ACTA Acta Sci. Pol., Hortorum Cultus 7(1) 2008, 45-52

EFFECT OF NITROGEN AND POTASSIUM FERTILIZATION ON THE NUTRITIONAL STATUS OF HOT PEPPER (*Capsicum annuum* L.) PLANTS AND ON SUBSTRATE SALINITY

Anna Golcz, Paweł Kujawski, Bartosz Markiewicz
Agricultural University in Poznań

Abstract. In the years 2004 and 2005, in an unheated greenhouse, an experiment was carried out with hot pepper 'Wulkan' cultivar. The purpose of studies was to determine the effect of nitrogen and potassium fertilization on the salinity of substrate in hot pepper growing and to show the dependence between the content of these elements in the substrate and in the indicator parts of the plant. Fertilization with nitrogen and potassium was differentiated in two levels: N 250 and K 300, and N 350 and K 400 mg·dm^{-3} substrate. It was found that a higher dose of nitrate and potassium caused an increase of EC in the substrate. A differentiated level of nitrogen fertilization had no effect on the nutritional status of hot pepper plants by this macroelement. On the other hand, potassium content in leaves was slightly higher with a higher fertilization level.

Key words: hot pepper, fertilization, nitrogen, potassium, salinity

INTRODUCTION

Most frequently, in horticultural production, the reason of substrate salinity is primarily an excessive content of NO_3^- and K^+ as well as Na^+, Cl^-, SO_4^{-2} [Kujawski and Golcz 2006]. Negative effect of salinity results also in the limitation of water availability caused by the decrease of osmotic potential of soil solution [Starck et al. 1995, Wahome et al. 2001] and leading in consequence to disturbances in almost all life processes [Kacperska 2005, Taiz and Zeiger 2005].

Salinity influenced negatively the physico-chemical properties of substrate by decreasing its permeability, it caused changes in pH values and limitation of the uptake of ions [Shannon and Grieve 1999, Nurzyński 2003].

Corresponding author – Adres do korespondencji: Anna Golcz, Paweł Kujawski, Bartosz Markiewicz, Department of Horticultural Plants Nutrition, Agricultural University in Poznań, str. Zgorzelecka 4, 60-198 Poznań, agol1@poczta.onet.pl

Harmfulness of salinity appears among others in the decreased ability of seed germination [Zapata et al. 2003], limitation of leaf size, reduced chlorophyll content in leaves [Di Martino et al. 2003], shaken ion balance [Grattan and Grieve 1999, Parida and Das 2005]. The number of leaves is reduced, and the growth inhibition of overground parts of plants is greater than the growth of underground parts [Alian et al. 2000, Jungklang et al. 2003, Taiz and Zeiger 2005]. The development of plant is also impeded and it is demonstrated by a smaller yield [Munns 2002, Wrochna and Gawroński 2004].

The objective of the presented studies was to demonstrate the effect of nitrogen and potassium fertilization on the salinity of substrate in the growing of hot pepper and to show the dependence between the content of these components in the substrate and the indicator parts of plants.

MATERIAL AND METHODS

A one factor experiment was carried out in the years 2004 and 2005, in an unheated greenhouse with hot pepper, 'Wulkan' cultivar. Seedlings were prepared according to agrotechnical recommendations for this species and in the phase of 8–10 correctly developed adequate leaves, planted in a constant place in mid-May. Vegetation period lasted four months (May – August).

Hot pepper was grown in pots of 5 dm^3 capacity in the density of 5 plants per 1 m^2. One combination included 16 plants.

The substrate consisted of mineral soil with raised peat in volumetric proportion v : v = 3:2. The substrate was limed with $CaCO_3$ on the basis of neutralization curve to pH = 6.5 In the experiment with hot pepper, fertilization with nitrogen and potassium was differentiated in two levels ($mg\cdot dm^{-3}$ of substrate): N – 250 and K – 300; and N – 350 and K – 400, using NH_4NO_3 and K_2SO_4 respectively. The remaining macro- and micro components were supplemented in the pre-plant fertilization to the following levels ($mg\cdot dm^{-3}$ substrate): 200 P using $Ca(H_2PO_4)_2$; 180 Mg in the form of $MgSO_4\cdot 7\ H_2O$ and 75 Fe, 35 Mn, 40 Zn, 10 Cu, 1.5 B, 1.5 Mo using single salts of these elements. By top-dressing only shortages of macro-elements were supplemented to the determined levels using $Ca(NO_3)_2$, $NH_4H_2PO_4$ K_2SO_4 and $MgSO_4\cdot 7\ H_2O$.

