

Hormones-induced modifications in the response of wheat flag leaf to NaCl

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Abstract

A field experiment was carried out to investigate the effects of presoaking the wheat grains (*Triticum aestivum* L.) in 33 or 66 mM NaCl and indolyl-3-acetic acid (IAA at 50 g m⁻³), gibberellic acid (GA₃ at 100 g m⁻³) or kinetin (100 g m⁻³) on some tolerance criteria in wheat flag leaf at different stages of development. At various stages of flag leaf development pretreatment with 33 or 66 mM NaCl decreased degree of succulence (particularly 66 mM), relative growth rate, net assimilation rate, relative water content, K⁺ content and K⁺/Na⁺ ratio and at the same time induced accumulation of abscisic acid and Na⁺. In the majority of cases grain pretreatment with GA₃ or kinetin and to a lesser extent with IAA alleviated either partially or completely the deleterious effect of salinity on the above mentioned parameters.

Key words: gibberellic acid, indolyl-3-acetic acid, kinetin, *Triticum aestivum*.

Introduction

Salinity is an increasing problem not only in maritime salt marshes but also on irrigated soils. Increasing salinity frequently induces succulence in dicotyledonous halophytes (Flower *et al.* 1977) and this was found also for *Atriplex hortensis* by Handly and Jennings (1977) and not by Jeschke and Stelter (1983).

Salt reduced leaf expansion and carbon gain in *Sorghum bicolor* (Richardson and McCree 1985) and water content in some grasses (Glenn 1987). Growth changes in salinized plant appear to be associated with high electrolyte levels contributing to toxicity and/or osmotic adjustment and turgor maintenance (Morgan 1984).

Certain trials have been made to improve salt tolerance using CCC, GA₃, kinetin or IAA. The present work was undertaken to find out to what extent the application of hormones induces modification in some tolerance criteria in flag leaves of NaCl-treated wheat plants.

Received 29 September 1994, accepted 12 April 1995.

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Materials and methods

A homogenous lot of wheat (*Triticum aestivum* L. cv. Giza 157) grains was selected. The grains were surface sterilized by soaking in 0.001 M HgCl₂ solution for 3 min, washed thoroughly with distilled water and then soaked in the solution with different combination of NaCl and growth regulators (Table 1).

Table 1. Combination of NaCl and growth regulators in different treatments.

	Treatment											
	1	2	3	4	5	6	7	8	9	10	11	12
NaCl [mM]	0	33	66	0	33	66	0	33	66	0	33	66
IAA [mg dm ⁻³]	0	0	0	50	50	50	0	0	0	0	0	0
GA ₃ [mg dm ⁻³]	0	0	0	0	0	0	100	100	100	0	0	0
kinetin [mg dm ⁻³]	0	0	0	0	0	0	0	0	0	100	100	100

Each group was separately soaked in the appropriate solution for an hour at room temperature in dark. After soaking all the grains were thoroughly washed with water and then sown in ordinary clay soil on 30 November 1990 in Mansoura district, Egypt. The grains were drilled in singles in rows 15 cm apart using the Afir method of planting. At the bud stage, the crop received 10 g(N) m⁻² [100 kg(N) ha⁻¹] as ammonium nitrate (33.5 % N₂).

Samples of four guarded flag leaves were taken after 90, 97, 102, and 117 d from planting.

Degree of succulence [mg(H₂O) cm⁻²] estimated according to Flowers *et al.* (1977), relative growth rate (RGR) according to Blackman (1951):

$$\text{RGR} = \frac{\lg M_2 - \lg M_1}{t_2 - t_1}$$

where lg M₂, lg M₁ refer to natural logarithm for dry mass of second and first sample. Net assimilation rate (NAR) was determined as recommended by Gregory (1926):

$$\text{NAR} = \frac{(M_2 - M_1)(\lg A_2 - \lg A_1)}{(A_2 - A_1)(t_2 - t_1)}$$

where M₁, M₂, A₁ and A₂ refer to dry mass and leaf area at t₁ and t₂, respectively.

The method of extraction of abscisic acid (ABA) was that originally described by Shindy and Smith (1975). For determination of abscisic acid in extracts, wheat coleoptile bio-assay was used (Wright 1969).

The relative water content (RWC) of flag leaves was determined according to Weatherley (1950).

For estimation of elements, a known amount of dry mass was digested in concentrated HNO₃ and made up to volume with distilled water. K⁺ and Na⁺

concentrations were measured by flame emission spectrophotometry (Younis *et al.* 1994).

The results were subjected to an analysis of variance (ANOVA). When the effect was significant ($P \leq 0.05$), the least significant difference was used to compare the treatments.

