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THE NUTRITIONAL STATUS OF EGGPLANT (*Solanum melongena* L.) DEPENDING ON PLANT TRAINING METHOD AND NITROGEN FERTILIZATION

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Abstract. The eggplant is a valuable plant mainly grown in a greenhouse and under the foil. Nowadays we have still too little informations about nutritional and fertilization need of that plant. Experiments involving eggplant of Epic F_1 cv. were carried out in 2004–2005 in unheated foil tunnel; the aim focused on evaluating the influence of pruning methods using plants treated with nitrogen in form of $N\text{-}NH_4$, $N\text{-}NO_3$, NH_2 applied at various rates. Achieved results revealed significantly influence of nitrogen forms on total nitrogen, phosphorus, and calcium, while no influence on potassium and magnesium contents in eggplant leaves. Instead, increasing nitrogen doses significantly elevated the nitrogen, phosphorus, and magnesium concentrations in plants. Improved light conditions within a plant profile due to cutting had positive effects on phosphorus and calcium contents in leaves as compared to plants pruned in their natural form. Considerable decrease of the subsoil pH value was recorded after applying the increasing rates of nitrogen fertilizers in a form of ammonium sulfate. Following levels of eggplant nutrition at full ripeness were considered as optimum: 0.28% to 0.45% $N\text{-}NO_3$ and 3.70 to 4.00% N-tot. in leaves, as well as 250 to 350 mg $N\text{-}NH_4\text{+}N\text{-}NO_3\cdot dm^{-3}$ in subsoil.

Key words: *Solanaceae*, nitrogen form and dose, macroelements, EC, pH

INTRODUCTION

Increased interests in cultivating and consuming the eggplant in Poland led to undertake studies upon agricultural practices of the vegetable grown in a greenhouse and under foil. Usefulness of numerous eggplant cultivars for those cultivation conditions was evaluated [Wierzbicka et al. 1990, Gajewski and Gajc-Wolska 1998] and some practices intensifying the fruit setting [Cebula and Ambroszczyk 1999, Cebula 2003, Kowalska 2003, Buczkowska 2005, 2010, Ambroszczyk et al. 2007, 2008, Sękara and Bieniasz 2008] along with nutritional requirements including the yield quality were also

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recommended [Herrmann 1996, Golcz and Markiewicz 2003, Golcz at al. 2005, Golcz at al. 2008, Markiewicz et al. 2008, Michałojć and Buczkowska 2008, 2011].

Available literature contains not much information on nutritional and fertilization needs of eggplant. To date, they were described as similar to those for tomato and pepper grown under coverage in agrotechnical studies and cultivation recommendations [Kauffman and Vorwerk 1971, Uliński and Glapś 1988].

Nitrogen is the only nutrient that is uptaken by plants in form of various ions and compounds. However, plants utilize NO_3^- or NH_4^+ [Marschner 1995]. Diverse reactions of plants towards particular nitrogen ions types are observed, although definitely larger group of plant species prefers nitrates over ammonium, despite of much higher energetic costs for NO_3^- assimilation [Starck 2003, 2008].

Presented study aimed at evaluating the optimum nutritional status of eggplants treated with nitrogen in forms of N-NH_4, N-NO_3, NH_2 applied in three rates. Moreover, the influence of these factors on plant training methods (natural and for three sprouts) was verified.

MATERIAL AND METHODS

Experiments involving eggplant of Epic F_1 cv. were carried out in 2004–2005 in unheated foil tunnel. The eggplant trasplant was prepared in a greenhouse according to common recommendations for the plant species. Seeds were sown at the beginning of March in both experimental years. The seedling was planted at the beginning of June. Vegetation period from seed sowing till experiment complete lasted about 7 months (3^{rd} March – 13^{th} September).

Plants were grown in foil cylinders of 10 dm^3 capacity each in density of 3.3 per 1 m^2 in peat of initial pH 4.6, that was limed using $CaCO_3$ to adjust pH value to 6.5. The experiment was set as free – factorial in complete randomized design. Each combination was represented by 8 plants (experimental units).

The influence of three factors was studied:

1. Nitrogen forms:

NH_4^+ as ammonium sulfate $(NH_4)_2SO_4$ (20.5% N);
NO_3^- as calcium nitrate $Ca(NO_3)_2$ (15.5% N);
NH_2 as urea $CO(NH_2)_2$ (46% N).

