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GROWTH AND PARTITIONING OF ASSIMILATES IN TOMATO TREES DUE TO THE DIFFERENT KINDS OF MULCHING[1]

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ABSTRACT - It is proposed to evaluate the growth of tomato plants grown in soil covered with different types of material. The experiment was conducted at WG Fruit Farm in Baraúna-RN during the period from July to November 2008. The experimental design was a randomized complete block with four replications. The treatments were arranged in split plots. The plots were the types of ground cover: bare soil (control), black polyethylene film (double-sided black), silver polyethylene film (double-sided black and silver), white polyethylene film (double-sided black and white) and black row cover (TNT), and the subplots sampling dates of plants of the hybrid tomato Mariana at intervals of fourteen days, from the seedling stage (14, 28, 42, 56, 70, 84 and 98 days after transplanting, DAT). The plants were harvested in the surface area of each plot, partitioned into leaves, stems, flowers clusters and fruit, and placed in an oven with forced circulation at 65 ºC, until constant weight is gotten. The characteristics assessed were: dry matter accumulation of leaves, twigs, flower clusters, fruit, total leaf area and leaf area index. Based on the dry mass of leaves, twigs, flower clusters, fruit and total, it was quantified partition of treated tomato grown in different mulching. Mulching treatments affected the growth of tomato plants with black row cover, white polyethylene and bare soil registering the highest mean of total dry matter, leaf area and leaf area index. The maximum leaf area index was obtained at 71 DAT in the treatments with black row cover (2.88), non-covered soil (2.36), white polyethylene (2.21), 77 DAT in silver polyethylene (2.17) and black polyethylene (1.72). At the end of the cycle, the plant has accumulated a mean of 28.30%, 11.98%, 3.92% and 55.82% of dry leaves, twigs, flowers and fruit clusters, respectively.

Key words: *Solanum lycopersicon* L, dry mass accumulation, assimilate partitioning, leaf area.

CRESCIMENTO E PARTIÇÃO DE ASSIMILADOS EM TOMATEIRO UTILIZANDO DIFERENTES TIPOS DE MULCHING

RESUMO - Este trabalho teve como objetivo avaliar o crescimento de plantas de tomate cultivado em solo coberto com diferentes tipos de materiais. O experimento foi desenvolvido na Fazenda WG Fruticultura, Baraúna/RN durante o período de julho a novembro de 2008. O delineamento experimental adotado foi o de blocos casualizados completos em esquema de parcelas subdivididas, com quatro repetições. As parcelas foram representadas pelos tipos de cobertura de solo (solo descoberto, filme de polietileno preto, filme de polietileno prateado, filme de polietileno branco e agrotêxtil preto) e as subparcelas pelas épocas de amostragens das plantas em intervalos de quatorze dias, a partir do transplantio das mudas (14, 28, 42, 56, 70, 84 e 98 dias após o transplantio). As características avaliadas foram: acúmulo de massa seca de folhas, ramos, cachos florais, frutos e total, área foliar e índice de área foliar. Com base na massa seca das folhas, ramos, cachos florais, frutos e total foi quantificada a partição de assimilados do tomateiro cultivado em diferentes coberturas do solo. As coberturas do solo afetaram o crescimento do tomateiro com o agrotêxtil preto, polietileno branco e o solo descoberto registrando as maiores médias de massa seca total, área foliar e índice de área foliar. O máximo de índice de área foliar foi obtido aos 71 dias após o transplantio (DAT) nos tratamentos com agrotêxtil preto (2,88), solo sem cobertura (2,36) e polietileno branco (2,21), e aos 77 DAT no polietileno prateado (2,17) e polietileno preto (1,72). No final do ciclo a planta acumulou em média 28,30%; 11,98%; 3,92% e 55,82% de massa seca nas folhas, ramos, cachos florais e frutos, respectivamente.

Palavras-chaves: *Solanum lycopersicon* L. Acúmulo de massa seca. Partição de assimilados. Área foliar.

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INTRODUCTION

The tomatoes are produced in practically all geographic regions of the world under different cropping systems and crop management. The northeastern Brazil is favorable for growing tomatoes, and the states of Bahia, Pernambuco and Ceará, in 2011, accounted for approximately 90% of production in this region (IBGE, 2013). Rio Grande do Norte, despite appropriate climatic conditions, not yet achieved enough to prevent the importation of other states production.

