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Effect of NaCl on the Growth of Tomato Plants (C. V. Carpy) and their Micropropagated Shoots

دراسة تأثير كلوريد الصوديوم على نمو نبات الطماطم من صنف كربي والقمم المريستيميه له

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Abstract: Tomato plants and shoot tips from *Lycopersicon esculentum* (C. V. Carpy), which is a moderately salt-tolerant plant, were grown on Hoagland's solution and MS (Murashige and Skoog, 1962) media respectively, containing various concentrations of NaCl. It was found that the shoot tips behaved in a similar fashion to the whole plant under salinity. A moderate level of salinity did not affect the growth of tomato plants and shoot tips. However, a high level of NaCl in the culture medium had a damaging effect. Plants and shoot tips accumulated Na^+ and Cl^- and less K^+.
Keywords: Tomato plants, shoot tips, *Lycopersicon esculentum,* C. V. Carpy, NaCl.

المستخلص: وجد أن القمم المريستيمية لنبات الطماطم، التي أخذت من بادرات طماطم معقمة من صنف كاربي المتوسط المقاوم للحرارة، والتي تم زراعتها على وسط غذائي مناسب يحتوي على تركيزات مختلفة من كلوريد الصوديوم، قد أعطت ظواهر مشابهة لتلك التي تحدث في النباتات الكاملة تحت ظروف الملوحة. وجد أيضاً أن التركيزات المتوسطة من الملوحة لم تؤثر في نمو نبات الطماطم، وكذلك قممه النامية، بينما وجد أن التركيزات العالية من كلوريد الصوديوم، في الوسط الغذائي قد أدت إلى تأثير ضار. لوحظ أن نباتات الطماطم وقممها المريستيميه قد إزداد تركيز الصوديوم والكلور بها بينما قل البوتاسيوم.
كلمات مدخلية: نبات الطماطم، قمم مريستسمية، صنف كاربي، كلوريد الصوديوم.

Introduction

The tolerance of plants to high salinity is usually studied in whole plants or isolated organs. Very little has been done with isolated tissues or cells. The study of the reaction of isolated tissues or cells to salt may answer the question as to the organizational level in which the control of salt tolerance is operating, (Tal, *et al.* 1978). Salinity is a very significant problem affecting one-third of the irrigated land on earth (Maas and Hoffman, 1977). Most crop plants are sensitive to moderate levels of salinity (Epstein, 1977). Since irrigation water tends to add salts to land, the scale of the problem is continually increasing. Most of the salt stresses in nature are due to sodium salts, particularly NaCl (Chapman, 1975).

Ashraf, *et al.* (1986) found that selected NaC1tolerant lines of Trifolium produced significantly greater dry matter than unselected control lines. Tolerant lines generally contained less Na^+ but more Cl^- in their shoots than normal lines. Tolerant lines also contained less K^+ in their shoots than unselected lines. The tolerant lines had significantly higher Ca^+ 2 in the shoot than the unselected line. Duke, *et al.* (1986) found that in plants, shoot and root dry weight production decreased with increasing levels of salt. Salim and Pitman (1983) assumed that growth reduction in plants grown in KCl solutions seemed to be related to higher K^+, Na^+ and Cl^- contents of the shoots due to higher rates of net transport from roots to shoots.

Venable and Wilkins (1978) found that the expected reduction in root growth through the toxic action of NaC1 was only shown in a simple form by the least tolerant plants. In most of the species, growth was stimulated at moderate salt concentrations and toxicity was only evident at the higher levels. El-Keltawi and Croteau (1987) found that 0.5 M NaC1 reduced overall growth and essential oil yields in *Mentha spicata*. Sinel'nikova, *et al.* (1986) found that salt-tolerant plants showed less marked changes in growth rate than susceptible ones under saline conditions, less marked changes in the chlorophyll protein/lipid complex in the leaves and an increase in beta-carotene content, unlike susceptible ones, which showed an increase in neoxanthine.

This paper is concerned with the effect of NaC1 on the relative growth rate and the net rate of Na^+, K^+ and $C1^-$ transport through the shoot of tomato plants as well as the cultured shoot tips.

