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Agronomic performance of watermelon crop on the basis of reused polypropylene and colored plastic mulches

Desempenho agronômico da cultura da melancia em função do polipropileno reutilizado e 'mulching' plástico de diferentes cores

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Abstract

The combined use of mulching and polypropylene in cucurbits crop is a viable technique for control of weeds and pests that has been widely used in agropolo Assu-Mossoró-Barauna, RN. The objective was to evaluate the yield and fruit quality of watermelon cultivated with mulching of different colors and protected with polypropylene with different times of uses. The experiment was conducted in Mossoro city, RN, using experimental design of randomized blocks with four replications, in a factorial 3 x 3, the first factor color polyethylene mulching (black, white and silver) and the second factor polypropylene uses time (new, reused once and reused twice). The variables analyzed were number of fruits per plant, weight of commercial fruits, commercial fruit productivity, non-commercial and total, soluble solids and titratable acidity. It was observed isolated effect of polypropylene for number of fruits per plant and soluble solids and significant effect of mulching interaction and polypropylene for commercial and total productivity. The reuse of polypropylene afforded effect on productivity and fruit quality. The reuse of the once and twice polypropylene provides fruits with a higher content of soluble solids. There was no effect of different color 'mulching' productivity and quality watermelon "Mickylee".

Additional keywords: *Citrullus lanatus* L.; protection of plants; soil cover.

Resumo

O uso combinado do 'mulching' e do polipropileno no cultivo de cucurbitáceas é uma técnica viável no controle de plantas daninhas e de pragas que vem sendo largamente utilizada no agropolo Assu-Mossoró-Baraúna-RN. Objetivou-se avaliar a produtividade e a qualidade dos frutos da melancia, cultivada com 'mulching' de diferentes cores protegido com polipropileno com diferentes tempos de uso. O experimento foi realizado no município de Mossoró-RN, utilizando delineamento experimental de blocos ao acaso, com quatro repetições, em esquema fatorial 3 x 3, sendo o primeiro fator cores de 'mulching' de polietileno (preta, branca e prata), e o segundo fator, tempos de uso de polipropileno (novo, reutilizado uma vez e reutilizado duas vezes). As variáveis analisadas foram número de frutos por planta, massa de frutos comerciais, produtividade de frutos comerciais, não comerciais e total, sólidos solúveis e acidez titulável. Observou-se efeito isolado do polipropileno para número de frutos por planta e sólidos solúveis, e efeito significativo da interação 'mulching' e polipropileno para produtividade comercial e total. A reutilização do polipropileno proporcionou efeito da produtividade e da qualidade dos frutos. O polipropileno novo promoveu maior número de frutos por planta e produtividade de frutos comerciais. A reutilização do polipropileno uma e duas vezes proporciona frutos com maior teor de sólidos solúveis. As diferentes cores de 'mulching' não interferem na produtividade e na qualidade da melancia "Mickylee".

Palavras-chave adicionais: *Citrullus lanatus* L.; cobertura de solo; proteção de plantas.

Introduction

World production of watermelon is approximately 105.4 million tons (FAOSTAT, 2015). In Brazil, the estimated production is two million tons of fruit, being top producers the states of Rio Grande do Sul and Goiás. In northeastern Brazil, the highlights are the states of Bahia and Rio Grande do Norte, with 212.5 and 121.1 thousand tons, respectively (IBGE, 2015).

In the agropolo Assu-Mossoro-Barauna, located in Rio Grande do Norte, the cultivation of watermelon is made with the same technology package used for the melon crop. Thus, the mulching and the protection of plants with low density polypropylene are common inputs for producers in the region. However, there is no study on the effect of the color of the polyethylene used as mulching, coupled with the reuse of polypropylene in watermelon crop, as for the productivity and quality of fruit produced (Dantas et al., 2013).

The use of the polyethylene mulching is a technique that consists in covering the soil surface, being widely used in cultivation of vegetables. This technology promotes reduction of nutrient losses by leaching caused by rain, accelerates the development, leading to earlier harvest, improves hygiene and quality of the fruit, and is also effective in controlling weeds, resulting in improved appearance of the fruit and increased productivity (Sampaio & Araujo, 2001; Dantas et al., 2011, Morais et al 2008, Liu et al., 2009).

