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NUTRIENT CONTENTS IN 'TOMMY ATKINS' MANGO LEAVES AT FLOWERING AND FRUITING STAGES

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ABSTRACT: The objective of this study was to evaluate the nutrient contents in 'Tommy Atkins' mango leaves at the flowering and fruiting stages under different strategies to reduce irrigation levels during flower induction. Five irrigation level reduction strategies, based on crop evapotranspiration (ETc) were used in the plots: T1 (0% ETc), T2 (25% ETc), T3 (50% ETc), T4 (75% ETc) and T5 (100% ETc); two production cycles in the split-plots; and in two development stages, flowering and harvest, in the split-split plots. The content of N, P, K, Ca, Mg, and S, as well as B, Cu, Fe, Mn, Zn, and Na was determined and leaf chlorophyll index was measured during the second cycle. The content of P, K, Mg, and Cu in the 'Tommy Atkins' mango trees leaves varied according to phases and cycles, regardless of the strategies to reduce irrigation levels in floral induction. The contents of N, Ca, B, Fe, Mn, and Na varied with stages and with the production cycles, in an independent manner. Foliar N contents were above the sufficiency range at the different development stages and cycles evaluated. The indices of a, b, and total chlorophyll varied independent of reading time. The nutrient contents with lower mobility in the plant, Ca, B, Fe and Mn increase in 'Tommy Atkins' mango trees leaves from flowering to fruiting, with the return of irrigation at 100% crop evapotranspiration, while the levels of N, P, K and Mg, nutrients with high mobility in plant decrease.

KEYWORDS: *Mangifera indica* L., water deficit, nutritional status.

INTRODUCTION

The mango (*Mangifera indica* L.), native of Asia, is grown in Brazil in diverse ecosystems with different technological levels. The semi-arid region of the Northeast, in particular Bahia, includes an agricultural area of great importance for Brazilian agribusiness. In 2012 the Brazilian production of mangoes exceeded 1,175,000 tons, the Northeast accounting for 66.54% of total production been Bahia the largest fruit producing state, with 54% of production (IBGE, 2014). This region has favorable climatic characteristics, linked to irrigation management and fertilization that promote the successful development and production of the culture.

In mango production system in the semi-arid region, the management of irrigation with water deficit is used as flowering inducer (BASSOI, 2012). The reduction of the amount of water applied through the reduction of irrigation levels in mango floral induction process, can alter the availability of nutrients in the soil and, consequently, their content in the plant.

The assessment of nutritional status of mango has some obstacles, as this species has variables phenological cycles that influence the absorption and translocation of minerals. On the other hand there are few studies that address the nutritional requirements or quantifying nutrient uptake by mango tree in different stages of development.

The mineral analysis of the leaf is useful to assess if there are disturbances in mango nutrition (ARAUJO, 2010; DURÁN ZUAZO et al., 2011), this because the existence of nutrients in the soil under appropriate conditions does not necessarily guarantee that these elements are absorbed. Soil reaction conditions, salinity or antagonism between elements can cause undesirable changes in

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nutrients absorption (SILVA et al., 2004). Leaf analysis is effective to detect imbalances and help the fertilizer recommendation for fruit. Leaf analysis can be used as a method to evaluate the fertility of the soil due to the high correlation between the concentration of nutrients in leaf and nutrient availability in soil. In appropriate time this analysis can help the recommendation of fertilizers to meet nutritional deficiencies in specific stages of phenological cycle and before the expression of deficiency symptoms (hidden hunger).

The nutrients contents in mango leaves vary throughout the cycle and may be grouped into two distinct stages, the first between harvesting and initiation of new flowering, period in which there are nutrients accumulation and the second during the period of development of the fruit to the harvest, when there is reduction in nutrient levels in leaves. The knowledge of the periods of greater demands in the plants shows the stage at which nutrients must be supplied or be available for them.

Despite the high technology applied to the mango culture, yet there is a demand for information about nutrition and fertilization of the mango culture. Although it is a common practice in irrigated perennial crops, there is a need for information on leaf nutrient contents in stages of flowering and fruiting during the floral induction. Given the above, the aim of the present study was to evaluate the nutrient content in 'Tommy Atkins' mango leaves at flowering and fruiting stages under different irrigation strategies during the floral induction.

MATERIAL AND METHODS

The research was conducted in 2012 and 2013 in an orchard of *Mangifera indica* L. cv. Tommy Atkins, 16 years old, grown in a spacing of 8 x 8 m, in an Eutrophic Fluvic Neosol, located in the Development Company of Valley of São Francisco and Parnaiba (CODEVASF) at an altitude of 530 m 14° 17'26"S and 42° 42'50"W.

The local climate is classified as Aw, hot and dry semi-arid, according to Köppen. The region has an average temperature of 25.6ºC, average rainfall of 680 mm per year, and the concentrated rainy season from November to April. The daily values of maximum temperature, minimum temperature, relative humidity, wind speed and precipitation during the evaluation period in two crop cycles, are given in Figure 1.

