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EVALUATION OF FOUR WHEAT *Triticum aestivium* L. GENOTYPES GROWN IN YEMEN FOR SALINITY TOLERANCE

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Abstract: This study is aimed to evaluate the relationship between the leaf content of Na, K, Ca and Mg and salt tolerance of some wheat (*Tritcum aestivium* L.) genotypes. Four wheat genotypes, namely: Ahqaf, Baftaim, Hadhramout and Buhooth that differe in their salt tolerance, were sown in a greenhouse pots with 5 kg. soil samples with EC of 3, 6, 9 and 12 dS / m. The experiment was carried out in split plot design with three replications. Contents of Na, K, Ca and Mg of upper and lower leaves were analysed at the booting stage. The results proved that the upper leaves of Buhooth tolerant genotype had the lowest content of Na, Ca and Mg and the highest content of K as compared to other genotypes. Also this genotype showed the highest K : Na ratio in the upper leaves and the highest content of Na, K, Ca and Mg in the lower leaves. The Ca and Mg contents were higher in the lower leaves than in the upper leaves of all genotypes. Increasing the salinity level caused a corresponding increase in Na, Ca and Mg contents and a reduction in K content of upper and lower leaves. A reduction in the K : Na ratio of the upper leaves was also observed with increasing soil salinity.

It may be concluded that the salinity tolerance is related to a mechanism which conserves the Na mineral concentration in the lower parts of the plant away from active and young parts and a high concentration of K in these parts and maintains a balance of Ca and Mg ions in plants.

Key words: wheat, salinity tolerance, ion content.

Introduction

Wheat is considered to be one of the most strategic winter crop in Yemen though its production does not fulfil the country requirement. The total wheat production recorded amount of 141884 tons in 2000, whereas the country requirement recorded more than 1635397 tons (Statistics and Agriculture Documentation Year Book, 2001). This reduction may be due to the wheat growth restrictions in a large area where the salinity which negatively affects the yield of this crop is expanded because of its sensitivity to salinity, particularly during seedling stage (Mohammed *et al*, 1987; and Cramer *et al* 1993).

Salinity affects most the biological and physiological processes in plant. The unbalanced ions and toxicity effects caused by the accumulation of salty ions in plant tissues increase the damage raised by unbalanced harmonic and enzymes activities which cause a reduction in the transmitting processes in the plants and inhibit the activity of food synthesis and lead to the appearance of certain degrees of damages on the plant (Greenway and Munns, 1989, Fageria, 1983 and Black 1989).

Altered ionic balance in the soil influences the mineral plant content particularly sodium (Na), potassium (K), calcium (Ca) and magnesium (Mg). This may lead to a negative effect on the biological process inside the plant. Salinity is considered to be the main important factor that affects ion content of plants. Crops varied in their salinity tolerance. So it becomes more important to utilize breeding programmes to introduce, select and evaluate genotypes that are salinity tolerance in order to select a desirable tolerant one which may have one or more tolerant mechanism, particularly a mechanism which conserves the balance of mineral content in plants. It was found that taking off Na from the young plant parts of high photosynthesis activity and increasing K ions conserve the a K:Na high ratio is one of the most important mechanism for salinity tolerance (Yeo and Flowers 1985; Flowers, 1987; Aslam *et al.*, 1993; Gregoiro and Senathivot 1993 and Shannon *et al*, 1994).

Laboratory and green house-based techniques have been developed to identify mineral tolerant and mineral sensitive plants precisely, i.e. using nutrient solution culture and pot trials. Since the main effect of mineral toxicity is the inhibition of root growth; The roots are not easily observed using soil culture. The screening a nutrient solution allows studying mineral toxicity, providing easy access to the root system and strict control over nutrient availability and pH (Blamey *et al.*, 1991).

Some researchers used this technique to screen maize genotypes which were tolerant to Al (Kasim and Wassom, 1990; candcado *et al.*, 1997; and Giaveno and Miranda Filho, 2000). Screening techniques using soil in glasshouse and pot trials are very representative of real conditions in the field (Howeler, 1991). Soil bioassays seem to reproduce more realistic field condition (Giaveno and Miranda Filho, 2002).

