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INFLUENCE OF SODIUM CHLORIDE ONTO GROWTH AND FLOWERING OF *ISOTOMA AXILLARIS* LINDL.

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Abstract

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To assess the effect of sodium chloride on growth and flowering of *Isotoma axillaris* their plants grew in pots filled with peat substrate and with sodium chloride. In 2011 the following dosages of sodium chloride were applied: 0, 5, 10, and 15 $g \cdot dm^{-3}$. In 2012 the dosages of sodium chloride were increased, and the following amounts were applied respectively: 0, 10, 20, and 30 $g \cdot dm^{-3}$. The presence of sodium chloride in the substrate diminished decorative qualities of the species under study, which included growth and flowering inhibition together with the decrease in the index of leaves greenness. Moreover, both the fresh and the dry matter of the plants decreased together with the increase in sodium chloride concentration in the substrate. This compound had also a negative influence onto the water percentage in the plants.

Keywords: sodium chloride, salinity, *Isotoma*

Abbreviations: NaCl – sodium chloride, EC – Electric Conductivity, SPAD – Soil-Plant Analyses Development

Introduction

Green belts, the important parts of which are flower beds (Majdecka – Strzeżek 2008), usually constitute at about 30% of the city area. As it is stressed by Todorova et al. (2004) creating flower beds lining streets is appreciated by street users. While designing flower beds in cities one needs to pay special attention to plant tolerance to sodium chloride (NaCl). As it is emphasized by Howard, Maier (2007) the most common way of de-icing street surface in winter is using this particular chemical compound. NaCl was first used for this purpose in 1930 (Ramakrishna and Viraraghavan, 2005). The major problem connected with sodium chloride usage is the fact that it is displaced together with the splashing of slush ice by moving vehicles and during the period of thaw. Therefore long-term monitoring of NaCl contents in city areas is of great importance. Moreover, excess accumulation of sodium chloride diminishes also soil permeability (Cunningham et al., 2008).

Chlorine is a microelement that takes part in numerous physiological and biochemical processes in plants. However, the excess amount of this element has a negative effect onto plants (Komosa and Gorniak, 2012). Plant reaction to high concentration of sodium chloride could be growth inhibition, occurrence of chlorosis, which might result in plant withering. Another problem is the threat of forcing out species which are not resistant to sodium chloride by halophytes.

There is a wide selection of plants that can be used on flower beds (Warcholinska and Fortuna and Antoszkiewicz, 2011). New plant species are offered for sale every year. *Isotoma axillaris* Lindl is a new species designed to be used on flower beds. Plants reach 30 cm in height. In Australia, where it comes from, it blooms at the end of winter and at the beginning of summer. In Poland it is an annual plant flowering from the middle of May up to the first autumn frosts. Its blue, white or pink flowers are hung on long peduncles. As far as the plant reaction to sodium chloride is concerned there is no information in the available literature, which is why deter-

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mining the tolerance of *Isotoma axillaris* to NaCl was considered purposeful.

Materials and Methods

The experiment was conducted in the years 2011 – 2012 in the greenhouse of the Department of Ornamental Plants of Poznań University of Life Sciences. Plants were grown in pots with saucers placed on tables.

Specimens of *Isotoma axillaris* at the beginning of the blooming period constituted the plant material. The plants were obtained from shoot cuttings rooted in April in the greenhouse. In the middle of April young plants were put into 0.3 dm^3 pots. After two weeks their tops were pinched in order to promote better tillering. During that time plants were not treated with any stress factors.

In 2011 the plants were placed in pots on 27 July. In 2012 the plants characterized by similar morphological parameters as the year before were planted into pots on 18 of June. In 2011 the planting took place later due to cold spring and extended growth period. 1.5 dm^3 flower pots filled with peat substrate were used in the process. Mineral components were added to the substrate up to the optimum levels for annual plants, and the pH of the substrate was within the range of 6.5 – 6.8. Each pot was filled with 1 dm^3 of the substrate. Afterwards the substrate was watered with 0.15 dm^3 of NaCl solution. In 2011 the following dosages of NaCl were used: 0, 5, 10, and 15 $g \cdot dm^{-3}$. In 2012 the amount of sodium chloride was increased and the following dosages were applied: 0, 10, 20, and 30 $g \cdot dm^{-3}$. The plants in the control group were watered with 0.15 dm^3 of tap water. Depending on the NaCl dosage applied different EC values of the substrate were obtained and they are presented in Table 1. Plants with the root clump of 0.3 dm^3 were planted in the substrate prepared in the mentioned above way. In order to avoid the shifts in NaCl content during the experiment each pot was placed on the saucer. Tap water was used to water the plants under study.

