Research Article

Md. Mostafizur Rahman*, Mobarok Hossain, Kaniz Fatima Binte Hossain, Md. Tajuddin Sikder, Mashura Shammi, Md. Rasheduzzaman, M Anwar Hossain, AKM Mahbubul Alam, M Khabir Uddin

Effects of NaCl-Salinity on Tomato (*Lycopersicon esculentum* Mill.) Plants in a Pot Experiment

<https://doi.org/10.1515/opag-2018-0061>

received February 19, 2018; accepted October 23, 2018

Keywords: salinity, agriculture, crop yield, organic matter, plant morphology

Abstract: Salinity intrusion is a global concern in relation to sustainable agricultural practices. About three-fourths of the coastal area in Bangladesh is affected by different levels of salinity. This study was conducted to observe the effects of NaCl-salinity on tomato (*Lycopersicon esculentum* Mill.) plants in a pot experiment. Morphological properties and yield of five varieties of Bangladesh Agricultural Research Institute tomato (BARI-T 1, BARI-T 2, BARI-T 3, BARI-T 4, and BARI-T 5) plants were exposed to NaCl-salinity (2, 4, 6 and 8 dS/m) through irrigation. Morphological properties such as number of leaves, leaf length, leaf width, number of days of flowering, number of flowers and number of branches were observed. Results showed that morphological properties of all studied tomato plants were affected by increasing NaCl-salinity, except number of days of flowering, and yield was reduced compared to the control group (tap water; 0.043 dS/m). The post-harvest pot soil was also affected by NaCl-salinity irrigation. This study can be useful in selecting salt-tolerant varieties in saline-affected areas.

1 Introduction

Salinity is one of the main obstacles to horticultural production, such as tomato cultivation, in the coastal and offshore areas of Bangladesh. The problems of salinity in irrigated agriculture in the tropics and sub-tropics are increasing day by day. Salinity intrusion has been increasing globally and threatens the community in the coastal area by contaminating the groundwater and reducing the consumptive value (Fatorić and Chelleri 2012; Safi et al. 2018). According to the IPCC report, salinity intrusion is associated with a rise in temperature and water stress, and the problem might be more serious with global climate change (IPCC 2014). Anthropogenic factors are the major driving force of increasing landward salinity (Singh 2014). In Bangladesh, about one million hectares of arable land in the coastal and off-shore areas are affected by varying degrees of salinity (Karim et al. 1990; Shammi et al. 2016). The reasons for increasing salinity in Bangladesh are: a) intrusion of sea water due to rivers drying during winter, b) cyclones in the coastal area and c) influx of salt from the ground to the surface through capillary movement during the dry season. Cropping intensity in salinity affected areas is decreased (62-114%) compared to the national average (159%) (Karim et al. 1990). Recent studies have reported higher salinity content than the recommended salinity level (<700 $\mu\text{S}/\text{cm}$) in the south-west coastal region of Bangladesh, affecting both surface and ground water (Shammi et al. 2016; Islam et al. 2016). Salinity is becoming a major problem in the south-west coastal region of Bangladesh, where irrigation water quality is affected by salinity (Islam et al., 2018) and every year, 200 ha of fodder crop area are affected by salinity (Alam et al. 2017). Excessive withdrawal of groundwater for irrigation and other uses may also contribute to increased salinity,

***Corresponding author: Md. Mostafizur Rahman**, Department of Environmental Sciences, Jahangirnagar University, Dhaka-1342, Bangladesh, E-mail: mmrahman@ees.hokudai.ac.jp

Mobarok Hossain, Mashura Shammi, M Anwar Hossain, M Khabir Uddin, Department of Environmental Sciences, Jahangirnagar University, Dhaka-1342, Bangladesh

Md. Mostafizur Rahman, Kaniz Fatima Binte Hossain, Md. Tajuddin Sikder, Graduate School of Environmental Science, Hokkaido University, Sapporo 060-0810, Japan

Mashura Shammi, Department of Environmental Pollution and Process Control, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi-830011, Xinjiang, PR China

Md. Rasheduzzaman, Department of Ecosystem Studies, School of Environmental Science, The University of Shiga Prefecture, Japan, 522-8533

M Anwar Hossain, Communication Division, Civil Aviation Authority of Bangladesh, Dhaka-1229, Bangladesh

AKM Mahbubul Alam, Senior scientific officer, Pulse research centre, BARI, Gazipur-1701, Bangladesh

due to inadequate drainage for leaching and removal of salts (Corwin et al. 2007).

