Research, Society and Development, v. 13, n. 3, e8313345247, 2024
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v13i3.45247

Selection of colored plastic-mulching films for the production of mini-tomatoes in the field

Seleção de filmes mulching-plásticos coloridos para a produção de minitomates a campo

Selección de películas plásticas de colores para la producción de mini tomates en el campo

Received: 02/29/2024 | Revised: 03/18/2024 | Accepted: 03/19/2024 | Published: 03/21/2024

Valdiney José da Silva
ORCID: https://orcid.org/0000-0002-2247-2493
Federal University of Uberlandia, Brazil
E-mail: neyjosilva@hotmail.com
Cláudio Ricardo da Silva
ORCID: https://orcid.org/0000-0003-4579-779X
Federal University of Uberlandia, Brazil
E-mail: cludio.ricardo@ufu.br
Roberto Terumi Atarassi
ORCID: https://orcid.org/0000-0002-2978-0050
Federal University of Uberlandia, Brazil
E-mail: robertota@ufu.br
Gabriel Mascarenas Maciel
ORCID: https://orcid.org/0000-0002-3004-9134
Federal University of Uberlandia, Brazil
E-mail: gabrielmaciel@ufu.br

Abstract
The objective of this research was to evaluate the effect of three plastic-mulching films of different colors in the cultivation of mini-tomato in the field. Two experiments were carried out: the first being sown in the summer and the second in the winter. Mini-tomatoes plants with distinct growing habit (determinate and indeterminate) were used and three plastic-mulching film color (black, black/silver, black/white) compared to control (uncovered soil) were tested. The design was in randomized blocks, 2x4 factorial schemes, with four repetitions. Soil temperature, productivity performance and quality of mini-tomatoes were determined. The plastic-mulching films increase the average soil temperature according to the color used. In summer, although small, the black/silver film improves the productive capacity of the mini-tomato with determined growth habit; however, none affects the total soluble solids content. In winter, the black plastic-mulching film favored the soluble solids content of both genotypes and the productivity of the indeterminate. The black plastic-mulching film is suggested as soil cover to produce mini-tomatoes in field conditions during the winter. In summer, low fruit yield quality can makes this technique unfeasible under field conditions.
Keywords: *Solanum lycopersicum*; Crop system; Microclimate; Soil temperature.

Resumo
O objetivo dessa pesquisa foi avaliar o efeito de três filmes de cobertura plástica de diferentes cores no cultivo de mini tomates a campo. Foram realizados dois experimentos: o primeiro conduzido no verão e o segundo no inverno. Utilizaram-se plantas de mini tomates com hábitos de crescimento distintos (um determinado e outro indeterminado) e testaram três cores de filmes plásticos (preto, preto/prata, preto/branco) comparados ao controle (solo descoberto). O delineamento foi em blocos casualizados, esquema fatorial 2x4, com quatro repetições. Foram determinados a temperatura do solo e o desempenho produtivo dos mini tomates. Os filmes de cobertura plástica aumentam a temperatura média do solo de acordo com a cor utilizada. No verão, apesar de baixa, o filme preto/prata melhora a produtividade de mini tomate das plantas de crescimento determinado; porém, nenhuma afeta o teor de sólidos solúveis totais. No inverno, o filme plástico preto favorece o teor de sólidos solúveis de ambos os híbridos e a produtividade do indeterminado. Sugere-se o filme plástico preto como cobertura de solo para produzir mini tomates a campo durante o inverno. No verão, baixa produção e qualidade dos frutos pode inviabilizar esta técnica em condições de campo.
Palavras-chave: *Solanum lycopersicum*; Sistema de cultivo; Microclima; Temperatura do solo.

Resumen
El objetivo de esta investigatión fue evaluar el efecto de tres películas plásticas de cobertura de diferentes colores en el cultivo de mini tomates en campo. Se realizaron dos experimentos: el primero en verano y el segundo en invierno. Se utilizaron miniplantas de tomate con diferentes hábitos de crecimiento (uno determinado y otro indeterminado) y

se probaron tres colores de películas plásticas (negro, negro/plateado, negro/blanco) en comparación con el control (suelo desnudo). El diseño fue en bloques al azar, esquema factorial 2x4, con cuatro repeticiones. Se determinó la temperatura del suelo y el comportamiento productivo de mini tomates. Las películas plásticas de cobertura aumentan la temperatura promedio del suelo dependiendo del color utilizado. En verano, a pesar de ser baja, la película negro/plateado mejora la productividad del minitomate en plantas de crecimiento determinado; sin embargo, ninguno afecta el contenido total de sólidos solubles. En invierno, la película plástica negra favorece el contenido de sólidos solubles de ambos híbridos y la productividad de los indeterminados. Se sugiere una película plástica negra como cobertura del suelo para producir mini tomates en el campo durante el invierno. En verano, la baja producción y calidad de los frutos pueden hacer que esta técnica sea inviable en condiciones de campo.
Palabras clave: *Solanum lycopersicum;* Sistema de cultivo; Microclima; Temperatura del suelo**.**

1. Introduction

The increased interest of consumers makes the cultivation of mini tomatoes an attractive option. However, in addition to the lack of cultural management research (Maciel *et al*., 2016), the cultivation predominates in greenhouse conditions (Araújo *et al*., 2016; Candian *et al*., 2017), which needs more initial investments.

