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EFFECT OF PLANT NUTRITIONAL STATUS ON THE YIELD OF EGGPLANT (*Solanum melongena* L.) GROWN IN ORGANIC SUBSTRATES. PART I. NITROGEN, PHOSPHORUS, POTASSIUM

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Abstract. In the years 2002–2003, in a foil tunnel, vegetation experiment in the growing of two eggplant cultivars 'Epic F_1' and 'Solara F_1' were carried out. Plants were grown in cylinders of 6 dm^3 capacity filled with substrate which consisted of: 1) raised peat (from Lithuania), 2) pine bark + low-moor peat (v : v = 1 : 1). In the vegetation period, top-dressing with nitrogen, phosphorus and potassium was applied. Fruit harvest was carried out many times. The total fruit yield was determined. Index parts of plants were sampled for analyses in which the following values were identified: in 'Epic' cultivars: 1.12–3.40% N; 0.42–1.14% P; 1.80–4.81% K. In 'Solara' cultivars, the following values were found: 1.17–3.50% N; 0.53–1.27% P; 1.96–4.00% K, depending on the substrate and the fertilization level. Differences were found in the total yield and in the nutritional status of plants, depending on the substrate, fertilization level, cultivar and term of sampling.

Key words: eggplant, organic substrate, total yield, nutritional status

INTRODUCTION

Among many factors exerting an effect on the size and quality of yield, fertilization, both the organic and the mineral one (with macro- and microelements) belongs to the more important factors. Plants should be given as many components as are required by the nutrition degree constituting the standard at which abundant and good quality yields are obtained. When a multiple harvest is applied, both an insufficient and an excessive nutrition cause a decrease of the main yield [Breś et al. 2003]. Uliński and Glapś [1988] found that eggplant, because of its quick vegetation growth and a quick production of a great amount of green matter, has high nutritive requirements. Kaufmann and Vorwerk [1971] showed that eggplant takes up similar amounts of nutritive components as

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hot pepper and in the period of fruiting, it has greater requirements for nutritive components than tomato. However, in reference to the unit of the produced plant matter, eggplant uses on the average more components than hot pepper.

The objective of the presented work was the estimation of the effect of the nutritional status regarding nitrogen, phosphorus and potassium on the general yield of eggplant (*Solanum melongena* L.) grown in organic substrates.

MATERIAL AND METHODS

In the years 2002–2003, in the Experimental Station Marcelin of the August Cieszkowski Agricultural University in Poznań, vegetation experiments were carried out with the culture of eggplant grown in beds in the spacing of 0.5×0.5 m, i.e. 4 plants · m^2 , in a foil tunnel of 7×30 m dimensions. Two eggplant cultivars 'Epic F_1' and 'Solara F_1' were planted in cylinders of 6 dm^3 capacity filled with substrate consisting of 1) raised peat from Lithuania, 2) pine bark from Cellulose Plant + fen peat from Biskupice near Poznań (v : v = 1 : 1). Basic pre-vegetational fertilization and top-dressing: low (N), standard (S) and high (W) with macro- and microelements were determined after the consideration of the initial contents of the components in the substrates and they were supplemented to the assumed levels (tab. 1) preserving the proper proportion of the macroelements. N : P : K = 1 : 0.9 : 1.7.

Table 1. Levels of top-dressing with nutritive components in eggplant
Tabela 1. Poziomy składników pokarmowych w nawożeniu oberżyny

Elements Składnik	Substrate – Podłoże mg · dm^{-3}		
	N	S	W
N	300	400	500
P	265	350	440
K	500	665	830
Ca	1500–2000		
Mg	125		
Fe	75		
Mn	35		
Zn	40		
Cu	10		

In the vegetation period, top-dressing was applied basing on substrate analysis carried out by the universal method according to Nowosielski [1988] in 0.03 M CH_3COOH.

