




Plastic soil covers in vegetative development, production and quality of strawberries

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ABSTRACT

The purpose this study was to evaluate the vegetative development, yield and quality of strawberry cultivars of short and neutral days as a function of soil cover. Two experiments were carried out in a protected environment. The experimental design used in both experiments consisted of randomized blocks, with subdivided plots. Harvests were carried out every two days, when the berries presented 75% of the red coloration of the epidermis, with evaluation of yield, number of fruits/plant, and fresh biomass of the fruits. For fruit quality, the pH, SS, titratable acidity, SS/TA ratio and fruit staining were evaluated. The contents of chlorophyll a and b, chlorophyll a + b and the chlorophyll a/b ratio in the leaves were also measured. At the end of the productive cycle, destructive evaluations of leaf number, leaf area and dry biomass of shoot were carried out. Cultivation on white PSC presented plants with lower vegetative development, higher yield, and fruit size. Among the cultivars of short days, Camino Real presented bigger and more attractive fruits regarding the appearance of color of epidermis. For neutral day cultivars, Aromas obtained higher yield.

Keywords: *Fragaria x ananassa* Duch.; mulching; small fruits.

INTRODUCTION

Strawberry cultivation in the Paraná State, Brazil, is mainly performed by small landowners and leaseholders, and the demand for labor is high, at 15 people/ha/year, being a source of income and an alternative for the maintenance of people in the farm. The main producing region is located in Curitiba and Jacarezinho counties, characterized by favorable climate and easy production and marketing (Ronque *et al.*, 2013).

The crop gains importance in other regions of Paraná State. Nevertheless, these producers often encounter difficulties, mainly due to the lack of information on the crop, management and choice of cultivars adapted to the conditions of the growing regions. This implies that producers fail to reach the production prospects, leading to economic losses and abandonment of the crops (Santin *et al.*, 2017; Dalla Rosa *et al.*, 2014).

The adaptability of the cultivar to a given region is expressed by the genotype-environment interaction, the latter being characterized mainly by temperature, photoperiod and soil, which determine fruit quality and productivity. The use of cultivars adapted to each region is a major factor for success in production (Oliveira e Scivittaro, 2011). Based on the plant response to these factors, the species are classified between short-day and day-neutral cultivars.

Short-day cultivars are temperature- and photoperiod-dependent, blooming when day length becomes less than 14 h and temperatures are below 25-26 °C. With the introduction of new cultivars with characteristics of neutral days or days insensitive to the photoperiod, it has become possible to produce strawberry in the periods considered as off-season, with the possibility of starting the crop outside the traditional period (Pereira *et al.*, 2013).

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In addition to the use of cultivars that are better suited to the region's conditions, some cultural techniques may assist in the productive performance of the crop, such as soil cover (Fan *et al.*, 2012), which promotes the reduction of water consumption by the plant, crop protection against soil erosion, and reduction of insect pests present in the soil, generating products of higher quality and with lower cost (Oliveira *et al.*, 2011).

Nevertheless, when the soil is covered, important parameters of the microclimate are also modified, such as soil temperature, whose amplitudes vary with the absorptivity and thermal conductivity of the material used in the cover (Yuri *et al.*, 2012), depending on the material used and the edaphoclimatic conditions of each region, which can promote the vegetative growth of the plants (Camargo *et al.*, 2010).

Considering the above, the objective of this study was to evaluate the vegetative development, yield and quality of strawberry short- and day-neutral cultivars as a function of soil cover, in Dois Vizinhos county, Paraná, Brazil.

MATERIAL AND METHODS

Due to the different arrival dates of the strawberry seedlings for planting, it was necessary to conduct two experiments, aiming to reduce the influence of the planting dates on the final result. The first experiment consisted of short-day strawberry cultivars (Camino Real and Camarosa) on white, black and silver soil cover (PSC), while the second experiment consisted of day-neutral cultivars (Monterey, Albion, San Andreas, Portola, and Aromas) on white, silver and black soil coverings.