This study aimes to investigate a mechanism for salt tolerance in four wheat (*Tritcum aestivum*) genotypes, to evaluate the range of tolerance of these genotypes in relation to their; Ca, Mg, Na and K contents in the upper and lower leaves and to compare the ratios of these ions to each other.

Materials and Methods

Four genotypes of wheat cultivars obtained from Seiyun Agricultural Research Centre, Yemen namely: Ahqf, Baftaim (local) Hadhramaut and Buhooth were selected to be evaluated for salinity tolerance. A saline sility clay soil at the upper 30cm. layer of this soil, air dried and grinded and then sieved by a 2 mm. sieve. The electrical conductivity (E.C.) of the soil extracts of these samples were determined using the methods of Singh (1980). The average E.C. value of these the extracts was about 25 dS/m. The degree of the E.C. of this saline soil was reduced by current irrigation till it reached 3 dS / m. A sufficient amount of this soil at the surface was taken, air dried, grinded and then sieved. The two soils were mixed in ratios to get four saturated soil samples with $E.C_e$ values of 3, 6, 9 and 12 dS/ m. The chemical and physical properties of these salinity levels were determined and demonstrated in Table (1). Soil pH was determined by the pH meter Concentrations of ; Na^+, K^+ , Ca^{++} and Mg^+ were also determined using the atomic absorption instrument. Chloride on was determined according to Iwasaki *et al* (1952). Ten seeds of each genotype per pot were sown in pots of 25cm in diameter with 5kgs soil samples with $E.C_e$ of 3, 6, 9 and 12dS/m. in a greenhouse under controlled environmental requirements at Faculty of Agriculture, University Putra, Malaysia, during October, 2007. The plants were then thinned to four plants at seedling stage..

A N.P.K compound fertilizer of a 27 : 27 : 0 respective ratios was added to each pot before sowing at level of 400 kg / ha. Urea (46 % N) was also added at a level of 280 kg/ha. to each pot in two doses, one month and two months after planting. The pots were irrigated by distilled water up to 25 % of field capacity during germination and seedling stages. The soil was then filled with distilled water up to a depth of 5 cm. above soil surface after tillering stage till booting stage. At the booting stage (100 days after planting) plant leaves at upper and lower nodes of all treatments were taken, dried and then grinded. Leaf Sample of 250 mg was put in a 50 ml glass beake; 10 ml of nitric acid, hyderochloric acid, and concentrated sulphuric acid in a respective ratio of 5 : 2 : 1 were added, left for one day and then put on a sandy bath of 80°C for 6 hours to conduct the digestive process; Then this digestive material was dissolved into a distilled water and completed to the volume in a 100 ml flask. Concentrations of Na, K, Mg and

Ca were determined using atomic absorption device according to Devitt *et al* (1981).

The experiment was conducted in a spilt plot design with three completely randomized replications. Genotypes occupied the main plots whereas the salinity levels occupied the sub – plots. Analysis of variance (ANOVA) was employed, and mean comparisons were made using the Statistical. Analysis System (SAS) Software Version 8.2 developed by SAS Institute Inc. (2001) ANOVA was used to detect the effects of genotype, salinity level and genotype - salinity level interaction.

Results and Disscusion

1. Sodium (Na)

The results in Table 2 revealed that the average concentration of Na in the upper leaves showed the highest value (21. 85 mg / g) in Ahqaf genotype, but other genotypes did not significantly differ between each other. The lowest concentration of Na (16. 33 mg / g) was recorded in the upper leaves of Buhooth genotype whereas the lower leaves of the same genotype recorded the highest average Na concentration (32. 55 mg / g) (Table 3).

