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How Soil Covers Can Affect the Dynamics of Temperature, Soil Moisture, and Productivity of Creeping Fresh Market Tomatoes?

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Abstract

The aim was to evaluate the influence of soil covers on the dynamics of soil temperature and moisture, canopy air temperature, and yield of creeping fresh market tomatoes. The experiment was carried out in randomized blocks design, using the tomato cultivar Thaise, with 5 treatments, 4 replications, with different soil covers: a) Uncovered soil (conventional planting); b) Mulching (double-sided plastic film - black and white); c) Sorghum; d) Sudan grass and e) Pearl millet), cultivated in Tangará da Serra, Mato Grosso, Brazil. Soil temperature was monitored at depths of 5, 10, 20, and 30 cm and in the crop canopy, using thermocouple sensors of the type "K". Soil moisture was monitored in the 0 to 30 cm layer, using of time-domain reflectometry (TDR) probes. Soil temperature and moisture were evaluated throughout the cycle and, in the end, the total and commercial yield of tomato crop. Soil covers have a positive influence on soil temperature and moisture in the cultivation of creeping fresh market tomatoes so that soil cover with mulching provides the highest soil temperature in the early stages of development and covers with mulching and pearl millet provide the highest values of soil moisture. The highest total and commercial yield of tomato were in the soil cover with mulching, with 110.71 and 75.93 t ha^{-1}, respectively, presenting ideal ranges of temperature and soil moisture, so that the other treatments do not differ from each other, with the average total yield of 91.45 t ha^{-1}.

Keywords: *Solanum lycopersicum* L., soil management, thermocouple sensors, time-domain reflectometry, mulching, straw

1. Introduction

The tomato crop (*Solanum lycopersicum* L.) has great representation in the national and world economy, so the demand for better quality fruit, with a good appearance and added value, grows (IBGE, 2022). Thus, alternative technological management are sought for the conservation of soil quality and sustainability of agriculture in the production chain (Stefanoski et al., 2013).

The production and development of the tomato crop are strongly influenced by meteorological conditions, requiring places and times with low relative humidity and low rainfall. The temperature range that the tomato crop tolerates is between 10 to 34 °C, with optimal temperatures for production between 21 to 28 °C (Jedrszczyk et al., 2016). The edaphoclimatic conditions directly affect the quality and productive potential of the crop, so managements aimed at reducing the contact of the tomato plant with the soil have been adopted, ensuring plant health and fruit quality (Jokela & Nair, 2016; Neves et al., 2016).

Soil temperature and moisture are determining factors for plant development. The variation in soil temperature and moisture has a broad biological influence, in the sense that they regulate the growth of the root system, absorption of nutrients and water, among others. The altitude, slope, and geographic location also influence the soil temperature (Jedrszczyk et al., 2016).

However, improper soil moisture conditions can limit the quality and yield of tomato fruits, as well as facilitate the occurrence of various bacterial and fungal diseases, the reduction of the soluble solids content, and the unevenness of fruit maturation (Marouelli et al., 2002; Brandão Filho et al., 2018).

In this sense, plastic film coverings (mulching) or with plant biomass can be used. Soil cover has some beneficial factors for the tomato plant production system, mainly for cultivars with a determined growth habit, such as reducing the thermal amplitude of the soil, maintaining soil moisture, controlling weeds, reducing loss of soil water by evaporation and nutrient cycling, resulting in better development and production of tomatoes and vegetables in general (Neves et al., 2016; Zhang et al., 2019a).

The use of soil covers in tomato plant cultivation helps in the soil-plant interaction processes, as it increases the activity and development of the roots in absorbing nutrients and water from the soil, due to the balance of temperature and humidity of the soil and temperature of the canopy of plants, provided by the soil cover (Furlani et al., 2008). In a study, authors found that soil cover with mulching increased soil temperature between 4.0 and 5.2 °C, about soil with straw mulch, increasing the efficiency of water use, promoting positive effects on roots and seedlings and soil microbial activity (Jedrszczyk et al., 2016).

Considering the above, the aim was to evaluate the influence of soil covers on the dynamics of soil temperature and moisture, canopy air temperature, and yield of creeping fresh market tomatoes.

2. Material and Methods

2.1 General Description

The experiment was carried out in the experimental field of the State University of Mato Grosso (UNEMAT) in Tangará da Serra, Mato Grosso, Brazil, located in the geographic coordinates of Latitude: 14º 65’ 00” S, Longitude: 57º 43’ 15” W, with an altitude of 440 meters. The climate of the region according to Köppen's classification is mega thermal or humid tropical (Aw), with dry winter and rainy summer (Souza et al., 2013). For the study region, the average air temperature, relative humidity, and average annual precipitation are respectively, 24.4 °C, 70-80%, and 1,830 mm (Dallacort et al., 2011). The soil of the experimental area is classified as dystroferric Red Latosol with a clayey texture (Moreira & Vasconcelos, 2007).

2.2 Experimental Design

A randomized block design (DBC) was used, consisting of 5 soil covers tested on creeping fresh market tomatoes (Thaise cultivar), 4 replications, with 20 experimental units (Figure 1). The treatments were the following soil covers: a) Uncovered soil (conventional planting); b) Mulching (double-sided plastic film - black and white, with 25 microns thick); c) Sorghum (*Sorghum bicolor* L. Moench) (JB 1330 cultivar); d) Sudan grass (*Sorghum sudanense*) (ANsf 306 cultivar); and e) Pearl millet (*Pennisetum glaucum* L.) (ANm 17 cultivar). The parcels consisted of 4 beds (5.0 x 1.2 m) using the tomato Thaise cultivar, from the salad group, with determined growth habits. The distribution of the parcels within the blocks was carried out by drawing lots.

