ACTA SCIENTIARUM POLONORUM Acta Sci. Pol. Hortorum Cultus, 19(4) 2020, 121–131

https://czasopisma.up.lublin.pl/index.php/asphc ISSN 1644-0692 e-ISSN 2545-1405 DOI: 10.24326/asphc.2020.4.11

ORIGINAL PAPER

Accepted: 12.12.2019

# FRUITING OF MELON (*Cucumis melo* L.) GROWN ORGANICALLY ON MULCHED SOIL

Halina Buczkowska, Renata Nurzyńska-Wierdak✉

Department of Vegetable and Herb Crops, Faculty of Horticulture and Landscape Architecture, University of Life Sciences in Lublin, Akademicka 15, 20-950 Lublin, Poland

**ABSTRACT**

Growing melon under temperate climate conditions is quite risky due to the high climatic requirements of this species. Vegetable growers use plastic film mulches to heat soil, to reduce weed infestation, and to maintain optimal soil moisture content. The aim of our study was to determine the suitability of white and black plastic film for soil mulching in melon cultivation under temperate climate conditions. Plants of three Polish heterotic cultivars of melon (*C. melo* L. var. *saccharinus* Naud.): Emir $F_1$, Junior $F_1$, and Seledyn $F_1$, as well as of the breeding line 61/2014 $F_1$ were the subject of this study. Two soil mulching methods were applied: black polyethylene (PE) plastic film and white PE plastic film, using for this purpose double-sided white-on-black PE plastic film. The use of black plastic contributed to a significant increase in marketable yield of melon fruits. The content of L-ascorbic acid and carotenoids in fruits of melon grown on white mulch proved to be higher than in those grown on black mulch. The Polish cultivars studied can be considered as tolerant to temperate climate conditions.

**Key words:** vegetables, cultivars, plastic mulch, yield quality, nutrients

## INTRODUCTION

Melon (*Cucumis melo* L., Cucurbitaceae) is an economically important vegetable species widely cultivated across the world. In nutritional and taste terms, melon fruits are appreciated higher than cucumber or watermelon fruits. Their nutritional value is associated with the presence of sugars, protein, fats, vitamins, organic acids, and mineral compounds, whose content is affected by different variability factors [Malik et al. 2014, Koubala et al. 2016]. Melon fruits also contain numerous secondary metabolites (including antioxidants) [Alagar Raja et al. 2015, El-Din Ibrahim and El-Masry 2016], which allows us to include them in the group of health-promoting vegetables. Vella et al. [2019] inform that in 2016 about 1.9 million tons of melon was harvested in the Mediterranean Sea region, with Spain, Italy, and France being the main European producers (respectively 35%, 34%, and 13% of the total harvest).

*C. melo* is characterized by significant genetic and phenotypic variability, which offers great possibilities of using this species in molecular breeding [Garcia-Mas et al. 2012, Pavan et al. 2017]. Naudin's taxonomy divides *C. melo* into a single wild variety, *C. melo* var. *agrestis*, and 6 cultivated varieties: *cantalupensis*, *inodorus*, *conomon*, *dudaim*, *flexuosus*, and *momordica* [Liu 2004]. Among them, there is *C. melo* var. *saccharinus* Naud. described as an intermediate variety between vars. *reticulatus* and *inodorus*, and even as var. *inodorus*. Guis' categories characterize *C. melo* var. *saccharinus* Naud. as a variety that produces medium size fruits with a round or

✉ renata.nurzynska@up.lublin.pl

oblong shape, smooth with grey tone, sometimes with green spots, which have very sweet flesh [Nũnez-Palenius et al. 2008], and are extremely durable in storage [Liu et al. 2004]. Intensive melon breeding produces measurable effects in the form of numerous varieties adapted to different growing conditions (open field, protected, and hydroponic cultivation) and grown for different uses (fresh vegetable market, processing). Hybrid varieties of melon currently have a significant and growing economic value [Garcia-Mas et al. 2012]. The selection of an appropriate melon variety is a key factor to achieve a satisfactory marketable yield even in less favorable growing years as well as to meet industry and consumer needs [Ban et al. 2006, Majkowska-Gadomska 2009, Krarup et al. 2016].

Growing melon under temperate climate conditions is quite risky due to the high climatic requirements of this species. In Europe production crops of melon are predominantly concentrated in open field and low polytunnels [Castellanos et al. 2011, Yilmaz et al. 2011, Franczuk et al. 2017]. Open field growing conditions can be improved by using, among others, plastic sheet and geotextile covers as well as soil mulching [Franczuk et al. 2017]. Plastic mulches directly affect the microclimate around the plant, modifying the surface radiation budget and reducing soil water loss [Kasirajan and Ngouajio 2012, Domagała-Świątkiewicz and Siwek 2015], and their use contributes substantially to an improved biological value of yield [Antonious and Kasperbauer 2002, Kasirajan and Ngouajio 2012]. The aim of our study was to determine the suitability of white and black plastic film for soil mulching in melon cultivation under temperate climate conditions. This paper presents the yield and biological value of several hybrid cultivars and one breeding line of melon belonging to the *saccharinus* group.

## MATERIALS AND METHODS

### Field experiment

A field experiment was conducted in 2015 and 2016 in a private, certified organic farm (Agrobiotest 04557) located in the Municipality of Ludwin, Lubelskie Voivodeship (province) (51.36°N, 22.83°E). This region is described as a moderately warm area with optimal humidity [Ziernicka-Wojtaszek 2009]. Table 1 presents the thermal and humidity conditions during the plant growing period analyzed.