Table 1
Using NaCl ($g \cdot dm^{-3}$) and obtained medium EC

2011 year		2012 year	
NaCl $g \cdot dm^{-3}$	EC [$mS \cdot dm^{-3}$]	NaCl $g \cdot dm^{-3}$	EC [$mS \cdot dm^{-3}$]
0 g	0.569	0 g	0.506
5 g	1.151	10 g	1.95
10 g	1.352	20 g	3.22
15 g	1.681	30 g	4.55
20 g	2.33	40 g	6.04

There were 12 plants in each combination, which gave 4 replications, each consisting of 3 plants.

During cultivation the plants were watered with tap water up to the same weight in order to ensure the same salinity level. In 2011 the plants were cultivated until 14 November when they started to wither (withering of lateral shoots). In 2012 the observation was ceased during a sudden decrease in the decorativeness of the plants under study (leaves withering) which started on 14 July.

Measurements of the plant height and diameter, the length of lateral shoots of the first level, the number of flowers and flower buds were taken at the beginning and at the end of the experiment. The values of the greenness index of leaves were also taken with the use of SPAD-502 Chlorophyll Meter by YARA (Gregorczyk and Raczynska, 1997). The third well-formed leaf from the top on the longest lateral shoot was used for the measurements. The increase in plant height and diameter and in the length of lateral shoots was calculated together with the change of the number of flowers and buds and the shifts in the index of leaves greenness. At the end of the experiment the plant fresh matter and afterwards the dry matter of the terrestrial part of the plant were determined. Also the water percentage in the plant was calculated.

The obtained results were analyzed statistically with Statistica software by means of analysis of variance and the means were grouped with the use of Duncan test at the significance level of $\alpha = 0.05$. The data were compared for each year separately.

Results and Discussion

The presence of sodium chloride resulted in the decrease in ornamental values of the species in question, which was manifested by growth and blooming inhibition and the decrease in the index of leaves greenness.

The increase in height of *Isotoma axillaris* was smaller after the application of sodium chloride (Table 2). In 2011 the percentage increase in the plant height was significantly largest in the control group (137.78%). In the second year of the experiment the value of this feature diminished together with the increase in NaCl concentration. The smallest growth in plant height (7.30%) was observed for the highest NaCl concentration (40 $g \cdot dm^{-3}$). *Tagetes* L. and *Ageratum* L. treated with 0.4%, 1.2% and 2.0% of NaCl reacted in the similar way as the species under study (Zapryanova and Atanassova, 2009) and the same reaction was also observed in *Vicia faba* var. *equina* Pers. at EC value of 9.0 $dS \cdot m^{-1}$ (Tavakkoli et al., 2010) and in *Zea mays* L. after the application of 75.0 $mol \cdot m^{-3}$ of NaCl (Sacała et al., 2002). Interesting results were obtained by Niu and Rodriguez (2006a) while studying

Achillea millefolium L., *Agastache cana* (Hook.) Wooton et Standl. and *Salvia coccinea* Buc'hoz ex Etl. With EC values of 2.0 $dS \cdot m^{-1}$ and of 4.0 $dS \cdot m^{-1}$ the plants were higher when compared with the control group. However, the authors used the mixture of NaCl, $MgSO_4 \cdot 7H_2O$, and $CaCl_2$ which might account for the obtained results.

