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YIELDING AND NUTRITIVE VALUE OF FIELD CULTIVATED EGGPLANT WITH THE USE OF LIVING AND SYNTHETIC MULCHES

Katarzyna Adamczewska-Sowińska, Eugeniusz Kołota
Wroclaw University of Environmental and Life Sciences

Abstract. Eggplant is grown in Poland mainly under shields because of high requirements in climat conditions. The utilization of mulches has played a great role in production of such vegetables. In 2008–2009 there was investigated the yielding of eggplant cv. Epic F_1 cultivated with living mulches – perennial ryegrass and white clover, which were sown three weeks before eggplant planting, in the term of planting and three weeks after planting, as well as with synthetic mulches: polyethylene black foil and non-woven polypropylene agrotextil. The experiment was established according to randomized split – plot method. Marketable yield of eggplant cultivated with the use of black foil was higher than that from the control treatment and mulched with black agrotextil cover by 7.8% and 10.4%, respectively. Eggplant yield obtained from cultivation with white clover was similar to that coming from plots covered with black foil. Cultivation of this vegetable with perennial ryegrass resulted in significant decrease in eggplant yield, average by 17% in relation to cultivation with the remaining mulches and by 15% as compared to control treatments. The content of reducing sugars and magnesium in eggplants fruits depended on the type of mulch and term of living mulches sowing, and in the case of potassium on the species used as living mulch.

Key words: *Solanum melongena* L., white clover, perennial ryegrass, black foil, non-woven polypropylene agrotextil

INTRODUCTION

Eggplant is a species of tropical and subtropical climatic zone. It is believed that this plant originates from India, as well as China and Japan [Kashyap et al. 2003]. Production of eggplant is located, first of all, in Asia, on the area ranging 1.8 mln ha, where yearly yield size amounts about 30 mln t. Leading world producers of this vegetable are China (18.3 mln t), India (8.5 mln t), Egypt, Turkey and also Iraq, Japan and Italy

Corresponding author – Adres do korespondencji: Katarzyna Adamczewska-Sowińska, Department of Horticulture, Wroclaw University of Environmental and Life Sciences, Pl. Grunwaldzki 24a, 50-363 Wrocław, tel. 71 320 17 25, e-mail: katarzyna.a-sowinska@up.wroc.pl

[FAOSTAT 2008]. In Europe half of eggplant cultivation takes place in Italy, on the area of approximately 10thous. ha, obtaining yearly yield size over 300 000 t fruit and in Romania, Ukraine, Spain and Greece.

Eggplants yield on field cultivation are different. Ertek et al. [2006] obtained fruit yield from 10 to 21 t per ha. When eggplants plantation was irrigated yield ranged from 27.4 to 43.5 t per ha [Cornillon and Dauple 1981].

In Asia eggplant has enjoyed wide popularity for hundreds of years due to its flavor and dietary properties, as well as the possibility of various ways of processing, preserving and long – distance transporting. Both its fruits and leaves are regarded in popular medicine as a remedy to different diseases [Kashyap et al. 2003]. Its antioxidant values, as well as properties stimulating the decrease in cholesterol level have been currently subjected to investigation [Guimarães et al. 2000, Nisha et al. 2009].

Until not so long ago, in climate conditions of Poland eggplant was cultivated only in greenhouses and high plastic tunnels. Recently, there has been observed a gradually growing interest in usability of this species for field cultivation as a result of new cultivars introduced to the market which characterize lower susceptibility to the conditions of stress, especially connected with low temperature and temperature fluctuations. This plurality of eggplant varieties, caused by considerable genetic diversity of *Solanum melongena* L. species and their related edible, as well as wild species belonging to *Solanum* genus [Kashyap et al. 2003, Sękara et al. 2007].

The aim of this investigation was the assessment of the possibility of eggplant cultivation in field conditions in the region of Lower Silesia, with the use of mulching to ensure higher yielding and improved yield quality.

