# Ion Uptake by Halophytic Plants to Mitigate Saline Stress in *Solanum lycopersicon* L., and Different Effect of Soil and Water Salinity

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**Abstract**: Soil and water salinization are affecting an increasing number of countries in the world, especially in arid and semi-arid regions, and cause sensible reductions of agricultural land extension and of crop yields. Consociation with halophytic plants is a promising but not yet widely investigated strategy of salt stress reduction in crops. In this experiment, tomato plants were cultivated in saline conditions, alone and in consociation with three different halophytic species (*Portulaca oleracea* L.; *Salsola soda* L.; *Atriplex hortensis* L.). The salinity was brought either by the soil or by the irrigation water. Consociation with *P. oleracea* gave the best results in terms of increase of tomato growth and yields, while *S. soda* caused excessive nutritional competition against tomato due to its fast growth, undoing the positive effects of saline ions uptake. *A. hortensis* gave intermediate results. Salinity of water resulted in causing more severe stress on the plants, and consequently highlighted more the benefical effect of salt uptake performed by the halophytes on the main crop; salinity of soil on the contrary appeared to be less decisive, probably due to the leaching effect of the irrigation water.

**Keywords**: soil salinity; water salinity; *Solanum lycopersicon* L.; halophytes; consociation

Progressive salinization of soils and waters is one of the most serious problems affecting today's agriculture and the economy of many countries. It has been estimated that every minute the world is losing, on average, 10 ha of cultivable land, 3 of which are due to salinization (Kovda 1983): this is equivalent to a loss of about 1 500 000 ha per year. Estimations of the total area affected nowadays by salinity range from 4 millions of hectares (Bot *et al.* 2000) to about 20 millions (Szabolcs 1994). Salinization of water is probably today the most relevant phenomenon of water-quality degradation (Vengosh 2003), especially in arid and semi-arid zones.

Soil and water salinity cause several physiological disorders in plants, connected with the abnormal concentration of saline ions in the rhizospheric environment; these can range from a cytotoxic and denaturating effect of the ions themselves (Bernstein 1975) to osmotic stress (Greenway & Munns 1980; Yeo 1983) and alteration of the ion uptake balance (Rains 1972; Flowers & Lauchli 1983). The final effect of this combination of circumstances is, by an agricultural point of view, reduction of quality and yield of crops (Van den Berg *et al.* 1967; Maas & Hoffmann 1977; Asch *et al.* 2000). During the years several strategies have been tested to mitigate the negative effects of salinity, the most significant of which being the application of silicon salts (Stamatakis *et al.* 2003; Zuccarini 2008); extra supply of potassium (Economakis & Daskalaki 2003; Zuccarini & Okurowska 2008); the use of biofertilizers such as mycorrhizal fungi (Cantrell & Linderman

2001; Zuccarini 2007) or more traditional agronomical strategies such as mulching (Shamas *et al.* 2002; Tejedor *et al.* 2003), grafting (Ruiz *et al.* 1997; Fernández-García *et al.* 2003) or leaching (Hanson 1993; Giuffrida & Lipari 2003).

A promising but not yet deeply investigated field is represented by the use of halophytic plants in consociation with crops cultivated in conditions of saline stress: the salt uptake and accumulation performed by the halophytes can reduce the severity of the stress at a rhizospheric level, providing better conditions for the growth of the agricultural species and, in conclusion, better yields. Halophytes are widely represented by both herbaceous, arbustive and arboreous plants, and many species are already diffused and appreciated as forages (Malcom & Pol 1986; O'Leary 1986), demonstrating the big versatility of use that these plants can offer; in this sense the family of Chenopodiaceae is of particular interest, comprising about 25% of all the halophytes known today (Le Houèrou 1993).

The scarcity of material in literature demonstrates how this technique has not been sufficiently analyzed yet; moreover, in most of the cases studies have been conducted in soilles conditions (Albaho & Green 2000; Zurayk *et al.* 2001), which constitutes a limitation. There are in fact good reasons to think that the use of halophytic plants in field can result in a positive effect on the cultivation both in the short-medium period – by reduction of salinity as illustrated above – and on the long term, by providing a partial bonification of the soil and, in case, also an amelioration of the physical characteristics of the substrate, as suggested by Graifenberg *et al.* (2003).

The study of this technique in field is also important because it represents the kind of application that is more likely to occur in the regions more affected by the problem of salinity, which are usually also the ones, arid and semi-arid, which have less easy access to the application of soilless cultures, and in this sense the investigation in hydroponic plants risks to result in an artefact of difficult application on a wide scale.