2. Nitrogen rate: 5; 10; 15 g N · $plant^{-1}$.

3. Plant training method: natural form; for three sprouts.

Nitrogen, phosphorus, potassium, and magnesium nutrition was uniform during the whole experiment and amounted to (in g · $plant^{-1}$):
nitrogen (N) – 5; 10; 15 g N in form of $(NH_4)_2SO_4$; $Ca(NO_3)_2$; $CO(NH_2)_2$;
phosphorus (P) – 7.0 g P in form of superphosphate $Ca(H_2PO_4)_2 \cdot H_2O$ – 20.2% P;
potassium (K) – 16 g K in form of potassium sulfate K_2SO_4 – 41.6 % K;
magnesium (Mg) – 7.0 g Mg in form of magnesium sulfate ($MgSO_4 \cdot H_2O$ 17.4% Mg);
iron (Fe) – 0.4 g Fe as EDTA Fe; copper (Cu) – 66.0 mg Cu as $CuSO_4 \cdot 5H_2O$; zinc (Zn) – 3.7 mg Zn as $ZnSO_4 \cdot 7H_2O$; manganese (Mn) – 25.5 mg Mn as $MnSO_4 \cdot H_2O$; boron (B) – 8.0 mg B as H_3BO_3; molybdenum (Mo) – 18.0 mg Mo as $(NH_4)_2Mo_7O_{24} \cdot 4H_2O$.

All nutrients – besides nitrogen – were provided into the subsoil at uniform levels. Prior to planting, during the subsoil preparation, whole dose of microelements, half of phosphorus, as well as 1/7 nitrogen, potassium, and magnesium doses were used. Another phosphorus dose was applied after the first eggplant fruit harvest. The remaining amounts of nitrogen, potassium, and magnesium were applied as post-crop dividing into 6 doses every 10 days. The subsoil moisture content was maintained at 70% level.

Nursery and protective practices were made in accordance to recommendations for the plant species. Leaf and subsoil samples were collected to chemical analyses in the mid of fruiting. Leaves were taken from the middle of plant height and after drying and digesting they were subject to determination of total nitrogen (Kjeldahl method), and after combusting: phosphorus (colorimetry), and K, Ca, Mg (AAS technique). Moreover, 2% CH_3COOH extract of leaves was subject to determine the N-NO_3 by means of Bremner distillation method with modifications by Starck.

The 0.03 M CH_3COOH extract of the subsoil was subject to determine: N-NH_4, N-NO_3 (applying the same methods as for plant material), P (colorimetry using ammonium vanadate), Cl with $AgNO_3$, K, Ca, and Mg (AAS), pH in H_2O, as well as electrical conductivity (salt contents) – conductometry.

The results were statistically verified using analysis of variance. The difference significant differences were evaluated using the Tukey's test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Results on nitrogen, phosphorus, potassium, calcium, and magnesium contents in eggplant leaves being mean values from two experimental years are presented in table 1.

Concentration of N-tot. in eggplant leaves amounted from 2.88 to 4.73% N-tot., which was significantly differentiated by a form and rate of nitrogen fertilizer. Its lowest content in eggplant leaves was recorded, when nitrogen was applied in a form of NO_3^- (3.21% N-tot.), while the highest after NH_4^+ use (4.11% N-tot.); furthermore, its levels in leaves increased (3.35; 3.70; 4.04% N-tot.), when nitrogen dose was enhanced (5; 10; 15 g N·plant^{-1}, respectively). Determinations of N-tot. and N- NO_3 in leaves and mineral nitrogen (N-NH_4 + N-NO_3) in subsoil were made in the middle at fruiting period. The lowest nitrogen dose affected the 3.35% N-tot. and 0.16% N-NO_3 along with 102 mg N-NH_4 + N-NO_3·dm^{-3} in subsoil; medium N rate – 3.7% N-tot., 0.28% N-NO_3 at 189 N-NH_4 + N-NO_3·dm^{-3} content in subsoil, as well as 4.04% N-tot. – 0.45% N-NO_3 at 284 mg N-NH_4 + N-NO_3·dm^{-3} content in the subsoil (fig. 1). Achieved results indicated significant influence of applied nitrogen fertilizers on N-tot. and N-NO_3 contents. Considerably more total nitrogen in leaves of eggplant was found, when calcium nitrate was used as compared to calcium nitrate and urea, as well as the largest percentage of N-NO_3 in leaves of plants treated nitrate form (fig. 2). Therefore, when the nutritional status of eggplant is to be evaluated, a nitrogen form should be taken into account, because different concentrations of N-NO_3 in eggplant leaves were recorded at the same dose, while different nitrogen forms. The plant training method had no any significant effects on nitrogen contents in studied plants. Studies performed by Kaufmann and Vorwerk [1971] revealed 3.68 ± 0.2% N as optimum nitrogen content in eggplant

