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VARIATION OF K^+ AND NA^+ CONCENTRATIONS IN ROOT AND SHOOT OF OILSEED RAPE AS AFFECTED BY SALINITY

Mehdi AZIZI[1], Mohammad Reza TOOKALLOO[2]

[1]Khorasan Razavi Agriculture and Natural Resources Research Center, Kalantari Highway, POBox 91735-488, Mashhad, Iran
[2]Islamic Azad University, Bojnourd Branch, 9417694686, Bojnourd, Iran

Corresponding author email: meh_azizi2003@yahoo.com

Abstract

Considering the importance of salinity in some regions of our province specially the lands under cultivation of oilseed rape, an experiment was conducted at greenhouse conditions for study the effect of four levels of salinity, ie. 2, 3, 6 and 9 ds/m produced from NaCl and $CaCl_2$ and different cultivars of oilseed rapes. The framework of experiment was factorial with 3 replications based on RCBD design. Results showed that, with increase of salinity , the concentration of K^+ and Na^+ in root and shoot of plants, were varied and the ratio of K^+/Na^+ increased too. Amongst cultivars, cv. Okapi had the least K^+/Na^+ concentration ratio. This proves that this cultivar has more compatibility with salinity stress and seems to be suitable for cultivation in saline soils and producing logic seed yield.

Key words: *rapeseed, NaCl, $CaCl_2$, K^+/Na^+, stress.*

INTRODUCTION

Iran poses dry and semi-dry climate conditions with an average precipitation less than 240 mm and uneven distribution. So there is a potential for formation and development of saline soils in many areas of arable lands. On the other hand,water used for irrigation tends to be more saline compared to last decades. Application of low-quality water with thousands milligrams of dissolved salts in these areas, has resulted in lower topsoil quality, i.e. increased soil salinity. Oilseed rape is susceptible to excessive soil salinity although a few tolerant varieties have been identified (Bhogal et al., 2011). This crop is considered as moderately tolerant and can tolerate salinity up to levels of 5-6 dS/m electrical conductivity. However reduction in yield can be expected (Thomas, 2003; Ashraf & McNeilly, 2004). The dominant salts and agents in our lands are Ca^{+2}, Na^+ and Cl^-. Because of the imbalance of Na with Ca and Mg, soil erosion can also be pronounced. Excess concentration of Na^+ in toxic rates has a direct effect on dry matter accumulation in plant and also destruction of physical properties of soil. Rapeseed uptakes less Na^+ than K^+,but when the concentration of sodium in soil solution or irrigation water is increased, symptoms of toxicity as chlorosis of leaves and tissues appeared. Studies shows that, Na^+ causes loosening of the conjunction force between the calcium bands with the cell walls, then prevent Ca^{+2} entrance into the cell and accelerate the exit of this ion (Maathuis and Amtmann, 1999). So this process causes the rapid depletion of calcium reservoirs in cell wall and its activity is affected adversely (Flowers & Yeo, 1989; Robinson et al. 1997). Rapeseed has a vacuole Na^+/H^+ antiport mechanism that can deliver Na^+ to vacuole and reserves it in high salinity concentrations. Cultivars with this efficient mechanism can tolerate moderate salinity levels (Zarghami, 2004).

Potassium is different from most other essential nutrients since it does not become part of structural components in the plant. Instead, most of the K^+ in plants remains dissolved in the cell sap having several major functions like enzyme activation (Thomas, 2003). Salinity and increasing of Na^+ in soil solution is resulted to decreasing of K^+ absorption by roots and then in plant cells. Therefore maintenance of high K^+ levels for plants in salt affected soils has a important role for crop production (Zarghami, 2004). Healthy cell membranes are selective and concentrate more K^+ than Na^+, so that the increased cytosolic K^+/Na^+ ratio, the more salt stress tolerance. The

K^+/Na^+ ratio that ultimately prevails in plant cell will depend on the action of transport systems located at plasma and vacuolar membranes. It probably involves K^+ selective, Na^+ selective and nonselective pathways, that occur in soil / root-symplast interface; root / xylem interface and also partitioning which may occur at a cellular level, between cytoplasm and vacuole and at a tissue level, e.g. recirculation of Na^+ and K^+ between old and young leaves. The aim of this experiment was evaluation of K^+/Na^+ ratio and then selecting the most tolerant rapeseed cultivar for mentioned region.