**Table 1.** Average air temperature and precipitation during the growing season of melon plants relative to long-term data

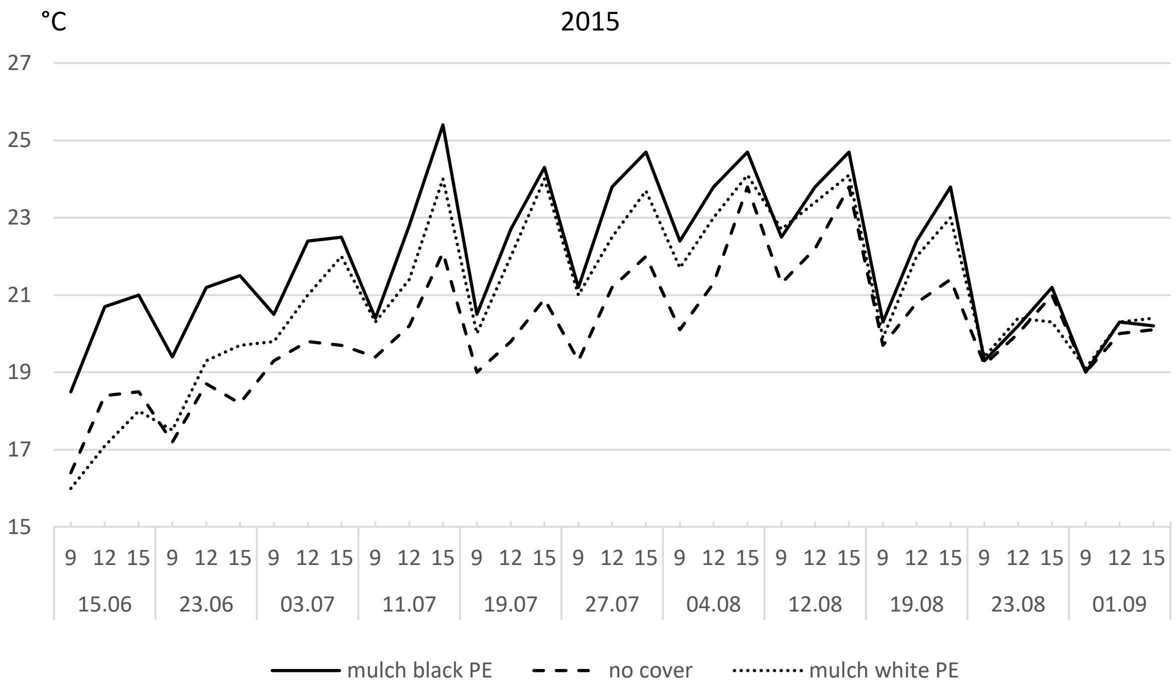
| Year | Temperature (°C) | | | | | Precipitation (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | June | July | August | September | Mean | June | July | August | September | ∑ |
| 2015 | 18.0 | 20.6 | 22.5 | 15.4 | 19.1 | 12.1 | 43.6 | 76.0 | 112.7 | 176.0 |
| 2016 | 18.6 | 18.4 | 18.8 | 15.2 | 17.7 | 19.2 | 19.9 | 18.7 | 159.0 | 73.7 |
| 1951–2010 | 16.3 | 18.0 | 17.2 | 12.6 | 16.0 | 65.9 | 82.0 | 70.7 | 53.7 | 279.3 |

**Table 2.** The mineral content (mg 100 $g^{-1}$) in the 0–20 cm soil layer

| Year | $pH_{H_2O}$ | $N\text{-}NO_3$ | P | K | Ca | Mg | Salinity (mg KCl·$dm^{-3}$) |
|---|---|---|---|---|---|---|---|
| 2015 | 6.5 | 25 | 110 | 155 | 1380 | 124 | 0.12 |
| 2016 | 6.7 | 40 | 90 | 168 | 1540 | 110 | 0.30 |

**Table 3.** The melon cultivation schedule in 2015–2016

| Year | Sowing seeds | Thinning seedlings | Soil mulching | Planting seedlings | Beginning of flowering | First harvest | Last harvest |
|---|---|---|---|---|---|---|---|
| 2015 | 13.05 | 27.05 | 7.06 | 9.06 | 24.06 | 1.08 | 2.09 |
| 2016 | 15.05 | 26.05 | 4.06 | 7.06 | 23.06 | 4.08 | 4.09 |



