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ORIGINAL PAPER

EFFECT OF THE DATE OF PLANTING SEEDLINGS AND POLYPROPYLENE FIBER COVERING ON THE YIELD, NUTRITIVE VALUE AND QUALITY OF CV. MALAGA F_1 MELON*

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Abstract

Melon is a species of high nutritional value, valuable medicinal properties as well as taste properties which are increasingly appreciated by consumers. It is sensitive not only to frost but also to temperatures below 10°C, which cause physiological disorders. Adequate thermal conditions for this plant's growth can be ensured by an appropriately late planting of seedlings. However, a late planting date does not guarantee a high yield of good quality fruit. Earlier planting of seedlings and improved growth conditions can be achieved through the use of flat covers. The effect of different planting dates of seedlings (15th and 25th of May and 4th of June) and the time when polypropylene fiber covers were removed (4 and 8 weeks after the planting of seedlings, before fruit harvest and control without covering) on the yield quality and selected nutritive value components of melon fruits was investigated. The experiment was conducted in 2008-2010, in central-eastern Poland (51°53′N, 22°27′E). Fruits from plants planted on 15th of May were characterized by the highest yield and weight of marketable fruits, the highest content of dry matter and total sugars, as well as the highest flesh thickness, but the lowest flesh firmness. However, the planting date had no influence on the content of monosaccharides, ascorbic acid and iron or on the acidity of melon flesh. Higher yields were obtained from the covered plants, however the duration of covering had no significant effect on the yield. Fruits from plants covered for 8 weeks or until harvest were characterized by thick flesh and higher weight as compared to ones harvested from plants covered for 4 weeks and uncovered. Covering had no influence on the content of investigated components of the nutritive value of melon fruits.

Keywords: *Cucumis melo* L., sugars, ascorbic acid, iron, acidity, weight and firmness of fruits.

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INTRODUCTION

Melon (*Cucumis melo* L.) is a species of high nutritional value, valuable medicinal properties as well as taste properties which are increasingly appreciated by consumers. In addition to its high consumer preference, melon is an extremely healthy food, being rich in ascorbic acid, carotene, folic acid and potassium as well as may other bioactive compounds beneficial for human health (Lester, Hodges 2008, Menon, Rao 2012). Kaur et al. (2013) found that melon juice reduced the ability of pancreatic cancer cells to metabolize glucose, thereby leading to their destruction.

According to Birch et al. (2000) and Majkowska-Gadomska (2009), the plant growth conditions are the main determinant of yield quality. The chemical composition of vegetables is genetically determined, but it is also modified by factors affecting the plant during its growth, particularly climatic conditions and agronomic practice (Lee, Kader 2000).

An important problem in the melon field cultivation in Poland is the late date of planting the seedlings (first 10 days of June), which is due to its sensitivity to low air and soil temperature. Fruits from plants planted in this period ripen in mid-August and, in cooler years, in early September. Before the first autumn frosts, which end the melon's growing season, a substantial number of fruit does not reach physiological maturity, which guarantees the best taste attributes.

Climate warming has resulted in an extended growing season in Poland, which allows planting many crop species earlier. Over the last decades, the average annual air temperature in eastern Poland has increased by 1-1.5°C and the growing season has extended by about 10 days (Górski, Zaliwski 2002). As the agro-climate is changing, it is now possible to begin melon planting in eastern Poland earlier than it has been suggested so far. However, spring frosts may pose a threat to earlier plantings. As a result, it seems rational to cover melon seedlings planted on earlier dates (Kosterna et al. 2009, Majkowska-Gadomska 2010*a*). Many authors have found that the use of covers affects the accumulation of the components determining the nutritional value and health benefits of vegetables (Shewfelt, Henderson 2003, Rosa 2014, Santos et al. 2015).

The study aimed to determine the effect of an earlier date of planting melon seedlings and different dates of the removal of polypropylene fiber cover on the yield quality and selected components of the nutritive value of melon fruits.

MATERIAL AND METHODS

The experiment was conducted in central-eastern Poland (51°53′N, 22°27′E) in 2008-2010. The field experiment was carried out on soil classified as Podzols (World Reference… 2014). The soil had a humus level of 37-43 cm. The average content of organic carbon was 2.1% and the value of pH determined in H_2O was 5.80. The content of macroelements in 1 dm^3 in the arable layer was as follows: 14 mg $N\text{-}NH_4$, 20 mg $N\text{-}NO_3$, 19 mg P_2O_5, 145 mg K_2O, 797 mg Ca and 76 mg Mg.

