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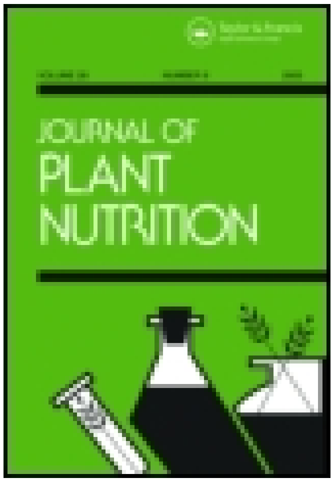

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Growth and Nutritional Disorders of Eggplant Cultivated in Nutrients Solutions with Suppressed Macronutrients

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ABSTRACT

The objective was to evaluate the effects of omitting macronutrients in the nutrients solution on growth characteristics and nutritional status of eggplants. The treatments were complete nutrients solution and solutions with nutrient omission: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). The experiment was carried out under greenhouse conditions with 3 replicates in a completely random design. Plant height, number of leaves per plant, leaf area, relative chlorophyll index, photosynthesis rate, stomatal conductance, dry matter, concentration levels of macronutrients in plant aerial part and root system, and nutritional disorders were evaluated. Omitting elements interfered in the concentration of elements in the various plant tissues and this had as consequences limited vegetative growth, reduced dry matter and led to the development of the typical deficiency symptoms of each element. Although potassium was the most demanded of all elements, nitrogen and calcium were the most growth limiting ones.

Keywords: *Solanum melongena*, Nutritional deficiency, Mineral nutrition.

INTRODUCTION

Eggplant (*Solanum melongena*) is a crop species of great economic importance, which is becoming of even greater importance all over the world since its fruits have been found to reduce cholesterol and blood pressure (Montemor and Souza, 2009). Being of tropical and subtropical origin, eggplant prefers regions of hot weather (mean temperature between 25 and 35°C during daylight and between 20 and 27°C during the nocturnal period) and, if under these conditions, it may be cultivated all year round (Embrapa, 2007).

In Brazil, the total production of eggplant in 2006 was of 78,217 t. The Southeast region was the largest producer (approximately 61,969 t, that is, 79.2% of the total production), followed by the South region, with 9,277 t (11.8%) and by the Northeast region with 3,292 t (4.2%), according to data published by the IBGE (2006). Even so, eggplant, from a market point of view, is, in Brazil, a species of secondary importance in comparison with other vegetables. Its recently discovered medicinal properties are thought to be capable of reversing this situation so that it will dispose of a sounder and more consolidated market.

Hydroponics is a cultivating technique that allows using balanced nutritional solutions in the presence of natural or artificial substrata, which has become an intensive production system (Rodrigues, 2002). In one of the few and pioneer research works carried out in Brazil, Haag and Homa (1968) investigated the effects of omitting nutrients on the development of eggplants growing in the nutritional solution of Hoagland and Arnon (1950). The lack of one given nutrient is considered as a preoccupying event since its essential and specific functions may be basic for the plants to have a normal productive performance.

Nutritional disorders independently of being caused by deficiency of, excess of, or unbalance of nutrients, result in loss of production. This reduction in production is, usually, preceded by visual symptoms which, most of the times, occur in the plant leaves, although sometimes the reduction in production takes place before the appearing of the symptoms (Malavolta et al., 1997). Visually diagnosing nutritional deficiencies with the concomitant knowledge of the plants contents of nutrients are fundamental tools to evaluate plants nutritional status so to be able to recommend the more adequate soil fertilizing procedures (Epstein, 1975).

Bearing these aspects in mind, the objective of this research work was to evaluate the effects of omitting nutrients in nutritional solutions where eggplants of the cultivar ‘Roxa Comprida’ were made to grow.

MATERIALS AND METHODS

The experiment was carried out under greenhouse conditions at the College of Agriculture and Veterinary, a unit of the Paulista State University, in Jaboticabal, state of São Paulo, Brazil. The eggplants of the ‘Roxa Comprida’ cultivar were made to grow in 8L vases containing a nutrients solution.

