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Liming and Manganese Foliar Levels in Orange

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ABSTRACT

Citrus cultures have a fundamental importance to the Brazilian economy; certain aspects such as plant nutrition, yield, and fruit quality are vital for the citrus industry sustainability. The present study evaluated the nutritional status of manganese in adult Pear orange trees using different lime rates topically applied to the soil. The direct evaluation of lime rates effects on leaf manganese (Mn) levels revealed a decrease of the nutrient correlated to its increased, as well as passage of time between application and measurement. Foliar sampling 30 months after surface lime application evidenced a high correlation of foliar manganese levels with soil base saturation of 10–20 cm. Leaf manganese levels which showed a great probability of high productivity were between 33 and 70 mg kg^{-1}.

Keywords: *Citrus*, plant nutrition, surface liming

INTRODUCTION

Brazil is the largest producer of citrus fruit and juice in the world, with about 1 million hectares of citrus cultivated land (IBGE, 2002). Orange crops specifically account for 50% of the 33 million tons of fruit produced in Brazil (Fernandes, 1998).

One of citriculture's most important aspects is orchard soil conditions, which should contain nutrients in sufficient levels able for assimilation and

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reasonably free from toxic materials and having sufficient physical and chemical properties. The literature contains numerous reports about soil pH influence, and soil acidity negative influence on production and plant nutrition (Andreotti et al., 2000; Gomes et al., 2002; Roque et al., 2004).

Nutrient uptake may have various factors of influence, like soil pH, nutrients acting as same in competition and others (Marschner, 1995).

Among nutrients required by an adult Pear orange, manganese is apart related to other micronutrients, which have their availability affected by liming practice (Pavan and Miyazawa, 1984) because of the occurrence of soil chemical modifications.

Reports in national literature show that liming had an influence over manganese uptake for some annual cultures (Rosolem et al., 2000; Caires and Fonseca, 2000), but in perennial cultures, particularly fruits, there is little information on this point.

Therefore, the present study evaluated increasing manganese (Mn) dosages improving soil acidity correction in adult Pear orange plant nutrition.

MATERIALS AND METHODS

The study was carried out at Citriculture Experimental Station of Bebedouro (EECB) an orchard Pear orange, planted in December 1985, on a Hapluxtox. Surface lime application was in July 1999, with randomized block design using five liming rates (0, 0.552, 1.104, 1.656, and 2.208 t ha^{-1}) and five repetitions. The level of 1.104 t ha^{-1} is recommended to increase the base saturation to 70% (Grupo Paulista de Adubação de Citros, 1996).

The study used lime with PRNT equal to 131%, containing 42% of calcium oxide (CaO) and 25% of magnesium oxide (MgO). Granule size was determined using screens sizes 10, 20, and 50, which amendment was 0, 1, and 9%, respectively.

Lime was hand-applied, on both plant sides, in an area extending 2.5 m from the tree trunk base, completing 5 m width from one row to another. Consequently, between rows, 2 m remained with no amendment applied.

Experimental blocks consisted of five plants, with three central trees evaluated and outside two used as borders. To reduce interference, the rows which received treatment were side by side to borders rows (Rosand and Santana, 1991).

Fertilization was (Grupo Paulista de Adubação de Citros, 1996) summing in kg ha^{-1}, urea 455, potassium chloride 43, and super phosphate 37 to 1999/2000 growing season; ammonium sulfate 91, ammonium nitrate 206, monammonium phosphate 46, and potassium chloride 114 to 2000/01 growing season; and, urea 430, potassium chloride 167, and super phosphate 122 to 2001/02 growing season. Three appliances of fertilizers (Sept/Oct, Dec/Jan, and Mar/Apr) were used equally all around the plant, in a strip about 0.5 m width, following the tree top (between 1.5 and 2.0 of trunk base), at the same local, where the soil samples were taken for chemical analysis.

