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# DYNAMICS OF MACRONUTRIENT CONTENTS IN THE SUBSTRATE WITH LOCALIZED PLACEMENT OF CONTROLLED RELEASE FERTILIZER OSMOCOTE PLUS IN THE GROWING OF PEPPER (*CAPSICUM ANNUUM* L.)

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A b s t r a c t. Pot experiment was carried out with the growing of pepper (*Capsicum annuum* L.). Before vegetation, controlled release fertilizer Osmocote Plus (10-11-18) was placed on the bottom of the pot that was then filled with peat substrate. The nutritive components embodied in this type of fertilizer are slowly released during 5-6 months. The dynamics of the macroelement contents in the peat substrate was analysed as the effect of Osmocote Plus (10-11-18) fertilizer application. It was shown that the use of localized placement of Osmocote Plus (10-11-18) fertilizer does not sufficiently enrich the substrate with nitrogen ($N\text{-}NH_4$ and $N\text{-}NO_3$), phosphorus and potassium. The maximal content of these components in relation to the applied rates showed the following values: ($N\text{-}NH_4$+$N\text{-}NO_3$) – 15.5%; P – 8.0% and K – 15.1%. The values were revealed in the final period of growing (September-October). Optimal content of magnesium in the substrate which was maintained throughout the whole growing period was not only the result of the application of Osmocote Plus (10-11-18), but it was also caused by the presence of magnesium in the lime fertilizer used for the liming of peat and by the water used for irrigation. It was found that localized placement of fertilizer in the substrate caused not only some problems in maintaining optimal nutrient resource level in the substrate for plants, but it also created many methodological problems. It refers to the method of sampling substrate for analyses, to the release of components from the fertilizer granules during extraction, and to the interpretation of results. The problem of substrate analyses with the use of slow-release fertilizers requires further methodological studies.

K e y w o r d s: pepper, controlled release fertilizers (CRF), Osmocote, localized fertilization, release of nutrients

## INTRODUCTION

Osmocote is historically the first coated fertilizer which has been offered on the market three decades ago. In a coat of dicyclopentadien copolimer with glycerine ester, which gradually decomposes as a result of biodegradation, there are mineral components in different proportions (Sharma 1979). The coat thickness imitates the rate of components release by way of diffusion and osmosis. As reported by other authors (Nowak *et al.* 1995), the release, in controlled amounts, starts 10-14 days after the introduction of granules into the substrate.

The period of fertilizer activity (3, 6, 8, 14 months) requires a mean temperature of 20-21°C and equalized humidity. Higher temperature accelerates and a lower temperature delays the release of components from the fertilizer (Michałojć and Nurzyński 2006). The producer of fertilizers (Scott Co.) assumes that plants are uniformly nourished during the whole period of vegetation. Thereby, in comparison with traditional fertilizers, the utilization of components from the fertilizers is increased to 80%.

Coated controlled release fertilizers are recommended for a single application before vegetation by mixing them with the substrate, or by localized placing them at definite points (Komosa *et al.* 1998). The studies of Nowak *et al.* (1995) indicate that the method of fertilizer application exerts an effect on the chemical analysis results of the substrate.

The objective of the presented studies was estimation of the dynamics of $N\text{-}NH_4$, $N\text{-}NO_3$ contents in the sum of both nitrogen forms and P, K and Mg from the substrate in which Osmocote Plus fertilizer was locally applied for the nutrition of pepper, and to show the pH and EC changes. The dynamics of the release of nitrogen, phosphorus and potassium from Osmocote Plus in the case when the fertilizer was mixed with the total volume of the substrate was presented earlier by Golcz and Komosa (2006).

## MATERIAL AND METHODS

Two years of experimental vegetative studies (from May till October) were carried out in an unheated greenhouse with pepper cultivar Delphin (Enza Zaden Co.) After substrate liming (54.8% CaO and 5.4% MgO) at the rate of 12.0 g $CaCO_3$ $dm^{-3}$ of peat, a single application of the controlled release fertilizer Osmocote Plus (10-11-18) (5-6 M), at the rate of 100 g $container^{-1}$ (10 g $dm^{-3}$ substrate·$plant^{-1}$) was applied by localized placement on the bottom of the pot. The introduced coated fertilizer contained (in mg $dm^{-3}$ ): $N\text{-}NH_4$ 550, $N\text{-}NO_3$ 450, P 484, K 1494, Mg 120, Fe 20, Mn 4, Cu 3, Zn 1, B 1, Mo 1. The total rate of fertilizer on the bottom of the pot represented a volume of 0.12 $dm^{-3}$.

