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EFFECT OF PLANT PRUNING AND TOPPING ON YIELDING OF EGGPLANT IN UNHEATED FOIL TUNNEL

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Abstract. Due to strong eggplant growth and the formation of large vegetative weight quantities in growing under glass and foil it was deemed useful to conduct studies on the effect of pruning intensity on yielding of this vegetable in rooms. The aim of the forego- ing studies was to demonstrate the effect of plant pruning and topping manner on yield quantity and earliness. The experiment was conducted in the years 2001–2003. The study objects were the plants of 'Epic F_1' cultivar. Eggplant was grown in rigid foil cylinders of the capacity of 10 dm^3 in the peat substrates. The plants were trimmed, managing for one, two, three, four, five, six guiding shoots and in the natural form, without trimming. Topping cut was performed in each combination after the first fruit harvest. The experiment was established and conducted as a two-factor one, in accordance with a complete randomization system: A – pruning method (a = 7), B – topped and non-topped plants (b = 2). Each combination of the examined factors was represented by 20 plants (experimental units). A significant effect of pruning intensity on the quantity and earliness yielding was demonstrated. The highest marketable fruit yield was obtained from plants managed for two (3.82 $kg \cdot m^{-2}$), three (3.98 $kg \cdot m^{-2}$), and four (3.87 $kg \cdot m^{-2}$) guiding shoots. Managing for one guiding shoot significantly decreased the total and marketable fruit number. The highest early yield was collected from plants managed for one and two guiding shoots. A single topping cut performed after the first fruit harvest did not affect marketable yield and marketable fruit number.

Key words: *Solanum melongena* L, quantity and earliness of yield, marketable fruits

INTRODUCTION

Extremely high thermal requirements constitute the reason why the optimal conditions for growing this plant can be secured in glasshouses and foil tunnels [Romano and Leonardi 1994]. That is why until the recent times this vegetable was not popular in

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Poland [Glapś and Górecki 1989, Wierzbicka et al. 1990]. Obtaining cultivars with lower environmental requirements, as well as the accessibility of the seeds of these cultivars contributed to the increased interest in growing eggplant in our country, as well as in initiating agrotechnical studies on this vegetable in a few scientific centers. So far these studies have focused on the usefulness of the cultivars' usability for growing in glasshouses and foil tunnels [Wierzbicka et al. 1990, Gajewski and Gajc-Wolska 1998, Cebula and Ambroszczyk 1999, Buczkowska 2005], learning about the biology of eggplant flowering, with indication to the fruit-setting intensifying procedures [Glapś and Górecki 1989, Kowalska 2003, 2008, Sękara and Bieniasz 2008].

Because of strong growth of eggplants and formation of large vegetative weight, what was found to be very important in glasshouse cultivation were study tasks concerning pruning to regulate the number of guiding shoots with simultaneous modification of the number of leaves and gemmae on main and lateral shoots. On the basis of these study results it is recommended in glasshouse eggplant growing to manage the plants for one, two, or maybe three guiding shoots [Paksoy and Akili 1994, Cebula and Ambroszczyk 1999, Cebula 2003, Pessarakli and Dris 2003, Ambroszczyk et al. 2007, 2008].

The length of cultivation period of eggplant and other thermophilous vegetables in unheated foil tunnels in our country is limited by the term of occurrence of the first autumn ground frosts. That is why also in eggplant production under foil the procedures are recommended that would limit the intense plant growth and affect faster fruit maturation [Pessarakli and Dris 2003, Buczkowska and Kowalska 2000].

The aim of this paper was to indicate the effect of plant pruning and topping on eggplant yielding in under foil growing, as well as to point to the optimal plant forming manner in producing this vegetable in unheated foil tunnels.

MATERIAL AND METHODS

The studies were conducted in the years 2001–2003, in an unheated foil tunnel, in a research station of the University of Life Sciences in Lublin, Felin. Potted eggplant seedlings were prepared in a glasshouse – multiplier, in pots (∅ 8 cm), in accordance with generally accepted principles, and planted into the foil tunnel in the first days of June. Eggplants were grown in rigid foil cylinders of the capacity of 10 dm^3 in peat substrate. The cylinders were positioned in the spacing of 50 cm × 60 cm, on the ground mulched with black polyethylene plastic, as well as with sawdust of coniferous trees, in 8–10 cm thick layer. The highmoor peat was lead to slightly acid reaction (pH 6.5–6.8) on the basis of Ca CO_3. neutralization curve. Before vegetation fertilizing was applied in the following amounts: N – 2.5 g, P – 3.0 g, K – 6.0 g, Mg – 1.5 g per 1 plant. Microelements were applied once in the following amounts: Cu – 133, Mn – 51, B – 16, Mo – 37, Zn – 7.4, Fe – 100 mg per 1 plant. By top dressing the plants were fertilized four times, applying jointly, per one plant: N – 9.0 g, P – 4.0 g, K – 18.0 g, Mg – 4.5 g.

