing fresh root and shoot of both Turnip and Chard. Moreover, the level of 40kg fed^{-1} Ca and 40kg fed^{-1} K combined with salicylic acid expressed as T11 caused the maximum significant effects for increasing root fresh weight by 91% for Turnip and 41% for Chard in corresponding to control.

Also, the same levels expressed as T11 gave the highest increase of shoot fresh weight by 62% for Turnip and 46% for Chard, respectively. This increment may be explained by the promising role of Ca and K to supply the growing plants with required nutrients which play important role in metabolic process as photosynthesis, respiration and carbohydrate synthesis. Salinity dominated by Na salts not only reduces Ca2+ availability but reduces Ca2+ transport and mobility to growing regions of the plant, which affects the quality of both vegetative and reproductive organs. Salinity can directly affect nutrient uptake, such as Na reducing K uptake or by Cl reducing NO3 uptake [29].

3.3 Chlorophyll Content

The applied levels of Ca and K fertilizers caused motivation in chlorophyll synthesis of Turnip and Chard at 40 day after sowing as compared with control treatment. With respect to Ca and K application, the applied Ca and K level of T6 treatment was better for increasing Chlorophyll a, b and Carotene of Turnip and Chard as compare to the rest of applied levels and control treatment under saline soil conditions (Fig. 1).

In contrast the application of salicylic acid combined with Ca and K application produced a promotion effect of total chlorophyll content. Moreover, the highest levels of 40kg fed^{-1} Ca and 40kg fed^{-1} K combined with 0.05mM SA (T_{11}) caused the maximum significant effects for chlorophyll a, b and carotene content which reached to 53, 85 and 72% for Turnip and 64, 83 and 74% for Chard as compared to control, while the levels of 40kg fed^{-1} Ca and 80kg fed^{-1} K combined with SA (T_{12}) gave 46, 78 and 65% for Turnip and 44, 75 and 72% for Chard, respectively. The increasing in chlorophyll and carotene content of Turnip and Chard were obtained as a result of the application of Ca, K and SA could be explained by the promising role of applied Ca and K in metabolic process as photosynthesis, respiration and carbohydrate synthesis. Salt stress refers to the excessive amount of soluble salts in the root zone which induce osmotic stress and ion toxicity in the growing plant. Among toxic ions, sodium (Na^+) has the most adverse effects on plant growth by its detrimental influence on plant metabolism in inhibiting enzyme activities [30]. Results indicated that salinity stress decreased chlorophyll rate due to decreases the photosynthetic activity. Plants grown at high salinity exhibited reduced fresh weight, chlorophyll content, water use, relative water content, and increased electrolyte leakage and K release compared to control plants [31]. Supplementary calcium could ameliorate the negative effects of salinity on chlorophyll and dry mass production [32]. Salicylic acid applied exogenously to barley plants is effective in ameliorating the adverse effects of salt stress [33]. The adverse effects of salt stress could be alleviated by foliar application of Salicylic acid used alone and more effectively in combination with *Azospirillum* and *Pseudomonas* inoculations [34].

3.4 Nutrient Content

Data presented in (Table 4) revealed that Ca and K fertilizers had significant effect on N, P and protein content of Turnip and Chard grown in saline soil. In this respect, it can be noticed that Ca and K application treatments (T6) had a pronounced effect on nutrient content comparing with other treatments and control. The maximum mean values of N, P and protein content were obtained as a result of application of 40kg fed^{-1} Ca and 40kg fed^{-1} K combined with 0.05mM SA, while the level of 40kg fed^{-1} Ca and 80kg fed^{-1} K (T12) gave the maximum mean value of P (%) of shoot. On the other hand, different fertilizers treatments increased protein content comparing with control. The protein content of Turnip and Chard root was highest in T11 treatment. It was increased by 68% in Turnip and 19% in Chard as compared to control treatment. The increasing in Protein content could be explained by synergistic effect for Calcium and potassium on nitrogen uptake by plant parts leading to increase protein content of root and shoot.