Table 2
Influence of NaCl dosage on morphological features of Isotoma axillaris (%)

Feature	Dosage of NaCl, $g \cdot dm^{-3}$	The year of experiment	
		2011	2012
Increase of plants height	0	137.78 b	68.53 d
	5	85.01 a	
	10	78.89 a	50.17 c
	15	67.65 a	
	20	75.40 a	28. 80 b
	30		26.49 b
	40		7.30 a
Increase of plants diameter	0	267.65 c	50.75 d
	5	215.93 b	
	10	131.64 a	25.78 c
	15	132.11 a	
	20	167.54 a	20.96 c
	30		10.82 b
	40		4.56 a
Increase of lateral shoots lenght	0	614.20 c	89.46 d
	5	276.16 b	
	10	222.08 b	48.41 c
	15	200.73 b	
	20	65.90 a	33.37 b
	30		24.67 b
	40		6.19 a
Change flowers number	0	1320.30 d	1133.33 d
	5	1262.05 d	
	10	643.97 c	1083.33 d
	15	470.84 b	
	20	213.58 a	552.78 c
	30		404.17 b
	40		183.33 a
Increase of flower buds number	0	426.67 c	366.25 c
	5	146.47 b	
	10	104.53 b	125.73 b
	15	54.11 ab	
	20	-2.13 a	89.73 b
	30		46.45 ab
	40		-1.83 a

Means followed by the same letter do not differ at the significance level α =0,05 according to the Duncan's test

Together with the increase in sodium chloride concentration the increase in the diameter of *Isotoma axillaris* (Table 2) was smaller. *Ageratum* reacted in a similar way. However, the diameter of *Tagetes* increased after the application of 0.4% concentration of NaCl. The plant diameter diminished together with the increase in NaCl concentration when the concentration of NaCl reached the value of 1.2% or higher, (Zapryanova and Atanassova, 2009).

In 2012 in the species under study in the control group the diameter increased by 50.75%, while with the NaCl concentration of 40 $g \cdot dm^{-3}$ it increased by only 4.56%. Similarly, the total lateral shoot length also diminished. In the control group the value of this feature was 89.46%, while in the plants growing in the substrate with 40 $g \cdot dm^{-3}$ of NaCl - it was only 6.19%. In 2011 in the control group the increase in the diameter was 267.65%, and with the highest dosage of NaCl - 20 $g \cdot dm^{-3}$ - it was only 167.54%.

The increase in the length of lateral shoots was dependent on NaCl as well. In the control group it was 614.20% while with the dosage of 20 g of $NaCl \cdot dm^{-3}$ it was only 65.90% (in 2011). In the second year of the experiment after the application of NaCl at the dosage of 40 $g \cdot dm^{-3}$ the value of this feature was 6.19%. The obtained results prove a very negative influence of sodium chloride onto *Isotoma axillaris*.

The number of flowers of *Isotoma axillaris* diminished significantly together with the increase in sodium chloride concentration over 10 $g \cdot dm^{-3}$ in the first year of the experiment and over 20 $g \cdot dm^{-3}$ in the second year of the experiment (Table 2). However, in 2012 the application of NaCl at the dosage of 10 $g \cdot dm^{-3}$ did not result in the significant decrease in the number of flowers. Such difference in the plant reaction to NaCl concentration might be due to the length of the experiment. The longer the stress factor operates the stronger is the plant reaction. Zapryanova and Atanassova (2009) noticed that the length of the blooming period in *Ageratum* and *Tagetes* diminished under the influence of NaCl. According to Fornes et al. (2007) *Calendula officinalis* L. and *Calceolaria integrifolia* Murray also exhibited a smaller number of flowers when the concentration of NaCl increased. In *Petunia x atkinsiana* D. Don, on the other hand, sodium chloride did not influence the number of flowers.

A similar tendency as in the case of the increase in the flower number was obtained for the percentage change of the number of flower buds. While analyzing the obtained results one might notice that even the smallest concentration of NaCl regardless of the year of the experiment resulted in significantly smaller number of buds. The final number of flower buds in comparison with the initial number was smaller after

the application of 20 g·dm^{-3} of NaCl in the first year of the experiment and after the application of 40 g·dm^{-3}of NaCl in the second year.

Fresh matter of the terrestrial part of *Isotoma axillaris* diminished together with the increase in sodium chlorine concentration (Table 3). A similar reaction was observed in *Petunia x atkinsiana*, *Calendula officinalis*, *Calceolaria integrifolia* (Fornes et al., 2007) and *Zea mays* (Sacala et al., 2002). In 2011 (the second year of the experiment) when larger plants were used in the experiment and their cultivation was longer the decrease in plant fresh matter was more noticeable. Thus, it might be stated that plant reaction to sodium chloride is conditioned not only by the applied concentration of this compound but also by the plant development phase. Different results were obtained by Rahesh et al. (1998) while examining *Ceriops roxburghiana* Arn. Together with the increase in NaCl concentration they observed an increase in the plant fresh matter.