The low density polypropylene, also known as non-woven fabric (NWF), or thermal blanket, is a material made of polypropylene filaments, quite light, porous, which allows the passage of water and gas, as well as 85% of the radiation that reaches its surface. In agriculture, various gramature scan be use dranging from 15 to 25 g m^{-2} (ABINT, 2000). This technology is used with the main objective to protect the culture from pest attack, considerably reducing the amount of spray in the area, promoting economic and environmental benefit. In the case of watermelon, it is used from planting to flowering initiation, since there is need for pollination of flowers to fruit formation. In the region, the one with white coloration and 15 g m^{-2} gramature has been used, and reused for up to three cycles (Dantas, 2010).

In the agricultural region of Assu-Mossoro--Barauna, polypropylene started being used in 2001, checking benefits beyond reducing the pest attack (Furiatti et al., 2008), Jiménez et al., 2001 for example, increased post-harvest life cycle (Gonzalez et al., 2006 and soluble solids content of fruit (Medeiros et al., 2007), increase of productivity (Morais et al., 2008).

In this context, the objective was to evaluate the productivity and fruit quality of watermelon grown with different colored mulches, protected with polypropylene with distinct times of use.

Material and methods

The experiment was conducted in the garden of the Department of Plant Sciences at the Federal Rural University of the Semi-Arid in Mossoro, RN, from September to December 2008, in soil classified as red-yellow eutrophic Argisol (EMBRAPA, 1999), with chemical characterization shown in Table 1.

Table 1 - Chemical characterization of the soil of the experimental area.

Layer	$pH_{(water)}$	P	K^+	Ca^{2+}	Mg^{2+}	Na^+	Al^{3+}	C	MO
		(mg dm^{-3})	---------- ($cmol_c$ dm^{-3}) ----------					--- (g kg^{-1}) ---	
0-20 cm	7.70	100.29	0.16	3.40	1.00	0.18	0.00	1.75	3.02
20-40 cm	7.70	22.56	0.16	3.10	1.50	0.18	0.00	1.50	2.59

The experimental design was randomized blocks in factorial 3 x 3 with four replications. Each experimental plot consisted of three rows 6.0 m long, spaced in 2.0 m between rows, totaling 36 plants. The useful area per plot was 10.0 m^2, corresponding to 10 plants of the central row, disregarding the two plants in the extremity, which were also considered borders, as well as the sidelines of the plot.

The treatments were formed by the combination of two factors: color of polyethylene mulches (black, white and silver) and polypropylene usage times (new, reused once and reused twice).

The polyethylenes used as mulching had the following specifications: 5.25 mm thick, 480 g m^{-2} grammage and 1.2 m wide. The low density polypropylene had white color, 15 g m^{-2} grammage and was 1.20 m wide.

In the soil preparation were performed plowing, gradation and furrows of 0.30 m depth to perform the planting fertilization, which was based on soil analysis. Organic fertilizer, 10 t ha^{-1}, and 500 kg ha^{-1} of the commercial formulation N-P_2O_5-K_2O 06-24-12 were applied in the furrow. Then took place the closing of the grooves and preparation of ridges. The polyethylenes were placed on the soil and subsequently drilled at a spacing of 0.50 m.

Seeds were sown directly in the field using the cultivar Mickylee. Then, it was extended the polypropylene, which remained for 31 days, until early flowering.

Dripping irrigation was performed, with emitters spaced at 0.5 m and 1.6 L h^{-1} flow, and the irrigation levels were estimated to meet the crop evapotranspiration, making use of the weather data from weather station located 2 km far, during the complete cycle it was applied a 302 mm irrigation level.

They were applied by fertigation 142 kg ha^{-1} N, 34.6 kg ha^{-1} P_2O_5 and 135 kg ha^{-1} K_2O, in the form of

urea, calcium nitrate, nitric acid, monoammonium phosphate, phosphoric acid and chloride potassium. As a source of micronutrients was applied, via foliar, at 38 days after sowing (DAS), 0.6 kg ha^{-1} of the commercial formulation containing 5.0% B, 1.5 Cu, 4% Fe, 5.4 Mg, 4.0% Mn, 0.1% Mo, 3.0% S and 1.5% Zn.