Data in (Table 5) demonstrated that, values of sodium was decreased with increasing the level of Ca and K applied The lower accumulation of sodium obtained as a result of the level of 40kg fed-1 Ca and 80kg fed-1 K (T6). While the application of 40kg fed-1 Ca and 40kg fed-1 K combined with SA gave the lowest mean value of Na in shoot (0.88 and 1.78%) and root (1.77 and 0.72%) of Turnip and Chard plants, respectively. High levels of supplemental Ca2+ led to greater uptake of Na and concluded that, in the calcifuges, blueberry, high Ca2+ accentuates the detrimental effects of Na on cell metabolism [35]. Chard accumulates higher levels of sodium in its shoot compared with Turnip under saline soil conditions. Chard is thus suitable for such soil conditions that limit the growing of many other sensitive vegetable species.

The high salt content lowers osmotic potential of soil water and consequently the availability of soil water to plants. The salt-induced water deficit is one of the major constraints for plant growth in saline soils.

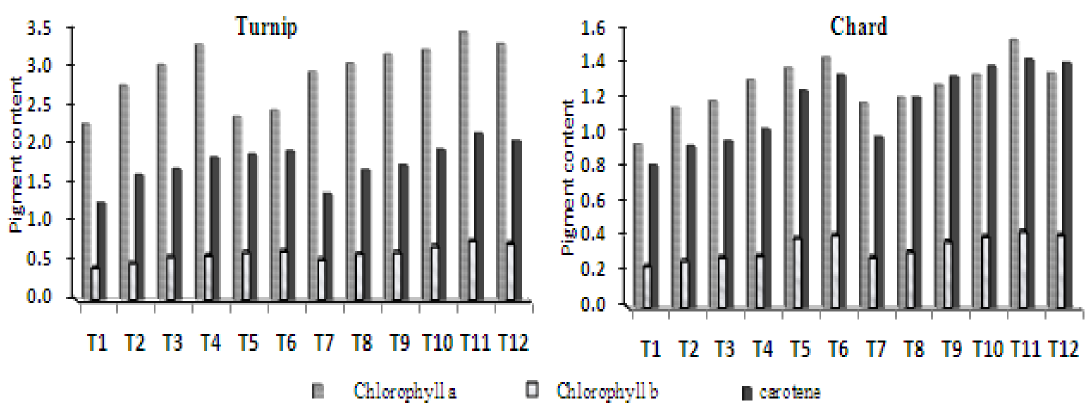

Fig. 1. Leaf pigment (mg g-1 fresh wt.) of turnip and chard after 40n day of sowing

T1: Control (without Ca and K), T2: 40Kg K_2O fed^{-1}, T3: 80Kg K_2O fed^{-1}, T4: 40Kg CaO fed^{-1}, T5: 40Kg CaO fed^{-1} + 40Kg K_2O fed^{-1}, T6: 40Kg CaO fed^{-1} + 80Kg K_2O fed^{-1}, T7: T1+ 0.05mM Salicylic Acid (SA), T8: T2 + 0.05mM SA, T9: T3 + 0.05mM SA, T10: T4+ 0.05mM SA, T11: T5 + 0.05mM SA, T12: T6 + 0.05mM SA. Fed=0.42 ha

Table 2. Growth parameters of turnip and chard at 40 day of sowing (Data mean of two seasons)

Treatments	Turnip					Chard				
	Root (g plant^{-1})		Shoot (g plant^{-1})		Root/Shoot	Root (g plant^{-1})		Shoot (g plant^{-1})		Root/Shoot
	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.	Fresh wt.	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.	Fresh wt.
T1	16.9	1.58	52.5	9.23	0.32	8.18	1.33	49.4	8.63	0.17
T2	18.2	1.81	58.2	10.3	0.31	8.9	1.38	54.3	11.4	0.16
T3	21.5	1.89	60.9	10.9	0.35	9.8	1.42	61.9	11.5	0.16
T4	22.2	1.99	64.4	11.3	0.34	10.3	1.53	64.9	11.9	0.16
T5	24.9	2.28	73.2	12.6	0.34	11.1	1.71	72.6	12.8	0.15
T6	26.4	2.39	73.7	13.9	0.36	12.3	1.79	74.2	13.7	0.17
T7	19.5	1.83	65.6	10.9	0.30	8.2	1.42	66.1	11.5	0.12
T8	23.2	2.22	70.3	11.9	0.33	10.4	1.58	70.5	12.2	0.15
T9	24.8	2.47	79.6	14.2	0.31	12.5	2.08	84.7	13.8	0.15
T10	27.4	2.68	81.8	14.8	0.33	14.3	2.29	85.9	14.2	0.17
T11	30.1	2.98	86.2	15.7	0.35	15.1	2.35	92.5	14.9	0.16
T12	28.8	2.86	84.3	15.3	0.34	15.0	2.33	90.8	14.1	0.17
LSD 5 %	1.91	0.72	2.56	`1.48		0.35	0.17	0.23	0.27	

