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Yield and quality in 'Caipira' melon in fertilization function

Produtividade e qualidade de melão 'Caipira' em função da adubação

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A R T I G O

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A B S T R A C T

The aim of this work was to evaluate the effect of different fertilizations and ground cover in the yield and quality of the fruits of irrigated 'Caipira' melon fruits (*Cucumis melo* var. acidulus) in tropical semiarid conditions. The experimental design was a randomized block design in a 3x2 factorial arrangement, with three replications. Three fertilization managements were compared (F1 - only mineral fertilization in the foundation, F2 – mineral and organic fertilization in the foundation, F3 - mineral fertilization in the foundation and leaf fertilization) under bare soil conditions and covered with black mulching. Five useful plants were evaluated per plot. The amount of mineral fertilization recommended for cultivation (40 kg ha^{-1} of Nitrogen, 120 kg ha^{-1} of P_2O_5 and 40 kg ha^{-1} of K_2O) was applied in the plots. The fruit average weight – FAW (kg), yield - Y ($t.ha^{-1}$), fruit length – FL (cm) and diameter - FD (cm), fruit pulp thickness - FPT (cm), fruit cavity diameter – FCD (cm) and total soluble solids – SS (°Bx) were evaluated. A comparison of the means between fertilization and soil cover was done using the Tukey test with 5% probability. The use of mineral fertilization associated with the organic at the foundation provided superior results for the variables analyzed, except for the SS and FCD. The use of mulching was responsible for increasing the FAW, Y and SS in the melon.

Palavras-chave:
Cucumis melo var Acidulus
Mulching
Adubação orgânica

R E S U M O

Objetivou-se com este trabalho avaliar o efeito de diferentes adubações e coberturas do solo na produtividade e qualidade dos frutos de melão 'Caipira' (*Cucumis melo* var. acidulus) irrigado em condições semiáridas tropicais. O delineamento experimental utilizado foi em blocos ao acaso em arranjo fatorial 3x2, com três repetições. Foram comparados três manejos de adubação (F1 - Somente adubação mineral em fundação, F2 - adubação mineral mais orgânica em fundação, F3 - adubação mineral em fundação mais adubação foliar) em condições de solo descoberto e coberto com mulching preto. Avaliaram-se cinco plantas úteis por parcela. Em todas as parcelas foi aplicada em fundação a quantidade da adubação mineral recomendada para a cultura (40 kg ha^{-1} de Nitrogênio, 120 kg ha^{-1} de P_2O_5 e 40 kg ha^{-1} de K_2O). Avaliou-se a massa média de fruto (kg), produtividade ($t.ha^{-1}$), comprimento e diâmetro dos frutos (cm), espessura da polpa (cm), cavidade interna (cm) e sólidos solúveis totais (°Brix). Realizou-se a comparação das médias entre as adubações e coberturas do solo a partir do teste de Tukey com 5% de probabilidade. O uso de adubação mineral associada à orgânica em fundação proporcionou resultados superiores para as variáveis analisadas, exceto para sólidos solúveis totais e cavidade interna do fruto. O uso de mulching foi responsável por elevar a massa média dos frutos, a produtividade e o teor de sólidos solúveis totais do melão 'Caipira'.

INTRODUCTION

The world melon production in 2016 it surpassed the 31 millions of tons, China is being the responsible for 51.37% of the total and Brazil was responsible for only 1.91%. In 2016, melon was the most exported fruit in Brazil, 233.7 thousand tons in total. The States of Ceará and Rio Grande do Norte are the biggest producers of melon in the country, accounting for 76% of production (FAO, 2018; IBGE, 2018).

The 'Caipira' melon (*Cucumis melo* var. Acidulus) is characterized by its accented aroma and flavor, besides the good acceptance by the consumer market (SOUSA et al., 2017).

The melon culture has aroused the crescent interest in the Brazilian semiarid region, however still are few searches about mineral nutrition of the 'Caipira' melon. To achieve the elevated yield and fruits with quality is necessary the knowledge of the nutritional requirements of the melon culture (MEDEIROS et al., 2008; FERREIRA et al., 2011).

There is demand for research that recommends efficient ways to manage the fertilization and irrigation that contribute to increasing the yield and quality of the fruits (OLIVEIRA et al., 2008).

Beyond the use of traditional minerals fertilizers, the plants nutritional requirements can be supplied by the organic fertilization. The use of organic fertilizers gets better the chemistry, physics and biologics characteristics of the soil, as well as the cycling of nutrients in the system soil-plant. Therefore, the right use contributes to the increase the cultures production, still acting on the soil quality, the water and the human health improvement (CAMARGO, 2012).