Both before and during the growing, at one month intervals, samples of the peat substrate in the pots, from their total thickness, were sampled vertically using a sampler designed for sampling from peat substrates. On the given sampling date, two samples were taken from one pot. The experiment was carried out in four replications, whereby one replication was represented by one pot. Component content was determined by universal method in the extract of 0.03M $CH_3COOH$ (Nowosielski 1988). N-$NH_4$ and N-$NO_3$ were determined by distillation method according to Bremner in Starck's modification, P – by colorimetric method with ammonium vanadomolybdate, K and Ca – photometrically, Mg – by spectrometric absorption method, pH – potentiometrically, salinity (EC) – conductometrically.

## RESULTS AND DISCUSSION

The initial content of macronutrients, pH and salinity in peat substrate (before liming) are presented in Table 1.

**Table 1.** Content of nutrients, pH and EC of substrate peat

| Study year | N-$NH_4$ | N-$NO_3$ | N-$NH_4$ + N-$NO_3$ | P | K | Ca | Mg | pH in $H_2O$ | EC (mS $cm^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| | (mg $dm^{-3}$ of substrate) | | | | | | | | |
| I | 105 | 4 | 109 | 16 | 16 | 70 | 23 | 3.7 | 0.18 |
| II | 42 | 2 | 44 | *tr. | 13 | 91 | 21 | 4.17 | 0.11 |

*tr.– traces.

In both years of studies, the peat was characterized by a low content of macronutrients, by a strongly acid reaction, and a low total salt concentration.

The dynamics of ammonium and nitrate nitrogen (N-$NH_4$ and N-$NO_3$) as well as the sum of N-$NH_4$+N-$NO_3$ in the peat substrate resulting from the localized placement of Osmocote Plus (10-11-18) are shown in Figure 1. On the first date of sampling (21st day of cultivation – June), the mean sum of ammonium and nitrate nitrogen contents (from 2 years of studies) amounted to 39.8 mg (N-$NH_4$+N-$NO_3$) $dm^{-3}$ of substrate, which – in relation to the theoretically calculated rate –converted into 1 $dm^3$ amounting to 1000 mg (N-$NH_4$+N-$NO_3$) $dm^{-3}$, gave 3.9% of the applied dose.

On the second (49th day of cultivation – July) and third dates of sampling (77th day of cultivation – August), the nitrogen content increased to 70.2 and 82.5 mg (N-$NH_4$+N-$NO_3$) $dm^{-3}$, constituting 7.0 and 8.2% of the applied rate. The highest nitrogen content was found in September and October (the 105th and 126th day of cultivation – September and October), when it amounted to 126.8 and 155.2 mg (N-$NH_4$+N-$NO_3$) $dm^{-3}$, respectively, giving 12.6 and 15.5% of the applied rate. In the first year of studies until about the 100th day of growing (June – September), there dominated the ammonium forms, while in the second year, already from the 49th day of cultivation (July), there dominated the nitrate form.