Aim of the present work is to test the effects of the consociation of tomato plants (*Solanum lycopersicon* L.) with three different species of halophytic plants (*Portulaca oleracea* L.; *Salsola soda* L.; *Atriplex hortensis* L.) in conditions of salinity, in order to point out the best combinations possible. Different kinds of salt stress have been also compared, being the salinity brought either by the soil or by the irrigation water.

## MATERIALS AND METHODS

The trial was run in an iron-PVC greenhouse with concrete floor, equipped with concrete benches of 1 × 6 × 0.25 m size filled with sandy soil (sand 85.8%, loam 7.65%, clay 6.55%). The greenhouse was not heated, and natural light was not artificially supplemented for the whole duration of the trial; an automatic drip-irrigation system was used.

The model species used for the trial was *Solanum lycopersicon* L. (cv. Jama), chosen for its agronomical importance and medium resistance to salinity (Maas & Hoffmann 1977). *Salsola soda* L., *Portulaca oleracea* L. and *Atriplex hortensis* L. were chosen as companion halophytic plants, also in virtue of their relative importance as minor crops (Lieth & Mochtchenko 2004), i.e. their possible role for human consumption.

The efficiency of the different halophytic plants in terms of salt uptake and accumulation was assessed on the basis of growth, yield and quality levels of tomato plants in the various treatments.

Two trials were performed. The first one was composed of four treatments, represented by tomato alone and associated with the different halophytes, all grown in non-saline soil (average EC of the saturated extract = 3 dS/m; exchangeable Na = 210 ppm) and irrigated with saline water (rain water added with 0.7 g/l of 20/20/20 N/P/K fertilizer plus 3g NaCl/l: EC = 5.8 dS/m).

The structure of the trial was therefore:
- *S. lycopersicon* alone (saline irrigation)
- *S. lycopersicon* + *S. soda* (75 g/m)
- *S. lycopersicon* + *P. oleracea* (10 g/m)
- *S. lycopersicon* + *A. hortensis* (4 g/m)

The second trial was composed of the same combinations, grown this time in saline soil (average EC of the saturated extract = 5.35 dS/m; exchangeable Na = 650 ppm) and irrigated with non-saline water (rain water added with just 0.7 g/l of 20/20/20 N/P/K fertilizer: EC = 0.84 dS/m).

The control was represented for both the trials by tomato alone grown in non-saline soil and irrigated with non-saline water, to provide growth, yield and quality values of the plant when grown in optimal conditions.

*S. soda* was sown 18 days and *A. hortensis* 4 days before the transplant of tomato plantlets; the sowing of *P. oleracea* was performed 14 days after the transplant. The times of sowing adopted were chosen on the basis of considerations about the different growth speed and aggressiveness of the three halophytes, in order to minimize nutrient and physical competition with the model species. All the halophytes were scattered broadcast; tomato plants were placed at a distance of 35 cm along the rows and 50 cm between the rows, corresponding to an investment of about 38 000 plants per hectare.

Fruits started to be picked two months and two weeks after the transplant, and lasted 28 days (being repeated every two-three days) because of the graduality of maturation. After weighting, a sample of fruits was chosen from each treatment to be destined to quality analyses.

At the end of the collection period, a sample of two tomato plants and – when present – of two halophytes was removed from each bench corresponding to a specific treatment; stem and leaves were measured (separately for tomato plants and jointly for the halophytes) for fresh weights and successively, after desiccation in 70°C forced draft oven during 7 days, for dry weights. After measurement of dry weights the dried samples were ground and destined to chemical analyses.

Electrical conductivity of soil saturated extract was measured from all benches at the end of the trial.

A sample of fruits of tomato plants from each treatment was subject to quality and chemical analyses.

First of all fruit consistency was evaluated with a penetrometer (HortPlus™), then fruits were homogenized. Dry matter percent (% d.m.) was then measured after keeping 100 g of the homogenized material in 70°C forced draft oven until constant weight. What was left of the homogenized was passed through rapid filters, and pH, titrable acidity and refractometric residue were measured on the filtered juice.

Dried ground samples of fruits, stems and leaves of tomato plants and halophytes from the different treatments were subject to chemical analyses.

Total Nitrogen was measured with Kjeldahl method (Stuart 1936). For analysis of Phosphorus, Potassium and Sodium parts of the samples were subject to nitroperchloric digestion; Phosphorus was measured with Morgan method (Morgan 1941), Potassium and Sodium by spectrophotometric way. Chlorine was measured with the Zall method (Zall *et al.* 1956).

Data were subject to analysis of variance using the SAS statistical software program. The significance of differences between means was then determined using Duncan's multiple range test (SAS Institute 1990).