Salinity disturbs crop establishment by decreasing the germination percentage and delaying seedling emergence (Begum et al. 1996; Siddiqy et al. 2014). At the later stage, salinity decreases the yield by affecting growth parameters. Salinity affects plant growth by disturbing water balance, creating an imbalance in plant nutrition and affecting plant physiological and biochemical processes (Yeo et al. 1985; Karim et al. 1993).

In Bangladesh, coastal areas comprise about 2.86 million ha and cover about 30 % of the total agricultural land of the country. Of this, nearly 1.056 million ha of cultivable land are affected by varying degrees of salinity, and 75% of cultivated land (very low to moderate salinity) are suitable for successful crop production (SRDI 2010). Moreover, tomato production in Bangladesh (6.46 t/ha) is lower than the world average (26.29 t/ha) (FAO 2011). A judicious selection of crops for saline soils is therefore considered an important intervention option for crop cultivation in saline-affected areas. Therefore, this study was carried out to examine the effects of NaCl-salinity on growth parameters, such as number of leaves, leaf length, leaf width, days of flowering, number of flowers, branches of plants and yield, of five Bangladesh Agriculture Research Institute-tomato (BARI-T) varieties in pot experiments under natural environmental conditions.

2 Materials and methods

The pot experiment was conducted under natural environmental conditions at the Net House (Laboratory of Oil Seed and Pulse Research Centre), BARI, Gazipur, Bangladesh. The research was conducted on five different varieties of tomato (*Lycopersicon esculentum* Mill.) plant (BARI-T 1, BARI-T 2, BARI-T 3, BARI-T 4, and BARI-T 5) with three replications. *The selected tomato plants are approved for commercial cultivation by BARI.* The effects of different levels of NaCl-salinity on the growth parameters and yield of tomato plants were studied.

2.1 Preparation of pot soil and collection of post-harvest soil samples

The soil was collected from one of the experimental fields on the BARI campus. Then, the collected soil was equally (20 kg per pot) divided into 75 (each replication has 25 pots) experimental pots (45 cm x 30 cm) for planting

the tomato plants. For preparing the soil, base doses of potassium (K_2O), phosphorous (P_2O_5) and gypsum as 81, 33 and 27 kg/ha, respectively, were applied to the soil. Urea was applied to each pot at the tiller initiation stage at 120 kg/ha. Before planting, 0.60 g TSP, 0.81 g MP and 0.95 g gypsum per pot were incorporated into the soil, and sufficient water was added to prepare the soil. The pots were kept in natural sunshine until harvesting of the crops. After that, post-harvest soil samples were taken from two different depths (top soil, 1-7 cm and subsoil, 8-15 cm) of each pot and put into separate polythene bags for further analysis. Triplicate soil samples from the same depth and the same stand were mixed together to make composite samples. After collection, the soil was dried and crushed for chemical analysis.

3 Experimental setup

3.1 Treatment design

Five different levels of NaCl-salinity (in terms of electrical conductivity) were applied as 0.043 dS/m (control), 2 dS/m, 4 dS/m, 6 dS/m and 8 dS/m throughout the experiment. Deionized (0.000048 dS/m) water was used to make irrigation water with the desired NaCl-salinity. The NaCl-salinity range was chosen for the evaluation of low to moderate salinity stress on tomato plants, as stated by SRDI (2010). After the treatment, selected growth parameters of each experimental tomato plant were studied, including number of leaves, leaf length, leaf width, number of flowers, days of flowering, number of branches and yield.

3.2 Planting of tomato seedlings

The healthy tomato seedlings were kindly provided by the Laboratory of Oil Seed and Pulse Research Centre, BARI, Bangladesh. Uniformly sized tomato seedlings (25 days old) were directly planted in the prepared experimental pots (eight seedlings per pot). After planting, tap water (0.043 dS/m) was applied to control pots and 2 dS/m NaCl-salinity irrigation water was added to the rest of the pots. When the first new leaf appeared, i.e. ten days after emergence (DAE), irrigation water with selected NaCl-salinity (2, 4, 6 and 8 dS/m) was applied, except for the control pots. Plants in the control groups were irrigated with tap water with an electrical conductivity (EC) of 0.043 dS/m. The salt solution was applied on a daily basis until harvesting.

