

THE EFFECT OF NON-WOVEN PP FABRIC COVERS ON THE YIELDING AND THE FRUIT QUALITY OF FIELD-GROWN SWEET PEPPERS

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Abstract. In recent years in Poland there has been an increasing interest in the field growing of sweet peppers, both among producers and consumers. Therefore, research should be conducted to select cultivars well adapted to less favorable temperature conditions and suitable for cultivation in the field, and to increase their yield. A field experiment was carried out in the years 2006–2008 in the Garden of the Research and Experimental Station of the University of Warmia and Mazury in Olsztyn to determine the effect on plant cover on the yield and the content of dry matter and organic compounds in sweet pepper fruit. In comparison with the control treatment (without protective cover), the use of non-woven PP covers increased the marketable yield of sweet pepper cv. Iga, Lena and Mira, and it decreased the marketable yield of cv. Zorza. Sweet pepper fruit in the control treatment had the highest average dry matter content. The use of non-woven PP covers contributed to dry matter accumulation only in the fruit of cv. Zorza. The fruit of sweet pepper plants grown without protective cover contained greater amounts of L-ascorbic acid. Non-woven PP covers had no effect on the concentrations of total and reducing sugars, which were highest (subject to cultivar and cultivation method) in 2007.

Key words: *Capsicum annuum* L., cultivation, cultivar, organic compounds

INTRODUCTION

Capsicum annuum L. is known to have a high biological value. Due to their high content of vitamin C, carotenoids and minerals, sweet peppers enjoy increasing popularity. Capsicum species are thermophilous, and their optimal growth temperature is 20–28°C, therefore they are grown under protective cover in regions characterized by less favorable climate conditions [Michalik 2000]. According to Nowaczyk and Nowaczyk [2000], Cebula [1998], Orłowski and Kołota [1992], pepper plants die when temperature falls below 0°C. Already at 6–8°C, the plants wither due to water intake inhibi-

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tion, and this process is irreversible. At 14°C, the growth of plants is suppressed, the flowers and fruit buds drop, and the set fruits undergo deformation and discoloration.

The climate conditions of Poland, in particular NE Poland, do not support the growing of sweet peppers in the open field. Due to late frost, seedlings can be planted out in the middle or at the end of May. In order to attain a high yield of good quality, pepper cultivars with a short growing season and low temperature requirements should be selected for growing in the field [Gajc-Wolska and Skapski 2001; Buczkowska and Bednarek 2005; Gajc-Wolska et al. 2005]. Unfavorable temperature conditions contribute to improving the existing methods of field cultivation of sweet peppers in Poland [Aiye-laagbe and Fawusi 1986; Buczkowska 1999, 2000; Rumpel and Grudzień 1990]. The use of non-woven PP fabric (17 g·m⁻²) protects plants against ground frost, in particular at the early growth stages [Siwek 2002; Michalik 2007]. Owing to their high biological value, field-grown pepper fruits are used for processing, but they cannot successfully compete on the fresh vegetable market with large, rich-colored fruits grown under cover.

The aim of this study was to determine the content of dry matter and selected organic compounds in the fruit of sweet pepper cultivars grown in the field in the Olsztyn area.

MATERIAL AND METHODS

A field experiment was conducted in the years 2006–2008 in the Garden of the Research and Experimental Station of the University of Warmia and Mazury in Olsztyn. Sweet peppers were grown in the field. Thirty plants of each studied cultivar, i.e. Iga, Lena, Mira and Zorza, were grown without protective cover, and thirty plants were covered with non-woven polypropylene (PP) (17 g·m⁻²) for three weeks. The seedlings of sweet pepper were grown in pots in a greenhouse, in line with the generally observed standards for sweet pepper cultivation, and they were planted out on 24 May 2006, 22 May 2007 and 19 May 2008, at 40 × 40 cm spacing. The required cultivation and protection measures were carried out over the growing period. The experiment was performed in a split-plot design, in three replications. The fruits were harvested on ripening. Harvest began on 18 August 2006, 24 July 2007 and 28 July 2008, and ended on 22 September 2006, 15 September 2007 and 15 September 2008. After harvest, the total and marketable yield of pepper fruit was estimated. Fruits representing each cultivar and cultivation method, harvested each year on 15 September, were selected randomly for laboratory analyses. Every year, the chemical composition of pepper fruit was determined in three replications. Dry matter content was measured by drying to constant mass at 105°C, L-ascorbic acid content was determined by the Tillmans method modified by Pijanowski, and the concentrations of total and reducing sugars – by the Luff-Schoorl method.