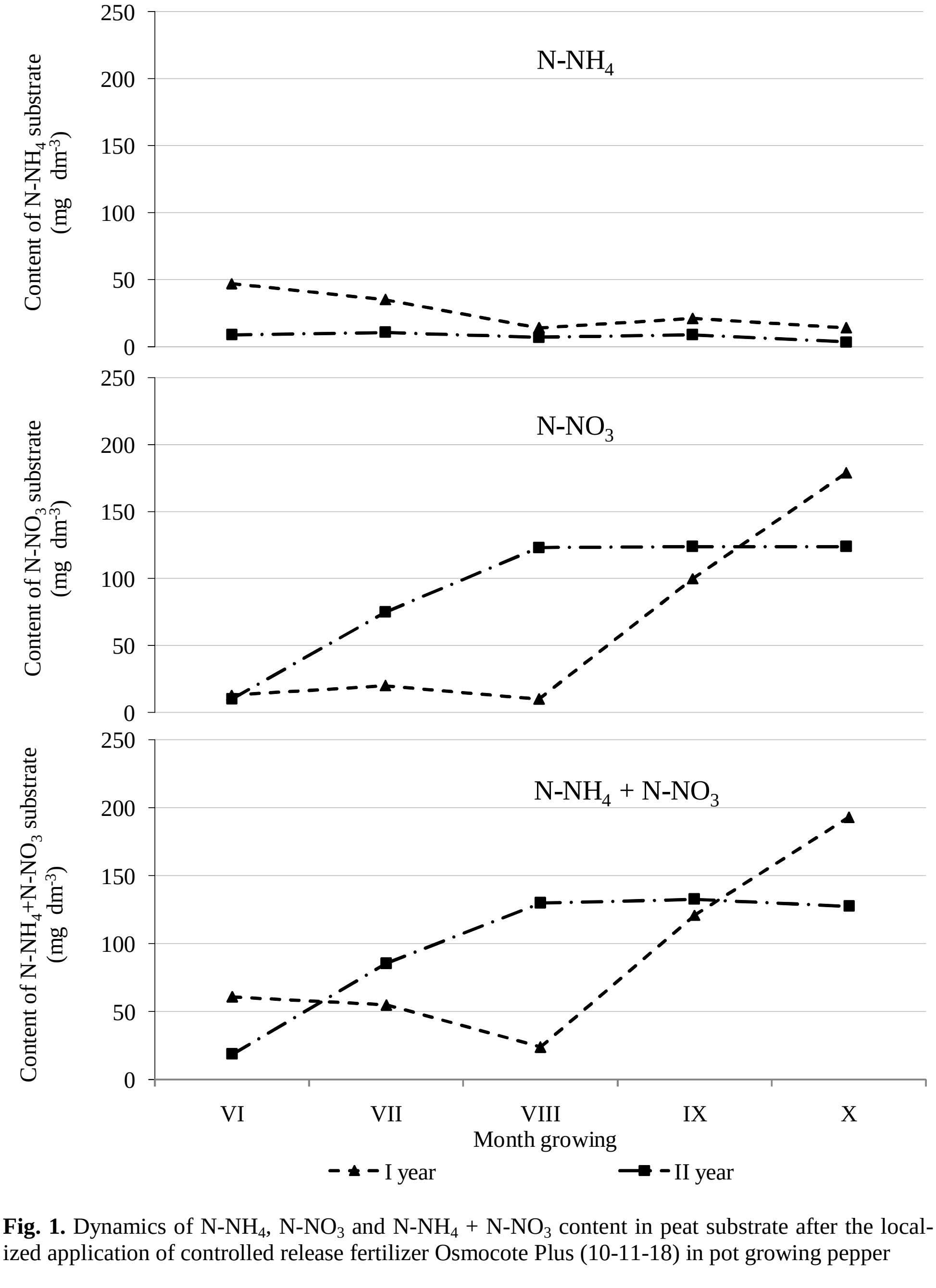


**Fig. 1.** Dynamics of $N\text{-}NH_4$, $N\text{-}NO_3$ and $N\text{-}NH_4$ + $N\text{-}NO_3$ content in peat substrate after the localized application of controlled release fertilizer Osmocote Plus (10-11-18) in pot growing pepper

Similarly as in the case of nitrogen, a small increase of phosphorus content from Osmocote Plus (10-11-18) was found (Fig. 2).

