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Full Length Research Paper

Calcified seaweed in production and fruit quality of 'Ponkan' tangerine tree

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Abstract

The study was conducted to evaluate the influence of calcified seaweed in production and fruit quality of 'Ponkan' tangerine. It was performed from December 2009 to June 2010 in an unirrigated commercial orchard, at Perdões, southern Minas Gerais, Brazil, at 21 ° 05' 27 "(S) and 45 ° 05' 27" (W).The experiment was conducted in a 4x2 factorial arrangement in a randomized block design with three replications and four plants per plot, with the two central plants evaluated. The treatments were four levels of calcified seaweed (0.0, 0.3, 0.6 and 1.2 kg plant^{-1}) applied to the soil in the canopy projection, combined with leaf application of two concentrations (0 and 5% of calcified seaweed) which was diluted in a backpack sprayer motor 20 L. The applications were split in December 2009 and March 2010. It was observed effect of calcified seaweed applied to soil in transverse diameter, longitudinal diameter, mass, acidity and soluble solids / acidity ratio. Regarding production, productivity, juice yield and soluble solids evaluated in 'Ponkan' tangerines no significant differences were observed with the application of calcified seaweed. The calcified seaweed applied to the leaves was not significant in the evaluated characteristics.

Keywords: *Citrus reticulata* Blanco, calcareous algae, *Lithothamnium*, marine bioclasts, nutrients.

INTRODUCTION

The 'Ponkan' (*Citrus reticulata* Blanco) is one of the most popular and appreciated tangerines for *in natura* consumption and for industrial processing in Brazil. Thus, its internal and external characteristics, such as size, juice yield, titratable acidity, soluble solids and soluble solids / acidity ratio, are considered in order to have better appearance and quality of fruits (Ramos et al, 2009).

However, most soils cultivated with *Citrus* plants in Southeastern of Brazil has high acidity, toxic levels of aluminum, low cation exchange capacity and low concentrations of bases, which may affect the production and fruit quality of 'Ponkan' tangerine. In order to solve this problem the application of calcified seaweed (*Lithothamnium* sp) can contributes to improved physical, chemical and microbiological characteristics of soil (Dias, 2000), including correction of acidity (Melo and Furtini Neto, 2003).

The addition of calcified seaweed in substrate cultivation has shown satisfactory results in the growth of 'Swingle' citrumelo (Araújo et al., 2007), 'Cleopatra' tangerine (Cruz et al., 2008), papaya (Hafle et al., 2009) and passion fruit (Souza et al., 2009).

The study was conducted to evaluate the influence of calcified seaweed in production and fruit quality of 'Ponkan' tangerine.

MATERIAL AND METHODS

The experiment was conducted from December 2009 to June 2010 in an unirrigated commercial orchard, at Perdões, southern Minas Gerais, Brazil, at 21 ° 05' 27 "(S) and 45 ° 05' 27" (W). The type climate is Cwb, according to Köppen classification, with hot, humid summers and dry, cold winters. The variations in the maximum temperature, minimum temperature, average temperature, precipitation and relative humidity were recorded during the evaluation period in Table 1.

The examined 'Ponkan' tangerine trees (*Citrus reticulata* Blanco) were thirteen years old. The trees were

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Table 1. Monthly means of maximum temperature (MaT), minimum temperature (MiT), mean temperature (MeT), precipitation (PR) and relative humidity (RH) during the experimental period

Months	MaT (℃)	MiT (℃)	MeT (℃)	PR (mm)	RH (%)
Dec. 2009	28,2	18,7	22,4	382,5	80
Jan. 2010	30,7	19,0	24,0	107,5	72
Feb. 2010	31,1	18,9	23,9	68,5	69
Mar. 2010	29,7	18,3	23,4	97,7	73
Apr. 2010	28,0	16,4	21,0	51,4	69
May 2010	25,9	13,5	18,5	10,4	59
June 2010	24,0	10,5	16,1	3,4	69