The use of colored plastic-mulching films in field conditions can contribute to the development (Jayakumar *et al*., 2017), production (Decoteau *et al*., 1989) and quality (Kasperbauer *et al*., 2001; Shiukhy *et al*., 2015) of various crop cultures, as well as favors crops in places or periods less favorable (Bonachela *et al*., 2012). These responses are associated with changes in temperature (Díaz-Pérez, 2010), soil evaporation (Khan *et al*., 2016), quantity and quality of the radiation reflected (Decoteau *et al*., 1989), presence of weeds (Cirujeda *et al*., 2012), soil physical and chemical structure (Wang *et al*., 2017) and the efficiency of the use of nutrients (Filipović *et al*., 2016), among other aspects.

However, considering changes made by the plastic-mulching in the microclimate, its intensity depends on the film color and the predominant meteorological conditions (Steinmetz *et al*., 2016). Thus, the responses of plants may differ between locations, seasons and species or varieties (Díaz-Pérez, 2009; 2010). This variability can generate indecisions regarding the choice of the most suitable color to produce mini tomatoes.

In addition, there are only a few studies aiming to evaluate the agronomic performance of mini tomatoes in the field conditions. Thereby, the color effect of plastic-mulching films is still poorly understood. Yuri *et al*. (2016), in Pernambuco, Brazil, tested six cultivars in two crops and found yields that ranged from 17.7 to 40.3 and 43.9 to 104.0 Mg ha^{-1} in the rainy and dry season, respectively, but used only plastic silver-color film.

In this sense, the objective of this research was to evaluate the effect of three colors of plastic-mulching films on soil temperature, yield and quality of mini-tomatoes fruits in field conditions.

2. Methodology

2.1 Characterization of the experimental area

Two experiments were carried out in Uberlandia, Minas Gerais State (18°52'52" S, 48°20'32" W, 807 m), one in the summer and the other in the winter of 2017. According to the Köppen classification, the climate region is classified as tropical Aw, with dry and cold winter and rainy and hot summer, average annual precipitation of 1500 mm concentrated from December to February, annual air temperature ranging between 17 – 26 °C and annual relative air humidity of 70%.

The soil is a dystrophic Red Latosol with a very clayey texture and showed in the 0.2 m layer before the summer and winter experiments: pH (H_2O) = 4.9 and 5.5; $Pmeh^{-1}$ = 3.5 and 17.6 mg dm^{-3}; K = 129 and 230 mg dm^{-3}; organic matter = 3 and 2%; base saturation = 35 and 58%; Al = 2 and 0 cmolc dm^{-3}, H+Al = 4.2 and 3.4 cmolc dm^{-3}; K = 0.3 and 0.6 cmolc dm^{-3}; Ca = 1.3 and 3.0 cmolc dm^{-3}; Mg = 0.6 and 1.1 cmolc dm^{-3}, respectively.

The soil preparations consisted of plowing and raising beds. For the summer experiment, because of low soil fertility, the soil fertilization was performed 30 days before seedling transplanting, distributed on the surface of the growing beds in the

dose of 50 kg ha^{-1} N (urea), 900 kg ha^{-1} P_2O_5 (superphosphate), and 100 kg ha^{-1} K_2O (chloride potassium), mechanically incorporated. Before, was applied a reactive dolomitic limestone aiming to elevate the base saturation to 70%. For the winter experiment, the soil fertilization was made 20 days before the seedling transplant, distributed in the furrow of cultivation to approximately 0.1 m soil depth, at a dose of 50 kg ha^{-1} N (urea), 500 kg ha^{-1} P_2O_5 (superphosphate), and 100 kg ha^{-1} K_2O (chloride potassium) and 4 liters per linear meter of farmyard manure. The fertilization followed the recommendations for tomato cultivation (Alvarenga 2013) based on soil analysis.

2.2 Treatments and experimental design

In the summer experiment, two genotypes of mini tomatoes plants, one with determined (genotype A) and other with indeterminate (genotype B) growth habit, developed by the Genetic Improvement of Tomatoes Program of the Uberlandia Federal University (UFU), were used. In the winter experiment, the genotypes were substituted by the commercial hybrids Abirú (determined) and Bubble Candy (indeterminate). The three colors of plastic-mulching film were: film of polyethylene of low density of black coloration (Nortene, Sao Paulo/SP, Brazil), multilayer film of polyethylene bicolor black/silver (Mulch More, Polysack, Leme/SP, Brazil) and film of low-density polyethylene with additive biodegradable bicolor black/white (Negreira, Sao Paulo/SP, Brazil). For the two-color plastics, the silver and white side were exposed to solar radiation, respectively. Each experiment was conducted in a factorial design (2 x 4), being two cultivars of mini tomatoes and four soil coverings (three plastic-mulching film colors plus control/no cover) designed as randomized blocks with four replications.

