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Evaluation of Na^+/K^+ ratio under salt stress condition in wheat

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Abstract: The king of cereal wheat belongs to poaceace family. It is a staple food of Pakistan. Total area of wheat cultivation in the world is about 13.4 billion hectares. Wheat is the most cultivated crop of the world and according to world agriculture report of 2014 it is grown on 220 million hectares worldwide. In agronomy its fruit is termed as caryopsis. There are almost more than 30 wheat varieties have been developed in Pakistan which are being cultivated throughout the country. Pakistan has also more than 30 wheat varieties that are cultivated across the country. Each variety has its own requirement of water and nutrients. In our research we have used six wheat varieties of the Punjab that are Inqalab-91, shafaq-06, Faisalabad-08, galaxy-13, Ujala-16 and anaj-17 to grow. For our current research study two concentration of NaCl i.e. 10 dS/m and 15 dS/m were prepared. Content of two different ions were checked in all six varieties and those ions are sodium (Na^+) and potassium (K+). It was noted that there were significant concentration of sodium ion (Na^+) in roots, shoots and leaves of all six varieties. Highest Na+/K+ ratio in leaves was found in Galaxy-13 under treatment of 15 dS/m NaCl. And under treatment of 10dS/m highest Na+/K+ ratio in leaves was recorded in Galaxy-13 too.
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Keywords: Salinity, Wheat, 10dS/m NaCl, 15dS/m NaCl, Na^+/K^+ ratio

1-Introduction

The king of cereal wheat belongs to poaceace family. It is a staple food of Pakistan. Total area of wheat cultivation in the world is about 13.4 billion hectares. Wheat is the most cultivated crop of the world and according to a report of 2014 it is grown on 220 million hectares worldwide [1]. In agronomy its fruit is termed as caryopsis. It is growing all over the globe and is second most growing crop after corn. History of wheat is as old as the history of man. It was 1st grown by some 9600BCE. Wheat was first ever cultivated by some 10,000 years ago during Neolithic revolution [2,3]. Einkorn and tetraploid wheat have been ever cultivated throughout the world [4-6]. Salinity is most challenging condition in Pakistan and across the globe for agriculture along with drought. Saline soils are the salt effected soils which have been distributed throughout the world with different amount of salts. Salts may be deposited by irrigation water, weathering and acid rains may also deposit salts in soil. Salinity can be measured by various parameters affecting rate of growth of crop production. Growth rate of wheat and maize is badly affected by salinity [7,8]. Saline soils are more sensitive to soil erosion and water logging process. Sodium ion which is found more abundantly in saline sodic soils caused adverse effects on plant growth. Due to addition of sodium in soil in the form of its salts like NaCl, it became the cause of increasing alkaline conditions of soil which are the actual cause of damaging of plant roots in soil and decreased the water holding capacity of soil. However the sodium and potassium are necessary for plant growth, cell signaling and osmotic adjustment of plant cells under stress conditions [9,10]. Under saline conditions the Na^+ uptake and holding activities of xylem cell are highly affected which caused to reduce plant growth and survival under salt conditions [11,12]. The most of crop plant species usually showed less genetic variation for salt tolerance [13,14]. Salt reduces the photosynthetic ability of plants [15-17]. There are various studies in which the use of silicon compounds has been found efficient sources to reduce saline conditions of soils. The seed germination rate, growth and development of plant seedlings are usually highly affected due to soil salt conditions. The use of silicon compounds have shown it as an efficient source to reduce Na^+ contents in leaves and roots, under saline conditions [18,19].

Statistical assessment of salt tolerance on the basis of Na+/K+ ratio

Six wheat accessions were selected for our current study. Leaves, roots and stems for each replication was taken in microtubes and kept in refrigerator at 5^O C for six days. By the help of

standard centrifugation technique [20] cell sap was extracted from leaves, shoots and roots of all six wheat varieties. Cell sap was diluted by mixing de-ionized water in it. With the help of flame photometer respective concentrations of sodium and potassium ions were measured for each wheat seedling. Relative Na^+/K^+ ratio was calculated from collected data to construct graphs as given in reulst.

Assessment of Na+/K+ ratio in leaves of Wheat varieties

Figure (a) shows relative sodium and potassium ions concentrations in leaves of all six accessions. Higher Na^+/K^+ ratio was noted in leaves of Galaxy-13 under the treatment of 10dS/m NaCl, followed by shafaq-06. While lowest Na^+/K^+ accumulation was found in leaves of Faisalabad-08 and Anaj-17. Galaxy-13 and shafaq-06 are most affected while Faisalabad-08 and Anaj-17 has shown resistance against salt stress. The accumulation of sodium ion was maximum in leaves under salt stress conditions. The control conditions showed very low near to negligible accumulation of Na^+ or K^+. Previous study also has showed that higher concentration of sodium ion (Na^+) reduces wheat plant growth during salinity [21]. In another study on drum and emmer wheat variety showed the same result that during salinity sodium accumulation is high that affects not only wheat growth but photosynthetic activities [22].