The experiments were conducted in a private property, from May 2017 to January 2018, in an umbrella-like greenhouse, with the upper part in a simple arc format, covered with a low-density polyethylene transparent film of 150 μ (microns) and ceiling height of 2.5 m. The property is located in the Alto Empossado community, city of Dois Vizinhos, Paraná State, Brazil (25°49'46" S, 53°03'59" W and 610 m altitude).

The climate of the region, according to the Köppen classification, is a Cfa climate, subtropical humid, with no defined dry season, mean maximum temperature of 22 °C and mean minimum temperature of 15 °C and annual precipitation of 1800 mm (Alvares *et al.*, 2013). The predominant soil in the region is classified as Dystroferic Red LATOSOL (Bhering *et al.*, 2008).

Soil samples were collected prior to the preparation of the beds and installation of the experiments and later referred to chemical analysis of the mineral elements present in the soil. According to the results of the soil analysis (Table 1), there was no need for liming and cover fertilization with phosphorus and potassium.

The experimental design used in both experiments was randomized blocks, in a subdivided plot scheme, with the plots constituted by the white, silver and black plots in both experiments, with subplots divided by the short-day cultivars (Camino Real and Camarosa) in experiment I and day-neutral cultivars (Monterey, Albion, San Andreas, Portola, and Aromas) in experiment II. Each subplot was constituted by two lines and seven plants per line, totaling 14 plants per subplot and four replications per treatment.

The preparation of the beds was performed 20 days before the planting of the seedlings, with dimensions of 0.20 m in height, 1.8 m in width and 0.70 m in width per subplot. The strawberry seedlings were purchased from the company Bioagro®, of Chilean origin (agricultural nursery Llahuen). The seedlings of the short-day cultivars (experiment I) were transplanted on May 19, 2017, and the seedlings of the day-neutral cultivars (experiment II) were transplanted on different dates, due to the need for accumulation of chill hours to make the cultivars suitable for transplantation (cv. Monterey on May 23, cultivars Albion and San Andreas on June 12, and cultivars Aromas and Portola on June 27, 2017). All cultivars were planted in spacing 0.30 x 0.30 m.

Irrigation in the beds was performed by dripping with two strips (per plot) and emitters every 0.20 m, with a flow rate per emitter of 1.7 L h⁻¹, in order to obtain uniform wetness, according to the needs of the crop. Fertigation was performed every two weeks with the aid of a Venturi system, and the nutrient solution used was that described by Trani *et al.* (2011), according to the crop phase. The data relating to relative air humidity (RH%) and mean air temperature were obtained every fifteen minutes by datalogger (HTH-1302), installed in a shelter located at the center of the greenhouse where the experiment was conducted.

Soil covers were installed on the beds, 30 days after the transplanting of the seedlings, using low-density polyethylene in the white, silver and black colors, according to the respective treatments. In the course of the cultivation, monitoring of diseases and pests was carried out on a continual basis, sometimes requiring the use of chemical controls for the control of the common spot (*Mycosphaerella fragariae*) with the fungicide azoxystrobin, as well as control of mites using the acaricide abamectin, both at the doses recommended by the manufacturers for the crop.

The central plants were considered as a usable subplot, the first and last plants of each row being discarded, resulting in eight usable plants per experimental unit. For characterization of the flowering, they were considered usable when 50% or more of the plants presented flowers, in the same way for the beginning of

the harvest. Crops were harvested every two days, and fruits were harvested with roughly 75% of the red-colored epidermis.

At harvest, the fresh biomass of the fruits (g) was determined by experimental unit by means of a semi-analytical balance, as well as number of fruits produced per experimental unit by counting, and mean biomass of the fruits, calculated by the ratio between total biomass and number of total fruits per experimental unit. The values obtained at each harvest for fruit biomass and number of fruits were summed within each experimental unit and divided by the number of plants that constituted each experimental unit, thus obtaining yield (g/plant), number of fruits per plant, and fruit biomass (g/fruit).