During the growing, the samples from the substrate and from the indicator parts of plant – (leaves from the middle part of stem) were taken twice for chemical analyses – at the stage of vegetation growth and in the full of fruiting. Irrigation and chemical protection against diseases and pests were carried out according to the actually accepted principles. No plant cutting was applied. In the second decade of August, when the fruits of hot pepper reached their physiological maturity, single harvest was carried out.

In the substrate, extracted with of 0.03 M CH_3COOH acc. to Nowosielski [1988], the contents of the following nutritive components: $N\text{-}NO_3$ and $N\text{-}NH_4$ – were determined by the distillation method acc. to Bremner in modification by Starck, as well as the content of K was determined by flame photometry and electrical conductivity (EC) in $mS\cdot cm^{-1}$ at volumetric proportion of substrate to water = 1 : 2.

In air dried (at ±55°C) ground leaves, the following determinations were carried out (IUNG 1972): total-N – by Kjeldahl's method on Parnas-Wagner apparatus after wet combustion in sulphosalicylic acid, and K by flame photometry after wet mineralization in H_2SO_4 and H_2O_2.

Statistical analyses were calculated using Duncan'a test at the significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

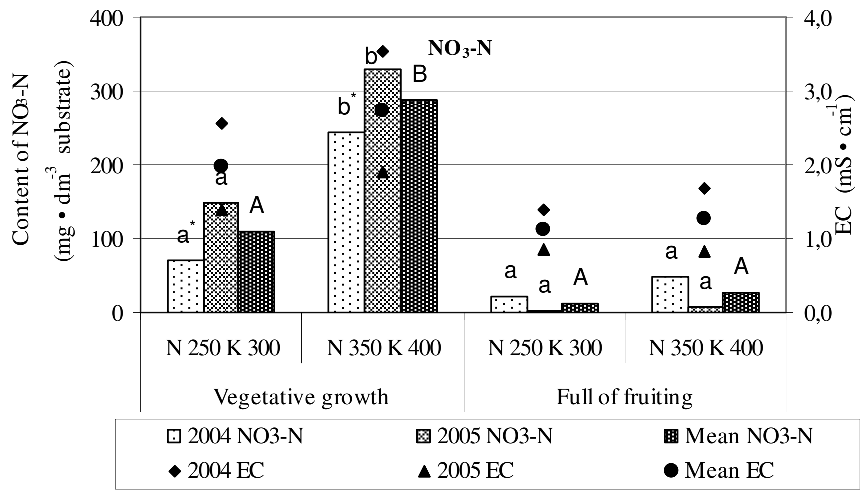
Hot pepper is sensitive to increased salt concentration [Kortuby-Amacher et al. 2000]. The optimal range of nitrogen and potassium content in the substrate for hot pepper is wide [Malinowski and Starck 1992, Nurzyński 1986]. When nitrogen fertilization is used, particularly in the interval of the upper critical levels, it can have an effect on the chemical composition of substrate as well as on the nutritional status of plants.

On the basis of the mean values from two years of studies, an analysis of the obtained results was carried out. After one month from the beginning of the culture (stage of vegetation growth), on the basis of analysis of NO_3-N content in the substrate, at a lower N and K fertilization, it was found that nitrogen content was 2.3 times lower than the assumed level (250 mg N·dm^{-3} of substrate) (fig. 1). On the other hand, at higher levels of N and K fertilization, the nitrogen level was only 1.2 times lower than the assumed one (350 mg N·dm^{-3} of substrate). It shows that in the first case, the plant has taken up 700 mg of nitrogen in the nitrate form, while in the second case, only 295 mg from 5 dm^{3} substrate was taken up. The conclusion is that a higher level of nitrogen and fertilization (by 100 mg each) caused an increase of the level of salinity by 0.74 mS·cm^{-1} which in effect decreased twice the nitrogen utilization by the plant.

The content of NH_4-N in the substrate during the vegetation stage was the same both in the combination with the lower and with the higher nitrogen and potassium fertilization (fig. 2), therefore, the use of this form of nitrogen by the plant was higher with a higher fertilization level.

