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EFFECT OF NITROGEN, PHOSPORUS AND POTASSIUM FERTILIZATION ON YIELDING AND BIOLOGICAL VALUE OF FRUITS OF AUBERGINE (*SOLANUM MELONGENA* L.)

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Abstract

A plant growing experiment was conducted in 2002-2003 on the aubergine cultivars Epic F_1 and Solara F_1 grown in an unheated polyethylene tunnel greenhouse at the Experimental Station in Marcelin, the University of Life Sciences in Poznań. Seedlings were planted on May 15 on beds at a 0.5 × 0.5 m spacing, i.e. 4 plants m^{-2}, into 6 dm^3 cylinders filled with a mixture, limed to pH_{H_2O} = 6.5, of mineral soil (light loamy sand containing 12% clay fraction – deposited on medium-heavy loam) with highmoor peat from Lithuania (v : v = 4 : 1). Basic fertilization – pre-vegetation and top dressing with macronutrients, based on an analysis of the substrate using the universal method in 0.03 M CH_3COOH, was determined to attain the assumed levels: L (N – 200, P – 175, K – 330 mg dm^{-3}), S (N – 300, P – 265, K – 500 mg dm^{-3}), H (N – 400, P – 350, K – 665 mg dm^{-}), while maintaining the N : P : K ratio at 1 : 0.9 : 1.7. The aim of this study has been to determine the effect of a fertilization level and cultivar on the yield and biological value of fruits of aubergine grown on a mixture of mineral soil with highmoor peat (v : v – 4 : 1). The total yield, number of fruits and weight of individual fruits were determined. Significant effect was found for the fertilization level and cultivar on the total yield, mean number of fruits and weight of a single aubergine fruit. Fruits of cv. Epic F_1 aubergine contained more vitamin C than fruits of cv. Solara F_1. In both years, the solids content in fruits of the two aubergine cultivars ranged from 4.0 to 5.5 %. A higher mean dry matter content in aubergine fruits was recorded in cv. Solara F_1.

Key words: aubergine, fertilization, biological value.

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WPŁYW NAWOŻENIA AZOTEM, FOSFOREM I POTASEM NA PLONOWANIE I WARTOŚĆ BIOLOGICZNĄ OWOCÓW OBERŻYNY *(SOLANUM MELONGENA* L.*)*

Abstrakt

W latach 2002-2003 przeprowadzono doświadczenia wegetacyjne z uprawą oberżyny odm. Epic F_1 i Solara F_1 w nieogrzewanym tunelu foliowym w Stacji Doświadczalnej Marcelin Uniwersytetu Przyrodniczego w Poznaniu. Rośliny sadzono 15 maja na zagonach w rozstawie 0,5 × 0,5 m, tj. 4 rośliny m^{-2}, w cylindrach o obj. 6 dm^3 wypełnionych zwapnowaną do pH_{H_2O} = 6,5 mieszaniną gleby mineralnej (piasek gliniasty lekki o zawartości 12% części iłowych – zalegający na glinie średniej) z torfem wysokim z Litwy (v : v = 4 : 1). Nawożenie podstawowe – przedwegetacyjne i pogłówne makroskładnikami, oparte na analizie podłoża wykonanej metodą uniwersalną wg NOWOSIELSKIEGO (1988) w 0,03 M CH_3COOH – ustalono do założonych poziomów z zachowaniem proporcji makroskładników N : P : K = 1 : 0,9 : 1,7 : N (N – 200, P – 175, K – 330 mg dm^{-3}), S (N – 300, P – 265, K – 500 mg dm^{-3}), W (N – 400, P – 350, K – 665 mg dm^{-3}). Celem pracy było określenie wpływu poziomów nawożenia na plon i wartość biologiczną owoców oberżyny uprawianej w mieszaninie gleby mineralnej z torfem wysokim (v : v – 4 : 1). Określono plon ogólny owoców, liczbę owoców, średnią masę pojedynczego owocu oraz wartość biologiczną owoców. Stwierdzono istotny wpływ poziomu nawożenia i odmiany na plon ogólny, średnią liczbę owoców oraz masę pojedynczego owocu oberżyny. Owoce oberżyny odmiany Epic F_1 zawierały więcej witaminy C niż owoce odmiany Solara F_1. We wszystkich latach badań zawartość ekstraktu w owocach obu odmian oberżyny wynosiła od 4,0 do 5,5%. Większą średnią zawartość suchej masy w owocach oberżyny oznaczono u odmiany Solara F_1.

Słowa kluczowe: oberżyna, nawożenie, wartość biologiczna.