The object of studies was eggplant of Epic F_1 cultivar (Seminis Vegetable, Poland). The plants were pruned leading to 1 shoot, 2 shoots, 3 shoots, 4 shoots, 5 shoots, 6 guiding shoots, and in a natural form, without pruning. Lateral shoots growing on guiding shoots were successively removed. Topping cut was made once, in each combination after the first fruit harvest in their first decade of August. This procedure was conducted manually, removing shoot tops together with two leaves. In each cutting method 40 plants (experimental units) were used, of which 20 plants were topped, and 20 were left untopped. The experiment was established and conducted as a two-factor experiment, according to complete randomization system: factor A – pruning method (a = 7); B – topping: topped and untopped plants (b = 2). Each combination of examined factors was represented by 20 plants.

The fruits were collected every 10 days from each plant separately in the phase of harvest maturity, which was determined by purple skin color, shining metallically. In each study year six harvests were performed (fig. 3). Depending on the combination , fruit harvests were conducted in the period from the third decade of July to the end of the second decade of September. In each harvest the weight and number of total and marketable fruits were determined. Non- marketable fruits included deformed ones, those of shapes untypical of the cultivar and those with visible symptoms of a disease.

In each study year the following yielding parameters were determined: total yield, marketable yield ($kg \cdot m^{-2}$) total and marketable fruit number ($pcs. \cdot m^{-2}$). Besides, in each of the examined combinations the early yield, as well as yield earliness and dynamics were determined. Earliness of yielding was defined as the share of early yield in total yield (%). As early yield it was agreed to assume fruit yield obtained in the first three harvests [Wierzbicka et al.1990]. Study results were statistically elaborated using variance analysis method. The significance of differences was determined by means of multiple T-Tukey's confidence intervals at 5% significance level.

RESULTS AND DISCUSSION

Eggplant yielding in an unheated foil tunnel in our climate depends on thermal conditions during flowering and fruit-setting periods, i.e. in July and August. On the basis of measuring mean daily air temperature under foil, as well as the value of mean monthly temperature outside it can be stated that the course of thermal conditions in the study years was differentiated (tab. 1). Definitely more favorable conditions for eggplant growth and yielding were in the years 2001 and 2002 than in the year 2003. In that year a significantly smaller marketable fruit yield was obtained (on average 2.52 $kg \cdot m^{-2}$) and the number of fruits (on average 8.9 $pcs. \cdot m^{-2}$), as compared to the years 2001 (respectively: on average 3.78 $kg \cdot m^{-2}$ and, on average: 13.3 $pcs. \cdot m^{-2}$) and 2002 (respectively: on average 4.12 $kg \cdot m^{-2}$ and, on average: 12.4 $pcs. \cdot m^{-2}$) (tab. 2).

On the basis of variance analysis a statistically significant effect of plant pruning during vegetation was demonstrated upon the mean marketable fruit yield. However, no effect was found of single plant topping procedure after the first fruit harvest upon that yielding parameter. Significantly higher mean marketable fruit yield was obtained from plants managed to three (3.98 $kg \cdot m^{-2}$), four (3.87 $kg \cdot m^{-2}$) and two (3.82 $kg \cdot m^{-2}$) guiding shoots, as compared to the yield of radically cut plants, only to one shoot (2.73 $kg \cdot m^{-2}$). No differences were statistically proven in mean marketable yield, which was obtained from plants managed to five (3.34 kg·m^{-2}) and six guiding shoots (3.34 kg·m^{-2}), and those remaining in the natural form (3.26 kg·m^{-2}).