Considering the necessity of improvement for the production of tomato, it has been trying to introduce new production technologies, such as the use of mulching. This technique has become important and very popular in the production of many kinds of vegetables, constituting, including, a basic condition for many of them to present products with acceptable level of quality and at profitable levels of productivity. The polyethylene (PET) plastic films have been widely used in the technique of mulching, differently from the black polypropylene, also known as non woven fabric. In turn, the white polypropylene has good use for protecting plants, mainly in the form of direct coverage on plants, as a blanket, and it has presented favorable results in leafy vegetables, such as pak choi (REGHIN et al., 2001) and lettuce (BOROSIC et al., 1994; OTTO et al., 2001). As it is used as mulching in lettuce crop, the black polypropylene or non woven was efficient in the control weeds, promoting better development and yield of plants with higher fresh matter (REGHIN et al., 2002).

The analysis of vegetal growth expressed to the morphophysiological conditions of the plant at intervals propose to follow the dynamics of the photosynthetic production assessed by the accumulation of dry matter (NIEUWHOF et al., 1991), which is probably the most relevant parameter, once it results from the association of several other components (AZEVEDO NETO et al., 2000). Thus, it is possible to evaluate the plant growth as a whole through growth analysis and observing the contributions of various organs to total growth (FELTRIM et al., 2008).

Klar and Jadoski (2002) studied pepper grown in soil covered by black polyethylene film and concluded that the leaf area was larger in the treatments with mulching compared to the ones without cover. Ibarra et al. (2001) concluded that melon grown under plastic cover (black plastic film) presented higher values of leaf area and dry weight of shoot than in uncovered soil. They verified, also in melon, that there is not effect of the mulching (black or silver double sided polyethylene film) for the leaf area in hybrids PX3912947 and Vera Cruz (MEDEIROS et al., 2006).

In this context this work had the aim to evaluate the growth of tomato grown in soil covered with different kinds of material.

MATERIAL AND METHODS

The experiment was developed from July to November 2008, in claysoil, at the farm WG Fruticultura, located in the countryside of Barauna, RN with the following geographic coordinates : (5° 05` South, 37° 38’ West and 95,0 m altitude).

The experimental design was of complete randomized blocks with four replications. The treatments were distributed in subdivided plots, which were represented by the kinds of mulching: uncovered soil (control), black, silver and white polyethylene film, and black polypropylene (non woven film), and the subplots by the time of samplings of hybrid tomato type Mariana: 14, 28, 42, 56, 70, 84 and 98 days after transplanting (DAT).

Soil preparation consisted of plowing and harrowing, followed by sulcal into lines with a depth of 20 cm, in which the fertilization was performed with 400 kg ha^{-1} of monoammonium phosphate (MAP), with subsequent closure of grooves. The fertilization in covered areas was daily performed through fertirrigation obeying the stages of crop development.

The seedlings were transplanted 25 days after sowing, at 2.0 m spacing between rows and 0.50 m between plants, with total area of 84 m^2 and profitable one of 24 m^2. The hybrid tomato used was Mariana, belonging to Saladete (Italian type), which has high yield potential and early maturity, high ruggedness, large fruit with ideal shape for the market, and fruit weight between 160 g and 180 g (SAKATA, 2008). It was used a drip irrigation system, with a flexible tape of 16 mm and drippers flow of 1.5 L h^{-1} for a pressure of 100 KPa and emitters spaced at 0.30 m. The amount of water needed for the irrigation was estimated according to the crop evapotranspiration. This method takes into account the reference evapotranspiration (ET_0) and the crop Kc for each stage of development.

The control of pests and diseases was conducted in accordance with conventional recommendations for the crop, using fungicides and insecticides. The weed control was done manually with hoes in the uncovered plots and between the beds of the covered plots. The weeds which happened near the burrows were removed manually.

Plants were sampled every 14 days from seedlings transplanting (14, 28, 42, 56, 70, 84, and 98 days after transplanting, DAT) in the profitable area of each plot. The plants were cut close to soil, fractionated into leaves, branches, floral clusters and fruits, washed, packed into paper bags and placed in an oven with forced air at 65° C, until reaching constant weight, obtaining the accumulation of dry matter of leaves, branches, floral clusters and fruits through the successive weights of dry matter. Also, the leaf area was determined through the disc method. By getting the dry matter of leaves (DML) and discs (DMD) and from the knowledge on the area of the discs (AD), we calculated the total leaf area (LA = (DML AD) / DMD).