Table 2. Summary of analysis of variance for (DT) transverse diameter (mm), (DL) longitudinal diameter (mm), (MA) mass (g), (JY) juice yield (%), (SS) soluble solids (°Bx), (TA) titratable acidity (%), (SS/TA) soluble solids / acidity ratio, (PD) production (boxes of 22kg per plant) and (PT) productivity (t ha^{-1}) of 'Ponkan' tangerine tree submitted to the application of calcified seaweed in soil (S) and leaves (L)

ANOVA	DT	DL	MA	JY	SS	TA	SS/TA	PD	PT
Soil	38,74*	19,40*	1360,73*	$10,95^{ns}$	$0,60^{ns}$	0,44*	27,08*	$0,18^{ns}$	$27,50^{ns}$
Leaves	$1,38^{ns}$	$2,36^{ns}$	$19,87^{ns}$	$0,02^{ns}$	$1,17^{ns}$	$0,03^{ns}$	$7,04^{ns}$	$0,38^{ns}$	$55,90^{ns}$
SxL	$19,30^{ns}$	$2,22^{ns}$	$190,20^{ns}$	$56,62^{ns}$	$0,12^{ns}$	$0,01^{ns}$	$4,81^{ns}$	$0,5^{ns}$	$75,74^{ns}$
Blocks	$19,39^{ns}$	$1,67^{ns}$	$125,90^{ns}$	$71,67^{ns}$	$0,14^{ns}$	$0,01^{ns}$	$0,79^{ns}$	$1,33^{ns}$	$198,66^{ns}$
Error	12,77	8,25	485,07	27,98	0,60	0,01	3,83	1,08	162,75
CV(%)	4,5	4,2	10,4	14,7	5,6	15,2	11,3	36,0	36,0

*Significant; ns not significant (p<0.05)

cultivated with a spacing 6 m x 3 m, grafted on 'Rangpur' lime (*Citrus limonia* Osbeck).

Soil physicochemical properties were measured for the 0-0.2 m: pH = 5.00; P = 3.19 mg dm^{-3}; K = 104.00 mg dm^{-3}; Ca = 1.10 Cmolc dm^{-3}; Mg = 0.40 cmolc dm^{-3}; Al = 0.80 cmolc dm^{-3}; H-Al = 5.22 cmolc dm^{-3}; soil base saturation = 25.28%; B= 0.70 mg dm^{-3}; Zn = 0.70 mg dm^{-3}; Cu = 6.20 mg dm^{-3}; Fe = 72.30 mg dm^{-3}; Mn = 29.30 mg dm^{-3}; S = 75.00 mg dm^{-3} and organic matter = 2,01 %.

The calcified sewed applied contained 46.27% CaO, 33.05% Ca, 4.23% MgO, 2.54% Mg, 99.26% of reactivity; 2.0 mg kg^{-1} Cu; 259.9 mg kg^{-1} Mn; 10.90 mg kg^{-1} Zn, 2.6 g kg^{-1} Fe; 101.90 mg kg^{-1} B, 0.78 g kg^{-1} P and 6.90 g kg^{-1} K.

The experiment was conducted in a 4x2 factorial arrangement in a randomized block design with three replications and four plants per plot, with the two central plants evaluated. The treatments were four levels of calcified seaweed (0.0, 0.3, 0.6 and 1.2 kg $plant^{-1}$) applied to the soil in the canopy projection, combined with leaf application of two concentrations (0 and 5% of calcified seaweed) which was diluted in a backpack sprayer motor 20 L. The applications were split in December 2009 and March 2010.

At harvest time, in June 2010, leaf samples were taken in productive branches for leaf analysis, the production was evaluated (boxes of 22 kg per plant), the productivity was estimated (t ha^{-1}) and twenty fruits per plot located in the middle part of the crown were randomly picked to evaluate transverse diameter (mm), longitudinal diameter (mm), mass (g), juice yield (%), titratable acidity (%), soluble solids (°Bx) and soluble solids / acidity ratio.

Data were subjected to analysis of variance and regression (p<0,05).

RESULTS AND DISCUSSION

There was no interaction between calcified seaweed applied to the soil with leaf application for the analyzed variables. The calcified seaweed applied to the soil influenced transverse diameter, longitudinal diameter, mass, acidity and soluble solids / acidity. The calcified seaweed applied to the leaves was not significant in the evaluated characteristics (Table 2).