The chemical evaluations were carried out at the Plant Physiology Laboratory of the Universidade Tecnológica Federal do Paraná (UTFPR), Dois Vizinhos *Campus*. For these evaluations, 10 fruits randomly selected by subplot were used, and the pH was evaluated by benchtop pH meter, as well as soluble solids (SS) using a digital refractometer (with results expressed in °Brix); titratable acidity (TA), by titration (with results expressed as a percentage of citric acid), according to the standards of the Adolfo Lutz Institute (Ial, 2008); SS/TA ratio; and coloring of the fruits by means of a digital colorimeter (Minolta Cr 200 b model), which included the determination of the 'l' values, varying from light to dark, with 100 corresponding to white and 0 (zero) to black and the 'c' component, which expresses the degree of chroma of the fruits, in which, according to the proposed classification, more colorful fruits present lower values and less colorful fruits.

Destructive evaluations, such as number of leaves per plant, leaf area (cm²) and dry shoot biomass (g), were performed at the end of the productive cycle. For these variables, three plants were used, after random selection in each subplot. The leaf area meter (CL-203 model laser area meter) was used to measure the leaf area and dry shoot biomass. The material was then taken to a forced air circulation oven with a temperature of approximately 45 °C until reaching constant mass.

The data were submitted to analysis of variance, with the means compared by the Tukey test at 5% error probability, using the statistical program SAS (Silva & Azevedo, 2009).

RESULTS AND DISCUSSION

Experiment I: short-day cultivars x plastic soil cover (PSC)

The variables analyzed did not show significant interaction between soil cover and cultivars. The cover colors did not show significant influence in the period of time that included transplanting until the flowering of the strawberry plants. Similarly, the cultivars did not present significant difference in the flowering (Table 2).

Table 2 shows that, for SH, the PSC had a significant influence in the period of time between transplanting to SH, whereas in black PSC, this period (in days) was lower when compared to white PSC. Among the cultivars, Camarosa presented a shorter period of time than Camino Real, with SH occurring two days prior. This difference in early harvest may be related to the genetics of the cultivar itself (Carvalho *et al.*, 2013).

Higher fruit yields was verified in white PSC, with 120 g more in fruits harvested in silver and black PSC, thereby representing a 17% higher yield. Regarding the cultivars, there was no significant difference for this variable, i.e., the yield in the municipality of Dois Vizinhos is the same irrespective of the short-day cultivar used. These yield values observed for both cultivars were smaller than those described by Carvalho *et al.* (2013), in Pelotas (RS), and larger those than reported by Pereira *et al.* (2013) in MG. These differences in yield can be related to the different climate conditions and soil in which the experiments were conducted.

In the climate factor, the temperature also influenced the yield of the cultivars. The mean temperature in the months of October to December in Dois Vizinhos was considered high, with low relative air humidity (Figure 1), hampering the productive development of the strawberries, in addition to causing the development of stolons. These results highlight the importance of previous studies in regions where strawberry cultivation is not yet widespread, as in the case of Dois Vizinhos.

For NFP, the PSC did not promote differences among cultivars. Nevertheless, the Camarosa cultivar presented a larger number, corroborating Shiukhy *et al.* (2015). For MFB, the cultivar Camino Real obtained fruits with higher biomass. Considering the importance of fruit size for marketing aspects and in light of the fact that small fruits do not present good commercial value, particularly when

Table 1: Soil chemical analysis of the experimental area

Depth (cm)	pH (CaCl ₂)	OM* g dm ⁻³	P mg dm ⁻³	Exchangeable cations (cmol _c dm ⁻³)						BS** (%)
				K ⁺	Mg ²⁺	Ca ²⁺	Al ³⁺	H + Al	CTC	
0-20	5.50	35.86	5.46	0.51	3.57	9.89	0.00	4.28	18.25	76.55

*OM = organic matter, **BS = base saturation.

marketed fresh, the choice for cultivars that present fruits with higher MFB and uniform fruits throughout the productive period is an important factor in the financial income of the crop.