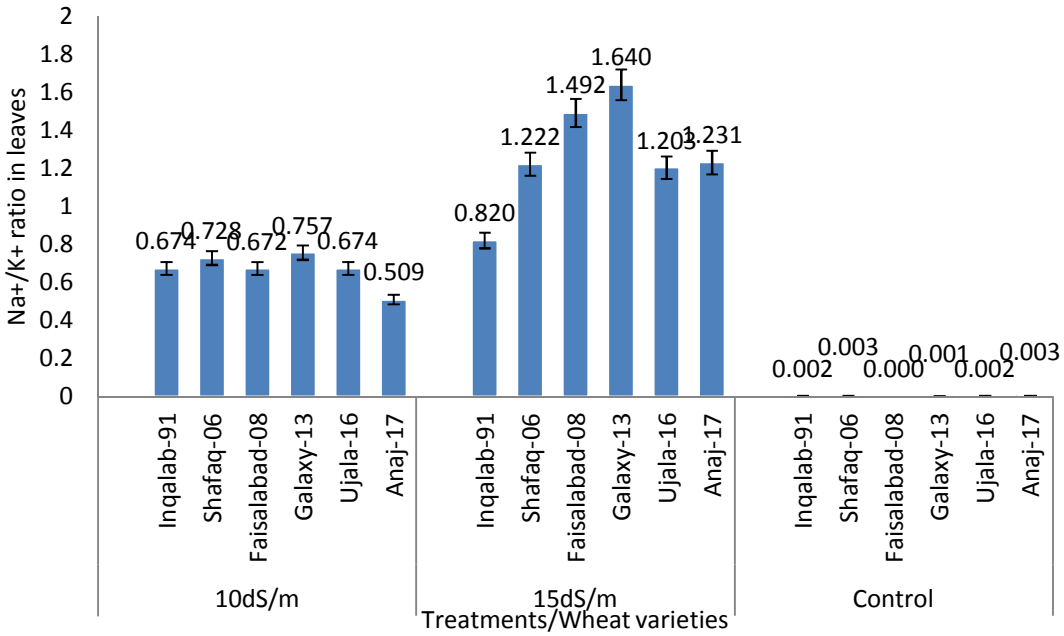

Fig (a) Showing relative concentration of sodium and potassium ion in wheat leaves of all genotypes under treatment of 10dS/m and 15dS/m NaCl

While under treatment of 15 dS/m NaCl highest ratio of Na+ and K+ ions was recorded in leaves of Galaxy-13 followed by Faisalabad-08. While least affected accessions are Inqalab-91 and Ujala-16. This means Inqalab-91 has highest tolerance against saline condition.

Assessment of Na+/K+ ratio in shoots of Wheat varieties

Figure (b) shows relative sodium and potassium ions concentrations in shoots of all six accessions. Higher Na+/K+ ratio was noted in shoots of Faisalabad-08 under the treatment of 10dS/m NaCl, followed by shafaq-06. While lowest Na+/K+ accumulation was found in shoots of Galaxy-13 and Anaj-17. Faisalabad-08 and shafaq-06 are most affected while Galaxy-13 and Anaj-17 has shown resistance against salt stress. Studies says ion accumulation increases in shoots during salt stress specially concentration of Na+ and K+ ions, there are special transporter proteins which help in entry of sodium ion in stem cells [23]. Under saline condition sodium ion plays a role of toxin specially in old leaves and shoots of wheat seedling where it enters in stele by the help of parenchyma cells and stunts the growth of seedling [24]. While under treatment of 15dS/m NaCl highest ratio of Na+ and K+ ions was recorded in leaves of Galaxy-13 followed by Anaj-17. While least affected accessions are Inqalab-91 and Shafaq-06. This means Inqalab-91 has highest tolerance against saline condition.