The treatments to which the plants were submitted were the following: 1. complete nutrients solution [nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn)], 2. nutrient solution complete but for N, 3. nutrient solution complete but for P, 4. nutrient solution complete but for K, 5. nutrient solution complete but for Ca, 6. nutrient solution complete but for Mg, 7. nutrient solution complete but for S. Each one of these treatments was repeated 3 times and the resulting experimental units were arranged in the greenhouse space according to a completely random design. During the duration of the experiment, the vases were moved around inside the greenhouse viewing to expose the plants to more uniform conditions of luminosity, humidity, and temperature.

The experiment was installed in a greenhouse with 20 day old eggplant seedlings transplanted to vases (1 seedling per vase) containing the Hoagland and Arnon (1950) solution diluted, in the first week, to 50% of its usual concentration and then, starting in the second week, till the end of the experiment, at its usual concentration.

The nutritive solutions were prepared with deionized water and replaced each 15 days. The pH was adjusted to 5.5 ± 0.5 with the help of a sodium hydroxide (NaOH) solution or a hydrochloric acid (HCl) 0.1 M solution. To replace the evapotranspirated water, deionized water was used with the nutritive solution being constantly oxygenated with the help of an air compressor.

The plants were harvested 56 days after transplantation (DAT). At that moment, plant height (from the soil level up to the apex of the last developed leaf), the total number of leaves per plant, the indirect measure of chlorophyll content from the reading of the chlorophyll relative index (ICR) in ten leaves by experimental unit with the help of the equipment of the OPTI-Sciences® model CCM-200, leaf area with the equipment LI-3100 Area Meter (LiCor, Lincoln, NE, USA), the rate of net photosynthesis, stomata conductance in 2 leaves per experimental unit with the help of an open system portable infrared gas analyzer (IRGA) model LICOR 6400, such as described by Santos Júnior et al. (2006) were measured. The measurements were made between 8 am and 3 pm in totally extended leaves in good phytosanitary conditions. The responses of the photosynthetic variables to the luminous intensity were determined for the density of photon flux (PPFD) of 550 µmol m^{-2} s^{-1} with the foliar chamber adjusted to operate with a carbon dioxide (CO_2) concentration of 380 ± 5 µmol mol^{-1}, temperature of 31 ± 1°C and water vapor of 21 ± 1 mmol mol^{-1} with leaf area of 1 cm^2.

The harvested plant material was washed with deionized water and divided in aerial part and root part and then taken to an oven with forced ventilation at 65°C until constant weight. This material was used to determine the dry matter weight and the macronutrients levels making use of the analytical procedures described by Bataglia et al. (1983).

During the experimental period, starting from the first week in which the nutrients solution had 100% of its full composition, the visual symptoms characteristic of each missing nutrient were daily described.

The experimental data were submitted to the analysis of variance and the means compared by the Tukey test ($P<0.05$) with the help of the AgroEstat (Barbosa and Maldonado Júnior, 2012) software. It was decided to indicate the significant differences pointed by the Tukey test in relation to the treatments with omitted elements and the treatment with complete nutrients solution.

RESULTS AND DISCUSSION

Nitrogen

The omission of nitrogen (N) caused reductions in all the variables related to the vegetative growth (plant height, number of leaves, leaf area), in the chlorophyll relative index, the stomatal conductance, and the net photosynthesis rate (Table 1).

The reductions in the stomatal conductance and in the net photosynthesis rate were rather drastic: 85% and 83%, respectively. Nitrogen participates directly in chlorophyll synthesis in addition to having an important role in the syntheses of enzymes [phosphoenolpyruvate carboxylase (PEPC) and Rubisco], which are active in atmospheric CO_2 fixation (Prado, 2008). The reduction in N availability for plants may cause reductions in the concentration of chlorophyll a and b (Cruz et al., 2007) this leading to lesser photosynthetic rate and consequently to lesser plant growth since these pigments are essential for the absorption of photons and the transporting of electrons (Heldt, 1997). The production of dry matter of the aerial part, and consequently in the whole plant was reduced when compared to plants that grew in the complete solution (Table 2).