Also in Table 2, it is observed that white PSC provided higher MFB when compared to black PSC. This result is explained by the different characteristics of the colors of the plastic soil cover in absorbing and reflecting the solar irradiation, in which the white color has the capacity to absorb less radiation and transmit less heat to the soil. The black color, in contrast, absorbs more radiation, transmitting more heat to the soil and increasing its temperature (Franquera & Mabesa, 2016). Plastic soil cover is a technology widely used by strawberry producers, as it helps reduce the temperature in the growing environment, allowing the plants express better their productive potential in regions with high temperatures (Kaur & Kaur, 2017).

Table 3 shows some chemical characteristics analyzed in strawberry fruits. For titratable acidity, SS/TA ratio and pH, no statistical differences were observed, neither due to PSC or to cultivars, i.e., for these analyzed variables, any PSC can be used for any cultivar.

The soluble solids (SS) content is a characteristic of great interest in fruits marketed fresh, as the consumer market tends to prefer sweet fruits with higher contents (Silva *et al.*, 2015). For PSC, SS did not present significant difference. With respect to the cultivars, Camarosa stood out when compared to Camino Real.

This superiority in SS for these cultivars was reported by Passos *et al.* (2015), in a study on the differentiation of cultivars in two different locations. Nevertheless, different results were presented by Pereira *et al.* (2013) in these crops in Maria da Fé and Inconfidentes counties, Minas Gerais state, Brazil. This SS difference is probably due to the adverse environmental conditions, insolation, and plant nutrition.

Table 4 presents the fruit coloration results, represented by luminosity (I) and color (c) of the fruit epidermis, NL, LA, and DSBM. The PSC did not present significant difference in color of the fruits, the use of any of the mentioned covers being possible.

Values below 29.24 indicate dark intense color fruits, being a desirable characteristic for consumers for fresh consumption, as well as for processing, as this coloration makes fruits more attractive to the eyes (Conti *et al.*, 2002).

Table 2: Flowering (FLW), start of harvest (SH), yield, number of fruits per plant (NFP) and fruit biomass (MFB) as a function of the PSC colors and strawberry cultivars (SCV)

PSC colors	FLW (days)	SH(days)	Yield (g plant ⁻¹)	NFP	BF (g)
White	65.00 a*	88.62 a	716.69 a	48.65 a	14.89 a
Silver	64.50 a	87.50 ab	596.39 b	43.27 a	13.90 ab
Black	63.50 a	86.50 b	596.30 b	44.99 a	13.50 b
SCV					
Camino Real	64.58 a	88.75 a	631.16 a	40.02 b	15.71 a
Camarosa	64.08 a	86.33 b	641.76 a	51.26 a	12.49 b
Averages	64.33	87.54	636.46	45.64	14.10
CVa (%)	2.48	1.49	18.74	14.30	5.34
CVb (%)	1.42	2.59	10.68	8.56	3.39

*Mean values followed by the same lowercase letter on the column do not differ statistically from each other by the Tukey test at 5% error probability.

