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MICRONUTRIENTS IN THE NUTRITION OF COCONUT

II. EFFECT OF MACRONUTRIENT DEFICIENCIES ON THE DISTRIBUTION OF Fe, Mn, Cu, Zn AND B IN LEAF COMPONENTS OF COCONUT SEEDLINGS

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SUMMARY

The uptake and distribution of Fe, Mn, Cu, Zn and B in coconut seedlings subjected to subtractive treatment of N, P, K, Ca and Mg were investigated. In each treatment half the number of seedlings were deprived of their nut reserves at the 3-leaf stage by a process of amputation.

It was apparent that one of the significant features in the nutrition of coconut seedlings upto the 3-leaf stage was the rapid mobilisation of boron in the reserves of the nut and translocation to regions of active growth.

In each treatment amputated seedlings generally showed less vigorous growth than the non-amputated seedlings, and hence these seedlings contained relatively lesser amounts of micronutrients.

The uptake of Mn was high in all leaf components of plants starved of nitrogen. It is suggested that a deficiency of nitrogen disrupts the mechanism controlling the metabolic movement of Mn in the plant, thus causing an increased uptake of Mn through non-metabolic processes.

Plants deprived of all nutrients had high concentrations of Cu in laminae and midribs. The concentration of copper in the laminae of these plants was at least five times greater than the highest found in the other treatments. The symptoms of severe chlorosis and drying of leaf margins observed in these plants are thought to be at least partly due to the accumulation of toxic levels of Cu in the leaves, when plants are deprived of macronutrients.

INTRODUCTION

The deficiency or an excess of a mineral nutrient inevitably causes disturbances in the balance of nutrient levels in plant components. Such situations can sometimes mask symptoms of a deficiency or an excess of a particular nutrient and may even provide confusing analytical data. It is obvious therefore, that for a better understanding of the nutritional problems of plants it is important to evaluate such relationships as they occur, when plants are subjected to conditions of either a nutrient stress or an excess.

Investigations on these lines have been carried out on a wide range of plants, but rarely has it been observed that two species or even two varieties behave identically to a given set of conditions.

Nathanael (1959, 1961, 1962), in a series of experiments studied the influence of major nutrient deficiencies on the growth of coconut seedlings. He also examined the distribution of major nutrients in plant components of seedlings subjected to subtractive treatment of these nutrients (unpublished). In order to obtain a complete picture of the mineral composition of coconut seedlings grown under such conditions, it was deemed desirable to extend this study to micronutrients as well.

The present paper describes the work carried out to determine the uptake and distribution of Fe, Mn, Cu, Zn and B in coconut seedlings subjected to subtractive treatment of N, P, K, Ca and Mg.

EXPERIMENTAL

1,500 fruits collected from a uniform plantation of 300 adult coconut palms (var. *typica*), constituted the source from which materials were drawn for this investigation.

After 12 weeks of storage, seednuts were de-husked and classified according to size, weight and vigour of shoot. 252 sprouted seednuts at the "crow's beak" stage were carefully selected for uniformity in size, weight and vigour of shoot, and planted in seven large pots at predetermined positions. A description of pots used in these studies could be found in a review elsewhere (Hewitt, 1966). The white silica sands used in the pots were first washed several times with filtered tap water, and finally allowed to leach in rain water.

The pots carried the subtractive treatment of N, P, K, Ca and Mg, with a minus-all-nutrients treatment and a plus-all-nutrients treatment serving as controls. Differential treatment commenced immediately after planting and continued daily with a nutrient solution containing the following concentrations of nutrients.

	ppm		*ppm*
N	170	Na	31
P	41	Fe	5.6
K	156	Mn	0.55
Ca	160	Cu	0.064
Mg	36	Zn	0.065
S	48	B	0.33
		Mo	0.048

Three months after planting, the number of plants per pot was reduced to 10, of which 5 were subjected to a process of amputation as described by Nathanael (1959), to separate the nuts from the young plants. A further nine months later, both amputated and non-amputated plants were uprooted from each treatment pot and subjected to chemical examination.

Plant samples

Chemical studies on plant materials were done at 4 stages during the course of the experiment as described below. At two of these stages (2nd and 3rd) only iron manganese and boron were determined.

(1) The first examination was done on the nutrient reserves of the fruit. For this purpose, 15 seednuts were selected at random 4 weeks after the pick, from the heap of fruits chosen for the experiment. The nut water and kernels of these were analysed for Fe, Mn, Cu, Zn and B.

(2) Approximately, 12 weeks after the pick 20 sprouted seednuts ("crow's beak" stage) were chosen, and the plant components were analysed for Fe, Mn and B.