It is shown in Table (3) that the high Na content in the lower leaves of Buhooth genotype accompanies with the corresponding increase in the salinity level as compared to other genotypes. This indicates the ability of this genotype to come over the effect of this undesirable element in the active young leaves and to maintain it in the lower part of the plant. Increasing the salinity level caused increases in the Na content in both the lower and upper leaves of all other genotypes (Table2). This is due to the increase in the Na contents of the soil, but the distribution of this mineral in the upper and lower leaves of studied genotypes differed according to their tolerance to salts. So Buhooth genotype, which is the most tolerance to salinity, maintains high Na content in its lower parts (Table 3). This result agrees those result reported by Fageria (1983), Gregoiro and Senathivot (1993).

The differences in the Na distribution inside the different parts of the investigated genotypes were reflected on their performance and growth. In Buhooth genotype which shows the highest tolerance to salinity, the maintaining high level of Na in its lower parts prevents the translocation of this element to its active parts. This resulted in highest values of dry matter weight of total vegetative parts and the lowest reduction percentages particularly at high salinity levels (9 and 12 dS / m) as compared to other genotypes. (Table 4). This may be due to the high activity and continuity of photosynthesis and biological processes in this genotype that is reflected on the growth and dry matter

Table(1): pH values and concentration of some soluble ions (me / L) for salinity levels 3,6,9 and 12 dS/ m of the investigated soil samples

Salinity level (ECe, dS/m)	Property					
	pH	Cl	Na	Ca	Mg	K
3	7.5	15.5	18.68	10.77	7.81	1.05
6	7.7	38.81	35.89	19.58	18.98	1.82
9	7.4	72.72	46.95	29.82	26.72	2.21
12	7.3	96.89	66.47	39.79	43.13	2.87

Table(2): Effect of salinity levels on Na concentration (mg / g) of upper leaves of four wheat genotypes

genotype	salinity level (dS/ m)				
	3	6	9	12	average
Ahqaf	15.4	16.5	24.0	31.5	21.85
Baftaim	14.7	15.8	17.7	18.1	16.58
Hadharomut	15.2	15.7	16.9	17.1	16.23
Buhooth	15.7	16.2	16.8	16.6	16.33
Average	15.15	16.15	18.75	20.82	

L.S.D. at 0.5%

Genotype = 0.36

Salinity level = 0.5

Genotype × Salinity level = 1.02

Table(3): Effect of salinity level on Na concentration (mg / g) of lower leaves of four wheat genotypes

genotype	salinity level (dS / m)				
	3	6	9	12	average
Ahqaf	10.34	16.56	19.81	32.30	19.75
Baftaim	19.32	23.11	29.30	34.12	26.46
Hadharomut	21.51	22.14	32.15	39.68	28.86
Buhooth	23.13	25.71	35.82	45.54	32.55
Average	18.58	21.88	29.36	37.91	

L.S.D. at 0.5%

Genotype = 0.98

Salinity level = 0.81

Genotype × Salinity levels 1.69

accumulation. The salt accumulation in a form to protect the young leaves with high active photosynthesis made the variety that has high active leaves tissues to tolerate the salinity even at its high concentration. Similar results were reported by Pitman *et al* (1981) and Flowers (1987).

The interaction effect of the genotype and the salinity level on the Na content of the upper leaves indicated on Table 2 shows that the continous increase in the Na concentration in the upper leaves of Ahqaf genotype is high while it is less higher in the Buhooth and Hadhramout genotypes. A small increase in this element in Buhooth genotype at salinity level of 9 dS/m to 6 dS/m and a stability at 12 dS/m were recorded. A mechanism which keeps Na ions away from cytoplasm and in the vacuoles, of the cell or by maintaing Na into the base of the stem or at parenchyma or at the vacuoles of the root cells may be involved. This mechanism can give a chance for the salts to be distributed to protect the young leaves with highly active photosynthesis; These results agree with those reported by Yeo and Flowers (1985) and Shannon *et al* (1994).

2. Potassium (K) and K : Na ratio in leaves

The K concentration significantly differed in the upper leaves of the investigated genotypes (Table 5). The accumulation of K ions in Buhooth genotype was the highest with an average of 21.54 mg/g compared to other genotypes, whereas Ahqaf genotype contained the least amount of K ions in upper leaves with an average of 18.46 mg/g (Table 5). However, in the lower leaves the genotypes did not significantly differ with each other (Table 6). Buhooth genotype maintins high levels of K in the plant whether in upper or lower leaves accompanied with high ability to translocate it from the lower leaves to higher leaves to keep high ratio of K: Na with increasing the salinity level (Table 7).