In this regard, many researches (SANTOS et al., 2011; RIBEIRO et al., 2014) have been carried out with a way to minimizing the costs of agricultural inputs by means of using the organic inputs in the soil, making possible define the appropriate doses, the frequency and the time of applications, beyond its effects in the final product characteristics.

Among the technologies that can contribute to the quality improvement of the vegetable products, there is the foliar fertilization. This practice has the function of complement and corrects the possible failures on the fertilization by soil, in addition to physiological stimulation in certain phases of culture; its utilization has shown positive responses in many olericulos (LUZ et al., 2010).

Besides the fertilization management, the use of mulching as the vegetal cover has been widespread in the world agriculture and in Brazil, with expressive gains on yield and reduced production costs, being used organic or synthetic materials (BRAGA et al., 2010; BRAGA et al., 2017).

Based on the above considerations, the aim of this work was evaluate the effect of different fertilization and soil cover about yield and quality of 'Caipira' melon irrigated in semiarid climate conditions.

MATERIAL AND METHODS

The experiment was conducted between the months of July and September of 2015, in the Center of Agrarian Science and Biodiversity (CCAB) of Cariri Federal University (UFCA), located in the municipality of Crato, south of Ceará State (07°14'02" S e 39°24'32" O), average altitude of 426 m and tropical humid climate (Aw) according to classification of Köppen. The soil of the experimental area is classified as Podzolic Red-Yellow Eutrophic, according to the classification of the Funceme map of soils (2014).

The experimental delineation adopted was in casualized blocks (DBC) in factorial scheme 3x2, with three replicates, totalizing 18 observations. The first factor was three managements in fertilization: F1 – mineral fertilization in the foundation; F2 – mineral and organic fertilization in the foundation; and F3 – mineral fertilization in the foundation plus leaf fertilization. The second factor were two soil coverages: C1 – black mulching, e C2 - soil without vegetation.

The seedlings were produced by sowing in pits, of commercial cultivar Topseed® 'Caipira' melon. To guarantee the desired amount of plants, on the eighth day after sowing, replanting was carried out in the pits where no seedlings appeared. Only one plant per well was maintained, and the roughing of the surplus plants was carried out 15 days after sowing (DAS).

The experimental plots measured 6.3 m², 3.6 m long by 1.8 m wide, containing seven plants spaced apart for 0.45 m between and 1.90 m between lines, the five central plants was considered the useful area of plots, with 4.75 m^2.

The analysis of the soil in the area before the implantation of the experiment, and the interpretation of the results, was performed for an adequate supply of fertilizer necessary to the crop. In the whole experimental area, the mineral fertilization was carried out in the foundation, according to recommendations for the crop, with doses applied based on the soil analysis, being: 40 Kg ha^{-1} of Nitrogen (89 kg ha^{-1} of urea), 120 kg ha^{-1} of P_2O_5 (667 kg $ha^{-1}$of simple superphosphate) and 40 kg ha^{-1} of K_2O (67 kg ha^{-1} of potassium chloride).

For the fertilizations, F2 and F3 were incorporated bovine manure tanned (4 liters/pit) (Table 1) and leaf fertilizer Nutrichem® (Table 2), respectively. For the plots that received leaf fertilization (F3), the first leaf fertilization was made at 35 DAS being repeated at intervals of 10 days for more two more times. The management of foliar fertilization was performed according to the manufacturer's recommendations and the applied dose was 1% (2 $L.ha^{-1}$), making a volume of mixture per plant of 17.1 mL, without the need to rinse the leaves.

Table 1. Nutritional composition of tanned bovine manure.

Component	Value	Unit
pH (H_2O)	8.25	---
M.O.	100.82	g kg^{-1}
P	5.06	mg dm^{-3}
K^+	0.716	mg dm^{-3}
Na^+	1.08	cmolc dm^{-3}
Ca^{2+}	4	cmolc dm^{-3}
Mg^{2+}	3.9	cmolc dm^{-3}
Al^{3+}	0	---
$H+Al^{3+}$	0.49	cmolc dm^{-3}
CE	5.48	$dS.m^{-1}$
CTC	10.18	cmolc dm^{-3}
SB	9.69	cmolc dm^{-3}
V	95.1	%

For the plots that the soil stayed uncovered (C2), was used banana straw on the central band of the beds in the period comprised between the sowing and germination, the measure kept the soil moisture and it favored the seeds germination. At 36 DAS, calcium and boron nutrients were applied to all plants to meet their deficiency, applications were repeated at 07 day intervals for three more times. CAB Max® fertilizer (Ca 8% and B 2%) was used in a dose of 0.3% (4 $L.ha^{-1}$) with 114 mL volume of mixture per plant, without rinse the leafs.

