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The Role of K in Alleviating Stress Affecting Growth and Some Organic and Mineral Components of Wheat

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ABSTRACT. The effect of NaCl-salinization (150 mM) and KCl addition (5, 10 and 15 mM) on growth and some organic and mineral components of wheat plants (*Triticum aestivum* L. c. Samma) were studied. Salinization with only NaCl induced a considerable reduction in growth, carbohydrates, proteins and the contents of K, Ca and Mg, whereas, the contents of free amino acids including proline were increased. The addition of KCl to the salinized media ameliorated the adverse effects of NaCl. This reduction counteraction was associated with high contents of proteins and K/Na ratios.

Keywords: Nacl-salinity, KCl, *Triticum aestivum,* growth, carbohydrate.

Soil salinization is a major problem of irrigated agriculture in the arid and semi-arid regions. The reduction in growth of many crop plants by salinity may result from salt effects on dry matter allocation, ion relations, water status, physiological processes, biochemical reactions and/or a combination of such factors (Greenway and Munnus, 1980, Epestin 1983). Attempts have been made to employ nutriophysiological methods to overcome the drastic effect of salinity on plant growth (Helal and Mengel 1979 and Gibson 1988). The results obtained were mostly encouraging for conducting studies using wheat plant which has not previously tested in view point of its growth and related parameters as affected by NaCl-salinization and KCl

Materials and Methods

Wheat grains (*Triticum aestivum* L. cv. Samma) were germinated in moist vermiculite until emergence for the primary leaves. At this stage equal number of seedlings were transplanted into 30 cm diameter pots, containing support medium (Vermiculite: perlite, 1:l, v/v). Pots were placed in trays containing nutrient solution (Hoagland and Arnon 1950. The plants were grown on this control solution for 10 days, soon after salinization was started. The pots of each of the tested plants were divided into five groups, with four replicates each. Irrigation was practised every two days for each different group by using 1/2 strength Hoagland solution containing various concentrations of NaCl and KCl (no salt, 150mM NaCl, 145mM NaCl + 5mM KCl, 140mM NaCl + l0mM KCl and 135mM NaCl + 15mM KCl). Moisture was kept constant at 70% of water holding capacity. The pots were transferred to a controlled growth chamber. Temperature was adjusted at 25 ± 2°C day/night was 14-10h, photosynthetic photon-flux density was 60-70 μmoles m^{-2} s^{-1}, and 60-70% relative humidity. All plants used in experiments were subjected to the effect of the chosen salinity level.

Transpiration rate was measured as described by Bozouk (1975). The stomatal frequency was determined using a square occular micrometer. The leaf area was measured by the disk method (Watson and Watson 1953).

Total photosynthetic pigments were determined colorimetrically (Metzner *et al.* 1965). For analysis of proline (Bates *et al.* 1975), carbohydrates (Fales 1951) and free amino acids (Mitchell *et al.* 1976) were used. The microkjeldhal technique was employed to detect the total combined nitrogen and soluble protein was determined according to the method outlined by Lowry *et al.* (1951). Segments taken from the three main organs of the plants were immediately frozen in liquid N_2 lyophilized and weighted.

Shoots (leaves and stems) and roots of the tested plants were harvested separately and weighed. They were then oven dried at 70°C. Concentrations of Na^+, K^+, Ca^{2+} and Mg^{2+} were determined in the dried samples using atomic absorption spectrophotometer (Model G-137).

The data were statistically analyzed to estimate the least significant difference using the method given by Snedecor and Cochrane (1967).

Results and Discussion

Data in Tables (1, 2) indicate that there is a reduction in stomatal frequency, transpiration rate concentration of pigment fractions and dry matter of wheat plants, when NaCl was applied at a rate of 150 mM. These results coincide with those reported by some investigators using various plant species (Zidan 1979 and Eshel 1985). However the application of KCl resulted in monitoring the negative effect of NaCl salinization on these parameters. Similar findings were obtained when other plant species has been tested (Muhammed *et al.* 1987 and Shaddad 1990). In this concern Jeschke (1984) demonstrated that in some plant genera including Atriplex, potassium may play a substantial role in cell maintenance of shoot and root meristems of salinized tissues.