Materials and Methods

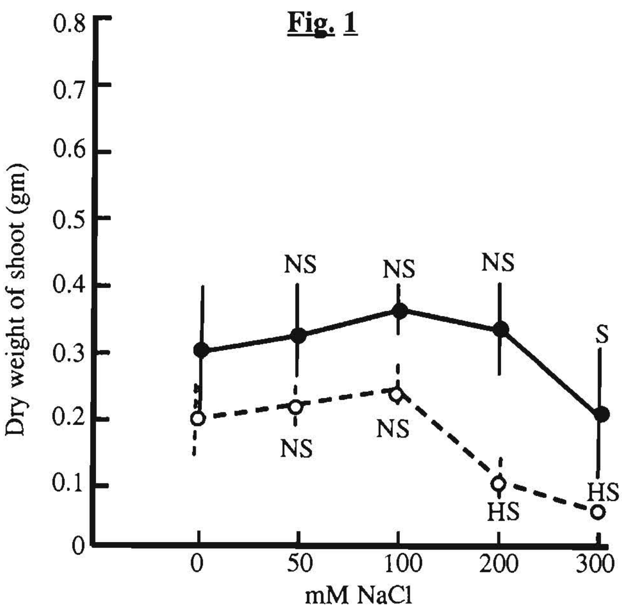
The tomato variety used is known to be cold resistant in outdoor cultivation, as well as moderately salt-tolerant. Micropropagated shoots were subcultured on MS hormone-free medium (Murashige and Skoog, 1962) containing 0, 50, 100, 200 and 300mm NaCl. Starting fresh weight was measured and 30 days later the final fresh weight was determined as well as the dry weight. Tomato seedlings two weeks old were grown for one week on Hoagland's solution (Hoagland and Arnon, 1950) containing the same mm of NaCl.

Materials were oven dried for 24 hours for Na^+ and K^+ analysis. Weighed samples of the dried materials were heated in test tubes with 1ml of concentrated nitric acid until completely dry. Then 10ml distilled water was added and Na^+ and K^+ contents were measured using a spectrophotometer (PYE UNICAM AP 191). Chloride was determined by heating the dried material with 10ml distilled water to 90°C for 6 hours, followed by centrifuging. The chloride in the supernatant was determined using $AgNO_3$ Tal, *et al.* (1987).

Results

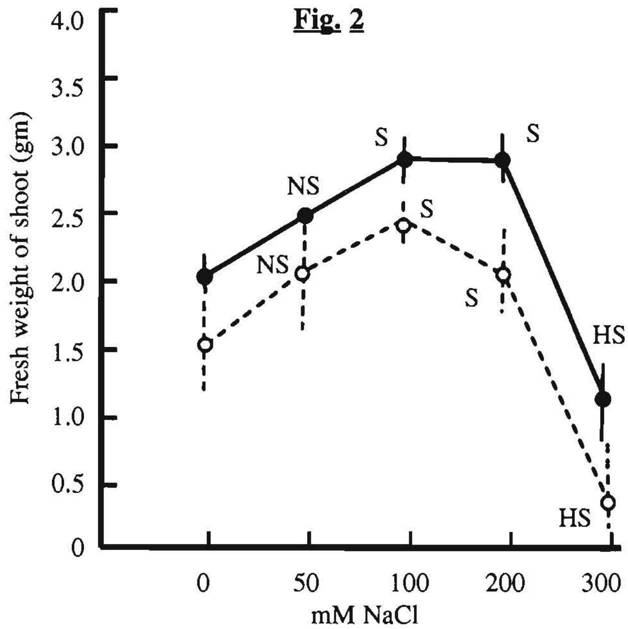
Effect of NaCl on Dry Weight

The dry weight of tomato plants and shoot tips grown on Hoagland's solution or on MS medium containing 50 and 100mm NaCl was higher than that of those grown on no NaCl (Fig. 1). The dry weight of intact tomato plants grown on 200mm NaCl was nearly similar to that of the control; however, it was greatly reduced with shoot tips. At 300mm NaCl the dry weight of both intact plants and shoot tips was sharply decreased.



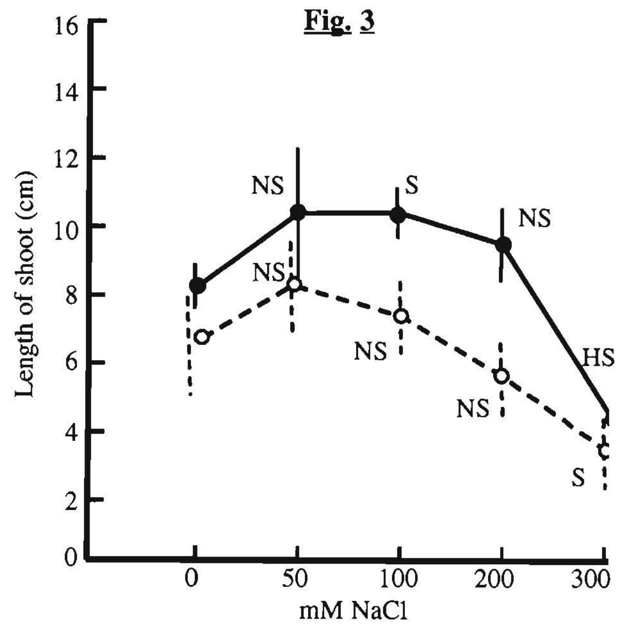
Effect of NaCl on Fresh Weight

The fresh weight of tomato plants and shoot tips exposed to 50, 100 and 200mm NaCl was increased compared to that of the control (Fig 2). However, at 300mm NaCl the fresh weight of both was significantly decreased.