Table 1. Monthly mean air temperature in unheated foil tunnel and outdoors in eggplant growing period in the years 2001–2003
Tabela 1. Średnia miesięczna temperatura powietrza w nieogrzewanym tunelu foliowym oraz na zewnątrz w okresie uprawy oberżyny w latach 2001–2003

Months Miesiące	Monthly mean air temperature Średnia miesięczna temperatura powietrza (°C)					
	unheated foil – tunnel nieogrzewany tunel foliowy			outdoors – na zewnątrz		
Years – Lata	2001	2002	2003	2001	2002	2003
June Czerwiec	19.7	20.7	20.3	15.3	17.8	17.4
July Lipiec	25.3	25.9	22.4	21.6	21.6	19.8
August Sierpień	24.9	25.4	20.1	19.7	20.5	18.9
September Wrzesień	16.7	18.1	16.0	11.9	12.9	13.5

On the basis of early yield results and yielding dynamics it can be concluded that the applied plant pruning methods had an advantageous effect on the earliness of eggplant yielding in an unheated foil tunnel (tab. 2, fig. 1 and 3). Significantly the greatest early yield was obtained in the objects from intensely pruned plants for one, two three guiding shots, where the share of early yield in total yield constituted from 52.5% (plants managed for three shoots) to 75.5% (plants managed for one shoot). On this basis it can be concluded that the intensity of eggplant pruning is a factor that determines the earliness of this vegetable yielding in a foil tunnel.

Plant pruning also significantly affected the number of fruits in marketable yield. The most fruits were collected from plants managed for three and four shoots (on average 13.9 pcs.·m^{-2}) and for two guiding shoots (on average 12.7 pcs.·m^{-2}). Radical pruning, managing for one shoot, significantly limited the number of marketable fruits (on average 9.1 pcs.·kg·m^{-2}). The number of fruits from plants conducted for five and six shoots, as well as those left in the natural form was on average from 10.7 to 11.8 pcs.·m^{-2} and did not significantly differ between the examined objects. Also, on the basis of variance analysis no significant effect of a single topping pruning was demonstrated upon the differentiation of marketable fruits number in the studied objects.

In the foregoing studies the mean marketable eggplant fruit yields obtained in the years 2001–2003 differed significantly (fig. 1 and 3, tab. 2). This reveals a substantial dependence of eggplant yielding under foil on thermal conditions during flowering and fruit setting periods (tab. 1). Kowalska [2003] in her studies on the assessment of the influence of flower pollination by bumblebee, as well as flower hormonization on the yielding of three eggplant cultivars grown under foil, obtained significantly the largest marketable fruit yield from Epic F$_1$ cultivar in the year 1999 (5.31 kg·m^{-2}), when the sum of effective temperatures (mean daily air temperature higher than 15°C) in the

Table 2. The effect of plant pruning and topping on the yielding of eggplant (mean for the years 2001–2003)
Tabela 2. Wpływ cięcia i ogławiania roślin na plonowanie oberżyny (średnio z lat 2001–2003)

Pruning method Metoda cięcia	Topping Ogławianie	Marketable yield Plon handlowy (kg m^{-2})	Share of marketable yield in total yield Udział plonu handlowego w plonie ogółem (%)	Early yield Plon wczesny (kg m^{-2})	Share of early yield in total yield Udział plonu wczesnego w plonie ogółem (%)	Number of marketable fruits Liczba owoców handlowych (No. per m^2)	Share of marketable fruits number in total fruit number Udział liczby owoców handlowych w liczbie ogółem (%)
1 shoot 1 pęd	**	2.57	94.1	2.21	80.9	8.3	86.4
	*	2.90	94.2	2.14	69.5	10.0	95.2
	mean	2.73	94.1	2.18	75.2	9.1	90.8
2 shoots 2 pędy	**	3.78	95.2	2.35	59.2	12.4	89.9
	*	3.85	94.4	2.47	60.5	12.9	92.8
	mean	3.82	94.8	2.41	59.8	12.7	91.4
3 shoots 3 pędy	**	3.82	93.2	2.08	50.7	13.3	94.3
	*	4.15	93.9	2.40	54.3	14.6	94.2
	mean	3.98	93.6	2.24	52.5	13.9	94.2
4 shoots 4 pędy	**	4.28	93.0	1.72	38.2	15.1	95.0
	*	3.45	95.7	1.32	36.5	12.7	99.2
	mean	3.87	94.3	1.52	37.4	13.9	97.1
5 shoots 5 pędów	**	3.72	91.9	1.54	38.0	12.9	91.5
	*	2.97	95.2	1.40	44.9	10.7	94.7
	mean	3.34	93.6	1.47	41.4	11.8	93.1
6 shoots 6 pędów	**	3.77	95.4	1.30	32.9	12.5	94.7
	*	2.92	92.7	1.27	40.3	10.0	91.7
	mean	3.34	94.1	1.28	36.6	11.2	93.2
Natural form Forma naturalna	**	3.18	95.1	1.42	47.5	9.9	93.4
	*	3.33	95.3	1.07	30.7	11.4	95.8
	mean	3.26	95.2	1.24	39.1	10.7	94.6
Mean for topping Średnio dla cięcia	**	3.58	93.7	1.80	47.1	11.3	86.9
	*	3.37	94.7	1.72	48.3	11.7	94.3
Mean for years Średnio dla lat	2001	3.78	98.7	1.85	48.9	13.3	96.4
	2002	4.12	91.3	2.27	55.1	12.4	85.5
	2003	2.52	92.1	1.16	46.0	8.9	89.9
Total mean Średnio ogółem		3.47	94.0	1.76	50.7	11.5	90.6
LSD$_{0,05}$ NIR$_{0,05}$							
pruning method (a) sposób ciecia (a)		0.590		0.238		1.72	
topping (b) ogławianie (b)		n.s. n.i.		n.s. n.i.		n.s. n.i.	
years (c) lata (c)		0.201		0.152		0.62	
interaction: (ab) interakcja		0.694		0.328		1.94	
(ac)		0.937		0.472		2.55	
(bc)		0.521		0.297		1.56	
(abc)		1.735		0.845		5.21	