(3) Three months after the commencement of this pot culture experiment (amputation stage), 3 plants from each treatment pot were uprooted and the plant components were analysed for Fe, Mn and B.

(4) Finally when the plants were 12 months old in the pots, leaf samples from the youngest fully opened leaf were taken from 3 amputated and 3 non-amputated plants in each treatment. The leaf components comprising the rachis, midribs and laminae were then analysed for Fe, Mn, Cu, Zn and B.

The general procedure for the preparation of plant samples for analysis, and the techniques used for the determination of micronutrients are described elsewhere (De Silva, 1973).

RESULTS AND DISCUSSION

The data summarised in Table 1 show the contents of micronutrients in the kernel and nut water of average-sized coconuts collected from a plantation which had been fertilized regularly with nitrogen, phosphorus and potassium. It is seen that while the contents of Fe, Cu and Zn in nut water constitute only about 1 percent of the total content, manganese and boron make up about one-fourth of the total, in nut water.

TABLE 1

Contents per seednut of Fe, Mn, Cu, Zn and B in kernels and nutwater of coconut (var. *typica*), 4 weeks after the pick. (Mean of 15 determinations)

	IRON		*MANGANESE*		*COPPER*		*ZINC*		*BORON*	
	ug Fe	*% of total*	*ug Mn*	*% of total*	*ug Cu*	*% of total*	*ug Zn*	*% of total*	*ug B*	*% of total*
Nut water	86.3	0.93	1021.6	22.60	33.6	1.19	39.0	0.82	106.2	28.27
Kernel	9241.7	99.07	3490.0	77.40	2802.4	98.81	4708.8	99.18	269.5	71.73
Total	9328.0	100	4511.6	100	2836.0	100	4748.8	100	375.7	100

TABLE 2

Distribution of Fe, Mn and B in plant components of coconut seedlings at the "crow's beak" stage (approximately 12 weeks after pick), expressed as percentages of the total content of each nutrient.

	IRON % *of total content*	*MANGANESE* % *of total content*	*BORON* % *of total content*
Shoot	2.10	0.95	25.08
Root	0.21	0.04	0.02
Cotyledon	6.25	28.08	20.48
Kernel	86.89	60.24	50.77
Nut water	4.55	10.69	3.65
Total	100	100	100

Table 2 gives the distribution of Fe, Mn and B in plant components of seedlings at the "crow's beak" stage expressed as percentages of the total content of each nutrient. These data show that the roots and shoots had drawn only a negligible portion of iron and manganese from the nut reserves at this stage of development. However, in the case of manganese, a fairly high quantity had been moved out from the reserves to the cotyledon. On the other hand, about a fourth of the total reserves of boron had been mobilised and transferred to the developing shoot.

The data summarised in Table 3 show the distribution of Fe, Mn an B in plant components of seedlings at the amputation stage. The analytical data for iron in kernels and cotyledons are not presented, as concordant replicate determinations were not obtained because of an analytical error.

TABLE 3

Contents of Fe, Mn and B (in micrograms) in plant components of coconut seedlings taken at the amputation stage (three-leaf stage, approx. 3 months after planting in pots)

Treatments	IRON		MANGANESE				BORON			
	Shoot	Root	Kernel	Coty-ledon	Shoot	Root	Kernel	Coty-ledon	Shoot	Root
+ All	316.6	144.1	2755.6	1714.2	319.8	332.9	142.6	151.6	164.5	56.1
− All	444.7	140.3	2734.4	809.4	163.3	148.9	174.0	247.0	95.2	34.9
− N	926.6	150.1	2830.8	937.2	475.2	239.9	130.2	154.2	197.9	47.7
− P	863.0	236.3	2896.8	1591.8	308.9	253.1	135.1	152.7	336.5	55.1
− K	884.2	259.3	2405.6	1378.2	285.0	307.1	161.9	163.0	236.1	71.8
− Ca	1067.4	123.7	2438.8	1125.8	296.3	307.0	136.0	191.2	240.5	32.4
− Mg	1376.6	205.2	2553.6	741.4	236.5	301.6	143.4	158.7	300.0	52.3

The elimination of N, P, K, Ca and Mg individually in nutrient solutions had induced a greater uptake of Fe to the shoot. This pattern however, is not seen strikingly in the roots. In the absence of data for the nut reserves, it is not possible to determine the contribution made by this source to the developing shoot and root.