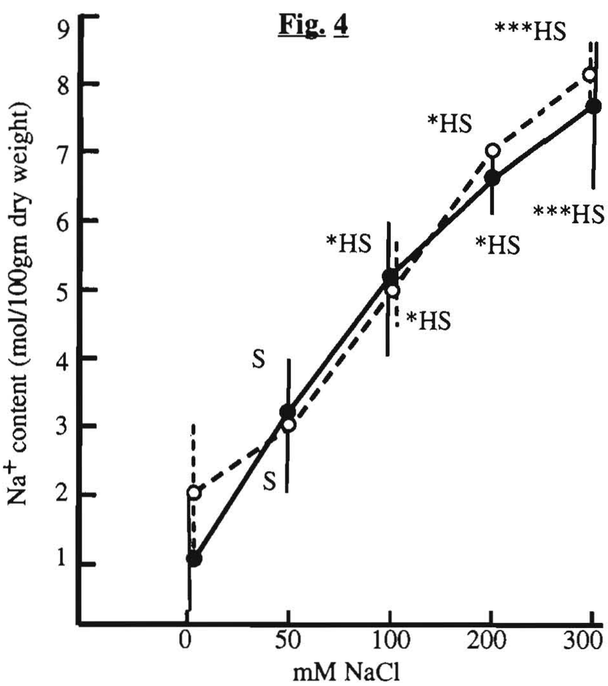
Effect of NaCl on Elongation

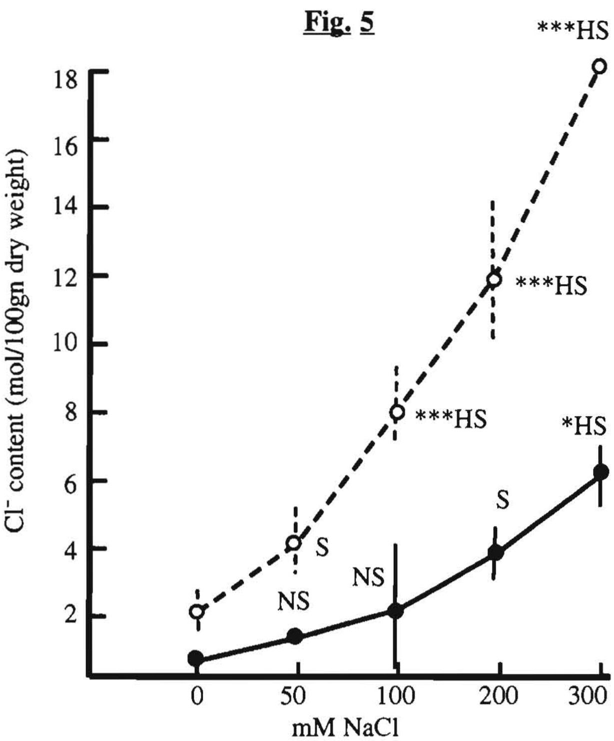
At 50 and 100mm NaCl the elongation of tomato plants and shoot tips was nonsignificantly increased (Fig 3). At 200mm NaCl there was a nonsignificant increase in tomato plants and a nonsignificant decrease in shoot tips. At 300m NaCl both tomato plants and shoot tips were significantly decreased.