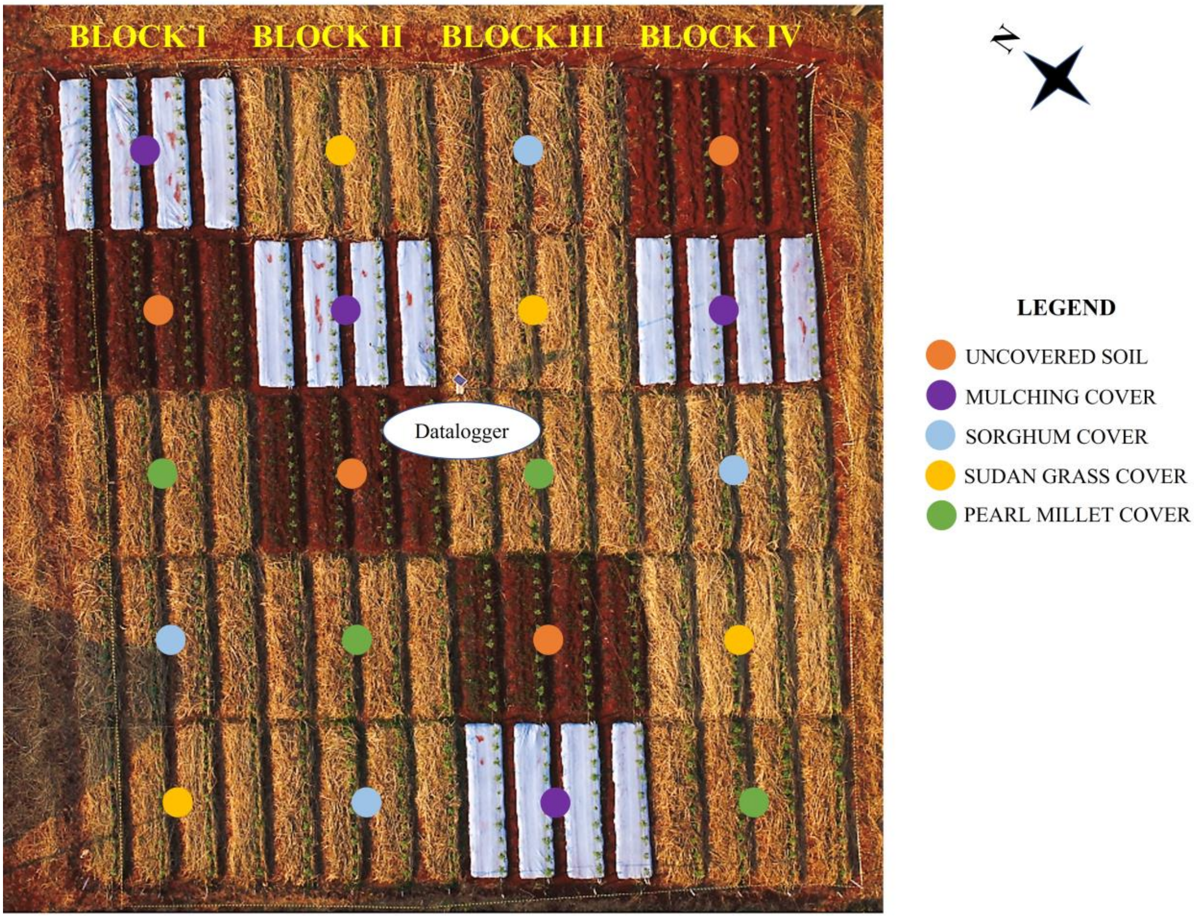

Figure 1. General superior view of the experiment and treatments arranged in blocks 20 days after transplanting (DAT). Tangará da Serra, Mato Grosso, Brazil, 2019

2.3 Installation, Implementing, and Harvesting

Soil preparation was carried out 30 days before the implementation of the experiment. Mowing of the site was carried out, followed by liming of the soil, raising the base saturation to 70% with dolomitic limestone with the relative power of total neutralization (RPTN) of 100%. Subsequently, it was incorporated with a plow and leveler harrow, and then, with a rotating hoe, the beds were surveyed.

The sowing to compose the cover was carried out on the beds, in the spacing between rows of 0.3 m, using 25.0 kg ha^{-1} of Sudan grass seeds ANsf 306 cultivar; 20.0 kg ha^{-1} of Pearl millet seeds ANm17 cultivar, and 15.0 kg ha^{-1} of Sorghum seeds JB 1330 cultivar. The cover crops were mowed at the beginning of their flowering, persisting on the surface of the beds and after transplanting the tomato plants' seedlings.

The tomato plant seedlings were produced under a protected environment covered with polyethylene plastic film, in trays of 128 cells, using commercial substrate filling and they were transplanted when they reached 22 days after sowing (08/01/2019), with a spacing of 0.5 m between plants and 1.2 m between rows, with an interval of 0.3 m between beds, totaling a total population of 13,333 plants ha^{-1}.

Fertilization was carried out according to the analysis of the surface layer soil (0-20 cm) that presented pH (water) = 5.8; P = 1.0 mg dm^{-3}; K = 93.7 mg dm^{-3}; Al = 0.0 cmol$_c$ dm^{-3}; Ca = 1.5 cmol$_c$ dm^{-3}; Mg = 0.9 cmol$_c$ dm^{-3}; H + Al = 6.0 cmol$_c$ dm^{-3}; B = 0.3 mg dm^{-3}; Zn = 3.1 mg dm^{-3}; Sum of bases = 2.6 cmol$_c$ dm^{-3}; CEC = 8.6 cmol$_c$ dm^{-3}; V = 30%; and organic matter - O.M. = 38.79 g dm^{-3}.

For planting, fertilization was used: urea (30 kg ha^{-1} of N), potassium chloride (60 kg ha^{-1} of K_2O), and simple superphosphate (1,200 kg ha^{-1} of P_2O_5). The top dressing was carried out by fertigation (drip system), in which it was used: calcium nitrate (270 kg ha^{-1} de N) and potassium chloride (540 kg ha^{-1} of K_2O), with applications every 5 days, also using zinc sulfate, ammonium sulfate, potassium nitrate and boric acid (Ribeiro et al., 1999).

The phenological stages of the crop were determined from the visual evaluation of the sowing time, transplanting of the seedlings, beginning of flowering, beginning of fructification, beginning of maturation, and last fruit harvest. For the productive variables, the total and commercial yield (t ha^{-1}) of the fruits were evaluated. The fruits were harvested when they completed maturation, weighed on a semi-analytical scale.

Irrigation was carried out in a drip system, with drippers spaced 0.3 m apart, working pressure of 10 m.c.a, in a daily irrigation shift, in which the Christiansen Uniformity Coefficient (CUC) for irrigation was 86%, and a tensiometer was also used to provide the ideal amount of water for the culture. The drip irrigation system was also used for fertigation, with an application interval of 5 days.

2.4 Soil and Canopy Air Temperature and Soil Moisture Sensors

Soil temperature was monitored at depths of 5, 10, 20, and 30 cm. The crop canopy air temperature was monitored at 10 cm above the soil. The sensors used were type “K” thermocouples (chrome and aluminum), arranged in the central area of the plot of each treatment, in horizontal alignment. Soil and air temperature values were expressed in °C.

In turn, soil moisture was monitored in the layer between 0 and 30 cm, in vertical alignment, using time-domain reflectometry (TDR) probes model CS-616 (Campbell Scientific Inc., Logan, USA), placed in the central area of the plot of each treatment, performing an average of soil moisture at this depth, with an accuracy of ±0.01 m^3 m^{-3} (CAMPBELL SCIENTIFIC, 2015; Freitas et al., 2018). The collected soil moisture data were adjusted by the equation proposed by Vasconcelos et al. (2018). Soil moisture data were expressed in volumetric moisture given in m^3 m^{-3}.