## RESULTS

### First trial (non saline soil and saline water)

The biomass production of tomato plants is generally lower in benches irrigated with saline water in comparison with control (Figure 1a); the minimum growth level was recorded anyway for tomato consociated with *S. soda*. In both consociations with *P. oleracea* and *A. hortensis* tomato plants grew more than the saline controls, and especially with *P. oleracea* ($P = 0.021$ in comparison with saline control).

The dry mass percentage shows less dramatic fluctuations among the treatments, but seems to be positively correlated with the level of stress undergone by the plants (Figure 1b); its highest values are registered for tomato plants consociated with *S. soda*, indicating the occurrence of probable competition stress.

The productivity, expressed as both number of fruits per plant and kg of fruits per plant, was maximum in the non saline control and minimum in the consociation with *S. soda*, even lower than in saline control ($P = 0.026$) (Figure 2). Among the different treatments the parameter Kg of fruits per plant varies more significantly of the number of fruits per plant, showing how saline stress affects the production of tomatoes acting more on their gauge than on their number. In particular, only by observing the yields in kg/plant it is possible to

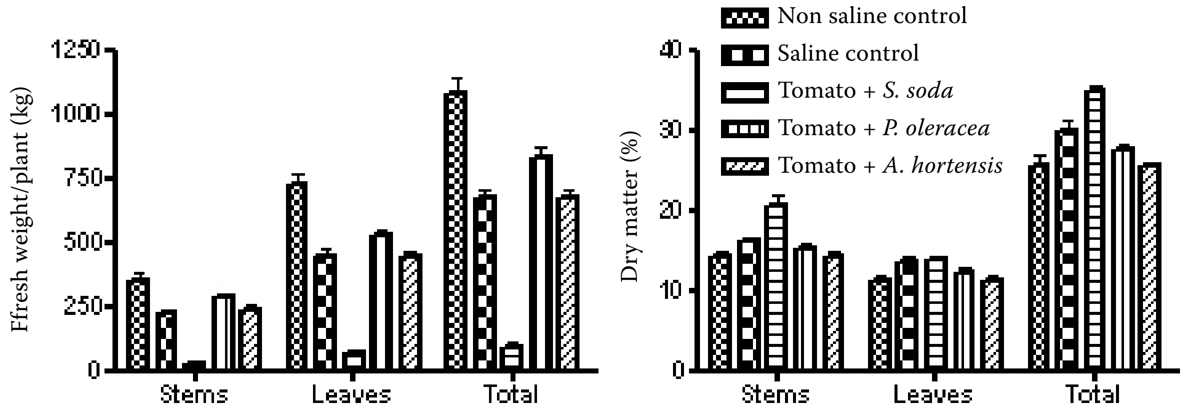


Figure 1. Growth (a) and dry matter percent (b) of tomato plants grown in non-saline conditions (control) and in non saline soil irrigated with saline water, cultivated alone and in consociation with three different halophytes

appreciate how the consociation with *P. oleracea* led to higher yields than the saline control, even if they were lower than the non-saline one (but at the limit of significance $P = 0.057$). The consociation with *A. hortensis* gave higher yields than the saline control too ($P = 0.036$), and in this case the difference is more remarkable than the one between levels of vegetative growth.

The pH of the fruits does not vary significantly among the different treatments, so as the resistance to pressure (Table 1); the latter shows anyway a slight trend to higher values in conditions of salt stress. Percentage of dry matter, titrable acidity and refractometric residue all increase in conditions of salinity, and in general their levels are lower in tomatoes grown in consociation than in saline controls. *P. oleracea* and *A. hortensis* give similar values, while in consociation with *S. soda* they tend to be lower and closer to the ones of non-saline control; this is particularly evident for the refractometric residue.

The absorption of Na is maximum in tomato plants from saline control, as expected, and decrease in all the consociation treatments; *S. soda* is associated with the lowest Na content in tomato plants tissues ($P = 0.019$ for the total) (Figure 3a). Cl shows similar patterns, but its reduction in the cases of consociation is less remarkable (Figure 3b). K absorption is significantly reduced in all saline treatments in comparison with non-saline control, and this happens more remarkably at leaf level (Figure 3c). Consociation with *P. oleracea* and, to a less extent, with *A. hortensis*, slightly enhance K uptake, while the presence of *S. soda* brings it to its minimum values. N shows similar patterns to K, but in this case the consociation with *A. hortensis* enhances its absorption (in comparison with saline control) more than *P. oleracea* (Figure 3d); *S. soda* gives again the worst results, but a less marked difference. N content is always on average higher in leaves than in stems. P absorption is always enhanced by saline conditions,

