Food ©2013 Global Science Books

The Effect of Salinity on Some Growth and Yield Parameters of Three Pepper (*Capsicum annuum* L.) Varieties Grown in Tunisia

Thouraya R'him* • Riadh Ilahy • Imen Tlili • Khamassy Nouri • Jebari Hager

Université de Carthage, Laboratory of Horticulture, National Agricultural Research Institute of Tunisia. Hedi Karray street, 2049 Ariana, Tunis, Tunisia

***Corresponding author*: * thouraya.rhim@yahoo.fr**

ABSTRACT

Pepper is one of the main vegetable crops grown and consumed in Tunisia and is therefore of economic importance. Interest in the selection of salt-tolerant crop is increasing due to the decrease of water irrigation quality worldwide. Therefore, some growth and yield parameters of three pepper cultivars 'Baker', 'Marconi' and 'Jrid' commonly grown in Tunisia and with different pungency were determined under three different salinity levels (S1=35, S2=70 and S3= 120 mM of NaCl) with regard to a control irrigated with tap water. All the growth and yield parameters varied significantly among the studied salinity levels. No statistical differences were found in stem thickness, plant height, shoot fresh weight and root fresh weight under all the studied salinity levels and for all the studied pepper cultivars. Under (S3) salinity level, yield was decreased by 75% in 'Jrid', by 81% in 'Baker' and by 100% in 'Marconi'. The blossom-end rot increases with increasing salinity levels in 'Baker' and 'Marconi' however no rotted fruit were observed in 'Jrid' under all the studied salinity levels. This study has demonstrated the variability in the responses of some pepper cultivars commonly grown in Tunisia to different salinity levels. This result can help the growers to choose such varieties in salt-rich fields or when only saline water should be used for crop irrigation. Nevertheless, there is a need to focus on the effect of these salinity levels on the nutrient, non nutrient, anti-nutrient compounds accumulation and the antioxidant activity in such cultivars.

Keywords: growth and yield parameters, pepper, salinity, yield

INTRODUCTION

The pepper (*Capsicum annuum* L.) is one of the main vegetable crops grown and consumed in Tunisia and is therefore of economic importance. In fact, in 2009, 20,000 ha were dedicated to this crop and its production amounted 200,000 t (GIL 2009).

In order to attain acceptable yield, pepper plants, such as any biological system, require optimum environmental condition (light, temperature, water availability, etc.). These conditions help the plant to reach its full genetic potential and attain therefore an acceptable yield and a good quality. Cold, drought and salinity stresses are the most important abiotic stresses responsible of crop failure worldwide, decreasing average yields for most major crops by more than 50% leading to significant losses attaining hundred of million dollars each year (Mahajan and Tuteja 2005) which represents a serious menace for the sustainability of agricultural industry (Mahajan and Tuteja 2005).

In Tunisia, salinity represents a serious problem leading to negative effect on pepper growth and yield (Van Der Beek and Ltifi 1991; Ibn Maaouia-Houimli *et al*. 2011; Zhani *et al*. 2012). Its gravity increases particularly with the frequency of dry years (Van Der Beek and Ltifi 1991; Chartzoulakis and Kalapkai 2000; Navarro *et al.* 2006). Therefore, the selection of salt tolerant crops is thought to be one of the most effective ways to overcome salinity problems (Navarro *et al.* 2006; Niu *et al.* 2010). Maas (1986) and recently, Niu *et al*. (2010) reported that plant tolerance to salinity is usually evaluated in one of the three following ways: (1) the ability of a plant to survive on saline soils, (2) the absolute plant growth or yield, and (3) the relative growth on saline soils as compared with that on non saline soils.

Therefore, and based on these facts, the aim of this study was to evaluate the effect of three salinity treatments (35, 70 and 120 mM of NaCl) with regard to a control irrigated with tap water on some morphological and physiological aspects of three pepper cultivars ('Baker', 'Marconi' and 'Jrid') grown in Tunisia.