Regarding the effect of NaCl salinization on carbohydrates and proteins (Tables 2 and 3), it may be concluded that addition of NaCl caused a consistent decrease in their content. Such decrease was associated with concomitant increase in the content of free amino acids including proteins (Table 4). This phenomenon may be interpreted as NaCl – salinity stimulated the conversion of carbohydrates into amino acids (Shadded 1990). Nevertheless, some workers postulated that NaCl salinity may slow down the rate of incorporation of free amino acids into protein chain (Helal and Mengel, 1979 and Devitt *et al.* 1987).

Concerning the relationship between soluble nitrogen and free amino acids it may be concluded that K treated plants recorded higher soluble nitrogen content and in the same time exhibited significant decrease in their content and , in the same time, exhibited significant decrease in their content of free amino acids (Tables 3 and 4). Such behavior may ascertain the role of potassium in protein synthesis. In this regard Mitchell *et al.* (1976) stressed the role of potassium in the proper utilization of amino acids for protein synthesis. Munnus *et al.* (1979) reported that protein synthesis may play an important role in increasing the osmotic pressure of cytoplasm and consequently enhance salt tolerance of plant. In accordance with this point of view, Conay and Lipman (1964) reported that there was biochemical evidence that the changes in the balance between K and Na in the tissues may affect nucleic acid synthesis. Thakur and Rai (1982) showed that drought resistant maize cultivars exposed to osmotic stress, accumulated more protein than in susceptible ones.

The values of some mineral composition in wheat plants as affected by NaCl salinity and K supply are given in Table 5. It is obvious that application of NaCl alone reduced the contents of K. Mg and Ca in both shoots and roots, however, it increased the content of Na considerably. As a result of such adverse effect the internal ratios of both K/Na and Ca/Na were lowered. These ratios are known to be critical for several metabolic functions in plant (Greenway and Munnus 1983, Wyn Jones and Lunt 1967).

The addition of potassium increased its content in the plant parts. This increase was in proportion to the rate of K-application (Table 5). It is worthy to mention that the addition of potassium affected the levels of the other cations. Consequently it may be concluded that it caused a slight increase in K/Na and Ca/Na ratio and this may have an impact on the salt tolerance in plant. In this respect Kingsbury *et al.* (1984) reported that in some cereals, there are inter cultivar differences in ion translocation and accumulation.

Munnus *et al.* (1979) in their study on wheat plant observed that the appropriate intracellular regulation of distribution contributes to the salt tolerance of some cultivars.

Table 1. Effect of NaCl salinity and K-supply on transpiration (g dm^2 day^{-1}), stomatal frequency (number of stomata mm^{-2}) and dry matter (g $plant^{-1}$) of wheat plants.

NaCl + KCl (mM)	Transpiration	Stomatal frenquency		Dry matter
		Lower epidermis	Upper epidermis	
0 + 0	3.21	136	47	1.52
150 + 0	1.85*	113*	42*	1.05*
145 + 5	3.11	138	48	1.41
140 + 10	3.65	148*	53*	1.45
135 + 15	3	145*	54*	1.48
L.S.D. at 1%	0.52	7.3	3.22	0.23

Table 2. Effect of NaCl-salinity and K-supply on pigment contents (mg g^{-1} leaf dry matter) and carbohydrate contents (mg g^{-1} dry matter) of wheat plants

NaCl + KCl (mM)	Pigment content			Carbohydrate content		
	1	2	3	Leaves	Stems.	Root
0 + 0	5.22	1.59	2.05	215	205	220
150 + 0	3.21*	1.12*	1.75*	185*	185*	197*
145 + 5	4.00	1.31*	2.10	197*	192*	202*
140 + 10	5.25*	1.25*	2.00	219	210	215
135 + 15	5.20*	1.31*	2.13	214	213	212
L.S.D at 1%	1.2	0.21	0.28	15	12	17

* Significant differences as compared with control plants.
1) Chlorophyll a
2) Chlorophyll b
3) Caroteins

Table 3. Effect of NaCl-salinity and K-supply on nitrogen content (mg g^{-1} dry matter) of the main organs of wheat plants

Nitrogen / NaCl+KCl (mM)	Leaves		Stems		Roots	
	Sol.	Insol.	Sol.	Insol.	So.	Insol.
0 + 0	6.21	16.22	5.33	17.11	5.85	14.15
150 + 0	4.35*	13.54*	4.37*	14.80*	3.71*	12.21
145 + 5	5.93	15.91	5.83	15.95	6.01	13.31
140 + 10	6.33	16.68	6.62*	18.22	6.22	14.2
135 + 15	7.25	16.34	6.50*	18.78	7.85	15.68
L.S.D. at 1%	1.15	2.15	1.00	2.15	1.31	2.01