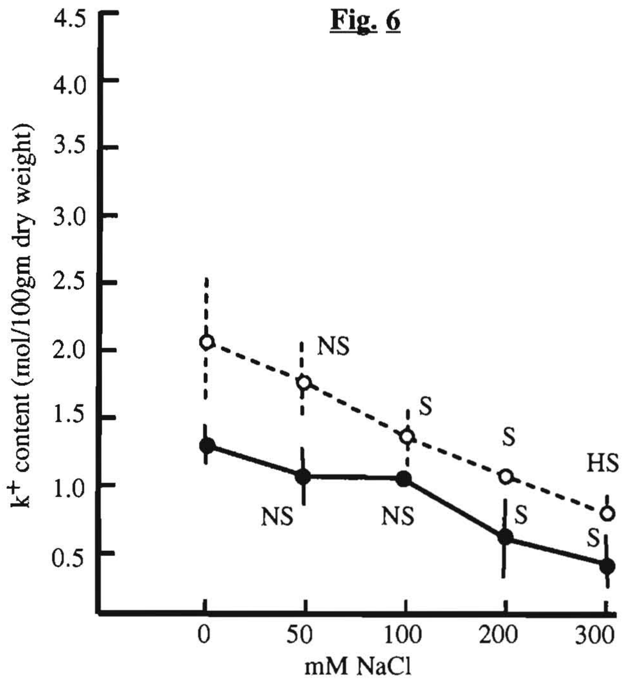
Effect of NaCl on Ion Uptake

The Na^+ and Cl^- ion uptake was sharply increased in both tomato plants and shoot tips (Fig 4 and 5). However, K^+ ion uptake was inversely proportional to the amount of NaC1 in the nutrient solution and in the MS media (Fig. 6).





NS = Non-significant $p < 0.05$
S = significant $p > 0.05$
HS = Highly significant $p < 0.02$
*HS = Highly significant $p > 0.02$
***HS = Highly significant $p > 0.01$



Discussion

A great similarity was found between the salt-tolerance of whole plants and calli derived from stems and roots as well as shoot tips of these plants (Tal, 1971). The fresh weight of intact tomato plants and shoot tips increased at the moderate levels of NaC1 (Fig 2), and decreased at the highest level of NaC1 (300 mm). This indicates that although the plants are able to survive, a relatively high level of NaC1 could affect these plants. Similar results were reported by Tal, *et al.* (1978) and Liljenberg, *et al.* (1985). Salinity appears to affect growth due to either toxic effects of Na^+ or $C1^-$ accumulation; or the low osmotic potential of the soil or solution.

Accumulation of solutes may lead to increased solute concentration in the leaves as part of osmotic adjustment, but this accumulation may go beyond the limits of regulation of cytoplasmic content with associated impairment of growth (Pitman, 1984). Pitman also found that salinity has characteristic effects on growth of plants. He reported that there was no clear correlation between rate of transport and relative growth rate. As seen in Figs. 1, 2 and 3, it seems that plant dry weight, fresh weight and elongation were affected only with high salinity (200 - 300mm NaCl).

As reported by Pitman (1984), the endogenous salt content in plants affects growth of plants through its effect on photosynthesis. Flowers, *et al.* (1977) also reported that salinity has a characteristic effect on plant growth. The increase in Na^+ and $C1^-$ uptake as well as the decrease in K^+ uptake (Figs. 4, 5 and 6) is contradicted by Greenway (1962) and

Gates, *et al.* (1970) with *Hordeum vulgaris* grown in a solution containing NaC1. They found that the more salt-tolerant types accumulated less sodium and chloride than the sensitive plants. On the other hand a positive correlation between Na^+ accumulation and salt-tolerance has been reported by Rush and Epstein (1976 and 1981). This positive correlation is confirmed by the present results, Dehan and Tal (1978) pointed out that salt-tolerant plants accumulated more $C1^-$ than cultivated species and this was also true in the calli derived from these plants.

However Ashraf, *et al.* (1986) found that salt-tolerant selected lines of *Trifolium* contained less Na^+ but more Cl^- in their shoots than unselected normal lines and also contained less K^+ in their shoots than unselected lines. Pitman (1984) reported that sudden salinization can lead to massive, nonselective uptake of Na and C1 to the root and shoot, compared with gradual increase in salinity. Storey and Wyn Jones (1978) studied the uptake of Na^+ and $C1^-$ by barley over a period of 96 hr., after transfer to a culture solution containing 250mm and found a rapid uptake of Na^+ and $C1^-$ to root and shoot and less uptake of K^+.

During the abrupt transfer to NaC1 there was a large and nonselective transport of Na^+ and $C1^-$ to the shoot, lasting 48 hrs., with less salt accumulation in the root. The large nonselective uptake could be due to plasmolysis of root cells, destroying the barrier set up by the symplast, but it could also be due to a change in membrane permeability. A similar explanation was also reported by Reid *et al.* (1983). Keifer and Lucas (1982) explained the ionic accumulation in plants under saline condition as possibly being due to changes in K^+ or Na^+ channels in the cell membrane.

The present results suggest that the better osmotic adjustment, which characterizes most salt-tolerant plants under high salinity, is operating at the cellular level and it could be the main requirement for a plant to be salt-tolerant.

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