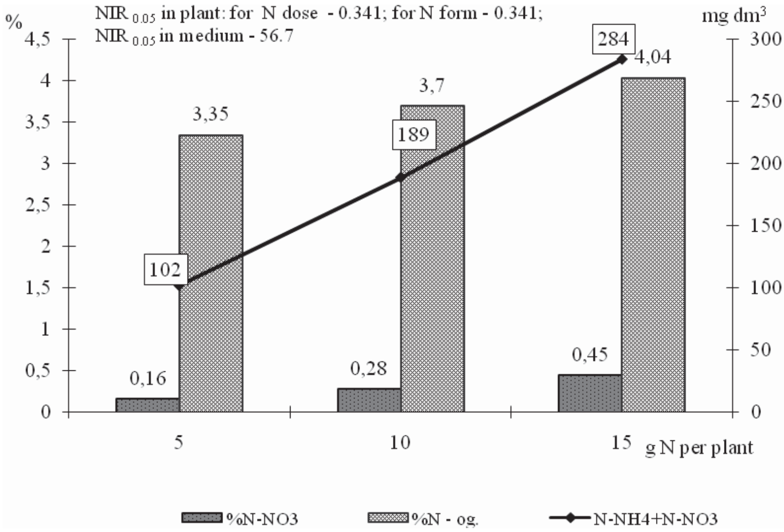

Fig. 1. Content of N- NO_3, N-tot. (% d.m.) in eggplant leaves and N-NH_4+N-NO_3 (mg·dm^{-3}) in medium of depending N dose

Rys. 1. Zawartość N-NO_3, N-og. (% s.m.) w liściach i N-NH_4+N-NO_3 (mg·dm^{-3}) w podłożu oberżyny w zależności od dawki azotu

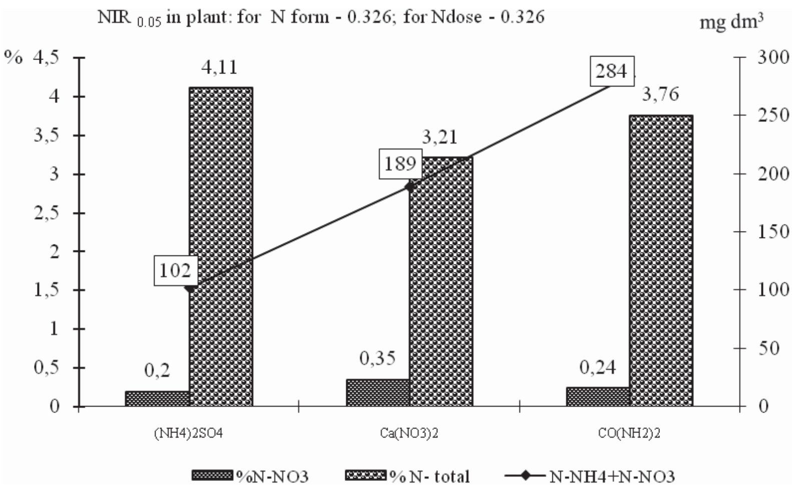

Fig. 2. Content of N- NO_3, N-tot. (% d.m.) in leaves and N-NH_4+N-NO_3 (mg·dm^{-3}) in medium eggplant of depending N form

Rys. 2. Zawartość N-NO_3, N-og. (% s.m.) w liściach i N-NH_4+N-NO_3 (mg·dm^{-3}) w podłożu oberżyny w zależności od formy azotu