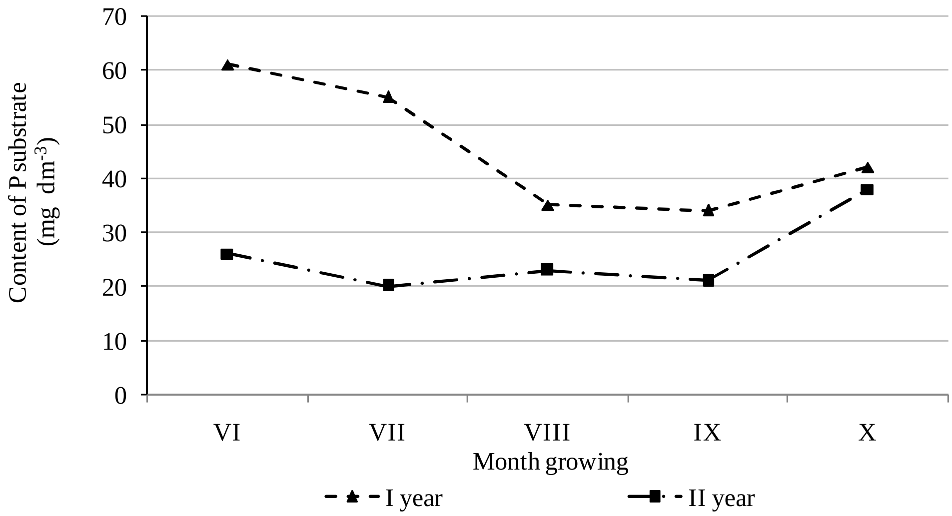


**Fig. 2.** Dynamics of P content in peat substrate after the localized application of controlled release fertilizer Osmocote Plus (10-11-18) in pot growing pepper

In the initial period of cultivation (June-July), on average from the two years of studies, 43.5 and 37.5 mg P $dm^{-3}$ of substrate showed a theoretical rate of 484 mg P $dm^{-3}$ , which made 8.9 and 7.7%. In the successive months of pepper cultivation (August and September, 77th and 105th days), the phosphorus content in the substrate was still smaller – showing 29.0 and 27.5 mg P $dm^{-3}$ which made only 5.9% and 5.6% of the applied rate. At the end of cultivation, on the 126th day (October), the phosphorus content increased to 39.2 mg P $dm^{-3}$ of substrate equalling 8.0% of the applied rate.

Similarly as in the case of nitrogen and phosphorus, a low content of potassium was found in the substrate as an effect of localized fertilization with Osmocote Plus (10-11-18) (Fig. 3). In the first year of the study, potassium content in the substrate resulting from Osmocote Plus application was maintained on a low level, showing from 18.0 mg K $dm^{-3}$ of substrate on the 165th day of cultivation (September) to 75.0 mg K $dm^{-3}$ of substrate on the 126th day of cultivation (October), which gives only 1.2% to 5.0% relative to the rate of 1494 mg K $dm^{-3}$ of substrate.

In the second year of the study, from the beginning of the cultivation to September (105th day), the potassium content in the substrate was systematically increasing, and in June it showed 2.0%, in July 6.5% and in August 13.0% of the applied rate. The highest increase of potassium content (227.0 mg K $dm^{-3}$ of substrate) was found in September when it amounted to 15.1%. That level corresponded to the optimal potassium content of 230-280 mg K $dm^{-3}$ of substrate (Breś *et al.* 2008, Komosa *et al.* 1998).