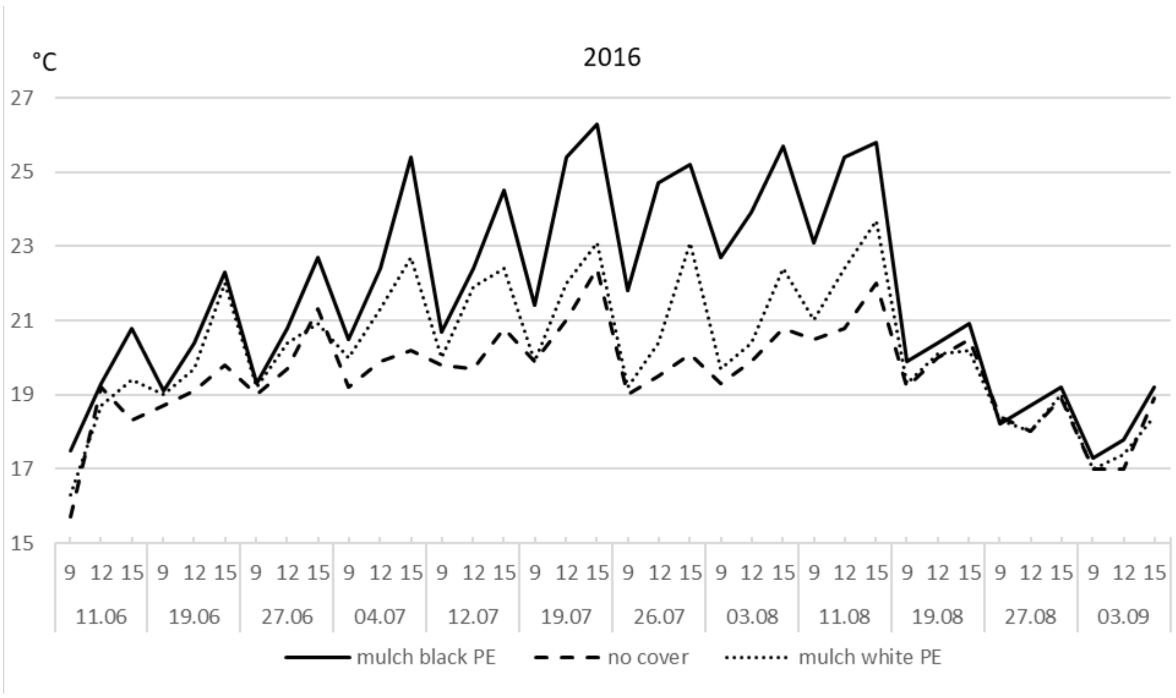




**Fig. 1.** Effect of soil cover black and white PE on soil temperature with (depth. 10 cm) during the vegetation period of melons

Runner bean was the previous crop for melon. In autumn manure was applied at a rate of 30 t·ha$^{-1}$. In spring nutrient content was determined in the soil plough layer (Tab. 2), and 14 days before planting seedlings nutrients were replenished by applying an organic compound fertilizer (Fertikal NPK 4-3-3 BIO: organic matter 70%, dry matter 88 %, total N 4.0%, including organic N 3.8%, $P_2O_5$ 3.0%, $K_2O$ 3.0%, MgO 1.0%, CaO 9.0%, $SO_4$ 1.0%), at a rate of 10 kg·100 m$^2$.

Plants of three Polish heterotic cultivars of melon (*C. melo* L. var. *saccharinus* Naud.): Emir $F_1$, Junior $F_1$, and Seledyn $F_1$, as well as of the breeding line 61/2014 $F_1$ were the subject of this study. Potted melon seedlings were grown in a heated greenhouse of the University of Life Sciences in Lublin according to the commonly accepted procedure for this species. A two-factor experiment was set up in a randomized block design with 4 replicates, with 10 plants per plot. The area of the entire experiment was 24 m$^{-2}$, while the area of a single plot was 6.0 m$^{-2}$. The dates of specific operations performed and other dates are shown in Table 3. A week before the planting date, drip irrigation tape was installed along designated rows. Two soil mulching methods were applied: black polyethylene (PE) plastic film and white PE plastic film, using for this purpose double-sided white-on-black PE plastic film with a thickness of 0.05 mm.

Melon seedlings were planted in the field in the first 10 days of June at a spacing of 1.20 × 0.5 m and with a density of 1.67 plants per 1 m$^{-2}$. To evaluate the effect of mulching on soil temperature in the growth zone of melon roots, the temperature of soil mulched with black PE plastic and with white PE plastic as well as of non-covered soil was measured once a week (at 9.00; 12.00; and 15.00) at a depth of 10 cm (Fig. 1). Throughout the entire growing season of melon, black PE plastic mulching was found to have a much more beneficial effect on soil temperature compared to soil covered with the white side of the plastic film and unmulched soil. Plant irrigation was used during the growing season. Due to a large rainfall deficit in 2016 (July–August), the total amount of water consumed per experimental area corresponded to 35 mm of rainfall, whereas in 2015 it was 15 mm. Fruit harvest started in the first 10 days of August. Fruits at full physiological maturity were harvested once a week. Fully mature fruits with a weight of not less than 300 g and without disease symptoms were classified as marketable fruits. Total yield, marketable yield (kg·m$^{-2}$), and number of total and marketable fruits (fruits·m$^{-2}$) were estimated.

### Laboratory experiment

Evaluation of the biological value of melon was conducted on 10 randomly selected fruits of each cultivar, taking into account selected parameters (dry matter, extract, total sugars, reducing sugars, L-ascorbic acid, carotenoids, and minerals). Chemical analyses were performed in 3 replicates. The percentage of dry matter in the fresh fruit (%) was determined gravimetrically at a temperature of +105°C, total extract (%) refractometrically, content of total sugars and reducing sugars (% FW) by the Luff-Schoorl method [Rutkowska 1981], L-ascorbic content (mg·100 g$^{-1}$ FW) by the Tillmans method [Grzelakowska et al. 2013], and carotenoid content spectrophotometrically according to Lichtenthaler and Wellburn [Torres et al. 2006]. The content of minerals: phosphorus, potassium, calcium, magnesium, and iron, was determined by atomic absorption spectrometry [Krełowska-Kulas 1993] using a SOLAAR AA spectrometer.

### Statistical analysis of data

The study results were statistically analyzed by analysis of variance as a two-factor experiment 4 × 2 (four treatments × two mulch types). The significance of difference was proven by Tukey's multiple range test at a 5% level of significance.

## RESULTS AND DISCUSSION

### Structure of melon fruit yield

The yields of the melon cultivars studied can be considered to be very good under temperate climate conditions. The selection of the variety proved to be appropriate due to its genetically high resistance to cucurbit downy mildew and tolerance to low temperature. The cultivars studied were characterized by a similar and comparable marketable fruit yield, which averaged from 1.41 to 2.79 kg·m$^{-2}$, depending on the cultivar and mulch used (Tab. 4). Dogan et al. [2008] obtained similar results in the cultivation of melon in Turkey's semi-dry climatic conditions, with irrigation application. This indicates high thermal tolerance of