The harvest of the fruits started at 62 DAS, with transfer at every seven days, totaling three harvests, being evaluated the following variables: number of fruits per plant (NFP), mass of marketable fruits (MF), commercial fruit productivity (CP), non-commercial productivity (NCP), total productivity (TP), soluble solids (SS) and titratable acidity (TA).

Data were subjected to analysis of variance, with means compared by the SNK test at 5% probability, using the SISVAR program.

Results and discussions

Significant effect was observed ($p<0.01$) in the interaction between the factors of color of mulches and polypropylene usage time for the commercial productivity (CP) and total productivity (TP) variables. As for there was effect to the isolated factors only of the polypropylene usage time for the variables CP, TP, NFP and SS (Table 2).

Table 2 - Summary of the analysis of variance of the characteristics commercial productivity (CP), non-commercial productivity (NCP), total productivity (TP), number of fruits per plant (NFP), mass of fruits (MF), soluble solids (SS) and titratable acidity (TA) of watermelon fruit, Mickylee cultivar.

Sources of Variation	[1]DF	CP	NCP	TP	NFP	MF	SS	TA
Block	3	4.942^{ns}	1.453^{ns}	4.545**	2.153^{ns}	1.739^{ns}	4.762**	1.493^{ns}
Mulching (M)	2	0.129^{ns}	0.525^{ns}	0.594^{ns}	0.450^{ns}	1.208^{ns}	0.464^{ns}	0.061^{ns}
Polypropylene(P)	2	8.240**	0.098^{ns}	9.970**	5.355**	0.361^{ns}	3.036**	0.393^{ns}
M x P	4	6.638**	1.269^{ns}	8.519**	1.536^{ns}	0.483^{ns}	0.402^{ns}	0.119^{ns}
CV (%)	-	7.29	82.04	6.31	10.68	8.44	3.82	11.76

[1] Degree of freedom; * significant at 0.05; ** significant at 0.01; ^{ns} non-significant.

Analyzing the unfolding of the interaction of color of mulches in the polypropylene usage time factor, it was observed a higher productivity (CP) with the use of mulching in white and black, associated with the new polypropylene. These combinations afforded increase of 12.1 and 18.6% respectively for silver mulching (Table 3). Similar results were observed by Negreiros et al. (2005) and Medeiros et al. (2007), in experiments with types of mulching (black and silver) with the culture of melon in the conditions of Mossoró-RN. According to Ghosh et al. (2006), the soil cover, regardless of the color of the mulch, promotes an increase in crop yield components compared to bare ground, being therefore widely used in agriculture.

In polypropylene reused once, the largest CP were obtained from the silver and white mulching, with no differences between them, they had an increasing average of 16.4% compared to the treatment with black mulching. In polypropylene reused twice, there was no significant difference between the colors of mulching, with an average CP of 75.74 t ha^{-1}. A reduction of 5.53% CP was observed when polypropylene was reused once, and of 12.2% CP when it was reused for the second time (Table 3).

For the unfolding of the polypropylene usage time factor interaction within the mulching factor, there was a significant effect for CP when using the black and white mulches. For white mulching, there was a reduction in productivity of 14.4% from the second reuse. For black mulching, it was found, on average, higher CP with the use of the new polypropylene (92 t ha^{-1}), however, there was a reduction in the average CP of 21.2% and 18.2% compared with polypropylene reused once and twice respectively.

With respect to TP, it was observed a result similar to CP, being explained by the fact that the TP results from the summation of and NCP and CP and there was no significant effect for the NCP (Table 3). Probably, this reduction in productivity was due to the higher incidence of pests in treatments that reused polypropylene, since these used to get threadbare with longer usage, enabling with this the pest entry since the beginning of the crop cycle, while the treatments that used the new polypropylene did not suffer this incidence

Thus, considering the high productivity of watermelon and the value of the fruit (R$ 0.30 to 0.70 per kg), variable with the time of year, any increase in productivity generates higher revenues to producers. Therefore, the recommendation to reuse or not the polypropylene on the farm should be evaluated carefully in each case, taking into account the following criteria: availability or not of new polypropylene, cost of polypropylene, value per kg of fruit paid to the producer, cost of each type of mulching and productivity goal to be achieved by the producer.