The omission of N caused reductions in the leaf levels of K and S (Table 3). The root system of plants which had grown in the complete solution showed a N level of 35.4 g kg^{-1} whereas in those which had grown in the solution with omitted N, that level was of 14.6 g kg^{-1}. The omission of N caused also reductions in the root levels of Mg and S (Table 3).

The negative effect of omitting N on the development of variables of the vegetative growth is amply discussed in the literature due to the importance N has for plant nutrition. According to Filgueira (2003) N favors vegetative growth, the accumulation of mass, the increment of leaf area, and, consequently, the expression of the crop producing potential. These effects are consequence of the effects of N on biochemical and physiological processes such as the ionic absorption, photosynthesis, respiration, cell multiplication, and differentiation (Malavolta et al., 1997). When the plants grew in the complete solution, the level of N in the aerial part of the plants was of 37.0 g kg^{-1} while in the plants which had grown in the solution with N omitted, that value was of 10.9 g kg^{-1} (Table 3). It is observed that in all treatments, the levels of N in plant leaves are to be classified as deficient if compared to the values found by Trani et al. (1997) and Silva (1999) (40 – 60 g kg^{-1}) and by Hochmuth and Maynard (1996) (42 – 60 g kg^{-1}). These differences in N level in plants may be attributed to genotype, the environmental conditions under which the experiments were conducted, and especially to the types of leaves collected. In this experiment all the plant leaves were collected whereas in the above mentioned experiments each leaf sample was constituted by one leaf only, from a completely mature plant, at its flowering phase (Trani et al., 1997).

Omitting N caused reductions in the concentration of all the nutrients in the aerial part, root system and the whole plant, with the exception of P, K, and S in the root system (Table 4). It was observed that the omission of N, because it caused reductions in the absorption of nutrients by the plant (Table 4), was the cause of the variability taking place in growth characteristics of eggplant (Table 1) and this resulted in the visual symptoms characteristic of the deficiency of N in plants – a uniform yellowing of the older leaves.

According to Malavolta et al. (1997), this symptom is associated with reduced production of chlorophyll. This has been the case in this experiment since values of chlorophyll relative index were of 63.6 when the plants grew in the complete solution and of 4.0 when N was omitted from the nutrients solution (Table 1). According to Embrapa (2007), the deficiency of N in eggplants may result in shortening plant height, slender culms, poorly developed flowers and fruits, and generalized chlorosis in the older leaves.

Haag and Homa (1968) have also reported the symptoms of N deficiency in plants: the older leaves have a pale color. The young leaves were poorly developed, small and with a clear green color. The stems of these plants were slender, the flowers were in small number, and the fruits were in small number and malformed. With the advancement of the deficiency, the older leaves became completely yellow and dropped off the plants.

Phosphorus

The eggplants growing in the phosphorus (P) deficient solution showed reductions in all the variables related to the vegetative development (plant height, number of leaves, leaf area), in the chlorophyll relative index, in the stomatal conductance, in the net photosynthesis rate (Table 1) and this led to reduced production of dry matter both of the aerial and the root parts (Table 2). These data are showing that the omission of P in the nutrient solution caused reductions of the order of 76.5 and 90.0% in stomatal conductance and net photosynthesis rate respectively. Net photosynthesis rate is reduced by the lack of P due the role this element plays in the energetic processes of the plant as a adenosine triphosphate (ATP) component when it is necessary for the conversion of luminous energy to chemical energy during photosynthesis (Prado, 2008). The plants deprived of P produced less dry matter due to the importance of that element in plant nutrition since P is linked to structural functions in the process of transference and storage of energy (Malavolta, 1989), with considerable influence on metabolic processes such as the synthesis of proteins and nucleic acids (Mengel and Kirkby, 1987).