MATERIALS AND METHODS

Plant culture

The experiment was carried out in an experimental plot at National Agricultural Research Institute of Tunisia. Three pepper cultivars from different origin and different pungency were used in this experiment ('Baker', 'Marconi' and 'Jrid'). 'Baker' is an open pollinated cultivar selected by the National Agricultural Research Institute of Tunisia with dark green immature fruit and dark red mature fruit and a high pungency. 'Marconi' is also an open pollinated non pungent pepper cultivar originating from Italy and used since several years in Tunisia. The fruit of 'Marconi' are characterized by green immature fruit and red ripe mature fruit. 'Jrid' is a local population from the Djérid region in the south of Tunisia with small and very pungent dark green immature fruits (2-5 cm) and red mature fruit. Seeds were sown in plug-seedling trays (Makrolon multi UV IQ-Relax Generation, Bayer Sheet, Europe Darmstadt, Germany•) on the 7th of January 2010. Seedling trays were placed under controlled condition (28°C 70% HR and 200 Micromoles m^{-2} s^{-1} for luminosity). Transplanting was carried out in 22nd of February 2010 in plastic pots with a planting density of about 3 plants/m². Pepper cultivars were grown in three replicates. Ferti-irrigation was adjusted to the needs of the plants at different ripening stages. The production method included fertilization with synthetic chemical fertilizers (Biopretection, Fouchana, Tunisia) (N, P, K) (13-5-30 + MgO) during the vegetative period and (11-40-30 + 2MgO) during the flowering and fructification period.

The characteristics of the different applied treatments consist of:

Received: 5 June, 2012. Accepted: 1 November, 2012.

Original Research Paper

Control: Tap water without NaCl.
S1: Tap water + 35 mM NaCl which correspond to 2.03 g salt/L of water.
S2: Tap water + 70 mM NaCl which correspond to 4.06 g salt/L of water.
S3: Tap water + 120 mM NaCl which correspond to 6.96 g salt/L of water.

All the treatments were applied after two weeks of transplantation in order to avoid pepper plant death caused by both salinity and transplanting shock as suggested by Niu *et al*. (2010).

Measurements

The measurement of the different growth and yield parameters was performed two month after the application of different saline treatments in order to help pepper plant to express a self defence toward the salt stress. Growth parameters include plant height, internode length, stem thickness, shoot and root fresh weight, leaf area and chlorophyll content. Yield parameters include the percentage of fruit set, yield, average fruit weight and the percentage of blossom-end rot.

1. Growth parameters

Shoot height was measured at the end of the experiment. Measurements were considered from the base to the highest apex of the plant. Stem thickness was measured at the end of the experiment using a digital calipper (0 – 150 mm). Measurements were performed just before the first bifurcation. Internode length was determined only for the fourth bifurcation. This parameter was expressed in mm. Shoot and root weight were determined at the end of the experiment using a precision balance type A&D (A&D Co. Ltd, Japan). Leaf area was also measured at the end of the experiment using a planimeter (LI 3000A). The determination of chlorophyll content was performed as described by Mougou *et al*. (1984). Leaf samples were collected from plant submitted to different saline conditions. Leaves were ground on a mortar and pestle using a flow of nitrogen. The obtained samples were homogenized with 100% acetone. After two centrifugations at 300 rpm during 10 min, supernatant was recovered for chlorophyll determination at 652 nm. Results were expressed as milligram of chlorophyll per gram of dry weight (mg chl/g DW).

2. Yield parameters

The percentage of fruit set was determined as the ratio between the total number of fruit set and the total number of flower in pepper plant. Plant yield was expressed in grams fresh weight per plant. Average fruit weight was expressed in gram fresh weight and the percentage of blossom-end rots was expressed as the ratio between the number of rotted fruits and the total number of fruits.

Chemicals

Acetone and the other reagent were of analytical grade and obtained from Sigma-Aldrich, Chemical Co., Milan.

Statistical analysis

The analysis of variance was carried out according to the General Linear Models (GLM) procedure developed by the Statistical Analysis Systems Institute (SAS, V6.0, Cary, NC). Means and standard errors were calculated. LSD test was also used for testing significant differences between means with a confidence level of 95%.