In the stage of harvesting maturity, a multiple fruit harvest was carried out and the total yield was determined. During vegetation, in two terms (VII and VIII) indicator parts of plants were sampled in order to determine the contents of macro- and microelements. For the determination of the content of the total component forms in the index

parts, the plant material was wet mineralized in concentrated acids. After mineralization, the following determinations were performed: total N – by distillation, Kjeldahl's method on Parnas-Wagner apparatus; P – by colorimetric method with ammonium molybdate (acc. to Schillak); K – by flame photometry.

RESULTS

On the basis of an analysis of the indicator parts sampled from plants grown in the year 2002, it was found that nitrogen content in the leaves of eggplant 'Epic F_1' cultivar grown in raised peat and in the mixture of pine bark with fen peat decreased in the time of vegetation (fig. 1). Index parts of 'Solara F_1' cv. grown in raised peat and in the mixture of pine bark with low-moor peat contained more nitrogen than the leaves of 'Epic F_1' cultivar. In the analysed index parts, the same dependences were found as in the 'Epic F_1' cv.

In the year 2003, nitrogen content in the index parts in both cultivars grown in peat, independent of the fertilization level and the term of sample taking, was contained in the interval from 2.24 to 3.40% N and it decreased during the vegetation time (fig. 1). In plant index parts grown in a mixture of substrates, the nitrogen contents were smaller, they did not exceed 2.5% N and they increased during vegetation.

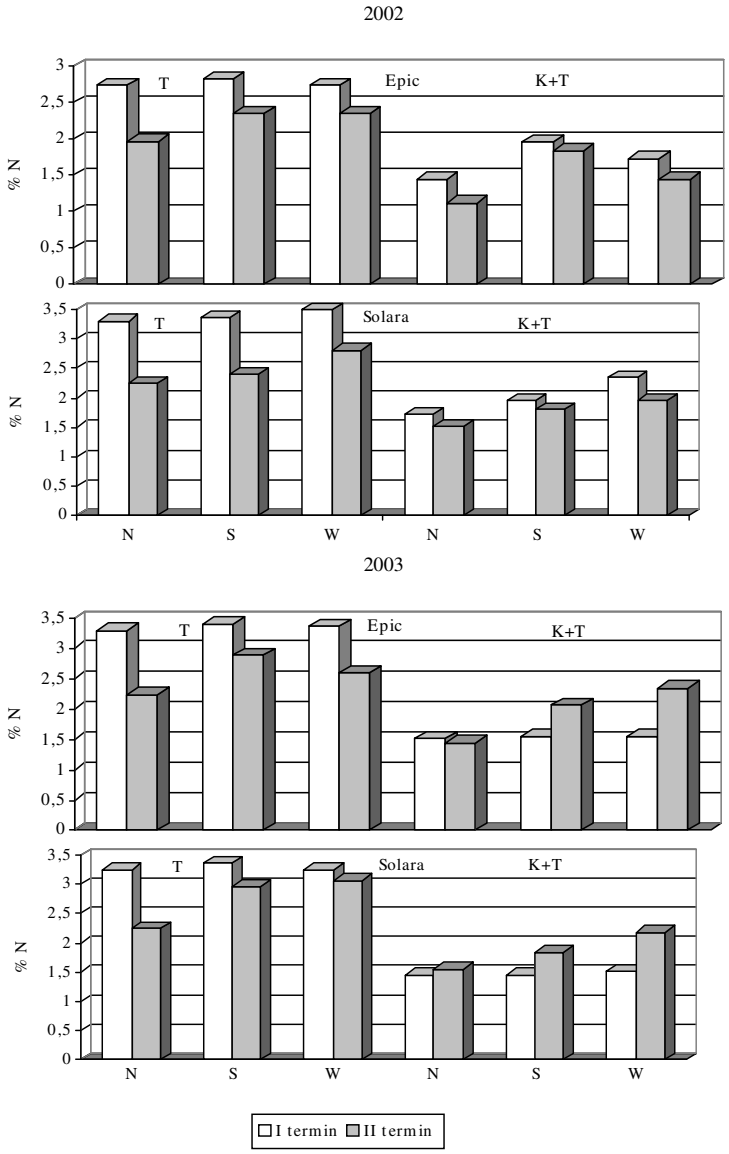
Analysing the index parts of 'Epic F_1' and 'Solara F_1' cvs. in 2002, higher content of phosphorus were found in the first term of analyses in plants grown in raised peat with the preservation of the same decreasing tendency in the second term of analyses (fig. 2). Plants grown in a bark-and-peat substrate contained lower contents of phosphorus than those grown in raised peat. Similarly as in the combination in peat, the phosphorus contents in the leaves of 'Epic F_1' cv. in the second term of analyses were smaller than those sampled in the first term, independent of the fertilization level. Such dependance was also confirmed in the leaves of 'Solara F_1' cv. grown in bark with peat, but only at the low fertilization level. On the other hand, at the standard level and with a high content of phosphorus in leaves in the second term, it was slightly higher than in the first term.