It was applied the validation to ensure the effectiveness of this method. Prior to the removal of the discs from the sampled leaves, they were scanned with a metric scale and we calculated the leaf area through an imaging software. Once the leaf area was obtained through the two methods, a relationship between them is done and a correction coefficient for the disc method is calculated, so that the leaf area was given by the equation: LA = [(DML AD) / DMD] x Correction coefficient.

Based on data of dry matter, the assimilate partitioning was calculated, expressed in percentage, as the fraction of dry matter of each organ (leaves, branches, floral clusters and fruits) divided by the total dry matter and multiplied by 100. The general formula for calculating the distribution of the accumulated biomass is expressed by the equation: **IP** (x) = (DM (x) / total DM) x 100, where IP (x) is the index of the component partition (x) expressed in percentage, (x) is the dry matter of any part of the plant expressed in grams (dry matter of leaves, branches, floral clusters or fruits). The total DM is the plant total dry matter, both the DM (x) and the total DM, all expressed in grams.

The data were subjected to analysis of variance through the software SAEG (RIBEIRO JÚNIOR, 2001) and non-linear regression (YIN et al., 2003) using the software SPSS 15, and for the ones which does not fit to this model, polynomial regressions were used through the software Table Curve (JANDEL SCIENTIFIC, 1991).

RESULTS AND DISCUSSION

There was relevant interaction between the factors mulching and time of sampling for the dry matter of leaves and fruits, total dry matter and leaf area. There was an isolated effect of the factors mulching and time of sampling for the dry matter of branches and floral clusters.

The evolution of the accumulation of dry matter of leaves presented similar behavior for all mulching, with slow growth until 28 DAT. Thereafter, there was an accelerated growth and stabilization from 70 DAT (Figure 1A). It was verified that only from 56 DAT the mulching affected the dry matter of leaves, and that at 98 DAT, the black polypropylene promoted the greatest accumulation of dry matter of leaves (Table 1A).