MATERIALS AND METHODS

A greenhouse factorial experiment with three rapeseed cultivars (ie. SLM046, Fornax and Okapi) and four salinity levels of, ECiw 2, 3, 6, 9 *dS/m* was conducted on 2007. Saline irrigation water was prepared via a uniform mixture (2:1), from NaCl and $CaCl_2$ salts. Experiment was performed in Khorasan Razavi Agric. & Natural Resources Res. Center with 3 replications. Seeds were planted in vases with 25cm diameter and 30cm height, each ones filled with 5 kg soil, taken from the nearby arable lands, passed through 6 mm sieves. Irrigation with saline water was applied based on standards and physical characteristics of soil and weighing pots daily. After emergence, each vase thinned to three plants. At rosette stage (6 leaves), plants were pulled up from the soil with contact root, then washed with distilled water and prepared for laboratory analysis for Na^+ and K^+ content in shoot and roots. Oven dried and milled parts of plants in different treatments, used for Flame Photometery. Results were processed using Mstat-C statistical software and traits mean were compared with Duncan's multiple range test.

RESULTS AND DISCUSSIONS

Mean comparison of K and Na contents in roots and shoots and the K^+/Na^+ ratio under salt stress conditions has shown in Table 1. Salinity had a significant effect on these traits ($P = 0.01$), in both root and shoot. These concentrations varied between cultivars too. K^+ content in the first three levels of salinity in roots and shoots showed no significant differences, but it was in maximum rate in EC 9 ds/m salinity level. Generally the K^+ content in shoot was higher than in roots. Increasing of K^+ with increasing salinity is a result of salinity tolerance in that cultivar (Zarghami, 2004). The same trend was observed as well for Na^+ in above and underground parts of the plants. The content of Na^+ in shoots was more than roots and also more than the sole percentage of K^+ in shoots. It seems that, sodium hardly translocates from leaves to root. It accumulates in leaves with Cl^- and causes some growth disorders. The K^+/Na^+ ratio increased with increasing of salinity levels in both shoot and roots. The greatest K^+ content was achieved in Cv. SLM046 roots and Okapi leaves respectively. The K^+ content in roots of Okapi was rather high too. This suggests that the Okapi cultivar has a capability for uptake more potassium from saline soils. It has a good adaptation with this stress. Also this cultivar can concentrate Na ions in leaf cell vacuoles and prevents to its toxicity via Na compartmentation mechanism in cells (Zarghami, 2004).

Table 1. Mean comparison of K and Na contents in rapeseed cultivars under different salinity treatments.

Treatments	K^+_{root} (%)	K^+_{shoot} (%)	Na^+_{root} (%)	Na^+_{shoot} (%)	K^+/Na^+ (Root)	K^+/Na^+ (Shoot)
Salinity						
< 2ds/m	0.79b	0.99 b	0.26 c	0.34 c	0.33 c	0.35 c
3 ds/m	0.75b	0.97b	0.46 b	1.33 b	0.61 b	1.37 b
6 ds/m	0.72b	1.10b	0.55 a	2.08 a	0.77 a	1.88 a
9 ds/m	0.92a	1.34a	0.61 a	2.32 a	0.67 ab	1.72 a
Cultivars						
Okapi	0.79ab	1.18 a	0.45 a	1.61 a	0.57 b	1.31 a
Fornax	0.74b	1.1 ab	0.48 a	1.42 b	0.65 a	1.30 a
SLM046	0.86 a	1.05 b	0.49 a	1.52ab	0.59ab	1.42 a
Letters show significant differences based on Duncan's Test.						

Table 2, shows the interaction effects of salinity × cultivars on K^+/Na^+ ratio variations in leaves and roots. Both Okapi and SLM046 cultivars, showed high K^+/Na^+ ratios in leaves and sometimes in their roots. These cultivars were more tolerant to salinity in this experiment. Potassium concentration in tolerant plant cells are kept under homeostatic control with cytosolic K^+ concentrations (Zhang et al. 2001). Then in high EC soils the more K^+/Na^+ ratio in plant tissues, the more cultivar tolerance to salinity stress.

Table 2. Mean comparison of K^+/Na^+ ratio in leaves and roots of rapeseed cultivars

Salinity (ds/m)	*Okapi*	*Leaves Fornax*	*SLM046*	*Okapi*	*Roots Fornax*	*SLM046*
< 2ds/m	0.36e	0.31 e	0.38 e	0.35 e	0.33 e	0.31 e
3 ds/m	1.37cd	1.30 d	1.48 bcd	0.58 d	0.65 cd	0.62 cd
6 ds/m	1.68bc	1.74 b	2.44 a	0.68bc	0.86 a	0.83 ab
9 ds/m	1.83bc	1.75 b	1.60 bcd	0.67bcd	0.76abc	0.60 cd

Letters show the significant difference range between treatments based on Duncan's Test.

CONCLUSIONS

There is a variability for salinity tolerance between rapeseed cultivars.

In this experiment Okapi and SLM046 cultivars showed adaptation and tolerance to high salinity levels in growing media.

In tolerant cultivars the K^+/Na^+ ratio tends to be increased because of the homeostatic control with cytosolic K^+ concentrations. Then plant can uptake more K^+ from soil solution compared to Na^+.

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