The plastic-mulching films were installed over the soil surface with the lateral extremities buried at approximately 0.05 m in the soil surface. The longitudinal extremities were fixed with U-shape clamps of galvanized wire. Once installed, the plastic-mulching films were pierced in the spacing of cultivation using a PVC pipe with a serrated edge of 0.05 m in diameter.

The seedlings were produced in expanded polyethylene trays of 200 cells, filled with commercial substrate based on coconut fiber, kept in a greenhouse. Transplanting was carried out when the seedlings presented two leaflets fully formed and occurred on January 14, 2017 and August 23, 2017, in summer and winter experiments, respectively. The transplanting were made in six growing beds, with 16.8 m length, 1.2 m wide, and 0.2 m height. The spacing between the growing beds was 0.8 m. The plants were disposed in double rows spaced at 1.3 m and 0.7 m between the rows, in the growing beds, and within the growing beds, respectively. On the line, the spacing between plants was 0.3 m. Ten plants in the useful area (3.0 m^2) were evaluated from a total of 14 plants in each plot (4.2 m^2) (Figure 1).

Figure 1 - Illustrations of the experimental area and soil covers: experimental design (A), control (B), plastic-mulching black/white (C), plastic-mulching black/silver (D) and plastic-mulching black (E).

Source: Authors (2024).

The side dressing fertilization was subdivided into weekly applications according to culture development and recommendations by Alvarenga (2013). The plants were conducted in the absence of staking, pruning, or disbudding. Weeds were periodically grubbed up manually. The control of pests and diseases were done with products recommended for tomato crop through preventive or curative sprays, always rotating products with different active principles.

The plants were irrigated by an irrigation system composed of one line of drip tubes (XFS-04-12, Rain Bird, USA), with emitters spaced every 30 cm. The average flow by emitter at 0.25 MPa is 1.8 L h^{-1}, with distribution uniformity close to 95%. The management of irrigation was performed aiming to refit the crop evapotranspiration (ETc) considering the crop coefficient (Kc) of each phenological stage and the reference evapotranspiration (ETo), calculated by the Penman-Monteith method standardized by the FAO 56 (Allen *et al*. 1998). The meteorological data were obtained from an automatic weather

station (Vantage Pro 2, Davis, USA) placed in the center of the experimental area.

2.3 Soil temperatures

The soil temperature of each plot was recorded in intervals of 30 minutes during each experiment. The values were computed to represent the average per phase of the culture: vegetative (transplanting-flowering), flowering (flowering-first harvest), and fruiting (first-last harvest). The measurement was performed with thermometers of copper-constantan type, positioned at 0.05 m soil depth and in the center of each plot. To record and store data, an automatic collector (CR10X, Campbell, USA) was used to connect to a multiplexer with an outlet for 32 pairs of differential channels (AM16/32, Campbell, USA).

2.4 Mini tomatoes

At the end of each mini tomato crop cycle, the yield (kg m^{-2}), the average weight per fruit (g $fruit^{-1}$), and total soluble solids in fruits (°Brix) were evaluated. The yield was obtained by the sum of the weights of the fruits in the useful plot. The number of fruits per plant was determined by counting the fruits harvested in the plot, divided by the number of useful plants. The average weight per fruit was determined by calculating the ratio between total weight and number of fruits harvested in the plot. The content of total soluble solids was obtained by averaging the individual readings of five fruits per plot with a uniform degree of ripeness, with the aid of a portable refractometer (RT-30 ATC, Instrutherm, Sao Paulo/SP, Brazil).

2.5 Statistical analyses

The data were subjected to analysis of normality and homogeneity of variances by the Shapiro-Wilk and Levene tests, respectively. Answered the presuppositions, the analysis of variance (F test) was performed ($p < 0.05$), and when significant differences were observed among levels, the averages were compared by Tukey test ($p < 0.05$). Because of different materials of mini tomatoes, the statistical analyzes were separated: one for summer and one for winter.

3. Results and Discussion

Regardless of plant growth habit of mini tomato, the plastic-mulching films increased soil temperature in relation to the control (Table 1).

Table 1 - Average soil temperature (°C) under the plastic-mulching film at 0.05 m soil depth during the development phase of the mini tomatoes plants.