** topped plants – rośliny ogławiane, * non-topped plants – rośliny nieogławiane

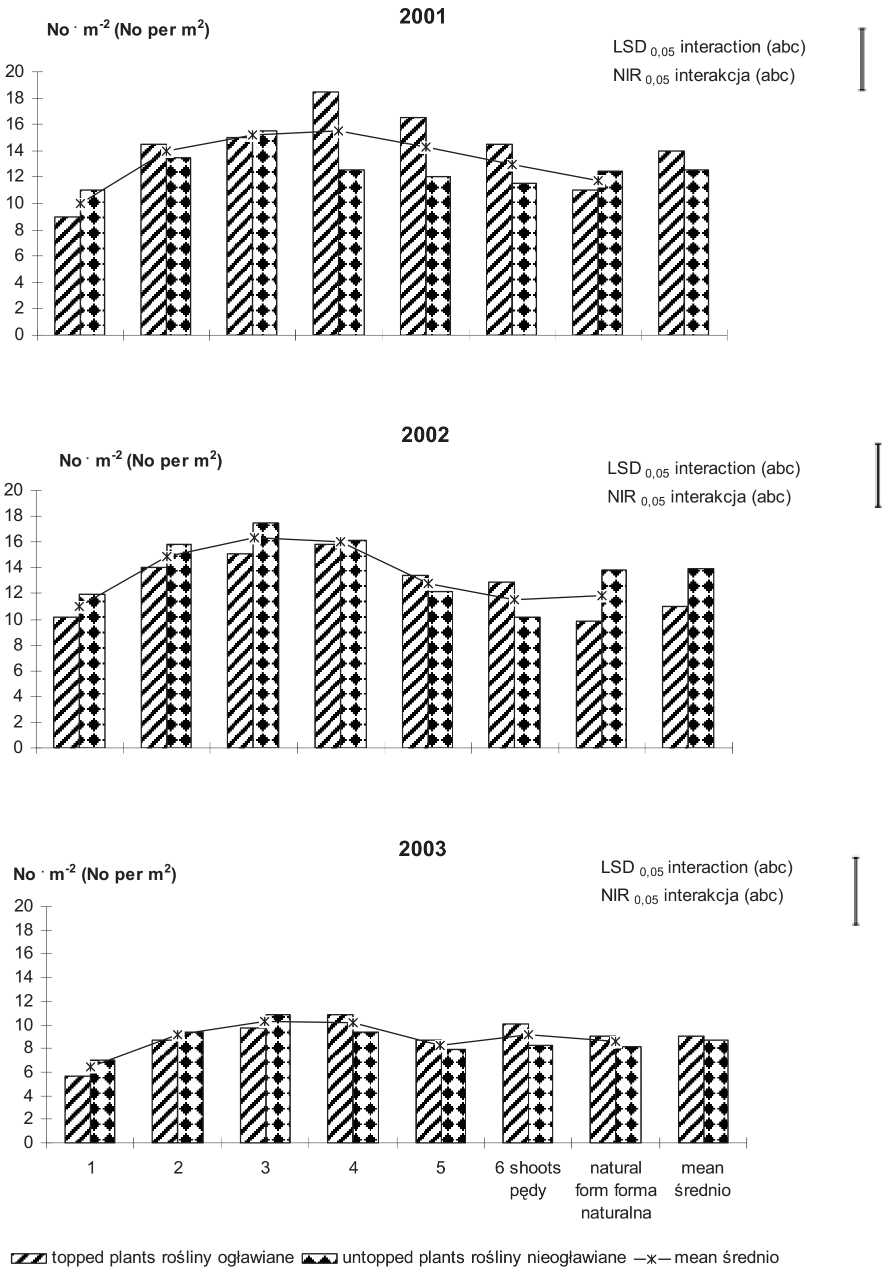

Fig. 1. The effect of plant pruning and topping on the marketable yield of eggplant in the years 2001–2003