The experiment was established in a split-block design with four replicates. The area of one plot for harvest was 12 m^2. The influence of two factors was investigated: 1) the date of planting cv. Malaga melon seedlings: 4th of June – traditionally recommended in Poland, 25th of May – date accelerated by 10 days, 15th of May – date accelerated by 20 days; 2) plant covering: for 4 and 8 weeks after the planting of seedlings, until fruit harvest, and without cover for control.

The seeds were sown 4 weeks before the date of planting the seedlings, i.e. 17th of April, 27th of April and 7th of May. The seedlings were planted at a spacing of 80 × 100 cm, 12 plants per plot.

Before the planting of seedlings in the field, they were hardened off and vine tops were removed, leaving three leaves on each plant.

Mineral fertilizers were applied in amounts that supplemented their content to the optimal level for melon: 75 kg N, 140 P, 160 K per 1 ha. Mineral fertilizers were in the form of urea, granular superphosphate and 60% potassium chloride.

The harvest was performed gradually, as the melon fruits ripened, which was determined on the basis of the skin color change and intensity of aroma. During the harvest, the marketable yield of fruits and their weight were determined. During the last harvest, fruit samples were collected (5 fruits of different size from each plot) to evaluate quality parameters and make laboratory analyses. The following were determined in the fruits: dry matter – using the drying-weight methods, total acidity – by titration (acid-base titration with phenolphthalein) and expressed as malic acid (g 100 g^{-1} f.m.), total sugars and monosaccharides (% f.m.) – with the Luff-Schoorl method, L-ascorbic acid (mg 100 g^{-1} f.m.) – using the Tillman's method modified by Pijanowski, and iron (mg kg^{-1} f.m.) – according to the colorimetric method with ortho-phenanthroline.

The thickness of the flesh (mm), the flesh weight of marketable fruit (kg), firmness of flesh (kgf) and biological efficiency of marketable fruit (% share of weight of flesh in the weight of fruit) were also determined.

The results of the experiment were statistically analysed by ANOVA at $F \leq 0.05$ following the mathematical model for the split-block design. Significance of differences was determined by the Tukey test at the significance level of $P \leq 0.05$. All the calculations were performed in Statistica® 12.0.

RESULTS AND DISCUSSION

Climatic conditions, mainly air temperature and precipitation, have a decisive effect on vegetable yield and its quality (Lee, Kader 2000, Jędrszczyk et al. 2012). In the years of study, the distribution of temperatures and precipitation in months of the melon's growing season varied and not always favoured the plant's growth and development (Table 1). In 2008, the air temperature and the distribution of precipitation were balanced but the marketable yield and the weight of fruit were the lowest among all the years of study. However, these fruits were characterized by the lowest firmness, which indicates their good harvest ripeness. They were also distinguished by a high biological efficiency and content of sugars, although their content of vitamin C was low (Table 2). Unstable weather conditions during the growth of melon in 2009 caused a low biological efficiency of the fruits. At the same time, quite favourable conditions during the fruit ripening were conducive to obtaining marketable fruits with the highest weight, characterized by the highest content of dry matter and sugar and a high content of vitamin C. The weather conditions in 2010 (especially the abundant rains in August) favoured an increase in the flesh weight of marketable fruit, which resulted in a high yield of marketable fruit, even though their ripening was delayed. This was demonstrated by the large flesh firmness and the low content of dry matter, total sugars and monosaccharides. Simultaneously, the best thermal conditions had a positive effect on the biological efficiency of fruit and on the accumulation of iron and vitamin C. Also Wierzbicka and Kuskowska (2002) found that high air temperatures favoured better synthesis of vitamin C by cucumber fruits. A similar dependence in potato tubers was noted by Wierzbicka (2011).