In 2003, in 'Epic F_1' cultivar, when a low fertilization level was applied and plants were grown in peat, the phosphorus content was decreased (fig. 3). An inverted dependence was found at the standard and at the high level of fertilization, where the content of this component systematically increased.

For plants grown in the mixture of pine bark and fen peat, the lowest contents of phosphorus in leaves in all fertilization combinations were found in the first term of sampling, in comparison with the second term.

'Solara F_1' cultivar was characterized by another dynamics of phosphorus content than the 'Epic F_1' cultivar. In the index parts of plants grown in raised peat, in all three fertilization levels, the same tendencies were noted. The highest contents of phosphorus were determined in the first term of sampling, while during vegetation, the content of phosphorus decreased.

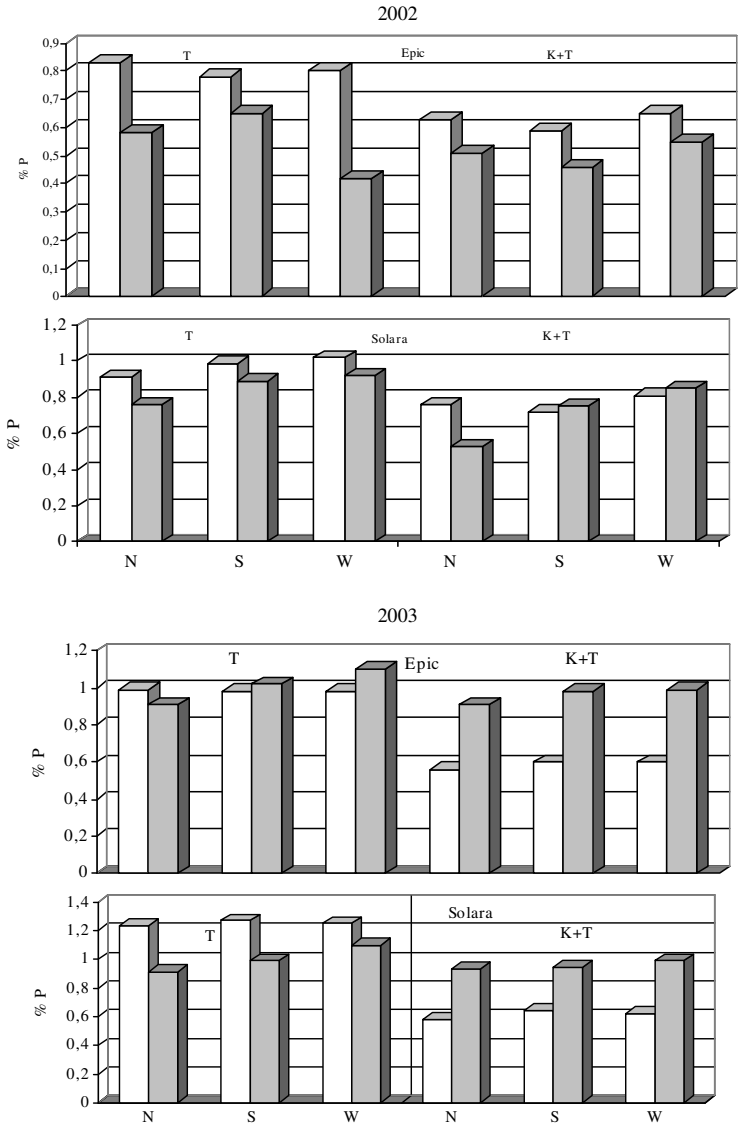
In the first term of sampling, the index parts of 'Solara F_1' cv. grown in the mixture of pine bark and fen peat, in comparison with raised peat, contained smaller phosphorus amounts. In the successive term of analyses, in the substrate mixture, the phosphorus content was higher.