**Table 4.** Structure of melon fruit yield (means for 2015–2016)

| Cultivar | Mulch | Marketable yield ($kg \cdot m^{-2}$) | Marketable yield in total yield (%) | No. of total fruits ($fruits \cdot m^{-2}$) | No. of marketable fruits ($fruits \cdot m^{-2}$) |
|---|---|---|---|---|---|
| Emir $F_1$ | BP* | 2.23 | 89.9 | 2.73 | 2.57 |
| | WP | 1.37 | 86.8 | 1.53 | 1.39 |
| | Mean | 1.80 | 88.3 | 2.13 | 1.98 |
| Junior $F_1$ | BP | 1.98 | 84.3 | 1.86 | 1.78 |
| | WP | 1.84 | 85.7 | 2.16 | 1.78 |
| | Mean | 1.91 | 85.0 | 2.01 | 1.90 |
| Seledyn $F_1$ | BP | 2.79 | 87.4 | 3.59 | 3.40 |
| | WP | 0.91 | 76.8 | 1.49 | 1.26 |
| | Mean | 1.85 | 82.1 | 2.54 | 2.33 |
| 61/2014 | BP | 4.08 | 89.8 | 5.29 | 5.14 |
| | WP | 1.50 | 72.6 | 2.93 | 2.30 |
| | Mean | 2.79 | 81.2 | 4.11 | 3.72 |
| Mean | BP | 2.77 | 87.8 | 3.37 | 3.22 |
| | WP | 1.41 | 85.8 | 2.03 | 1.74 |
| | Mean | 2.09 | 86.8 | 2.70 | 2.48 |
| $LSD_{0.05}$ | | | | | |
| Cultivar | | 1.213 | | 0.338 | 0.297 |
| Mulch | | 0.358 | | 1.010 | 0.877 |
| Interaction | | 1.934 | | 0.558 | 0.474 |

* BP – black plastic, WP – white plastic

**Table 5.** Weight parameters of marketable melon fruit (means for 2015–2016)

| Cultivar | Mulch | Average fruit weight | Fruit weight range |
|---|---|---|---|
| | | kg | |
| Emir $F_1$ | BP* | 0.87 | 0.36–1.99 |
| | WP | 0.98 | 0.44–2.05 |
| | Mean | 0.93 | 0.40–2.02 |
| Junior $F_1$ | BP | 1.11 | 0.49–2.44 |
| | WP | 0.91 | 0.46–2.13 |
| | Mean | 1.01 | 0.47–2.28 |
| Seledyn $F_1$ | BP | 0.79 | 0.39–2.53 |
| | WP | 0.73 | 0.31–1.37 |
| | Mean | 0.76 | 0.35–1.45 |
| 61/2014 | BP | 0.79 | 0.36–1.04 |
| | WP | 0.65 | 0.33–1.04 |
| | Mean | 0.72 | 0.34–1.04 |
| Mean | BP | 0.89 | 0.39–1.75 |
| | WP | 0.82 | 0.38–1.64 |
| | Mean | 0.86 | 0.38–1.69 |

* BP – black plastic, WP – white plastic; marketable fruit weight: $LSD_{0.05}$; cultivar: 0.198; mulch: 0.172; interaction: 0.289

the Polish melon cultivars, whose productivity equals that of cultivars grown under more favorable climatic conditions. The use of black plastic contributed to a significant increase in marketable yield of melon fruits (Tab. 4). The percentage of marketable yield in total yield was highest (88.3%) for the cultivar Emir $F_1$ grown using black plastic (87.8%), compared to the other cultivars. Likewise, Nikolić et al. [2012] achieved the highest tomato fruit yield using red and black plastic mulch. However, the obtained results are in contradiction with those found by Díaz-Pérez [2010] because they reveal a decrease in pepper plant growth and fruit yield on black mulches compared to silver and white mulches in autumn cultivation. But on the other hand, the total pepper fruit yield in spring was higher on sliver mulch with a black strip, whereas it was lowest on silver and white mulches. It therefore seems that the use of colored and white mulches should be adapted not only to the crop species, but also to the growing season.

The analysis of the number of fruits showed the breeding line 61/2014 to be the best because its plants produced significantly the highest number of total fruits and marketable fruits (respectively 4.11 and 3.72 fruits·m$^2$). The interaction cultivar × mulch proved to be significant for marketable yield as well as for number of total fruits and number of marketable fruits. Number of fruits produced by melon plants is an economically important trait which is genetically and environmentally determined [Fergany et al. 2011]. In this study, the average number of fruits per melon plant was 1.2–2.5, depending on the cultivar and mulch used. Growing melon in Oman, Ohashi et al. [2009] obtained 3.8–10.8 fruits per plant, with a unit fruit weight of 0.4–1.6 kg. In the present study, the achieved number of fruits per plant was even more than fourfold lower, but the weight of a single fruit was more comparable (0.34–2.28) (Tab. 5). This is in agreement with the reports of Purquerio et al. [2003] as well as Fergany et al. [2011], thus showing that average number of melon fruits and average fruit weight are most frequently inversely proportional. Plants of the cultivars Junior $F_1$ and Emir $F_1$ produced fruits with the highest weight (respectively 1.01 and 0.93 kg), whereas cvs. Emir $F_1$ and Seledyn $F_1$ did not differ significantly in this respect (respectively 0.93 and 0.76 kg). The wide range of the fruit weight (0.34–2.28 kg) and also the interaction between cultivar and mulch application indicate a significant impact of genetic and environmental factors on the process of melon fruiting.