The omission of P from the nutrients solution reduced its concentration both in the plant aerial part (90.4%) as in its root system (87.1%), as shown in Table 3. Plants growing in the complete solution had P levels within the values considered adequate by Trani et al. (1997) and Silva (1999), that is between 3 and 12 g kg^{-1} and by Hochmuth and Maynard (1996), that is, between 3 and 6 g kg^{-1}.

Plants growing in the nutrients solution without P exhibited P levels lower than those values. Table 3 also shows that the omission of P caused reductions of N, K, Mg, and S in the leaves and of N, Ca, Mg, and S in the roots.

The omission of P reduced the content of this element of 97.2% in the plant aerial part, of 90.6% in the roots, and of 97.1% in the whole plant. In addition to that, the omission of P caused reductions in the contents of all the other elements in the plant aerial part, in the roots and in the whole plant (Table 4).

The omission of P led to the development of the visual symptoms characteristic for this element, that is, rickety plants with the older leaves showing a darker green color. Flower dropping is possible and this results in very low productions (Embrapa, 2007). P deficiency symptoms in plants are not clearly defined with the exception of number of flowers - the number of flowers is severely decreased and this may lead to no fruit production at all (Haag and Homa, 1968). As the P deficient plant gets older, the older leaves become yellow and drop off the plant.

Young and intermediate leaves show a darker green coloration.

Potassium

Eggplants that did not receive potassium (K) in their nutrient solution were of shorter height, a decreased number of leaves, a reduced leaf area, and a reduced in chlorophyll relative index (Table 1) and all this resulted in lower production of dry matter in the aerial and in the subterranean parts of the plant as in comparison with plants that had developed in complete nutrients solution (Table 2).

Plants growing in the K deficient solution had lower levels of K in the plant aerial part (93.3%) and in the root system (89.2%) (Table 3). It is possible to observe that the plants growing in the complete solution had foliar levels of K within the ranges indicated as adequate by Trani et al. (1997) and by Silva (1999), that is, from 35 to 60 g kg^{-1} and by Hochmuth and Maynard (1996), that is, from 35 to 50 g kg^{-1}, whereas those developing in the K deficient solution had inadequate levels of K. Omitting K in the nutrient solution led to plants with deficient levels of other nutrients : S in the leaf tissue and P and Mg in the root system (Table 3). Actually, the omission of K from the nutrients solution resulted in plants showing deficiencies of all the other nutrients in the aerial part of the plant, in the root system and in the whole plant (Table 4).

The problems previously mentioned resulting from the deficiency of K caused the plants to develop visual symptoms such as chlorotic margins in the older leaves with this being followed by necrosis. The necrosis that follows chlorosis grows from the leaf margins to its interior

(Embrapa, 2007). These symptoms are ascribed to the fact that K is redistributed throughout the whole plant when the plant is growing in K deficient soils, or nutritive solutions (Mengel and Kirkby, 1987). Passos (1999) maintains that K is a key element for the synthesis of chlorophyll - the results of our work show that plants growing in K deficient solution had reduced chlorophyll relative index (67.1% of that found in plants growing in the complete nutritive solution, as shown in Table 1). Haag and Homa (1968) reported to have observed that the first visual symptoms of K deficiency in eggplants started to be visible 63 days after planting – these signs consisted of a yellowing (chlorosis) of the older leaves margins which was followed by a necrotic growth towards the center of the leaf. If the K deficiency persisted those symptoms started to be verified in the intermediate leaves.

Calcium

The plants which received no calcium (Ca) in the nutrient solution were of shorter height, smaller number of leaves, smaller leaf area, lower chlorophyll relative index, and lower stomatal conductance (Table 1) and all those problems resulted in plants with lower production of dry matter both of the aerial and the subterranean parts (Table 2). Root system dry matter was reduced of 45.4% in plants growing in Ca deficient solutions - Ca is part of the pectins, which are needed for cell elongation and division (Prado, 2008). The effect on the production of dry matter was even more severe in the plant aerial part – plants growing in the Ca deficient solution had 90.1% less of dry matter in comparison with those that had grown in the complete solution. In addition to that, the omission of Ca in the nutrients solution caused reductions in the levels of the other nutrients as well (Table 4).