Explantations– Objaśnienia: Nutrition level – Poziomy nawożenia: N – low – niski, S – standard – standardowy, W – high – wysoki, T – raised peat – torf wysoki, K + T – pine bark + low-moor peat – mieszanina kory z torfem niskim

Fig. 1. Changes in nitrogen content in the indicator parts of 'Epic' and 'Solara' cultivars in the vegetation periods of the years 2002–2003

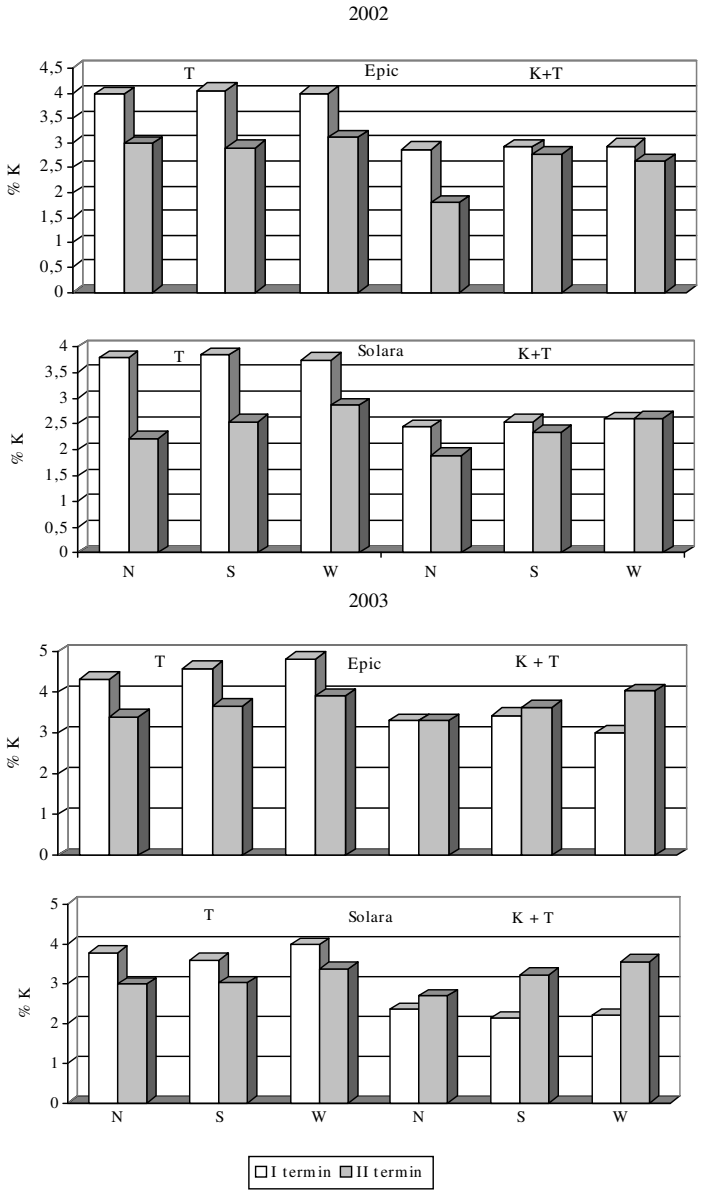
Rys. 1. Zmiany zawartości azotu w częściach wskaźnikowych odmiany 'Epic' i 'Solara' w okresie wegetacji w latach 2002–2003