**Quality parameters of melon fruits**

The commercial value of melon varieties is closely related to their content of nutritional and biologically active substances. The most important quality attribute of ripe melon fruits is their sweet taste, resulting from the level of sucrose. In sweet melons, the absence of appropriate sugar leads to reduced quality because sweetness alone is the major quality component [Burger et al. 2003], whereas the sugar accumulation trait is controlled by a single recessive gene called *suc* [Nũnez-Palenius et al. 2008]. Sugars are the major soluble solids in fruit juice. Other soluble substances include organic and amino acids, soluble pectins, etc. [Magwaza et al. 2015, Chanson-Rolle et al. 2016]. The soluble solids concentration (SSC) in the fruit flesh of the melon cultivars analyzed in our study was on average 8.35% (Tab. 6). The breeding line 61/2014 was characterized by higher SSC (9.05%) than cv. Seledyn $F_1$ (7.22%). The cultivars Emir $F_1$, Junior $F_1$, and Seledyn $F_1$ did not differ significantly in terms of SSC. The use of white plastic mulch promoted the accumulation of soluble solids in melon fruits (10.03%) compared to black plastic (6.67%), which may indicate more favorable moisture conditions. Maboko et al. [2017] inform that the use of white plastic film for soil mulching in chard crops contributes to stronger soil water retention than the use of black plastic film (respectively 59.6% and 55.9%). Long et al. [2006] recommend maintaining melon plants free of water stress from flowering until the end of harvest in order to maximize fruit yield and quality (no stress 11.2% SSC, stress before harvest 8.8% SSC, stress before and during harvest 9.5% SSC). The effect of the color of plastic mulch on soil water status is not fully explained yet. In the study by Díaz-Pérez [2010], mulch color was not related to soil water status and there was no relationship between soil water status and root zone temperature under the mulch. This author explains it by the fact that all mulches had a similar thickness and were made of low-density polyethylene, which probably entails similar water vapor transfer properties [Díaz-Pérez 2010]. Likewise, the mulch used in this

**Table 6.** Nutritional and antioxidant substances in melon fruits (means for 2015–2016)

| Cultivar | Mulch | Soluble solids (%) | Total sugars (% FW) | Reducing sugars (% FW) | L-ascorbic acid ($mg \cdot 100g^{-1}$ FW) | Carotenoids ($\mu g \cdot 100g^{-1}$ FW) |
|---|---|---|---|---|---|---|
| Emir $F_1$ | BP* | 6.70 | 5.62 | 3.34 | 7.36 | 758 |
| | WP | 10.40 | 7.43 | 4.76 | 5.27 | 826 |
| | Mean | 8.55 | 6.52 | 4.05 | 6.32 | 792 |
| Junior $F_1$ | BP | 7.92 | 5.45 | 3.50 | 11.37 | 823 |
| | WP | 9.22 | 7.28 | 4.70 | 9.68 | 701 |
| | Mean | 8.57 | 6.36 | 4.10 | 10.52 | 762 |
| Seledyn $F_1$ | BP | 5.50 | 4.98 | 3.34 | 11.58 | 382 |
| | WP | 8.93 | 6.96 | 4.41 | 18.26 | 552 |
| | Mean | 7.22 | 5.97 | 3.87 | 14.92 | 467 |
| 61/2014 | BP | 6.56 | 3.79 | 2.36 | 9.07 | 420 |
| | WP | 11.55 | 5.68 | 3.20 | 12.98 | 620 |
| | Mean | 9.05 | 4.74 | 2.78 | 11.03 | 470 |
| Mean | BP | 6.67 | 4.96 | 3.14 | 9.85 | 596 |
| | WP | 10.03 | 6.84 | 4.26 | 11.55 | 675 |
| | Mean | 8.35 | 5.90 | 3.70 | 10.70 | 635 |
| $LSD_{0.05}$ | | | | | | |
| Cultivar | | 1.551 | 0.995 | 0.615 | 0.572 | 66.1 |
| Soil cover | | 0.826 | 0.528 | 0.326 | 0.271 | 35.2 |
| Interaction | | 2.628 | 1.682 | 1.039 | 0.864 | 112.3 |

* BP – black plastic, WP – white plastic; the level of the component in the fresh weight (FW) of fruit flesh

study was homogenous in terms of material and only differed in color.

Sucrose accumulation is controlled by several hormones and enzymes as well as it depends quantitatively on environmental and physiological factors. Nũnez-Palenius et al. [2008] report that among 14 genotypes classified as *cantaloupensis*, the total sugar content ranged from 40 to 100 mg·g FW, while sucrose accounted for 50–70% of total sugars, though several genotypes showed lower levels. The values characteristic for the melon cultivars examined in the present study were within a similar range: 4.74–6.52% FW of total sugars and 2.78–4.10% of reducing sugars (Tab. 6). Fruits of plants grown on white plastic mulch accumulated more total sugars and soluble sugars than other plants.

L-ascorbic acid and carotenoids are included in the group of antioxidants with a synergistic effect. They are capable of capturing oxygen and chelating ions participating in radical formation [Moise et al. 2014]. Their presence in plant products has significant health-promoting value. Melon fruits analyzed in this study were found to have a high L-ascorbic acid and carotenoid content, respectively 6.32–14.92 $mg \cdot 100\ g^{-1}$ and 467–792 $\mu g \cdot 100\ g^{-1}$ (Tab. 6). Among the cultivars studied, Seledyn $F_1$ showed the highest L-ascorbic acid content (14.92 $mg \cdot 100g^{-1}$), while Emir $F_1$ and Junior $F_1$ had the highest carotenoid content (respectively 792 and 762 $\mu g \cdot 100\ g^{-1}$). Our results exceed most of the results found in the study by Fergany et al. [2011] where the total carotenoid content ranged from 30.8 to 146.3 $\mu g \cdot 100\ g^{-1}$ of the fruit flesh weight, while L-ascorbic acid ranged between 1.4 and 9.0 $mg \cdot 100\ g^{-1}$ of the weight of the fresh melon fruit. Fergany et al. [2011] noted a correlation between melon botanical groups, fruit color, carotenoid content, and simple sequence repeats (SSRs). These authors classify melon varieties as follows: the *acidulus* group with white flesh, a lower carotenoid content, and belonging to SSRs A and B; and the *momordica* group with orange flesh, a higher carotenoid content, and belonging to SSRs C and D. This is in agreement with our results which show that the cultivars Emir $F_1$ and Junior $F_1$ with orange color of the fruit flesh contain more carotenoids than the other ones with lighter flesh.