MATERIALS AND METHODS

Field experiments were conducted in Research – Development Station of Department of Horticulture at Wroclaw University of Environmental and Life Sciences in the years 2008–2009. For living mulches two – factorial experiment was established according to randomized split – plot method in three replications. The first factor involved comparison of usability of living mulches – white clover (*Trifolium repens* L.) and perennial ryegrass (*Lolium perenne* L.) for eggplant cultivation. Living mulches were sown in the following terms: 3 weeks before eggplant planting, during its planting and 3 weeks after eggplant was planted (factor II). Additionally, there were applied synthetic mulches: black foil and non-woven polypropylene agrotextil. Control treatment consisted of not mulched plots. Independence for comparison living mulches, synthetic mulches and control treatment was established one – factorial statistical analysis. The size of one plot was 3 m^2 (2.0 × 1.5 m).

Seeds of Epic F_1 eggplant cultivar were sown on 2^{nd} April in a greenhouse into boxes for seedlings, 1 g per each box. In the stage of developed cotyledons seedlings were planted out into pots of 12 cm diameter. The medium for transplants production was peat substrate. Transplants were planted in the field on 2^{nd} June in spacing 60 × 50 cm. Preparation of the field consisted in deep fall ploughing, followed by harrowing and chiseling in the spring. Nitrogen fertilization, in the form of ammonium nitrate, in the dose of 150 kg ha^{-1}, was introduced when using rotary cultivator, directly before planting eggplants Five weeks later there was applied top – dressing fertilization in the amount of 50 kg N ha^{-1}. Eggplant was cultivated on degraded black earth featuring pH 7.25 and the following fertility data: 130 mg K dm^{-3} and 200 mg P dm^{-3}. Fruit harvest took place once a week, between 10th July and 23rd September (2008), as well as between 22nd July and 30th September (2009). There were determined total yield size and unit fruit weight. During full fruiting period, in mid August, there were collected fruits to undergo chemical analyses and determination of dry matter content (by gravimetric method), vitamin C (titrimetric method), reducing sugars (Lane-Eynona method), P and Ca (colorimetric method), as well as K and Mg (Flame colorimetric method). Examination results were subjected to statistical analysis by Tukey method at significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

Kashyap et al. [2003] reported that eggplant yield is determined, to a high degree, by environmental conditions, while the temperature remains the main stress factor. Optimum growth temperature ranges between 22 and 30°C and at night it should not fall below 18–24°C [Lawande and Chavan 1998]. Eggplant is more tolerant to draught than red pepper or tomato, yet to obtain high yield it is necessary to provide its medium with an appropriate moisture level. Optimum conditions for vegetable growth can be ensured by, among others, application of synthetic mulches, such as black foil or non-woven polypropylene agrotextil which reduce water evaporation from soil, elevate its temperature and reduce weeds growth [Buczkowska 1999, Siwek et al. 2007]. On the basis of the examination results it is possible to state that eggplant cultivation with the use of black polyethylene foil as a mulch brought about the most advantageous effect (tab. 1). Average marketable yield obtained from this treatment amounted 16.31 t ha^{-1} and unit fruit weight was 236 g. It was proved that the mentioned yield was higher, in comparison to control treatments and those mulched with black polypropylene agrotextil, by 7.8% and 10.4%, while unit fruit weight showed elevated values by 12.4% and 7.3%.

Synthetic mulches can be replaced by living ones, especially in cultivation following an ecological and integrated system. These mulches positively affect physical and biochemical properties of soil, as well as the environment surrounding cultivated plants, enriching it with CO_2 and reducing the occurrence of pests. Eggplant, as the species featuring considerable plant height and long plant growing period, cultivated from transplants, is well suitable for integrated cultivation with living mulches. One of the factors conditioning its successful cultivation is the choice of undersown species [Leary and De Frank 2000, Hooks and Johnson 2003]. In our experiment, introduction of white clover provided for harvesting eggplant fruit yield comparable, as far as statistical data are concerned (15.43 t ha^{-1}), to the yield obtained from plots covered with black foil. Unit fruit weight for the mentioned treatment amounted 239 g. Cultivation of this vegetable together with perennial ryegrass did result in significant decrease in eggplant yield average by 17% in relation to its cultivation with the remaining mulches and by 15% as compared to control treatments. Lesser competition between white clover and the vegetable it was cultivated with, in comparison to other living mulches species, was also recorded in tomato cultivation [Adamczewska-Sowińska 2004], common cabbage [Poniedziałek and Stokowska 1999] and sweet corn [Jędrszczyk and Poniedziałek 2007]. Positive influence of other plants of broadbean species accompanying vegetables was observed in cultivation of tomato, red pepper and *Solanum aetiopicum* as well [Ofori and Gamedoagbao 2005, Adamczewska-Sowińska 2008, Adamczewska-Sowińska and Kołota 2008].