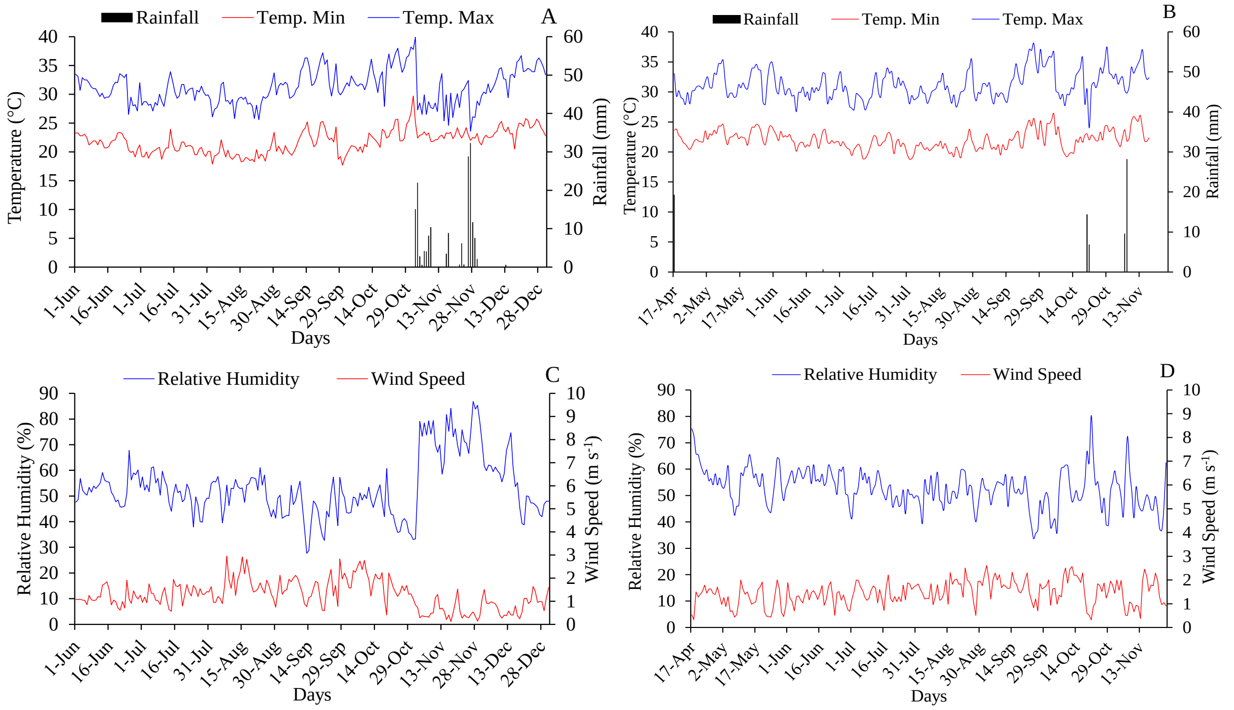

FIGURE 1. Maximum temperature (Temp. Max), minimum temperature (Temp. Min) and rainfall in the first (A) and second (B) evaluation cycle, average relative humidity and average wind speed during the first (C) and second (D) evaluation cycle, Guanambi, Bahia, Brazil.

The treatments were arranged in a randomized block design in sub-divided plot in time, with six replications and a useful plant as experimental unit. It was used in plots five irrigation level during flowering induction period (EI), in two production cycles: T1 (0% of ETc without irrigation on EI), T2 (reduction on irrigation level to 25% of ETc on EI), T3 (reduction on the irrigation level to 50% of ETc on EI), T4 (reduction on the irrigation level to 75% of ETc on EI) and T5 (full irrigation, 100% ETc on EI) and 100% return during the fruiting stage (EII); subplots, two production cycles; and the sub-subplots, two developmental stages: flowering and fruiting. For evaluation of the chlorophyll indices treatments were arranged in a randomized block design, in split plot in time, using in the plots, five reduction strategies of irrigation levels and subplots eight reading times.

During the experimental period were used crop management techniques adopted in public irrigation perimeters of the Brazilian semiarid region. The mango trees were trimmed in order to stimulate growth of buds, and then the plants were fertilized with 48 g / plant of P_2O_5 (MAP - monoammonium phosphate) and 157.5 g / plant of N (urea), 87 g / plant of K_2O (potassium chloride), 60 g of FTEBR - 12. 250 g of magnesium sulfate and 27.4 kg of manure per plant. Applications were made in open circular grooves distant one meter from the trunk under the crown of each plant. In the second evaluation cycle based on leaves analyzes the same fertilizations were repeated, besides two applications with 40 g 100 L^{-1} of zinc (zinc sulfate). Until the emission of the second vegetative flow during the first production cycle, the management of irrigation was performed daily, with all evapotranspirometric demand supplied to the plant. The stoppage of mango growth (chemical stress) was held from Paclobutrazol (PBZ) application, a systemic growth regulator from the group of triazoles. The applied dose was 0.5 g of active ingredient per linear meter of mango diameter canopy. During the PBZ absorption (20 days) management of irrigation was performed by applying 100% of crop evapotranspiration (ETc). Next were applied the treatments with different irrigation levels, which remained in the water stress period scheduled to flowering induction, that is, until 60% of the plants showed up flowering. When the plants had shriveled leaves, 35 days after application of PBZ three sprayings were conducted with calcium nitrate at 2.5% (14% of N and 19% of Ca) in seven day intervals with a volume of 800 liters of syrup per hectare in each application, in order to break buds' dormancy and induce a uniform flowering. The sprayings provided to the plants 8.4 kg of Nitrogen.