When analyzing the level of antioxidants, L-ascorbic acid and carotenoids, in fruits of melon grown on white and black plastic mulch, we demonstrated that the latter type of mulch contributed to an increased content of both components (Tab. 6). This confirms the results of other authors. Antonious and Kasperbauer [2002] found that the use of yellow and white mulches resulted in a higher content of beta-carotene and L-ascorbic acid in carrot compared to other colored mulches and without soil mulching. A study by Aliabadi et al. [2019] indicates that mulching used in tomato cultivation results in a higher level of L-ascorbic acid in fruits.

The mineral composition of melon fruits is presented in Table 7. Fruits of the studied cultivars were shown to have a varying level of phosphorus, potassium, calcium, magnesium, and iron, which was also affected by the mulches used (except for potassium, calcium, and magnesium). Similar results were obtained by Majkowska-Gadomska [2009]. Fergany et al. [2011] report that melon fruit weight is positively correlated with fruit Fe content, but it is not significant for K, P, and Zn concentrations. In this study, the cultivars Emir $F_1$ and Junior $F_1$ were characterized by the highest fruit weight, but the level of iron proved to be highest in cv. Emir $F_1$. Kołota and Balbierz [2015] report that soil mulching with black plastic film and black agrotextile increases the total and marketable yield of pattypan squash, but does not affect the fruit chemical composition. In our study, fruits of melon grown on white plastic accumulated more dry matter

**Table 7.** The mineral composition of melon fruit (means for 2015–2016)

| Cultivar | Mulch | Dry matter (%) | P | K | Ca | Mg | Fe |
|---|---|---|---|---|---|---|---|
| | | | $g \cdot kg^{-1}$ FW | | | | $mg \cdot kg^{-1}$ FW |
| Emir $F_1$ | BP* | 6.51 | 1.49 | 29.0 | 1.63 | 1.28 | 59.1 |
| | WP | 8.52 | 2.27 | 22.0 | 1.67 | 1.24 | 33.9 |
| | Mean | 7.52 | 1.88 | 25.5 | 1.65 | 1.26 | 46.5 |
| Junior $F_1$ | BP | 6.44 | 1.45 | 19.8 | 0.91 | 1.05 | 16.2 |
| | WP | 7.03 | 1.57 | 25.1 | 1.13 | 1.21 | 28.1 |
| | Mean | 6.74 | 1.51 | 22.4 | 1.02 | 1.13 | 22.1 |
| Seledyn $F_1$ | BP | 5.02 | 1.68 | 24.4 | 1.07 | 1.11 | 26.9 |
| | WP | 6.18 | 1.77 | 34.3 | 1.21 | 1.23 | 27.7 |
| | Mean | 5.60 | 1.72 | 29.3 | 1.14 | 1.17 | 27.3 |
| 61/2014 | BP | 5.67 | 1.93 | 28.3 | 1.17 | 1.47 | 31.2 |
| | WP | 8.25 | 2.07 | 23.4 | 0.91 | 1.12 | 29.5 |
| | Mean | 6.96 | 2.00 | 25.8 | 1.04 | 1.29 | 30.3 |
| Mean | BP | 5.89 | 1.64 | 25.4 | 1.19 | 1.23 | 33.3 |
| | WP | 7.49 | 1.92 | 26.2 | 1.23 | 1.20 | 29.8 |
| | Mean | 6.69 | 1.78 | 25.8 | 1.21 | 1.21 | 31.5 |
| $LSD_{0.05}$ | | | | | | | |
| Cultivar | | 0.605 | 0.35 | 2.61 | 0.286 | 0.237 | 3.09 |
| Mulch | | 0.321 | 0.19 | n. s. | n. s. | n. s. | 1.64 |
| Interaction | | 1.022 | 0.59 | 4.40 | 0.483 | 0.401 | 5.23 |

* BP – black plastic, WP – white plastic; the level of nutrients in the fresh weight (FW) of fruit flesh
n.s. – no statistically significant difference

and phosphorus than those grown on black plastic. Díaz-Pérez [2010], in turn, reports that the concentration of minerals in pepper leaves and fruits did not exhibit any response to mulch in autumn, whereas in spring some nutrients differed depending on mulching application.

Vegetable growers use plastic film mulches to heat soil, to reduce weed infestation, and to maintain optimal soil moisture content. The effectiveness of mulching depends to the greatest extent on environmental conditions and the crop plant species/cultivar. Under temperate climate conditions, the selection of the optimal color of plastic film depends on summer temperature. Siwek et al. [2007] proved that black mulches, followed by white and transparent ones, have the most beneficial effect on yield of leafy vegetables under temperate climate conditions. A study by Adamczewska-Sowińska et al. [2016] reveals that soil mulching with black or transparent polyethylene plastic film, after prior herbicide application, is a beneficial agronomic practice that significantly increases eggplant fruit yield. The results of our study are in agreement with the results of Díaz-Pérez [2010] which indicate that black mulches increase root zone temperature compared to white or silver mulches because they have a greater ability to absorb a larger amount of incoming infrared radiation.

## CONCLUSIONS

To sum up, plastic film mulches significantly affected the microenvironment, growth, and fruiting of melon plants. Throughout the entire growing season, black PE plastic mulching was found to have a much more beneficial effect on soil temperature compared to soil covered with the white side of the plastic film and unmulched soil. The use of black plastic contributed to a significant increase in marketable yield of melon fruits. The content of L-ascorbic acid and carotenoids in fruits of melon grown on white mulch proved to be higher than in those grown on black mulch. The Polish cultivars studied can be considered as tolerant to temperate climate conditions. The breeding line 61/2014 stood out in terms of number of fruits produced, the cultivar Seledyn $F_1$ was characterized by the highest L-ascorbic acid content in its fruits, while Emir $F_1$ and Junior $F_1$ showed the highest fruit carotenoid content.