Table 1. Quality parameters of fruits of tomato plants grown in non saline soil and irrigated with saline water

| | Resistance to pressure (kg/cm) | pH | % d.m. | Titrable acidity (% citric acid) | °Brix (22°C) |
|---|---|---|---|---|---|
| Non-saline control | 4.7a* | 4.14a | 5.1a | 0.545a | 4.25a |
| Saline control | 5.5b | 4.11a | 6.6c | 0.646b | 6.00b |
| Tomato + *S. soda* | 4.9a | 4.10a | 4.9a | 0.552a | 4.60a |
| Tomato + *P. oleracea* | 4.5a | 4.17a | 5.5b | 0.562a | 5.80b |
| Tomato + *A. hortensis* | 5.1ab | 4.11a | 5.4b | 0.606ab | 5.75b |

*Values of the same column marked with the same letter are not statistically different at $P < 0.05$, according to Duncan's multiple range test

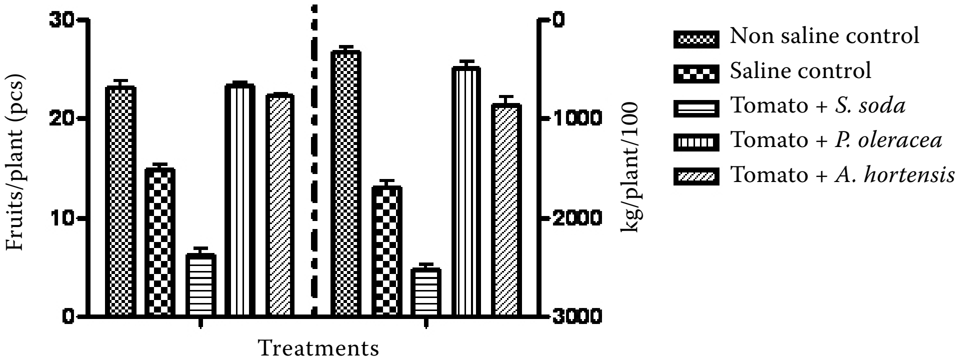


Figure 2. Fruit production, expressed both in number and weight, of tomato plants grown in non-saline conditions (control) and in non saline soil irrigated with saline water, cultivated alone and in consociation with three different halophytes

and the maximum concentrations are registered for tomatoes in saline control and in consociation with *S. soda* (Figure 3e).

EC of saturated extract at the end of the trial is significantly higher in all saline combinations, being maximum in saline control (Table 3); its minimum enhancement is registered in the consociation with *S. soda*.

**Second trial (saline soil and non saline water)**

Biomass production of tomato plants from saline control is slightly, non significantly lower than the one from non-saline control ($P = 0.062$); in conditions of consociation the biomass drops more, reaching its minimum levels in the consociation with *S. soda* ($P = 0.039$) (Figure 4a).

Percentage of dry matter slightly increases in saline control, and more remarkably in all the consociation treatments (Figure 4b).

An analogue trend can be detected in fruit production, being both the number of fruits and average gauge higher in monoculture treatments than in consociation, even if no significant difference is observed from the consociation with *P. oleracea* ($P = 0.075$) (Figure 5).

The pH of the fruits does not vary significantly among the different treatments, so as the resistance to pressure, while resistance to pressure and refractometric residue get lower in all the consociation treatments (Table 2). Percentage of dry matter does not vary significantly between saline and non-saline control, but get higher when tomatoes were grown in consociation; titrable acidity shows fluctuations that do not indicate a precise trend.

Na content does not vary significantly between saline and non-saline control, and is slightly reduced by the presence of halophytes (Figure 6a); the levels of Cl significantly drop in the plants

Table 2. Quality parameters of fruits of tomato plants grown in saline soil and irrigated with non saline water

| | Resistance to pressure (kg/cm) | pH | % d.m. | Titrable acidity (% citric acid) | °Brix (22°C) |
|---|---|---|---|---|---|
| Non-saline control | 4.5b* | 4.14a | 5.1b | 0.605b | 5.25c |
| Saline control | 5.2c | 4.23a | 4.9ab | 0.587ab | 4.90b |
| Tomato + *S. soda* | 3.9a | 4.21a | 5.8c | 0.564a | 4.10a |
| Tomato + *P. oleracea* | 4.2ab | 4.18a | 5.9c | 0.662c | 3.75a |
| Tomato + *A. hortensis* | 4.8bc | 4.16a | 4.7a | 0.622c | 4.00a |

*Values of the same column marked with the same letter are not statistically different at $P < 0.05$, according to Duncan's multiple range test