In the period of fruiting, no big differences between the levels of nitrogen and potassium fertilization in the NO_3-N and NH_4-N content in substrate were found (fig. 1 and 2). On the other hand, EC continued to be higher in the substrate with a higher level fertilization, but it did not have any effect on the uptake of nitrogen by the plant.

An analysis of potassium content in the substrate gave a similar relation between the levels of fertilization as in case of nitrogen (fig. 3). However, the differences were not so significant. With a lower fertilization level, potassium content in substrate determined in the period of vegetative growth was about 1.6 times lower than the initial one, while with a higher level, it was 1.2 times lower. In the combination with the fertilization of 300 mg K per dm^{3}, the plant took up 550 mg of potassium, while with the fertilization of 400 mg K, the uptake was definitely lower because it amounted only to 300 mg K from 5 dm^{3} of substrate. So, the increase of substrate EC by 0.74 mS·cm^{-1} evoked by a higher fertilization with nitrogen and potassium caused a limited uptake of potassium by the plant. During the full of fruiting, the determined potassium contents in the substrate were lower than in the period of vegetation growth, which was connected with the correct utilization of this component by the plant. Difference between the two levels of N and K fertilization were not great and they amounted to 35 mg K·dm^{-3} substrate.



* Means indicated by the same letter for fertilization level are not significantly different at α = 0.05
Średnie oznaczone tymi samymi literami dla poziomu nawożenia oznaczają różnice nieistotne przy α = 0,05

Fig. 1. Effect of two levels of nitrogen and potassium fertilization on EC and content of NO_3-N in substrate

Rys. 1. Wpływ dwóch poziomów nawożenia azotem i potasem na EC oraz zawartość N-NO_3 w podłożu

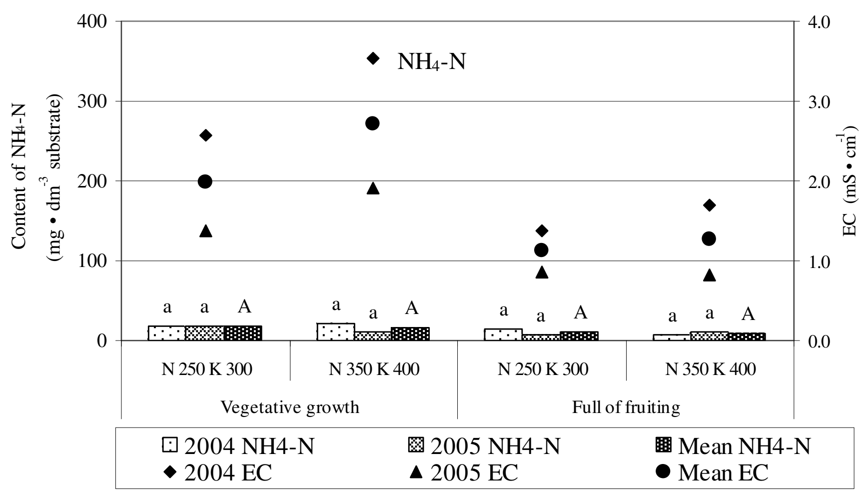


Fig. 2. Effect of two levels of nitrogen and potassium fertilization on EC and content of NH_4-N in substrate

Rys. 2. Wpływ dwóch poziomów nawożenia azotem i potasem na EC oraz zawartość N-NH_4 w podłożu

Table 1. Content of total nitrogen and potassium in the leaves of hot pepper in two development phases of plants depending on the fertilization level by nitrogen and potassium

Tabela 1. Zawartość ogólna azotu i potasu w liściach papryki ostrej w dwóch fazach rozwojowych roślin w zależności od poziomu nawożenia azotem i potasem

	Stage of development Faza rozwojowa	Year – Rok	Fertilizer level – Poziom nawożenia	
			N 250 K 300	N 350 K 400
Total N Azot ogółem (%)	Vegetative growth Wzrost wegetatywny	2004	4.73 a*	4.80 a*
		2005	4.42 a	4.36 a
		Mean – Średnia	4.58 a	4.58 a
	Full of fruiting Pełnia owocowania	2004	2.56 a	2.49 a
		2005	2.25 a	2.59 b
		Mean – Średnia	2.41 a	2.54 a
K (%)	Vegetative growth Wzrost wegetatywny	2004	7.04 a	7.92 b
		2005	6.69 a	6.71 b
		Mean	6.87 a	7.32 a
	Full of fruiting Pełnia owocowania	2004	4.47 a	4.89 a
		2005	4.15 a	4.69 a
		Mean	4.31 a	4.79 a