Rys. 1. Wpływ cięcia i ogławiania roślin na plon handlowy oberżyny w latach 2001–2003

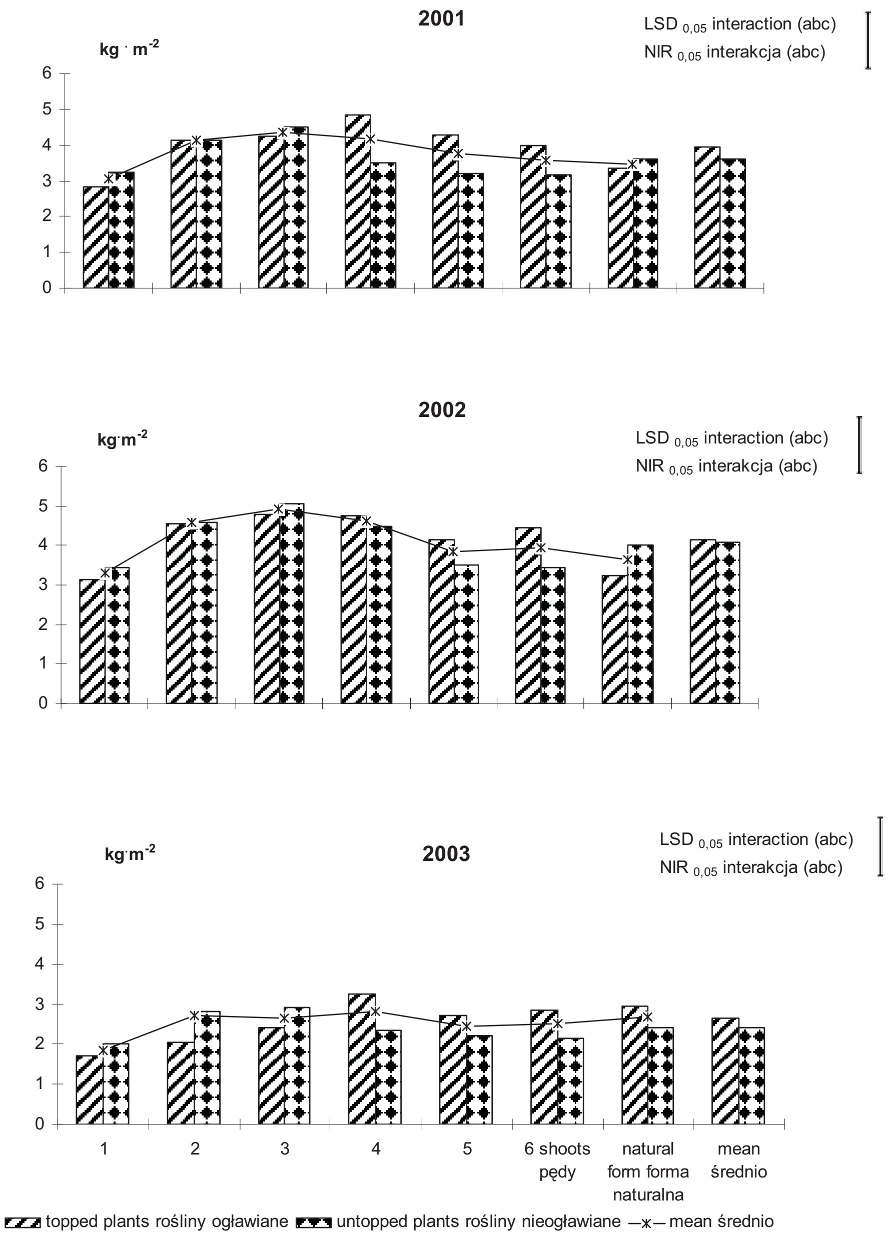

Fig. 2. The effect of plant pruning and topping on the number of marketable eggplant fruits in the years 2001–2003