Table 2. Leaf fertilizer composition

Nutrient	Composition	Nutrient	Composition
N (5.0%)	67.5 g/l	Cu (0.2%)	2.7 g/l
P_2O_5 (8.0%)	108.0 g/l	Mn (0.5%)	6.7 g/l
K_2O (5.0%)	67.5 g/l	Zn (0.1%)	13.5 g/l
Mg (0.6%)	8.1 g/l	COT (6.0%)	81.0 g/l
B (0.4%)	5.4 g/l		

Source: Miller Chemical and Fertilizer Corporation, 2015.

The irrigation system used was drip irrigation, with use of drip tape for the distribution with emitters spaced at 30 cm and flow of 1.6 $L.h^{-1}$ with pressure of 1 bar; the irrigation time was 2 hours and the irrigation time was 24 hours.

The harvest was made when the fruits reached the 50% change in color from dark green to light yellow, the indicative point of fruit harvest. The harvest occurred in five steps, the first one was made at 65 DAS and the last one at 80 DAS, in 3 days intervals.

The analysis after harvest was realized at the Laboratory of Product Technology of the Center for Agrarian Sciences and Biodiversity of UFCA. Was evaluated the fruit average weight – FAW (kg) in semi-analytical balance to obtain the full yield – Y ($t.ha^{-1}$) from the conduction of two fruits per plant.

With the aid of a digital caliper, the fruit length – FL (cm) and fruit diameter - FD (cm), the fruit pulp thickness – FPT (cm) measured in the equatorial region, after sectioning in the longitudinal direction the intern fruit cavity diameter - FCD (cm) measured in the transversal direction in the equatorial region. Determinate the total soluble solids - SS (cm) of two representative fruits for a plot with the aid of a portable refractometer.

The statistical analyses were made using the SISVAR software, for the ANAVA procedure. It was realized the comparison of the means of fertilization and coverage by the Tukey test at 5% of probability.

RESULTS AND DISCUSSIONS

According to the observed results, it was found that the values of coefficient of variation (CV) varied from low to medium according to the Sample Quantities (SQ) for the analyzed variables, given greater precision to the results. As described in table 3, for the fruit diameter (FD), was verified the presence of statistical significance for the fertilization factor at the 1% level and the equality for the coverage factor at the levels evaluated by the Tukey test.

Table 3. Synthesis of the analysis of variance and the test of averages for fruit diameter (FD), fruit length (FL), fruit average weight (FAW) and yield (Y)

Treatments	FD (cm)	FL (cm)	FAW (kg)	Y ($t.ha^{-1}$)
Fertilization (F)				
F1	9.80 b	17.83 b	0.99 b	23.20 b
F2	11.03 a	22.10 a	1.47 a	34.60 a
F3	10.76 a	19.28 ab	1.10 b	25.30 b
Coverage (C)				
C1	10.66	20.59	1.33 a	31.30 a
C2	10.41	18.87	1.03 b	24.10 b
TEST F				
F	10.81^{**}	8.23^{**}	25.58^{**}	25.58^{**}
C	1.20^{NS}	3.95^{NS}	27.21^{**}	27.21^{**}
F*C	4.24^{*}	0.43^{NS}	2.58^{NS}	2.58^{NS}
CV%	4.56	9.31	10.52	10.52

F1: Mineral fertilization in the foundation; F2: Mineral fertilization plus organic in the foundation; F3: Mineral fertilization in foundation plus leaf fertilization; C1: Mulching coverage; e C2: Soil without vegetation. The averages followed by the same lowercase letter in the column do not differ from each other by the Tukey test at 5% probability.**: significant (P<0.01); *: significant (P<0.05); NS: Not significant (P>0.05); CV%: Coefficient of variation.

In contrast, it was observed that there was a significant interaction between the factors that was evaluated in this study at the level of 5%, the unfolding of the interaction with the results are presented in the table 4.

Table 4. The interaction of fertilization and coverage factors on the fruit diameter (FD)

Fertilization	Coverage	
	C1	C2
F1	10.4 a A	9.20 b B
F2	11.0 a A	11.1 a A
F3	10.6 a A	10.9 a A

F1: Mineral fertilization in the foundation; F2: Mineral fertilization plus organic in the foundation; F3: Mineral fertilization in foundation plus leaf fertilization; C1: Mulching coverage; and C2: Soil without vegetation. The averages followed by the same lowercase letter in the columns and upper case in the lines do not differ statistically from each other according to the Tukey test at 5% probability.