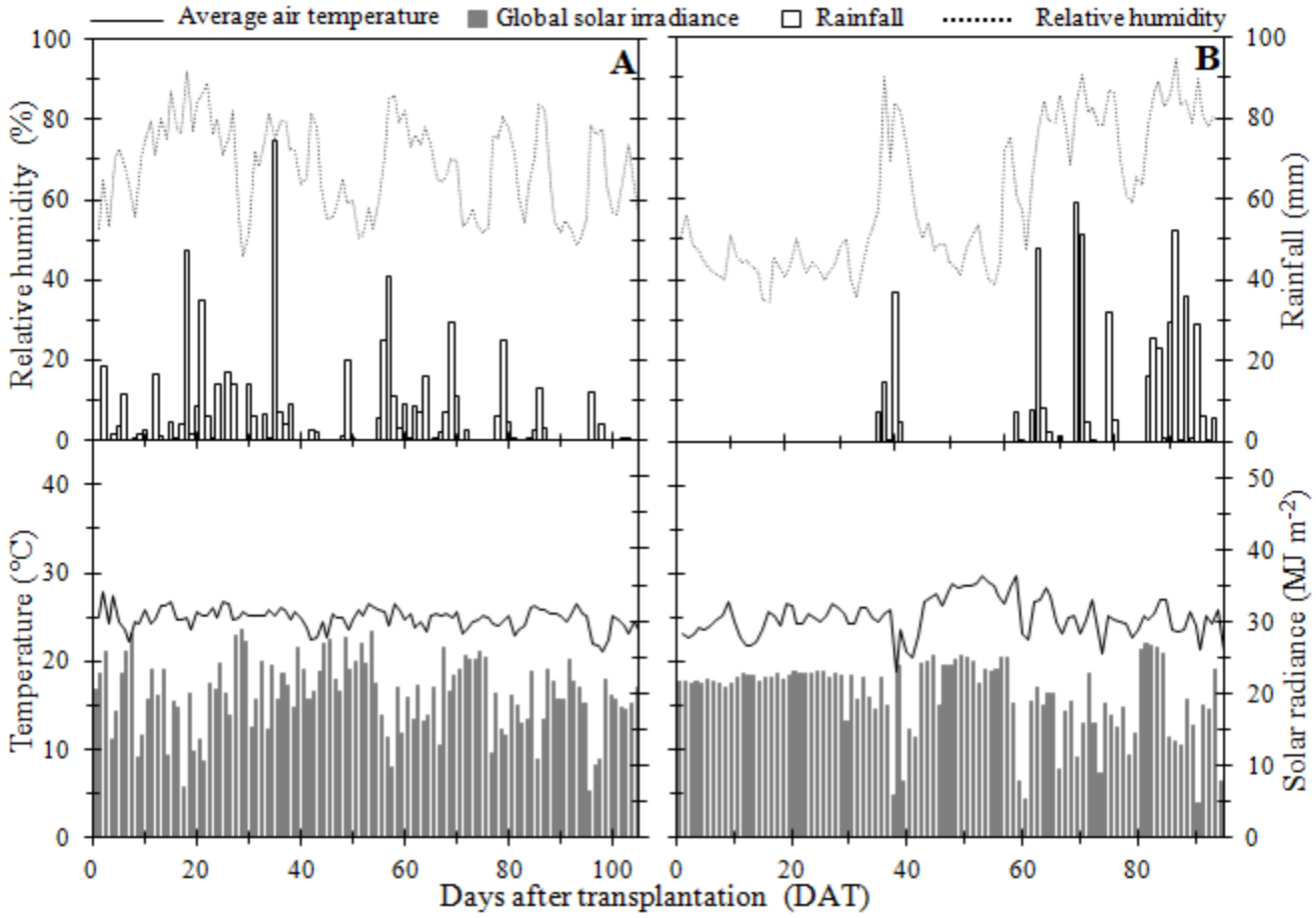
Plastic film	Summer			Winter		
	Initial	Medium	Final	Initial	Medium	Final
Control	27.4 a	27.1 a	26.1 a	26.4 a	24.9 a	24.2 a
Black/White	30.0 b	28.5 b	28.1 b	28.0 b	26.3 b	25.6 b
Black/Silver	33.1 c	30.8 c	29.2 c	30.3 c	26.8 c	25.8 bc
Black	32.9 c	31.3 c	29.6 c	31.1 d	27.1 c	25.9 c
CV (%)	1.68	3.52	2.43	1.24	1.20	0.98

Averages followed by different letters in the column differ by Tukey's test ($p < 0.05$). Source: Authors (2024).

This increase was higher in summer. Temperature values obtained in the plastic-mulching treatments were 1.4 to 5.5 °C and 1.4 to 4.7 °C higher than the control in summer and winter, respectively. The average value of the soil temperatures followed the order (highest to lowest): black, black/silver, black/white and control.

The global solar irradiance can have been the main factor responsible for the variation in temperature (Figure 2).