RESULTS AND DISCUSSION

Growth parameters

Different growth parameters including plant height, internode length, stem thickness, shoot and root fresh weight leaf area and chlorophyll content are shown in **Fig. 1**. For all the studied pepper cultivars stem thickness, plant height, shoot fresh weight, internode length, root fresh weight, leaf area and chlorophyll content varied significantly between the applied treatments ($P < 0.01$). Stem thickness decreased significantly a 27.17% in 'Baker', a 39.45% in 'Marconi' and a 39.45% in 'Jrid' at (S3) with regard to non salt-stressed plants. However, under the different studied salinity levels varying from (S1) to (S3), stem thickness values remained statistically unchanged.

Similar trend was also observed in plant height. In fact, values decreased significantly a 39.23% in 'Baker', a 43.58% in 'Marconi' and a 38.10% in 'Jrid' at (S3) with regard to non salt-stressed plants. Plant height remained statistically unchanged under all the applied salinity treatments. As a consequence, the different applied salinity levels decreased internode length significantly a 42% in all the studied cultivars under (S3) salinity level with regard to non salt-stressed plants at the end of the experimental period. Under lower salinity levels (S1 and S2), internode length remained statistically unchanged in both cultivars 'Baker' and 'Marconi'.

Shoot fresh weight as all other growth parameters decreased significantly a 65%, a 67% and a 71% in 'Baker', 'Marconi' and 'Jrid' respectively at (S3) with regard to non salt-stressed plants. The main decrease was observed under (S1). Shoot fresh weight remained statistically unchanged under all the applied salinity levels. Similar trend was observed for root fresh weight but with greater effect attaining a 74% in 'Baker', a 77% in 'Marconi' and a 76% in 'Jrid'.

The effect of salinity levels on leaf area was also almost similar to those on shoot and root fresh weight. The decrease in leaf area attained a 76% in 'Jrid' however, in the sweet pepper 'Marconi' (S2) and (S3) had statistically the same effect on leaf area.

Wigniarajah *et al*. (1975) reported that in beans high NaCl levels inhibited leaf expansion and it was largely due to an inhibition of cell division rather than to cell expansion. Furthermore, at high salinity levels above 100 mM leaf abscission contribute to the reduced pepper leaf area (Chartzoulakis and Kalapaki 2000). This is caused by ion accumulation in pepper plant leaves particularly the old ones (Greenway and Munns 1980).

Chlorophyll content varied significantly under the different applied treatments in cultivar-dependent manner. The decrease in chlorophyll content was a 36% in 'Baker' a 52% in 'Marconi' and a 53% in 'Jrid'.

Generally our study demonstrated that increasing salinity levels is associated to a reduction in plant height, internode length, stem thickness as well as shoot and root fresh weight. This decrease is as important as the applied salinity level increase. The decrease in plant height under different salinity levels was reported in various crop species. Zribi *et al*. (2008) reported that increasing salinity reduced the stomatal conductance and the water potential for tomato (*Lycopersicon esculentum* Mill.). Keutgen and Pawelzik (2008) studying the effect of salinity on two different Strawberry (*Fragaria vesca*) cultivars namely 'Elsanta' and 'Korona', reported that salinity decreased mean fruit weight in strawberry fruits however, dry matter and contents of total soluble carbohydrates, as well as sweetness index of fruit remained unchanged. Ben Naceur *et al*. (2008) reported also a depressive effect of salt on germination, growth and grain yield in some North African wheat (*Triticum durum*) varieties. Botia *et al*. (2005) studied the effect of salinity on two (*Cucumis melo* L.) cultivars namely 'Amarillo Oro' and 'Galia' and found that salinity reduced the marketable yield by 39% and 12% respectively. Rubio *et al*. (2009) reported that salinity decreased total fruit yield and marketable fruit yield for the sweet pepper (*C. annuum* L. cv. Somontano) by 23% and 37%, respectively. The marketable fruit reduction by salt treatment was mainly due to the increase in the number of fruit affected by blossom-end rot. Finally Zhani *et al*. (2012) showed that increasing NaCl concentration, for three Tunisian chili pepper (*Capsicum frutescens*) cv: 'Tebourba', 'Korba' and 'Awlad Haffouz', induced a significant decrease on plant height, root length, leaves number, leaf area and chlorophyll amount. The fresh and dry weights