Table 4 shows that there was no statistical difference for fruit diameter (FD), using F1, F2 and F3 fertilizer with mulching (C1), but in the absence of cover (C2), fruits with larger diameter were obtained from fertilization with bovine manure (F2) and foliar fertilization (F3), while only the use of mineral fertilization (F1) produced smaller fruits.

When analyzing the behavior of the cover factor within the fertilization factor for the variable FD (Table 4), it was observed that fertilization with bovine manure (F2) and foliar fertilization (F1) presented similar results ($p > 0.05$) for both the levels of the cover factor, however, the use of mulching is beneficial when using only mineral fertilization.

For the fruit length (FL), it was not found the significant interaction and statistical meaningfulness to the coverage factor for the Tukey test at 5% probability (Table 3). For the fertilization factor, it was observed a significant difference.

For the fertilization factor, a significant difference ($p < 0.01$) was observed, one of the best results provided by bovine manure supplementing the mineral fertilization (F2), differing from mineral fertilization (F1), which expressed the lowest values for this variable. The mineral fertilization added foliar fertilization (F3) obtained intermediate results, being statistically the same as the others

The fruit average weight (FAW) and the yield (Y) of 'Caipira' melon for being correlated variables that present equality statistics meaningfulness at 1% level to both analyzed factors (Table 3). For the first factor (fertilization), the mineral fertilization plus organic was superior to the others that behave statistically equals. It was observed that the addition of 4 L per pit of cattle manure (F2), promoted an increased by about 32.7% in FAW and consequently in Y ($t.ha^{-1}$) in relation to only mineral fertilization, showing that mineral fertilization plus organic fertilization increases the FAW.

These data in contrast the obtained results by Ribeiro et al. (2014), by standing that the use of organic fertilization do not provides any immediate earnings to the Y ($t.ha^{-1}$) and the FAW (kg). The authors justify that the short cycle of the melon plant is insufficient to the organic matter decomposition and the use of nutrients for the plants. Zavattaro et al. (2017) observed that a positive effect of long-term manure with bovine manure occurs and therefore, the best results are obtained with long cycle crops. The authors also note in their findings that the C and N gains from the crops, with mineral fertilization combined with cattle manure, are similar to the gains obtained only with the use of cattle manure, indicating, therefore, that the capacity of the manure to replace mineral fertilizers.

For the soil coverage, it is verified that the use of mulching showed up more satisfactory than the soil without vegetation, for the increase the FAW and the Y of about 23.0% (Table 3).

It is observed in Table 5 that the total soluble solids (SS) found in the fruits did not differ statistically ($p > 0.05$) for the fertilization factor. For the coverage factor, we noticed the occurrence of statistical difference ($p < 0.05$), the soil covered with mulching produced the highest values of SS (°Bx). The values found in this research for SS were lower than those required by the national and international consumers markets, which are 8° and 10°Bx, respectively. But some management practices for this purpose may have positive effects for this characteristic.

The fruit pulp thickness (FPT) related to the fertilization demonstrates the statistical meaningfulness at 1% level (Table 5), the fertilization F1 and F3 are show statistically equals and lower than the fertilization F2 that has the best results. For soil cover, there was no significant difference for fruit pulp thickness. In the fruit cavity diameter (FCD) we observed statistics similarity to the fertilization factors. There was no significant interaction between the factors by the Tukey test at 5% of probability.

Table 5. Synthesis of the analysis of variance and the mean test for total soluble solids (SS), fruit pulp thickness (FPT) and fruit cavity diameter (FCD)

Treatments	SS (°Bx)	FPT (cm)	FCD (cm)
Fertilization (F)			
F1	5.10	2.42 b	5.37
F2	5.30	3.26 a	5.87
F3	5.20	2.79 b	5.32
Coverage (C)			
C1	5.60 a	2.82	5.35
C2	4.80 b	2.82	5.68
TEST F			
F	0.19^{NS}	14.19^{**}	2.3^{NS}
C	5.12^{*}	0.003^{NS}	2.0^{NS}
F*C	2.23^{NS}	1.06^{NS}	0.26^{NS}
CV%	13.92	9.68	8.88

F1: Mineral fertilization in the foundation; F2: Mineral and organic fertilization in the foundation; F3: Mineral fertilization in foundation plus leaf fertilization; C1: Mulching coverage; and C2: Soil without vegetation. The averages followed by the same lower case letter in the columns and upper case in the lines do not differ statistically from each other according to the Tukey test at 5% probability.**: significant (P<0.01); *: significant (P<0.05); NS: not significant (P>0.05); CV%: coefficient of variation.