Though the contents of manganese in the kernels had not been affected by the treatments, a tendency for a greater uptake of manganese is evident in plants deprived of nitrogen. As was observed at the "crow's beak" stage there has not been a conspicuous movement of manganese from the reserves to the growing tissues. The low content of manganese in plants deprived of all nutrients could be due to their retarded growth.

In the case of boron, as was observed in the "crow's beak" stage, a fair portion of reserve boron had been mobilised and moved out to the growing regions. This is also indicated by the higher proportion of boron in the cotyledons as compared to the kernels. The following points are noteworthy as they provide additional evidence for the greater need of boron at regions of active growth:

(*a*) The presence of a relatively higher quantity of boron in the storage tissues, and low contents in shoots and roots of plants deprived of all nutrients.

(*b*) The low content of boron in the poorly developed roots of the calcium starved plants.

In general it is apparent that one of the significant features in the nutrition of coconut seedlings upto the 3-leaf stage (amputation stage), is the rapid mobilisation of boron in the reserves of the nut and translocation to regions of active growth.

Figures 1-5 illustrate the distribution of Fe, Mn, Cu, Zn and B in leaf components of amputated and non-amputated seedlings which had received differential treatment for 12 months.

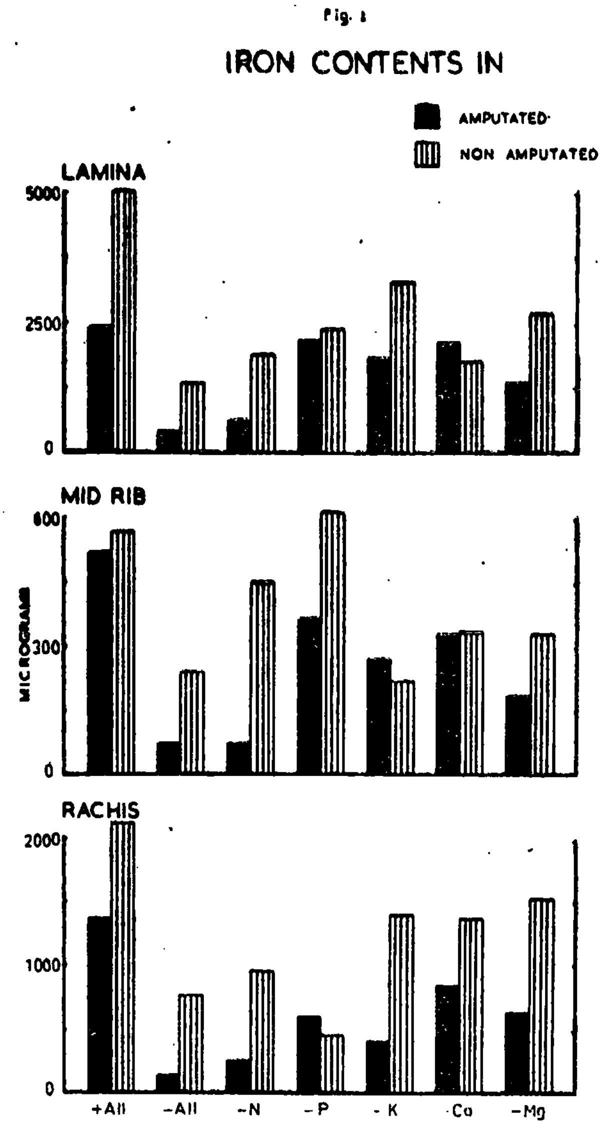

Fig. 1. Total iron in leaf components (1st leaf) of amputated and non amputated seedlings.