3.3 Observation and data collection

The experiment was laid out in a completely randomized design, with three replications having five treatments. During the investigation, growth parameters were noted in the fields at three times, i.e. 15, 30 and 45 DAE. All data were collected by direct observation with the help of measuring equipment, such as measuring tape and a digital weight machine. Four randomly selected plants were used from each treatment group for data collection.

3.4 Soil sample analysis

Soil pH was determined by pH meter (Mettler-Toledo AG 8603), EC was measured by portable multi-meter (Hach, sensION + MM150), P was analysed by phosphorus analyzer, K, Ca, and Na were analyzed by using AAS (AA240Z, VARIAN spectra AA-55B), organic matter (OM) was determined by specific colorimetric method and total N was studied via a modified Kjeldhal method (Stark and Hart, 1996). All data were analyzed by one way-ANOVA, followed by post hoc analysis (Tukey's range test), using the SPSS 16.0 program. A difference was only considered significant at $p < 0.05$.

Ethical approval: The conducted research is not related to either human or animal use.

4 Results

4.1 Effects of NaCl-salinity on leaf traits

The number of leaves, leaf length, and leaf width were recorded after NaCl-salinity treatment of studied tomato plants. Results for the leaf traits showed that different tomato plants showed distinct responses to salinity stress (Fig. 1-3). All five tomato varieties showed a significant ($p < 0.05$) decrease in number of leaves in response to 6 dS/m and 8 dS/m salinity compared to the control group (Fig. 1). However, upon 2 dS/m salinity treatment, only BARI-T 2 and BARI-T 4 showed a significant ($p < 0.05$) decrease in leaf number compared to the control treatment, whereas BARI-T 1 and BARI-T 4 also showed significantly ($p < 0.05$) reduced numbers of leaves with 4 dS/m NaCl-salinity (Fig. 1). Similarly, leaf length of all tomato plants was significantly ($p < 0.05$) reduced in the 6 dS/m and 8 dS/m salinity treatment groups compared to the control group (Fig. 2). On the other hand, only BARI-T 4 showed a significantly ($p < 0.05$) lowered leaf length in

response to 4 dS/m salinity (Fig. 2). Moreover, another leaf trait (leaf width) responded similarly to 6 dS/m and 8 dS/m NaCl-salinity in all tomato varieties (except BARI-T 3 against 6 dS/m treatment) (Fig. 3). However, BARI-T 5 showed a significant response to 2 dS/m and 4 dS/m, whereas BARI-T 1 also showed a significant response to 4 dS/m salinity treatment (Fig. 3) compared to the control group (tap water).

4.2 Effects of NaCl-salinity on flowering traits

Selected flowering traits, such as number of days of flowering, number of flowers and number of branches were also counted during the entire period of the study. Results showed that, compared to the control group, all five tomato varieties showed significant differences in the number of days required for flowering in response to the treatment regime (2-8 dS/m NaCl-salinity) (Fig. 4). In addition, the number of flowers in all five tomato varieties was significantly ($p < 0.05$) lower than in the control group upon 4, 6 and 8 dS/m NaCl-salinity stress (Fig. 5). However, only two varieties (BARI-T 1 and BARI-T 2) showed a significant ($p < 0.05$) reduction in flower numbers compared to the control at 2 dS/m salinity treatment (Fig. 5). On the other hand, at 6 and 8 dS/m salinity stress, all five tomato plants showed a significant reduction in the number of branches, except BARI-T 3 (Fig. 6). However, BARI-T 3 and 5 showed a significant reduction in number of branches at 4 dS/m, and BARI-T 2 and 4 showed similar results in response to 2 dS/m salinity stress in comparison with the control (Fig. 6).

4.3 Effects of NaCl-salinity on fruit yield

Fruit yield was considered to be one of the most important parameters of tomato plants in relation to the effect of NaCl-salinity in this study. The net fruit yield was calculated in kg/yield/plant unit. The net production of tomato was adversely affected by NaCl-salinity (Fig. 7). All studied tomato plants were found to have a significantly reduced yield ($p < 0.05$) at 6 and 8 dS/m salinity compared to the control plants (Fig. 7). However, at 4 dS/m salinity, treatment groups BARI-T 1, BARI-T 4 and BARI-T 5 also showed a significantly decreased net yield compared to control plants (Fig. 7).