Table 1. The effect of mulches on marketable yield and mean weight of eggplants fruit (mean values for 2008–2009)
Tabela 1. Wpływ ściółkowania na plon handlowy oraz średnią masę owocu oberżyny (średnio dla lat 2008–2009)

Termin siewu żywych ściółek i ściółki syntetyczne Sowing term of living mulches and synthetic mulches	Plon handlowy Marketable yield of eggplant fruit, $t \cdot ha^{-1}$			Średnia masa owocu Mean fruit weight g		
	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean
3 tygodnie przed sadzeniem oberżyny 3 weeks before eggplants planting	12.89	9.66	11.28	230	212	221
W terminie sadzenia oberżyny In the term of eggplants planting	15.61	12.83	14.22	243	222	232
3 tygodnie po posadzeniu oberżyny 3 weeks after eggplants planting	17.78	16.09	16.94	243	238	240
Średnia dla żywych ściółek Mean for living mulches	15.43	12.86	14.15	239	224	231
Czarna folia Black foil		16.31			236	
Czarna włóknina polipropylenowa Black non-woven polypropylene agrotextil		14.78			220	
Kontrola bez ściółek Control without mulches		15.13			210	

LSD α = 0.05 for: – NIR α = 0,05 dla:		
1. kind of living mulch – gatunku żywej ściółki (I)	1.91	n.s. – n.i.
sowing term of living mulch – terminu siewu żywej ściółki (II)	1.87	n.s. – n.i.
interaction – interakcji I × II	2.60	n.s. – n.i.
2. kind of mulch – rodzaju ściółki	2.60	n.s. – n.i.

Another factor – sowing term of living mulches – was also of a marked effect on eggplant yielding. White clover and perennial ryegrass sown 3 weeks before planting eggplants proved to be the most competitive to them, which caused that harvested yield size was the smallest in the whole experiment. Unit fruit weight ranged 230 g and 213 g respectively. Shortening of white clover growing period by 3 and 6 weeks and, therefore, reduction of biomass it formed at the beginning of eggplant growing period resulted in the increase in this vegetable yield by 21.1% and 37.9%. The mentioned yield size was the same as that originating from cultivation with synthetic mulches or even larger. Then unit fruit weight amounted 243 g. Obtaining comparable yield of eggplant growing together with perennial ryegrass was possible only when sowing of this under

Table 2. The effect of mulches on dry matter, vitamin C and reducing sugars contents in eggplant fruits (mean values for 2008–2009)
Tabela 2. Wpływ ściółkowania na zawartość suchej masy, witaminy C i cukrów redukujących w owocach oberżyny (średnio dla lat 2008–2009)

Termin siewu żywych ściółek i ściółki syntetyczne Sowing term of living mulches and synthetic mulches	Sucha masa Dry matter (%)			Witamina C (mg 100 g^{-1} św.m.) Vitamin C (mg 100 g^{-1} f.m.)			Cukry redukujące Reducing sugars (%)		
	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean
3 tygodnie przed sadzeniem oberżyny 3 weeks before eggplants planting	10.46	9.64	10.05	5.46	5.96	5.71	3.18	3.03	3.11
W terminie sadzenia oberżyny In the term of eggplants planting	9.06	8.72	8.89	5.20	5.78	5.49	2.78	2.91	2.85
3 tygodnie po posadzeniu oberżyny 3 weeks after eggplants planting	9.91	10.01	9.96	5.75	5.62	5.69	2.63	3.05	2.84
Średnia dla żywych ściółek Mean for living mulches	9.81	9.46	9.64	5.47	5.79	5.63	2.86	3.00	2.93
Czarna folia Black foil	7.48			4.82			3.48		
Czarna włóknina polipropylenowa Black non-woven polypropylene agrotextil	9.25			5.10			2.94		
Kontrola bez ściółek Control without mulches	9.06			5.95			2.94		