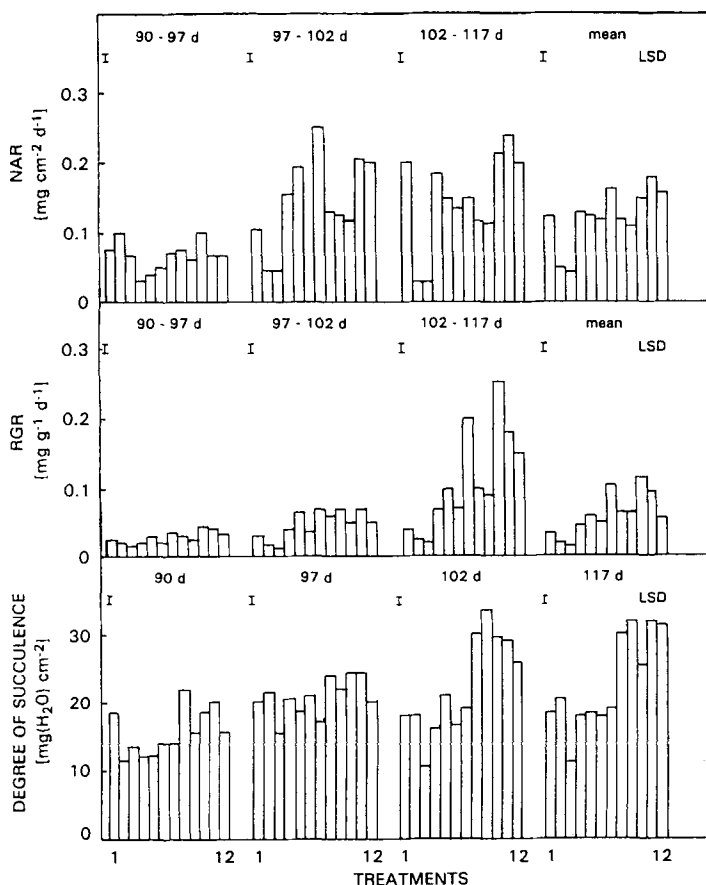


Fig. 1. The effect of grain presoaking in NaCl combined with IAA, GA₃ or kinetin on the degree of succulence, relative growth rate and net assimilation rate of *Triticum aestivum* flag leaf at different stages of development. For the treatments of 1 to 12 see Table 1.

Results and discussion

The lower level of salinity (33 mM NaCl) increased the succulence of flag leaf in 97, 102- and 117-d-old seedlings. On the other hand, the higher level of salinity (66 mM NaCl) decreased significantly the succulence of flag leaf (Fig 1.). Similarly, Jeschke and Stelter (1983) found that salinity increased succulence of *Atriplex hortensis* consistently with leaf age. Flag leaf succulence of the NaCl-treated plant was

stimulated by GA₃ or kinetin treatments. These effects may be attributed to the fact that GA₃ or kinetin increased the fresh matter of flag leaf and at the same time induced insignificant increase in flag leaf area of NaCl-treated wheat plants (Aldesuquy 1992).

Relative growth rate and net assimilation rate of wheat flag leaf increased with the increase of plant age (Fig. 1). These results were in good conformity with those obtained by Abd El-Gawad *et al.* (1985). 33 or 66 mM NaCl led to decrease in relative growth rate and net assimilation rate of flag leaf (Fig 1.).

In the majority of cases RGR of NaCl-treated plants was maintained when the grains were presoaked in GA₃ or kinetin and to a lesser extent with IAA. Kinetin also increased the net assimilation rate of NaCl-treated plants. These effects were mainly due to the fact that the presoaking in these hormones increased the dry matter of NaCl-treated plants (Aldesuquy 1992).

