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Na^+ and K^+ relations in shoot of early growth wheat cultivars (*Triticum aestivum* L.)

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ABSTRACT

Ions concentration of seventeen wheat cultivars (Triticum aestivum L.) in NaCl salinity (16 dS m-1 and two weeks exposure) was assessed to evaluate the ability of these traits in salt screening. There was an increase in Na^+ concentration and decrease in K^+ concentration in salinity stress compared to control condition in shoot parts. Even thought, there was a clear relation between salt tolerance or salt sensitivity and Na^+ concentration in shoot plant. It seems that the increase in concentration of Na^+ concentration can be criteria to distinct salt tolerance in the shoot of early wheat plant. Therefore Na exclusion measurement can be applied with other trait such as yield and yield components to screen wheat cultivars in salinity condition.

Introduction

Soil salinity is estimated to affect 800 million hectares of land worldwide that this amount including 7% of total farmland in the world. It is estimated more than 20% of the irrigated land in the world is presently affected by salinity this amount is around 45 million hectares (Fao, 2005). So it seems salinity is one of the most serious abiotic stresses in the dry lands that influence plant production.

Screening in germoplasm for salinity tolerance might be result in producing new verity that able to have considerable production in different environment condition including salinity tolerance (Inamullah et al.). There is big variation between genotypes and lines in bread wheat that indicating different opportunity for breeders to manipulation for increasing salinity tolerance. But it seems salinity tolerance is quantitative trait and it depend complicate mechanisms that make some restrictions and problems in identification of suitable variety (Mian et al. 2011).

Plants have different mechanisms to avoid or reduce harmful effects of salt stress. One of the most important mechanisms is involving Na^+ exclusion from transpiration stream and sensitive shoot tissue because Na^+ accumulation in the cellular levels result in harmful effect on membrane structure and protein degradation (Mian et al. 2011). Study and investigation of sodium exclusion in the root and adjusment of sodium stream to the shoot base asnd upper part of plant and sodium control in long distance , sodium compartmentation in the cells and tissues is constituve the important aspect of these studies (Flowers and Colmer 2008). Na^+ exclusion from more sensitive part of plant like shoots and leaves in some species like wheat and barley is the effective mechanism to avoid Na+ toxicity in these parts (Munns 2005). Increasing in Na^+ concentration result in leaves damage, decline in leaves longevity, photosynthesis reduction in leaves and at least yield decrease (Husain et al. 2003).

Thereby, Na+ exclusion is best candidate for targeted genetic manipulation for increasing salinity tolerance in plants (Munns and Tester 2008).

Screening of germplasm for salinity tolerance based on Na^+ exclusion or K^+/Na^+ ratio trait are less affected by environment conditions but some studies shows there is to significant evidence in amount of sodium accumulation and salt tolerance(Munns et al. 2002; Munns et al. 2006).

K^+ Is one of the important metabolites that play important role in cellular functions (Siddiqui et al. 2010). In wheat plant there is significant relation between salt tolerance and K^+/Na^+ ratio.

Intercellular K^+/Na^+ homoeostasis is important for cell metabolism, enzyme activation (lee, 2001) and can be used as key trait for screening of salinity tolerance in the wheat plants (Poustini and Siosemardeh, 2004).This study focused on ion distribution in different wheat genotypes and it's Correlation with salt tolerance mechanism.

Material and methods

This study was carried out in greenhouse from the middle of October to the middle of November 2010. The air temperature ranged from 22 to 28 ◦C during the day and 14 to 17 ◦C during the night. The experimental treatments were arranged as factorial based on a completely randomized design with three replications. Treatments consisted of two levels of salinity [1.6(control), and 16 dS m-1(salinity stress)] and wheat cultivars. Seventeen cultivars of spring wheat (Triticum aestivum L.) from Iranian economic cultivars were used in this study. They were Roshan, Tabasi, Hirmand, Chamran(as tolerance cultivars), Atrak, Tajan, Ghods, Shiraz(as sensitive cultivars), Falat, Alvand, Kavir, Mahdavi, Niknejad, Dez, Pishtaz and Star(as intermediate cultivars).