LSD α = 0.05 for: – NIR α = 0,05 dla:	Dry matter	Vitamin C	Reducing sugars
1. kind of living mulch – gatunku żywej ściółki (I)	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.
sowing term of living mulch – terminu siewu żywej ściółki (II)	n.s. – n.i.	n.s. – n.i.	0.34
interaction – interakcji I × II	n.s. – n.i.	n.s. – n.i.	0.34
2. kind of mulch – rodzaju ściółki	n.s. – n.i.	n.s. – n.i.	n.s. – n.i.

Table 3. The effect of mulches on P, K, Mg and Ca contents in eggplant fruits (mean values for 2008–2009)
Tabela 3. Wpływ ściółkowania na zawartość P, K, Mg, Ca w owocach oberżyny (średnio dla lat 2008–2009)

Termin siewu żywych ściółek i ściółki syntetyczne Sowing term of living mulches and synthetic mulches	P (%)			K (%)			Mg (%)			Ca (%)		
	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean	koniczyna biała white clover	życica trwała perennial ryegrass	średnia mean
3 tygodnie przed sadzeniem oberżyny 3 weeks before eggplants planting	0.20	0.21	0.21	3.14	2.85	3.00	0.23	0.23	0.23	0.19	0.20	0.20
W terminie sadzenia oberżyny In the term of eggplants planting	0.19	0.20	0.20	3.56	2.97	3.27	0.28	0.27	0.28	0.21	0.24	0.23
3 tygodnie po posadzeniu oberżyny 3 weeks after eggplants planting	0.20	0.21	0.21	3.37	2.99	3.18	0.25	0.26	0.26	0.20	0.22	0.21
Średnia dla żywych ściółek Mean for living mulches	0.20	0.21	0.21	3.36	2.94	3.15	0.25	0.25	0.25	0.20	0.22	0.21
Czarna folia Black foil		0.20			3.24			0.27			0.21	
Czarna włóknina polipropylenowa Black non-woven polypropylene agrotextil		0.22			2.83			0.25			0.21	
Kontrola bez ściółek Control without mulches		0.23			3.27			0.26			0.21	
LSD α = 0.05 for: – NIR α = 0,05 dla:												
1. kind of living mulch – gatunku żywej ściółki (I)			n.s. – n.i.			0.20			n.s. – n.i.			n.s. – n.i.
sowing term of living mulch – terminu siewu żywej ściółki (II)			n.s. – n.i.			n.s. – n.i.			0.02			n.s. – n.i.
interaction – interakcji I × II			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.
2. kind of mulch – rodzaju ściółki			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.			n.s. – n.i.

sown mulch plant took place in the latest term. Reduction of competition on the part of living mulches by diminishing their biomass, which, in turn resulted from shortening of plant growing period, did positively influence vegetables yielding in research by other authors [Müller-Schärer 1996, Weber et al. 1999, Adamczewska-Sowińska 2004, Adamczewska-Sowińska and Kołota 2008].