Table 1

Mean air temperature and rainfalls during the growing period of melon in 2008-2010

Years	Months					Growing season of melon
	May	June	July	August	September	
Air temperatures (°C)						
2008	12.7	17.4	18.4	18.6	12.2	15.9
2009	12.9	15.7	19.4	17.7	14.6	16.1
2010	14.0	17.4	21.6	19.8	11.8	16.9
Mean (1960-2003)	13.2	16.2	17.6	16.9	12.7	15.3
Rainfalls (mm)						
2008	85.6	49.0	69.8	75.4	63.4	343.2
2009	68.9	145.2	26.4	80.9	24.9	346.3
2010	93.2	62.6	77.0	106.3	109.9	449.0
Mean (1960-2003)	54.3	69.3	70.6	59.8	48.2	302.2

Table 2

Yield, quality and nutritive value of melon fruits in the years of study

Years	Marketable yield (kg m^{-2})	Weight of marketable fruit (kg)	Flesh thickness (mm)	Weight of flesh (kg)
2008	3.60*a**	1.46*a*	32*a*	1.04*a*
2009	4.29*b*	1.71*c*	32*a*	1.15*b*
2010	4.83*c*	1.65*b*	32*a*	1.18*c*
	biological efficiency (%)	firmness (kgf)	dry matter (%)	acidity
2008	71*b*	2.00*a*	7.0*b*	0.44*a*
2009	67*a*	2.05*b*	7.6*c*	0.43*a*
2010	71*b*	2.35*c*	5.9*a*	0.46*a*
	total sugars	monosaccharides	ascorbic acid (mg 100 g^{-1} f.m.)	iron (mg kg^{-1} d.m.)
2008	1.6*b*	4.6*c*	16.6*a*	4.9*a*
2009	1.8*c*	4.2*b*	18.1*b*	4.9*a*
2010	1.3*a*	3.6*a*	18.5*b*	6.4*b*

* Values followed by the same letters are not significantly different at $P \leq 0.05$

The marketable yield of melon fruits amounted to 4.24 kg m^{-2}, and the weight of marketable fruits 1.61 kg on average (Figure 1). The planting of seedlings accelerated by 10 and 20 days caused an increase in the yield and weight of marketable fruit, by 16% and 25% and by 2.5% and 3.1%, respectively. Irrespective of the date of planting, the covering of melon plants increased the fruit yield (by 3.82-4.05 kg m^{-2}) in comparison with melons grown without cover. The beneficial effect of flat covers on higher yields of thermophilic vegetables has been shown by Wierzbicka and Kuskowska (2002), Majkowska-Gadomska (2010a) and Rosa (2014). In our research, it was enough to cover the melon plants with polypropylene fiber for 4 weeks to obtain a significant increase in the marketable yield. The cover left over on the plants for a longe time did not cause a further significant increase in yield. This is consistent with the results of Ibarra et al. (2001), Majkowska-Gadomska (2010*a*) and Santos et al. (2015), according to which the extension of the melon covering period did not cause significant changes in the yield level. In our study, a significant increase in the weight of marketable fruit owing to the use of cover was obtained from the plants planted on 15th and 25th of May (by 14-15.6 % and 5-11%, respectively), although the length of covering time did not modify significantly that feature.

The fruit of the melon cultivar Malaga F$_1$ contained 6.8% of dry matter on average (Table 3). The dry matter content in melon fruits found by Majkowska-Gadomska (2010*a*, *b*) was similar, while that determined in the previous study by Zaniewicz-Bajkowska et al. (2010) and Kosterna et al.