The reading depths of the soil temperature and moisture sensors and in the crop canopy were determined with these depths because they are the layers in which there are more oscillations of these variables up to 30 cm for the cultivation of fresh market tomato, interfering with its yield (Campagnol et al., 2014).

The sensors were connected to a multiplexer board, connected to a Datalogger model CR1000 (Campbell Scientific Inc., Logan, USA), which performed the readings every 30 seconds, storing the data at 1-minute intervals and the hourly average. The arrangement of the sensors and the assembled data acquisition system can be seen in Figure 2.

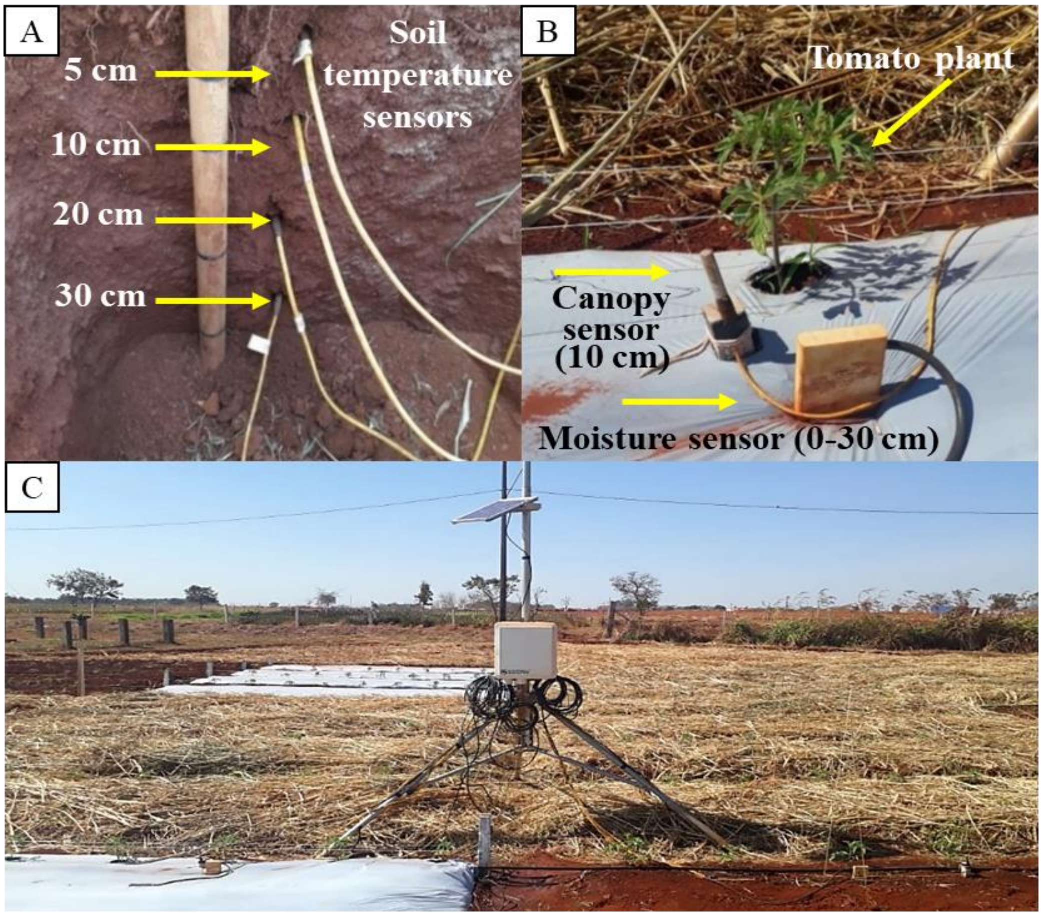

Figure 2. Arrangement of soil temperature sensors (A), canopy and soil moisture sensors (B), and data acquisition system used in experiment (C)

2.5 Statistical Analysis

Total and commercial yield data were subjected to homoscedasticity of variances by the Shapiro-Wilk test (1965) and ANOVA, and the means were compared by the Scott-Knott test at $p \leq 0.05$ if significant. The analyzes were carried out with the aid of Sisvar v. 5.8 (Ferreira, 2014) and SigmaPlot v. 12.0 (SYSTAT SOFTWARE, 2021).

3. Results and Discussion

3.1 Meteorological Elements

The values of precipitation, irrigation, average air temperature, relative humidity, and solar radiation during the crop season can be seen in Figure 3. The cultivation period was 109 days after transplanting (DAT) between 08/01/2019 and 11/18/2019. The average air temperature and relative humidity during this period were 26.36 °C and 65.10%, respectively. The total amount of water applied (precipitation + irrigation) was 778.71 mm, and the mean incidence of solar radiation was 18.16 MJ m^{-2} d^{-1}.

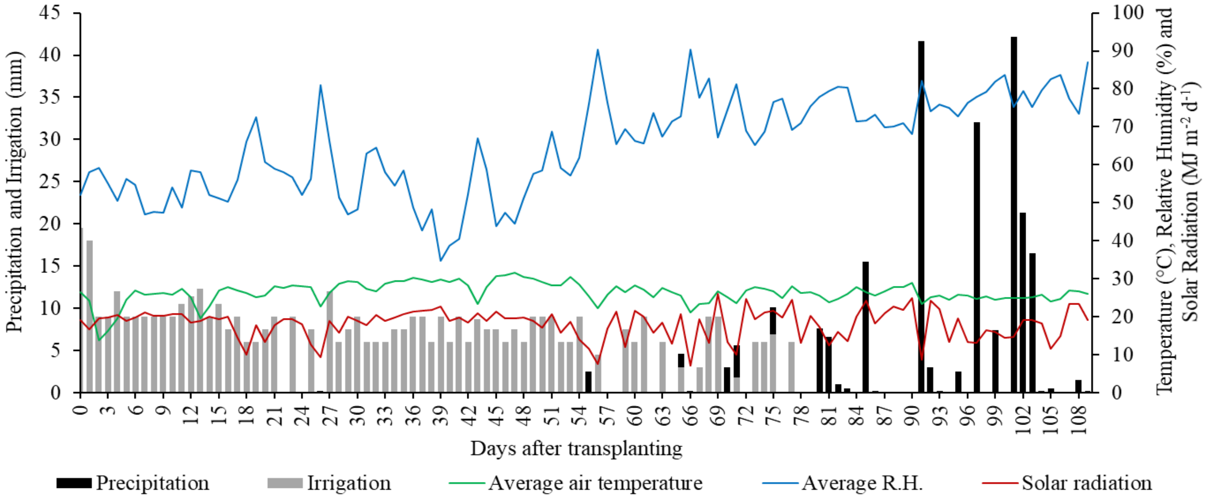

Figure 3. Precipitation, irrigation, average air temperature, relative humidity (RH), and solar radiation during the experiment between 08/01/2019 and 11/18/2019. Tangará da Serra, Mato Grosso, Brazil, 2019

Considering the ecophysiology of the tomato plant and the meteorological conditions for the good development and production of the crop, it can be stated that there were no periods of thermal or water stress. The optimal temperature for development is 18 to 23 °C, with limits between 12 and 32 °C, and the average water demand during the cycle is 450.0 mm (Becker et al., 2016).