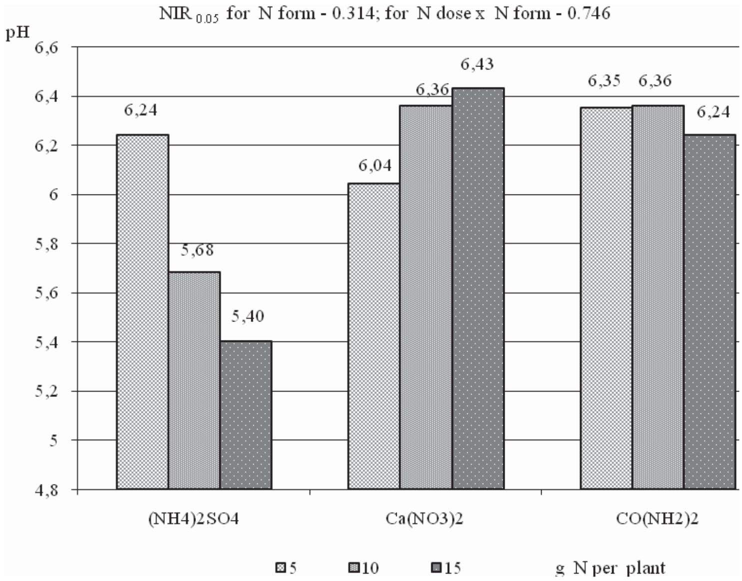

Fig. 3. The effect of N form and N dose on reaction of medium $pH_{(H2O)}$
Rys. 3. Wpływ dawki i formy azotu na odczyn podłoża $pH_{(H2O)}$

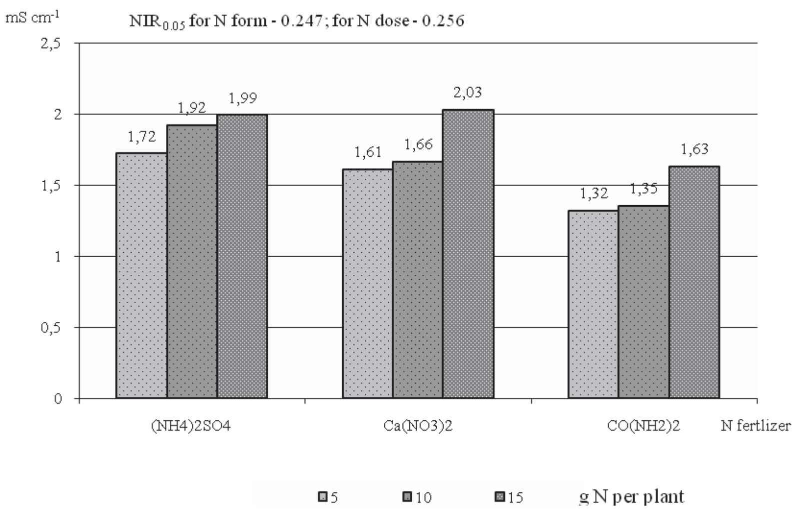

Fig. 4. The effect of N form and N dose on salinity (EC) in medium
Rys. 4. Wpływ dawki i formy azotu na stężenie soli (EC) w podłożu

Table 1. Content N-total., P, K, Ca, Mg (% d.m.) in eggplant leaves dependent on plant training method and different of nitrogen fertilization (means for years 2004–2005)

Tabela 1. Zawartość N-og., P, K, Ca, Mg (% s.m.) w liściach oberżyny w zależności od sposobu prowadzenia roślin i zróżnicowanego nawożenia azotem (średnie z lat 2004–2005)