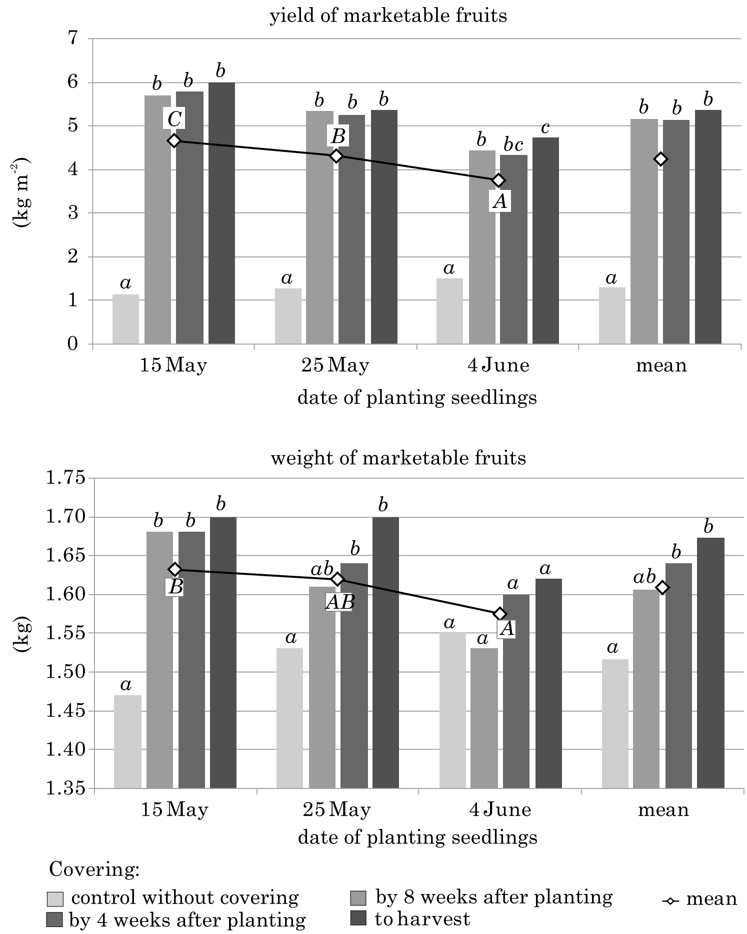

Fig. 1. Yielding of melon (mean from 2008-2010).
Values followed by the same lowercase or uppercase letters are not significantly different at $P \leq 0.05$

(2010) was lower. In this research, the dry matter content depended on the date of planting the seedlings. The highest one was found in the fruits harvested from plants planted on 15th of May, being significantly lower in fruits from plants planted on 4th of June. A significant, albeit irregular effect of the duration of plant covering in connection with the different dates of planting the seedlings was noticed. Fruits from plants planted on the first date had the highest dry matter content if covered for 4 weeks, while those planted on the second and third accumulated most dry matter if covered until harvest. Fruits harvested from the plants planted on the first date of planting and covered until harvest had the lowest content of dry matter

Table 3

Content of dry matter and acidity of melon fruits (mean 2008-2010)

Covering	Dry matter (%)				Acidity			
	15 May#	25 May	4 June	mean	15 May	25 May	4 June	mean
Control without covering	7.0*ab**	6.4*a*	6.7*ab*	6.7*a*	0.44*ab*	0.45*ab*	0.47*a*	0.45*a*
for 4 weeks after planting	7.3*b*	6.8*bc*	6.6*ab*	6.9*a*	0.40*a*	0.46*b*	0.43*a*	0.43*a*
for 8 weeks after planting	7.1*ab*	6.7*ab*	6.5*a*	6.8*a*	0.45*b*	0.41*a*	0.43*a*	0.43*a*
until harvest	6.7*a*	7.1*c*	6.9*b*	6.9*a*	0.42*ab*	0.46*b*	0.47*a*	0.45*a*
Mean	7.0*B***	6.8*AB*	6.7*A*	6.8	0.43*A*	0.44*A*	0.45*A*	0.44

date of planting seedlings
* values within columns followed by the same lowercase letters are not significantly different at $P \leq 0.05$
** values within rows followed by the same uppercase letters are not significantly different at $P \leq 0.05$

was the lowest. Majkowska-Gadomska (2010*b*) found that fruits from plants cultivated under polypropylene fiber were characterized by a lower content of dry matter as compared to fruits from uncovered control. However, according to Ibarra et al. (2001), the content of dry matter in melon fruits from plants covered with polypropylene fiber was significantly higher than from the control plot without cover.

Beside sugars and flavour volatiles, acidity is a major determinant of the taste and quality of most fruits. In our research, the total acidity of melon flesh amounted to 0.44 g 100 g^{-1} f.m. and was similar to that reported by Majkowska-Gadomska (2010*a*). Among fruits obtained from the plants planted on 15th of May, the highest total acidity of flesh was determined in the ones harvested from the plants covered for 8 weeks, and its was significantly lower in fruits from plots covered for 4 weeks (Table 3). Our comparison of the total acidity of fruit flesh from the plants planted on 25th of May showed that it was the highest in fruits from the plants covered for 4 weeks and until harvest, while being significantly lower in fruits from plants from covered for 8 weeks. The covering of plants with polypropylene fiber during the last period of cultivation did not cause significant differences in the total acidity of fruit flesh. Majkowska-Gadomska (2010a) repoted that covering plants with polypropylene fiber did not cause significant changes of flesh acidity.

Irrespective of the investigated factors, melon fruits contained 4.1% f.m. of total sugars and 1.6% f. m. of monosaccharides on average (Table 4). The content of total sugars was 3.33 % f.m. in the research by Kosterna et al. (2010) and 3.86% f.m. in the study by Zaniewicz-Bajkowska et al. (2010). Lester et al. (2005 and 2006) reported higher amounts, i.e. 5.46 and 5.35% f.m. A higher content of monosaccharides in fruits of melon (3.65% f.m. and 5.1 mg 100 g^{-1} f.m.) was found by Majkowska-Gadomska (2010*a*) and Ouzounidou et al. (2006).