Table 4. Effect of NaCl-salinity and K-supply on total free amino acids and proline content (mg g^{-1} dry matter) of the main organs of wheat plants

NaCl + KCl (mM)	Total free amino acids			Proline		
	Leaves	Stems	Roots	Leaves	Stems	Roots
0 + 0	3.95	4.05	4.21	0.53	0.37	0.4
150 + 0	5.49*	6.12*	6.23*	0.98*	0.68*	0.62*
145 + 5	4.21	4.59	5.22	0.78*	0.52	0.53
140 + 10	4.01	4.22	5.03	0.63	0.44	0.44
135 + 15	3.65	4.08	4.22	0.6	0.35	0.45
L.S.D. at 1%	1.31	1.11	1.48	0.25	0.2	0.19

* Significant differences as compared with control plants.

Table 5. Effect of NaCl-salinity and K-supply on some mineral composition (mg g^{-1} dry matter) in shoots and roots of wheat plants

NaCl + KCl	Na	K	Ca	Mg	K/Na	Ca/Na
Shoots						
0 + 0	4.64	32.11	29.45	15.72	6.92	6.34
150 + 0	30.21*	23.12*	15.21*	12.45*	0.77*	0.5*
145 + 5	25.11*	25.05*	15.51*	11.81*	1.00	0.62
140 + 10	23.24*	29.15	13.11*	10.33*	1.25	0.56
135 + 15	21.34*	32.21	13.18*	10.28*	1.51	0.62
L.S.D. at 1%	4.93	4.78	3.22	2.88		
Roots						
0 + 0	5.11	30.13	24.22	15.6	5.89	4.74
150 + 0	33.51*	24.05*	17.81	13.33	0.72	0.53
145 + 5	29.21*	26.15*	17.51*	13.23	0.96	0.59
140 + 10	24.33*	32.17	16.32	12.89*	1.32	0.67
135 + 15	20.43*	33.25	16.01*	12.05*	1.73	0.78
L.S.D. at 1%	5.11	3.82	2.71	2.43	-	-

* Significant differences as compared with control plants.

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ازالة الضرر المترتب على نمو نبات القمح تحت ظروف ملحية غير ملائمة باستخدام البوتاسيوم

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يهدف هذا البحث الى التعرف على التغيرات الحياتية لنبات القمح عند معاملته بالملوحة (١٥٠ مليمول من كلوريد الصوديوم) وما يطرأ على هذه التغيرات الحياتية بعد إضافة مستويات مختلفة من البوتاسيوم (٥، ١٠، ١٥، مليمول من كلوريد البوتاسيوم) إضافة إلى ما يمكن أن يعكسه البحث من جوانب تطبيقية.

وقد أسفر البحث عن نتائج يمكن إيجازها فيما يلي:

١ - أحدثت الملوحة انخفاضاً واضحاً في كل من معدل النتح وعدد الثغور ومحتوى اصباغ البناء الضوئي لأوراق نبات القمح والوزن الجاف، هذا وقد أدت المعاملة بالبوتاسيوم إلى زيادة واضحة في تلك الدالات لنبات القمح.

٢ - انخفضت كميات السكريات والبروتين في كل من الأعضاء الرئيسية الثلاثة لنبات القمح باستخدام الملوحة، وأدّت معاملة النبات بالبوتاسيوم بأي من التراكيز الثلاثة من البوتاسيوم إلى زيادة واضحة في كميات السكريات والبروتين بالمقارنة بالنباتات المعاملة بالملوحة فقط.

٣ - ادت الملوحة إلى زيادة واضحة في كمية الأحماض الأمينية بما فيها البرولين (منظم الاسموزيه في الخلية في كل من الأوراق والسوق والجذور لنبات القمح،

إلا أنه بعد معاملته بأي من التراكيز الثلاثة المستخدمة من البوتاسيوم انخفضت كميات الأحماض الأمينية والبرولين في كل من أعضاء النبات الثلاثة.

٤ - أدت الملوحة إلى تغيرات واضحة في التركيب المعدني لكل من المجموع الخضري والجذري لنبات القمح، حيث زادت كمية الصوديوم وحدث نقص واضح في كميات البوتاسيوم والكالسيوم والماغنسيوم، إلا أنه بعد معاملة النبات بالمستويات المختلفة من البوتاسيوم حدث نقص في كمية الصوديوم وزيادة في كمية البوتاسيوم والكالسيوم والماغنسيوم