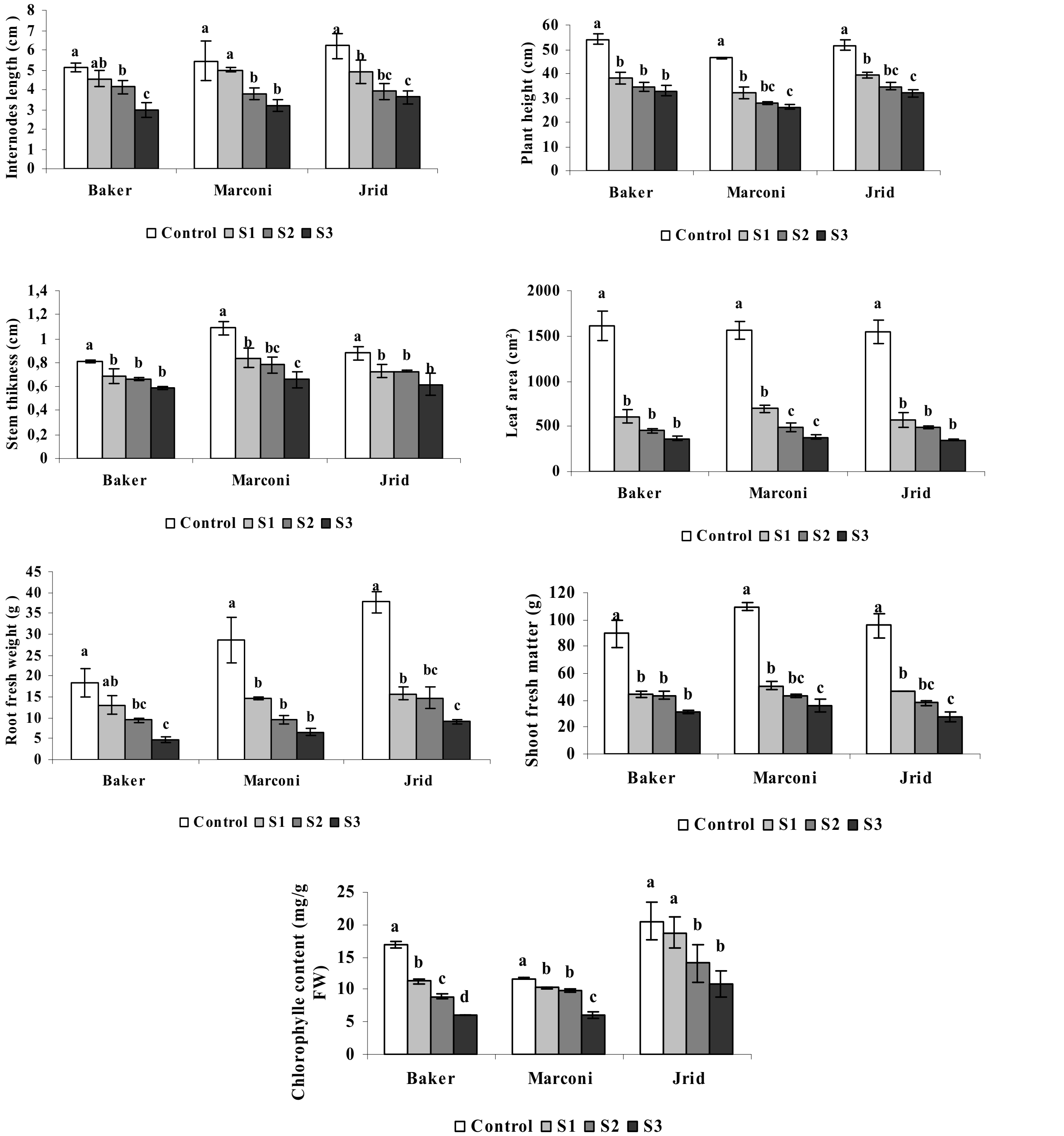

Fig. 1 Different growth parameters including plant height, internode length, stem thickness, shoot and root fresh weight, chlorophyll content and leaf area. Data are means of three replicates ± standard error. Bars marked with the same letters are not significantly different (LSD test, $P < 0.05$). S1 = 35 mM NaCl, S2 = 70 mM NaCl, S3 = 120 mM NaCl.

were also affected.