Table 4

Content of sugars in the melon fruits (mean 2008-2010)

Covering	Total sugars (% f.m.)				Monosaccharides (% f.m.)			
	15 May#	25 May	4 June	Mean	15 May	25 May	4 June	mean
Control without covering	4.2*a**	4.2*a*	3.9*a*	4.1*a*	1.6*a*	1.6*a*	1.6*a*	1.6*a*
for 4 weeks after planting	4.2*a*	4.0*a*	3.9*a*	4.0*a*	1.6*a*	1.5*a*	1.6*a*	1.6*a*
for 8 weeks after planting	4.3*a*	4.0*a*	4.0*a*	4.1*a*	1.6*a*	1.6*a*	1.5*a*	1.6*a*
until harvest	4.3*a*	4.3*a*	4.2*a*	4.3*a*	1.6*a*	1.6*a*	1.5*a*	1.6*a*
Mean	4.3*B***	4.1*A*	4.0*A*	4.1*A*	1.6 *A*	1.6 *A*	1.6*A*	1.6

#, *, ** Explanations as in Table 3

The content of total sugars in fruits of melon was significantly affected by the date of planting the seedlings. The total sugar content in fruits from the plants planted on 15th of May was significantly higher than in fruits from the plants planted on 25th of May and 4th of June (by 0.2 and 0.3% f.m., respectively)

The content of total sugars and monosaccharides in fruits of melon plants cultivated without cover and under polypropylene fiber was similar. The same results were obtained by Majkowska-Gadomska (2010b). A higher content of sugars in fruits of sweet pepper cultivated under polypropylene fiber was found by Dobromilska (2000). However, Michalik (2010) did not observe significant differences in fruits of sweet pepper grown under polypropylene fiber and without cover.

The biological value of edible parts of vegetables is determined by the ascorbic acid content. According to Lee and Kader (2000), the higher the intensity of sunlight during the growing season, the higher the vitamin C content in plant tissue. An average content of ascorbic acid in the fruits of cv. Malaga F_1 melon was 17.8 mg 100 g f.m., thus beng similar to results reported earlier by Zaniewicz-Bajkowska et al. (2010) from their experiment conducted in central eastern Poland. A higher content of ascorbic acid in fruits of cv. Malaga F_1 melon (26.5 mg 100 g f.m.) was found by Majkowska-Gadomska (2010*b*). Higher concentrations of this nutrient were also determined in fruits of melon by Lester et al. (2005) 25.87 mg 100 g f.m., Lester et al. (2006) 27.1 mg 100 g f.m., Ouzounidou et al. (2006) 18-28 mg 100 g^{-1} f.m. and Wolbang et al. (2008) 22.6 mg 100 g f.m. A much lower content of L-ascorbic acid in fruits of melon (8-13 mg 100 g^{-1} f.m.) was found by Lin et al. (2004).

Our experiment results did not demonstrate a significant influence of the date of planting seedlings or the use of polypropylene fiber cover on the content of ascorbic acid in fruits of melon. Likewise, Majkowska-Gadomska (2010*a*) did not find significant differences in the ascorbic acid content correlated with polypropylene fiber covering. However, fruits of sweet pepper in the study by Michalik (2010), plants of garlic tested by Rekowska and Skupień (2007) and plants of kohlrabi examined by Biesiada (2008) cultivated without cover had a significantly higher content of L-ascorbic acid than edible parts of these vegetable species cultivated under polypropylene fiber.

Fruits of melon contain 5.4 mg·kg^{-1} f.m. of iron on average. In the study by Majkowska-Gadomska (2010*a*) conducted on this same cultivar, the content of iron was higher: 6.5 mg kg^{-1} f.m. Also, the content of iron in melon fruits found by Wolbang et al. (2008) achieved a higher level 8.2 mg kg^{-1} f.m.