Researchers evaluating the evapotranspiration and crop coefficient of tomato salad grown in a protected environment in the municipality of Rio Largo, Alagoas, Brazil, verified crop evapotranspiration (ETc) during the growing period of 213.79 mm, determined in lysimeters (Reis et al., 2009).

3.2 Total Tomato Cycle

The total cycle, from sowing to the end of harvest, comprised a period of 130 days, of which the vegetative phase, from sowing to the emission of the first inflorescence lasted 46 days, of which 22 days was the duration of the seedling production phase from sowing to transplantation, and the vegetative stage after transplantation corresponded to 24 days. Considering the period between transplanting and final harvest, the cultivation cycle was 109 days (Figure 4).

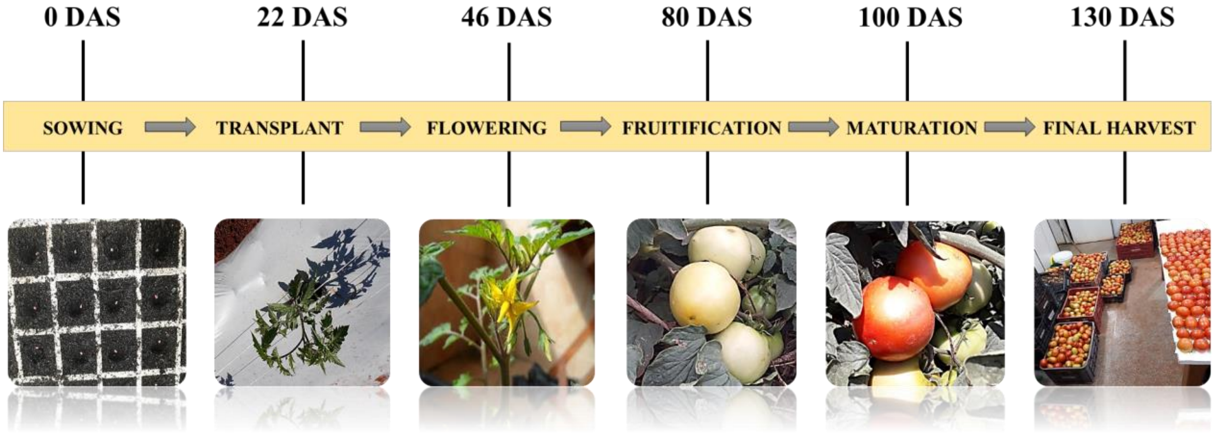

Figure 4. Duration of phenological stages in days after sowing (DAS) of creeping fresh market tomatoes cultivated in different soil covers

The period between flowering and completion of fruit filling lasted 34 days, after which the fruits took 20 days to reach full maturation. The fruits were harvested as soon as they reached full maturation, the period from the first to the last harvest was 30 days. Most tomato cultivars with a determined habit have a cycle of up to 125 days, but this depends on the climatic conditions in the region, as observed in this study (130 days) (EMBRAPA, 2003; Trento et al., 2021).

3.3 Soil Temperature

3.3.1 Daily Soil and Canopy Temperature Variation

The soil temperature variation at depths of 5, 10, 20, and 30 cm and in the canopy (10 cm above the soil) throughout the tomato plant cycle can be seen in Figure 5. For the evaluation in the canopy of the plant, it is verified that there is no influence of the treatments in the reduction of temperature and thermal amplitude, so that the dynamics of variation resembles that of the air temperature, presenting mean values of 25.66, 27.26, 25.49 and 26.25 °C in the stages of formation, flowering, fruiting and maturation, and harvest, respectively.

At a depth of 5 cm, there is a differentiation between the treatments in terms of temperature variation, so that the mean values observed for the mulching, Sudan grass, sorghum, uncovered soil and pearl millet treatments were 30.07, 29.84, 30.02, 29.55, and 31.65 °C, respectively. At 10 cm in-depth, the effects of treatments are more evident, so that mulching and uncoated provide the highest temperature values about the others, with the same dynamics for a depth of 30 cm.

It is observed that, regardless of the treatment, from 60 DAT (from flowering to fructification), there is a reduction in the daily temperature range of the soil, due to the greater shading of the canopy due to the growth of the crop, completely occupying the bed area, substantially reducing the absorption of radiation by the soil, decreasing the variation in temperature of the soil and canopy of the plants, being predominant in the initial stages of the crop, leading to higher yields.