Nutritive value of eggplant fruits resembles that of tomato. Kunachowicz et al. reported [2006] that 100 g fresh mass of eggplant edible parts contain: 6.3 g total sugars, 305 mg K, 18 mg Ca, 33 mg P, 16 mg Mg, 0.6 mg Fe, 42 µg beta carotene, 2 mg vitamin C and vitamins of B group. Fruits of this species are also rich in omega-3 (13 mg 100 g^{-1}) and omega-6 (63 mg 100 g^{-1}) fatty acids, as well as in phytosterols (7 mg 100 g^{-1}) (NutritionData). In this experiment fruit of eggplant cultivated with the use of black foil contained considerably lower amounts of dry matter (7.48%) in comparison to those coming from other treatments (9.40%) and, at the same time, it occurred that their content of reducing sugars was markedly higher (tab. 2). On the basis of chemical analysis results it was possible to determine that the quantity of vitamin C in eggplant fruits ranged 4.82–5.96 mg 100 g^{-1} f.m. and it did not depend on the effect of experimental factors. Kowalski et al. [2003] reported that fruits of Epic F_1 eggplant cultivar grown in not heated plastic tunnel contained average 10.66 mg 100 g^{-1} f.m. of this vitamin. In another experiment, conducted in a greenhouse, vitamin C content was estimated as about 6.5 mg 100 g^{-1} f.m. [Ambroszczyk et al. 2008]. It was recorded that in fruits originating from cultivation with living mulches this component showed higher values by 13.5% than in fruits collected from control treatments. In previously conducted research the authors also proved that edible parts of vegetables cultivated together with living mulches accumulate higher amounts of dry matter and vitamin C [Adamczewska-Sowińska 2004, 2008; Adamczewska-Sowińska and Kołota 2008].

Macroelements content in fruits of eggplant cultivated in the field was lower than the one obtained in experiments carried out by Kowalski et al. [2003], Golcz et al. [2005], Michałojć and Buczkowską [2008] in not heated plastic tunnels or greenhouses (tab. 3). Statistical analysis determined that the quantity of potassium and calcium was not diversified due to experimental factors. Potassium content was significantly higher in fruits harvested from plots sown with white clover as compared to those collected from cultivation with perennial ryegrass, while significantly lowest values of magnesium contained fruits originating from eggplant cultivated with living mulches sown before this vegetable planting.

CONCLUSIONS

1. The use of black foil and living mulches - white clover and perennial ryegrass sown three weeks after eggplant and white clover sown in the term of eggplant planting, provided similar yield – to that obtained in to the control treatment.

2. Nutritive value of eggplant fruit slightly depended on experimental factors. Only the content of reducing sugars and magnesium was related to the type of mulch applied and the term of living mulches sowing, while potassium content depended on the species used as living mulch.

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PLONOWANIE I WARTOŚĆ ODŻYWCZA OBERŻYNY UPRAWIANEJ W POLU Z ZASTOSOWANIEM ŚCIÓŁEK ŻYWYCH I SYNTETYCZNYCH

Streszczenie. Oberżyna uprawiana jest w Polsce głównie pod osłonami z uwagi na wysokie wymagania klimatyczne. Ściółkowanie gleby może być dobrym rozwiązaniem spełniającym wymagania tego typu warzyw. W doświadczeniu polowym przeprowadzonym w latach 2008–2009 w uprawie oberżyny (*Solanum melongena* L.) odmiany Epic F_1 zastosowano żywe ściółki: życicę trwałą i koniczynę białą wysiewane na trzy tygodnie przed posadzeniem oberżyny, w terminie jej sadzenia oraz trzy tygodnie po posadzeniu oraz czarną folię polietylenową i włókninę polipropylenową. Rozsadę sadzono w pole 02.06. w rozstawie 60 × 50 cm. Plon handlowy oberżyny uprawianej na czarnej folii był większy niż w kontroli i na ściółce z czarnej włókniny o 7,8% i 10,4%. Średnia masa owocu zwiększyła się odpowiednio o 12,4% i 7,3%. Zastosowanie koniczyny białej jako żywej ściółki umożliwiło zebranie plonu oberżyny porównywalnego pod względem statystycznym z poletkami pokrytymi czarną folią. Uprawa z życicą trwałą spowodowała istotny spadek plonu w stosunku do uprawy z pozostałymi ściółkami (o 17%) i do kontroli (o 15%). Zawartość cukrów redukujących i magnezu zależała od rodzaju zastosowanej ściółki i terminu wysiewu żywych ściółek, a potasu od gatunku żywej ściółki.

Słowa kluczowe: *Solanum melongena* L., koniczyna biała, życica trwała, czarna folia, czarna włóknina

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