3.5 kg of soil (mixture of farm soil, sand, and farmyard manure in a 3:2:1 ratio) were put into the pots. Ten grains were sowed in each pot. They were daily irrigated with water until seedlings establishment (21days). Afterwards, the pots were watered (NaCl 150mM) to the saline levels (16 dS m-1) by

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adjustment the water content of soil nearby the field capacity. After 14 days (35 days after sowing) shoot and root of plant was separated manually and dried at 60◦C for 72 h. Ion measurements were taken from the 2 N chloride acid extract of the samples(0.5 g) that had been burned at 600 8C for 4 h, using a flamephotometer.

The analysis of variance of the data was done by SAS, 9.1 software. The data mean comparisons were made following Least Significant Difference (*LSD*) Test at 5% probability level.

Results and Discussion

Analysis variance of data's results shows salinity not only has effect on K^+ and total [Na^+ K^+] concentration but also has significantly difference on main traits and their interactions (table 1).

Base on expectations response of genotypes to salt stress result in sodium concentrations increased more that 50 % in the young leaves. In contrast K^+ concentration didn't show same pattern. In some genotypes K^+ concentration increased in in some of them we had deficit in K^+ accumulation. We expected all the resistance genotype in response to salinity shows less sodium accumulation in the young leaves, but the result indicating tolerate genotypes like Chamran and Roshan had high amount of sodium accumulation in their leaves and the other hand Hirmand and Tabasi that was sensitive genotype had less amount of sodium concentration in the leaves.

Sodium concentration in all the genotypes showed big difference in treated samples compared with control ones. But amount of total sodium more less was the same, for example: sodium concentration in Chamran, Roshan, Hirmans and Tbasi genotypes respectively was 0.49, 0.46, 0.44 and 0.39 Mg g^{-1} DW. It seem Chamran genotype is exceptional in this case. Total overview in Na^+ concentration data's shows some genotypes are inefficient in sodium exclusion including: Shiraz, Tajan and kavir that most of them are sensitive genotype under salt stress (Fig. 1). Similarly, differential sheath retention of Na^+ have been previously reported on two durum wheat varieties showing marked differences to salt and drought stress (Brini et al., 2009).

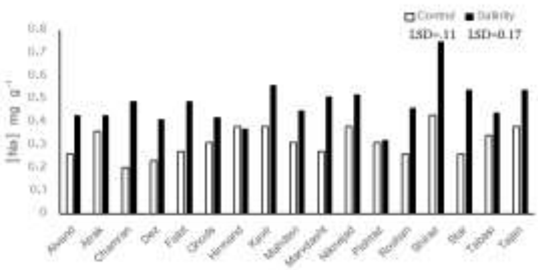

Fig. 1.Na^+ concentration in wheat cultivars in salinity and normal conditions

As matter of fact response of K^+ concentration in different genotype under salt stress was complicate. However it seems in salinity condition K^+ accumulation in leaves decrease but in some genotypes like Ghods, Star and Roshan this amount increased significantly. In the other hand Tajan genotype shows 27% decrease in K^+ concentration compare with control sample. Interestingly we observed average of sodium amount in leaves in different genotypes; salinity and control condition weren't significant and generally except some genotypes we didn't have difference in sodium accumulation in control and salt stress. In this vegetative stage sodium compartment in root that is less sensitive than leaves. One of the most important mechanisms is involve Na^+ exclusion from transpiration stream and sensitive shoot tissue (Munns, 2008) (Fig. 1).

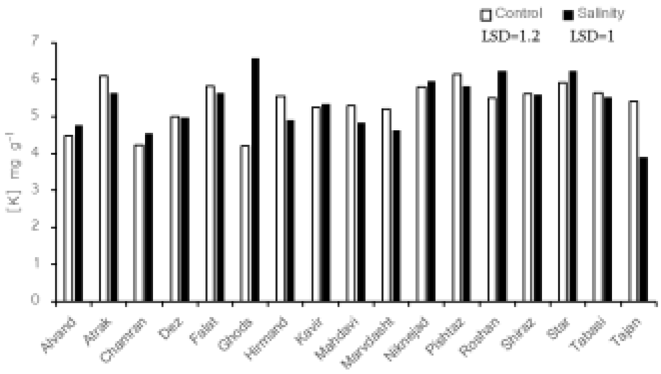

Fig. 2 .K^+ concentration in wheat cultivars in salinity and normal conditions

According to the sodium increasing and constant amount of K^+ we look for decrease in K^+/Na^+ ratio. And the result shows it clearly.in this case Ghods genotype was an exception and because of High value of Potassium had different pattern.Under salinity condition K^+/ Na^+ ratio in Shiraz and Tajan were less but Pishtaz, Roshan and Tabasi that were tolerate genotypes shows maximum amount of K^+/ Na^+ ratio.Reaction of Hirmand and Star genotype in case of K^+/ Na^+ trait was interesting. Hirmand is tolerate genotype and able to moderate sodium and potassium concentration in the leaves so in salinity condition $Na^+/K+$ ratio just change 2% compared with control conditions but in the other hand decreasing in K^+ amount in salinity result in big difference of K+/Na+ ratio (about 50%) in control and salinity condition.