T1: *Control (without Ca and K),* ***T2****: 40Kg K_2O fed^{-1},* ***T3****: 80Kg K_2O fed^{-1},* ***T4****: 40Kg CaO fed^{-1},* ***T5****: 40Kg CaO fed^{-1} + 40Kg K_2O fed^{-1},* ***T6****: 40Kg CaO fed^{-1} + 80Kg K_2O fed^{-1},* ***T7****: T1+ 0.05mM Salicylic Acid (SA),* ***T8****: T2 + 0.05mM SA,* ***T9****: T3 + 0.05mM SA,* ***T10****: T4+ 0.05mM SA,* ***T11****: T5 + 0.05mM SA,* ***T12****: T6 + 0.05mM SA. Fed=0.42ha*

Table 3. Yield parameters of turnip and chard at harvest (Data mean of two seasons)

Treatments	Turnip					Chard				
	Root (g plant^{-1})		Shoot (g plant^{-1})		Root/Shoot	Root (g plant^{-1})		Shoot (g plant^{-1})		Root/Shoot
	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.	Fresh wt.	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.	Fresh wt.
T1	41.8	6.82	57.3	9.71	0.73	13.8	7.16	80.3	15.94	0.17
T2	43.3	7.18	68.3	10.57	0.63	14.3	8.17	91.8	17.31	0.16
T3	47.6	8.65	78.9	12.09	0.60	17.5	8.56	92.3	19.69	0.19
T4	48.3	9.15	81.3	12.26	0.59	18.8	8.96	94.8	21.42	0.20
T5	58.1	9.68	95.7	13.56	0.61	19.3	10.28	95.3	22.14	0.20
T6	59.5	9.78	98.1	14.74	0.61	20.5	10.85	96.7	22.82	0.21
T7	66.3	8.54	73.9	11.63	0.90	16.1	8.21	95.6	19.36	0.17
T8	68.3	10.32	82.9	12.58	0.82	18.2	10.16	103.5	21.65	0.18
T9	71.3	11.13	83.5	14.98	0.85	18.6	11.19	112.9	22.94	0.16
T10	78.5	11.17	90.9	15.05	0.86	18.8	11.28	113.7	25.46	0.17
T11	79.8	11.45	92.6	18.47	0.86	19.5	11.79	116.9	28.71	0.17
T12	78.2	11.21	91.1	15.45	0.86	17.6	11.51	144.6	28.96	0.12
LSD 5 %	3.54	1.42	2.50	0.63		0.71	0.68	1.91	2.05	

T1: Control (without Ca and K), T2: 40Kg K_2O fed^{-1}, T3: 80Kg K_2O fed^{-1}, T4: 40Kg CaO fed^{-1}, T5: 40Kg CaO fed^{-1} + 40Kg K_2O fed^{-1}, T6: 40Kg CaO fed^{-1} + 80Kg K_2O fed^{-1}, T7: T1+ 0.05mM Salicylic Acid (SA), T8: T2 + 0.05mM SA, T9: T3 + 0.05mM SA, T10: T4+ 0.05mM SA, T11: T5 + 0.05mM SA, T12: T6 + 0.05mM SA. Fed=0.42 ha

Calcium and potassium of Turnip and Chard root and shoot increased with increasing Ca and K application. Application of T12 treatment produced the maximum values of Ca and K of Turnip and Chard as compared with the rest of treatments and control. Maintaining an adequate supply of calcium in saline soil solutions is an important factor in controlling the severity of specific ion toxicities, particularly in crops which are susceptible to sodium and chloride injury [36]. In citrus grown under saline conditions, calcium was found to be effective at reducing the transport of both sodium and chloride from roots to leaves, thereby alleviating foliar injury and/or defoliation [37].