Figure 2 - Rainfall, global solar irradiance, relative humidity and average air temperature during the experiments in summer (A) and winter (B).

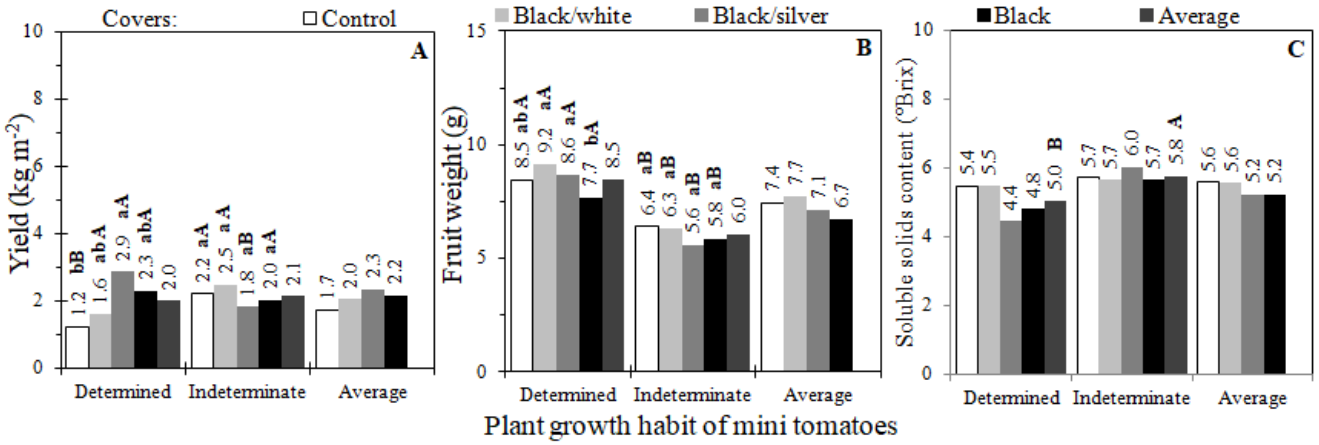


Source: Authors (2024).

In summer, great solar irradiance can have contributed to maximize the differences between the plastic-mulching films and in all of them, including the black/white, the soil temperature was higher than the control. Unlike this, for moderate climatic regions it is expected that the black plastic-mulching increases soil temperature while the white decrease it (Steinmetz *et al*., 2016).

The modifications in the soil temperature caused by plastic-mulching film may have favored the productive performance and quality of the mini tomatoes' plants, but the responses were distinct. In summer (genetic materials), the yield and weight per fruit (Figure 3) obtained on each plastic-mulching film depended on the growth habit.

Figure 3 - Yield (A), fruit weight (B) and total soluble solids (C) of mini tomatoes in plastic-mulching films in the summer of 2016/2017. Averages followed by different lowercase letters for plastic films within each growth habit and capitalized letters between growth habits for each plastic film differs by Tukey's test ($p < 0.05$).



Source: Authors (2024).

At this time, increased productivity only was obtained with the determined growth habit using the black/silver plastic-mulching film. This growth habit appears as an option to reduce costs and an alternative of cultivation to produce special sauces (Maciel *et al*., 2016).

On the other hand, neither plastic-mulching increased the yield of the indeterminate growth genotype. Bogiani *et al*. (2008), in Ilha Solteira, SP, evaluating the black and black/white plastic-mulching films also found no changes in productivity of this growth habit, contrasting with was expected due to greater energy conversion efficiency of reflective plastic-mulching (black/white).

Excesses of rainfall (Figure 2A) during entire summer experiment may be main reason why all treatments show low yield. Yuri *et al*. (2016) studying six cultivars of mini tomatoes using a black/silver plastic-mulching also obtained minor yield at this time of the year. Filgueira (2013) confirms low production and fruit quality of tomatoes in the rainy period due to hardship phytosanitary management. Among the growth habits, the indeterminate may have been more influenced by rainy conditions due to its greater leaf architecture, which made phytosanitary practices even more difficult.