N fertilizer nawóz (b)	Dose N $g \cdot plant^{-1}$ Dawka N $g \cdot rośl.^{-1}$	N-total – N ogółem			P			K			Ca			Mg		
		training method – sposób prowadzenia (a)														
		natural form forma naturalna	3 shoots 3 pędy	means średnio	natural form forma naturalna	3 shoots 3 pędy	means średnio	natural form forma naturalna	3 shoots 3 pędy	means średnio	natural form forma naturalna	3 shoots 3 pędy	means średnio	natural form forma naturalna	3 shoots 3 pędy	means średnio
$(NH_4)_2SO_4$	5	3.56	3.67	3.61	0.28	0.32	0.30	3.82	4.00	3.91	2.27	3.09	2.68	0.13	0.19	0.16
	10	4.11	4.08	4.10	0.30	0.33	0.32	3.45	4.11	3.78	2.40	3.14	2.77	0.15	0.26	0.20
	15	4.73	4.52	4.62	0.37	0.38	0.37	3.73	3.78	3.76	2.29	2.87	2.58	0.17	0.26	0.21
Mean – Średnio		4.13	4.09	4.11	0.31	0.34	0.33	3.66	3.96	3.81	2.32	3.03	2.67	0.15	0.24	0.19
$Ca(NO_3)_2$	5	2.88	3.12	3.00	0.23	0.23	0.23	3.94	4.17	4.05	2.90	2.99	2.94	0.16	0.24	0.20
	10	3.06	3.40	3.23	0.19	0.22	0.20	3.76	4.32	4.04	3.29	3.12	3.36	0.19	0.34	0.26
	15	3.31	3.54	3.42	0.19	0.19	0.19	3.76	3.86	3.81	3.81	3.97	3.89	0.27	0.38	0.33
Mean – Średnio		3.08	3.35	3.21	0.20	0.21	0.21	3.82	4.11	3.97	3.33	3.36	3.35	0.20	0.32	0.26
$CO(NH_2)_2$	5	3.40	3.44	3.42	0.26	0.29	0.27	3.93	4.56	4.25	2.51	2.94	2.72	0.17	0.23	0.20
	10	3.69	3.83	3.76	0.25	0.28	0.27	4.05	4.47	4.26	2.35	2.70	2.52	0.15	0.23	0.19
	15	4.02	4.16	4.09	0.27	0.31	0.29	3.87	4.15	4.01	2.94	3.15	3.05	0.22	0.29	0.25
Mean – Średnio		3.70	3.81	3.76	0.26	0.29	0.28	3.95	4.39	4.17	2.60	2.93	2.76	0.18	0.25	0.21
Mean for N dose Średnio dla dawki N	5	3.28	3.41	3.35	0.26	0.28	0.27	3.90	4.24	4.07	2.56	3.01	2.78	0.15	0.22	0.19
	10	3.62	3.77	3.70	0.25	0.28	0.26	3.75	4.30	4.02	2.68	2.99	2.84	0.16	0.27	0.21
	15	4.02	4.07	4.04	0.28	0.29	0.29	3.79	3.93	3.86	3.01	3.33	3.17	0.22	0.31	0.27
Mean – Średnio		3.64	3.75	3.70	0.26	0.28	0.27	3.81	4.16	3.98	2.75	3.11	2.93	0.18	0.27	0.22
$NIR_{0,05}$ – $LSD_{0.05}$																
form N – forma N (a)			0.326			0.024			n.s. – n.i.			n.s			0.072	
dose N – dawka N (b)			0.326			0.024			n.s. – n.i.			0.540			n.s. – n.i.	
training method – sposób prowadzenia (c)			n.s. – n.i.			0.016			n.s. – n.i.			0.367			0.049	
interaction – interakcje:																
a × b			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	
a × c			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	
b × c			n.s. – n.i.			0.056			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	
a × b × c			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	

Table 2. Content P, K, Ca, Mg, Cl (mg · dm^{-3}) in medium in the middle of eggplant cultivation period (means for years 2004–2005)
Tabela 2. Zawartość P, K, Ca, Mg, Cl (mg · dm^{-3}) w podłożu w połowie okresu uprawy oberżyny (średnie z lat 2004–2005)

N fertilizer nawóz (a)	Dose N g·plant^{-1} Dawka N g·rośl.$^{-1}$	P			K			Ca			Mg			Cl		
		training method – sposób prowadzenia (c)														
		natural form forma naturalna	3 shoots 3 pędy	means średnio	natural form forma naturalna	3 shoots 3 pędy	means średnio	natural form forma naturalna	3 shoots 3 pędy	means średnio	natural form forma naturalna	3 shoots 3 pędy	means średnio	natural form forma naturalna	3 shoots 3 pędy	means średnio
$(NH_4)_2SO_4$	5	302	444	373	324	455	390	1609	1978	1794	164	347	255	60	62	61
	10	306	394	350	376	411	394	1511	1864	1687	168	316	242	70	65	67
	15	294	280	287	295	217	256	1336	1586	1461	130	197	164	70	65	68
Mean – Średnio		301	373	337	332	361	347	1485	1809	1647	154	287	220	67	64	65
$Ca(NO_3)_2$	5	540	422	481	391	295	343	2005	2225	2115	181	188	184	70	60	65
	10	440	374	407	261	309	285	1725	2295	2010	150	190	170	60	60	60
	15	436	500	468	314	220	267	2780	2470	2625	230	143	187	55	55	55
Mean – Średnio		472	432	452	322	275	298	2170	2330	2250	187	174	180	62	58	60
$CO(NH_2)_2$	5	426	470	448	278	295	286	1619	1929	1774	271	257	264	70	60	65
	10	390	456	423	323	264	294	1801	1639	1720	228	238	233	60	60	60
	15	344	462	403	166	209	188	1714	1844	1779	231	236	234	68	55	62
Mean – Średnio		387	463	425	256	256	256	1711	1804	1758	243	244	244	66	58	62
Mean for N dose Średnio dla dawki N	5	243	445	344	331	348	340	1744	2044	1894	205	264	235	67	61	64
	10	412	408	410	320	328	324	1679	1933	1806	182	248	215	63	62	63
	15	358	414	386	258	215	236	1943	1967	1955	197	192	195	64	58	61
Mean – Średnio		338	422	380	303	297	300	1789	1981	1885	195	235	215	65	60	63
$NIR_{0,05}$ – $LSD_{0.05}$																
form N – forma N (a)			n.s. – n.i.			n.s. – n.i.			452.3			60.9			n.s. – n.i.	
dose N – dawka N (b)			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	
training method – sposób prowadzenia (c)			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	
interaction – interakcje:																
a × b			n.s. – n.i.			n.s. – n.i.			107.2			n.s. – n.i.			n.s. – n.i.	
a × c			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	
b × c			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	
a × b × c			n.s. – n.i.			n.s			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.	