According to Majkowska-Gadomska (2010*a*), the covering of melon plants resulted in a significant increase in the iron content of fruits as compared to the uncovered control. Wierzbicka et al. (2007) found that the content of iron in fruits from cucumber plants covered with polypropylene fiber was significant higher than obtained in the cultivation technology without cover. In this research, a significant influence of the use of cover on the content of iron in melon fruits occurred only in the case of plants planted the earliest. The highest content was determined in fruits from plants grown without cover and from plants covered until harvest, while being significantly lower in fruits from plants covered for 4 weeks. The differences reached 1.1 and 0.9 mg kg^{-1} f.m., respectively.

One of the quality properties of melon fruits is the thickness and weight of flesh. In this study, the average thickness and weight of flesh of melon fruits from the cv. Malaga F_1 plants were 32.4 mm and 1.12 kg (Figure 2). According to Majkowska-Gadomska (2010*a*), the same cultivar was characterized by a significant thinner flesh of fruits (22 mm). In our experiment, the thickness and weight of flesh of marketable fruits harvested from plants planted on 4th of June was significantly lower than in fruits from plants planted in May. The most favourable effect on the flesh thickness was achieved when seedings had been planted 20 days earlier than the traditional planting date in June. The thickness and weight of flesh of marketable fruits harvested from plants planted on 15th of May and covered with polypropylene fiber, irrespective of how long the cover was kept, was significantly higher as compared to the same traits of fruits grown without cover. Among marketable fruits from plants planted on 25th of May, the highest thickness and weight of flesh were acchieved by fruits obtained from the plots covered with polypropylene fiber until harvest and for 8 weeks, while being significantly lower in fruits from uncovered plants. In the case of fruits harvested from plants planted on 4th of June, the use of cover did not cause significant differences in the thickness and weight of flesh. This is in agreement with the research by Majkowska-Gadomska (2010*a*), who concluded that covering plants planted in early June with polypropylene fiber had no influence on the flesh thickness of cv. Malaga F_1 melon.

The study also showed a significant influence of the examined factors on the firmness of fruit flesh. Significantly the highest flesh firmness was determined in fruits from plants planted on 4th of June (2.23 kgf), it was lower in fruits from plants planted on 25th of May (2.16 kgf) and significantly the lowest flessh firmness was found in fruits from plants planted on 15th of May (2.00 kgf).