The omission of Ca in the nutrients solution resulted in visible symptoms in the plants such as irregularly shaped leaves, dots of necrotic lesions between the leaves innervations, and death of budding points at leaves and roots tips. The omission of Ca causes the leaves of eggplants to have an inadequate growth so that they are small when they reach maturity. The leaves margins undergo a yellowing process, which grows towards the central area of the leaf. Flower and fruit formation is severely hampered. In the fruits, the symptoms of Ca deficiency are the “black background”, apical or style rot (Embrapa, 2007). In this experiment it was verified that the symptoms of Ca deficiency were first seen as a yellowing of the leaves margins, which moved through the leaf vascular bundles and ended by covering the whole leaf surface. The young leaves were observed not to develop, keeping themselves small, wavy, and with a green-yellow color. The branches and petioles were very slender and flowers and fruits were in small number (Haag and Homa, 1968).

Magnesium

The omission of magnesium (Mg) in the nutrients solution caused reductions in plant height, number of leaves, leaf area, chlorophyll relative index, and stomatal conductance (Table 1). It was also observed that dry matter production was reduced of 81.5% in the plant aerial part and of 80.5% in the whole plant (Table 2).

Mg and N levels in the plant aerial part were, respectively, reduced of 93.1% and of 17% when Mg was omitted from the nutrients solution (Table 3).

Mg concentration in the plant aerial part in plants growing in the complete solution was found to be within the values considered as adequate by Trani et al. (1997) and by Silva (1999), that is, between 3 and 10 g kg^{-1}, and slightly above the values Hochmuth and Maynard (1996) considered as the adequate ones, that is 3 and 6 g kg^{-1}. The plants growing in the Mg deficient solution were found to be deficient in Mg. Omitting Mg resulted in plants with 98.1% less of Mg in the plants aerial part, 83.6% less of Mg in the root system, and 97.6% less of Mg in the whole plant. In addition to that, omission of Mg brought about a reduction in the levels of all the other nutrients in the plant aerial part and of S in the roots (Table 4). The Mg levels in the plants growing in the Mg deficient solution were enough to cause the visible symptoms characteristic of the deficiency of that element: a chlorosis developing between the nervures of the older leaves – this symptom was also found by Embrapa (2007). In our experiment, this symptom was verified to occur at the end of the plant cycle since at the beginning, the Mg reserves in the plant were enough for the plant needs. Haag and Homa (1968) reported to have also observed a yellowing of young leaves which became wavy, followed by a chlorotic development between nervures in the older leaves. These authors also observed that plants in which Mg was lacking bore no fruit.

Sulfur

The omission of sulfur (S) caused a reduction in all vegetative characteristics of the eggplants - plant height, number of leaves and leaf area, the chlorophyll relative index, stomatal conductance, and the net photosynthesis rate (Table 1) and this resulted in a reduction of 50.1% in the plant aerial part dry matter and of 49.5% in the whole plant dry matter (Table 2). Stomatal conductance was reduced of 85% and the net photosynthesis rate of 73.8%. These reductions are explained by the fact that S is a component of ferrodoxin, a low molecular weight protein that takes part in oxidation-reduction reactions of the photosynthesis (Prado, 2008).

The omission of S in the nutrients solution resulted in plants having 76.0% less of S in the aerial part and 84.8% less in the root system (Table 3). The concentration of S in the plants aerial part was lower than the values indicated as adequate by Hochmuth and Maynard (1996), that is, between 4 and 6 g kg^{-1}, not only in the plants growing in the S deficient solution but also in those growing in the complete solution. These differences are attributed to genotype, the type of leaves that were collected, and to different cultivation conditions.