## REFERENCES

Adamczewska-Sowińska, K., Krygier, M., Turczuk, J. (2016). The yield of eggplant depending on climate conditions and mulching. Folia Hort., 28(1), 19–24. DOI: 10.1515/fhort-2016-0003

Alagar Raja, M., Sahithi, G., Vasanthi, R, Banji, D., Rao, K.N.V., Selvakumar, D. (2015). Study of phytochemical and antioxidant activity of *Cucumis melo* var. *agrestis* fruit. J. Pharm. Phytochem., 4(2), 303–306.

Aliabadi, B.T., Hassandokht M.R., Etesami, H., Alikhani, H.A. Dehghanisanij, H. (2019). Effect of mulching on some characteristics of tomato (*Lycopersicon esculentum* Mill.) under deficit irrigation. J. Agr. Sci. Tech., 21(4), 927–941.

Antonious, G.F., Kasperbauer, M.J. (2002). Color of light reflected to leaves modifies nutrient content of carrot roots. Crop Sci., 42, 1211–1216.

Ban, D., Goreta, S., Borošić, J. (2006). Plant spacing and cultivar affect melon growth and yield components. Sci. Hortic., 109, 238–243. DOI:10.1016/j.scienta.2006.04.015

Burger, Y., Sa'ar, U., Distelfeld, A., Katzir, N., Yeselson, Y., Shen, S., Schaffer, A.A. (2003). Development of sweet melon (*Cucumis melo*) genotypes combining high sucrose and organic acid content. J. Amer. Soc. Hort. Sci., 128(4), 537–540.

Castellanos, M.T., Cabello, M.J., Cartagena, M.C., Tarquis, A.M., Arce, A., Ribas, F. (2011). Growth dynamics and yield of melon as influenced by nitrogen fertilizer. Sci. Agric. (Piracicaba, Braz.), 68(2), 191–199.

Chanson-Rolle, A., Braesco V., Chupin, J., Bouillot, L. (2016). Nutritional composition of orange juice: a comparative study between french commercial and homemade juices. Food Nutr. Sci., 7, 252–261. DOI: doi.org/10.4236/fns.2016.74027

Díaz-Pérez, J.C. (2010). Bell pepper (*Capsicum annum* L.) grown on plastic film mulches: Effects on crop microenvironment, physiological attributes, and fruit yield. Hort. Sci., 45(8), 1196–1204.

Dogan, E., Kirnak, Ć.H., Berekatoglu, Ć.K., Bilgel, Ć.L., Surucu, Ć.A. (2008). Water stress imposed on muskmelon (*Cucumis melo* L.) with subsurface and surface drip irrigation systems under semi-arid climatic conditions. Irrig. Sci., 26, 131–138. DOI: 10.1007/s00271-007-0079-7

Domagała-Świątkiewicz, I., Siwek, P. (2015). Effect of biodegradable mulching on soil quality in stenotermal vegetable crop production. Proc. ECOpole, 9(2), 425–439. DOI: 10.2429/proc.2015.9(2)050

El-Din Ibrahim, M.E., El-Masry, H.G (2016). Phenolic Content and antioxidant activity of cantaloupe (*Cu-*

*cumis melo var. cantalupensis*) and food application. Int. J. Nutr. Food Sci., 5(1), 16–24. DOI: 10.11648/j.ijnfs.20160501.13

Fergany, M., Balvir Kaur, Monforte, A.J., Pitrat, M., Rys, C., Lecoq, H., Dhillon, N.P.S., Dhaliwal, S.S. (2011). Variation in melon (*Cucumis melo*) landraces adapter to the humid tropics of southern India. Genet. Resour. Crop. Evol., 58, 225–243. DOI: 10.1007/s10722-010-9564-6

Fergany, M., Kaur, B., Monforte, A.J., Pitrat, M., Rys, C., Lecoq, H., Dhillon, N.P.S., Dhaliwal, S.S. (2011). Variation in melon (*Cucumis melo*) landraces adapter to the humid tropics of southern India. Genet. Resour. Crop. Evol., 58, 225–243. DOI: 10.1007/s10722-010-9564-6

Franczuk, J., Rosa, R., Kosterna-Kelle, E., Zaniewicz-Bajkowska, A., Panasz, M. (2017). The effect of transplanting date and covering on the growth and development of melon (*Cucumis melo* L.). Acta Agrobot., 70(2), 1699. DOI: 10.5586/aa.1699

Garcia-Mas, J., Benjak, A., Sanseverino, W., Bourgeois, M., Mir, G., González, V. M., Hénaff, E., Câmara, F., Cozzuto, L., Lowy, E., Alioto, T., Capella-Gutiérrez, S., Blanca, J., Cañizares, J., Ziarsolo, P., Gonzalez-Ibeas, D., Rodríguez-Moreno, L., Droege, M., Du, L., Alvarez-Tejado, M., Lorente-Galdos, B., Melé, M., Yang, L., Weng, Y., Navarro, A., Marques-Bonet, T., Aranda, M.A., Nuez, F., Picó, B., Gabaldón, T., Roma, G., Guigó, R., Casacuberta, J.M., Arús, P., Puigdomènech, P. (2012). The genome of melon (*Cucumis melo* L.). PNAS, 109(29), 11872–11877.

Grzelakowska, A., Cieślewicz, J., Łudzińska, M. (2013).The dynamics of vitamin c content in fresh and processed cucumber (*Cucumis sativus* L.). Chem. Didact. Ecol. Metrol., 18(1–2), 97–102. DOI: 10.2478/cdem-2013-0022

Kasirajan, S., Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: a review. Agron. Sustain. Dev., 32, 501–529. DOI: 10.1007/s13593-011-0068-3.