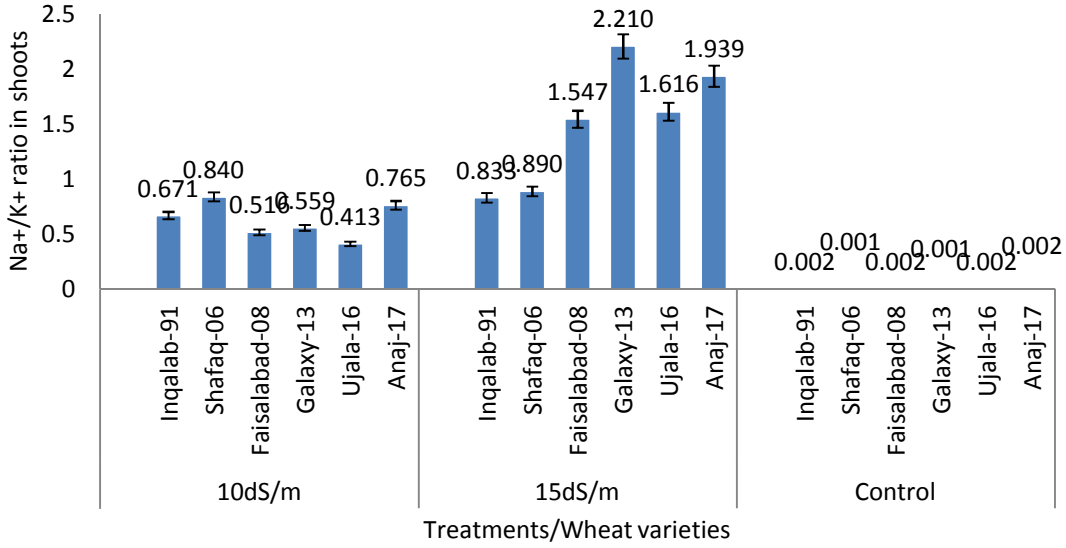

Fig (b) Showing relative concentration sodium and potassium ion in wheat shoots of all genotypes under treatment of 10dS/m and 15dS/m NaCl

Assessment of Na+/K+ ratio in roots of Wheat varieties:

Figure c shows relative sodium and potassium ions concentrations in shoots of all six accessions. Higher Na+/K+ ratio was noted in roots of Faisalabad-08 under the treatment of 10dS/m NaCl, followed by Anaj-17. While lowest Na+/K+ accumulation was found in roots of Shafaq-06 and Ujala-16. Faisalabad-08 and Anaj-17 are most affected while Shafaq-06 and Ujala-16 has shown resistance against salt stress.

There is high amount of salts in irrigation water; all ions can evaporate except that of sodium ion and roots accumulate this ion by its epidermal cells. There are ports for the entry of sodium ion controlled by special genes that facilitates penetration of Na+ instead of K+, there is higher uptake of Na+ in saline condition as compared to K+ in wheat plant causing stunt growth [25].

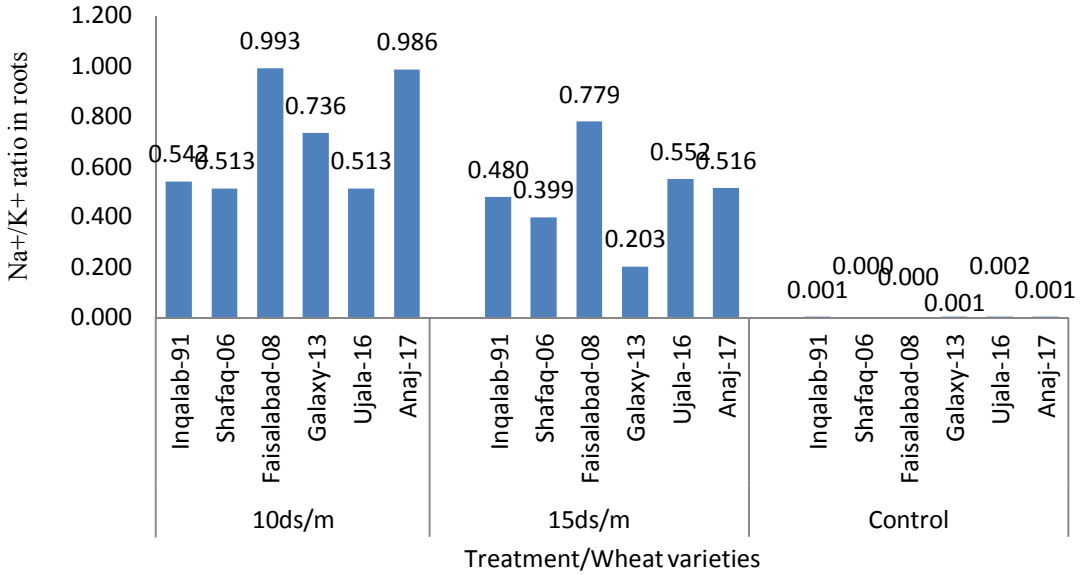

Fig (c) Showing relative concentration of sodium and potassium ion in wheat roots of all genotypes under treatment of 10dS/m and 15dS/m NaCl

While under treatment of 15dS/m NaCl highest ratio of Na+ and K+ ions was recorded in leaves of Faisalabad-08 followed by Ujala-16. While least affected accessions are Shafaq-06 and Galaxy-13. This means Galaxy-13 has highest tolerance against saline condition.

Conclusions

There were least accumulation of Na^+ and K^+ in stem was reported for wheat genotypes Faisalabad-08 and Inqalab-91 which indicated that these genotypes have salt stress tolerance. It was concluded from our study that the genotypes which were efficient in accumulating Na^+ and K^+ ions without any adverse effect on their growth may be used as salt tolerance wheat genotypes for improvement of wheat grain yield under salt stress environment.

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