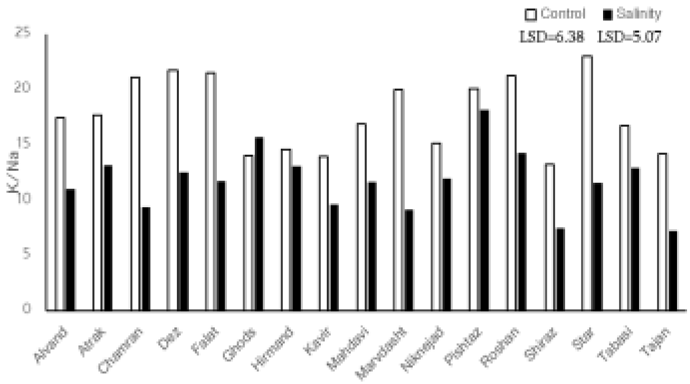

Fig. 3 .K^+/Na^+ ratio in wheat cultivars in salinity and normal conditions

So these result indicating Hirmand, Chamran, Roshan genotype base on K^+/Na^+ ratio have high potentil to salinity resistance but Atrak, Tajan, are sensitive genotypes.K^+/Na^+ selectivity is one of the important criteria for screening salt tolerance and sensitive genotypes (Munns, 2006) Salt- tolerance Plants able to restrict Na^+ in less sensitive parts of plants like roots. So K^+/Na^+ discrimination can be used as key trait for evaluation of salinity tolerance in the wheat plants. Sodium and potassium concentrations in flag leaf was significantly different in 17 genotypes and Na+ concentration was higher in sensitive genotypes.

According to the constant amount of K^+ in most of the genotypes it seems the difference between total sodium and potassium is related to the sodium.

Table 1. Analysis of Variance for K, Na, K/Na and [K+Na]

S.O.V	df	Mean Square			
		K	Na	K/Na	[K+Na]
Variety	16	1.08**	0.01**	22.92**	0.67*
Salinity	1	0.0001 ns	0.45**	613.8**	0.73 ns
Variety* Salinity	16	0.62*	0.008*	14.1**	1.10**
Error	68	0.029	0.004	7.47	0.31
C.V%	-	10.19	17.45	18.50	9.7

ns: Non-significant, *and**: Significant at 5% and 1% prabability levels, respectively

But it should be notice sodium concentration in cellular level is lower than potassium concentration (it is about 2 times). So screening of tolerance genotype base on [K^++Na^+] trait isn't logical.

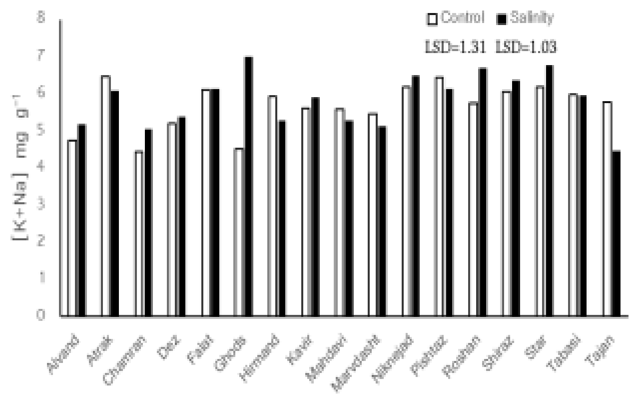

Fig. 4. [K+Na] concentration in wheat cultivars in salinity and normal conditions

In the Previous studies showed tolerate genotype are able to exclude sodium in their vegetative parts these genotypes always have acceptable ratio of K^+/Na^+ to avoid sodium accumulation in young and sensitive parts of plant Instead compartment additional sodium to the older part like old leaves and leaf sheaths (Munns and James 2003; Poustini and Siosemardeh 2004; Zhu 2001).

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