Regarding production, productivity, juice yield and soluble solids evaluated in 'Ponkan' tangerines no significant differences were observed with the application of calcified seaweed (Table 3). These production values and juice yield were similar to those found by Pio et al. (2006), however the soluble solids were higher than the same authors found that the maximum value of 11.85

Table 3. Production (boxes of 22 kg per plant), productivity (t ha^{-1}), juice yield (%) and soluble solids (°Bx) of 'Ponkan' tangerines depending on the calcified seaweed application (kg $plant^{-1}$)

Calcified Seaweed	Production	Productivity	Juice yield	Soluble solids
0,0	2,7 a	33,1 a	35,1 a	13,6 a
0,3	3,1 a	38,1 a	37,9 a	14,4 a
0,6	2,8 a	34,6 a	35,5 a	13,9 a
1,2	2,9 a	35,6 a	35,1 a	13,8 a
CV(%)	36,05	36,04	14,74	5,59

Mean values followed by the same letters in the column don't differ by 'F' test (p<0,05)

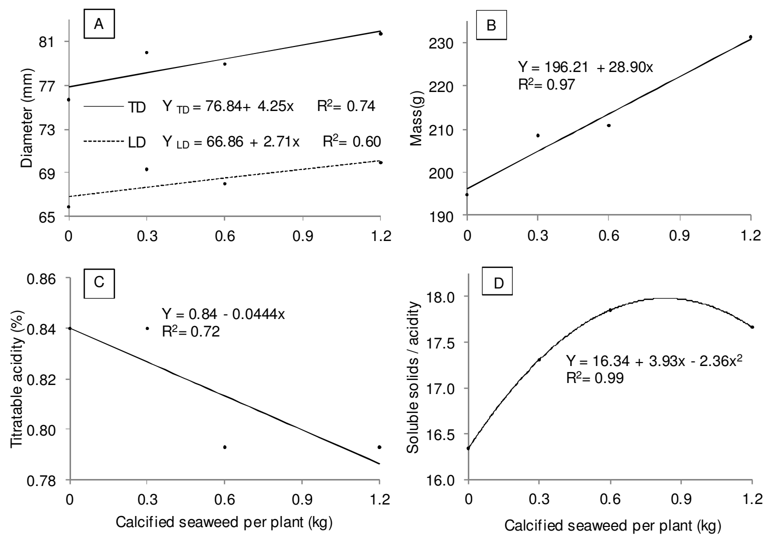

Figure 1. [A] (TD) transverse diameter (mm) and (LD) longitudinal diameter (mm); [B] mass (g), [C] titratable acidity (%) and [D] soluble solids / acidity ratio of 'Ponkan' tangerines depending on the calcified seaweed application (kg $plant^{-1}$)

°Bx. This result can be attributed to low rainfall during fruit maturation (Table 1), which may have caused the concentration of soluble solids content in tangerines because the orchard was not irrigated.

Plants that received application of 1.2 kg of calcified seaweed showed an increase of 6.6%, 8.0% and 17.7% compared to plants without application, on the diameter transverse, longitudinal diameter and mass of fruits, respectively (Figures 1A and 1B). This result can be attributed to the availability of larger quantities of N, K, P and Mg for plants (Figure 2A, 2B, 2C and 2E).

The effect satisfactory of calcified seaweed resembles those obtained in other cultural practices to improve fruit quality, such as increase in fruit size by reducing the number of tangerine per plant (Ramos et al. 2009; Cruz et al. 2010). This suggests that the application of calcified seaweed favors the availability of nutrients to the source by minimizing the competition between the sinks.

Using all the common cultural practices to 'Ponkan' tangerine tree, but irrigation and leaf fertilization, Esposti et al. (2008) obtained fruits with final size of 80 mm diameter and mass 220 g, this values were similar to those obtained with calcified seaweed application of 1.2 kg per plant.