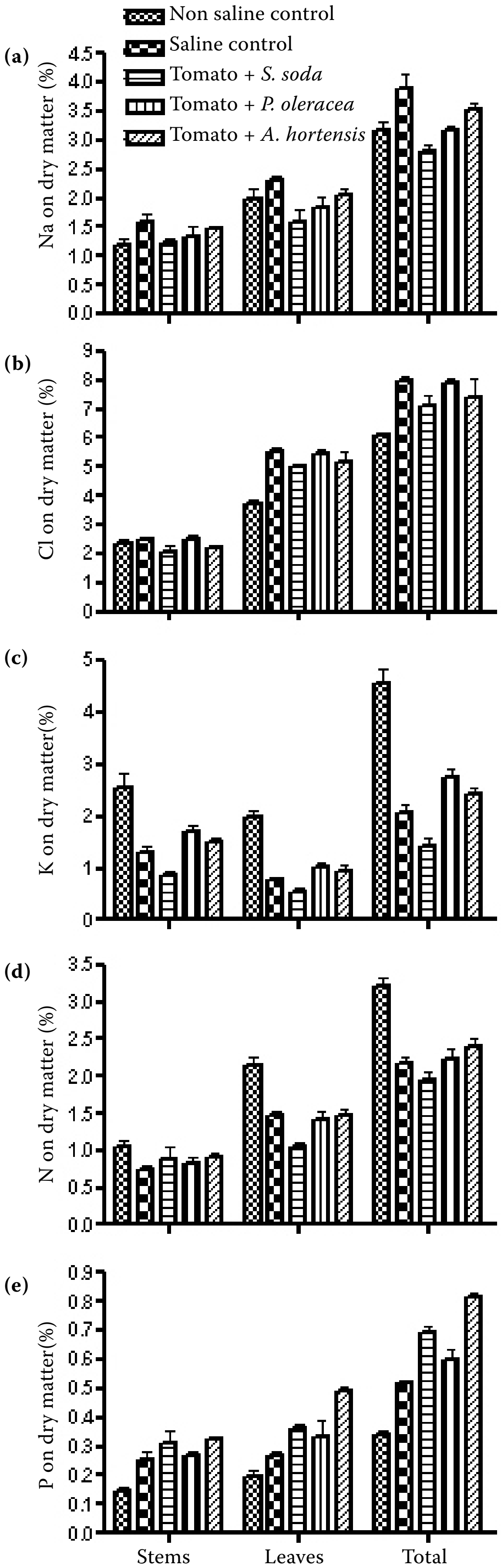


Figure 3. Ion uptake of tomato plants grown in non-saline conditions (control) and in saline soil irrigated with non saline water, cultivated alone and in consociation with three different halophytes; (a) Na; (b) Cl; (c) K; (d) N; (e) P

grown in consociation ($P$ = 0.045 and $P$ = 0.032 in cases of consociation with *P. oleracea* and *S. soda* respectively) (Figure 6b). K reaches the highest concentration in consociation with *P. oleracea*, but in all other cases the saline treatments have slightly lower concentration than the saline control (Figure 6c). N does not show significant fluctuations (Figure 6d), while P content is lower in consociation (Figure 6e).

EC of the saturated extract at the end of the trial is slightly but significantly higher in saline control if compared to non saline one (Table 3); its level is always lower when halophytes were present, and the lowest value is recorded in presence of *S. soda*.

## DISCUSSION

The data clearly show how saline stress can result in a consistent reduction of both growth and yields of the model species, as already widely demonstrated in literature (Pasternak 1987; Munns 1993; Igartua 1995); these effects occur both when salinity comes from the irrigation water and when it is a preliminary condition intrinsic to the medium of cultivation. It is noteworthy that the yield reductions usually occur as a reduction of the average gauge of the fruits, while the number of berries per plant remains virtually unchanged: this way of manifestation of the saline stress is relatively common, and typical of tomato plants (Sifola *et al.* 1995; Pomper & Breen 1997). This phenomenon can be seen clearly in the graphics showing fruit production, in which the fruit number/fruit weight ratio significantly increases in conditions of saline stress. On the opposite, the effects of salinity on the quality of the fruits, which constitutes the final result and central aim of the agronomical activity, are positive. In fact they provide the berries with higher contents both in salt (as a direct effect of the abiotic stress underwent by the plants, Ashraf & Orooj 2006) and in simple sugars (which are produced and accumu-