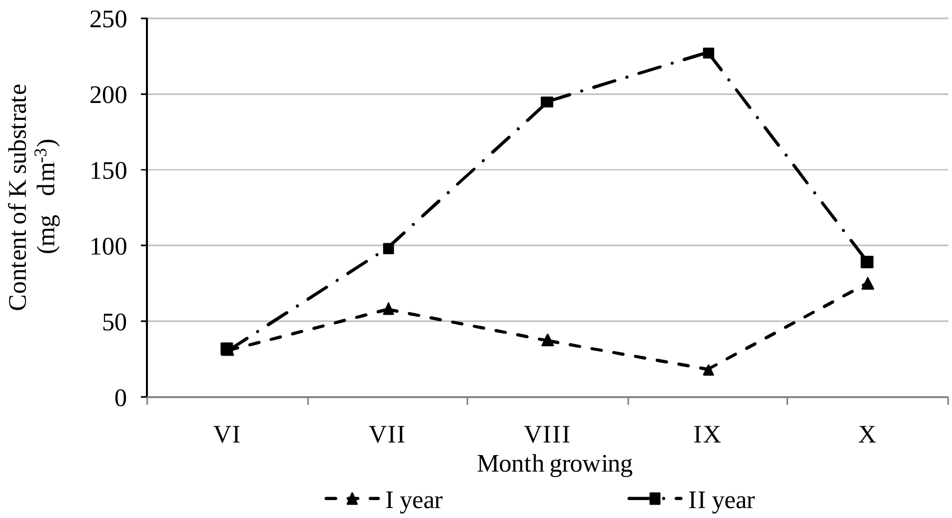


**Fig. 3.** Dynamics of K content in peat substrate after the localized application of controlled release fertilizer Osmocote Plus (10-11-18) in pot growing pepper

Enrichment of the substrate with magnesium, in both years of studies, was similar (Fig. 4). It must be stressed that the determined magnesium content in the substrate was the effect of Osmocote Plus application, as well as of liming (3.2% Mg) and irrigation with tap water (13.6 mg Mg $dm^{-3}$).

In the first 49 days of cultivation (June-July) the content of magnesium amounted on average (in the period of two years of studies) to 189.0 mg Mg $dm^{-3}$ of substrate, which corresponded do the optimal ranges for pepper which are 180–220 mg Mg $dm^{-3}$ of substrate (Breś *et al.* 2008, Komosa *et al.* 1998). In the successive months of growing, in both years of studies, the magnesium content increased in the vegetation period.

Noteworthy is the high content of calcium in the peat substrate which exceeded the optimal range for pepper (500-1500 mg Ca $dm^{-3}$ of substrate (Breś *et al.* 2008, Komosa *et al.* 1998) (Fig. 5). Also the substrate reaction (slightly acid to neutral) (Fig. 6) is worth considering.

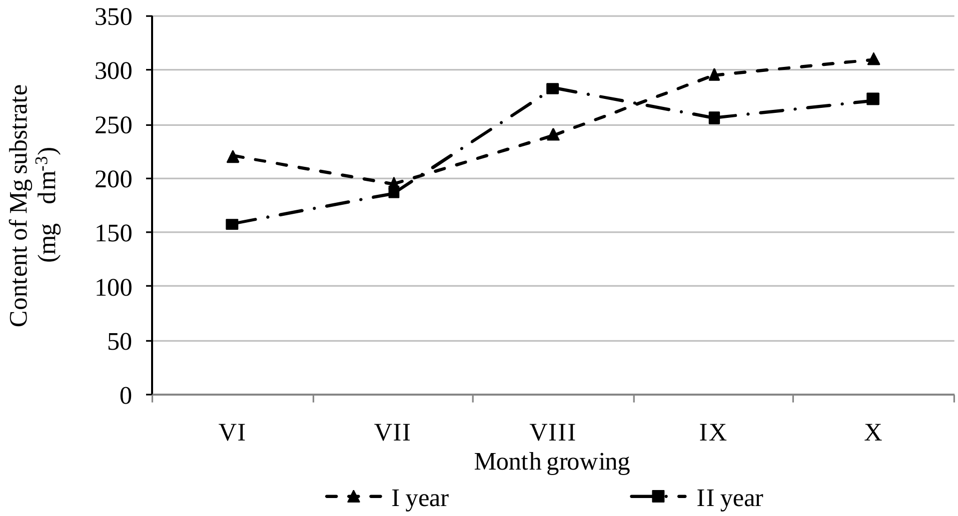


**Fig. 4.** Dynamics of Mg content in peat substrate after the localized application of controlled release fertilizer Osmocote Plus (10-11-18) in pot growing pepper