These results are in agreement with those of Ibn Maaouia-Houimli *et al*. (2008), who reported that salinity decreased the length, leaf area and dry matter of shoots. They also attributed the decline on plant growth mainly to the decrease in water availability but not to the injury of the photosynthetic apparatus. Rubio *et al*. (2009) also studying the effect of K^+ and Ca^{2+} fertilization on yield, blossom-end rot incidence and fruit quality in pepper under moderate salinity, reported that salinity decreased total fruit yield and marketable fruit yield. The marketable fruit yield reduction by salt treatment was mainly due to the increase in the number of fruit affected by blossom-end rot. Zribi *et al*. (2008) exploring the application of chlorophyll fluorescence for the diagnosis of salt stress in tomato cv 'Rio Grande' reported that tomato plants grown under controlled conditions and submitted during 28 days to saline stress ranging from 0 to 25, 50, 100, 150 and 200 mM of NaCl significantly decreased plant growth with increasing salinity. Finally, Zhani *et al*. (2012), studying the selection of salt tolerant Tunisian cultivars of chilli peppers (*Capsicum frutescens*) cv. 'Tebourba', 'Korba' and 'Awlad Haffouz' reported that different salinity stress levels had significant effect on germination percentage and germination time. Increasing NaCl concentration, for all cultivars, induced a significant decrease on plant height, root length, leaves number, leaf area and chlorophyll amount. The fresh and dry weights are also affected. The inhibition of vegetative growth in pepper at high salinity levels is associated with marked inhibition of photosynthesis. In fact, Nieman *et al*. (1988) reported that the salt stress reduced the growth of pepper because it decreases photosynthate assimilation.

Yield parameters

Different yield parameters including the percentage of fruit set, yield, average fruit weight and the percentage of blossom-end rot are shown in **Fig. 2**. For all the studied pepper cultivars the percentage of fruit set, yield, average fruit weight and the percentage of blossom-end rot varied