Flowering induction in the second cycle was performed only with water stress without using chemical stress. The treatments were applied in the same stage as described in the first cycle, plus three calcium nitrate sprays (dosage 2.5% on seven day intervals), beginning when the plants had breakable leaves and branches epinasty.

Irrigation management in the experiment course was based on the reference evapotranspiration (ETo), crop coefficient (Kc) and the location coefficient (KI). The ETo was determined daily by the Penman-Monteith method, from data of the local weather station, located next to the area of the evaluated mangos.

In calculating the ETc, the values of crop coefficient (Kc) in the two crop cycles ranged from 0.3 to 0.8 according to SIMÃO et al. (2004), and REIS et al. (2011). The location coefficient (KI) was calculated considering the area shaded by the plant reaching value of 0.96 according to SANTOS (2012).

The daily irrigation time used for each treatment was used according to COTRIM et al. (2011), SANTOS et al. (2014a), NEVES et al. (2013) and SANTOS & MARTINEZ (2013), considering 0.90 as the application efficiency. These determinations were performed using IRRIMANGA software, computational tool to obtain evapotranspiration and calculation of irrigation time for mango crop management (SANTOS, 2012). The rainfall that occurred in the experimental area were quantified and discounted from the ETc to obtain the irrigation time. The control of the applied irrigation level was done through the closing records at the beginning of the corresponding bypass line of each treatment.

The accumulated irrigation applied in both culture cycles appear in Figure 2. It is observed that in the first year of cultivation the irrigation return with 100% of ETc occurred on July 17, while for the second growing cycle occurred on July 11.

It was used the located irrigation method with micro-sprinkler system with a transmitter spaced 0.40 m per plant stem, with a flow rate of 48 L h^{-1} at pressure of 150 KPa.

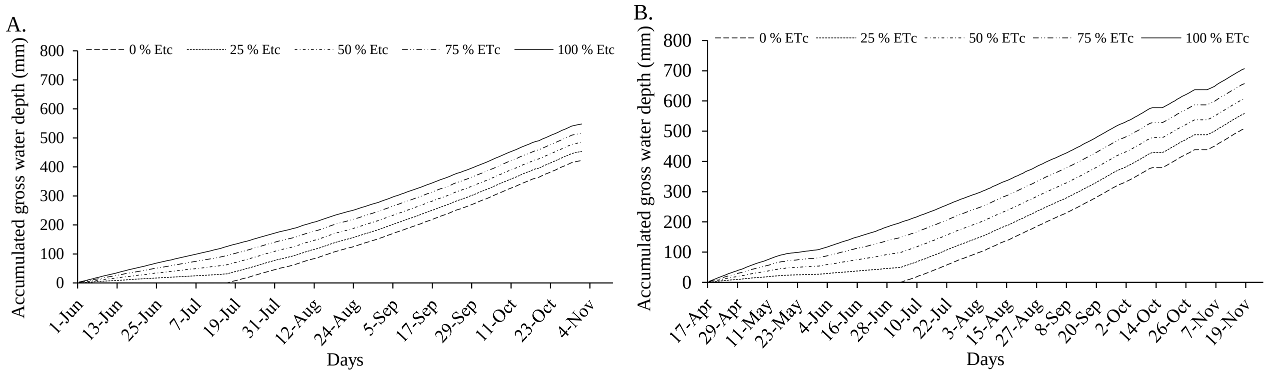

FIGURE 2. Accumulated irrigation applied in the 'Tommy Atkins' mango tree, for the different treatments in 2012 (A) and 2013 (B) under micro sprinklers. Guanambi, BA.

Soil analyzes were carried out from collected samples at different points in the area at depths of 0-25; 25-50; 50-75 and 75-100 m. In each depth were taken several simple samples at random terrain points, forming a composite sample that was sent to the laboratory. The chemical characteristics of the Fluvic Neosol on the experiment site are listed in Tables 1 and 2 and were determined according to DEFELIPO & RIBEIRO (1997). Values are shown for four layers of 0.25 m, in a profile of 1 m of soil, where there is larger concentration of mango root system (SANTOS et al., 2014b). The physic-hydric soil characteristics are given in Table 3, determined according to EMBRAPA (1997) and the curve adjusted to the data pairs, water content in soil and tension in Figure 3.

TABLE 1. Chemical characteristcs of Fulvic Neosol. Guanambi-BA.