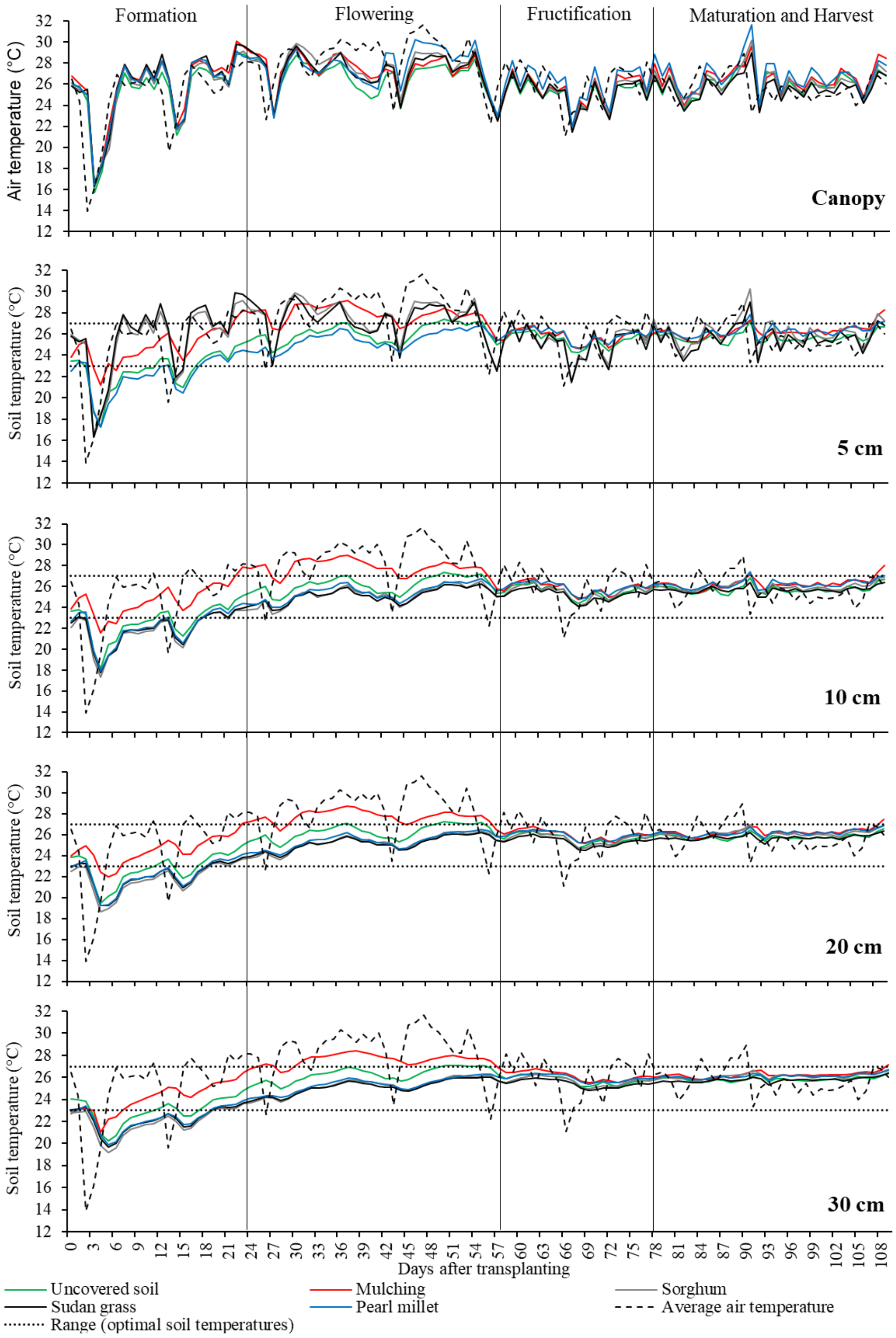

Figure 5. Daily variation of soil temperature (5, 10, 20, and 30 cm depth) and canopy temperature (10 cm above the soil) in the cultivation of tomatoes cultivated in different soil covers in Tangará da Serra, Mato Grosso, Brazil, between 08/01/2019 and 11/18/2019. Optimal minimum and maximum soil temperatures (23 and 27 °C)

In general, for all depths, soil cover with mulching provides higher soil temperature in the initial stages of development (formation and flowering) of the fresh market tomato, with an average of 26.18 °C, with an increase of 6.34, 10.16, 9.78, and 8.90% to treatments with uncovered soil, sorghum, Sudan grass, and pearl millet, respectively. For the other stages of development (fructification, maturation, and harvest) for all depths and coverages, they present an average value of 25.55 °C.

Such variations are related to the canopy shading provided by the crop and soil moisture, which is related to its diffusivity in depth. When the leaf area index (LAI) is still low, at the beginning of the cycle, the temperature variability is greater. As the attenuation of radiation by the crop canopy occurs, less variation is observed in all treatments evaluated (Funari & Pereira Filho, 2017). The irrigation system used can also interfere with the variation in soil temperature, since soil moisture influences the heat transfer by conduction so this is reduced in low moisture conditions (Funari & Pereira Filho, 2017; Oliveira et al., 2019).

The ideal soil temperature for the full development of the tomato plant is 27 °C (Jones, 2003), while for Ilić et al. (2015), evaluating the stress of tomato plants at high temperatures, found that the ideal temperature is 23 °C, where these temperatures are close to those observed in this study. The ideal soil temperature depends on the light intensity and the growth and development phase, with a temperature between 13 and 25 °C being ideal (Shamshiri et al., 2018).

Baudoin et al. (2013) recommended that soil temperature should be larger than 14 °C when ambient relative humidity is between 70 and 90%. Shamshiri et al. (2018) cite that depending on the stage of development of the tomato crop, the optimum soil temperatures can vary and these authors provide a detailed summary of the literature that suggests the optimum, marginal, and failure temperatures for tomato cultivation.

3.3.2 Hourly Soil Temperature Variation

The hourly variation in soil temperature can be observed at depths of 5, 10, 20, and 30 cm throughout the tomato cycle (Figure 6).

We observed that for depths of 20 and 30 cm, the highest soil temperatures occur between 2 p.m. and 8 p.m. and present a reduced soil thermal amplitude, as expected and also observed by Gasparim et al. (2005) using the same types of sensors in treatments with different amounts of straw as soil cover. It should be noted that the soil cover through crops (sorghum, Sudan grass, and pearl millet) reduced the hourly range of soil temperature about uncovered soil and with mulching (plastic) cover.

Researchers evaluating the monthly and seasonal variability of soil temperature under different cover and depth conditions in the region of Tangará da Serra, Mato Grosso, Brazil, the same soil in the experiment verified that soil cover influences the diurnal variability of soil temperature. The authors found mean temperatures of 28.1, 28.0, 27.9, and 27.8 °C for depths of 5, 10, 20, and 40 cm, respectively, in uncovered soil (Oliveira et al., 2019).