Plant dry matter was significantly smaller in the first year of the experiment after NaCl application at the dosage of 20 g·dm^{-3}, and in the second year of the experiment after the application of 30 and 40 g·dm^{-3} (Table 3). Plant dry matter decreased under the influence of NaCl also in the study of *Petunia x atkinsiana*, *Calendula officinalis*, *Calceolaria integrifolia* and *Zea mays* by F Fornes et al. (2007) and Sacala et al. (2002). In the case of *Ceratostigma plumbaginoidea* Bunge, *Gazania rigens* (L.) Gaertn. and *Teucrium chamaedrys* L. NaCl application also resulted in the decrease in the dry matter of the terrestrial part of the plant (Niu and Rodriguez, 2006b). Different results were obtained for *Delosperma cooperi* (Hook. f.) L. Bolus. Together with the increase in EC values the dry matter of the terrestrial part of the plant also increased. It was only with EC value of 12 dS·m^{-1} when the dry matter diminished significantly. Also Rahesh et al. (1998) while studying *Ceriops roxburghiana* observed an increase in the dry matter together with the increase in NaCl concentration.

In both years of the experiment the water percentage in *Isotoma axillaris* was dependent on NaCl concentration (Table 4). In 2011 significantly lowest water percentage (64.60) was observed after the application of NaCl at the dosage of 10 g·dm^{-3}. That was probably due to the large amounts of the plant dry matter. However, this value did not differ significantly from the water percentage obtained after the following dosages of NaCl: 15 and 20 g·dm^{-3}. In 2012 significantly smaller water percentage (77.46) was obtained after the application of sodium chloride at the dosage of 40 g·dm^{-3}. Small water content caused by NaCl was obtained in *Ceratostigma plumbaginoides*, *Gazania rigens* (Niu and Rodriguez, 2006b) and in *Petunia x atkinsiana* (Fornes et al., 2007). However, in the case of plants which are NaCl tolerant the water percentage might not be subject to any change just as in the case of

Table 3
Influence of NaCl dosage on fresh and dry matter of plants of Isotoma axillaris (g)

Feature	Dosage of NaCl, g·dm^{-3}	The year of experiment	
		2011	2012
Fresh matter of plants	0	19.8 c	9.7 c
	5	12.7 b	
	10	11 b	10 c
	15	7.3 a	
	20	6.6 a	8.6 c
	30		5.6 b
	40		3.7 a
Dry matter of plants	0	2.9 b	1.4 b
	5	2.9 b	
	10	3.0 b	1.4 b
	15	2.6 b	
	20	1.8 a	1.2 b
	30		0.9 a
	40		0.8 a

Means followed by the same letter do not differ at the significance level α =0,05 according to the Duncan's test.

Table 4
Influence of NaCl dosage on water percentage in plant and greenness index of leaves of Isotoma axillaris (%)

Feature	Dosage of NaCl g·dm^{-3}	The year of experiment	
		2011	2012
Water percentage in plant	0	81.40 c	86.03 b
	5	76.56 bc	
	10	64.60 a	85.55 b
	15	68.27 ab	
	20	73.36 abc	85.69 b
	30		83.72 b
	40		77.46 a
Change of greenness index of leaves	0	17.30 c	7.78 d
	5	9.77 b	
	10	6.79 b	2.84 d
	15	9.85 b	
	20	-2.34 a	-10.11 c
	30		-15.84 b
	40		-35.39 a

Means followed by the same letter do not differ at the significance level α =0,05 according to the Duncan's test.

Calceolaria integrifolia (Fornes et al., 2007) and *Delosperma cooperi* (Niu and Rodriguez, 2006b)

NaCl also influenced the index of leaves greenness (Table 4). In 2011 significantly largest increase in these characteristics was obtained in the control group. The application of 20 $g \cdot dm^{-3}$ of NaCl in both 2011 and in 2012 resulted in a significant decrease in the index of leaves greenness even below the initial value. Similar reaction to sodium chloride as in the case of *Isotoma axillaris* was observed in *Vicia faba* var. *equina* (Tavakkoli et al., 2010), and in *Calendula officinalis* and *Calceolaria integrifolia* (Fornes et al., 2007). While examining *Petunia x atkinsiana* Fornes et al. (2007) observed an increase in the index of leaves greenness together with the increase in NaCl concentration. Rahesh et al. (1998) proved stimulating influence of NaCl onto chlorophyll content in a plant on the basis of *Ceriops roxburghiana*.