Kołota, E., Balbierz, A. (2015). Yield potential and fruit quality of scallop squash (*Cucurbita pepo* L. var. *patissonina* Greb. f. *radiata* Nois.) cultivars grown for processing. Acta Agrobot., 68(3), 261–266. DOI: 10.5586/aa.2015.030

Koubala, B.B., Bassang'na, G., Yapo, B.M., Raihanatou, R. (2016). Morphological and biochemical changes during muskmelon (*Cucumis melo* var. Tibish) fruit maturation. J. Food Nutr. Sci., 4(1), 18–28. DOI: 10.11648/j.jfns.20160401.14

Krarup, C., Jacob, C., Contreras, S. (2016). Pre- and postharvest attributes of muskmelon cultivars for fresh-cut cubes. Cien. Inv. Agr., 43(1), 43–51. DOI: 10.4067/S0718-16202016000100004

Krełowska-Kułas, M. (1993). Badanie jakości produktów spożywczych. PWE, Warszawa.

Liu, L., Kakihara, F., Kato, M. (2004). Characterization of six varieties of *Cucumis melo* L. based on morphological and physiological characters, including shelf-life of fruit. Euphytica, 135, 305–313.

Long, R.L., Walsh, K.B., Midmore, D.J (2006). Irrigation scheduling to increase muskmelon fruit biomass and soluble solids concentration. Hort. Sci., 41(2), 367–369. DOI: 10.21273/HORTSCI.41.2.367

Maboko, M.M., Du Plooy, C.P., Sithole, M.A., Mbave, A. (2017). Swiss chard (*Beta vulgaris* L.) water use efficiency and yield under organic and inorganic mulch application. J. Agr. Sci. Tech., 19, 1345–1354.

Magwaza, L.S., Opara, U.L. (2015). Analytical methods for determination of sugars and sweetness of horticultural products – A review. Sci. Hortic., 184, 179–192.

Majkowska-Gadomska, J. (2009). Mineral content of melon fruit (*Cucumis melo* L.). J. Elementol. 14(4), 717–727.

Malik, A.A., Vashisht, V.K., Singh., K., Sharma., A.D., Singh, K., Singh, H., Monforte, A.J., McCreight, J.D., Dhillon Received, N.P.S. (2014). Diversity among melon (*Cucumis melo* L.) landraces from the Indo-Gangetic plains of India and their genetic relationship with USA melon cultivars. Genet. Resour. Crop Evol., 61, 1189–1208. DOI: 10.1007/s10722-014-0101-x

Moise, A.R., Al-Babili S., Wurtzel, E.T. (2014). Mechanistic aspects of carotenoid biosynthesis. Chem. Rev., 114(1), 164–193. DOI: 10.1021/cr400106y

Nikolić, B., Radulović, M,. Spalević, V., Nenezić E., (2012). Mulching methods and their effects on the yield of tomato (*Lycopersicon esculentum*, Mill.) in the zeta plain. Agricult. Forest., 52. (1–4), 17–33.

Nũnez-Palenius, H.G., Gomez-Lim, M., Ochoa-Alejo, N. (2008). Melon fruits: genetic diversity, physiology, and biotechnology features. Crit. Rev. Biotechnol., 28, 13–55. DOI: 10.1080/07388550801891111

Ohashi, A., Al-Said, F.A., Khan, I.A. (2009). Evaluation of different muskmelon (*Cucumis melo*) cultivars and production systems in oman. Int. J. Agric. Biol., 11(5), 596–600.

Pavan, S., Marcotrigiano, A.R., Ciani, E., Mazzeo, R., Zonno, V., Ruggieri, V., Lotti, C., Ricciardi, L. (2017). Genotyping-by-sequencing of a melon (Cucumis melo L.) germplasm collection from a secondary center of diversity highlights patterns of genetic variation and genomic features of different gene pools. BMC Genomics, 18(59). DOI: 10.1186/s12864-016-3429-0

Purquerio L.F.V., Filho, A.B.C., Barbosa, J.C. (2003). Efeito da concentração de nitrogênio na solução nutritiva e do número de frutos por planta sobre a produção do meloeiro. Hortic. Bras., 21(2), 185–190.

Rutkowska, U. (1981). Wybrane metody badania składu i wartości odżywczej żywności. Wyd. Lek. PZWL, Warszawa.

Siwek, P., Kalisz, A., Wojciechowska, R. (2007). Effect of mulching with film of different colours made from original and recycled polyethylene on the yield of butterhead lettuce and celery. Folia Hort. Ann., 19(1), 25–35.

Torres, C.A., Andrews, P.K. (2006). Developmental changes in antioxidant metabolites, enzymes, and pigments in fruit exocarp of four tomato (*Lycopersicon esculentum* Mill.) genotypes: β-carotene, high pigment-1, ripening inhibitor, and 'Rutgers'. Plant Physiol. Biochem., 44 (11–12), 806–818. https://doi.org/10.1016/j.plaphy.2006.09.013

Vella, F.M., Cautela, D., Laratta, B. (2019). Characterization of polyphenolic compounds in cantaloupe melon by-products. Foods, 8, 196. DOI: 10.3390/foods8060196

Yilmaz, H., Demircan, V., Kurtluk, S. (2011). An economic analysis of open-field melon (*Cucumis melo* L.) production in Cankiri province of Turkey. Bulg. J. Agric. Sci., 17(4), 484–490.

Ziernicka-Wojtaszek, A. (2009). Weryfikacja rolniczo-klimatycznych regionalizacji Polski w świetle współczesnych zmian klimatu. Acta Agrophys., 13(3), 803–812.