3.5 Nutrient Ratios and Selectivity's

Figs. (2 and 3) indicated that application of Calcium and potassium had influenced the K^+/Na^+ and Ca^{2+}/Na^+ of Turnip and Chard. Application of T11 treatment of 40 kg fed^{-1} Ca + 40kg fed^{-1} K combined with SA was the best to maintain lower ratios for increase salinity tolerant of Turnip and Chard plants followed by T12 and T6 treatments as compared to rest of the treatment involved and control. The presence of adequate Ca^{2+} in the substrate influences the K^+/Na^+ selectivity by shifting the uptake ratio in favor of K at the expense of Na. Improvement in Ca^{2+} mediated membrane integrity invariably leads to reduction of K leakage from root cells and a more favorable root-K status [38,39]. K^+/Na^+ ratio and proline accumulation as an important features to be explored in programs for selection and /or development of tolerant cultivars of the tropical world affected by salinity [40].

Optimal K^+/Na^+ ratio is vital to activate enzymatic reactions in the cytoplasm necessary for maintenance of plant growth and yield development. Minimizing Na^+ uptake and preventing K^+ losses from the cell may help to maintain a K^+/Na^+ ratio optimum for plant metabolism in the cytoplasm under salt-stress conditions [30].

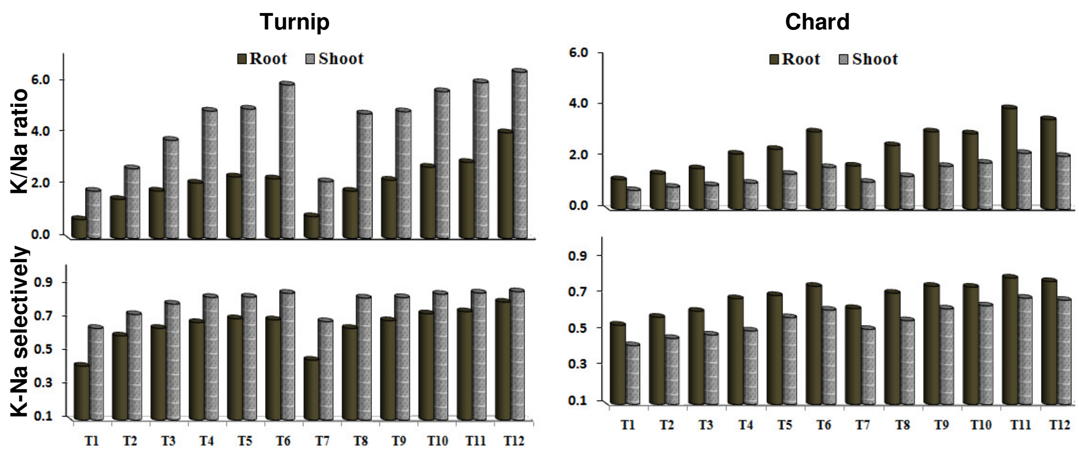

Fig. 2. Potassium, sodium ratio and selectivity of root and shoot for turnip and chard at harvest