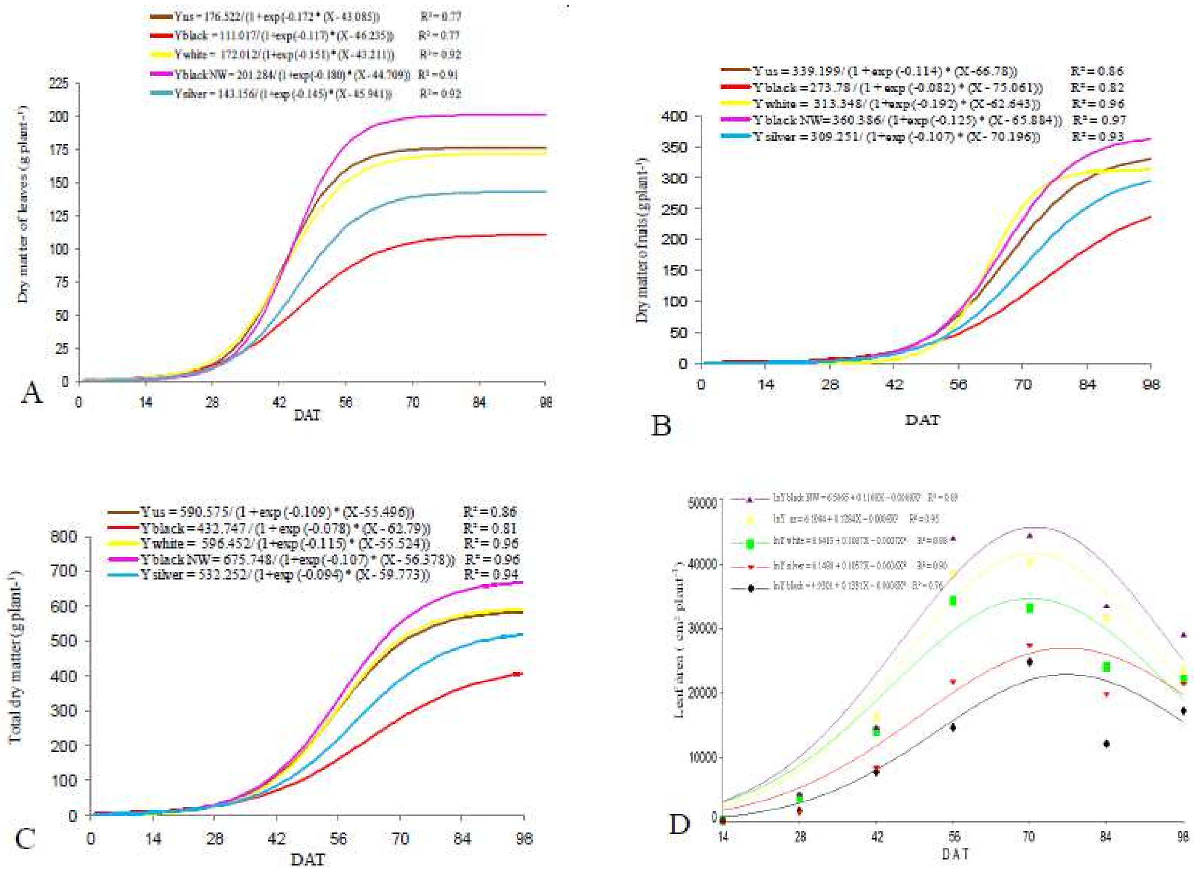

Figure 1. Accumulation of dry matter of leaves (A), fruits (B), total dry matter (C), and leaf area (D) of tomato Mariana grown with different kinds of mulching and of plants at intervals of fourteen days, from the seedling stage. Barauna, RN, UFERSA, 2008.

The accumulation of dry matter of branches was slow until 28 DAT, followed by an accelerated increase and stabilization from 70 DAT (Figure 2A). The same sigmoidal behavior in the accumulation of dry matter of branches observed in this work was observed by Fayad et al. (2001), both in growing under field conditions (cv. Santa Clara) and in protected area (EF-50). Among the used kinds of mulching, the black polypropylene film (48.74 g plant^{-1}), white polyethylene (44.32 g plant^{-1}) and the uncovered soil (42.72 g plant^{-1}) were the ones which proposed the highest accumulation of dry matter of branches, however, they did not differ from the silver polyethylene (37.79 g plant^{-1}). This last one was similar to the black polyethylene, which promoted the lower accumulation, with mean of 27.51 g plant^{-1} (Table 2).

Table 1. Mean values of tomato Mariana grown with different kinds of mulching in function days after transplanting (DAT). Barauna, RN, UFERSA, 2008.

Mulching	14 DAT	28 DAT	42 DAT	56 DAT	70 DAT	84 DAT	98 DAT
	Dry matter of leaves (g plant^{-1})						
Uncovered Soil	1.17 a	18.65 a	77.33 a	160.63 ab	189.72 a	180.11 a	157.55 b
Black Polyethylene	0.64 a	9.11 a	46.04 a	77.44 d	120.58 b	80.70 c	128.25 b
Silver Polyethylene	0.78 a	9.08 a	52.96 a	113.03 c	149.24 ab	126.83 b	150.92 b
White Polyethylene	1.33 a	19.66 a	75.93 a	151.39 b	177.09 a	162.01 a	173.52 b
Black Polypropylene (Non Woven Film)	1.11 a	19.63 a	72.80 a	181.79 a	205.38 a	182.03 a	211.91 a
	Dry matter of fruits (g plant^{-1})						
Uncovered Soil	-	-	5.36 a	68.29 a	223.82 a	259.43 ab	353.33 ab
Black Polyethylene	-	-	1.84 a	23.79 a	158.52 b	141.40 c	253.34 c
Silver Polyethylene	-	-	2.87 a	53.47 a	163.68 b	237.53 b	301.91 bc
White Polyethylene	-	-	6.93 a	67.14 a	254.25 a	297.75 a	321.95 b
Black Polypropylene (Non Woven Film)	-	-	3.73 a	78.16 a	248.28 a	300.98 a	385.50 a
	Total dry matter (g plant^{-1})						
Uncovered Soil	1.56 a	24.44 a	113.33 a	300.04 a	499.66 a	542.26 a	600.19 b
Black Polyethylene	0.94 a	12.71 a	68.67 a	144.79 c	338.63 b	271.56 c	454.88 c
Silver Polyethylene	1.08 a	12.78 a	80.04 a	225.36 b	392.30 b	456.80 b	537.15 bc
White Polyethylene	1.76 a	26.83 a	116.47 a	287.90 ab	527.06 a	555.43 a	597.38 b
Black Polypropylene (Non Woven Film)	1.53 a	26.00 a	106.6 a	341.64 a	557.05 a	591.63 a	708.27 a
	Leaf area (g plant^{-1})						
Uncovered Soil	254.9a	3811.3a	16288.5a	38385.2a	40461.6a	31755.5a	23639.8ab
Black Polyethylene	135.2a	1654.3a	7775.7a	14661.6d	24858.2c	12114.1c	17217.1c
Silver Polyethylene	152.9a	1684.0a	8695.1a	21982.2c	27651.8c	20128.7b	21748.4bc
White Polyethylene	245.7a	3768.9a	14086.9a	34409.4b	33227.3b	24044.1b	22119.9bc
Black Polypropylene (Non Woven Film)	248.9a	4020.2a	14333.9a	43801.6a	44218.1a	33280.3a	28826.0a