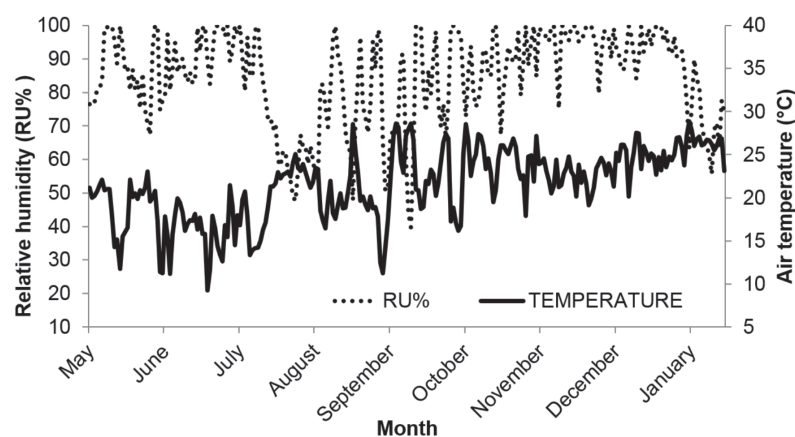


Figure 1: Relative air humidity (%) and mean temperature observed in the experimental area, from May 2017 to January 2018.

According to the same author, fruits with coloration below 36.08 mean little colored fruits, and this experiment presented values above 38.

Among the cultivars, cv. Camarosa presented an epidermis with greater luminosity and darker coloration than cv. Camino Real. Considering the importance of the external aspect of the fruit in marketing, mainly fresh, cv. Camarosa presents more attractive fruits for marketing, as already reported by Oliveira *et al.* (2011).

In the NL, LA and DSBM evaluations performed at the end of the productive cycle, the results of Table 4 demonstrate lower vegetative development of the plants under white PSC, when compared to silver and black PSC. Thus, it can be inferred that, because white PSC absorbs less solar radiation, it generates less heat transmitted to the soil, causing the plants to present lesser vegetative growth.

In addition to the PSC factor, the strawberry cultivar tends to present greater vegetative growth and emit stolons under high temperature conditions, consequently decreasing yield, in particular among short-day cultivars,

which are more sensitive to these conditions (Strassburger *et al.*, 2010). Thus, the use of soil cover materials such as white PSC is an alternative to help reduce soil temperature and favor the reproductive development of strawberry, particularly in regions of subtropical climate, where temperatures in the production months are high.

Experiment II: day-neutral cultivars x plastic soil cover (PSC)

Table 5 shows the results for flowering (FLW), start of harvest (SH), yield, mean number of fruits per plant (NFP) and mean fruit biomass (MFB) as a function of the PSC colors and strawberry cultivars (SCV). In general, these analyzed variables showed no significant interaction between the PSC's and cultivars. For FLW, SH, NFP and MFB, the results found did not indicate significant differences for PSC.

Notwithstanding, cv. Monterey presented a longer vegetative period between transplantation and flowering and, subsequently, between transplantation and start of harvest. On the other hand, cultivars Aromas and Portola

Table 3: Titratable acidity (AT), soluble solids (SS), SS/TA ratio and pH as a function of the PSC colors and strawberry cultivars (SCV)

PSC colors	TA (%)	SS (°Brix)	SS/AT	pH
White	1.09 a*	6.01 a	5.58 a	3.41 a
Silver	1.11 a	5.97 a	5.44 a	3.39 a
Black	1.06 a	5.66 a	5.38 a	3.41 a
SCV				
Camino Real	1.09 a	5.64 b	5.23 a	3.43 a
Camarosa	1.08 a	6.12 a	5.70 a	3.38 a
Averages	1.09	5.88	5.47	3.41
Cva(%)	8.00	5.03	8.64	1.06
CVb(%)	14.90	5.57	16.65	1.85

*Mean values followed by the same lowercase letter on the column do not differ statistically from each other by the Tukey test at 5% error probability.