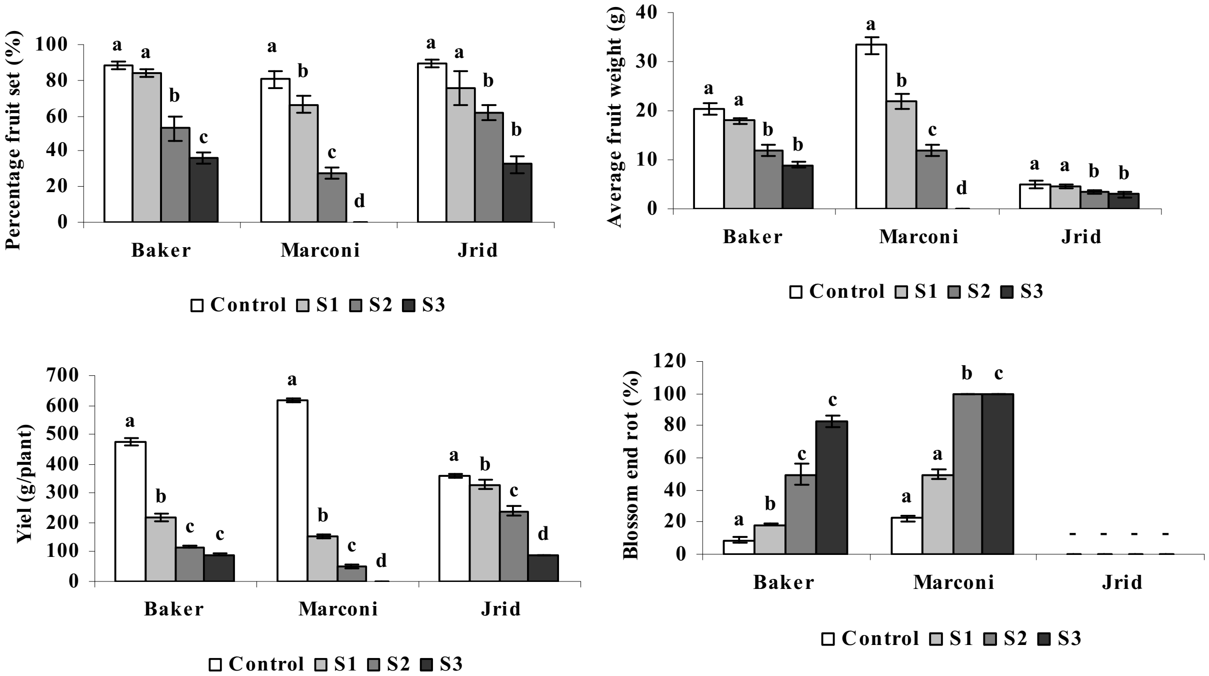

Fig. 2 Different yield parameters including the percentage of fruit set, average fruit weight, yield and the percentage of blossom-end rot. Data are means of three replicates ± standard error. Bars marked with the same letters are not significantly different (LSD test, $P < 0.05$). S1 = 35 mM NaCl, S2 = 70 mM NaCl, S3 = 120 mM NaCl.

significantly between the applied treatments ($P < 0.01$). From the result of the control (tap water), 'Marconi' (616.66 g/plant) appeared more productive than 'Baker' (20.33 g/plant) or 'Jrid' (5 g/plant). Even though non-treated 'Jrid' plants showed the highest percentage of fruit set (89.66%) compared to 'Baker' (88.33%) or 'Marconi' (80.33%). Total fruit yield decreased significantly with increasing salinity. The importance of this decrease was cultivar-dependant. In fact, although total yield was significantly influenced by different applied salinity levels ($P < 0.01$) in all cultivars, (S2) and (S3) showed statistically similar results. Compared to the control (tap water), the decrease in pepper yield was 75.19% in 'Jrid', 80.77% in 'Baker' and 100% in 'Marconi' which was directly correlated to a decrease in fruit set.

In our study although the three salinity levels used induced an increase in rotted fruit percentage by 347.82% in 'Marconi' and 818% in 'Baker', interestingly, under all the applied salinity levels no rotted fruits were observed in 'Jrid'. In a previous study, R'him *et al.* (2008) studying the blossom-end rot incidence in relation to morphological parameters and calcium content in fruit of four pepper varieties, concluded that 'Marconi' and 'J27' were more susceptible to blossom-end rot than 'Jrid' and 'Beldi'.

It appears from our results that a severe salinity level (S3), decreased significantly and considerably the percentage of fruit set, average fruit weight and therefore the yield in all the studied pepper cultivars. Similarly, Chartzoulakis and Kalapaki (2000) observed that pepper yield decrease under salinity above 10 mM and that the yield per plant was only affected at salinity above 50 mM. However, Rubio *et al.* (2009) attributed the decrease in fruit yield to a decrease in the percentage of fruit set and therefore to the number of fruit per plant. In addition, Rubio *et al.* (2009) reported that salinity decreased total fruit yield and marketable fruit yield for the sweet pepper (*C. annuum* L. cv. 'Somontano') by 23 and 37%, respectively. The marketable fruit reduction by salt treatment was mainly due to the increase in the number of fruit affected by blossom-end rot.

Our results showed also that plant yield was largely decreased even under moderate salinity (S1). In fact, this reduction was 50% in 'Jrid', 54.68% in 'Baker' and 75.13% in 'Marconi'. In addition, in all the studied pepper cultivars salinity-associated decrease in yield started at the same salinity level as reported by Chartzoulakis and Kalapaki (2000). However, since the yield reduction rate in 'Jrid' was obviously lower than that in both cultivars 'Baker' and 'Marconi' we can conclude that 'Jrid' is more suitable when saline water should be used for irrigation.

CONCLUSIONS

This study has demonstrated that responses of pepper to salinity differ according to their genotypes. Salinity levels decreases the growth and yield parameters even though this decrease was cultivar-dependent the pepper 'Jrid' characterized by the highest pungency showed an important tolerance to high salinity levels and produced fruit with no blossom-end rot under all the studied salinity levels. This result can help the growers to choose such varieties in salt-rich fields or when only saline water should be used for crop irrigation.