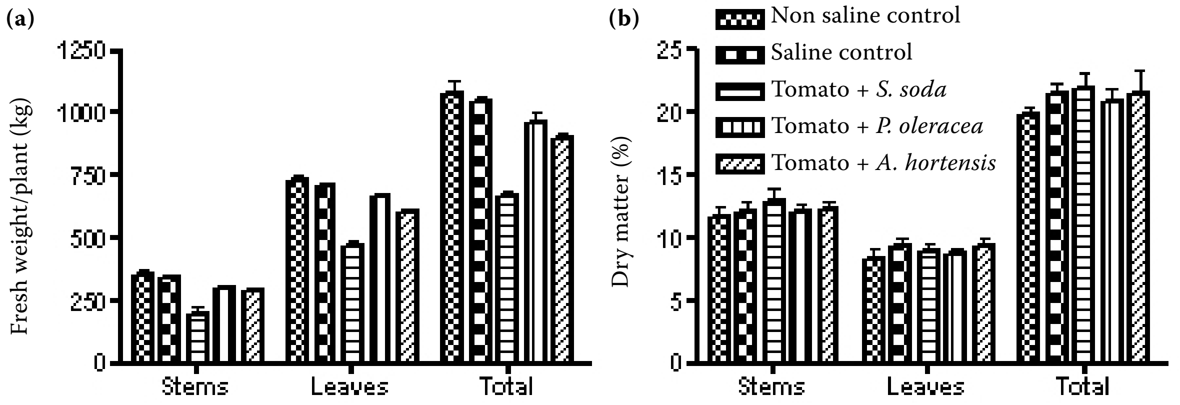


Figure 4. Growth (a) and dry matter percent (b) of tomato plants grown in non-saline conditions (control) and in saline soil irrigated with non saline water, cultivated alone and in consociation with three different halophytes

lated in higher quantity as an immediate osmotic response to salinity, Watanabe *et al.* 2000), and the combined effect of these circumstances is an exaltation of the organoleptic characteristics of the fruit itself, also enhanced by higher firmness of the tissues.

The effects of consociation with halophytic plants are in all encouraging, since a general trend towards a mitigation of the condition of stress in the tomato plants can be detected; this constitutes a precious evidence, due to the scarcity of data related to this subject in literature (Albaho & Green 2000; Graifenberg *et al.* 2003).

Significant differences persist anyway according to the species used as companion plant. *P. oleracea* stands out as the best performing one in consociation with *S. lycopersicon*, allowing rates of growth and yield that almost equal the ones of control, unstressed plants. This is possible because of its combination of good rate of ion uptake, which provides good edaphic conditions for the model plant, with a moderate growth rate, resulting in negligible competition for nutrients against *S. lycopersicon*. Already Graifenberg *et al.* (2003) observed optimal results for *P. oleracea* in terms salt stress reduction in tomato plants, but in that case the worst performances of *S. soda* were due to an excessively delayed time of sowing, resulting in not sufficient salt ion uptake by the halophyte when the tomato was in full growth. Qasem (1992) also studied the levels of nutrient accumulation by *P. oleracea* when associated with tomato, without evidencing excessive competition.

*S. soda*, on the opposite, presents such an aggressive growth to constitute a serious obstacle for the normal development of tomato plants, and its use can be therefore a double-edged weapon. In fact, its tendency to the rapid production of high quantities

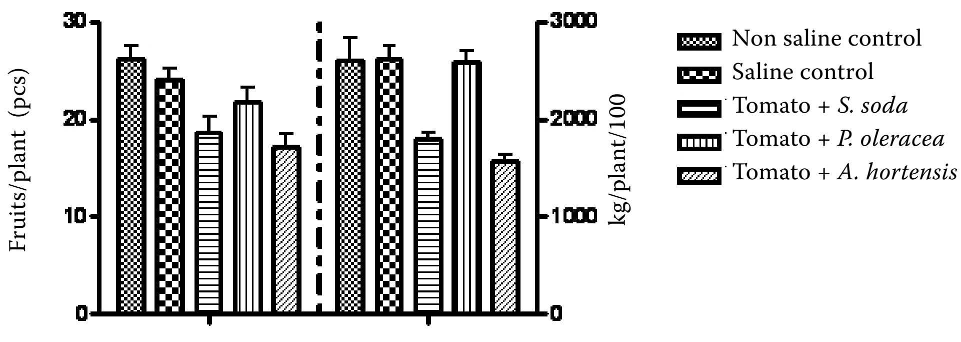


Figure 5. Fruit production, expressed both in number and weight, of tomato plants grown in non-saline conditions (control) and in saline soil irrigated with non saline water, cultivated alone and in consociation with three different halophytes