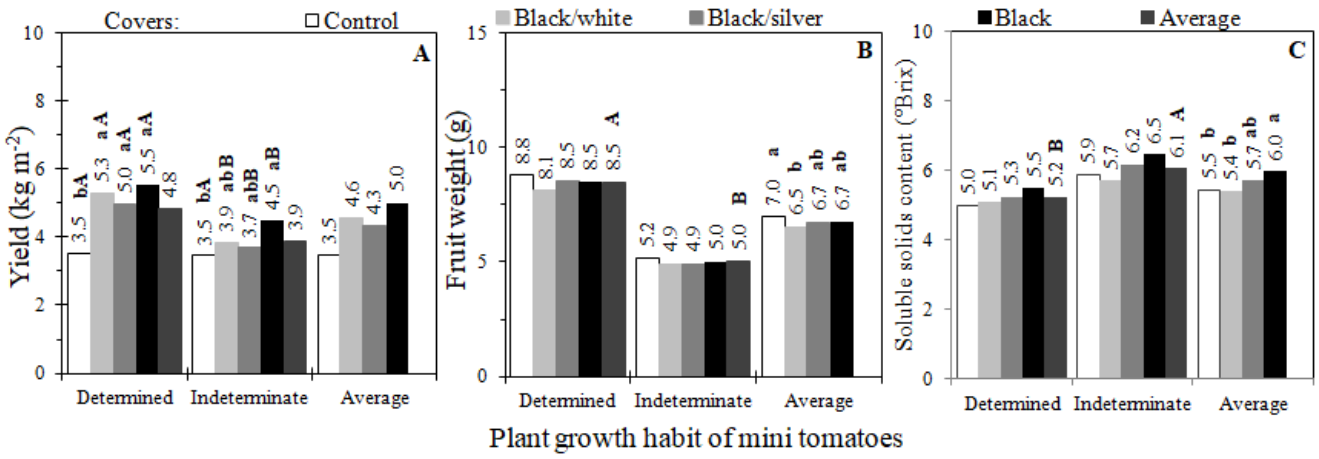
For the content of total soluble solids (Figure 3C) no differences occurred in this time (summer). In contrast to this work, Shiukhy *et al*. (2015) obtained higher content value of total soluble solids in strawberry on plastic-mulching with a greater ratio of reflected light in the far-red/red. Based on this plastic-mulching film characteristic increases in content of total soluble solids using the black color were expected. However, according to Kasperbauer *et al*. (2001) the influence of this plastic-mulching film property may be related to the predominant of sunny days during the fruit development phase. Thus, an explanation for no plastic-mulching film has change the content of total soluble solids in the summer (rainy) may be associated to occurrence of greater cloudiness (highest daily variation of global solar radiation) (Figure 2A) in the fruiting phase. In addition, the high soil moisture induced by excessive rainfall may also have affected the content of total soluble solids (Campagnol *et al*., 2014) and all values were lower than those found for most of the cultivars of mini tomatoes (Alvarenga, 2013).

Between the mini-tomatoes plants, the indeterminate presented 0.8 °Brix more than the determinate. The largest °Brix values in plants of indeterminate growth can be correlated to its greater number of leaves - great source/drain relation per plant (Maciel *et al*., 2015).

In winter, the weather conditions were less restrictive (Figure 2B) and the both weight per fruit and total soluble solids

content (Figure 4) of the two growth habits tested (commercial hybrids) were affected by the color of the plastic-mulching film.

Figure 4 - Yield (A), fruit weight (B) and total soluble solids (C) of mini tomato in plastic-mulching films in the winter of 2017. Averages followed by different lowercase letters for plastic films within each genotype and capitalized letters between genotypes for each plastic film differs by Tukey's test ($p < 0.05$).



Source: Authors (2024).

In both hybrids minor fruits were obtained in the black/white plastic-mulching film. Unlike the other groups of tomatoes, small fruits can be an attractive characteristic of this group, as there is no need to cut them (Sento-Sé *et al*., 2014).

The total soluble solids content in the winter of both hybrids presented greater value on the black plastic-mulching film. Unlike the previous experiment (summer) the water supply until the beginning of fruit ripening was predominantly via irrigation, which helped to prevent moisture excess. In addition, the fruiting occurred with the predominance of sunny days, which, combined with a greater ratio of reflected light in the far-red/red of the black plastic-mulching film may have favored a greater content of total soluble solids, agreeing with the results found by other studies (Kasperbauer *et al*., 2001; Shiukhy *et al*., 2015). Between mini tomatoes plants, similarly to the summer, the indeterminate growth habit presented superior °Brix value (1.3 °Brix).

For yield (Figure 4A), the influence of the color also depended on the growth habit. Compared to the control, while the indeterminate presented greater yield only in black, in the determined all were superior, but it did not differ between plastic-mulching films. This distinct response of the plants may be a result of the peculiar adaptations of each genetic group, which, due to the scarcity of research, are still little known in mini tomatoes plants of determinate growth habit (Maciel *et al*., 2016).

The increase of productivity of the determinate (Abirú) in all plastic-mulching films may be a consequence of greater water use efficiency due to the film physical barrier to soil evaporation (Jayakumar *et at*., 2017; Khan *et al*., 2016), increased availability of soil nutrients (Filipović *et al*., 2016), effective weed control (Cirujeda *et al*., 2012) and improvement of the soil physical and chemical structure (Wang *et al*., 2017), which are more affected by the presence than by the color of the plastic-mulching film.

On the other hand, for the indeterminate (Bubble Candy) the optical properties of the black plastic-mulching film in winter may be benefiting it productivity. Decoteau *et al*. (1989), in Florence, South Carolina, United States, achieved greater productivity of tomato plants grown on these plastic-mulching films and confirmed productive stimulus from films with larger

relative proportion between the far-red and red spectra.