Table 4: Luminosity (l), coloring (c), number of leaves (NL), leaf area (LA) and dry shoot biomass (DSB) as a function of the PSC colors and strawberry cultivars (SCV)

PSC colors	Luminosity 'l'	Coloring 'c'	NL	LA(cm ²)	DSB (g)
White	27.82 a	40.30 a	47.25 b	4463.53 b	54.88 b
Silver	27.47 a	39.11 a	60.54 a	5526.39 a	68.45 a
Black	28.09 a	39.91 a	65.25 a	6098.73 a	70.99 a
SCV					
Camino Real	26.97 b	38.58 b	52.97 b	4547.85 b	60.14 b
Camarosa	28.62 a	40.97 a	62.39 a	6177.92 a	69.40 a
Averages	27.79	39.78	57.68	5362.88	64.77
Cva(%)	3.57	3.87	11.25	11.36	13.10
CVb(%)	3.81	2.39	10.70	17.62	11.47

*Mean values followed by the same lowercase letter on the column do not differ statistically from each other by the Tukey test at 5% error probability.

had a shorter vegetative period, differing statistically from Albion and San Andreas, which presented intermediate values. The day-neutral cultivars have the ability to emit flowers, regardless of the photoperiod and temperature (Ali & Radwan, 2008) but have direct interference in their phenology due to genotype, environmental factors, and seedling quality (Rosa *et al.*, 2013).

The fact that cv. Monterey was the first cultivar to be transplanted in May made its vegetative period longer than in other cultivars, which were transplanted in June. This difference in the transplantation period is due to the fact that the cultivars present different needs in the terms of chilling hours for floral induction, being sent to producers only when they reach the stipulated need for each genotype.

For the production of fruits, white PSC was superior to black PSC, presenting higher yield by 20% (160 g per plant, as seen in Table 5), similar to experiment I, with short-day cultivars (Table 2). These results are explained by the fact that white PSC provides greater reflected radiation and, consequently, lower radiation transmitted to the soil, directly influencing soil temperature, especially in the more superficial layers (Sener & Türemis, 2017).

Regarding the cultivars, Aromas presented statistically higher yields than the other cultivars studied and, for NFP, did not differ statistically from cv. Portola. Aromas, which presented high NFP. This ability to produce a large number of fruits per plant with high biomass resulted in Aromas obtaining higher yields than the other cultivars. Strawberry production is directly related to the number of fruits per plant and the biomass of the fruits, which, in addition to defining crop productivity, comprise important parameters in fruit quality.

Radin *et al.* (2011), when studying cultivars Aromas, Tudla, Camarosa and Oso Grande in two regions of Rio Grande do Sul state, Brazil, observed a better yield potential for Aromas when compared to the others. In general, cv. Aromas obtained higher yield than that found by Pereira *et al.* (2013) for the same cultivar. The success and potentiation of production depends on the use of the most suitable cultivar for the conditions of each region (Costa *et al.*, 2015).

Also in Table 5, it can be verified that MFB did not present significant difference for PSC. Regarding the cultivars, Portola obtained lower values in relation to the other cultivars, presenting small fruits, with a mean mass of 10.62 g. This result is unsatisfactory, especially when the fresh marketing of these fruits is desired.

Some chemical characteristics of the fruit and the color of the fruits, represented by luminosity and coloring of the fruit epidermis, are presented in Table 6. The PSC did not present a significant difference in all analyzed variables, i.e. The different PSC colors did not influence fruit quality characteristics.

For TA and SS/TA ratio, the cultivars did not differ statistically from one another. For SS, cultivar Albion was superior to cultivars San Andreas, Aromas and Portola, not differing from cultivar Monterey. Pereira *et al.* (2013), when studying strawberry cultivars in two regions of Minas Gerais found values of 7.03 °Brix for Albion and 5.66 °Brix for Aromas, close to those presented in this study. The same authors claim that the variation in the SS content is mainly related to cultivar, stage of maturation, and climate. The pH of cultivar Monterey differed only from San Andreas, with values of 3.56 and 3.43, respectively, and the other cultivars did not differ statistically from one another.