Layer	pH	O.M.	P	K	Ca	Mg	Al	H+Al	BS	CEC (T)	CEC (t)	V	M
m		dag kg^{-1}	mg dm^{-3}		cmol$_c$ dm^{-3}							(%)	
0.00 – 0.25	7.12	1.63	190.40	301.00	5.43	1.84	0.00	1.30	8.04	9.34	8.04	86.10	0.00
0.25 – 0.50	7.23	1.26	55.50	171.00	5.16	1.88	0.00	1.10	7.48	8.58	7.48	87.20	0.00
0.50 – 0.75	7.72	0.50	23.10	17.00	2.08	0.94	0.00	1.10	3.06	4.16	3.06	73.60	0.00
0.75 – 1.00	7.72	1.63	15.30	38.00	5.03	2.62	0.00	0.50	7.75	8.25	7.75	93.90	0.00

water pH; P and K - Mehlich-1 extractor; Ca, Mg and Al - Extractor: KCl - 1 mol L^{-1}; H + AL – Extractor : Calcium acetate 0.5 mol L^{-1} - Ph 7.0; BS = Base Sum; CEC (t) - Effective Cation Exchange Capacity; CEC (T) - Cation Exchange Capacity at pH 7.0; V = Base Saturation Index; M = Aluminum Saturation Index and M.O. = Organic matter - C. Org x 1,724. - Walkley - Black.

TABLE 2. Micronutrient contents in FulvicNeosol. Guanambi-BA.

Layer	Cu	Fe	Mn	Zn
m	mg dm^{-3}			
0.00 – 0.25	1.42	64.60	71.90	5.84
0.25 – 0.50	2.63	100.70	50.80	1.77
0.50 – 0.75	2.73	116.90	17.50	0.41
0.75 – 1.00	1.21	171.60	37.40	0.96

Cu, Fe, Mn e Zn - Extractor of $Mehlich^{-1}$

TABLE 3. Physical and hydric characteristics of the soil in the study area. Guanambi-BA.

Layer m	Sand Thick	Sand Thin	Silt	Clay	Density of soil	Density of particles	FC	WP
	g kg^{-1}				kg dm^{-3}		m^3 m^{-3}	
0.00 – 0.25	80	410	270	240	1.62	2.51	0.43	0.15
0.25 – 0.50	50	430	280	240	1.38	2.58	0.37	0.12
0.50 – 0.75	10	760	120	110	1.34	2.62	0.19	0.05
0.75 – 1.00	0	160	520	320	1.31	2.66	0.54	0.16

FC – field capacity; WP – wilting point.

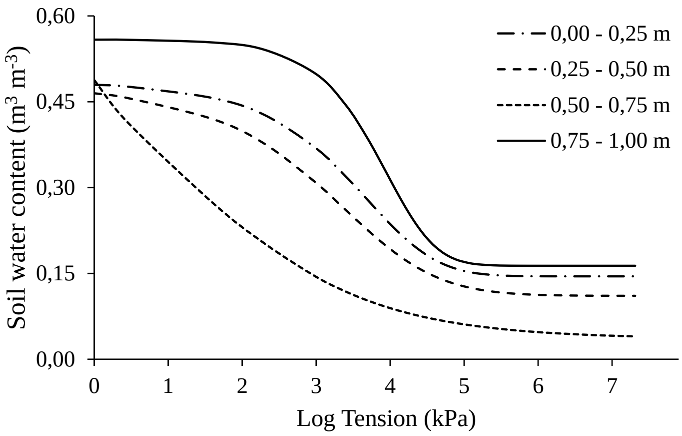

FIGURE 3. Soil retention curve of the experimental area for the four depths studied. Guanambi-BA.

Soil moisture was monitored daily with the use of Time Domain Reflectometry (TDR) during the trial period in an experimental unit for each treatment at depths of 0.125; 0.375; 0.625 and 0.875 m at one meter from the tree trunk. Readings of soil dielectric constants were registered (K_a) measured by TDR before and after irrigation.

To estimate the soil moisture with TDR, calibration equation was used according to SANTOS & MARTINEZ (2013). Obtaining the relationship between the dielectric constant values read by TDR and soil water content (θ) was performed with samples deformed in accordance with SANTOS et al. (2010) and was presented on Table 4. The humidity values of soil in four depths before and after irrigation were measured only in the first production cycle due to the unavailability of equipment within one year, and will be presented in the results of humidity regarding the surface layer (0.00 to 0.25 m), due to greater moisture changes in all treatments.

TABLE 4. Models to estimate the water content in the 'Tommy Atkins' mango tree orchard soil. Guanambi-BA.

Layers (m)	Calibration equations
0.00 – 0.25	$\theta = 0.000023K_a^3 - 0.001474K_a^2 + 0.043010K_a – 0.256019$, R^2 =0.98 0,98
0.25 – 0.50	$\theta = 0.012121K_a – 0.059308$, $r^2 = 0.96$
0.50 – 0.75	$\theta = 0.012230K_a – 0.066887$, $r^2 = 0.96$
0.75 – 1.00	$\theta = 0.013641\ K_a – 0.,059207$, $r^2 = 0.99$

Source: SANTOS & MARTINEZ (2013).