The omission of S resulted in lower levels of N, K, and Mg in the plant aerial part and in lower levels of P and Mg in the roots (Table 3). When S was omitted from the nutrients solution, the levels of S were reduced of 88.3% in the plant aerial part, of 85.1% in the root system, and of 88.1% in the whole plant (Table 4).

The symptoms of S deficiency started to be visible only in the last week of evaluation: small leaves, with rolled up leaf margins, chlorosis initially in the younger leaves. These symptoms were also observed and described by Embrapa (2007) to which they added fruits less glossy. Haag and Homa (1968) reported to have difficulty in describing the symptoms of S deficiency in eggplant due to the fact that this species is not particularly demanding of S. The signs they were capable of observing were young leaves slightly chlorotic and fruits a bit paler.

The complete solution permitted to detect the following order of importance of the macronutrients in eggplants: 1. In the plant aerial part: K>N>Ca>Mg>P>S; 2. In the roots: K>N>Ca>P>Mg>S and, 3. In the whole plant: K>N>Ca>Mg>P>S (Table 4). Similar results were reported by Haag and Homa (1968) in eggplants up to 126 days of age. According to results reported by those authors the following sequence of nutrients accumulation was observed in leaves: K>N>Ca>P>S>Mg, specially for the three more extracted nutrients.

CONCLUSIONS

The omission of macronutrients interfered in the concentration of these elements in the various plant parts, reducing the vegetative growth, the production of dry matter and was the cause of the development of the deficiency symptoms.

The nutrients limiting more seriously eggplant development were N and Ca, although K was the most demanded one.

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TABLE 1 Height, number of leaves, leaf area, chlorophyll relative index (IRC), stomatal conductance, net photosynthesis rate, in eggplants aerial part and roots as determined by the omission of macronutrients in the nutritive solution

Treatments	Height	Number of leaves	Leaf area	IRC	Stomatal Conductance	Net Photosynthesis rate
	cm		cm^2		-------mmol m^{-2} s^{-1}--------	
Complete solution	54.7	14.2	3026.9	63.6	2.0	66.1
- N	8.3*	4.0*	41.3*	6.8*	0.3*	10.9*
- P	24.7*	6.8*	661.1*	38.6*	0.2*	15.5*
- K	34.3*	10.7*	691.0*	20.9*	1.5	54.6
- Ca	11.7*	6.3*	139.6*	27.9*	0.5*	49.3
- Mg	22.7*	9.7*	732.9*	4.8*	1.8	47.6
- S	32.3*	8.0*	1334.9*	31.0*	0.3*	17.3*
DMS	9.8	2.4	486.3	11.7	1.1	19.9
C.V.%	13.0	10.1	18.4	15.1	19.1	19.1

* - Significant and lower than the check treatment in the column according to the Tukey´s test at the level of 5% of probability.

TABLE 2 Dry matter production of eggplants as determined by the omission of macronutrients from the nutrients solution

Treatments	Matéria seca		
	Aerial part	Roots	Whole plant
	g por planta		
Complete solution	66.0	1.1	67.1
- N	3.4*	0.8	4.2*
- P	16.9*	0.7	17.6*
- K	21.4*	0.3*	21.7*
- Ca	6.5*	0.6*	7.1*
- Mg	12.2*	0.9	13.1*
- S	32.9*	1.0	33.9*
DMS	7.7	0.3	7.6
C.V.%	12.2	16.4	11.9

* - Significant and lower than the check treatment in the column according to the Tukey´s test at the level of 5% of probability.