Means followed by different letter in a column are different ($p \leq 0.05$).

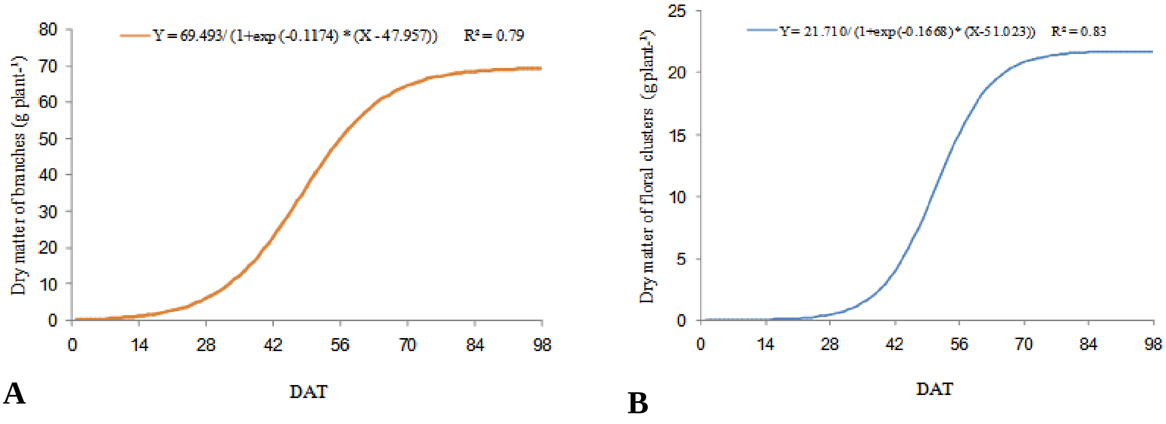

Figure 2. Accumulation of dry matter of branches (A) and of floral clusters (B) of tomato Mariana grown in intervals of fourteen days, from the seedling stage. Barauna, RN, UFERSA, 2008.

It was observed that there was a slow increase in the accumulation of dry matter of floral clusters from 28 to 42 DAT. From this moment accelerated growth, with a tendency to stabilize at 70 DAT occurred (Figure 2B). Among the kinds of mulching, it was verified that the black polypropylene (16.69 g plant^{-1}) and the white polyethylene (15.60 g plant^{-1}) were the ones which promoted the highest average over the cycle (Table 2).

Table 2. Mean values of dry matter of floral clusters and branches over the cycle of tomato Mariana grown with different kinds of mulching. Barauna, RN, UFERSA, 2008.

Mulching	Dry matter of floral clusters (g plant^{-1})	Dry matter of branches (g plant^{-1})
Uncovered Soil	14.50 AB	42.72 A
Black Polyethylene	9.65 B	27.51 B
Silver Polyethylene	13.11 AB	37.79 AB
White Polyethylene	15.60 A	44.32 A
Black Polypropylene (Non Woven Film)	16.69 A	48.74 A

Means followed by the same letter in the same column do not differ (Tukey test at 5% probability).

The accumulation of dry matter of fruits was slow from 42 to 56 DAT in the different kinds of mulching. From 56 DAT, with their increased number and development, there was an intense accumulation of dry matter, until about 84 DAT (Figure 1B). The maximum accumulation of dry matter of fruits occurred at 98 DAT, reaching the uncovered areas, black, silver and white polyethylene, and black polypropylene, respectively, 353,33; 253,34; 301,91; 321,95 e 385,50 g plant^{-1} (Table 1).

