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Short Communication

Enhancing salt tolerance in adult tomato plants by drought pretreatment applied at the seedling stage

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Abstract: In this study seedling of tomato plants, grown in seedling trays, were subjected to drought (at the 5th leaf stage) for the maximum period that permitted subsequent recovery of at least 90% of the pre-treated plants. Pre-treated and non pre-treated seedlings were transplanted in field plots (36 m^2). After well establishment of transplants, they were either irrigated with non-saline water (0.55 dSm^{-1}) or saline water (4.5 dSm^{-1}) Drought pre-treatment reduced reduction percentage of growth parameters and yield of tomatoes, as influenced by irrigation with saline water, than those of un pre-treated. However, differences between values of such parameters in both drought treated or non-treated plants were not significant except with plant dry weight. It could be suggested that such interesting strategy need further studies in order to maximize the efficiency of this technique in increasing salt tolerance in crops.

Key words: Salt tolerance, tomato growth, and yield, drought pre-treatment

زيادة المقاومة للملوحة في النباتات البالغة عن طريق المعاملة بالجفاف فى مرحلة البادرات

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الملخص: عرضت بادرات الطماطم (في مرحلة الورقة الحقيقية الخامسة) والنامية فى صوانى إنتاج الشتلات الى تأخيرالرى لأطول فترة ممكنة بحيث تسمح بعدها بإستشفاء 90% على الأقل من البادرات التى عوملت. شتلت البادرات التي عوملت بالجفاف وكذلك التى لم تعامل الى الحقل في وحدات تجريبية مساحتها 36 م². أوضحت النتائج أن صفات النمو و المحصول في النباتات التي سبق معاملاتها بالجفاف تأثرت بدرجة أقل (كانت ا لنسب المئوية للنقص أقل)، كنتيجة لريها بالمياه المالحة، عن تلك التى لم تعامل بالجفاف.إلا أن الفروق في صفات النمو(بإستثناء الوزن الجاف للنبات) والمحصول للنباتات المعاملة والغير معاملة لم تكن معنوية. ولذلك يمكن إقتراح أن هذا التكنيك الشيق يحتاج الى مزيد من الدراسات من أجل زيادة كفاءة في رفع مقاومة المحاصيل للملوحة.

الكلمات المفتاحية: مقاومة الجفاف، نمو الطماطم، الانتاج، معاملة بالجفاف.

Introduction

Salinity is a common consequence of irrigation in many parts of the world, especially in arid and semi-arid regions (particularly in some areas in Africa and in Western Asia) where rainfall is insufficient to leach salts from root zone. Salinity of soil or of irrigation water is a significant factor in reducing crop productivity. Great effort has been devoted to overcome the deleterious effects of salinity on plants. Some cultural techniques such as treatment of seedlings with drought or other stress conditions ameliorates the adaptation of adult plants to salinity. As plants exposed to a stress often show tolerance to other stresses "cross-tolerance" (Takahashi et al., 1994, Ryu et al., 1995 and Sabehat et al., 1998). In the case of cross-tolerance, it has been suggested that specific proteins are induced by one kind of stress and are involved in the protection against other kinds of stress (Pareek et al., 1995 and Sabehat et al., 1998). Gozalez-Fernandez (1996) observed that tomato plants, which had previously been subjected to a drought stress pretreatment, were able to grow better than non-pretreated plants after 21 d of salt treatment. Recently, it has been observed that adaptation of pretreated plants was maintained throughout the growth cycle (Cuartero et al., 2006 and Cayuela et al., 2007). Also the time of adaptation induction (pretreatment) was only possible during specific times (Amzallag et al., 1993) as pretreatment at particular growth stages increase the capacity of plants to adapt to salinity (Cuartero et al., 2006).

The objective of this study is to test the efficiency of stress treatments, such as drought, applied at early growth stages in enhancing salt tolerance of adult plants and this may be an interesting strategy for increasing salt tolerance in crops.

Materials and Methods

Seeds of tomato (Lycopersicon esculentum Mill. cv. Floradade) were planted on the 11th of January in the 2001 season, individually in seedling trays (48 holes) in a plastic house. The growing media was consisted of peat moss and vermcolite (1:1) beside fertilizers. Cultural practices such as irrigation and foliar fertilization were applied uniformly and at the same time for all seedlings. Half of the seedlings were subjected to drought (by withholding irrigation water) at the 5th leaf stage for the maximum period that permitted subsequent recovery of at least 90 % of the pre-treated plants (Cuartero et al., 2006 and personal communication with Professor Cuarteto). While the other half was not subjected to such treatment. After recovery of seedlings they were transplanted on the 10th of March to field plots in the Agricultural Experimental Station of the Faculty of Agriculture of Menufiya University in Shibin El-Kom, Egypt. The soil at the experimental site was clay loam.