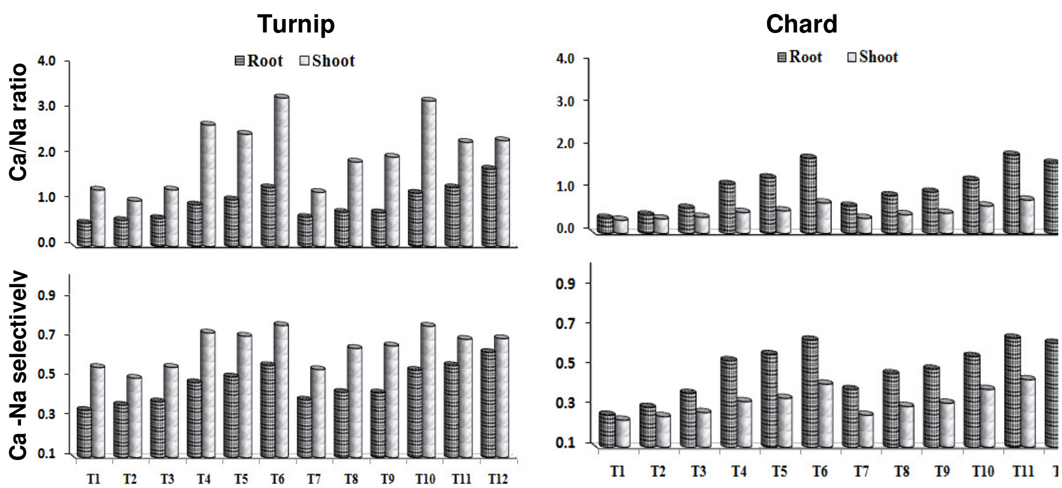

Fig. 3. Calcium, sodium ratio and selectivity of root and shoot for turnip and chard at harvest

T1: Control (without Ca and K), T2: 40Kg K_2O fed^{-1}, T3: 80Kg K_2O fed^{-1}, T4: 40Kg CaO fed^{-1}, T5: 40Kg CaO fed^{-1} + 40Kg K_2O fed^{-1}, T6: 40Kg CaO fed^{-1} + 80Kg K_2O fed^{-1}, T7: T1+ 0.05mM Salicylic Acid (SA), T8: T2 + 0.05mM SA, T9: T3 + 0.05mM SA, T10: T4+ 0.05mM SA, T11: T5 + 0.05mM SA, T12: T6 + 0.05mM SA. Fed=0.42 ha

Table 4. Nitrogen and phosphorus content of turnip and chard at harvest (Data mean of two seasons)

Treatments	Turnip						Chard					
	Nitrogen %		Phosphorus %		Protein %		Nitrogen %		Phosphorus %		Protein %	
	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
T1	1.81	1.22	0.450	0.316	11.31	0.76	0.72	0.800	0.115	0.216	4.50	1.25
T2	1.84	1.24	0.472	0.327	11.50	0.78	0.73	0.802	0.117	0.218	4.56	1.26
T3	1.87	1.25	0.491	0.331	11.69	0.78	0.76	0.812	0.119	0.221	4.75	1.33
T4	1.92	1.27	0.51	0.336	12.00	0.79	0.78	0.815	0.121	0.273	4.88	1.34
T5	1.96	1.31	0.554	0.339	12.25	0.82	0.82	0.816	0.122	0.315	5.13	1.35
T6	1.99	1.36	0.653	0.341	12.44	0.85	0.84	0.818	0.123	0.327	5.25	1.36
T7	1.85	1.25	0.462	0.356	11.56	0.78	0.86	0.822	0.118	0.251	4.75	1.39
T8	1.87	1.28	0.575	0.367	11.69	0.80	0.88	0.823	0.121	0.293	4.81	1.39
T9	1.92	1.27	0.658	0.371	12.00	0.79	0.89	0.824	0.123	0.326	4.94	1.40
T10	1.99	1.32	0.715	0.376	12.44	0.83	0.91	0.826	0.124	0.367	5.13	1.41
T11	2.06	1.39	0.754	0.381	12.88	0.87	0.98	0.828	0.126	0.391	5.38	1.43
T12	2.03	1.38	0.735	0.379	12.69	0.86	0.97	0.827	0.125	0.388	5.31	1.42
LSD 5 %	0.07	0.08	0.062	0.018	1.04	0.037	0.024	0.037	0.025	0.061	1.05	0.17

T1: Control (without Ca and K), T2: 40Kg K2O fed-1, T3: 80Kg K2O fed-1, T4: 40Kg CaO fed-1, T5: 40Kg CaO fed-1 + 40Kg K2O fed-1, T6: 40Kg CaO fed-1 + 80Kg K2O fed-1, T7: T1+ 0.05mM Salicylic Acid (SA), T8: T2 + 0.05mM SA, T9: T3 + 0.05mM SA, T10: T4+ 0.05mM SA, T11: T5 + 0.05mM SA, T12: T6 + 0.05mM SA. Fed=0.42 ha