INTRODUCTION

The most suitable soils for aubergine are the ones with pH close to neutral (pH 6.5-7.0), friable, medium-heavy, rich in humus and nutrients, with a sufficient amount of water, but not water-logged. Such soils are chernozems, alluvial soils and sandy loams rich in humus, with good air and water relations.

The research conducted by Polish authors on aubergine cultivation in polyethylene tunnel greenhouse mostly deals with organic substrates, particularly peat (BUCZKOWSKA 1998 MICHAŁOJĆ, BUCZKOWSKA 2008, 2009). Aubergine may also be grown on substrates enriched with peat and on mixtures of peat and bark (GAJEWSKI, GAJC-WOLSKA 1998). The high cost of crop cultivation in tunnels stimulates the search for more economical solutions.

The aim of this study has been to determine the effect of a fertilization level and cultivar on the yield and biological value of fruits of aubergine grown on a mixture of mineral soil with highmoor peat (v:v – 4:1).

MATERIAL AND METHODS

In 2002-2003, a plant growing experiment was conducted on aubergine cvultivars Epic F_1 and Solara F_1 grown in an unheated polyethylene tunnel greenhouse at the Experimental Station in Marcelin, the University of Life Sciences in Poznań. Seedlings were planted on May 15 on beds at a 0.5 x 0.5 m spacing, i.e. 4 plants m^{-2}, into 6 dm^3 cylinders filled with a mixture, limed to pH_{H_2O} = 6.5, of mineral soil (light loamy sand containing 12% clay fraction – deposited on medium-heavy loam) with highmoor peat from Lithuania (v : v = 4 : 1). Basic fertilization – pre-vegetation and top dressing with macronutrients, based on an analysis of the substrate using the universal method in 0.03 M CH_3COOH, was designed so as to attain the assumed levels: low (N), standard (S) and (W) – Table 1, while maintaining the N : P : K ratio at 1 : 0.9 : 1.7. The other macro- and micronutrients constituted the background of the experiment.

Table 1

Nutrient levels in pre-vegetation fertilization and top dressing of aubergine

Nutrient	Fertilization			
	pre-vegetation	top dressing		
	(mg dm^{-3})			
	LSH	L	S	H
N	250	200	300	400
P	220	175	265	350
K	415	330	500	665
Ca	1500 - 2000			

Top dressing was performed 3 times at 4-week intervals. Deficits of nitrogen, phosphorus and potassium were supplemented to the assumed levels. In the experiments, mineral fertilizers, i.e. NH_4NO_3, KH_2PO_4 and K_2SO_4, were applied.

The total yield, number of fruits and weight of individual fruits were determined.

The following quality parameters were determined in fresh aubergine fruits (FORTUNA et al. 2003):

1) dry weight – with the oven-dry method,
2) vitamin C – according to Tillmans (PN – 90/A – 75101/11),
3) total solids – by refractometry (PN – 90/A – 75101/02).

The total yield, number of fruits and the weight of individual fruits were analyzed statistically using Duncan's test for three-factorial experiments at a significance level α = 0.05. Factor *A* was the year of the study (2), factor *B*

– fertilization level (3) and factor *C* – cultivar (2). In total, the experiment consisted of 12 combinations 4 replications, while each replication was composed of 5 plants.

RESULTS AND DISCUSSION

In the experiment, the mean yield of fruits in the second year of the experiment (3.86 kg m^{-2}) was significantly higher than in the first year (2.83 kg m^{-2}) – Table 2. The difference between the years in terms of the mean total yield of fruits may have been caused by the lower mean daily temperature and insolation in the first 6 weeks of the experiment.

Table 2

The effect of fertilization level and cultivar on the total yield of aubergine fruits

Year	Nutrition level	Total yield (kg m^{-2})			
		cultivar (*C*)		mean (*A* x *B*)	mean (*A*)
(*A*)	(B)	Epic	Solara		
I	L	2.15 ^{b*}	1.60 ^{a}	1.88 ^{a}	2.83 ^{a}
	S	2.73 ^{c}	2.20 ^{b}	2.46 ^{b}	
	H	4.58 ^{f}	3.74 ^{de}	4.16 ^{d}	
	mean (*A* x *C*)	3.15 ^{b}	2.51 ^{a}		
II	L	3.51 ^{d}	2.97 ^{c}	3.24 ^{c}	3.86 ^{b}
	S	3.89 ^{de}	3.95 ^{e}	3.92 ^{d}	
	H	4.88 ^{f}	4.00 ^{e}	4.44 ^{e}	
	mean (*A* x *C*)	4.09 ^{d}	3.64 ^{c}		
Mean (*C*)		3.62 ^{b}	3.08 a		
Mean (*B* x *C*)		2.83 ^{b}	2.28 ^{a}		
		3.31 ^{c}	3.07 ^{bc}		
		4.73 ^{e}	3.87 ^{d}		
Mean (*B*)		2.56 ^{a}			
		3.19 ^{b}			
		4.30 ^{c}			

L
L. S. H – fertilization level
L – low
S – standard
H – high

* Means marked with the same letters do not differ significantly at a level of $\alpha = 0.05$.