The accumulation of total dry matter was slow until 42 DAT, intensifying thereafter until about 70 DAT, and tended to stabilize from 84 DAT, getting the maximum accumulation at 98 DAT (Figure 1C). It was observed on the schematic representation of the evolution of dry matter accumulated in plants the same sigmoidal pattern of growth proposed by Challa et al. (1995), which shows roughly exponential in the initial stage; following an approximately linear pattern of growth; and showing a decrease in the rate of growth at the end of the crop cycle. Fontes et al. (2005) observed a continuous accumulation of total dry matter along the pepper crop cycle.

Similarly to what was observed for the accumulation of dry matter of leaves and fruits, it was verified that, at 98 DAT (Table 1), the black polypropylene (non woven) film was the one which promoted the highest accumulation of total dry matter, with a mean of 708.27 g plant^{-1}, followed by the white polyethylene (597.38 g plant^{-1}), uncovered soil (600.19 g plant^{-1}), silver polyethylene (537.15 g plant^{-1}) and black polyethylene (454.88 g plant^{-1}).

The leaf area, for the different kinds of mulching, presented a slow initial growth, and increased rapidly to reach the maximum value estimated of 41.759, 22.913, 27.008, 34.746 and 45.842 cm^2 plant^{-1} at 71, 77, 77, 71 and 71 DAT, respectively, for the uncovered soil, black, silver and white polyethylene, and black non woven film, with subsequent decrease until the end of the evaluation period (Figure 1D). Pace et al. (1999) affirm that the slow initial growth happens because the plants spend most part of the energy for fixation in soil, so the roots are the preferential drainage of photoassimilates during this stage. This decrease of leaf area occurred possibly due to the appearance of fruits on the plant, causing the redirection of production of assimilates to the fruits and also because of the leaf senescence and abscission at the end of the cycle.

It was found that only from 56 DAT the mulching affected the leaf area, and at 98 DAT the black non woven film was the one which promoted the highest average values of leaf area, with 28826.01 cm^2 plant^{-1}, not unlike the uncovered soil (23639.80 cm^2 plant^{-1}). In turn, this one did not differ from the white (22119.95 cm^2 plant^{-1}) and silver polyethylene (21748.44 cm^2 plant^{-1}). The black one promoted the lowest average value of leaf area (17217.14 cm^2 plant^{-1}) (Table 1).

The percentage of dry matter of leaves, branches and floral clusters decreased over the cycle, while the one of fruits increased from 42 DAT (Figures 3A, 3B, 3C, 3D and 3E). In the early cycle, at 14 DAT, the leaves behaved as source and drain, then, as the tomato got in the reproductive stage, they behaved as source, accumulating 26.3%; 29.0%; 28.2%; 28.1% and 29.9% of dry matter, respectively, in the uncovered soil, white, black and silver polyethylene, and black non woven films at the end of cycle. From 28 DAT, there was the floral clusters, which accumulated, at the end of cycle, in the uncovered soil, white, black and silver polyethylene, and black non woven films, respectively, 11.4% and 3.5%; 13.1% and 4.0%; 11.9% and 4.2%; 11.7% and 4.0%; 11.8% and 3.9% of the total dry matter produced by the plant. The fruits behaved as the main drain of plant, accumulating, at the end of the evaluation period, 58.9%; 53.9%; 55.7%; 56.2% and 54.4% of total dry matter produced, respectively, in the uncovered soil, white, black and silver polyethylene, and black non woven films. Acording to Marschner (1995), as the plants got in the reproductive stage, there is an increased translocation of carbohydrates and other compounds from leaves to fruits, as a result of the predominance of the reproductive stage on the vegetative stage. Fayad et al. (2001), by working with tomato Santa Cruz and Salad, concluded that the fruits were the main drain of the plant since the early fructification until the last harvest of ripe fruits, accumulating more than 50% of the total dry matter produced by the plant. Similar results were obtained by Tanaka et al. (1974), Hall (1977), Bhantt and Srinivasa (1997), Andriolo et al. (2004), Peluzio et al. (1999), Flores (2007), and Guimarães et al. (2009). The results observed in this work differ from the ones obtained by Gargantini and Blanco (1963) and Rocha (2009).