Table 5. Sodium, potassium and calcium content of Turnip and Chard at harvest (Data mean of two seasons)

Treatments	Turnip						Chard					
	Sodium %		Potassium %		Calcium %		Sodium %		Potassium %		Calcium %	
	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
T1	2.84	1.48	2.07	2.71	1.45	1.84	1.53	3.18	1.78	2.35	0.54	0.98
T2	2.69	1.31	4.07	3.54	1.54	1.31	1.33	3.03	1.85	2.63	0.57	1.03
T3	2.57	1.30	4.72	4.95	1.58	1.62	1.09	2.97	1.74	2.78	0.64	1.12
T4	2.23	1.02	4.78	5.04	2.04	2.73	0.89	2.82	1.93	2.89	1.02	1.38
T5	2.17	1.12	5.18	5.62	2.23	2.77	0.87	2.33	2.05	3.21	1.13	1.23
T6	2.22	0.87	5.13	5.18	2.87	2.85	0.71	2.06	2.16	3.38	1.25	1.47
T7	2.47	1.31	2.08	2.88	1.58	1.56	1.24	2.81	2.11	2.98	0.79	0.99
T8	2.32	0.94	4.25	4.54	1.74	1.75	0.93	2.47	2.33	3.18	0.82	1.08
T9	2.24	0.95	5.06	4.67	1.66	1.87	0.91	2.16	2.77	3.64	0.88	1.02
T10	1.85	0.92	5.11	5.24	2.17	2.95	0.89	2.05	2.64	3.72	1.11	1.31
T11	1.77	0.88	5.22	5.32	2.29	2.02	0.72	1.78	2.85	3.91	1.32	1.39
T12	1.32	0.84	5.41	5.42	2.25	1.96	0.84	1.84	2.96	3.83	1.38	1.55
LSD 5 %	0.47	0.25	0.69	0.36	0.27	0.14	0.21	0.28	0.36	0.33	0.09	0.11

T1: Control (without Ca and K), T2: 40Kg K_2O fed^{-1}, T3: 80Kg K_2O fed^{-1}, T4: 40Kg CaO fed^{-1}, T5: 40Kg CaO fed^{-1} + 40Kg K_2O fed^{-1}, T6: 40Kg CaO fed^{-1} + 80Kg K_2O fed^{-1}, T7: T1+ 0.05mM Salicylic Acid (SA), T8: T2 + 0.05mM SA, T9: T3 + 0.05mM SA, T10: T4+ 0.05mM SA, T11: T5 + 0.05mM SA, T12: T6 + 0.05mM SA. Fed=0.42 ha

Increased salinity reduced Ca^{2+}/Na^{+} ratios in the roots and shoots of Turnip and Chard (Figs. 2 and 3). Higher rate of calcium level applied ameliorated the effect of soil salinity on decreasing Ca^{2+}/Na^{+}. Application of 40kg Ca fed^{-1} + 40kgK fed^{-1}combined with 0.05mM SA was better to improve both Ca^{2+}/Na^{+} ratio as compare to rest of the treatment and control. Calcium plays an important role in plant tissues and it also affects the regulation and function of Na and K [39,29]. In saline soils there is a high Ca concentration, but competitive effects of Na may cause Ca deficiency**.** The addition of Ca increases the Ca^{+}/Na^{+} ratio and the K^{+}/Na^{+} ratio in shoots and improves germination and growth.

Potassium –Na and Ca-Na selectivity's in root and shoot of Turnip and Chard in Fig. 2 and 3) was low under saline soil condition as control treatment. Whereas, the application of Ca and K at different levels improved the K–Na and Ca-Na selectivity's. Application of 40kg Ca fed^{-1} + 40kg K fed^{-1} combined with SA was better to increase K-Na and Ca-Na selectivity's and increasing salinity tolerance of Turnip and Chard grown in saline soil.

4. CONCLUSION

Turnip and Chard could tolerate the soil salinity and produce higher yield under balanced application of Calcium and potassium combined with salicylic acid which is most effective in ameliorating the adverse effects of salt stress.