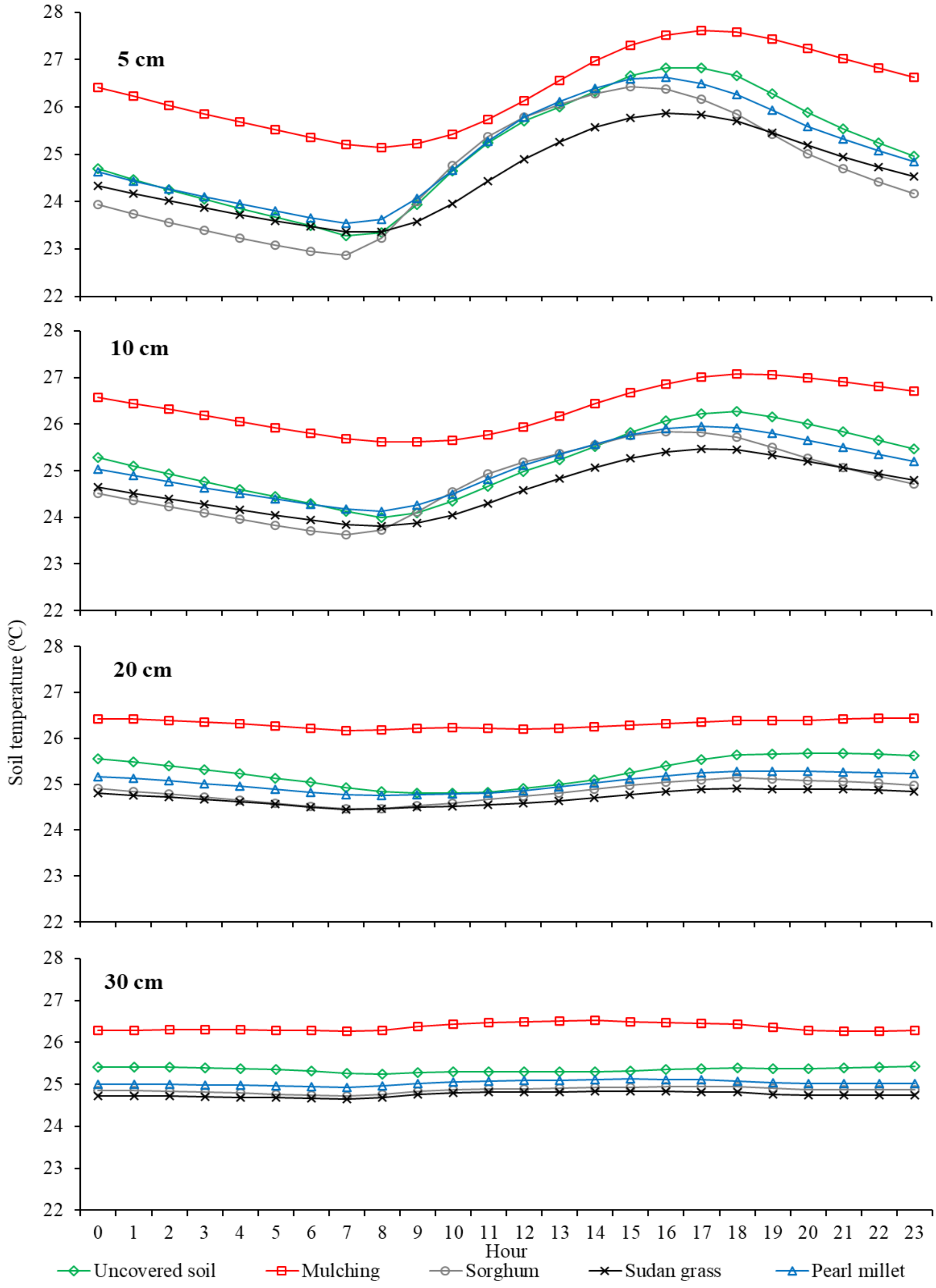

Figure 6. Hourly variation of soil temperatures at 5, 10, 20, and 30 cm depth in the different soil covers in the tomato cultivation in Tangará da Serra, Mato Grosso, Brazil

The thermal amplitude of the soil temperature in depth can be verified as a function of the evaluated treatments. In the evaluation carried out in the canopy crop of the tomato plant, there is a similarity between the treatments, so that the treatments without soil cover and Sudan grass presented a smaller thermal amplitude (Figure 7).

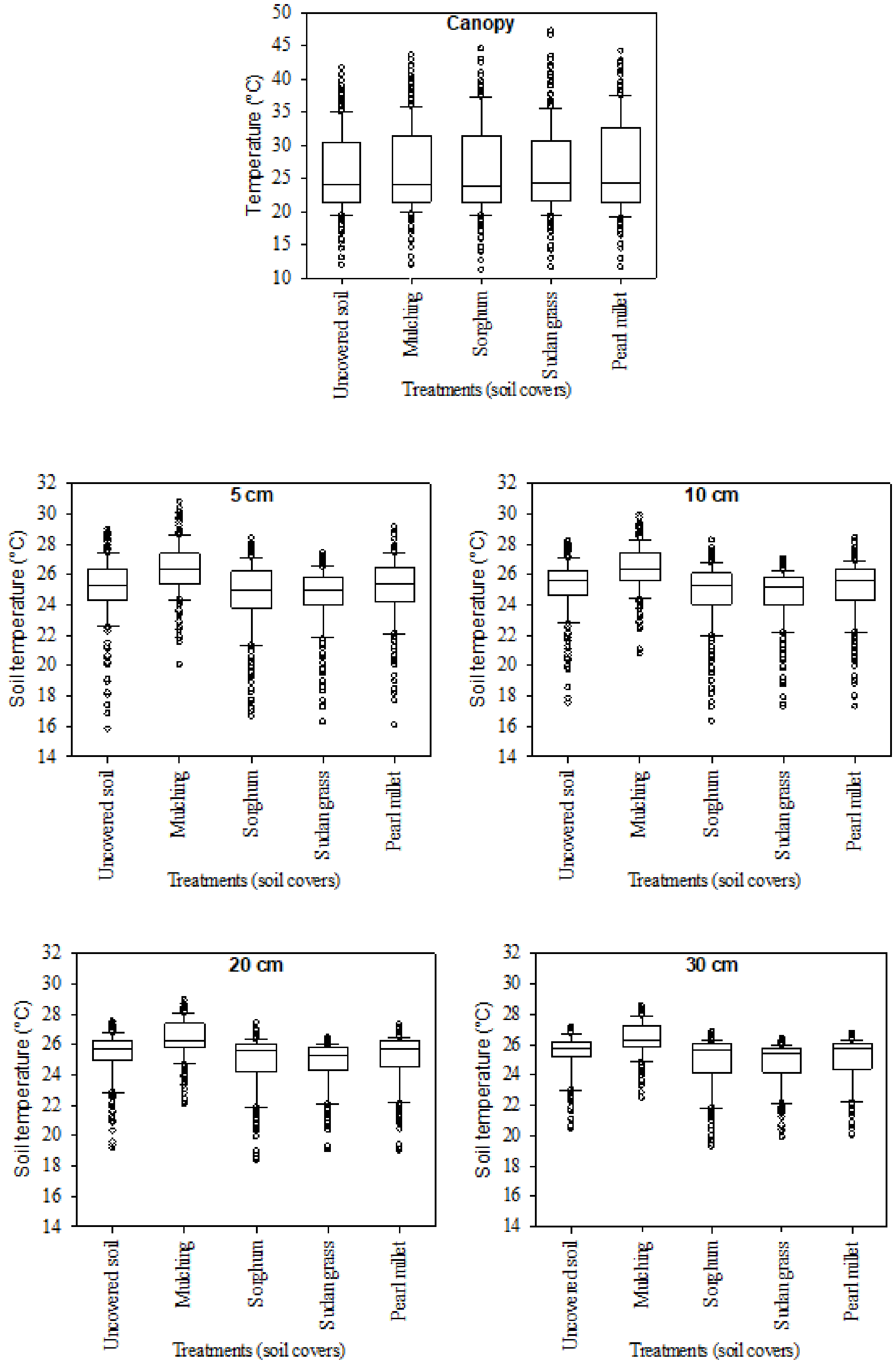

Figure 7. Variation of canopy air temperature (10 cm above the soil) and soil temperature at

different depths (5, 10, 20, and 30 cm) for creeping fresh market tomatoes in different soil covers

With the increase in depth, there is a considerable decrease in the thermal amplitude in all treatments, especially the 20 and 30 cm. Nonetheless, soil cover with mulching has the highest average temperature, however, with reduced amplitude, as for the other treatments. It was also found that the lowest averages were provided by treatments consisting of Sudan grass, sorghum, and pearl millet. It has already been observed that the residues on the soil, due to the coverings used, reduce the temperature and the thermal amplitude, due to the reflection and absorption of incident solar energy, thus reducing the loss of water through evaporation (Wierenga et al., 1982; Furlani et al., 2008).