The leaf samples were taken in the stages of flowering and fruiting in two crop cycles. Sampling was performed in 30 experimental units, on four cardinal points, 12 leaves per plant totaling 360 leaves. All samples were determined the content of N, P, K, Ca, Mg and S (dag kg^{-1}) and B, Cu, Fe, Mn, Zn and Na (mg kg^{-1}) according to MALAVOLTA et al. (1997). The N content determined by sulfuric acid digestion, Kjeldahl method; P, K, S, Ca, Mg, Cu, Fe, Mn, Zn, Na, determined by nitric perchloric digestion; and B by dry digestion.

Measurements of chlorophyll indices were performed in the second production cycle with ClorofiLOG meter, Falker model CFL 1030®. The measures were taken in the central position of intact leaves, always at noon time on four cardinal points of the plant to obtain average values. It was measured the *a* (*Chla*), *b* (*Chlb*) and *total* (*Chlt*) chlorophyll indices. Readings were not performed in the first cycle by unavailability of equipment.

Data were submitted to analysis of variance to verify the significance of interactions or independent effects of the tested factors and compared the means by Tukey test at 5% probability.

RESULTS AND DISCUSSION

There was an interaction between stages and cycles only for K, P, Mg and Cu in 'Tommy Atkins' mango leaves (Table 5). The K differed between stages of flowering and fruiting in both cycles, with higher values in the flowering cycle I. P levels were also higher in the flowering, but there was no difference between the cycles at this stage. The highest Cu contents were observed in the flowering cycle I, although there were differences between stages in both cycles, there was no cycle effect in the fruiting stage. As for the Mg the highest levels also occurred in the flowering cycle I, however there was no difference between stages in cycle II as well as the cycles did not differ in fruiting.

TABLE 5. Average contents of phosphorus, potassium, magnesium and copper in the flowering and fruiting stages in two production cycles in 'Tommy Atkins' mango leaves. Guanambi-BA, 2012-2013.

Stages	Potassium		Phosphorus		Magnesium		Copper	
	(g kg^{-1})						(mg kg^{-1})	
	I	II	I	II	I	II	I	II
Flowering	12.4Aa	9.9Ab	1.3Aa	1.3Aa	3.0Aa	2.6Ab	3.29Aa	2.70Ab
Fructification	9.7Ba	8.8Bb	0.9Bb	1.0Ba	2.4Ba	2.6Aa	2.14Ba	2.19Ba
CV (%)	14.85		17.14		21.65		32.64	

Means followed by the same letters, lowercase in lines and uppercase in columns, do not differ at 5% probability by the Tukey test.

The 'Tommy Atkins' mango leaves expressed potassium levels above the one considered sufficient, 5 g kg^{-1} to 10 g kg^{-1} according to SILVA et al. (2002), only in the flowering stage of the first cycle. MEDEIROS et al. (2004) reported that foliar K is commonly higher in flowering compared to other phenological stages of mango culture. From flowering to fruiting, the K content in the leaves decreased, showing a great remobilization of this nutrient from the leaves to the fruits (MEDEIROS et al., 2005). The K^+ is related to photosynthesis, carbohydrates transport, hydric and osmotic regulation of the plant and therefore to the factors protection of abiotic anti-stresses (MARSCHNER, 2012). In the leaf area with low K there is putrescine accumulation, which leads to senescence and necrosis. The deficiency manifests itself by the migration of element from the tip and the edge of the leaves to the central region, from old leaves for new leaves and from leaves to fruits, greater K drain in fructification, because the element is highly mobile in the plant, in cells and tissues, because it is not a structural element.

The phosphorus content for two-stage of culture development and for two studied cycles ranged from 0.9 g kg^{-1} to 1.3 g kg^{-1} (Table 5), which is consistent with the levels found by COSTA PINTO et al. (2010) in 'Tommy Atkins' mango orchards of high productivity. These values are within the proper range for the flowering and fruiting in mango trees that is from 0.8 kg^{-1} to 1.6 g kg^{-1}, according to SILVA et al. (2002).

The results for potassium and phosphorus can be explained by the fact that these elements are exported in large proportions to the mango fruit (COSTA et al., 2011). Thus, as the reproductive organs are preferred drains, the trend is that these elements are mobilized from leaf to fruit (DIAS et al., 2013). Similar results were observed by SALOMÃO et al. (2006) when studying the variation in mineral composition in litchi leaves and stem. DURÁN ZUAZO et al. (2011) also observed decrease in the concentrations of K and P as the flowering of mango progressed.