The production factors evaluated were close to those obtained by some cultivars tested by Yuri *et al*. (2016) using the black/silver plastic-mulching film in two seasons. However, depending on the site, growing season and cultivar (Bonachela *et al*., 2012), this study showed that the color of the plastic-mulching film may influence the productive factors of mini tomatoes. For the summer, only determined growth genotype conducted on black/silver plastic-mulching film presented greater yields than control. On the other hand, in winter, only indeterminate growth hybrid cultivated on black plastic-mulching film presented higher yield.

The soil temperatures on the black and black/silver plastic-mulching films were higher than the black/white and the control. Studies carried out in different locations for various cultures obtained similar results (Decoteau *et al*., 1989; Díaz-Pérez, 2009; Filipović *et al*., 2016). According to Díaz-Pérez (2009), the production of broccoli in spring in Tifton, United States, was favored when using dark colored plastic film due to their heating capacity. However, unlike this study, the temperature in Tifton, United States, were above the recommended range and reduced the productivity of bell pepper cultivated in autumn due to the variations in the soil temperature and humidity affected the uptake of nutrients and decreased their accumulation (Díaz-Pérez, 2010).

Regarding the fruit size, although the plastic-mulching film and the growth habit have influenced the results from both experiments, the fruit weights were appropriated for the market (4 to 12 g fruit^{-1}) (Filgueira, 2013) in all treatments, with grammage between 5 and 9 g approximately. The determined growth produced bigger fruits, however, the absence of pruning, in particular in the indeterminate may have contributed to the reduction in the fruit size since it has an inverse relationship with the population density due the greater number of inflorescences intensify the competition for assimilates (Candian *et al*, 2017).

4. Conclusion

The plastic-mulching film increases the average soil temperature according to the color used and its choice depends on the season and cultivar.

In summer, the black/silver film improves the productive capacity of the genotypes of mini tomatoes with determined growth habit. No changes to the soluble solids content of the fruit occur among the plastic-mulching films and genotypes.

In winter, the black plastic-mulching film favors the soluble solids content of both hybrids and the productivity of the hybrid with indeterminate growth habit.

The black plastic-mulching film is adequate to produce mini tomatoes in field conditions during the winter using the two commercial hybrids. In summer and for the two genotypic materials, no color is recommended for cultivation in the field.

Acknowledgments

To the Foundation for Research Support of the State of Minas Gerais (FAPEMIG) by the financial support to the experiments conducted.

References

Allen, R. G., Pereira, L. S., Raes, D. & Smith, M. (1998). Crop evapotranspiration. Guidelines for Computing Crop Water Requirements. *Irrigation and Drainage Paper 56*, FAO, Rome. https://appgeodb.nancy.inra.fr/biljou/pdf/Allen_FAO1998.pdf.

Alvarenga, M. A. R. (2013). *Tomate: produção em campo, em casa de vegetação e em hidroponia*. Ed. UFLA, 455pp.

Araújo, H. F., Leal, P. A. M., Zorzeto, T. Q., Nunes, E. F. & Betin, P. S. (2016) Mini tomato production in organic system under greenhouse with partial control of meteorological elements. *Revista Brasileira de Engenharia Agrícola e Ambiental*. 20, 800-805. 10.1590/1807-1929/agriambi.v20n9p800-805.

Bogiani, J. C., Anton, C. S., Seleguini, A., Faria Júnior, M. J. A. & Seno, S. (2008). Tip pruning, plant density and plastic mulching in tomato yield in protected cultivation. *Bragantia*. 67, 145-151. 10.1590/S0006-87052008000100018.

Bonachela, S., Granados, M. R., López, J. C., Hernández, J., Magán, J. J., Baeza, E. J. & Baille, A. (2012). How plastic mulches affect the thermal and radiative microclimate in an unheated low-cost greenhouse. *Agricultural and Forest Meteorology*. 152, 65-72. 10.1016/j.agrformet.2011.09.006.

Campagnol, R., Abrahão, C., Mello, S. C., Oviedo, V. R. S. C. & Minami, K. (2014). Impactos do nível de irrigação e da cobertura do solo na cultura do tomateiro. *Irriga*. 19, 345-357. 10.15809/irriga.2014v19n3p345.

Candian, J. S., Martins, B. N. M., Cardoso, A. I. I., Evangelista, R. M. & Fujita, E. (2017). Stem conduction systems effect on the production and quality of mini tomato under organic management. *Bragantia*. 76, 238-245. 10.1590/1678-4499.558.