Fig. 1. Effects of NaCl-salinity on number of leaves in five BARI-T plants. Error bars indicate mean $\pm$ SD (n=3). Asterisk *, $\blacktriangle$, #, ♦, and • denote a significant difference between the saline-treated group and control group of BARI-T 1, BARI-T 2, BARI-T 3, BARI-T 4 and BARI-T 5, respectively at $p < 0.05$.

Fig. 2. Effects of NaCl-salinity on length of the leaf in five BARI-T plants. Error bars indicate mean $\pm$ SD (n=3). Asterisk *, $\blacktriangle$, #, ♦, and • denote a significant difference between the saline-treated group and control group of BARI-T 1, BARI-T 2, BARI-T 3, BARI-T 4 and BARI-T 5, respectively at $p < 0.05$.

Fig. 3. Effects of NaCl-salinity on width of the leaf in five BARI-T plants. Error bars indicate mean $\pm$ SD (n=3). Asterisk *, $\blacktriangle$, #, ♦, and • denote a significant difference between the saline-treated group and control group of BARI-T 1, BARI-T 2, BARI-T 3, BARI-T 4 and BARI-T 5, respectively at $p < 0.05$.

Fig. 4. Effects of NaCl-salinity on number of days of flowering in five BARI-T plants. Error bars indicate mean $\pm$ SD (n=3).

Fig. 5. Effects of NaCl-salinity on number of flowers in five BARI-T plants. Error bars indicate mean $\pm$ SD (n=3). Asterisk *, $\blacktriangle$, #, $\blacklozenge$, and $\bullet$ denote a significant difference between the saline-treated group and control group of BARI-T 1, BARI-T 2, BARI-T 3, BARI-T 4 and BARI-T 5, respectively at $p < 0.05$.

Fig. 6. Effects of NaCl-salinity on number of branches in five BARI-T plants. Error bars indicate mean $\pm$ SD (n=3). Asterisk *, $\blacktriangle$, #, $\blacklozenge$, and $\bullet$ denote a significant difference between the saline-treated group and control group of BARI-T 1, BARI-T 2, BARI-T 3, BARI-T 4 and BARI-T 5, respectively at $p < 0.05$.

Fig. 7. Effects of NaCl-salinity yield in five BARI-T plants. Error bars indicate mean $\pm$ SD (n=3). Asterisk *, $\blacktriangle$, #, $\blacklozenge$, and $\bullet$ denote a significant difference between the saline-treated group and control group of BARI-T 1, BARI-T 2, BARI-T 3, BARI-T 4 and BARI-T 5, respectively at $p < 0.05$.

5 Discussion

A line of evidence suggests that, depending on plant species and variety, there is great variability in resistance to salinity (Ashraf and Foolad 2007). The visual appearance of tomato plants during salt stress can be used as an indicator of plant growth under different salinity conditions. In this study, low (2 dS/m) to moderate (8 dS/m) salinity stress was investigated because usually tomato plants are expected to survive within a moderate salinity range (Siddiky et al. 2015). From the results of leaf traits, it can be revealed that all studied tomato varieties were negatively affected by 6 and 8 dS/m salinity stress (Fig. 1-3). Therefore, the studied tomato plants are susceptible to moderate levels of salinity. However, a solution culture experiment showed that the leaf symptoms “BT14 (BARI Tomato 14)” and “BHT5 (BARI Hybrid Tomato 5)” are tolerant germplasm to salinity with score 1.0 (1 most tolerant and 4 is least tolerant) (Siddiky et al. 2014). Different tolerance ranges to salinity were also reported based on the morphological features of different growth stages of tomato plants (Chookhampaeng et al. 2007; Oztekin and Tuzel 2011). The effects on early developmental stages ultimately produce some negative outcomes in net crop production. For instance, the fruit weight of tomato was reported to show a significant variation among different germplasms of tomato, and in general, there was a significant decrease in fruit yield compared to controls in plants treated with high concentrations of salt (Siddiky 2012; Siddiky et al. 2015). In this study, a significant decrease in tomato yield

was found in all five studied BARI-T (1-5) varieties (Fig. 7) at 6 and 8 dS/m salinity levels. The ionic imbalance in the tomato plant due to excess amounts of salt might be the reason for the reduction of growth parameters of the tomato plants under salinity stress. It was stated that under salinity condition, the uptake of Na^+ is generally high compared to K^+ and Ca^{2+} , thus inducing ion deficiencies (Singh et al. 2004).