Explantations – Objaśnienia: see figure 1 – patrz rysunek 1

Fig. 2. Changes in phosphorus content in the indicator parts of 'Epic' and 'Solara' cultivars in the vegetation years 2002–2003

Rys. 2. Zmiany zawartości fosforu w częściach wskaźnikowych odmiany 'Epic' i 'Solara' w okresie wegetacji w latach 2002–2003



Explantations – Objaśnienia: see figure 1 – patrz rysunek 1

Fig. 3. Changes in potassium content in the indicator parts of 'Epic' and 'Solara' cultivars.in the vegetation periods of 2002–2003

Rys. 3. Zmiany zawartości potasu w częściach wskaźnikowych odmiany 'Epic' i 'Solara' w okresie wegetacji w latach 2002–2003

In the mixed substrate, the dynamics of phosphorus content in the index parts at all fertilization levels was the same.

In 2002, the eggplant leaves contained greater amounts of potassium in the first term of sampling, particularly in the raised peat, independent of the fertilization level (fig. 1). In both organic substrates, potassium content in plant index parts decreased during vegetation. Index parts of 'Solara F_1' cv. grown in organic substrates contained a little less potassium than the leaves of 'Epic F_1' cultivar. During vegetation, there occurred a slight decrease of potassium content in all fertilization combinations with the exception of the mixture of bark with peat in 'Solara F_1' cv. with a high level of fertilization.

Potassium content in index parts in the year 2003 depended on the fertilization level (fig. 3). The highest content of potassium was found in eggplant leaves of both cultivars grown in raised peat in the first term of analyses. During vegetation, potassium content decreased at all levels of fertilization.

When the low level of potassium fertilization was used, then in the index parts of 'Epic F_1' cultivar grown in the mixture of bark with peat, the potassium content was maintained on the same level throughout the whole vegetation period. In the remaining fertilization combinations, the P content increased in the second sampling term. Index parts of 'Solara F_1' cv. contained less potassium in comparison with 'Epic F_1' cultivar.

Potassium content in the index parts of 'Solara F_1' cv. grown in raised peat, was decreased identically as in the 'Epic F_1' cv. in the period of vegetation. An inverted relation occurred in the analysed index parts of plants grown in mixed substrate.

Table 2. Effect of substrate, fertilization level and cultivar on the total yield of eggplant fruits (in 2002)

Tabela 2. Wpływ rodzaju podłoża, poziomu nawożenia i odmiany na plon ogólny owoców oberżyny (2002 r.)

Substrate Podłoże	Nutrition level Poziom nawożenia	Total yield – Plon ogólny, kg · m^{-2}			
		cultivar – odmiana (C)		mean – średnia	mean – średnia
(A)	(B)	Epic	Solara	(A×B)	(A)
Raised peat Torf	N	4.45 d*	4.52 d	4.48 c	4.96 b
	S	4.76 de	5.06 e	4.91 d	
	W	5.85 f	5.09 e	5.47 e	
	mean – średnia (A×C)	5.02 b	4.89 b		
Pine bark with low-moor peat Kora + torf	N	3.15 a	3.56 b	3.35 a	3.82 a
	S	3.56 b	3.75 bc	3.65 b	
	W	4.93 e	4.00 c	4.46 c	
	mean – średnia (A×C)	3.88 a	3.77 a		
Mean – Średnia (C)		4.45 a	4.33 a		
Mean – Średnia (B×C)		3.80 a	4.04 ab		
		4.16 bc	4.40 cd		
		5.39 e	4.55 d		
Mean – Średnia (B)		3.92 a			
		4.28 b			
		4.97 c			

*Mean marked by the same letters do not differ significantly at the level of $\alpha = 0.05$

*Średnie oznaczone tymi samymi literami nie różnią się istotnie na poziomie $\alpha = 0{,}05$

Table 3. Effect of substrate, fertilization level and cultivar on the total yield of eggplant fruits (in 2003)

Tabela 3. Wpływ rodzaju podłoża. poziomu nawożenia i odmiany na plon ogólny owoców oberżyny (2003 r.)