The results found for FL and FD reinforce that found by Santos et al. (2014), in which organic fertilization led to larger fruits in length and diameter, compared to only mineral fertilization, and contradicts the results obtained by Amariz et al. (2009) that show significant influence on the soil cover types in the length and diameter of the melon fruits. It is possible that the results of this study are related to the ability of organic matter to improve soil properties, leading to improved plant development (Silva et al., 2011), as well as the ability to reduce plant water consumption and soil moisture losses, as well as attenuating the negative effects of soil acidity and alkalinity (ALVES et al., 2009; FREIRE et al., 2011).

For Oliveira et al. (2010), in his study with okra, submitted to fertilization with bovine manure with and without mineral fertilization, attributes the increase of fruit yield, good quality of manure combined with the adequate amount of application, which offers gradually mineral elements, as the mineralization of organic matter occurs, thus supplying the plants in macronutrients.

Souza et al., (2018) when studying melon plants submitted to mineral fertilization and organic fertilization, both combined and used separately, the dry matter yield of leaves, stems, fruits and shoots of melon plants was not affected, however, the application of bovine manure increased the availability of the organic forms of nitrogen in the soil. Similarly, Irineu et al. (2018) observed a significant effect on the application of enriched bovine biofertilizer, on the number of seeds and weight of 100 seeds, attributing these gains the availability of nutrients supplied to the soil by the biofertilizer, as well as the adequate supply of the plants.

It is still noticeable, that the biggest FAW found in this study was 31% superior to the best result found by Viana et al. (2007) that evaluated different doses of potassium in melon cultivar Bonus 2.

This study verified increments in Y and FAW in the presence of mulching and this data contradict the found by Câmara et al. (2007) and Braga et al. (2010) which observed for the fruit average weight and yield, respectively, the absence of effect among the types of soil cover in the cultivation of yellow melon. Braga et al. (2017) evaluating mulching (black polyethylene) and uncovered soil for yellow melon hybrids, didn't observe significant differences for the fruit average weight and yield, thus, the results obtained in this study, show that there is an increase in the 'Caipira' melon (FAW and Y) with soil covered (mulching).

The best Y obtained in this study was higher than the national, northeastern and Ceará average to the melon culture, that are respectively 26.8; 29.0 and 30.2 t per hectare according to the Brazilian Institute of Geographic and Statistics (IBGE, 2018). Comparing the obtained data to the mineral fertilization plus organic (F2) and the mulching coverage (C1), there was an increase in 4.4 e 1.1 $t.ha^{-1}$, respectively, in relation to the average yield in the state of Ceará.

The SS data studied contrasted with the hypothesis of Ferreira et al. (2001) and Araújo et al. (2000), the authors concluded that the total soluble solids is not influenced by the soil cover types (polyethylene and uncovered). However, they do not agree with the results obtained by Monteiro et al. (2007), who, studying the productivity and quality aspects of the melon submitted to the effects of plastic mulch, observed that there was a significant influence of the plastic covering on the Y, FAW, FL and FD, at the 1% level of significance. SS and FPT to the 5% level.

Because the 'Caipira' melon is still a variety less studied, it can be attributed to the low values of the content of the SS to three hypotheses:

The first one justified on the absence of more effective control of irrigation in the two weeks that preceded the harvest. Filgueira (2009) affirms that the water excess in the soil can decrease the fruit SS and its quality.

The second hypothesis is in function of the necessity of potassium fertilization increase, this nutrient has a relevant importance in the production and, principally, in the quality of melon fruits, since this element performs an important function in the synthesis and degradation of starch and in carbohydrate translocation (MEDEIROS et al., 2008; SILVA et al., 2014), being this way strictly related to the increase in the fruit content of sugars.

The third hypothesis attributes to the used variety the feature of low values to the SS. However, is not found in the work literature and/or agronomic characterization of the studied variety.

The data found for the FPT in this search corroborate with the obtained data by Santos et al. (2011) and Santos et al. (2014) who found the largest pulp thickness in the melons that was cultivated with organic fertilization compared to the mineral fertilization.

For the coverage of the soil, there was no significant difference in the FPT, corroborating to Câmara et al. (2007) who, when studied the yellow melon was cultivated in the same types of coverage that was used in this present study, verified that there was no significant influence of this variable.

CONCLUSIONS

The use of mineral fertilization in foundation together with the organic fertilization provided the best results to the yield but do not elevate the total soluble solids content of the fruits. The use of mulching in the soil was efficient to elevate the fruit average weight, the yield and the total soluble solids content of the 'Caipira' melon fruits.

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