ACKNOWLEDGEMENT

Authors heartily express their thanks to the Land owner, Koom Oshim, El–Fayoum governorate, Egypt for his kind cooperation and assistance extended throughout the field experimentation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mandhania S, Madan S, Sheokand S. Differential response in salt tolerant and sensitive genotypes of wheat in terms of ascorbate, carotenoids proline and plant water relations. Asian J. Exp. Sci. 2010;1(4):792-797.
2. statistics FAO. Global network on integrated soil management for sustainable use of salt-affected Soils. Rome, Italy: FAO Land and Plant Nutrition Management Services; 2005.
3. Marschner H. Mineral Nutrition of Higher Plants. London: Academic Press. 1995;889.
4. Patel AD, Pandey AN. Growth, water status and nutrient accumulation of seedlings of Holoptelea integrifolia (Roxb.) Planch in response to soil salinity Plant Soil and Environment. 2008;54:367–373.
5. Zamani Z, Nezami MT, Habibi D, Khorshidi MB. Effect of quantitative and qualitative performance of four canola cultivars (*Brassica napus* L.) to salinity conditions. Adv. in Environ. Biol. 2011;4(3):422-427.
6. Islam MR, Bhuiyan MAR, Prasad B, Quddus MA. Salinity effect on yield and component characters in rapeseed and mustard varieties. Journal of Biological Sciences. 2001;1(9):840-842.
7. Cheema MA, Malik MA, Hussain A, Shah SH, Basra SMA. Effects of time and rate of nitrogen and phosphorus application on the growth, seed yield and oil yield of Canola (*Brassica napus L.*). J. Agron and Crop Sci. 2001;186(2):103-110.
8. Brandt H, Cutforth W, Entz MH,. Volkmar KM. Comparing *Brassica* oilseed crop productivity under contrasting N fertility regimes in the semiarid Northern Great Plains. Can. J. Plant Sci. 2003;83:489-497.
9. Santamaria P, Elia A, Serio F, Gonella M, Parente A. Comparison between nitrate and ammonium nutrition in fennel, celery and Swiss chard. J. Plant Nutr. 1999;22:1091–1106.
10. Shannon MC, Grieve CM, Lesch SM, Draper JH. Analysis of salt tolerance in nine leafy vegetables irrigated with saline drainage water. J. Am. Soc. Hort. Sci. 2000;125:658–664.
11. Amador B, Yamada M, Yamaguchi S. Influence of calcium silicate on growth, physiological parameters and mineral nutrition in two legume species under salt stress. J of Agron and Crop Sci. 2007;193:413-421.
12. Munns R. Comparative physiology of salt and water stress. Plant Cell Environ. 2002;25:239-250.
13. Rameeh V, Rezai A, Saeidi G. Study of salinity tolerance in rapeseed. Commun. Soil Sci. Plant Analysis. 2004;35:2849-2866.
14. Gorham J. Genetics and physiology of enhanced K/Na discrimination. In: Genetic aspects of plant mineral nutrition. Randall P, Ed; Kluwer Academic Publishers,

Dordrecht, The Netherlands. 1993;151-159.