leaves. Golcz at al. [2005], Markiewicz et al. [2008] determined from 3.40 to 3.50% N-tot. in leaves of Epic F_1 cv. grown in peat. In studies by Michałojć and Buczkowska [2008, 2011], the highest quantitative and qualitative eggplant fruit yield was achieved after applying calcium nitrate at 15 g N·plant^{-1} rate. Thus, nitrogen contents from 0.28% to 0.45% N-NO_3 and 3.70–4.00% N-tot., as well as 250–350 mg N-min.·dm^{-3} in subsoil, should be considered as optimum nutrition level for eggplant during full fruiting.

Phosphorus content in eggplant leaves amounted to 0.19–0.38% P, which was significantly differentiated due to all studied factors, although phosphorus concentration in the subsoil oscillated from 280 to 540 mg P dm^3 (tab. 2). Considerably higher P content was found at plants pruned for 3 sprouts rather than in their natural form. Therefore, it can be concluded that more light intensity in a plant profile might have positive effects on phosphorus uptake in leaves. It was confirmed by experiments made by Amboszczyk et al. [2007, 2008]. In addition, more phosphorus in eggplant leaves was recorded after applying NH_4^+, while less due to NO_3^-, because calcium makes phosphorus retarding and decreases its availability for plants. Studies by Kaufmann and Verwerk [1971] upon eggplant leaves revealed content of 0.26 ± 0.04% P as the most optimum, while Golcz at al. [2005], Markiewicz et al. [2008] indicated much higher value of 0.42 up to 1.14% P.

Potassium concentration in eggplant leaves was 3.45–4.56% K, whereas in the subsoil from 209 to 455 mg K dm^3. Statistical analysis did not confirm any substantial influence of studied factors on the element content. Instead, a tendency of decreasing the potassium level in leaves along with the nitrogen rate, regardless of the nitrogen form applied, was observed. Less potassium was found at plants of natural conformation rather than those pruned for three sprouts. Kaufmann and Ververk [1971] recorded 3.75 ± 0.49% K, while Golcz at al. [2005], Markiewicz et al. [2008] found more diverse potassium contents – from 1.8 to 4.81% K.

Calcium content in eggplant leaves amounted to 2.27–3.97% Ca, and in subsoil 1336–2780 mg Ca dm^3 subsoil. Significant impact of the plant training method and nitrogen form on calcium concentration in plant leaves was proven. Significantly more calcium was found at plants pruned for 3 sprouts rather than those grown in natural form, as well as when nitrogen as calcium nitrate was applied. These results can be accounted for by improved availability of calcium from $Ca(NO_3)_2$. Studies performed by Kaufmann and Verwerk [1971] revealed much higher calcium contents in eggplant leaves (5.09 ± 0.48% Ca).

Magnesium level in eggplant leaves was 0.13–0.38% Mg, while from 130 to 347 mg Mg dm^3 subsoil. Remarkable influence of the plant training method and nitrogen rate on the element content was observed. Significantly higher magnesium concentration was found at plants pruned for three sprouts and its concentration increase along with the nitrogen dose increase.