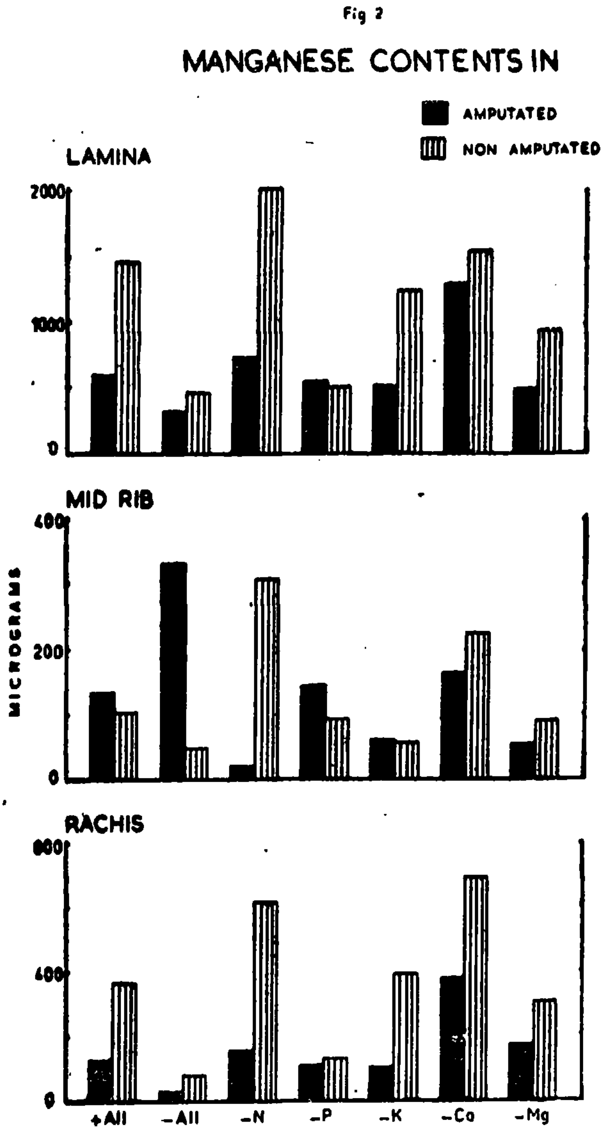

Fig. 2. Total manganese in leaf components (1st leaf) of amputated and non amputated seedlings.

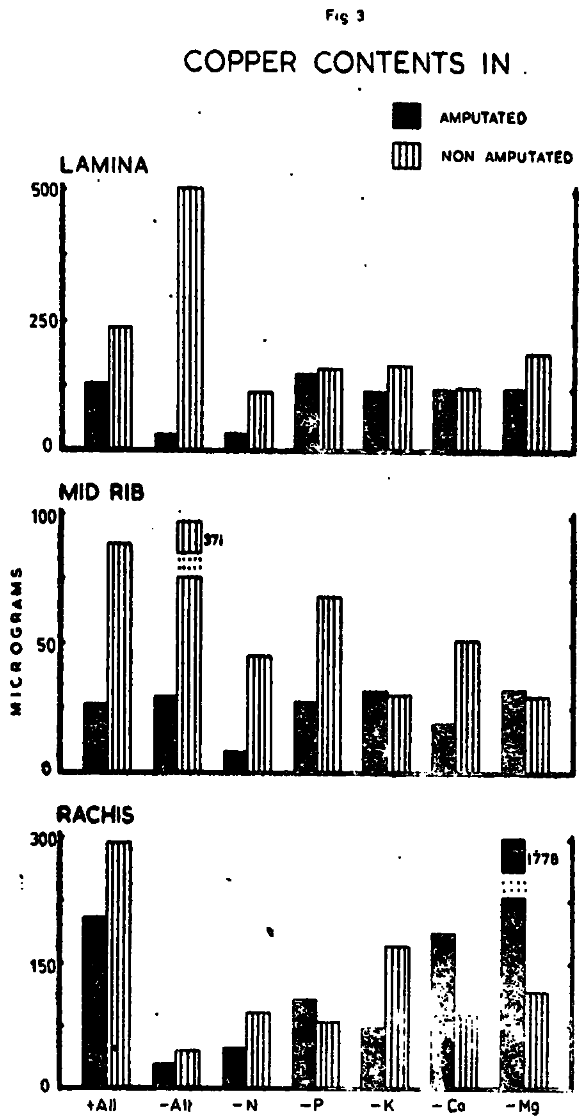

Fig. 3. Total copper in leaf components (1st leaf) of amputated and non amputated seedlings,