For the NFP, it was noted that with the use of the new polypropylene there was an increase of 13.1% compared to the average of reused polypropylenes (Table 4). For the MF, there was no difference between the tested factors, being verified great uniformity to this feature, which can be an attribute of the cultivar. MF was 4.2 kg, being within the range of mass required for the export market (2.3 to 6.0 kg).

Table 3 - Non-commercial fruit productivity (NCP), commercial productivity (CP), total productivity (TP) of watermelon fruit, Mickylee cultivar.

'Mulching'	NCP (t ha^{-1})			CP (t ha^{-1})			TP (t ha^{-1})		
	Polypropylene								
	New	Reused once	Reused twice	New	Reused once	Reused twice	New	Reused once	Reused twice
Silver	2.46 Aa	4.50 Aa	2.95 Aa	77.62 Ba	84.58 Aa	79.76 Aa	80.08 Aa	88.05 Aa	82.71 Aa
White	5.09 Aa	3.62 Aa	2.45Aa	87.04 Aa	84.32 Aa	72.19 Ab	92.13 Aa	87.94 Aa	74.64 Ab
Black	1.07 Aa	2.89 Aa	4.10 Aa	92.09 Aa	72.53 Bb	75.28 Ab	93.16 Aa	75.42 Bb	78.42 Ab
Mean	2.87	3.33	3.15	86.25	80.48	75.74	88.45	83.80	78.59
Reduction (%)	-	-16.02	-9.75	-	-5.53	-12.18	-	-9.93	-14.92

*Means followed by the same capital letter in the column and by the same lower case letter in lines do not differ by SNK test at 5% probability.

Table 4 - Average values of number of fruits per plant (NFP), mass of fruit (MF), soluble solids (SS) and titratable acidity (TA) of watermelon, Mickylee cultivar.

Treatments	NFP (unity)	MF (kg)	SS (ºBrix)	TA (g citric acid 100 mL^{-1} of juice)
Color of mulching				
Silver	1.97 A	4.14 A	10.7 A	0.117 A
White	2.04 A	4.10 A	10.6 A	0.115 A
Black	1.97 A	4.30 A	10.5 A	0.117 A
Reuse of polypropylene				
New	2.15 A	4.12 A	11.0 A	0.117 A
Reused once	1.92 B	4.24 A	10.5 AB	0.114 A
Reused twice	1.90 B	4.16 A	10.4 B	0.119 A

Means followed by the same capital letter in the column do not differ by SNK test at 5% probability.

For the soluble solids content, it was observed only effect of the polypropylene usage time factor, being the new and the reused once those which provided higher values when compared to reused twice. This decrease in soluble solids content in the reused twice can be attributed to the entry of pests, due to the polypropylene wastage, resulting in the onset of cracks, as the polypropylene has been exposed to sun, wind, and in the withdrawal, during the flowering stage of previous crops.

Average of 10.6ºBrix was observed in soluble solids (SS) content, demonstrating that all treatments showed fruits with SS suitable for export, since the requirement of this market is for fruits with at least 9.0ºBrix.

Regarding the color of mulching factor in the SS variable, there was no significant effect. However, all colors of mulching provided SS equal or superior to 10.5 ºBrix. In the melon crop, Araujo (2000), Câmara et al. (2007) and Dantas et al. (2013) found no influence of cover crops on the soluble solids content. The factors tested showed no effect on titratable acidity (TA), thus had generally mean value of 0.117, which is consistent with those found by Proietti et al. (2008) and Szamosi et al. (2007), who obtained titratable acidity values in watermelon between 0.06 and 0.11%.

Conclusions

The new polypropylene provides greater number of fruits per plant and productivity of commercial fruits

The reuse of the polypropylene once and twice provides fruits with a higher content of soluble solids.

The use of polypropylene favors productivity and quality of "Mickylee" watermelon.

Different colors of plastic mulches do not interfere with productivity and quality of "Mickylee" watermelon.

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