The results were validated statistically by Duncan's test, at a significance level of $\alpha = 0.05$.

RESULTS

The key factors that affect the yield and quality of sweet pepper fruit include weather conditions over the growing season (from May to September), cultivar and cultivation method. In the present study, the day of planting out the seedlings, the beginning and end of harvest as well as the obtained yield were determined by weather conditions. The most favorable weather conditions for growing sweet peppers in the open field were noted in 2007, when air temperature from May to September reached 15.3°C, and was by 0.3°C higher than the long-term average, and mean precipitation total was by 27.6 mm higher than the long-term average (tab. 1).

Table 1. Average day temperature and precipitation during vegetation of field sweet pepper in the years 2006–2008 and in multiyear

Tabela 1. Średnia dobowa temperatura i suma opadów w trakcie wegetacji papryki słodkiej w latach 2006–2008 i w wieloleciu

	Year Rok	Month – Miesiąc					mean
		May maj	June czerwiec	July lipiec	August sierpień	September wrzesień	May–September średnia maj–wrzesień
Temperature Temperatura °C	2006	12.5	16.0	20.9	18.2	14.6	16.3
	2007	13.8	16.7	16.8	16.8	12.6	15.3
	2008	12.3	16.8	18.5	18.4	14.9	16.2
	mean średnia z lat 1961–2000	12.5	15.8	17.2	16.8	12.6	15.0
Precipitation Suma opadów mm	2006	89.2	79.2	29.3	165.0	51.0	83.0
	2007	93.5	88.1	173.7	68.0	57.6	96.2
	2008	27.0	32.7	57.7	102.1	22.9	48.5
	mean średnia z lat 1961–2000	57.6	69.5	81.6	75.2	59.0	68.6

Weather conditions during the growing seasons of 2006–2008 had a decisive effect on the yield of sweet peppers. In 2006 and 2008, too high temperatures and low precipitation led to excessive flowering and premature fruit drop, and heavy rainfall in August contributed to slowing down the process of fruit setting and ripening.

Throughout the experiment (2006–2008), cv. Zorza grown without protective cover was characterized by the highest total and marketable yield (3.11 kg m⁻² and 2.49 kg m⁻² respectively). The yield of the remaining pepper cultivars was lower, but they positively responded to non-woven PP covers, and the yield of protected plants was insignificantly higher than that of plants grown in the field (fig. 1).

The dry matter content of sweet pepper fruit was largely dependent on cultivar and weather conditions. The highest dry matter accumulation was noted in the fruit of sweet peppers cv. Iga, Lena and Mira in the treatments without protective cover. The fruit of cv. Zorza grown under non-woven PP covers had a higher dry matter content (tab. 2).



Fig. 1. Yielding of sweet pepper grown in the field (2006–2008)

Rys. 1. Plonowanie papryki słodkiej uprawianej w polu (2006–2008)

Table 2. The content of dry matter and L-ascorbic acid in sweet pepper plants fruits grown in the field in the years 2006–2008

Tabela 2. Zawartość suchej masy i kwasu L-askorbinowego w owocach papryki słodkiej uprawianej w polu w latach 2006–2008

Cultivar Odmiana	Year Lata	Dry master, % Sucha masa, %			L-ascorbic acid, mg·100 g ⁻¹ f.m. Kwas L-askorbinowy, mg·100 g ⁻¹ ś.m.		
		plants without shields rośliny bez oslon	plants shielded rośliny oslaniane	mean średnia	plants without shields rośliny bez oslon	plants shielded rośliny oslaniane	mean średnia
Iga	2006	8.03	7.45	7.74	164.45	147.30	155.87
	2007	6.75	7.91	7.33	188.50	162.75	175.62
	2008	8.28	6.52	7.40	150.45	79.21	114.83
	mean – średnia	7.67	7.29	7.48	167.80	129.75	148.77
Lena	2006	8.17	6.71	7.44	132.30	121.23	126.76
	2007	7.43	6.34	6.88	155.82	145.19	150.50
	2008	8.07	7.42	7.74	110.91	52.84	81.87
mean – średnia	7.89	6.82	7.35	130.01	106.42	118.21	
Mira	2006	5.17	4.82	4.99	135.33	106.80	121.06
	2007	5.30	4.34	4.82	130.35	120.81	125.58
	2008	5.59	6.22	5.87	182.27	76.61	129.44
	mean – średnia	5.35	5.13	5.24	149.32	101.41	125.36
Zorza	2006	5.10	7.81	6.45	110.44	90.76	100.57
	2007	4.88	5.53	5.20	120.80	56.87	88.83
	2008	5.32	5.35	5.33	176.65	107.43	142.04
	mean – średnia	5.10	6.23	5.66	135.96	85.02	110.459
LSD NIR α = 0.05	a – cultivar – odmiana			0.49		23.07	
	b – growing – uprawa			n.s. – n.i.		14.46	
	a × b			0.59		26.38	