The plots consisting of five rows 6 m long and 1.2 m wide transplants were set at 30 cm apart. Each plot area was 36 m^2 and the distance between any two adjacent plots was not less than 1.5 m. Cultural practices such as pest control, harrowing and fertilization were carried out when needed following the recommendations of the Ministry of Agriculture in Egypt.

Once the plants became well established, drought-treated and non-treated plants were irrigated either by fresh water (non saline i.e., 0.55 dSm^1) or saline water (4.5 dSm^{-1}). Irrigation was applied by furrow system, as water was delivered to furrows in the plots by tubes (PVC, 16 mm internal diameter). The irrigation water came from large storage tanks. One was filled with saline water (4.5 dSm^{-1}), and the second with non saline water i.e., 'fresh' water (0.55 dSm^{-1}). The fresh water used originated from a well (about 90 m deep and similar to that of water from the river Nile in the area), while the saline water was that fresh water with sodium chloride added to raise the EC to the required value. Irrigation occurred when the available soil moisture (ASM) reached 70 ± 3 % and sufficient water was added to return the soil moisture to field capacity.

A complete block design with 3 replicates was used. The experimental design was carried out according to the method described by Snedecor (1956).

The data were subjected to the proper analysis of variance and the significance of differences between treatments was determined by least significant difference (Steel and Torrie 1981).A plant sample was taken at 82 days after transplanting, with which to assess plant growth and dry matter. Each sample consisted of three plants picked from outer rows of each plot (leaving the 3 inner rows for yield determination).Yield and fruit characteristics were also determined.

Results and Discussion

It is clear from Table 1 that irrigation with saline water significantly reduced plant growth parameters and yield of tomato plants, either subjected to drought pre-treatment or not. However, plants drought pre-treated showed less reduction percentage in all growth parameters studied as well as fruit yield than of those un-pretreated when all irrigated with saline water, but differences were significant only in plant dry weight. Our results were in accordance with those obtained by Cayuela et al., (2007) who found that tomato plant dry weight (after 50 days of salt treatments) and fruit yield, (at the end of the harvest period i.e., 150 d of salt treatments) were significantly higher in drought-pretreated than in non-pretreated plants. They also added that drought pretreatment of seedlings increases the long-term salinity resistance of tomato.

The obtained results suggest that drought pre-treatment at seedling stage could enhance salt tolerance of adult plants, but further studies may be required to raise the efficiency of such pre-treatment in inducing salt tolerance in plants. Sort of stress condition, proper stage of pre-treatment, size of container and growing media may required further attention. Also, stress level necessary to trigger the adaptive response is related to the tolerance degree of genotype (Cayuela et al., 2001).

The physiological responses of pre-treatment stress conditions concerning ionic, nutritional, and osmotic regulation may responsible for enhancing salt tolerance in plants (Balibrea et al., 1999). To further elucidate, plants express a number of genes in response to water deficit. Adaptation to water deficit brings about changes in the metabolic processes and perhaps in the structure of the cell that allows the cells to continue metabolism at low water potential (Ingram and Bartels, 1996). Dehydration and other stresses cause: elevation in the cytosolic free calcium ion (Ca^{+2}) concentration (Knight et al., 1991); accumulation of abscisic acid (ABA) in plant organs (Lee et al., 1993 and Moons et al., 1995) co-ordinate osmotic regulation (Yamaguchi-Shinozaki and Shinozaki, 2005) responsible for cellular Na^+ efflux (Zhu, 2003) and controls Na^+ loading into the xylem of the root thereby restricting accumulation of the toxic ion in the shoot (Shi et al., 2002). The long-term response to adaptation, may suggests that plants are able to discriminate different stimuli and then store the impression of individual stimuli in a unique way.

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Table 1. Effect of pre-treatment and un pre-treatment of drought stress on some plant growth characters, (measured at 82 days after transplanting) and yield components of tomato irrigated later either by fresh water (FW) or saline water (SW). The data in parentheses are the values relative to the un- pretreatment irrigated with fresh water.

Characters Treatments*	Plant height cm	Total DW/ plant g.	Leaf area /plant m^2	Yield / plant kg	Fruit No/plant	Average fruit weight g	Dry matter content in fruits %
Unpre-treat.+FW	84 (100)	283.8(100)	1.389(100)	2.79(100)	23.6(100)	118.1(100)	5.50(100)
Unpre-treat.+SW	76 (91)	233.9(82)	1.138(82)	1.88 (68)	19.3 (82)	97.5 (83)	5.79(105)
Pre-treat. + FW	85 (101)	288.2(101)	1.388(100)	2.81(101)	23.7(100)	118.6(100)	5.52(100)
Pre-treat. + SW	79 (94)	255.0(90)	1.22 (88)	2.10 (75)	20.5 (87)	102.4 (85)	5.79(105)
L.S.D $_{at\ 0.05}$	4.5	20.8	0.11	0.54	2.4	6.3	0.3

*Unpre-treat. = Un pretreatment , Pre-treat = Pre treatment, Fw = Fresh or non saline water (0.55 dS/m), SW = Saline water (4.5 dS/m).

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