The average reduction in K in the upper leaves at the highest salinity level (12 dS/m) compared to that at the third salinity level (9dS/m) and between 9 and 6 d S/m levels were nearly close to each other. The level of Ca was not reduced more in the upper leaves by increasing the salinity in the upper leaves. This may be due to the reduction in the Na increase in these levels using 12 dS/m salinity level compared to 9 dS/m one (Table 2), as well as the increase in the Ca concentration in soil as a result of increasing the salinity level (Table 1). This results in an increase in the plant permeability for K ions versus Na and continous of K translocation to the upper plant parts in presence of Na. Similar observations were also approved by Lahaye and Epstein (1969) and Aslam *et al* (1993).

Table(4): Effect of salinity level on dry matter of total vegetative parts of plant (g) of four wheat genotypes

genotype	salinity level (dS / m)				
	3	6	9	12	average
Ahqaf	9.210	6.586	4.109	2.564	5.617
Baftaim	9.627	8.511	7.211	6.742	8.023
Hadharomut	10.118	9.178	7.319	8.919	8.384
Buhooth	9.542	8.929	7.818	7.428	8.429
Average	9.624	8.301	6.614	5.913	

L.S.D. at 0.5%
Genotype = 1.371
Salinity level = 1.105
Genotype × Salinity level = N.S

Table(5): Effect of salinity levels on K concentration (mg / g) in leaves of four wheat genotypes.

genotype	salinity level (dS / m)				
	3	6	9	12	average
Ahqaf	24.66	22.01	16.99	10.17	18.46
Baftaim	22.68	20.81	18.01	15.13	19.16
Hadharomut	23.29	21.42	19.28	17.78	20.44
Buhooth	23.88	22.40	20.69	19.20	21.54
Average	23.63	21.66	18.74	15.57	

L.S.D. at 0.5%
Genotype = 1.02
Salinity level = 0.68
Genotype × Salinity level = 1.39

Table(6): Effect of salinity levels on K concentration (mg / g) of lower leaves of four wheat genotypes

genotype	salinity level (dS/ m)				
	3	6	9	12	average
Ahqaf	15.18	11.01	9.52	8.12	10.96
Baftaim	15.67	13.38	11.74	9.71	12.63
Hadharomut	14.79	13.40	12.98	11.79	13.24
Buhooth	15.56	14.23	15.89	12.23	13.73
Average	15.30	13.01	11.78	10.46	

L.S.D. at 0.5%
Genotype = 1.47
Salinity level =1.29
Genotype × Salinity level = N.S.

The results in Table 7 also indicated a reduction in the K : Na ratio in Ahqaf genotype with increasing the salinity level till it reached 0.32 % 12 dS/m salinity level, whereas a higher ratio were recorded in the other genotypes with good performance of Buhooth genotype which showed a higher ratio of K : Na throughout all levels of salinity. The reduction in of K : Na ratio in Ahqaf genotype was gradual with an increasing the salinity level. This may be due to its ability to mainatain a higher K and lower Na concentration in its upper leaves. Tolerant wheat is distinguished from sensitive one by its low Na concentration, high K concentration and high K : Na ratio. It may be also due to the effect of K on the activity of the enzymes and mechanism of pore behaviour. Moreover, the tolerant variety keeps a high concentration of Na in all leaves and a high concentration of K in the young leaves. This agrees with results announced by Ponnamperuma, (1994) and Mohammed *et al* (1987). This indicates the importance of K: Na mechanism which affects the pores movement, photosynthesis, control of transpiration and activities of some enzymes.