Table 5: Flowering (FLW), start of harvest (SH), yield, mean number of fruits per plant (NFP) and mean fruit biomass (MFB) as a function of the strawberry cultivars (SCV) and PSC

PSC colors	FLW (days)	SH(days)	Yield (g planta ⁻¹)	NFP	MFB (g)
White	45.27 a*	70.27 a	793.04 a	55.94 a	14.46 a
Silver	44.33 a	69.87 a	685.99 ab	50.72 a	13.69 a
Black	44.87 a	70.47 a	633.12 b	46.59 a	13.92 a
SCV					
Monterey	60.22 a	89.22 a	675.23 b	46.01 b	14.61 a
Albion	47.33 b	74.11 b	597.68 b	37.94 b	15.73 a
San Andreas	49.00 b	70.89 b	657.64 b	46.33 b	14.20 a
Aromas	31.55 c	56.22 d	892.06 a	59.63 a	14.95 a
Portola	36.00 c	60.55 c	697.62 b	65.51 a	10.62 b
Averages	44.82	70.20	704.05	51.08	14.02
CVa (%)	11.74	8.17	17.51	17.54	7.42
CVb (%)	11.11	4.31	15.82	13.23	8.12

*Mean values followed by the same lowercase letter on the column do not differ statistically from each other by the Tukey test at 5% error probability.

In the colorimetric variables, cv. San Andreas presented lighter characteristics (luminosity *l*) when compared to Albion. In contrast, cultivars Monterey and Portola presented darker coloration than the others, according to the classification described by Conti *et al.* (2002). For coloration *c*, cultivars Albion and Monterey showed more colorful fruits than the others.

This can be explained by the fact that these fruit pigments require luminosity and, during the period in which the experiment was carried out, there was a predominance of cloudy and rainy days, and in addition to the decreased solar radiation, the relative humidity of the air (%) remained high for most of the growing period, mainly in the productive period, from August to December (Figure 1). Thus, the colorimetric variables negatively influence components of flavor, such as SS, TA and SS/TA, as presented in Table 6.

The values of chlorophyll a, chlorophyll b, chlorophyll a + b, chlorophyll a/b ratio and number of leaves plant⁻¹ (NL) did not show a significant difference for the PSC (Table 7). For the cultivars, the concentration of chlorophyll a in leaves was higher for cv. San Andreas when compared to Monterey.

San Andreas presented higher results than the other cultivars, due to the chlorophyll a/b ratio, possibly with the characteristic of the cultivar, because the evaluations of color and luminosity of the fruit showed that this cultivar also stood out compared to the others. In the chlorophyll a/b ratio, cultivar Monterey was superior to the other cultivars. This superiority in the relationship is explained by the fact that cv. Monterey presented a low value of chlorophyll b, which in turn, influences the chlorophyll a/b ratio.

Table 7 also shows that the number of leaves per plant (NL) was quite variable, according to each cultivar. This

characteristic is a genetic factor presented by each cultivar, being evidenced in the leaf area (LA). Even with the differences presented in NL, when the LA was evaluated, no significant difference was observed, i.e., the plants presented LA from 2404.03 to 2841.98 cm². The LA and DSB of the plants in the white PSC presented lower values when compared to the silver PSC. Being a creeping plant, strawberry presents an underdeveloped stem with foliar biomass representing practically the entire shoot of the plant. The plastic soil cover directly influences the vegetative development of the strawberry, as reported by Shiukhy *et al.* (2015).

Casierra-Posada *et al.* (2011), in studies in Colombia, found lower LA for strawberry cultivars when using silver PSC. This difference in results is mainly due to the adverse edaphic climatic conditions of the region where the study was conducted, such as mean temperatures of 13 °C, low luminosity and altitude 2,500 m above sea level. The silver PSC reflects more sunlight and absorbs less energy, lowering the temperature of the soil. When this occurs, under milder conditions, such as those of Colombia, there is a decrease in the microbiological activity of the soil, affecting the development of the strawberries.

With the implementation of this study, it is possible to consider a significant production achieved with the studied cultivars, with considerable gain with the use of white PSC. Considering the good economic value of the crop and its characteristic for production by family farming, which often makes use of knowledge of crops in other producing regions, which sometimes are not more suitable for those conditions, or even the empirical knowledge on cultivation. Future studies should be conducted, aiming at the improvement and innovation of cultivation practices and methods targeted at the southwest region of Paraná, Brazil.