*Means indicated by the same letter in the line are not significantly different at $\alpha = 0.05$

Średnie oznaczone tymi samą literą w wierszu oznaczają różnice nieistotne przy $\alpha = 0,05$

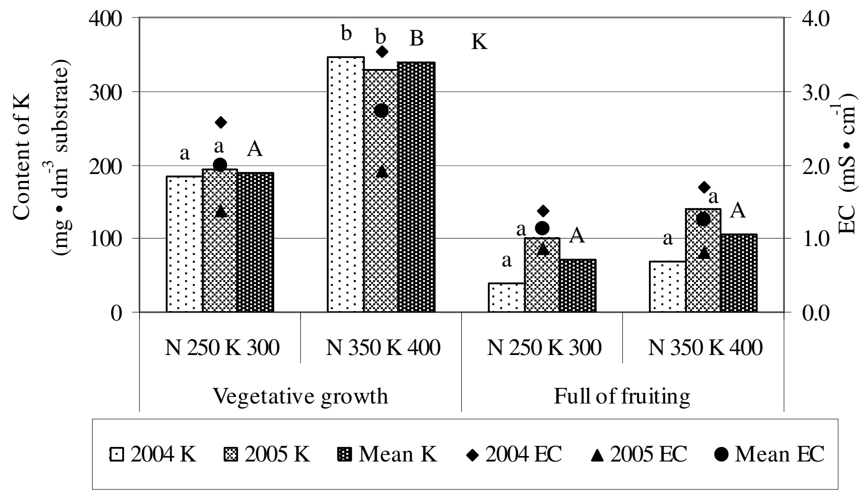


Fig. 3. Effect of two levels of nitrogen and potassium fertilization on EC and content of K in substrate

Rys. 3. Wpływ dwóch poziomów nawożenia azotem i potasem na EC oraz zawartość K w podłożu

The mean EC values of substrate for the given developmental stage were similar to the results shown in Nurzyński's work [2003]. On the basis of the above studies, it was found that a high effect on the salinity of substrate was exerted by the increase of nitrogen content in the form of nitrate as well as the content of potassium in the substrate.

Very interesting results were obtained in the status of hot pepper plants nutrition (tab. 1). In both developmental stages, the contents of total nitrogen in the indicator parts of plants were the same, or they were very similar. In a substrate with a higher N and K fertilization in the stage of vegetation growth, the determined NO_3-N content was almost twice so high (fig. 1), however, it had no effect on the nitrogen nutritional status of the plant (tab. 1).

The nutritional status with potassium was similar in two analysed fertilization combinations (tab. 1). On the basis of substrate analysis, similarly as in case of nitrogen, a lower utilization of potassium had no significant effect on K content in the leaves of hot pepper. Leaves of plants fertilized with potassium at the level of 400 mg $K \cdot dm^{-3}$ of substrate contained by about 0.5% K more of this macroelement in the phase of vegetation growth and by 1.0% K in the full of fruiting as compared with potassium at the level of 300 mg $K \cdot dm^{-3}$ of substrate.

CONCLUSIONS

1. It was found that an increased content of nitrate and potassium caused an increase of EC in the substrate.

2. A differentiated level of nitrogen fertilization had no effect on the nutritional status of hot pepper plants by this macroelement.

3. On the other hand, potassium content in leaves was slightly higher with a higher potassium fertilization level.

REFERENCES

Alian A., Altman A., Heuer B., 2000. Genotypic difference in salinity and water stress tolerance of fresh market tomato cultivars. Plant Sci. 152, 59–65.

Di Martino C., Delfine S., Pizzuto R., Loreto F., Fugi A., 2003. Free amino acids and glycine betaine in leaf osmoregulation of spinach responding to increasing salt stress. New Phytol., 158, 455–463.

Grattan S.R., Grieve C.M., 1999. Salinity – mineral nutrient relations in horticultural crops. Sci. Hort., 78, 127–157.

IUNG, 1972. Meotdy badań laboratoryjnych w stacjach chemiczno-rolniczych. Cz. II. Badania materiału roślinnego. IUNG Puławy, 25–83.