Linear reduction in titratable acidity (Figure 1C) and increased of soluble solids / acidity ratio (Figure 1D) occurred as a function of calcified seaweed applied. Reduction of 6.4% in acidity was observed in the fruit harvested from plants that received 1.2 kg of calcified seaweed compared to fruits of plants without the application (Figure 1C). This result may be attributed to the effect of the calcified seaweed which contributes to the assimilation of nutrients by plants (Day, 2000) and thus favoring the reduction in acidity during ripening of

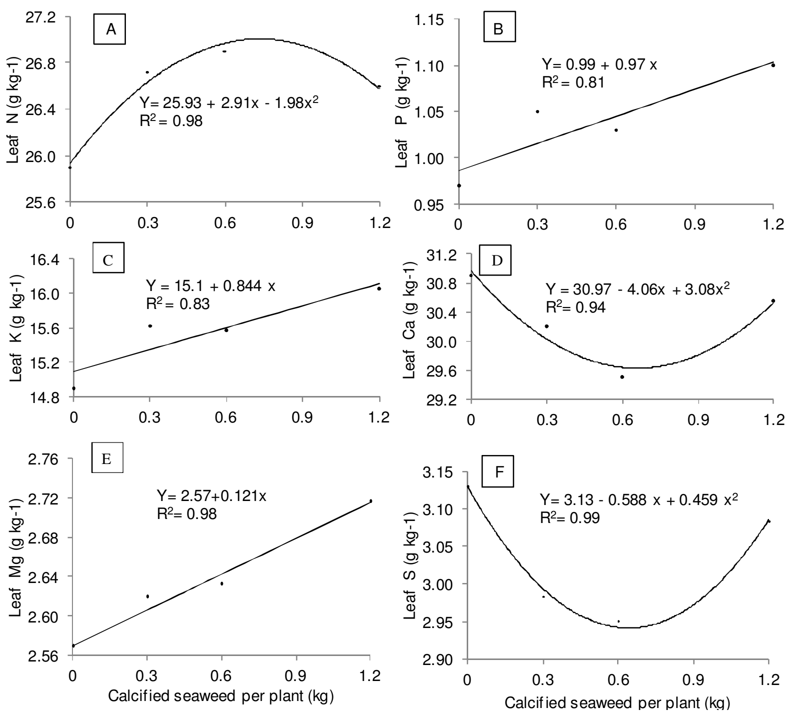

Figure 2. Leaf levels of [A] nitrogen (g kg^{-1}); [B] phosphorus (g kg^{-1}); [C] potassium (g kg^{-1}); [D] calcium (g kg^{-1}); [E] magnesium (g kg^{-1}) and [F] sulfur (g kg^{-1}) of ‘Ponkan’ tangerine trees depending on the calcified seaweed application (kg $plant^{-1}$)

fruits. The highest soluble solids / acidity ratio (17.8) was estimated with 0.83 kg $plant^{-1}$ of calcified seaweed, which occurred due to the reduction in acidity.

The leaf levels of N and S with the application of *calcified seaweed* (Figure 2A and 2F) remained within satisfactory values, suggested by Quaggio et al. (2005) to *Citrus* (23-27 g kg^{-1} of N and 2-3 g kg^{-1} of S). These levels also agreed with those found by Santos et al. (2011) in ‘Ponkan’ tangerine trees using organic waste and chemical fertilizers.

The application of calcified seaweed increased the leaf levels of P and Mg (Figures 2B and 2D), and thus approached the levels considered adequate for this plants (1.2-1.6 g kg^{-1} of P and 2.5-4.0 g kg^{-1} of Mg). This demonstrates the potential of the calcified seaweed to improve the chemical characteristics of soil, favoring the availability of nutrients to plants (Dias, 2000).

The Ca levels (Figure 2D) increased from 0.7 kg $plant^{-1}$ of calcified seaweed, reaching values close to those considered optimum for ‘Ponkan’ tangerine trees (35-45 g kg^{-1}). The increase in nutrient content with application of calcified seaweed was also observed by other authors in bean (Melo and Furtini Neto, 2003). The authors attributed this fact to the increase in the levels of exchangeable Ca and Mg in the soil, caused by *Lithothamnium*, which favored uptake by the root system of the crop.

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