The lowest temperature observed in the open treatment compared to mulching is related to the region's soil class (dystroferric Red Latosol) and soil moisture, since the direct radiation interception by the soil surface results in its rapid drying, reducing deep heat conduction (Funari & Pereira Filho, 2017; Oliveira et al., 2019). In this case, this dry layer of soil would work as a kind of "cover" to heat transmission and water loss, without, however, the other benefits provided by soil cover with mulching.

3.4 Soil Moisture

The values of irrigation, precipitation, and volumetric soil water content (m^3 m^{-3}) throughout the cycle are presented in Figure 8. The soil in the study region presents moisture in field capacity (FC) and permanent wilting point (PWP) at values of 0.361 and 0.232 m^3 m^{-3}, respectively (Silva, 2016), where it is observed that the moisture has reduced, but it did not reach the PWP, except for the treatment without covering, which in the fruiting phase reached values close to PWP, whereas for pearl millet and mulching in some rainfall or irrigation occurrences there was an increase in soil moisture above the FC.

As for the variation of moisture, there is a proximity between treatments during the first 30 days after transplanting (DAT), with the uncoated treatment presenting the lowest values to the other treatments. From 50 DAT onwards, the difference between treatments is accentuated, so that the treatments with pearl millet and mulching provide the highest values of soil moisture compared to the uncoated ones. This period coincides with the period of greatest demand for the crop, and this greater maintenance of moisture can result in greater yield since water availability is directly related to the absorption and translocation of nutrients and photoassimilates (Reichardt & Timm, 2019).

Pearl millet showed good soil cover and maintenance of soil moisture. However, due to its low C/N ratio and rapid decomposition, it did not keep the soil moisture similar to the polyethylene film, evidenced from 71 DAT onwards. The same can be observed for sorghum and Sudan grass, with less intensity. In a study evaluating the release of nutrients by pearl millet straw at different phenological stages, the half-life of remaining nutrients in straw was from 20 to 38, from 41 to 54, from 5 to 6, from 38 to 49, from 21 to 41, and 17 to 40 days after management for nutrients N, P, K, Ca, Mg and S, respectively (Carpim et al., 2008). In another research evaluating the production, decomposition, and nutrient cycling in crotalaria and pearl millet residues, cultivated single and intercropped, it was verified that the highest rates of decomposition and nutrient release occur from 0 to 18 days after management. It was also found that K is the most rapidly available nutrient (Soratto et al., 2012).

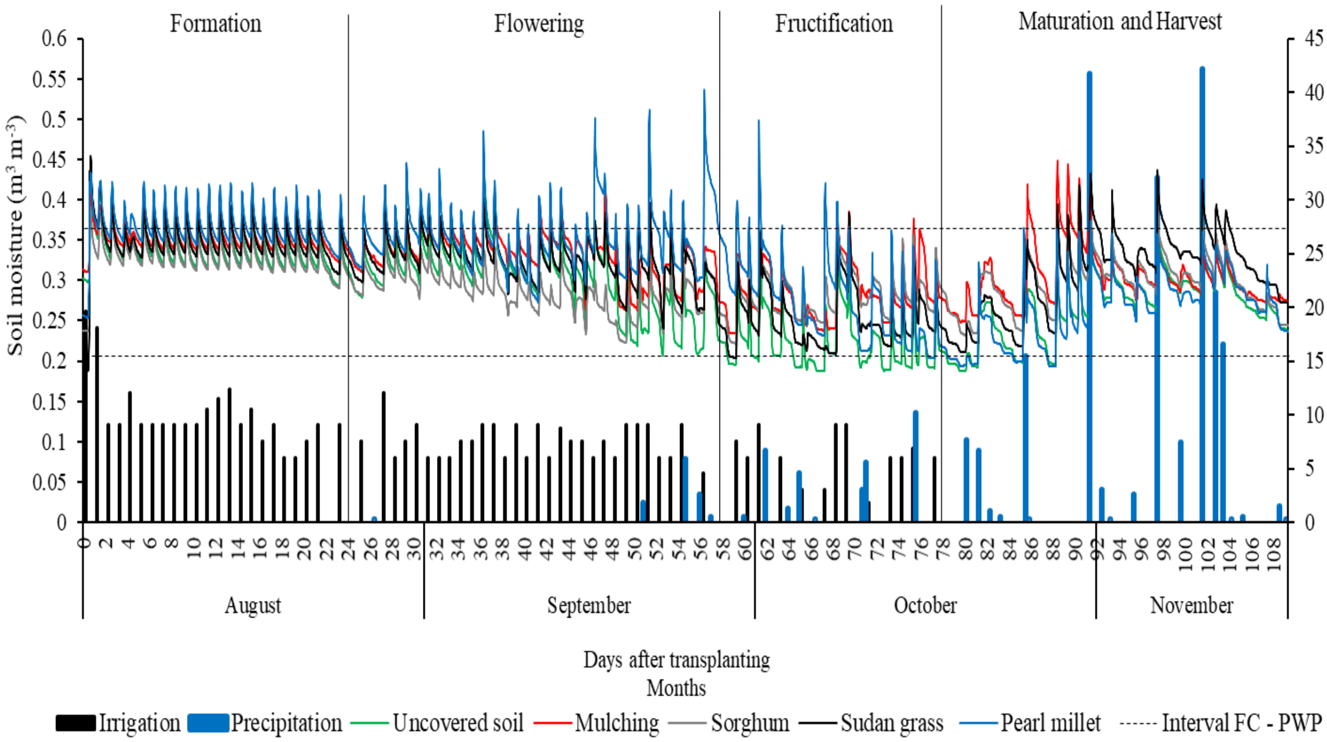

Figure 8. Irrigation, precipitation, and variability of soil volumetric water content (m^3 m^{-3}) for the cultivation of creeping fresh market tomatoes as a function of different soil covers along its cycle (Formation, Flowering, Fructification, Maturation, and Harvest) between 08/01/2019 and 11/18/2019 in Tangará da Serra, Mato Grosso, Brazil. FC = field capacity; PWP = permanent wilting point. The lines show soil moisture between treatments

It is recommended that the tomato plant be cultivated in areas that have low precipitation and relative humidity values, as the plant is sensitive to very high values, with risks of pathogen proliferation. It is essential to maintain optimal soil moisture levels at the beginning of the tomato plant life cycle, from the emission of the first flower to full fruit development (Freitas, 2018). Thus, the fruiting stage is the most sensitive to soil water deficit, since inadequate irrigations compromise fruit yield and quality, which the amount of water applied by irrigation must be sufficient to raise soil moisture to field capacity (Santana et al., 2011; Cui et al., 2020).