The copper content in ‘Tommy Atkins’ mango leaves was higher in flowering for two studied cycles (Table 5). However it remained below the recommended, 10 g kg^{-1} to 50 g kg^{-1} (SILVA et al., 2002). This was probably due to the low availability of the nutrient in the soil, although the Cu content in the soil, 1.42 mg dm^{-3} from 0 to 25 cm and 2.63 mg dm^{-3} on layer from 25 to 50 cm and were considered good and high, respectively, by Mehlich-1 extractor. Low concentrations of metal ions as Cu^{++}, Fe^{++}, Mn^{++} and Zn^{++} in the leaves in semiarid regions are associated with high these nutrient concentrations in the soil, indicating restriction on availability of this nutrient for plants, for example by high pH, normally above 7.0 (Table 2). For the pH is the main factor that limits the availability of these nutrients in the soil as observed by SILVA et al. (2012), with decreases in the solubility of these captions up to a hundred times, with the pH increase when it ranges from 6 to 8 (MORTVEDT, 2001). Additionally, high activity clays predominant in the soil of this study, highly electronegative, contribute to the formation of inner-sphere complexes with these metal cations, such as copper, dramatically decreasing their availability to plants. Similar results to the concentrations in the soil were reported by COTRIM (2009), working with different irrigation level in the same area of study. POLITI et al. (2013) and COSTA PINTO et al. (2010) found common copper deficiencies in the Lower Basin of the São Francisco Valley orchards. Despite fertilization carried out in two cycles, they were also identified low foliar concentrations of Cu, however the source used, silicates, FTE to supply micronutrients, has low reactivity and solubility, particularly in soils with pH higher than 6.5. Although with levels below the range, they were not shown nutrient deficiency symptoms in the plant.

Potassium excess may have favored the Mg deficiency in mango leaves on the first fruiting cycle. The reference values for Mg indicated by SILVA et al. (2002) for Mg range from 2.5 g kg^{-1} to 5 g kg^{-1}. The absorption of this nutrient can be inhibited with high concentrations of K. This was verified by GALLI et al. (2009) in mango varieties conducted in organic farming system. In the second crop cycle there was no difference between nutrients among the analyzed stages, remaining within the sufficiency range.

Comparing the levels of nutrients in the leaves between cycles it appears that K, Mg and Cu in flowering were higher in the first cycle. While in fructification, the P content was higher in the leaves of ‘Tommy Atkins’ mango in cycle II and K in cycle I. Perhaps this was due to previous fertilizations followed by periods of water restriction.

Higher phosphorus concentrations in the second fruiting cycle are related to the low productivity of the orchard in this cycle, indicating less remobilization for fruit, because the translocation depends on the drain size. Also the high pH contributes to this (COTRIM, 2009).

In general, the levels of nutrients change with age of the tissue. To MEDEIROS et al. (2005) and COSTA et al. (2011) in study with mango, elements with great mobility in the phloem as phosphorus, potassium and magnesium (MARSCHNER, 2012) have defined tendency to decrease with the age of the leaves, a fact proven by FERNANDES et al. (2011) for those nutrients in potato tubers.

The content of nutrients N, Ca, B, Fe, Mn and Na in ‘Tommy Atkins’ mango leaves differ between the stages of flowering and fruiting regardless of the irrigation level used and the production cycles (Table 6). With the exception of nitrogen, which content was higher in flowering, and zinc which were similar between these stages, all other information expressed higher content in fruiting compared to flowering.

TABLE 6. Average contents of nitrogen, calcium, boron, iron, manganese, zinc, and sodium at the flowering and fruiting stages in 'Tommy Atkins' mango tree leaves. Guanambi - BA, 2012-2013.

Stages	Nitrogen	Calcium	Boron	Iron	Manganese	Zinc	Sodium
	($g\ kg^{-1}$)		($mg\ kg^{-1}$)				
Flowering	20.0A	20.0B	25.66B	80.07B	167.30B	18.37A	80.50B
Fructification	17.5B	27.2A	54.19A	117.06A	254.15A	15.64A	132.84A
CV (%)	14.27	24.84	33.43	53.99	54.61	45.29	34.58

Means followed by the same capital letters in columns do not differ at 5% probability by the Tukey test.

The higher N content found in 'Tommy Atkins' mango leaves in flowering as well as their content above the reference values (12 g kg^{-1} to 14 g kg^{-1}) (SILVA et al., 2002) in two stages may derive from calcium nitrate applications for the management of floral induction, before sampling the leaves. Values higher than those of reference were found by ROZANE et al. (2007) when evaluating the size of sample in mango leaf. According to COSTA et al. (2011), nitrogen may suffer temporary changes due to the fertilization.

Higher contents of Ca, B, Fe, Mn and Na were observed in fruiting period compared to flowering, while zinc content did not differ between the stages. The increase in nutrient content between flowering and fruiting may be associated with increased on irrigation level in the fruiting period (100% ETc), which enables a better movement of these nutrients on soil and their absorption by the plant, as Ca and B are elements of low mobility in the plant (MARSCHNER, 2012), i.e. lower redistribution by leaves phloem to the fruit.

Among the abiotic factors the water plays fundamental role in the Ca use efficiency, since the contact ion root and its absorption by the plant preferably takes place by mass flow and follows the transpiration flow. The xylem is the ascending conductive vessel and the redistribution of Ca in the plant is insignificant, when multiple drains are involved, calcium moves to the leaves that have greater transpiration surface (AULAR & NATALE, 2013) at detriment of the fruit. This often justifies the occurrence of the pulp and seed internal collapse, even in soils with high calcium content.