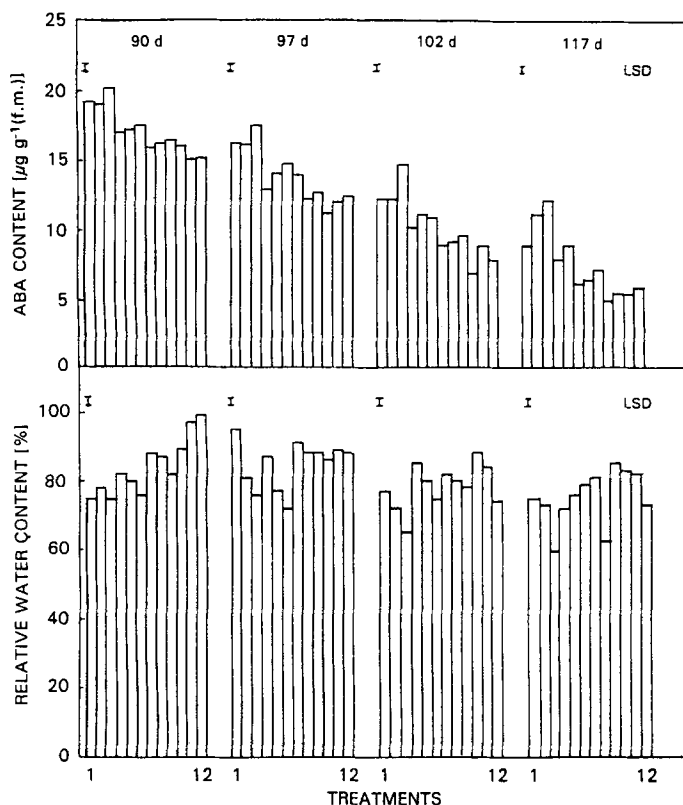


Fig. 2. The effect of grain presoaking in NaCl combined with IAA, GA₃ or kinetin on abscisic acid and relative water contents of *Triticum aestivum* flag leaf at different stages of development. For the treatments of 1 to 12 see Table 1.

33 or 66 mM NaCl induced marked reduction in relative water content except on the day 90 from sowing. Presoaking of grains in GA₃, kinetin and to a lesser extent in

IAA induced increase in relative water content of NaCl-treated plants if compared with those treated with NaCl only (Fig. 2).

66 mM NaCl caused an increase ($P < 0.01$) in abscisic acid content while 33 mM NaCl caused non-significant increase in ABA level (Fig. 2). The elevation of ABA probably be due to *de novo* synthesis of ABA within flag leaf. These results are in accord with the results reported by Itai and Vaadia (1971), Davenport *et al.* (1980), Zeevaart (1983) and Abo-Hamed *et al.* (1990). Grain pretreatment with IAA, GA₃ or kinetin induced marked reduction ($P < 0.01$) in ABA content in flag leaf of NaCl-treated plants. IAA, GA₃ or kinetin may interfere with abscisic acid accumulation within flag leaf. Kinetin appeared to be the most effective hormone in this target. These results were in good agreement with those obtained by Norman *et al.* (1983) who found that cytokinins including BA inhibit ABA synthesis and suggested that BA might inhibit stress-induced ABA accumulation.

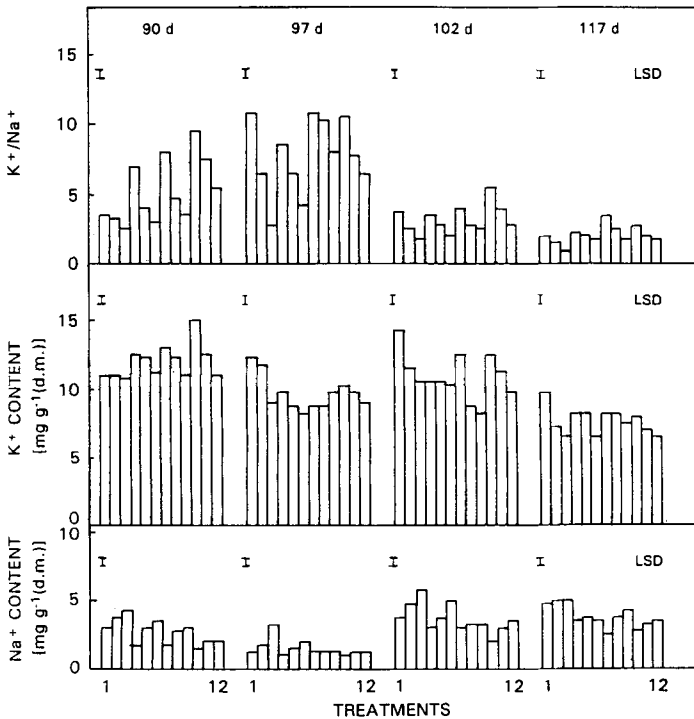


Fig. 3. The effect of grain presoaking in NaCl combined with IAA, GA₃ or kinetin on the sodium content, potassium, and sodium potassium ratio of *Triticum aestivum* flag leaf at different stages of development. For the treatments of 1 to 12 see Table 1.

At each developmental stage, the two salinity levels induced accumulation of Na⁺ that was associated with decreases in K⁺ and K⁺/Na⁺ level in wheat flag leaf (Fig. 3), similarly as was demonstrated by Imamul-Huq and Larher (1983), Hasaneen *et al.* (1989), Abo-Hamed *et al.* (1990). Grain presoaking in IAA, GA₃ or kinetin induced accumulation of K⁺ in flag leaf (except at 97 d from sowing) with concomitant

restriction of Na^+ and consequently increased K^+/Na^+ ratio (Fig. 3). These changes appear to be important contributing factors in the increased salt tolerance caused by hormonal pretreatment. In support of this conclusion, El-Deep (1984) found that presoaking of maize, safflower and pea seeds in GA_3 or IAA reduced the accumulation of Na^+ in shoot and roots of the salinized plants.