Soil samples from of 0–10, 10–20, and 20–40 cm depths were taken at 6, 12, 18, 24, 30, and 36 months intervals, while samples from 40–60 cm depth, were taken at 18, 24, 30, and 36 months intervals. Four subsamples (one subsample in each series of four) were taken from each plant, totaling 12 per block, in order to make one composite sample. Samples were taken at a distance about 1.5 and 2.0 m from the plant base. Soil samples chemical analyses used to calculate base saturation (van Raij et al., 2001).

Leaf samples for chemical analysis of manganese as well as the fruit production were drawn from the three central plants of each treatment; being the same from which soil samples were (Quaggio et al., 1996).

July and August had a principal harvest, after which was computed the remaining production, as the Pear variety tends to produce fruits all year long.

Manganese levels foliar analysis and yields were evaluated in the field at harvest (Bataglia et al., 1983).

Statistical analysis was built with SAS®. Regression analysis for leaf manganese levels as a function of applied lime levels (direct effect) was carried out as well as a regression analysis of leaf manganese as a function of base saturation (indirect effect), using the GLM (General Linear Models) and REG (Regressions) modules (Littell et al., 1991; Freund and Littell, 2000).

Analysis by Mathematic Chance method was carried (Wadt et al., 1998) for the nutrient studied, using two probabilities in each factor, calculated as following:

$$P_1 = \frac{A_i}{A}$$

And,

$$P_2 = \frac{A_i}{C_i}$$

Where P_1 and P_2 are probabilities; A_i is treatment numbers of high productivity in class "i"; A, total treatments numbers of high productivity; C_i, total treatments numbers in class "*i*".

Classes and their respective intervals were calculated considering observation numbers and all data general amplitude, with class numbers determined through following formula:

$$n = \sqrt{N}$$

Where n is class numbers and N is observation numbers (in this case, treatments).

Treatments were classified in high and low productivity, values of 50 and 45 t ha^{-1}, were utilized respectively, for 2000/01 and 2001/02 harvest, with mean standard deviation base. Treatments which had low yields were classified in low productivity group.

RESULTS AND DISCUSSION

After statistical analysis, it was verified that lime levels, the time after application both had effects, as well as an interaction of these two factors effected the level of leaf manganese (Figure 1). Rising lime levels were proportional to reducing leaf manganese levels, the higher lime rate the higher the pH, and as soil Mn levels tend to diminish in concentration as pH levels rise, this micronutrient uptake is also affected. This direct effect of liming action on the decrease of leaf manganese levels was reported in cotton (Rosolem et al., 2000), passion fruit tree (Prado et al., 2004), and both guava tree and star fruit tree.

This occurrence, represented by the diminishing leaf manganese levels in function with surface lime levels, was widely studied in Brazil in soybeans (Ritchey et al., 1981; Novais et al., 1989). Tests and reports in commercial production areas at Cerrado region of Brazil, noted the relationship between decreasing uptake of manganese in virtue of surface lime incorporation (Tanaka et al., 1989) or because lime excessive application, known as super liming (Tanaka et al., 1992).

Effect of time after liming, estimated in a quadratic tendency, shows an inverse correlation between time after liming and leaf manganese levels, where

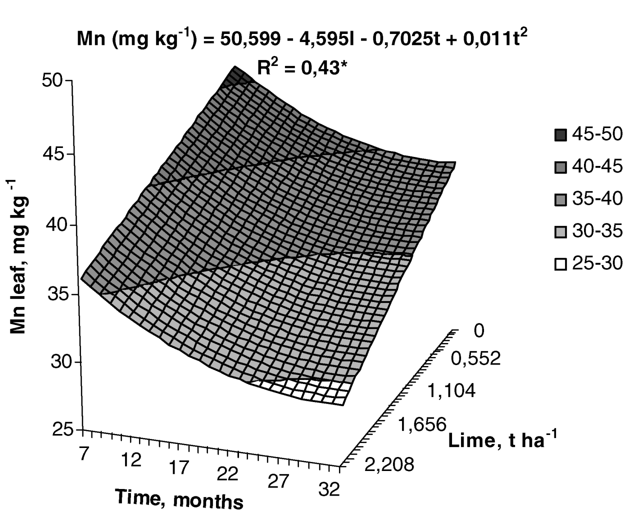

Figure 1. Effect of liming rates and time after application on leaf Mn levels in 'Pêra' orange.