Substrate Podłoże	Nutrition level Poziom nawożenia	Total yield – Plon ogólny, kg · m^{-2}			
		cultivar – odmiana (C)		mean – średnia	mean – średnia
(A)	(B)	Epic	Solara	(A×B)	(A)
Raised peat Torf	N	5.02 c	6.55 d	5.79 c	6.30 b
	S	6.35 d	7.92 e	7.14 d	
	W	5.44 c	6.50 d	5.97 c	
	mean – średnia (A×C)	5.60 c	6.99 d		
Pine bark with low- moor peat Kora + torf	N	4.16 b	2.78 a	3.47 a	4.55 a
	S	5.29 c	5.14 c	5.21 b	
	W	5.45 c	4.48 b	4.96 b	
	mean – średnia (A×C)	4.97 b	4.13		
Średnia Mean (C)		5.28 a	5.56 b		
Mean – Średnia (B×C)		4.59 a	4.67 a		
		5.82 c	6.53 d		
		5.44 c	5.49 b		
Średnia – Mean (B)		4.63 a			
		6.17 c			
		5.47 b			

*Mean marked by the same letters do not differ significantly at the level of α = 0.05

*Średnie oznaczone tymi samymi literami nie różnią się istotnie na poziomie α = 0,05

Plant yield is among others an index of the status of plant nutrition. It was shown that the plant nutrition status exerted an effect on the total yield of eggplant. The highest mean value of the total fruit yield in 2002 was obtained from plants grown in raised peat (4.96 kg · m^{-2}), while a lower yield (by 20%) was obtained from plants grown in bark with peat (3.82 kg · m^{-2}), in the index parts in which lower nitrogen, phosphorus and potassium contents were determined (tab. 2). The mean total yield of both eggplant cultivars increased significantly with the increase of fertilization level reaching maximum 4.97 kg · m^{-2} when the content of nitrogen, phosphorus and potassium in the substrate was supplemented to the high level (W). The eggplant cultivars 'Epic F_1' and 'Solara F_1' used in the studies, in spite of insignificant differences in the nutritional status with nitrogen, phosphorus and potassium did not differ significantly regarding the size of the total yield. In 'Epic F_1' cultivar, it amounted to 4.45 kg · m^{-2} in comparison with 'Solara F_1' cv. – 4.33 kg · m^{-2} .

In the year 2003, there occurred the same dependences as in the previous year of studies. The highest mean total yield of eggplant fruits (6.30 kg · m^{-2}) was obtained when the plants were grown in raised peat (tab. 3). When they were grown in bark with peat, the yield was smaller by 28% and it amounted to 4.55 kg · m^{-2}. The obtained results differed significantly. In both cultivars, the highest yield of fruits ('Solara F_1' 7.92 kg · m^{-2} and 'Epic F_1' 6.35 kg · m^{-2}) was obtained when plants were grown in raised peat with the standard level of fertilization.

In 2003, the mean total yield of 'Epic F_1' and 'Solara F_1' fruits differed significantly. Both cultivars yielded better than in the year 2002.