The Ca, Fe, Mn and Zn contents are in accordance with SILVA et al. (2002). Similar results were observed by PINTO et al. (2011) in mango orchards in the Bahia backlands.

Only at the flowering Boron contents in leaves were below the adequate levels (50 to 100 mg kg^{-1}), however, did not reach the levels of deficiency (10 mg kg^{-1}) specified by SILVA et al. (2002).

GALLI et al. (2009) also found levels below recommended when evaluating the level of nutrients in mangos trees in São Paulo. POLITI et al. (2013) evaluated the nutritional status of 63 mango orchards at the Valley of São Francisco Lower Basin and found large number of areas with B contents above sufficiency range.

The contents of B, Fe, Zn, Na and N in 'Tommy Atkins' mango leaves differed between the two production cycles evaluated, regardless of the reduction strategies of irrigation level used and phenological stages (Table 7). Significant differences in B, Fe, Na and Zn contents in the leaves were identified for the two studied cycles. The lowest values occurred in cycle I to B, Fe and Na, while for zinc, the lowest value was recorded in cycle II. It is noted that the contents of nitrogen were similar between cycles, probably due to the spraying of fertilizer nitrate base to break buds dormancy in the flowering induction process.

TABLE 7. Average contents of nitrogen, boron, iron, zinc, and sodium in two crop cycles in ‘Tommy Atkins’ mango tree leaves. Guanambi - BA, 2012-2013.

Cycles	Boron	Iron	Zinc	Sodium	Nitrogen
	(mg kg^{-1})				(g kg^{-1})
Cycles I	34.40B	87.12B	20.01A	89.41B	19.3A
Cycles II	45.45A	110.01A	14.00B	123.94[a]	18.3A
CV (%)	33.43	53.99	45.29	34.58	14.27

Means followed by the same capital letters in the columns do not differ at 5% probability by Tukey test.

The variation on leaves nutrients content as the developmental stage in which sampling was carried out may be associated with several factors related to the physiology of the plant, as demand from fruiting and the emission of vegetative and reproductive branches (RAMÍREZ & DAVENPORT, 2010). The variation between cycles may be associated with weather variables, such as temperature, radiation, precipitation, among others, which can interfere with the physiological and nutritional behavior of plants (FAGERIA et al., 2009), for influencing the nutrient transport processes in soil and its consequent absorption by the plant. Another factor that can contribute to the increased concentration in the second cycle is the stoppage on plant growth. Despite of performed fertilizations and irrigations after the harvest of the first cycle, few plants issued shoots. Thus part of collected material for analysis where from old leaves. In addition, the low productivity of the orchard in the second cycle constitutes in a weak drain, concentrating nutrients in the leaves at the expense of their migration to the fruits.

There was no interaction between irrigation level, production cycles and phenological stages for nutrient content in ‘Tommy Atkins’ mango leaves. The different reduction strategies of irrigation levels used in the process of floral induction in mango did not influence leaf nutrients levels. There was exception for nitrogen because the F test analysis of variance at 5% probability indicated influence of irrigation strategies, regardless of production cycles and phenological stages, but this effect was not proven by the Tukey test (Figure 4).

Foliar sprays of calcium nitrate, during the floral induction process favored the high concentrations of nutrients in the leaves of different treatments by using 8.4 kg ha^{-1} of N. Contents of N on flowering and fruiting are above the appropriate range (12 to 14 g kg^{-1}) (SILVA et al., 2002) for mango culture. Nitrogen is considered key nutrient in mango growth because there is an antagonism between growth and flourishing, considering the relationship between vegetative/ flowering / fruiting outbreaks (SILVA et al., 2004). However, their excessive content is associated with the incidence of internal collapse, particularly when considered antagonistic relationship to calcium, while the sources of N applied at the time of floral induction were nitric and not ammonia.

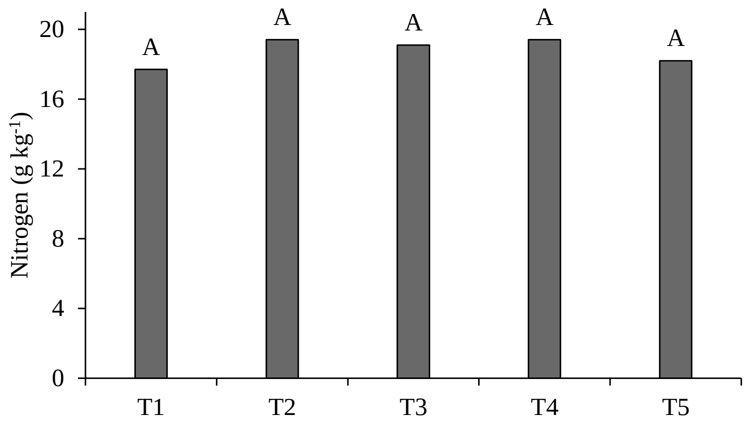

FIGURE 4. Average contents of nitrogen in the leaves of ‘Tommy Atkins’ mango tree under different irrigation level reduction strategies. Guanambi-BA.