Conclusions

- *Isotoma axillaris* is susceptible to sodium chloride at the following dosages: 5, 10, 15, 20, 30, 40 $g \cdot dm^{-3}$.
- Increasing dosages of sodium chloride result in plant growth inhibition and in diminishing number of flowers and flower buds of *Isotoma axillaris*.
- Both the fresh and dry matter of *Isotoma axillaris* diminish under the influence of sodium chloride.
- Sodium chloride application results in smaller water percentage in *Isotoma axillaris*.
- Together with the increase in sodium chloride concentration the index of leaves greenness in *Isotoma axillaris* decreases.

References

Cunningham, M. A., E. Snyder, D. Yonkin, M. Ross, T. Elsen, 2008. Accumulation of deicing salt in soils in an urban environment. *Urban Ecosystems*, **11**: 17-31.

Fornes, F., R. M. Belda, C. Carrión, V. Noguera, P. García – Augustín and M. Abad, 2007. Pre – conditioning ornamental plants to drought by means of saline water irrigation as related to salinity tolerance. *Scientia Horticulturae*, **113**: 52-59.

Gregorczyk, A. and A. Raczyńska, 1997. Study of the correlation between Arnon's method and measurements of chlorophyll content using a chlorophyll meter. Folia Universitatis Agriculturae Stetinesis 181. *Agricultura*, **5**: 119-123.

Howard, K. W.F. and H. Maier, 2007. Road de – icing salt as a potential constraint on urban growth in the Greater Toronto Area, Canada. *Journal of Contaminant Hydrology*, **91**: 146-170.

Komosa, A. and T. Górniak, 2012. The effect of chloride on nutrient contents in fruits of greenhouse tomato (Lycopersicon esculentum Mill.) grown in rockwool. *Acta Sci.entiarum Polonorum, Hortorum Cultus*, **11**: 43-53.

Majdecka – Strzeżek A., 2008. The characteristic of Spa Parks in Poland. Annals of Warsaw University of Life Sciences – SGGW. *Horticulture and Landscape Architecture*, **29**: 213-223.

Niu, G. and D. S. Rodriguez, 2006a. Relative of salt tolerance of five herbaceous perennials. *Hort Science*, **41**: 1493-1497.

Niu, G. and D. S. Rodriguez, 2006b. Relative of salt tolerance of selected herbaceous perennials and groundcovers. *Scientia Horticulturae*, **110**: 352-358.

Rahesh, A., R. Arumugam and V. Venkatesalu, 1998. Growth and photosynthetic characteristics of Ceriops roxburghiana under NaCl stress. *Photosynthetica*, **35**: 285-287.

Ramakrishna, D. M. and T. Viraraghavan, 2005. Enviromental impact of chemical deicers – a rievew. *Water, Air and Soil Pollution*, **166**: 49-63.

Sacała, E., A. Demczuk, E. Grzyś and A. Sobczak, 2002. The effects of salt stress on growth and biochemical parameters in two maize varieties. *Acta Societatis Botanicorum Poloniae*, **2**: 101-107.

Tavakkoli, E., P. Rengasamy and G. K. McDonald, 2010. High concentrations of Na^+ and Cl^- ionsin soil solution have simultaneous determinal effects on growth of faba bean under salinity stress. *Journal of Experimental Botany*, **61**: 4449-4459.

Todorova, A., S. Asakawa and T. Aikoh, 2004. Preferences for and attitudes towards street flowers and Teres in Sapporo, Japan. *Landscape and Urban Planning*, **69**: 403-416.

Warcholińska, A. and B. Fortuna – Antoszkiewicz, 2011. The use of flora in seasonal decorations of Urban public space based on the example of The Royal Rote in Warsaw. Annals of Warsaw University of Life Sciences – SGGW. *Horticulture and Landscape Architecture*, **32**: 53-61.

Zapryanova, N. and B. Atanassova, 2009. Effects of salt stress on growth and flowering of ornamental annual species. *Biotechnology and Biotechnological Equipment*, **23**: 177-179.

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