Rys. 2. Wpływ cięcia i ogławiania roślin na liczbę owoców handlowych w latach 2001–2003 period from June to September was definitely higher (373.3°C) than in the same period in the years 1998 (254.8°C) and 2000 (274.4°C). In the years 2001–2003 the thermal conditions course during flowering and eggplant fruit-setting periods was differentiated as well, which was demonstrated by Buczkowska and Bednarek [2005] in their paper on the assessment of the relationship between peppers yielding in the field and the thermal conditions. These authors found out that in the years 2001 and 2002 the total effective temperature (higher than 10°C) in July and August in the years 2001 and 2002 equaled, respectively 680.0°C and 703.6°C, whereas in the year 2003 it was only 598.6°C. On this basis it can be concluded that there is a substantial dependence of eggplant yielding in the foil tunnel upon the thermal conditions outside, which is also emphasized by authors of other papers [Wierzbicka et al. 1990, Gajewski and Gajc-Wolska 1998, Kowalska and Buczkowska 2004, Buczkowska 2005, Markiewicz et al. 2008, Michałojć and Buczkowska 2008, 2009].

Results concerning eggplant yielding, achieved in the conducted studies are convergent with those obtained by the above quoted authors, excluding Wierzbicka et al. [1990], who obtained from eggplant cultivars available in Poland in 1980s a definitely higher mean total fruit yield (ranging from 5.2 to 7.7 kg·m^{-2}).

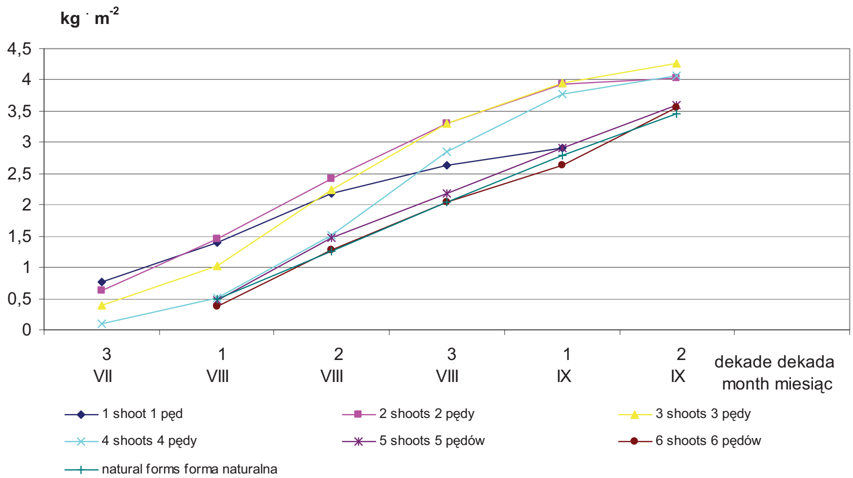

Fig. 3. The effect of plant pruning on the earliness and yield dynamics of eggplant (mean for topping and years 2001–2003)

Rys. 3. Wpływ cięcia roślin na wczesność i dynamikę plonowania oberżyny (średnio dla ogławiania i lat 2001–2003)

The results of marketable yield included in this paper reveal that intense plant pruning for one guiding shoot caused a significant decrease of eggplant marketable yield in growing under foil. Radical eggplant pruning is appropriate, and even desirable in glasshouse growing, where there are optimal thermal conditions, the plants are distinguished by very intense growth and the growing and harvest periods are definitely longer than in an unheated foil tunnel (fig. 3) [Cebula and Ambroszczyk 1999]. Ambroszczyk et al. [2007, 2008] pointed to many aspects of intense eggplant pruning in a glasshouse – the plants were managed for one main shoot with various modifications of the number of leaves and gemmae on lateral shoots. They regarded as the gemmae on the lateral shoots. They included into the most important ones the improvement of light conditions in the plant profile, increase of binding effectiveness, improvement of fruit quality. These authorities proved that in longer harvest periods radical pruning does not cause significant yielding decrease.