3. Calcium (Ca) and Magnesium (Mg) :

The calcium and Mg in plants increased with increasing the salinity level. due to increasing of their concentrations in the soil solution (Table 1) Competitive activity of these ions at one side and Na at the other side. May occur leading to decrease in Na absorption and thus a reduction in reducing the permeability of plasma membrane for Na. some reports showed these observations (Greenway and Munn 1980 and Cramer *et al* 1993).

It was well noticed in Tables 8 and 9 that there is an increase in the Ca concentration in lower leaves as compared to its concentration in the upper leaves of all genotypes. The increase in the Ca concentration in the upper leaves of Ahqaf genotype was significant compared to other genotypes, as well as a significant effect of the genotypes and the salinity level on the Ca concentration was observed in the upper leaves. The increase in Ca concentration along with increasing on the salinity level was high of Ahqaf genotype, whereas the interaction effect of the two factors was not significant in the lower leaves. In addition to this, increase in the Ca concentration was high in the lower leaves of Buhooth genotype compared to the other genotypes. This may have a negative effect on the salinity tolerance for Ahqaf genotype and vice versa for Buhooth genotype, because of the association of Ca and Na in high ratio in the upper leaves causing damage in plants. Therefore, maintaining a medium ratio of Ca: Na is important for salinity tolerance due to the

Table(7): K : Na ratios in the upper leaves of four wheat genotypes

genotype	salinity level (dS / m)				
	3	6	9	12	average
Ahqaf	1.61	1.31	0.69	0.32	0.98
Baftaim	1.53	1.32	1.01	0.81	1.17
Hadharomut	1.56	1.37	1.13	1.04	1.28
Buhooth	1.60	1.39	1.20	1.13	1.33
Average	1.58	1.35	1.01	0.83	

L.S.D. at 0.5%
Genotype = 0.06
Salinity level = 0.05
Genotype × Salinity level = 0.11

Table(8): Effect of salinity levels on Ca concentration (mg / g) of upper leaves of four wheat genotypes

genotype	salinity level (dS / m)				
	3	6	9	12	average
Ahqaf	18.00	21.5	24.4	31.8	23.93
Baftaim	19.4	18.4	22.5	22.5	20.70
Hadharomut	20.2	19.6	21.0	21.7	20.63
Buhooth	19.8	21.2	20.4	21.6	20.75
Average	19.35	20.18	22.08	24.40	

L.S.D. at 0.5%
Genotype = 2.31
Salinity level 1.98
Genotype × Salinity level = 3.98

Table(9): Effect of salinity level on Ca concentration (mg / g) of lower leaves of four wheat genotypes

genotype	salinity level (dS/ m)				
	3	6	9	12	average
Ahqaf	23.62	28.30	33.90	45.18	32.75
Baftaim	26.71	32.72	40.11	53.11	38.16
Hadharomut	24.83	27.12	42.90	50.84	36.42
Buhooth	23.97	30.64	44.69	56.34	38.91
Average	27.78	29.70	40.40	51.37	

L.S.D. at 0.5%
Genotype = 4.66
Salinity level = 2.82
Genotype × Salinity level = N.S.

relation of these ions to the growth and development of the roots and also to increase the Ca membrane permeability and cell expansion and extension.

Magnesium ions behaved in plants similarly to Ca on (Tables 10 and 11). Its concentration in the upper leaves was less than that in the lower ones in all genotypes. However it significance increased in the lower leaves of Buhooth genotype, but Ahqaf genotype has a significantly content of Mg in the upper and the lower leaves. Its concentration was increased in Ahqaf genotype particularly in the upper leaves with increasing the salinity level. Accumulation of Mg was high with increasing the salinity level in the lower leaves of Buhooth genotype which made this genotype with least damage effects caused by this ion On the contrary, the high accumulation of Mg in the upper leaves of Ahqaf genotype added more qualitative damages to the negative effect of Na and Ca ions.

Conclusion

It may be concluded that the salinity tolerance in Buhooth genotype is related to a mechanism which maintains the Na concentration in the lower plant parts and keeps it away from the active and young parts and conserving high levels of K in these parts as compared to Na, as well as keeping a balance between plant contents of Ca and Mg ions.