15. Schorder JI, Ward JM, Gassmann W. Perspectives on the physiology and structure of inward–rectifying K channels in higher plants: biophysical implications for K uptake. Annual Review of Biophyics and Bimolecular Structure. 1994;23:441-471.
16. Ashraf M, McNeilly T. Salinity tolerance in *brassica* oilseeds. Critical Rev. of Plant Sci. 2004;23(2):157-174.
17. Bandeh-Hagh A, Toorchi M, Mohammadi A. Growth and osmotic adjustment of canola genotypes in response to salinity. J. of Food, Agric. and Environ. 2008;6(2):201-208.
18. Horvath E, Szalai G. Janda T. Induction of abiotic stress tolerance by salicylic acid signaling. Plant Growth Regul. 2007;26:290-300.
19. Borsani O, Valpuesta V. Botella MA. Evidence for a role of salicylic acid in the oxidative damage generated by NaCl and osmotic stress in Arabidopsis seedlings. Plant Physiol. 2001;126:1024-1030.
20. Tari I, Csiszar J, Szalai G, Horvath F, Pecsvaradi A, Kiss G, Szepesi A, Szabo M, Erdei L. Acclimation of tomato plants to salinity after a salicylic acid pre-treatment. Acta Biol. Szegediensis. 2002;46:55-60.
21. Arfan M, Athar HR, Ashraf M. Does exogenous application of salicylic acid through the rooting medium modulate growth and photosynthetic capacity in two differently adapted spring wheat cultivars under salt stress. J. Plant Physiol. 2007;6:685-694.
22. Fahad S, Bano A. Effect of salicylic acid on physiological and biochemical characterization of maize grown in saline area. Pak. J. Bot. 2012;44(4):1433-1438.
23. Rebecca B. Soil Survey Methods Manual. Soil survey investigations report. No 42 Natural Resources Conservation Services; 2004.
24. Lichtenthaler HK, Wellburn AR. Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Biochem. Soc. Trans. 1983;11:591–592.
25. Faithfull NT. Methods in Agricultural Analysis: A Practical Handbook. CABI, Publishing. 2002;292.
26. Gomez KA, Gomez AA. Statistical procedures for agricultural research; John Wiley and Sons, New York; 1984.
27. Rengel Z. The role of calcium in salt toxicity. Plant Cell Environ. 1992;15:625-632.
28. Khodary SEA. Effect of salicylic acid on the growth, photosynthesis and carbohydrate metabolism in salt-stressed maize plants. Int. J. Agri. Biol. 2004;6:5–8.
29. Grattan SR, Grieve CM. Salinity-mineral nutrient relations in horticultural crops. Scientia Horticulture. 1999;78:127-157.
30. Abdul Wakeel. Potassium–sodium interactions in soil and plant under saline-sodic conditions. Journal of Plant Nutrition and Soil Science. 2013;176(3):344–354.
31. Kaya C, Halil Kirnak, David Higgs. The Effects of Supplementary Potassium and Phosphorus on Physiological Development and Mineral Nutrition of Cucumber and Pepper Cultivars Grown at High Salinity (NaCl). Journal of Plant Nutrition. 2001;24(9):1457-1471.
32. Khayyat M, Rajaee S, Sajjadinia A, Eshghi S, Tafazoli E. Calcium effects on changes in chlorophyll contents, dry weight and micronutrients of strawberry (*Fragaria ananassa* Duch.) plants under salt stress conditions. Fruits. 2009;64(1):1-10.
33. El-Tayeb MA. Response of barley grains to the interactive effect of salinity and salicylic acid. Plant Growth Regul. 2005;45:215–224.
34. Rabia Naz, Asghari Bano. Influence of exogenously applied salicylic acid and plant growth promoting rhizobacteria inoculation on the growth and physiology of sunflower (*Helianthus annuus* L.) under salt stress. Pak. J. Bot. 2013;45(2):367-373.
35. Wright GC, Patten KD, Drew MC. Labeled sodium (^{22}Na) uptake and translocation in rabbiteye blueberry exposed to sodium chloride and supplemental calcium. J. Amer. Soc. Hort. Sci. 1995;120:177-182.
36. Maas EV. Salinity and citriculture. Tree Physiol. 1993;(12):195-216.
37. Ban Äuls J, Serna MD, Legaz F, Talon M, Primo-Millo E. Growth and gas exchange parameters of citrus plants stressed with different salts. J. Plant Physiol. 1997;150:194-199.
38. Alberico GJ, Cramer GR. Is the salt tolerance of maize related to sodium exclusion? I. Preliminary screening of seven cultivars. J Plant Nutr. 1993;16:2289-2303.
39. Cachorro P, Ortiz A, Cerda A. Implications of calcium nutrition on the response of

(*Phaseolus vulgaris L.*) to salinity. Plant and Soil. 1994;159:205-212.

40. Prakash R Patel, Sushil S Kajal, Vinay R Patel, Vimal J Patel, Sunil M Khristi. Impact of salt stress on nutrient uptake and growth of cowpea. Braz. J. Plant Physiol. 2010;22(1):43-48.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=704&id=24&aid=6549