In eggplant growing in unheated tunnels less intense pruning is recommended. Managing eggplants for three or four guiding shoots is to be considered optimal, which was also started by other authors [Paksoy and Akilli 1994, Pessavakli and Dris 2003, as well as Michałojć and Buczkowska 2008, 2009].

In the studies conducted in a glasshouse no effect of plant pruning intensity was demonstrated upon the earliness of eggplant yielding [Cebula 2003, Ambroszczyk et al. 2007, 2008]. In this paper favorable effect of pruning intensity on the earliness and dynamics of eggplant yielding in a foil tunnel was stated (tab. 2 fig. 3). However, it was not proven that plant topping procedure, performed in each variant after the first fruit harvest, significantly differentiated the size of mean marketable yield and the number of the obtained marketable fruits. Neither did this procedure affect the earliness and dynamics of yielding. These results constitute the confirmation of those obtained earlier by Kowalska and Buczkowska [2004] and authorize us to state that in commodity growing of eggplant in an unheated foil tunnel the procedure of plant topping after the first fruit harvest is not effective. Yielding intensification is guaranteed, however, by pruning and managing of eggplants for three or four guiding shoots [Michałojć and Buczkowska 2008, 2009].

CONCLUSIONS

1. It was demonstrated that pruning intensity significantly affects the quantity and earliness of eggplant yield in under foil growing. The greatest marketable yield was obtained from plants managed for two, three and four guiding shoots. The highest early fruit yield was collected from plants managed for one, two and three guiding shoots.

2. Intense plant pruning – managed for one guiding shoot only caused significant limitation of total and marketable fruits number.

3. One topping cut, performed after the first fruit harvest did not significantly affect the marketable fruit yield and the number of fruits obtained in the marketable yield.

4. Eggplant yielding in an unheated foil tunnel was differentiated in the study years. The course of thermal conditions during flowering and fruit setting affected eggplant yielding under foil.

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WPŁYW CIĘCIA I OGŁAWIANIA ROŚLIN NA PLONOWANIE OBERŻYNY W NIEOGRZEWANYM TUNELU FOLIOWYM

Streszczenie. Z uwagi na silny wzrost roślin oberżyny i tworzenie dużej ilości masy wegetatywnej w uprawie pod szkłem i folią za potrzebne uznano badania nad wpływem intensywności cięcia na plonowanie tego warzywa w pomieszczeniach. Celem niniejszych badań było wykazanie wpływu sposobu cięcia oraz ogławiania roślin na wielkość i wczesność plonu. Doświadczenie prowadzono w latach 2001–2003. Obiekt badań stanowiły rośliny odmiany 'Epic F_1'. Oberżynę uprawiano w cylindrach z folii sztywnej, o pojemności 10 dm^3 w substracie torfowym. Rośliny cięto prowadząc na jeden dwa, trzy, cztery, pięć, sześć pędów przewodnich oraz w formie naturalnej bez cięcia. Cięcie ogławiające wykonywano w każdej kombinacji po pierwszym zbiorze owoców. Doświadczenie założono i przeprowadzono jako dwuczynnikowe według układu kompletnej randomizacji: A – metoda cięcia (a = 7), B – rośliny ogławiane i nieogławiane (b = 2). Każda kombinacja badanych czynników reprezentowana była przez 20 roślin (jednostek eksperymentalnych). Wykazano istotny wpływ intensywności cięcia na wielkość i wczesność plonowania. Największy plon handlowy owoców otrzymano z roślin prowadzonych na dwa (3,82 $kg \cdot m^{-2}$), trzy (3,98 $kg \cdot m^{-2}$), cztery (3,87 $kg \cdot m^{-2}$) pędy przewodnie. Prowadzenie na jeden pęd przewodni znacznie zmniejszyło liczbę owoców ogółem oraz handlowych. Największy plon wczesny zebrano z roślin prowadzonych – na 1 pęd oraz 2 pędy przewodnie. Jednokrotne cięcie ogławiające wykonane po pierwszym zbiorze owoców nie wpłynęło na plon handlowy oraz liczbę owoców handlowych.

Słowa kluczowe: *Solanum melongena* L, wielkość i wczesność plonu, owoce handlowe

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