DISCUSSION

In our own studies, the following element contents were determined in the index parts of 'Epic F_1' cultivar: 1.12–3.40% N; 0.42–1.14% P; 1.80–4.81% K; while in 'Solara F_1' cv., the values were: 1.17–3.50% N; 0.53–1.27% P and 1.96–4.00% K, depending on the substrate and fertilization level. On the other hand Kaufmann and Vorwerk [1971] reported that the standard content in the leaves of eggplant were: N – 3.68, P – 0.26, K – 3.75% d.m. According to Raghupathi and Bhargava [1998], the standard contents of macroelements were within the following ranges: N 2.85–3.88; P 0.33–0.80; K 2.16–3.50%. Analysis of index parts showed higher content of nitrogen, phosphorus and potassium in plants grown in raised peat and lower content in plants grown in bark with peat which was reflected in the total yield of fruits. The main total yield of eggplant fruits from the years 2002–2003 was equal at the standard and at the high levels of fertilization (5.22 kg · m^{-2}) (tab. 4).

Table 4. Mean total yield of eggplant in the years 2002–2003
Tabela 4. Średni plon ogólny oberżyny w latach 2002–2003

Nutrition level Poziom nawożenia	Total yield – Plon ogólny, kg · m^{-2}		
	year – rok		mean – średnia
	2002	2003	
N	3.92	4.63	4.27
S	4.28	6.17	5.22
W	4.97	5.47	5.22

The obtained results confirm the results of the studies of Cebula [1993] who reported that eggplant yield in the cultivations under cover ranged from 5 to 7 kg · m^{-2}. The wide C:N proportion in fresh bark causes that it is difficult to determine the proper fertilization level with nitrogen which could be able to prevent any negative effects of biological sorption of nitrogen [Pudelski 1995]. This process also could have exerted an effect on the nitrogen content in the index parts. High content of phosphorus in the index parts of plants even if low level of fertilization confirm that eggplant have high nutrient requirement for phosphorus during flowering and fruit-bearing period [Buczkowska 2004]. The content of phosphorus estimated in leaves are higher than citted literature show a possibility of acumulation of this nutrient by studies varieties of eggplants.

CONCLUSIONS

1. The fertilization level with nitrogen, phosphorus and potassium had an effect on the total yield of fruits and on eggplant nutritional status with these macroelements.
2. The highest total yield of fruits was obtained when the plants were grown in raised peat.
3. Plants grown in raised peat contained higher amounts of nitrogen, phosphorus and potassium in the index parts in comparison with plants grown in bark with peat.

4. The content of nitrogen, phosporus and potassium in the index parts of plants grown in raised peat was decreased in the time of vegetation, while this dependence was not so distinct in case when plants were grown in bark with peat.

5. Higher content of nitrogen and phosphorus were found in the index parts of 'Solara F_1', while higher potassium content were shown by 'Epic F_1' cultivar.

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WPŁYW STANU ODŻYWIENIA ROŚLIN NA PLON OBERŻYNY (*Solanum melongena* L.) UPRAWIANEJ W PODŁOŻU ORGANICZNYM. CZ. I. AZOT, FOSFOR, POTAS

Streszczenie. W latach 2002–2003 w tunelu foliowym przeprowadzono doświadczenia wegetacyjne z uprawą dwóch odmian oberżyny 'Epic F_1' i 'Solara F_1'. Rośliny uprawiano w cylindrach o objętości 6 dm^3 wypełnionych podłożem, które stanowiło: 1) torf wysoki z Litwy, 2) korę sosnową + torf niski (v : v = 1 : 1). W okresie wegetacji stosowano nawożenie pogłówne azotem, fosforem i potasem Wykonywano wielokrotny zbiór owoców. Określono plon ogólny owoców. Pobierano części wskaźnikowe roślin do analiz, w których oznaczono: u odmiany 'Epic' 1,12–3,40% N; 0,42–1,14% P; 1,80–4,81% K, natomiast u odmiany 'Solara' 1,17– 3,50% N; 0,53–1,27% P; 1,96–4,00% K w zależności od podłoża i poziomu nawożenia. Stwierdzono różnice w plonie ogólnym, oraz w stanie odżywienia roślin w zależności od podłoża, poziomu nawożenia, odmiany i terminu pobrania prób.

Słowa kluczowe: oberżyna, podłoże organiczne, plon ogólny, stan odżywienia

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