The subsoil analysis made at full eggplant fruiting revealed great diversification of pH value (fig. 3). The subsoil acidity was adjusted to pH 6.5. prior to plant setting to pots. After about 10 vegetation weeks when the highest nitrogen rate was applied in a form of ammonium sulfate, the pH value decreased to 5.4. Such dependence univocally indicates the acidifying feature of ammonium sulfate. Increasing nitrogen rates in a form of calcium nitrate had alkalizing effects on the subsoil. The minute changes of the subsoil pH value were recorded due to urea. All nutrients – besides nitrogen – were provided into the subsoil at uniform levels. Achieved results indicate high phosphorus and magnesium, moderate potassium and calcium, and optimum of chlorides levels in the subsoil (tab. 2). It should be underlined that recognizing the salts concentration in a subsoil provides with additional evaluation of the subsoil abundance in nutrients. In the present study, salt concentrations in subsoil amounted from 1.32 to 2.03 $mS \cdot cm^{-1}$, which was differentiated by forms and rates of nitrogen. Larger EC values were recorded after applying ammonium sulfate and calcium nitrate rather than urea as well as higher N dose (fig. 4). The range of salt concentrations for plants moderately sensitive to salinity – among others pepper and tomato – is 2–4 $mS \cdot cm^{-1}$ [Breś et al. 2009]. Evaluating the subsoil abundance in nutrients leads to a conclusion that plants had their appropriate quantities at full fruiting.

CONCLUSIONS

1. Significant influence of applied nitrogen forms on nitrogen, phosphorus, and calcium contents, as well as the lack of their effects on potassium and magnesium concentrations in eggplant leaves was recorded.
2. Increasing nitrogen rates considerably increased nitrogen, phosphorus, and magnesium levels at plants.
3. Improving the light conditions in a plant's profile by means of cutting had positive effects on phosphorus and calcium contents increase in leaves as compared to plants trained in their natural form.
4. High subsoil abundance in phosphorus and magnesium, moderate in potassium and calcium, as well as considerable decrease of pH value after increasing nitrogen rates in a form of ammonium sulfate, was observed.
5. Nitrogen contents from 0.28% to 0.45% $N\text{-}NO_3$ and 3.70–4.00% N-tot. in leaves, as well as 250–350 mg $N\text{-}NH_4 + N\text{-}NO_3 \cdot dm^{-3}$ in subsoil, should be considered as optimum nutrition level for eggplant during full fruiting.

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STAN ODŻYWIANIA OBERŻYNY (*Solanum molongena* L.) W ZALEŻNOŚCI OD SPOSOBU PROWADZENIA ROŚLIN I NAWOŻENIA AZOTEM

Streszczenie. Oberżyna jest cenna rośliną, uprawianą głównie w szklarni i pod folią. Obecnie stale brakuje informacji dotyczących potrzeb pokarmowych i nawozowych tej rośliny. Badania z oberżyną odmiany Epic F_1 przeprowadzono w latach 2004–2005 w nieogrzewanym tunelu foliowym. Ich celem było określenie wpływu sposobu prowadzenia roślin nawożonych azotem formie $N\text{-}NH_4$, $N\text{-}NO_3$, NH_2 w zróżnicowanych dawkach. Uzyskane wyniki wykazały istotny wpływ form azotu na zawartość azotu ogółem, fosforu i wapnia oraz brak wpływu na zawartość potasu i magnezu w liściach oberżyny. Natomiast wzrastające dawki azotu istotnie zwiększały zawartość azotu, fosforu i magnezu w roślinach. Polepszenie warunków świetlnych w profilu roślin poprzez cięcie, korzystnie wpłynęło na wzrost zawartości fosforu i wapnia w liściach w porównaniu z roślinami prowadzonymi w formie naturalnej. Stwierdzono istotne obniżenie w podłożu wartości pH po zastosowaniu wzrastających dawek azotu w postaci siarczanu amonu. Za optymalny poziom odżywiania roślin oberżyny azotem w pełni owocowania uznano zawartość od 0.28% do 0.45% $N\text{-}NO_3$ oraz 3.70–4.00% N-og. w liściach roślin, oraz od 250 do 350 mg $N\text{-}NH_4 + N\text{-}NO_3 \cdot dm^{-3}$ w podłożu.

Słowa kluczowe: *Solanaceae*, dawka i forma azotu, makroskładniki, EC, pH

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