Moreover, the addition of NaCl solution to the pot soil might have deleterious effects on the physico-chemical properties of the soil (Fontes and Ronchi 2002). Therefore, the physico-chemical properties such as pH, OM, Na, K, Ca, P and total N status of the post-harvest pot soil were studied. The results of pot soil properties after NaCl-salinity (2, 4, 6, and 8 dS/m) irrigation compared to fresh water (control) irrigation are shown in Table 1. It is clear from the findings that there is a significant effect of NaCl-salinity on the physico-chemical properties of post-harvest pot soil. In the control pot, the initial pH of the pot soil was 5.02, and after increasing salinity, the maximum pH reached a value of 6.15 (8 dS/m). For tomato cultivation, the optimum soil pH range lies between 6.00 to 6.8, so application of moderate levels of salinity maintains soil pH within the tolerable range. The OM also increased with the addition of NaCl-solution to the soil, rising to 1.68% (8 dS/m) compared to the control (1.49%). The Na concentration eventually increased from 0.56 mg/kg (in control) to 2.01 mg/kg (8 dS/m) in treated soil and K concentration rose from 0.37 mg/kg (control) to 0.85 mg/kg (8 dS/m). Likewise, the addition of NaCl solution increased the concentration of Ca from 3.73 mg/kg (control)

Table 1. Physico-chemical properties of post-harvest soil from the experimental pots.

Salinity level (dS/m)	pH	OM (%)	Na (mg/kg)	K (mg/kg)	Ca (mg/kg)	P (mg/kg)	Total N (%)
Control	5.02	1.49	0.56	0.37	3.73	1.35	0.12
2	5.20	1.50	1.21	0.49	4.25	2.15	0.09
4	5.70	1.62	1.53	0.65	5.80	2.50	0.06
6	5.94	1.65	1.87	0.70	5.96	3.04	0.05
8	6.15	1.68	2.01	0.85	6.15	3.75	0.05

to 6.15 mg/kg (8 dS/m). In response to application of NaCl solution to the pot, almost every studied parameter (pH, OM, Na, K, Ca, and P) increased with salinity, except total nitrogen (N) (Table 1). It is thus noted, that with increasing salinity, growth-affecting parameters change in soil, and ultimately fruit production halves. The decrease in total N might be the cause of reduction in growth and development of tomato plants (Fontes and Ronchi 2002).

6 Conclusion

As salinity tolerance of crops has been considered a promising adaptation option to ensure sustainable agricultural practice, this scientific study was carried out to discover a saline-tolerant variety of tomato plant. It confirmed that NaCl-salinity significantly affects the growth of five varieties of BARI tomato plants. Under moderate salinity stress (>4 dS/m), none of the studied tomato plants (BARI-T 1-5) is suitable for cultivation. Based on this physiological study, it might be a very good starting point to further investigate saline-tolerant varieties using biochemical analyses.

Acknowledgement: The authors would like to convey thanks to the laboratory staff at Bangladesh Agricultural Research Institute (BARI) for their kind cooperation during the study.

Conflict of interest: Authors declare no conflict of interest.