Table(10): Effect of salinity levels on Mg concentration (mg /g) in upper leaves of four wheat genotypes

genotype	salinity level (dS/ m)				
	3	6	9	12	average
Ahqaf	13.2	14.5	16.9	19.2	15.95
Baftaim	13.2	13.8	15.1	17.6	14.93
Hadharomut	12.8	13.6	14.2	15.4	14.00
Buhooth	12.5	13.1	14.3	15.1	13.75
Average	12.93	13.75	15.13	16.83	

L.S.D. at 0.5%

Genotype = 0.76

Salinity level = 0.62

Genotype × Salinity level = 1.22

Table(11): Effect of salinity levels on Mg concentration (mg /g) in lower leaves of four wheat genotypes

genotype	salinity level (dS/ m)				
	3	6	9	12	average
Ahqaf	13.70	14.53	17.70	25.11	17.76
Baftaim	15.67	18.87	23.18	21.87	19.90
Hadharomut	15.89	18.72	24.87	26.11	21.40
Buhooth	16.98	21.74	27.44	28.02	23.55
Average	15.56	18.47	23.30	25.28	

L.S.D. at 0.5%
Genotype = 1.26
Salinity level = 1.54
Genotype × Salinity level = 3.08

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تقييم أربعة تراكيب وراثية لمحصول القمح *Tritcum aestivium* L. المزروعة في اليمن من حيث تحملها للملوحة

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يهدف هذا البحث إلى تقييم محتوى نباتات أربعة تراكيب وراثية هي : أحقاف ، بافطيم ، حضرموت و بحوث من القمح (*Tritcum aestivium L.*) المزروعة باليمن مختلفة التحمل للملوحة من عناصر الصوديوم والبوتاسيوم والكالسيوم والمغنيسيوم وعلاقته بآلية التحمل . فقد تمّ زراعة التراكيب الوراثية المذكورة في تربة ذات مستويات ملوحة 3 و 6 و 9 و12 ديسي سيمنز / م في أصص ذات سعة 5 كغم لكل منها . نُفذت التجربة وفقا لتصميم الألواح المنشقة في ثلاثة مكررات . وتم تقدير محتوى النباتات من الصوديوم و البوتاسيوم و الكالسيوم و المغنيسيوم في الأوراق العلوية و السفلية عند مرحلة البطان booting stage . أظهرت النتائج احتواء الأوراق العلوية لنباتات التركيب الوراثي المتحمل للملوحة (بحوث) على أقل تركيز للصوديوم و الكالسيوم و المغنيسيوم و أعلى تركيز لعنصر البوتاسيوم مقارنة بالتراكيب الأخرى . كما احتوى هذا التركيب الوراثي على أعلى نسبة للبوتاسيوم إلى الصوديوم في الأوراق العلوية من النبات . وقد تفوق هذا التركيب الوراثي (بحوث) أيضا في محتواه من عناصر الصوديوم و الكالسيوم و المغنيسيوم والبوتاسيوم في الأوراق السفلية من النباتات. كان محتوى الأوراق السفلية من عنصري الكالسيوم و المغنيسيوم أعلى من الأوراق العلوية في جميع التراكيب الوراثية . أدت زيادة مستويات الملوحة إلى زيادة تركيز عناصر الصوديوم و الكالسيوم و المغنيسيوم في الأوراق العلوية والسفلية في حين أدت إلى خفض تركيز البوتاسيوم الأوراق العلوية و السفلية. كما أدت زيادة الملوحة إلى خفض نسبة البوتاسيوم إلى الصوديوم في الأوراق العلوية للنباتات. من خلال هذه الدراسة يمكن الأستنتاج بأن تحمل نبات القمح للملوحة ذات علاقة بآلية المحافظة على تركيز عنصر الصوديوم في الأوراق السفلية بعيدا عن المناطق الفعالة والغنية في حين المحافظة على نسبة عالية من البوتاسوم في تلك الاجزاء مع المحافظة على توازن تركيز كل من عنصري الكالسيوم و المغنيسيوم في النبات.