Jungklang J., Usui K., Masumoto H., 2003. Differences in physiological responses to NaCl between salt-tolerant *Sesbania rostrata* Brem. & Oberm. and non-tolerant *Phaseolus vulgaris* L. Wed Biology and Management 3, 21–27.

Kacperska A., 2005. Plant Physiology. Publishers. PWN.

Kortuby-Amacher J., Koening R., Kitchen B., 2000. Salinity and plant tolerance. Electronic publishing:wysywig://main3/http://searchpdf.adobe.com/proxies/2/8/7/53.html, 1–3.

Kujawski P., Golcz A., 2006. Concentration of anions Cl^-, SO_4^{-2} and NO_3^- in substrate during the growing of hot pepper (*Capsicum annuum* L.). Acta Agrophisica 134, vol. 7(3), 643–650.

Malinowski D., Starck J.R., 1992. Influence of changes in potassium and calcium levels and ratio of these elements in the nutrient solution on the growth and yield of paprika cultivated in mineral wool. Ann. Warsaw Agricult. Univ. SGGW, Hort., 16, 15–24.

Munns R., 2002. Comparative physiology of salt at water stress. Plant, Cell and Environ., 25, 239–250.

Nowosielski O., 1988. Zasady opracowywania zaleceń nawozowych w ogrodnictwie. Warszawa, PWRiL, 3–309.

Nurzyński J., 1986. Plonowanie papryki w zależności od nawożenia azotowo-potasowego. Zesz. Nauk. AR w Krakowie, 211, 16, 63–71.

Nurzyński J., 2003. Nawożenie roślin ogrodniczych. Wyd. AR w Lublinie, 44–48.

Parida A.S., Das A.B., 2005. Salt tolerance and salinity effect on plants. a review Ecotoxicology and Environmental Safety, 60, 324–349.

Shannon M.C., Grieve C.M., 1999. Tolerance of vegetable crops to salinity. Sci. Hort., 78, 5–38.

Starck Z., Chołuj D., Niemyska B., 1995. Fizjologiczna reakcja roślin na niekorzystne warunki środowiska. Wyd. SGGW Warszawa.

Taiz L., Zeiger E., 2005. Plant Physiology, Edition: Taiz L., Zeiger E. Sinauer Associates, Inc., Publishers.

Wahome P.K., Jesch H.H., Gritter I., 2001. Mechanisms of salt stress tolerance in two rose rootstocks *Rosa chinensis* 'Major' ad *Rosa rubiginosa*. Sci. Hort., 87, 207–216.

Wrochna M., Gawroński S.W., 2004. Evaluation of the usefulness of ornamental plants from Chenopodiaceae and Amaranthaceae families for growing in salinitied localities. Roczniki AR w Poznaniu, Ogrodn., 37, 233–238.

Zapata P.J., Serrano M., Preyel M.T., Amorós A., Botella M.A., 2003. Changes in ethylene and polyamine profiles of seedlings of nine cultivars of *Lactuca sativa* L. in response to salt stress during germination. Plant Sci., 164, 557–563.

WPŁYW NAWOŻENIA AZOTEM I POTASEM NA STAN ODŻYWIENIA PAPRYKI OSTREJ (*Capsicum annuum* L.) I ZASOLENIE PODŁOŻA

Streszczenie. W latach 2004 i 2005 w nieogrzewanej szklarni przeprowadzono doświadczenia z papryką ostrą odmiany 'Wulkan'. Celem badań było określenie wpływu nawożenia azotem i potasem na zasolenie podłoża w uprawie papryki ostrej oraz wykazanie zależności między zawartością tych składników w podłożu a częścią wskaźnikową rośliny. Nawożenia azotem i potasem zróżnicowano do dwóch poziomów N 250 i K 300 oraz N 350 i K 400 mg·dm^3 podłoża. Wykazano, że zwiększona zawartość azotu azotanowego oraz potasu powodowała wzrost EC podłoża. Zróżnicowany poziom nawożenia azotem nie miał wpływu na stan odżywienia roślin papryki tym makroskładnikiem. Natomiast zawartość potasu w liściach była nieznacznie większa przy wyższym poziomie nawożenia.

Słowa **kluczowe**: papryka ostra, nawożenie, azot, potas, zasolenie

Accepted for print – Zaakceptowano do druku: 19.03.2008