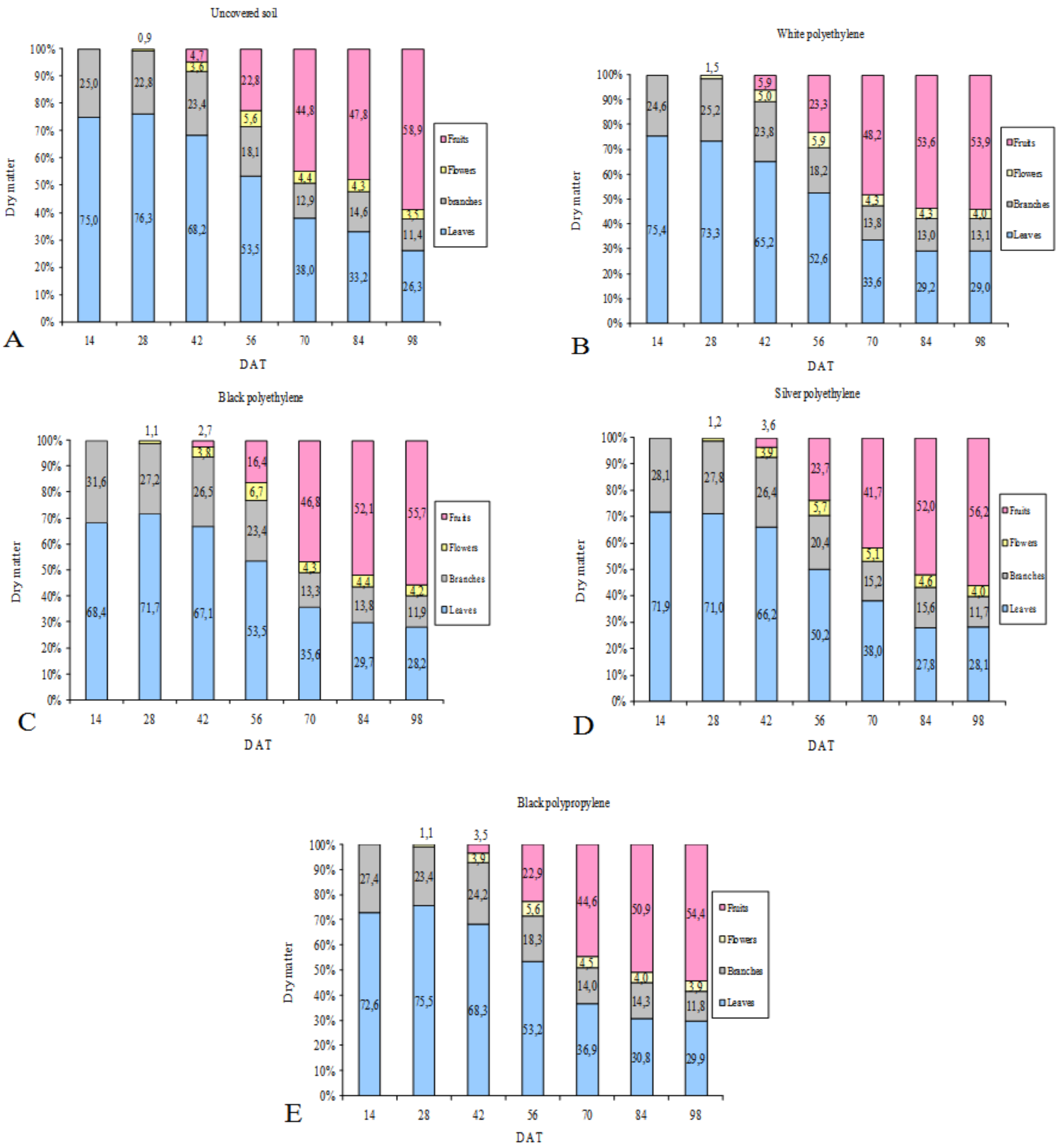

Figure 3. Percentage distribution of biomass accumulated in tomato 'Mariana' grown in uncovered soil (A), white polyethylene (B), black polyethylene, (C) silver polyethylene (D) and black polypropylene (E). Barauna, RN, UFERSA, 2008.

CONCLUSIONS

The mulching (uncovered soil, white, black and silver polyethylene, and black non woven film) affected the growth of tomato, recording the highest means of total dry matter and leaf area.

The maximum leaf area was obtained at 71 DAT with black non woven (28826.01), uncovered soil (23639.80) and white polyethylene (22119.95) films, and silver (21748.44) and black polyethylene (17217.14) at 77 DAT.

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