Table 1
Values of F probability for the significance of linear regression between the leaf manganese and base saturation, in all samples

	0–10 cm	10–20 cm	20–40 cm	40–60 cm
Months		Harvest 2000/01		
6	**0.0036**	**0.0010**	**0.0039**	—
		Harvest 2001/02		
6	**0.0245**	**0.0025**	**0.0089**	—
12	0.6068	0.1411	0.2342	—
18	0.1203	**0.0169**	**0.0075**	**0.0332**
		Harvest 2002/03		
6	<**0.0001**	<**0.0001**	**0.0083**	**—**
12	<**0.0001**	**0.0176**	0.0594	**—**
18	0.2766	<**0.0001**	0.0795	0.0796
24	<**0.0001**	**0.0050**	**0.0446**	0.0594
30	<**0.0001**	**0.0017**	0.1125	**0.0152**

Values in bold: $p < 0.05$ (F significant the 5% of probably).

this effect is heightened immediately after liming, and decreases with time passage. As applied lime had 131% PRNT, its reaction in soil was probably rapid, therefore, at first leaf sample, which occurred 7 months after liming, lime could have reacted, having its effects tending to decrease with time, and consequently, the changes effected on nutrients availability in soil and its plant nutrient uptake.

Projecting that manganese availability in soil can be affected temporarily (Miyazawa et al., 1993) if soil has sun direct exposure, if soil drying temperatures were increased, if oxidation processes and soil sterilization occurred, or if additional manganese was applied. Although tests were not protected against solar radiation, roots active in nutrient uptake are located in high percentage, at areas covered by tree's crown; that casts a shadow on soil as well as in a majority of times, being covered by volunteer vegetation. Drying temperature is a laboratory process, and probably, ambient temperature effect on plant manganese availability was not significant, because, although differences occurred in temperatures year to year, these should be greater.

During the experiment, no additional manganese source was added to the soil. Since lime reaction was quick, this element availability occurred in the first semester immediately after liming, therefore, results of soil analysis correlated with manganese leaf levels are those carried out six months after surface liming. After this period, manganese quantity in leaf tends to decrease since uptake has the same tendency to diminish over time, and plant tends to immobilize a good part of this element internally, besides exporting another part with harvest (Table 1) (Marschner, 1995).

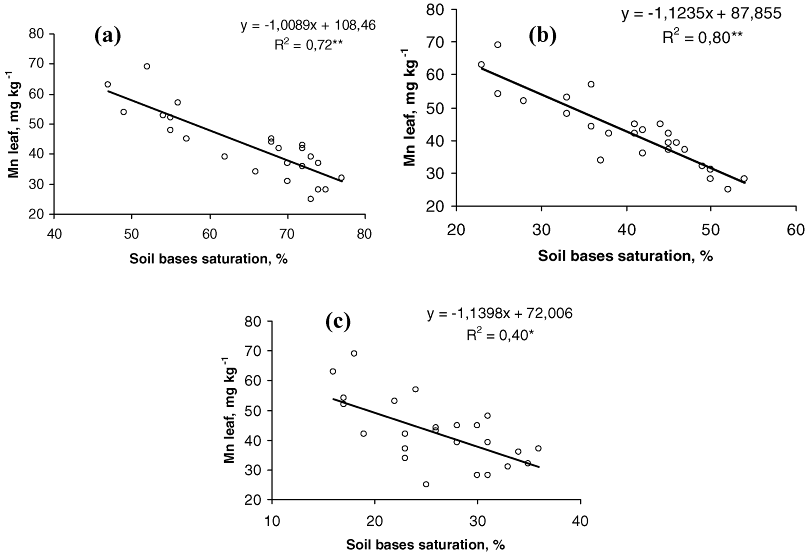

Figure 2. Foliar Mn levels, 7 months after surface application of lime, as a function of base saturation at levels of 0–10 (a), 10–20 (b), e 20–40 (c) cms, in the sample taken 6 months after liming.