The total yield of fruits in case of plants growing on the mixture of mineral soil with highmoor peat in the years 2002-2003 ranged from 1.60 to 4.88 kg m^{-2}. A significant effect of the fertilization level on the total yield of aubergine fruits was observed. The lowest mean yield was harvested at the low fertilization level (2.56 kg m^{-2}), while the highest – at the high fertilization level (4.30 kg m^{-2}). Yielding of plants was significantly affected by the aubergine cultivar. The mean total yield harvested in both years was higher from cv. Epic F_1 (3.15 and 4.09 kg m^{-2}) than from cv. Solara F_1 (2.51 and

3.64 kg m^{-2}). The range of the harvested yield was lower than that given by CEBULA and AMBROSZCZYK (1999), who reported that the yield of aubergine fruits grown in a tunnel ranged from 6.83 to 10.17 kg m^{-2}.

A significantly higher mean number of fruits (10.77 fruits m^{-2}) was harvested in the second year of the experiment in comparison to the first year (8.75 fruits m^{-2}) – Table 3. Moreover, a significant effect of the ilization level on the mean number of fruits – from 7.78 fruits m^{-2} at the application of the low fertilization level to 11.70 fruits m^{-2} at the high fertilization level. The number of fruits in the experiment ranged from 5.10 fruits m^{-2} to 12.60 fruits m^{-2} depending on the year, cultivar and fertilization level. The mean number of fruits in this study was similar that those reported by other authors (CEBULA 1996).

Table 3

The effect of the fertilization level and cultivar on the mean number of aubergine fruits

Year	Nutrition level	Number of fruits (pcs. m^{-2})			
		cultivar (*C*)		mean (*A* x *B*)	mean (*A*)
(*A*)	(*B*)	Epic	Solara		
I	L	7.20 ^{b}	5.10 ^{a}	6.15 ^{a}	8.75 ^{a}
	S	8.40 ^{bc}	7.80 ^{bc}	8.10 ^{b}	
	H	13.35 ^{h}	10.65 ^{e}	12.00 ^{d}	
	mean (*A* x *C*)	9.65 ^{b}	7.85 ^{a}		
II	L	9.03 ^{cd}	9.78 ^{de}	9.41 c	10.77 ^{b}
	S	10.98 ^{ef}	12.00 ^{fg}	11.49 d	
	H	12.60 ^{gh}	10.21 ^{de}	11.40 d	
	mean (*A* x *C*)	10.87 ^{c}	10.66 ^{c}		
Mean (*C*)		10.26 ^{b}	9.26 ^{a}		
Mean (*B* x *C*)		8.11 ^{a}	7.44 ^{a}		
		9.69 ^{b}	9.90 ^{b}		
		12.98 ^{c}	10.43 ^{b}		
Mean (*B*)		7.78 ^{a}			
		9.80 ^{b}			
		11.70 ^{c}			

Key: see Table 2

The weight of a single fruit differed significantly between the years (Table 4). Moreover, a significant effect of the fertilization level was observed on this yield parameter. The recorded mean weight of a single fruit ranged from 303.52 g to 390.32 g depending on the year, cultivar and fertilization level. The recorded fruit weight was higher than reported by CEBULA (1996). Moreover, CEBULA and AMBROSZCZYK (1999), in their study on yielding of several aubergine cultivars, obtained the mean weight of a single fruit within the range from 346 to 475 g, depending on the cultivar.

Table 4

The effect of the fertilization levels and cultivar on the weight of a single aubergine fruits

Year	Nutrition level	Mass of single fruits (g)			
		cultivar (*C*)		mean (*A* x *B*)	mean (*A*)
(*A*)	(*B*)	Epic	Solara		
I	L	316.47 ^{ab}	319.70 ^{ab}	318.07 ^{ab}	327.33 ^{a}
	S	326.37 ^{ab}	305.80 ^{a}	316.08 ^{a}	
	H	343.85 ^{ab}	351.80 ^{bc}	347.82 ^{b}	
	mean (*A* x *C*)	328.9 ^{a}	325.76 ^{a}		
II	L	389.00 ^{c}	303.52 ^{a}	346.26 ^{b}	358.79 ^{b}
	S	353.95 ^{bc}	328.52 ^{ab}	341.23 ^{ab}	
	H	387.45 ^{c}	390.32 ^{c}	388.88 ^{c}	
	mean (*A* x *C*)	376.80 ^{c}	340.79 ^{a}		
Mean (*C*)		352.85 ^{b}	333.27 ^{a}		
Mean (*B* x *C*)		352.73 ^{bc}	311.61 ^{a}		
		340.16 ^{ab}	317.16 ^{a}		
		365.65 ^{bc}	371.06 ^{c}		
Mean (*B*)		332.17 ^{a}			
		328.66 ^{a}			
		368.35 ^{b}			