In a study with yield tomato cultivars subjected to water deficit, plants reduced plant height, fruit production, number of leaves, photosynthetic rate, transpiration, and increased leaf temperature, making it necessary to maintain ideal soil moisture levels during the entire crop cycle (Morales et al., 2015).

Experimental results show that the nature of the soil cover directly influences the variations in soil moisture, verifying higher fluctuations when the planting area is not covered, in which variations in soil moisture tend to decrease with the increase in the depth of sampling. Also, when mulching was used, there was a considerable reduction in the percentage of split fruits, due to the reduction in soil moisture variation, corroborating the results of this study (Santana et al., 2011; Campagnol et al., 2014; Zhang et al., 2019b).

3.5 Tomato Yield

The commercial and total tomato yields ranged from 61.91 to 75.93 t ha^{-1} and from 88.89 to 110.71 t ha^{-1}, respectively (Figure 9).

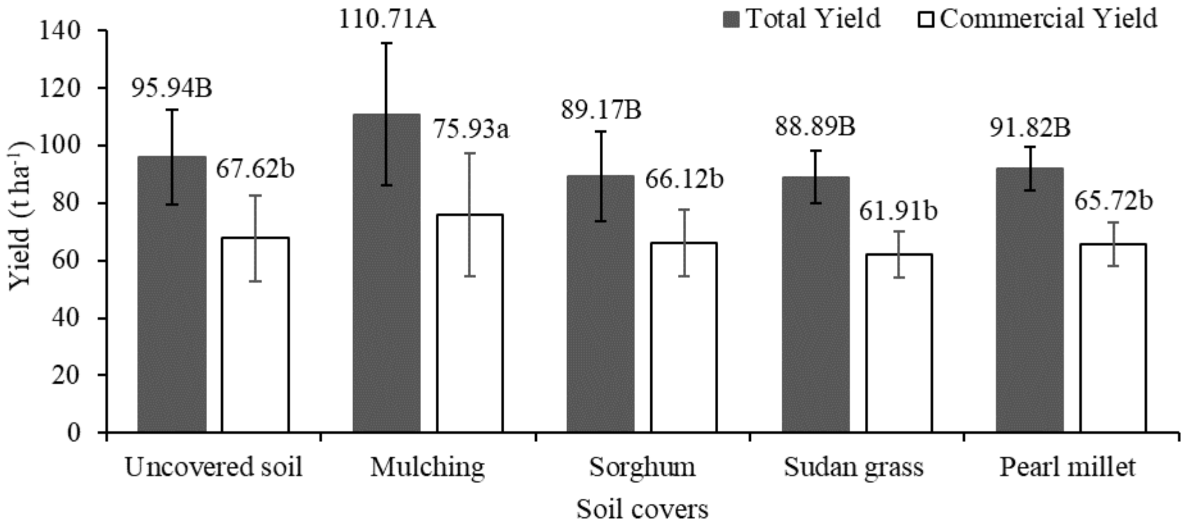

Figure 9. Total yield (TY) and commercial yield (CY) for creeping fresh market tomatoes cultivated on different soil covers in Tangará da Serra, Mato Grosso, Brazil. Uppercase (total yield) and lowercase (commercial yield) equal letters do not differ significantly between soil covers by the Scott-Knott test ($p \leq 0.05$)

It is verified that the treatment with mulching differed from the others for the total and commercial yield of tomato, with yield of 110.71 and 75.93 t ha^{-1}, respectively. The difference in yield from the mulching treatment to the undressed treatment was 14.77 t ha^{-1}, which represents a difference of 13.34%. In this sense, we can state that the highest average soil temperature, also observed for this treatment, was not limited to the growth, development, and production of the tomato plant. This is also associated with the fact that the mulching treatment provided greater soil moisture during the reproductive period (from 70 to 105 DAT).

The greater soil moisture may have contributed to the conduction and redistribution of temperature in-depth, without any damage to plant metabolism. According to Ilić et al. (2015), Higher temperatures and constant soil moisture using plastic cover (mulching) aid in greater mineralization of the soil and increase microbial activity. Thus, in the superficial layers of the soil, the availability of nitrogen for plants can increase.

It is important to emphasize that, despite the vegetal coverings (sorghum, Sudan grass, and pearl millet) have a similar yield to the uncovered soil, where the uncovered soil treatment is considered the least advantageous, because, over the years, soil degradation and wear will occur, affecting the soil microclimate and increased thermal amplitude, and consequently, the decrease in yield (Almeida et al., 2018).

Soil cover using mulching has increased the yield and growth of several vegetables, especially tomatoes (Soares et al., 2013; Campagnol et al., 2014; Mendonça et al., 2021). According to the authors, the increase in yield and growth is due to changes in air and soil temperature close to the cover, greater availability of nutrients, and better water balance. Corroborating the aforementioned authors, Verdial et al. (2001) used mulching (double-faced plastic film, black and white) for the production of American lettuce, in which they reported greater yield compared to covering with sugarcane bagasse and control. The authors reported greater yield with the use of mulching due to the increase in soil temperature, which may have favored the absorption of nutrients, with greater root activity, justifying the higher yield of the fresh market tomato using mulching cover.

Researchers found that precipitation is one of the factors that most influence soil temperature fluctuations, so in situations of high rainfall, the smallest variations in the hourly average temperature are observed (Oliveira et al., 2019). It is verified that the soil coverings with sorghum, pearl millet, and Sudan grass did not differ statistically from the treatment without covering, where they presented similar averages of tomato yield.

Researchers are studying the effects of pruning, plant density, and soil plastic cover on the yield of tomatoes grown in a protected environment showed that the use of mulching reduced the percentage of small-sized fruits (Bogiani et al., 2008), which is very interesting from an economic point of view since small fruits are less attractive to consumers. In research evaluating tomato yield and quality as a function of soil and plant cover with agro textile, yields between 82.4 and 101.6 t ha^{-1} were verified for bare soil and with the agro textile blanket (Factor et al., 2009).

4. Conclusions

Soil covers have a positive influence on temperature and moisture in the cultivation of creeping fresh market tomatoes, so that soil cover with mulching offers the highest soil temperature in the early stages of development and as covers with mulching and pearl millet provide the highest soil moisture values.

There was no difference in air temperature in the canopy of plants between treatments, showing the ideal average temperature for cultivation.

The highest total and commercial yield was observed in the soil cover with mulching, with the total yield of 110.71 t ha^{-1} and commercial yield of 75.93 t ha^{-1}, presenting ideal ranges of temperature and soil moisture, so that the other treatments do not differ from each other, with an average total yield of 91.45 t ha^{-1}.

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