TABLE 3 Macronutrients concentration, in eggplants aerial part and roots as determined by the omission of macronutrients in the nutritive solution

Tratamentos	N	P	K	Ca	Mg	S
	g.kg^{-1}					
			Aerial part			
Complete solution	37.0	5.2	37.4	14.8	7.2	2.5
- N	10.9*	3.6	26.4*	14.2	3.9	1.6*
- P	32.1*	0.5*	24.3*	9.5	2.8*	1.3*
- K	34.0	3.8	2.5*	9.0	5.1	1.7*
- Ca	31.7*	4.4	33.9	0.7*	5.1	1.9
- Mg	30.7*	3.8	36.7	11.5	0.5*	2.0
- S	29.4*	4.0	31.0*	14.7	3.0*	0.6*
DMS	4.0	1.9	5.9	7.0	1.5	0.7
C.V.(%)	4.9	18.6	7.7	19.8	14.2	15.8
			Roots			
Complete solution	35.4	6.2	37.0	6.6	5.8	4.6
- N	14.6*	5.9	34.1	5.9	5.1*	3.2*
- P	26.6*	0.8*	34.9	3.1*	1.6*	3.2*
- K	34.7	5.2*	4.0*	6.4	5.2*	4.5
- Ca	34.0	5.4*	21.8*	1.5*	4.8*	3.7*
- Mg	32.0	5.7	35.7	5.8	1.1*	3.9
- S	34.1	4.8*	33.2	6.0	5.1*	0.7*
DMS	3.4	0.5	9.6	1.3	0.6	0.7
C.V.(%)	4.1	4.1	12.1	9.3	5.7	7.1

* - Significant and lower than the check treatment in the column according to the Tukey´s test at the level of 5% of probability.

TABLE 4 Macronutrients accumulation, in eggplants aerial part and roots as determined by the omission of macronutrients in the nutritive solution

Tratamentos	N	P	K	Ca	Mg	S
		mg por planta				
			Aerial part			
Complete solution	2442.6	344.6	2462.4	980.2	346.7	167.9
- N	37.0*	12.1*	89.0*	47.7*	12.9*	5.3*
- P	544.8*	9.7*	412.6*	161.9*	47.1*	22.5*
- K	727.9*	80.7*	52.6*	189.8*	108.3*	36.6*
- Ca	205.7*	28.4*	220.8*	4.5*	33.5*	12.6*
- Mg	372.3*	46.9*	447.0*	141.0*	6.6*	24.5*
- S	967.1*	130.2*	1020.6*	483.0*	99.4*	19.7*
DMS	304.4	88.8	303.4	216.4	82.4	40.2
C.V.(%)	14.4	34.2	16.2	27.1	30.0	34.9
			Roots			
Complete solution	36.6	6.4	38.2	6.8	6.1	4.7
- N	12.1*	5.0	28.5	4.9*	4.2	2.7*
- P	18.6*	0.6*	24.4*	2.2*	1.1*	2.2*
- K	11.4*	1.8*	1.4*	2.1*	1.7*	1.5*
- Ca	21.6*	3.4*	13.8*	1.0*	3.0*	2.3*
- Mg	28.8	5.1	32.1	5.2	1.0*	3.6*
- S	34.3	4.8	33.3	6.0	5.1	0.7*
DMS	12.3	1.7	12.3	1.7	1.8	0.9
C.V.(%)	18.9	16.2	17.9	14.8	20.9	13.3
			Whole plant			
Complete solution	2479.2	350.9	2500.6	987.0	352.7	172.5
- N	49.1*	17.1*	117.4*	52.6*	17.1*	8.1*
- P	563.5*	10.3*	436.9*	164.0*	48.1*	24.8*
- K	739.3*	82.5*	54.0*	191.9*	110.0*	38.1*
- Ca	227.2*	31.8*	234.6*	5.5*	36.6*	14.9*
- Mg	401.1*	52.1*	479.2*	146.2*	7.5*	28.0*
- S	1001.3*	135.0*	1053.9*	488.9*	104.6*	20.5*
DMS	303.9	88.68	302.3	215.5	81.5	40.2
C.V.%	13.9	32.7	15.5	26.5	30.2	32.9

* - Significant and lower than the check treatment in the column according to the Tukey´s test at the level of 5% of probability.