REFERENCES

Ben Naceur M, Rahmoune C, Sdiri H, Meddahi ML, Selmi M (2001) Effet du stress salin sur la germination, la croissance et la production en grains de quelques variétés maghrébines de blé. *Science et Changement Planétaire/ Sécheresse* **12 (3)**, 167-174

Botia P, Navarro JM, Cerdà A, Martínez V (2005) Yield and fruit quality of two melon cultivars irrigated with saline water at different stage of development. *European Journal of Agronomy* **23**, 243-253

Chartzoulakis K, Klapaki G (2000) Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages. *Scientia Horticulturae* **86**, 247-260

Groupement Interprofessionnel des Légumes (GIL) (2009) *Groupement Interprofessionnel des Légumes*, Ministère de l'agriculture et des Ressources Hydrauliques

Greenway H, Munns R (1980) Mechanisms of salt tolerance in nonhalophytes. *Annual Review of Plant Physiology* **31**, 149-190

Ibn Maaouia-Houimli S, Denden M, Ben El Hadj S (2008) Induction of salt tolerance in pepper (*Capsicum annuum*) by 24-epibrassinolide. *EurAsian Journal of Biosciences* **2 (10)**, 83-90

Ibn Maaouia-Houimli S, Denden M, Dridi-Mouhandes B, Ben Mansour-Gueddes S (2011) Caractéristiques de la croissance et de la production en fruits chez trois variétés de piment (*Capsicum annuum* L.) sous stress salin. *Tropicultura* **29 (2)**, 75-81

Keutgen JA, Pawelzik E (2008) Impact of NaCl stress on plant growth and mineral nutrient assimilation in two cultivars of strawberry. *Environmental and Experimental Botany* **65 (2-3)**, 170-176

Maas EV (1986) Salt tolerance of plants. *Applied Agricultural Research* **1**, 12-26

Mahajan S, Tuteja N (2005) Cold, salinity and drought stresses: An overview. *Archives of Biochemistry and Biophysics* **444**, 139-158

Mougou A (1984) Evolution de la résistance à la sécheresse chez plusieurs espèces de tomate. PhD thesis, National Agronomic Institute of Tunisia, Tunis, 208 pp

Munns R, Termaat A (1986) Whole-plant responses to salinity. *Australian Journal of Plant Physiology* **13**, 143-160

Navarro JM, Flores P, Garrido C, Martínez V (2006) Changes in the contents of antioxidant compounds in pepper fruits at different ripening stages, as affected by salinity. *Food Chemistry* **96**, 66-73

Nieman RH, Clark RA, Pap D, Ogata G, Maas EV (1988) Effects of salt stress on adenine and uridine nucleotide pools. *Journal of Experimental Botany* **39**, 301-309

Niu G, Rodriguez DS, Crosby K, Leskovar D, Jifon J (2010) Rapid screening for relative salt tolerance among Chile pepper genotypes. *Hort Science* **45**, 1192-1195

R'Him T, Jebari H (2008) La nécrose apicale en relation avec certains paramètre morphologique et la teneur en calcium dans les fruits chez quatre variétés de piment (*Capsicum annuum* L.). *Biotechnologie, Agronomie Société et Environnement* **12 (4)**, 361-366

Rubio JS, Garcia-Sàncheza F, Rubio F, Martinez V (2009) Yield, blossom-end rot incidence, and fruit quality in pepper plants under moderate salinity are affected by K+ and Ca^{2+} fertilization. *Scientia Horticulturae* **119**, 79-87

Van Der Beek JG, Ltifi A (1991) Evidence for salt tolerance in pepper varieties (*Capsicum annuum* L.) in Tunisia. *Euphytica* **57**, 51-56

Wignarajah K, Jennings DH, Handley JF (1975) The effect of salinity on growth of *Phaseolus vulgaris* L. I. Anatomical changes in the first trifoliate leaf. *Annals of Botany* **39**, 1029-1038

Zhani K, Elouaer MA, Aloui H, Hannachi C (2012) Selection of a salt tolerant Tunisian cultivar of chilli pepper (*Capsicum frutescens*). *Eurasian Journal of Biosciences* **6**, 47-59

Zribi L, Gharbi F, Rezgui F, Rejeb S, Nandi H, Rejeb MN (2008) Application of chlorophyll fluorescence for the diagnoses of salt stress in tomato *"Solanum lycopersicum* (variety Rio Grande)". *Scientia Horticulturae* **120 (3)**, 367-372