of biomass results on one side in an effective reduction of saline ions content in the rhizospheric region (with a consequent mitigation of salt stress), but on the other side leads to a competition for nutrients and even for irradiation against tomato plants that are still of little size. These negative effects can be maybe partially reduced by acting on the time of sowing in relation to the transplant of tomato plants: the importance of the times of sowing and transplant for consociated crops has been already put in evidence by some authors (Andersen *et al.* 2007; Smith & Gross 2007); *S. soda* does not appear anyway to be a good choice in consociation, as it emerges from the presented data. In particular, the lowest Na absorption by tomato plants grown in consociation with it, associated with the lowest growth rate, show how the nutritional competition caused by *S. soda* is so strong to be even over the positive effect of massive reduction of saline ions in the rhizosphere; *A. hortensis* shows intermediate results between *P. oleracea* and *S. soda*, so it can be used to provide effective reduction of salt stress provided that special care is taken in aspects such as its time and density of sowing. In the light of these observations, it emerges how the ideal halophytic plant to use in consociation with a salt-stressed crop is the one which joins maximum saline ion uptake with minimum nutrient absorption, connected with a moderate vegetative growth (Fowler *et al.* 1992; Qasem 1992), and *P. oleracea* stands out as the closest to this ideal model among the three ones that have been used for this trial. This does not exclude anyway that better results can be obtained also by the use of other species, putting special care in times and densities of sowing (Graifenberg *et al.* 2003).

Relevant differences can be detected between the two trials in terms of the severity of saline stress affecting the model plants. In the first trial (saline water on non-saline soil) tomato plants show relevant negative effects on growth and yield, and the positive effects of consociation with halophytes – especially *P. oleracea* – are particularly evident. The effectiveness of saline water in causing salt

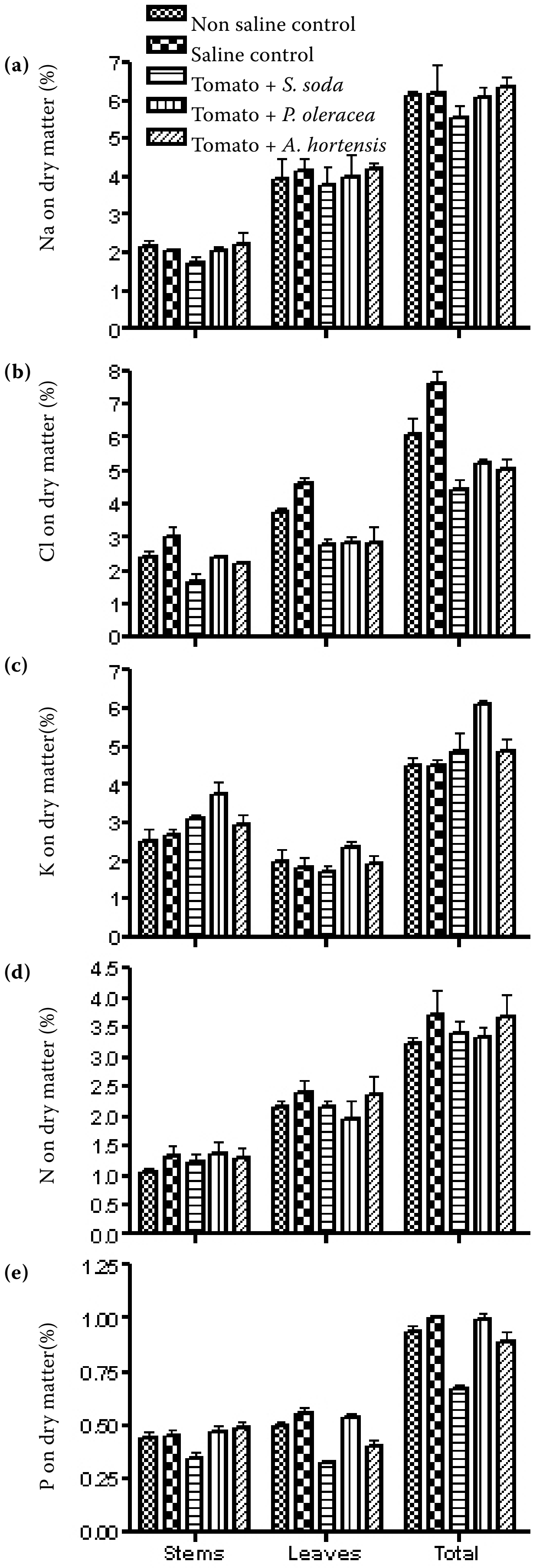


Figure 6. Ion uptake of tomato plants grown in non-saline conditions (control) and in saline soil irrigated with non saline water, cultivated alone and in consociation with three different halophytes; (a) Na; (b) Cl; (c) K; (d) N; (e) P