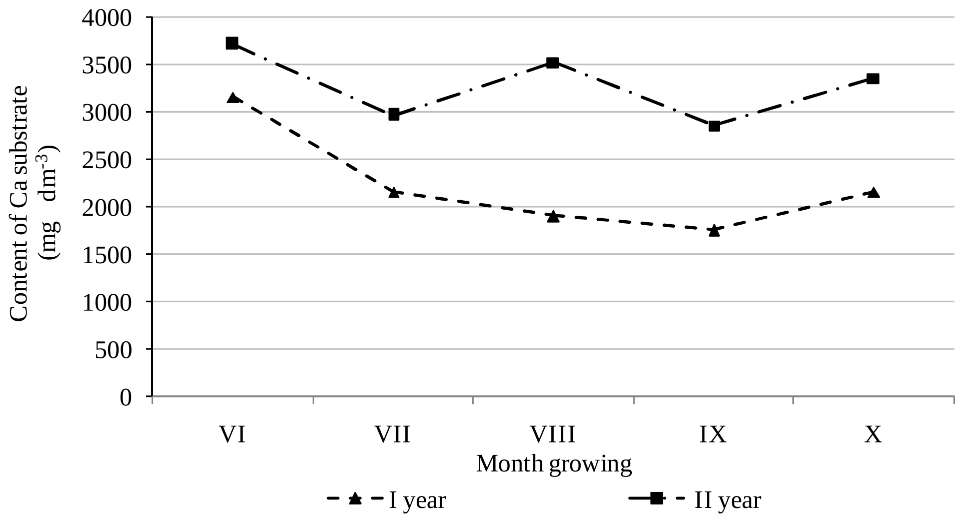


**Fig. 5.** Dynamics of Ca content in peat substrate after the localized application of controlled release fertilizer Osmocote Plus (10-11-18) in pot growing pepper

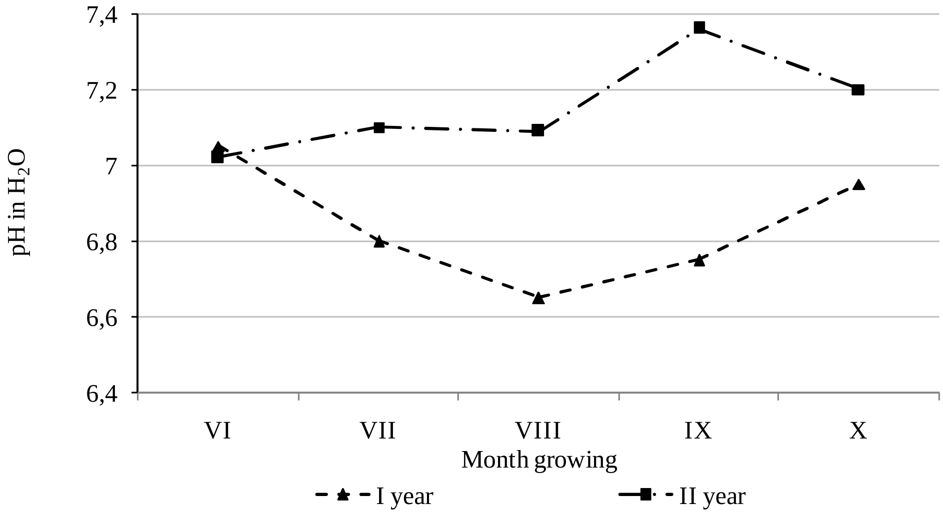


**Fig. 6.** Changes pH of substrate in growing of pepper

Calcium content in the substrate on the 126th day of cultivation was, on average, 2200 mg Ca dm$^{-3}$ of substrate, with pH in $H_2O$ from 6.65 to 7.05, while in the second year, it was 2545 mg Ca dm$^{-3}$ of substrate, and pH in $H_2O$ showed from 7.02 to 7.36. In the first year of the study, calcium level in the substrate, until September (105th day of cultivation) was decreasing, while in the second year, it showed some oscillations.

Study results concerning salinity reflect the dynamics of nutrient contents in the substrate, mainly as a result of its enrichment with Osmocoet Plus (10-11-18) (Fig. 7). In the first year of the study, until the 195th day of cultivation, electrical conductivity (EC) did not exceed the admissible salt concentration (1.6 mS cm$^{-1}$) (Breś *et al.* 2008). On the other hand, on the 126th day of pepper growing (October), in the first year of studies, and on the 77th and 105th day of growing (August – September) in the second year of studies, salinity was the result of more intensive enrichment of substrate with magnesium and potassium and from Osmocote Plus, as well as a high content of calcium.