References

- Abd El-Gawad, A.A., Abo-Sheatia, A.M., Edris, A.S.: Potential productivity of wheat in Egypt. II. Growth analysis studies of certain wheat cultivar. - Ann. agr. Sci. Fac. Agr. Ain Shams Univ. (Cairo) **30**: 835-848, 1985.
- Abo-Hamed, S.A., Younis, M.E., El-Shahaby, O.A., Haroun, S.A.: Plant growth metabolism and adaptation in relation to stress conditions. IX Endogenous levels of hormones, minerals and organic solutes in *Pisum sativum* plants as affected by salinity. - Phyton **30**: 187-199, 1990.
- Aldesuquy, H.S.: Growth and pigment content of wheat as influenced by the combined effects of salinity and growth regulators. - Biol. Plant. **34**: 275-283, 1992.
- Blackman, G.E.: Physiological and ecological studies in the analysis of plant environment. - Ann. Bot. **15**: 373-408, 1951.
- Davenport, T.L., Morgan, P.W., Jordan, W.R.: Reduction of auxin transport capacity with age and internal water deficit in cotton petioles. - Plant Physiol. **65**: 1023-1025, 1980.
- El-Deep, B.A.: The effect of plant hormones and salinity on some physiological activities of some plants. - M Sc. Thesis. Assiut University, Assiut, Egypt, 1984.
- Flowers, T.J., Troke, P.F., Yeo, A.R.: The mechanism of salt tolerance in halophytes. - Annu. Rev. Plant Physiol. **28**: 89-121, 1977.
- Glenn, E.P.: Relationship between action accumulation and water content of salt-tolerant grasses and a sedge. - Plant Cell Environ. **10**: 205-212, 1987.
- Gregory, F.G.: The effect of climatic conditions on the growth of barley. - Ann. Bot. **40**: 1-26, 1926.
- Handley, J.F., Jennings, D.H.: The effect of ions on leaf succulence of *Atriplex hortensis* var. *cupreata*. - Ann. Bot. **41**: 1109-1112, 1977.
- Hasaneenen, M.N.A., Younis, M.E., El-Saht, H.M.: Plant growth, metabolism and adaptation in relation to stress conditions. VI. Differential effects of sodium sulphate on growth and element of *Phaseolus vulgaris* and *Zea mays*. - Qatar Univ. Sci. Bull. **9**: 113-123, 1989.
- Imamul-Huq, S.M., Larher, F.: Osmoregulation in higher plants. Effect of NaCl salinity on non-nodulated *Phaseolus aureus* L. I. Growth and mineral content. - New Phytol. **93**: 203-206, 1983.
- Itai, C., Vaadia, Y.: Cytokinin activity in water stressed shoots. - Plant Physiol. **47**: 87-90, 1971.
- Jeschke, W.D., Stelter, W.: Ionic relation of Garden Orache, *Atriplex hortensis* L.: Growth and ion distribution at moderate salinity and the function of bladder hairs. - J. exp. Bot. **34**: 795-810, 1983.
- Morgan, J.M.: Osmoregulation and water stress in higher plants. - Annu. Rev. Plant Physiol. **35**: 299-319, 1984.
- Norman, S.M., Bennet, R.D., Maier, V.P., Poling, S.M.: Cytokinins inhibit abscisic acid biosynthesis in *Cercospora rosicola*. - Plant Sci. Lett. **28**: 255-263, 1983.
- Richardson, S.G., McCree, K.J.: Carbon balance and water relations of sorghum exposed to salt and water stress. - Plant Physiol. **79**: 1015-1020, 1985.
- Shindy, W.W., Smith, O.: Identification of plant hormones from cotton ovules. - Plant Physiol. **55**: 550-554, 1975.
- Weatherley, P.E.: Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. - New Phytol. **49**: 81-97, 1950.

- Wright, S.T.C.: An increase in the "inhibitor B" content of detached wheat leaves following a period of wilting. - *Planta* **86**: 10-20, 1969.
- Younis, M.E., Abbas, M.A., Shukry, W.M.: Salinity and hormone interactions in affecting growth, transpiration and ionic relations of *Phaseolus vulgaris*. - *Biol. Plant.* **36**: 83-89, 1994.
- Zeevaart, J.A.D.: Metabolism of ABA and its regulation in *Xanthium* leaves during and after water stress. - *Plant Physiol.* **71**: 477-481, 1983.