Key: see Table 2

The dry matter content in the analyzed fruits ranged from 7.27 % to 10.01 % d.m. (Table 5). The effect of a cultivar and fertilization level on the mean dry matter content in aubergine fruits was observed. A higher mean dry matter content was determined in cv. Solara F_1 (9.42% d.m.) than in cv. Epic F_1 (8.72% d.m.). The mean content of dry matter in fruits increased

Table 5

The effect of the fertilization level and cultivar on the dry matter content in aubergine fruits

Year	Nutrition level	Dry matter (%)			
		cultivar (*C*)		mean (*B*)	mean (*A*)
(*A*)	(*B*)	Epic	Solara		
I	L	7.27	8.98	8.22	8.87
	S	8.76	9.52		
	H	9.24	9.46		
II	L	7.35	9.28	9.43	9.28
	S	9.71	9.74		
	H	10.01	9.59	9.57	
Mean (*C*)		8.72	9.42		

Key: see Table 2

with an increasing fertilization level from 8.22 to 9.57% d.m. The mean dry matter content in fruits determined in this study did not exceed ± 10%. A low dry matter content in fruits of aubergine grown in organic substrates was obtained by CEBULA (1996) and CEBULA and AMBROSZCZYK (1999).

The total solids content in fruits of aubergine grown on mineral soil with highmoor peat ranged from 4.00 to 5.50% depending on the year, fertilization level and cultivar (Table 6).

Table 6

The effect of the fertilization level and cultivar on the total solids content in aubergine fruits

Year	Nutrition level	Extract (%)			
		cultivar (*C*)		mean (*B*)	mean (*A*)
(*A*)	(*B*)	Epic	Solara		
I	L	5.5	4.0	5.00	4.66
	S	4.5	4.0		
	H	5.0	5.0		
II	L	5.5	5.0	4.62	4.91
	S	4.5	5.5		
	H	5.0	4.0	4.75	
Mean (*C*)		5.00	4.58		

Key: see Table 2

ESTEBANA et al. (1992) claimed that aubergine fruits contained the biggest amounts of ascorbic acid on day 42 from their setting. In this study, aubergine fruits were collected for analyses about 40 days after their setting. The content of vitamin C in aubergine fruits ranged from 12.9 mg% to 23.7 mg%, only slightly exceeding the values reported by CEBULA, AMBROSZCZYK (1999) – Table 7. The investigations conducted by WIERZBICKA, KUSOWSKA

Table 7

The effect of the fertilization level and cultivar on the vitamin C content in aubergine fruits

Year	Nutrition level	Vitamin C (mg%)			
		cultivar (*C*)		mean (*B*)	mean (*A*)
(*A*)	(*B*)	Epic F_1	Solara F_2		
I	L	17.2	17.2	17.2	14.7
	S	15.1	12.9		
	H	12.9	12.9		
II	L	17.2	17.2	16.1	18.31
	S	21.6	15.1		
	H	23.7	15.1	16.1	
Mean (*C*)		17.96	15.06		

Key: see Table 2

(2002) showed that the vitamin C content in vegetables depended primarily on the species as well as the cultivar. The biosynthesis of this compound in fruits is also significantly affected by insolation (WO•NIAK et al. 2002).

CONCLUSIONS

1. Significant effect was found of the fertilization level and cultivar on the total yield, mean number of fruits and weight of a single aubergine fruit.

2. It is recommendable to provide aubergine growing on mineral soil mixed with highmoor peat (v:v – 4:1) with pre-vegetation supplementation consisting of nitrogen, phosphorus and potassium brought in the substrate to the following levels (mg dm^{-3}): N – 250, P – 220, K – 415, while the top dressing treatment (from the third week of the growing season) should maintain the content of the nutrients in the substrate at: N – 400, P – 350 and K – 665.

3. Fruits of aubergine cv. Epic F_1 contained more vitamin C than fruits of cv. Solara F_1.

4. In fruits of both aubergine cultivars in the two years of the study, the total solids content ranged from 4.0 to 5.5%.

5. A higher mean dry matter content in aubergine fruits was recorded in cv. Solara F_1.

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