On the basis of the presented studies and earlier publications, it must be stated that the method of application to peat substrate of the multi-compound Osmocote Plus (10-11-18) fertilizer, whose action was assumed to last for a period of 5-6 months, exerted a significant effect on the dynamics of the macronutrients content in the substrate. The application of the fertilizer by a localized method (point placement of fertilizer on the bottom of the pot) in the growing of pepper (*Capsicum annuum* L.) cv. Delphin caused only a slight enrichment of the substrate with nitrogen – 3.9% to 15.5%, phosphorus – 5.68% to 8.98% and with potassium – 1.2% to 15.1% of the applied rate. Only the content of magnesium corresponded to the optimal range for cultivation of pepper in peat substrate.

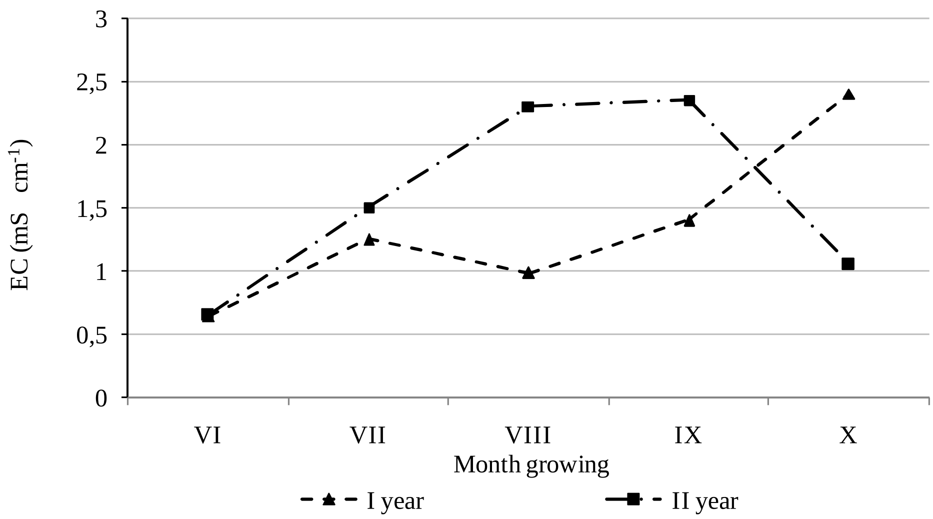


**Fig. 7.** Changes EC of substrate in growing of pepper

However, one must stress that this level was not only the effect of Osmocote Plus (10-11-18) application, but it was also caused by the applied liming of the substrate and by irrigation with water enriched with magnesium. For comparison, mixing of fertilizer with the total substrate volume (Golcz and Komosa 2006) increased, already during the first 21 days of growing, the enrichment of the substrate, as a result of the application of Osmocote Plus (10-11-18), to 71.1% of nitrogen ($N\text{-}NH_4$+$N\text{-}NO_3$), 98.9% of phosphorus and 44.0 – 100.0% of potassium (Golcz and Komosa 2006).

On the basis of our experiments (Komosa *et al.* 1998, Michałojć and Nurzyński 2006), it can be stated that using controlled release fertilizers for the nutrition of plants in a systematic sequence for a long period of time, the standard method of sampling from the external root clod layer gave significantly lower results than in the case when the fertilizers were mixed with the total volume of substrate. This can be explained by the concentration gradient of diffusion components in the substrate from the place where the fertilizer was placed. Therefore, the method of fertilization constitutes a significant factor which has to be considered in the interpretation of the chemical analyses of the substrate.

## CONCLUSIONS

1. The method of Osmocote Plus (10-11-18; 5-6 M) application had a significant effect on the dynamics of macronutrient contents in peat substrate during the growing of pepper.
2. Application of fertilizer by a localized method (pointed placement on the bottom of pots) in the growing of pepper caused low enrichment of the substrate fertility, which for nitrogen was 3.9-15.5%, phosphorus 5.68-8.98% and potassium 1.2-15.1% of the applied rate.
3. Content of magnesium in the substrate was optimal for growing of pepper, however this range was also a result of liming of the substrate and watering of plants.
4. Chemical analyses of substrates enriched with the controlled release fertilizers (CRF) evoked problems with interpretation of results. Some amounts of nutrients are released from the granules of fertilizer during chemical extraction of nutrients from the substrates. It seems to be necessary to remove the granules from substrates before analyses.