Cirujeda, A., Aibar, J., Anzalone, A., Martín-Closas, L., Meco, R., Moreno, M. M., Pardo, A., Pelacho, A. M., Rojo, F., Royo-Esnal, A., Suso, M. L. & Zaragoza, C. (2012). Biodegradable mulch instead of polyethylene for weed control of processing tomato production. *Agronomy for Sustainable Development*. 32, 889-897. 10.1007/s13593-012-0084-y.

Decoteau, D. R., Kasperbauer, M. J. & Hunt, P. G. (1989). Mulch surface color affects yield of fresh-market tomatoes. *Journal of the American Society for Horticultural Science*. 114, 216-219. http://www.personal.psu.edu/drd10/Site/Publications_files/MulchColorTomatoYield.pdf.

Díaz-Pérez, J. C. (2009). Root zone temperature, plant growth and yield of broccoli [*Brassica oleracia* (Pleck) var *italica*] as affected by plastic film mulches. *Scientia Horticulturae*. 123, 156-163. 10.1016/j.scienta.2009.08.014.

Díaz-Pérez, J. C. (2010). Bell pepper (*Capsicum annum* L.) grown on plastic film mulches: effects on crop microenvironment, physiological attributes, and fruit yield. *HortScience*. 48, 1196-1204. 10.21273/JASHS.127.1.127.

Filgueira, F. A. R. (2013). *Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de hortaliças*. 3ª ed. rev. ampl. Viçosa: UFV. 421pp.

Filipović, V., Romić, D., Romić, M., Borošić, J., Filipović, L., Mallmann, F. J. K. & Robinsond, D. A. (2016). Plastic mulch and nitrogen fertigation in growing vegetables modify soil temperature, water and nitrate dynamics: Experimental results and a modeling study. *Agricultural Water Management*. 176, 100-110. 10.1016/j.agwat.2016.04.020.

Jayakumar, M., Janapriya, S. & Surendran, U. (2017). Effect of drip fertigation and polythene mulching on growth and productivity of coconut (*Cocos nucifera* L.), water, nutrient use efficiency and economic benefits. *Agricultural Water Management*. 182, 87-93. 10.1016/j.agwat.2016.12.012.

Kasperbauer, M. J., Loughrin, J. H. & Wang, S. Y. (2001). Light reflected from red mulch to ripening strawberries affects aroma, sugar and organic acid concentrations. *Photochemistry and Photobiology*. 74, 103-107. 10.1562/0031-8655(2001)074<0103:LRFRMT>2.0.CO;2.

Khan, M. N., Ayub, G., Ilyas, M., Klan, M., Haq, F. U., Ali, J. & Alam, A. (2016). Effect of different mulching materials on weeds and yield of chili cultivar. *Pure and Applied Biology*. 5, 1160-1170. 10.19045/bspab.2016.50139.

Maciel, G. M., Fernandes, M. A. R., Hillebrand, V. & Azevedo, B. N. R. (2015). Influência da época de colheita no teor de sólidos solúveis em frutos de minitomate. *Scientia Plena*. 11, 1-6. 10.14808/sci.plena.2015.120203.

Maciel, G. M., Fernandes, M. A. R., Melo, O. D. & Oliveira, C. S. (2016). Potencial agronômico de híbridos de minitomate com hábito de crescimento determinado e indeterminado. *Horticultura Brasileira*. 34, 144-148. 10.1590/S0102-053620160000100022.

Sento-Sé, G. V. T., Gomes, A. S., Gonçalves, F. M., Silva, M. C., Costa, N. D., Yuri, J. E. & Resende, G. M. (2014). Performance of mini tomatoes cultivars in summer conditions of Sumedium Valley of São Francisco River. *Horticultura Brasileira*. 31(2), 1017-1022.

Shiukhy, S., Sarjaz, R. M. & Chalavi, V. (2015). Colored plastic mulch microclimates affect strawberry fruit yield and quality. *International Journal of Biometeorology*. 59, 1061-1066. 10.1007/s00484-014-0919-0.

Steinmetz, Z., Wollmann, C., Schaefer, M., Buchmann, C., David, J., Tröger, J., Muñoz, K., Frör, O., & Schaumann, G. E. (2016). Plastic mulching in agriculture. Trading short-term agronomic benefits for long-term soil degradation? *Science of the Total Environment*. 550, 690-705. 10.1016/j.scitotenv.2016.01.153.

Wang, L., Li, X. G., Lv, J., Fu, T., Ma, Q., Song, W., Wang, Y. P., & Li, F. M. (2017). Continuous plastic-film mulching increases soil aggregation but decreases soil pH in semiarid areas of china. *Soil and Tillage Research*. 167, 46-53. 10.1016/j.still.2016.11.004.

Yuri, J. E., Costa, N. C., Lima, M. A. C., Resende, G. M., Ferreira, T. D. & Silva, M. C. (2016). Mini tomato cultivars for the Sub-mid São Francisco Valley, Brazil. *Revista Caatinga*. 29, 1015-1020. 10.1590/1983-21252016v29n427rc.