Table 3. Electrical Conductivity (EC, dS/m) of saturated soil extract at the beginning and at the end of the trial, for the two different combinations of soil and irrigation water

| | First trial | | Second trial | |
|---|---|---|---|---|
| | saline water | | saline soil | |
| | EC start | EC end | EC start | EC end |
| Non-saline control | 3.03a*A** | 2.86aA | 3.07aA | 3.08aA |
| Saline control | 3.03aA | 5.83cC | 5.38bC | 3.89bB |
| Tomato + *S. soda* | 2.98aA | 4.15bB | 5.30bC | 3.27aA |
| Tomato + *P. oleracea* | 2.99aA | 4.45bC | 5.31bD | 3.62abB |
| Tomato + *A. hortensis* | 3.01aA | 4.32bB | 5.35bC | 3.84bB |

*Values of the same column marked with the same letter are not statistically different at $P < 0.05$, according to Duncan's multiple range test; **values of the same line marked with the same letter are not statistically different at $P < 0.05$, according to Duncan's multiple range test

stress is moreover demonstrated by the data of EC of the saturated extract: its values significantly increase at the end of the trial, showing a progressive salinization of the substrate due to repeated saline irrigations. This constitutes an evidence of the negative effect of the use of saline waters for irrigation (Bajwa *et al.* 1986), and puts the accent on the necessity of a combined approach in those regions were such waters are the only ones available. In fact, disposing of saline water to irrigate non saline soils can be in a first step mitigated by techniques like consociation with halophytes, but on longer periods of time the reiteration of saline irrigations can affect the soils so radically to make them become unsuitable for agriculture, as it is rapidly happening nowadays (Altman 1999; Batterbury *et al.* 2002). In this sense, strategies that just aim at an immediate reduction of saline stress must be accompanied by operations aimed at a maybe slow, but constant, requalification of soils, in order to limit the loss of soil cohesion, chemical and physical fertility, that is one of the first consequences of salinization and one of the first causes of desertification. For example, treating the soil with mulching (Hoy *et al.* 1994; Tang & Zhang 1996; Rasiah & Yamamoto 2002) can give some interesting results; even leaching with the same saline water that causes the problem, but supplied in higher quantities, can prolong the life of an agricultural soil (Ayers & Westcott 1985; Hanson 1993).

In the second trial (non-saline water on saline soil) the data show a significantly lower severity of the saline stress on all the cultivated plants. This results, intuitively, in milder growth and yield reductions, but at the same time the action of the halophytes becomes less beneficial and potentially it can bring damage. This is because the benefits of the consociation are connected with the absorption of saline ions from the circulating solution, but in the cases in which these ions are not at high concentrations, the action of nutritional competition prevails. So, the growth and production of tomatoes in consociation are not remarkably better than the ones of saline controls, and in the presence of *A. hortensis* or, more, of *S. soda* they can become dramatically lower. This different situation in comparison with trial No. 1 can also be appreciated by the lower level of saline ions performed by both the tomato plants and the halophytes, demonstrating an effective lower disposability of those ions.

The most probable reason of the lower level of saline stress in the second trial is connected to the leaching action performed by the non-saline irrigation water on the initially saline soil: this data can be a valid evidence of the utility of leaching with big volumes of water (even when they are saline or of scarce quality, Bernstein & Francois 1973; Hoffman *et al.* 1979) on salinity affected soils to guarantee a prolongation of their fertility.

## PROPOSALS AND CONCLUSIONS

The strategy against salt stress in crops tested in this experiment is quite new, as it is demonstrated by the scarcity of literature on this subject. The few researches that have been conducted on the effects of consociation with halophytes mostly deal with crops cultured in soilless conditions, providing a significant but yet not complete insight on the problem. In fact, if on one side the hydroponic system gives the opportunity to carefully control all the nutritional, physical and chemical parameters involved in plant production, on the other side it excludes the natural stochasticity that is connected with open field cropping and that can variously influence, tentatively enhancing, the positive effects of halophytes.

During the last years the few researches performed on this subject tended to present a more theorical and physiological approach, giving secondary importance to the opportunity of its actual application on a large scale. As it emerges from the bibliographic data and from the results of this research, consociation with halophytes is a promising strategy to face soil and water salinization, and it is favourable that future researches, performed with a more applicative approach, will broaden the level of knowledge and be responsible for the adoption of such tecnhnique in the farming policies of producers located in zones affected by salinity. It is in fact opinion of the Author that this strategy can be of easy and wide applicability, thanks to its cheapness and its technical feasibility, it can be compatible with regimes of organic farming and with developing countries, due to the fact that no high technology is involved with it.

Aspects to be object of future researches, for which it is needed to get a deeper insight, are the ones connected with new possible halophytic species to be used, different kinds of soils and the effects of different sowing times and densities of both the crops and the companion plants.

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