Table 3. The content of total and reducing sugars in sweet pepper fruits plants grown in the field in 2006–2008

Tabela 3. Zawartość cukrów ogółem i redukujących w owocach papryki słodkiej uprawianej w polu w latach 2006–2008

Cultivar Odmiana	Lata Years	Total sugars, g·100 g ⁻¹ f.m. Cukry ogółem, g·100 g ⁻¹ ś.m.			Reducing segars, g·100 g ⁻¹ f.m. Cukry redukujące, g·100 g ⁻¹ ś.m.		
		plants without shields rośliny bez osłon	plants shielded rośliny osłaniane	mean średnia	plants without shields rośliny bez osłon	plants shielded rośliny osłaniane	mean średnia
Iga	2006	5.15	5.03	5.09	4.77	4.85	4.81
	2007	5.81	4.78	5.29	4.63	4.49	4.56
	2008	3.14	3.61	3.37	2.74	2.31	2.51
	mean – średnia	4.70	4.47	4.58	4.05	3.88	4.00
Lena	2006	4.91	4.26	4.58	4.24	4.31	4.27
	2007	4.63	4.07	4.31	4.05	3.91	3.98
	2008	3.93	3.59	3.76	2.56	2.31	2.43
	mean – średnia	4.49	3.97	4.23	3.62	3.51	3.56
Mira	2006	4.71	2.58	3.64	4.40	1.91	3.15
	2007	3.57	4.90	4.23	3.00	3.36	3.18
	2008	2.04	3.01	2.52	1.20	2.35	1.77
	mean – średnia	3.44	3.50	3.47	2.87	2.54	2.70
Zorza	2006	2.35	2.40	2.37	2.00	2.25	2.12
	2007	3.61	5.49	4.55	2.91	4.29	3.60
	2008	3.84	3.00	3.42	2.60	2.24	2.42
	mean – średnia	3.27	3.63	3.45	2.23	2.93	2.58
LSD NIR $\alpha = 0.05$	a – cultivar – odmiana			n.s. – n.i.			0.63
	b – growing – uprawa			n.s. – n.i.			n.s. – n.i.
	a × b			n.s. – n.i.			0.90

The fruit of pepper plants grown without protective cover accumulated considerably more L-ascorbic acid than the fruit of plants covered with non-woven PP fabric. The average difference between the above treatments, subject to cultivar and the year of study, reached 40.1 mg 100 g⁻¹ fresh weight (tab. 2).

The use of non-woven PP fabric had no influence on the concentrations of total and reducing sugars in sweet peppers, which were affected by cultivar and the interaction of both experimental factors. The highest content of total and reducing sugars was recorded in 2007, at 4.59 g 100 g⁻¹ fresh weight and 3.83 g 100 g⁻¹ fresh weight, respectively (tab. 3). Unfavorable climate conditions in 2008 resulted in a low content of total and reducing sugars in the fruit of sweet peppers of the analyzed cultivars.

DISCUSSION

Gajc-Wolska and Skapski [2002] demonstrated that the use of protective cover during the first four weeks after planting out the seedlings resulted in a higher, good-quality yield of sweet peppers. In this experiment a higher total yield of pepper fruit was attained in the control treatment. Among the tested cultivars, Zorza was characterized by

the highest yield per plant at 3.11 kg m^{-2} , which shows that the yield of sweet peppers grown in the Warmia region in 2006–2008 was lower, compared with the findings of other authors, in the range of $1\text{--}5 \text{ kg m}^{-2}$ [Michalik 1999; Buczkowska and Bednarek 2005; Michalik 2007]. Stępowaska and Kosson [2003] reported a considerably higher yield of sweet peppers of the analyzed cultivars. The above suggests that the appropriate selection of cultivars and cultivation methods enables to obtain a satisfactory yield.