References

- Ashraf M., Foolad M.R., Improving plant abiotic-stress resistance by exogenous application of osmoprotectants glycine betaine and proline, *Environ. Exp. Bot.*, 59, 206-216
- Begum F., Sultana W., Nessa A., Begum S.N., Effect of NaCl salinity stress on seed germination and seedling growth of maize, *Seed Res.*, 1996, 24, 97-101
- Chookhampaeng S., Pattanagul W., Theerakulpisut P., Screening some tomato commercial cultivars from Thailand for salinity tolerance, *Asian J. Plant Sci.*, 2007, 6, 788-794
- Corwin D.L., Rhoades J.D., Šimůnek J., Leaching requirement for soil salinity control: Steady-state versus transient models, *Agric. Water Manage.*, 2007, 90, 165-180
- FAO, Global network on integrated soil management for sustainable use of salt affected soils, FAO, Rome
- Fatorić S., Chelleri L., Vulnerability to the effects of climate change and adaptation: The case of the Spanish Ebro Delta, *Ocean Coast. Manage.*, 2012, 60, 1-10
- Fontes P.C.R., Ronchi C.P., Critical values of nitrogen indices in tomato plants grown in soil and nutrient solution determined by different statistical procedures. *Pesq. Agropec. Bras.*, 2002, 37, 1421-1429
- IPCC, Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. In: Field C.B., et al. (Eds.), Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge, 2014
- Islam M.A., Zahid A., Rahman M.M., Rahman M.S., Islam M.J., Akter Y., et al., Investigation of groundwater quality and its suitability for drinking and agricultural use in the south central part of the coastal region in Bangladesh, *Expo. Health*, 2016, 9, 27-41
- Islam M.A., Rahman M.M., Bodrud-Doza M., Muhib M.I., Shammi M., Zahid A., et al., A study of groundwater irrigation water quality in south-central Bangladesh: a geo-statistical model approach using GIS and multivariate statistics, *Acta Geochim.*, 2018, 37, 193-214
- Karim M.A., Nawata E., Sigenaga S., Effects of salinity and water stress on the growth, yield and physiological characteristics in hexaploid triticale, *Jpn. J. Trop. Agric.*, 1993, 37, 46-52
- Karim Z., Hussain S.G., Ahmed M., Salinity problems and crop intensification in the coastal regions of Bangladesh, *BARC, Dhaka*, 1990
- Oztekin G.B., Tuzel Y., Comparative salinity responses among tomato genotypes and rootstocks, *Pak. J. Bot.*, 2011, 43, 2665-2672
- Safi A., Rachid G., El-Fadel M., Doummar J., Abou Najm M., Alameddine I., Synergy of climate change and local pressures on saltwater intrusion in coastal urban areas: effective adaptation for policy planning, *Water Int.*, 2018, 43, 145-164
- Shammi M., Karmaker B., Rahman M.M., Islam M.S., Rahman R., Uddin M.K., Assessment of Salinity Hazard of Irrigation Water Quality in Monsoon Season of Batiaghata Upazila, Khulna District, Bangladesh and adaptation strategies, *Pollution*, 2016, 2, 183-197

- Shammi M., Rahman R., Rahman M.M., Moniruzzaman M., Bodrud-Doda M., Karmakar B., Uddin M.K., Assessment of salinity hazard in existing water resources for irrigation and potentiality of conjunctive uses: a case report from Gopalganj district, Bangladesh, *Sustain. Water Resour. Manag.*, 2016, 2, 369–378
- Siddiky M.A., Khan M.S., Rahman M.M., Uddin M.K., Performance of tomato (*Lycopersicon esculentum* Mill.) germplasm to salinity stress, *Bangladesh J. Bot.*, 2015, 44, 193-200
- Siddiky M.A., Sardar P.K., Hossain M.M., Khan M.S., Uddin M.K., Screening of different tomato varieties in saline areas of Bangladesh, *Int. J. Agric. Res. Innov. Technol.*, 2012, 2, 13-18
- Siddiky M.A., Khan M.S., Rahman M.M., Uddin M.K., Performance of tomato (*lysopersicon esculentum*) germplasms grown in Bangladesh for salinity tolerance, *Agrivita*, 2014, 36, 128-133
- Singh A.L., Basu M.S., Singh N.B., Mineral disorders of groundnut, National Research Center for Groundnut (ICAR), Junagadh, 2004
- Singh A., Optimization modelling for seawater intrusion management, *J. Hydrol.*, 2014, 508, 43–52
- Soil Resources Development Institute (SRDI), Aaline soils of Bangladesh, Ministry of Agriculture, Dhaka, 2010
- Stark J.M., Hart S.C., Diffusion technique for preparing salt solutions, Kjeldahl Digests, and Persulfate Digests for Nitrogen-15 Analysis, *Soil Sci. Soc. Am. J.*, 1996, 60, 1846-1855
- Sultana N., Ikeda T., Itoh R., [Effect of NaCl salinity on photosynthesis and dry matter accumulation in developing rice grains](#), *Environ. Exp. Bot.*, 1999, 42, 211-220
- Yeo A.R., Capcorn S.J.M., Flowers T.J., The effect of salinity upon photosynthesis in rice (*Oryza sativa* L.): gas exchange by individual leaves in relation to their salt content, *J. Exp. Bot.*, 1985, 36, 1240-1248