T1 (0% of ETc, without irrigation), T2 (reduction of irrigation level to 25% of ETc), T3 (reduction of irrigation level to 50% of ETc), T4 (reduction of irrigation level to 75% of ETc) and T5 (complete irrigation, 100% of ETc). Means followed by the same letter on the chart bar do not differ at 5% probability by the Tukey test.

Chlorophyll index measured in ‘Tommy Atkins’ mango leaves differed from readings, regardless of reduction strategies of irrigation level (Table 8). Significant differences were observed between the reading 4, reading 1and other readings for *a* chlorophyll, whereas for the *b* chlorophyll and *total* chlorophyll only reading 4 differed from the others. Difference on reading 4 in comparison to the other occurred due to better environmental conditions in the period. As noted in Figure 2, precipitation occurred in the first week of November, timing of reading 4, favoring improvement in the physiological functions of the plant due to reduced environmental stress caused by high temperatures, lower relative humidity and wind speeds up average occurred in previous days. Although reading 4 also chlorophyll b ratio more related to stress, have increased the increase was greater in chlorophyll *a*, thus contributing to the higher *total* chlorophyll index.

TABLE 8. Rates of Chlorophyll *a*, chlorophyll *b* and *total* chlorophyll in ‘Tommy Atkins’ mango tree leaves during the second crop cycle. Guanambi - BA, 2013.

Readings	Chlorophyll a	Chlorophyll *b*	*total* Chlorophyll
1	30.64 B	13.18 B	43.82 B
2	30.15 BC	12.44 B	42.58 B
3	29.83 BC	12.43 B	42.26 B
4	36.23 A	15.12 A	51.35 A
5	29.13 C	12.87 B	42.00 B
6	29.20 BC	11.99 B	41.18 B
7	29.20 BC	12.75 B	42.00 B
8	29.20 BC	12.59 B	42.31 B
9	29.20 C	12.20 B	41.12 B
CV(%)	6.13	13.97	8.35

Means followed by the same capital letters in columns do not differ at 5% probability by the Tukey test.

Chlorophyll indices are highly correlated with the levels of nitrogen in the plant. However, despite high levels of the nutrient analyzes in leaf, low chlorophyll levels possibly indicate the influence of nitrates sprays in the plants, that is, the contents found do not match with the plant has. RIBEIRO et al. (2010) were using a SPAD-502 chlorophyll meter in mango orchards grown in water comfort, found *total* chlorophyll values that ranged from 53.25 to 60.25 with N contents from 4.90 to 8.75 g kg^{-1}, much lower than those recorded in this study, 17 to 20 g kg^{-1}.

The variation in soil moisture in the layer from 0.00 to 0.25 m, before and after irrigation, is shown in Figure 5. Note the interference deficit at Stage I (flowering), in which the soil moisture in the surface layer reaches 0.10 m^3 m^{-3}, and at the end of Stage II (Fruiting) due to the return of the irrigation level applied at 100% of ETc for all treatments, the moisture content for the different treatments are in average of 0.30 m^3 m^{-3}. This corroborates with the higher levels of Ca, B, Fe and Na observed in fruiting period in relation to flowering.

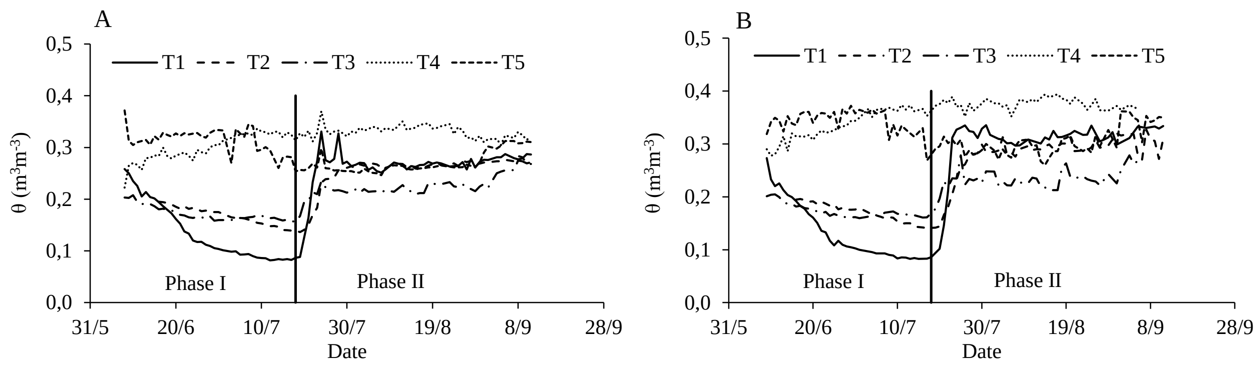

FIGURE 5. Soil water content for the different treatments, before irrigation (A) and after irrigation (B) in the first evaluation cycle. Guanambi, BA, 2012.

CONCLUSIONS

The nutrient content with lower mobility in the plant, Ca, B, Fe and Mn increase in 'Tommy Atkins' mango leaves from flowering to fruiting with the return of irrigation at 100% of crop evapotranspiration, while the levels of N, P, K and Mg high mobility nutrients in plant, decrease.

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