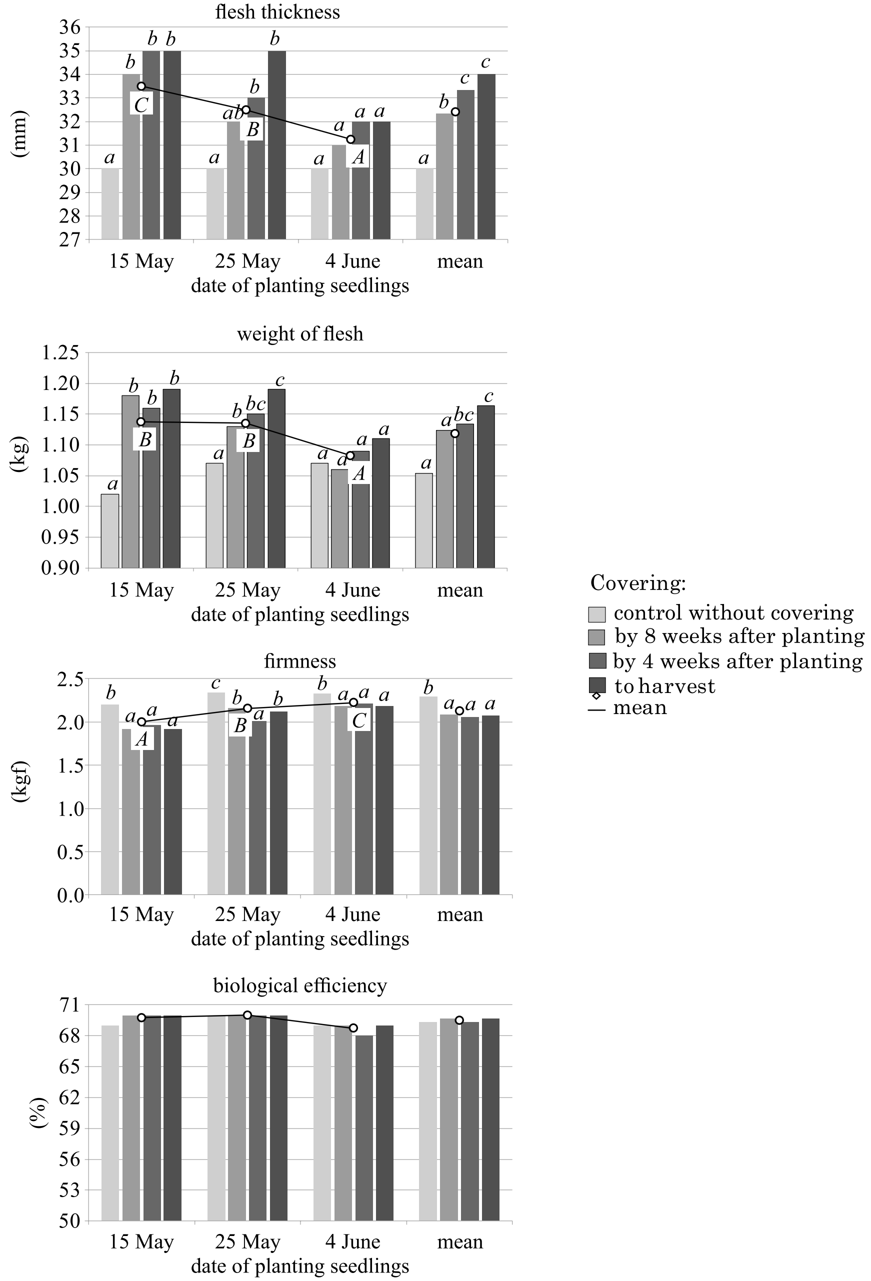

Fig. 2. The quality of marketable melon fruits (mean from 2008-2010).
Values followed by the same lowercase or uppercase letters are not significantly different at $P \leq 0.05$

Table 5

Content of ascorbic acid and iron in the melon fruits (mean 2008-2010)

Covering	Ascorbic acid (mg 100g^{-1} f.m.)				Iron (mg kg^{-1} f.m.)			
	15 May#	25 May	4 June	Mean	15 May	25 May	4 June	mean
Control without covering	17.1*a**	17.7*a*	17.4*a*	17.4*a*	5.8*b*	5.6*a*	5.8*a*	5.7*a*
for 4 weeks after planting	17.8*a*	18.2*a*	18.0*a*	18.0*a*	4.7*a*	5.3*a*	5.5*a*	5.2*a*
for 8 weeks after planting	17.7*a*	17.9*a*	17.6*a*	17.7*a*	5.1*ab*	5.1*a*	5.7*a*	5.3*a*
until harvest	18.2*a*	18.2*a*	17.4*a*	17.9*a*	5.6*b*	5.5*a*	5.2*a*	5.4*a*
Mean	17.7*A***	18.0*A*	17.6*A*	17.8	5.3*A*	5.4*A*	5.6*A*	5.4

#, *, ** Explanations as in Table 3

With respect to plants planted on 15th of May and 4th of June, significantly higher firmness of flesh was characteristic for fruits from the uncovered cultivation than from plots covered with polypropylene fiber. The duration of covering had no a significant effect on flesh firmness. Regarding plants planted on 25th of May, the significantly highest flesh firmness had the fruits harvested from plants grown without polypropylene fiber (2.34 kgf) and the significantly lowest value of this trait was achieved by fruits from plants covered for 8 weeks (2.01 kgf).

The biological efficiency of marketable fruit reached 69.5%. The investigated factors and their interactions were not found to have an influence on the biological efficiency of marketable fruit of cv. Malaga F_1 melon grown in our experiment.

CONCLUSION

1. The weather conditions had a significant influence on the growth, development and yield of cv. Malaga F_1 melon. In the all years of the research, satisfying yields were obtained under the weather conditions of central eastern Poland.

2. The earliest planting date had the best effect on the marketable yield and average weight of marketable fruit. The marketable yield and average weight of marketable fruit from covered plants were significantly higher than from uncovered plants. The duration of covering had no significant effect on the yield parameters.

3. Fruits from plants planted on 15th of May were characterized by the highest thickness of flesh as well as the highest content of dry matter and total sugars. The lowest firmness of fruit flesh in fruits from plants planted the earliest proves of their ripeness, which determines the taste. The planting date had no influence on the content of monosaccharides, ascorbic acid and iron as well as on the acidity of melon flesh.

4. Fruits from plants covered for 8 weeks or until harvest were characterized by thicker flesh and higher weight as compared to harvested from plants covered for 4 weeks and uncovered. Fruits from plants covered with polypropylene fiber were more mature, which was evidenced by the lower firmness of their flesh. Covering had no influence on the nutritive value of melon fruits.

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