The content of the analyzed chemical compounds in pepper fruit was dependent on weather conditions, cultivar and the interaction between cultivar and cultivation method. Cultivation methods affected the L-ascorbic acid content of pepper fruit only in 2006 and 2008. This is consistent with the results of previous studies which indicated that the dry matter content of sweet pepper fruit was determined by cultivar [Buczkowska and Sawicki 2008]. In the present experiment the dry matter content of sweet pepper fruit was insignificantly lower. Compared with plants covered with PP fabric, the fruit of cv. Lena and Iga in the control treatment contained the largest amount of dry matter. The use of non-woven PP covers had a beneficial effect on dry matter accumulation only in cv. Zorza, which was found to be by 1.13% higher than in the fruit harvested in the control treatment. Błażewicz-Woźniak [2010] observed no significant effect of plant covers on the dry matter content of fennel. Plants covered with non-woven fabric had an inconsiderably lower dry matter content of the edible parts, in comparison with the control treatment.

The fruit of the investigated cultivars differed significantly with respect to the concentrations of L-ascorbic acid, total sugars and reducing sugars. The use of plant covers affected L-ascorbic acid content, which was lower by $40.12 \text{ mg} \cdot 100 \text{ g}^{-1}$ fresh weight on average, compared with the control treatment. These values are similar to those reported by Buczkowska and Sawicki [2008], Michalik [2000], Gajc-Wolska and Skapski [2002]. The sweet pepper cultivars analyzed in the present study had a similar L-ascorbic acid content as the heterotic cultivars studied by Gajc-Wolska et al. [2005]. Neither cultivar nor plant covers had a significant effect on the accumulation of total sugars in sweet pepper fruit. The cultivar significantly affected the reducing sugar content of sweet peppers, whereas the effect of non-woven PP covers was statistically non-significant in this respect. The values obtained in the experiment conducted in 2006–2008 are comparable with earlier findings [Michalik 1999, 2000; Buczkowska and Sawicki, 2008]

Majkowska-Gadomska [2010] carried out a five-year study investigating the effect of plant covers on the chemical composition of melon fruit and found that the use of non-woven PP fabric positively influenced dry matter content, but had no significant effect on the levels of the remaining components of melon fruit.

The results obtained in 2006–2008 are inconclusive as regards the effect of plant covers on the yield and content of selected organic compounds in sweet pepper fruit.

CONCLUSIONS

Weather conditions in the Warmia region over the growing seasons (from May to September) of 2006–2008 had a significant effect on the yield and quality of field-

grown sweet peppers. The marketable yield of cv. Iga, Lena and Mira increased in response to the use of non-woven PP covers.

Cv. Zorza grown without protective cover was characterized by the highest total and marketable yield.

Apart from weather conditions, also varietal features affected the chemical composition of field-grown sweet peppers. The fruit of cv. Iga and Lena grown without protective cover had the highest dry matter content. The fruit of cv. Iga in the control treatment contained the greatest amount of L-ascorbic acid.

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WPLYW OSŁANIANIA ROŚLIN WŁÓKNINĄ NA PLONOWANIE I JAKOŚĆ OWOCÓW PAPRYKI SŁODKIEJ UPRAWIANEJ W POLU

Streszczenie. W ostatnich latach w Polsce obserwuje się wzrostową tendencję w polowej produkcji papryki słodkiej. Większe zainteresowanie zarówno producentów, jak i konsumentów jej owocami zobowiązuje nie tylko do prowadzenia w szerszym zakresie badań nad wytypowaniem przydatnych odmian do uprawy w mniej korzystnych warunkach termicznych, ale także doskonalenia zabiegów usprawniających plonowanie papryki słodkiej w polu. W doświadczeniu polowym przeprowadzonym w latach 2006–2008 w Ogrodzie Dydaktyczno-Doświadczalnym Uniwersytetu Warmińsko-Mazurskiego w Olsztynie badano wpływ osłaniania roślin papryki słodkiej na plon oraz zawartość w owocach suchej masy i składników organicznych. W porównaniu do nieosłanianej kontroli osłony z włókniny polipropylenowej zwiększyły plon handlowy odmian Iga, Lena i Mira oraz zmniejszyły plon handlowy odmiany Zorza. Najwięcej suchej masy średnio z lat stwierdzono w owocach papryki słodkiej z obiektów nieosłanianych włókniną, jedynie w owocach odmiany Zorza z roślin osłanianych włókniną oznaczono więcej suchej masy. Więcej kwasu L-askorbinowego zawierały owoce badanych odmian papryki słodkiej z roślin nieosłanianych. Osłanianie roślin papryki włókniną nie miało wpływu na zawartość cukrów ogółem i redukujących. Najwięcej ich było (średnio z odmiany i metody uprawy) w 2007 roku.

Słowa kluczowe: *Capsicum annuum* L., uprawa, odmiana, składniki organiczne

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