Table 6: Titratable acidity (TA), soluble solids (SS), SS/TA ratio, pH, luminosity of the epidermis (*l*), epidermal coloration (*c*), as a function of the strawberry cultivars and PSC

PSC colors	AT (%)	SS (°Brix)	SS/AT	pH	Luminosity 'l'	Coloration 'c'
White	1.15 a*	6.38 a	5.59 a	3.46 a	37.71 a	44.50 a
Silver	1.03 a	6.63 a	6.35 a	3.47 a	37.29 a	44.16 a
Black	1.12 a	6.04 a	5.46 a	3.50 a	36.79 a	44.02 a
SCV						
Monterey	1.09 a	6.75 ab	6.23 a	3.56 a	36.13 cd	41.69 c
Albion	1.22 a	7.35 a	6.09 a	3.47 ab	34.95 d	40.34 c
San Andreas	1.03 a	6.04 bc	6.03 a	3.43 b	39.28 a	47.50 a
Aromas	1.11 a	5.51 c	5.00 a	3.45 ab	38.49 ab	47.61 a
Portola	1.05 a	6.09 bc	5.65 a	3.47 ab	37.47 bc	44.01 b
Averages	1.10	6.35	5.80	3.48	37.26	44.23
Cva (%)	5.96	16.16	17.59	2.07	6.04	4.98
CVb (%)	13.17	13.26	17.65	2.37	2.85	3.29

*Mean values followed by the same lowercase letter on the column do not differ statistically from each other by the Tukey test at 5% error probability.

Table 7: Chlorophyll a (C a), chlorophyll b (C b), chlorophyll a + b (C a+b) and chlorophyll a/b ratio (C a/b), number of leaves (NL), leaf area (LA) and dry shoot biomass (DSB) as a function of the strawberry cultivars and PSC

PSC colors	C a**	C b	C a+b	C a/b	NF	LA(cm ²)	DSB (g)
White	44.67 a*	14.19 a	58.87 a	3.17 a	40.89 a	2263 b	46.81 b
Silver	44.03 a	13.07 a	57.09 a	3.39 a	49.31 a	2946 a	53.26 a
Black	43.60 a	13.15 a	56.75 a	3.35 a	48.87 a	2653 ab	49.26 ab
SCV							
Monterey	42.91 c	11.95 c	54.85 c	3.60 a	43.22 bc	2538 a	54.72 a
Albion	44.11 ab	13.63 b	57.74 b	3.24 bc	37.30 c	2404 a	49.51 a
San Andreas	45.06 a	14.85 a	59.92 a	3.05 c	52.63 a	2553 a	46.97 a
Aromas	44.50 ab	13.43 b	57.93 b	3.33 b	52.37 ab	2766 a	47.88 a
Portola	43.93 bc	13.48 b	57.41 b	3.27 bc	46.26 abc	2841 a	49.80 a
Averages	44.10	13.47	57.57	3.30	46.35	2620	49.78
Cva(%)	3.12	8.16	3.58	6.65	17.68	13.02	9.97
CVb(%)	1.71	6.12	2.35	5.04	14.47	17.13	14.92

*Mean values followed by the same lowercase letter on the column do not differ statistically from each other by the Tukey test at 5% error probability. **C a = chlorophyll a, C b = chlorophyll b, C a+b = chlorophyll a+b and C a/b = chlorophyll a/b ratio.

CONCLUSIONS

The cultivation under white PSC results in plants with lower vegetative development and greater yield and fruit size.

Among the short-day cultivars, Camino Real presented bigger and more attractive fruits in terms of appearance of epidermal color.

For day-neutral cultivars, Aromas obtained higher yield per plant, while Portola presented lower fruit biomass.

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