## REFERENCES

Breś W., Golcz A., Komosa A., Kozik E., Tyksiński W., 2008. Horticultural plants nutrition (in Polish). Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu.

Golcz A., Komosa A., 2006. Release of nitrogen, phosphorus and potassium from controlled release fertilizer Osmocote Plus in growing of peppers (*Capsicum annuum* L.) (in Polish). Acta Agrophysica, 7(3), 567-576.

Komosa A., Golcz A., Rokossowska E., 1998. Application of slow- and fast-acting fertilizers in cultivation of pepper (in Polish). Fol. Univ. Agric. Stetin., 190 Agricultura, (72), 153-158. Ann.

Michałojć Z., Nurzyński J., 2006. Guide-book for exercises in horticultural fertilization (in Polish). Wydawnictwo Akademii Rolniczej w Lublinie.

Nowak J.S., Strojny Z., Wiśniewska-Grzeszkiewicz H., 1995. Influence of controlled-release fertilizers on the growth of *Philodendron selloum* and *Chamaerops humilis* (in Polish). Zesz. Nauk. Inst. Sadow. i Kwiac., tom 2, 107-116.

Nowosielski O., 1988. Principles for the elaboration of fertilization recommendations in horticulture (in Polish). PWRiL, Warszawa.

Sharma G.C., 1979. Controlled-release fertilizers and horticultural applications. Scientia Horticulture, 11, 107-129.

# DYNAMIKA ZAWARTOŚCI MAKROSKŁADNIKÓW W PODŁOŻU PRZY ZLOKALIZOWANYM ZASTOSOWANIU NAWOZU WOLNODZIAŁAJĄCEGO OSMOCOTE PLUS W POJEMNIKOWEJ UPRAWIE PAPRYKI (*CAPSICUM ANNUUM* L.)

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Streszczenie. W doświadczeniu z uprawą papryki (*Capsicum annuum* L. odm. 'Delphin') w podłożu torfowym zastosowano przedwegetacyjnie w sposób zlokalizowany (punktowo), na dnie wazonu, nawóz o spowolnionym działaniu Osmocote Plus 10-11-18 z którego składniki pokarmowe uwalniane są przez okres 5-6 miesięcy. Analizowano dynamikę zawartości makroelementów w podłożu torfowym, jako efekt stosowania nawozu. Wykazano, że przy zlokalizowanym stosowaniu nawozu Osmocote Plus 10-11-18 jest nie wystarczające wzbogacanie podłoża w azot ($N-NH_4$ i $N-NO_3$) fosfor i potas. Maksymalne oznaczone zawartość tych składników, w stosunku do zastosowanej dawki, wynosiły: 15,5% dla $N-NH_4+N-NO_3$, 8,0% dla P i 15,1% dla K i zaznaczyły się w końcowym okresie uprawy (wrzesień-październik). Optymalna zawartość magnezu w podłożu, utrzymująca się przez cały okres uprawy, była nie tylko wynikiem stosowania Osmocote Plus 10-11-18, ale również obecnością magnezu w nawozie wapniowym (kredzie) użytym do wapnowania torfu oraz wody stosowanej do podlewania. Stwierdzono, że zlokalizowane umieszczenie nawozu w podłożu stwarza nie tylko problemy z utrzymaniem optymalnej zasobności podłoża dla roślin, ale również wyłania wiele problemów metodycznych. Dotyczy to sposobu pobierania prób do analiz, uwalnianie się składników z granul nawozowych w czasie ekstrakcji oraz interpretacji wyników. Problem analiz podłoży z zastosowaniem nawozów o spowolnionym działaniu wymaga dalszych badań metodycznych.

Słowa kluczowe: papryka, nawozy wolnodziałające o kontrolowanym działaniu, Osmocote, nawożenie punktowe, nawożenie zlokalizowane, uwalnianie składników