Perennial plants tend to slow nutritional responses, because nutrients come part directly from soil and part from interior cycles (Marschner, 1995). That way, nutrients available in soil at a given moment can be assimilated and metabolized by plants, but it will not result necessarily in an increase in leaf level of it: it can be stored and later redistributed. This nutritional aspect is one of difficult study in perennial plants, like fruits. Soil treatments applied responses require considerable time to make changes in leaf levels, in this manganese study this answer was rapid, because foliar levels were altered soon after first leaf sampling subsequent to surface lime application (Figure 2).

Orange production for 2000/01, 2001/02 and 2002/03 harvests were respectively 47, 34, and 13 t ha^{-1}. The two first harvest years, in spite of the fact they were not changed significantly by surface liming, were above the national average, which was between 20 and 25 t ha^{-1} (IBGE, 2002). The productivity of harvest year 2002/03 was low due to the climate influence during that period; therefore, the data which came from that harvest was not utilized in the statistics analysis.

Through a regression analysis, it was not possible to estimate with the experimental data a model that could describe a relationship existing between leaf manganese levels and fruit yield. However, using Mathematic Chance method it was possible to check manganese reference value. Intervals inferior limits indicate minimum value or critical level for 2000/01 (Figure 3a) harvest

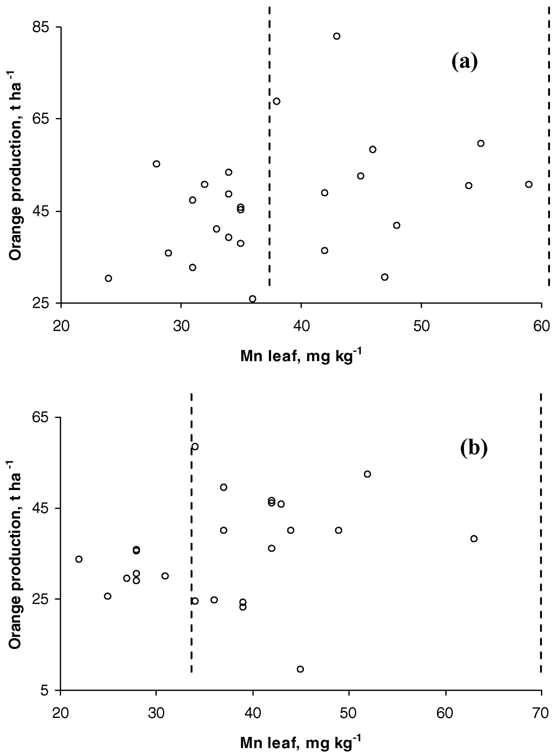

Figure 3. Graphics representation of the range with probability of high production by mathematical chance method.

and 2001/02 (Figure 3b) harvest a superior limit, maximum value of manganese levels found in the respective harvests. Therefore, it was verified that the inferior limit for the 2000/01 harvest was 38 mg kg^{-1}, while, for the 2001/02 harvest that value was 33 mg kg^{-1}. Those values agree, which indicates leaf manganese levels between 35–300 mg kg^{-1} (Quaggio et al., 1996).

CONCLUSIONS

Manganese leaf levels decrease in relation to lime amount increase, as through time passage after surface liming.

Base saturation at the sixth month after lime surface application best correlated with foliar manganese levels.

Leaf samples taken at 30 months after liming showed the highest correlation between leaf manganese levels with a base saturation at the 10–20 cm layer.

Leaf manganese levels which had the greatest correlation to high productivity were the same as officially recommended by the state or between 33 and 70 mg kg^{-1}.

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