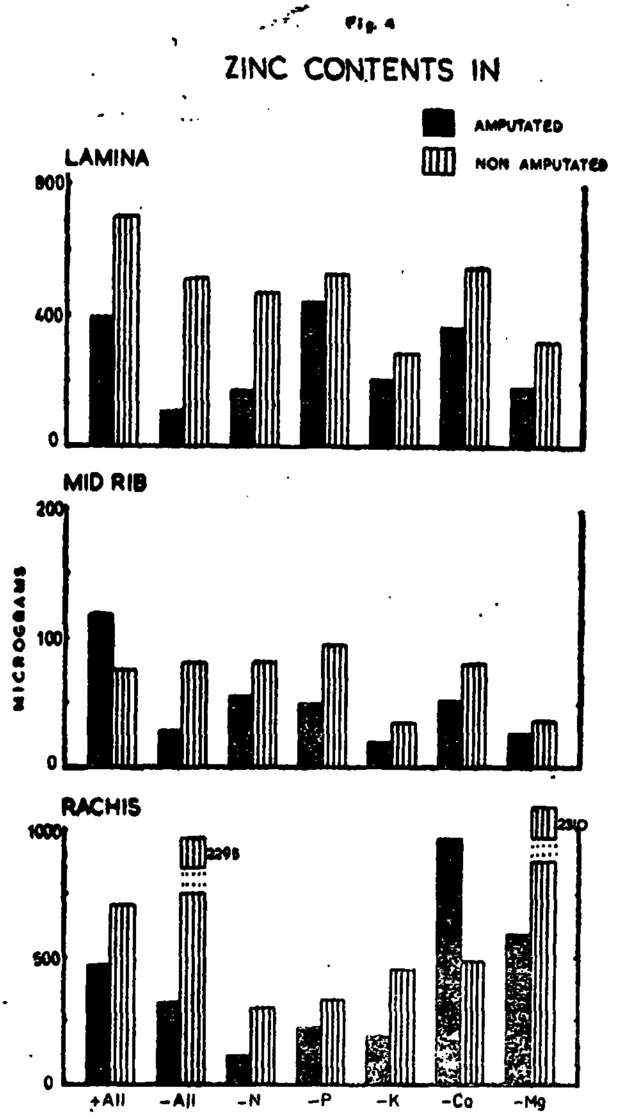

Fig. 4. Total zinc in leaf components (1st leaf) of amputated and non amputated seedlings.

Fig. 5

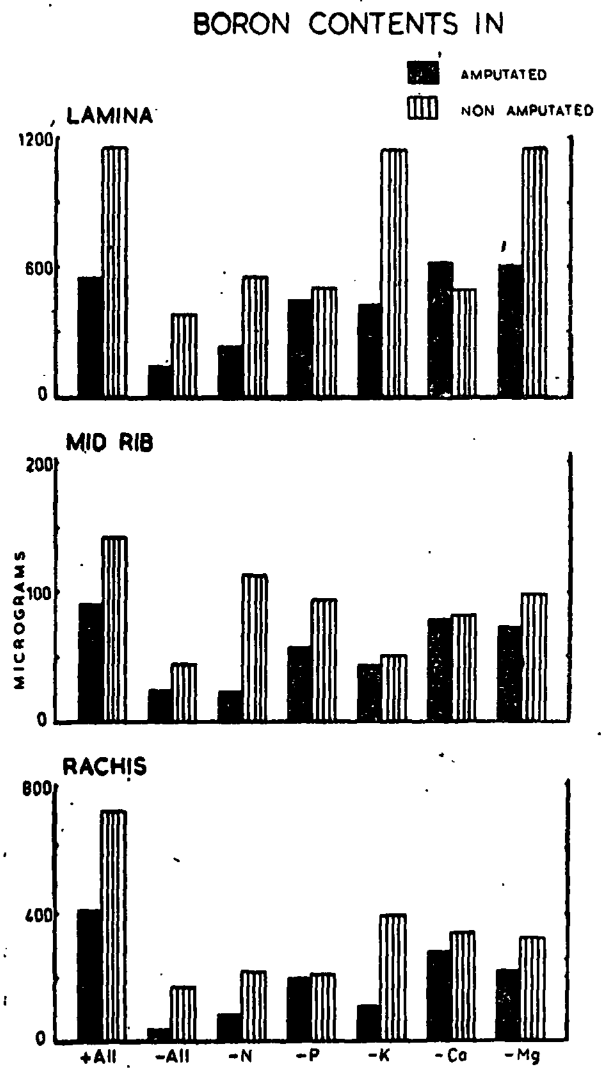

Fig. 5. Total boron in leaf components (1st leaf) of amputated and non amputated seedlings.

Amputated seedlings generally showed less vigorous growth than non-amputated plants in all treatments. For this reason to facilitate comparison, the data expressed as the total content per plant component are presented in histograms. It is apparent that on account of the different rates of growth of seedlings, the leaf components of plants that were amputated had lower amounts of the nutrients than in those of their non-amputated counterparts.

Iron

The contents of iron in all leaf (first leaf) components of the 'plus-all' plants stood conspicuously high when compared to the others. Although in the rachis of plants deprived of K, Ca and Mg, the iron contents were fairly high, only K-deficient plants reflected this trend in the laminae. Iljin (1952), Hewitt and Bolle-Jones (1953), Bolle-Jones (1955) and De Kock *et al.* (1960), have suggested that potassium increases the mobilisation and efficient utilisation of iron, but in the present study absence of potassium has not shown to affect seriously the movement of iron.

Rediske and Biddulph (1953), Bingham (1963) the Watanabe *et al.* (1965) found that excess phosphorus limited the mobility of Fe. On the other hand Warnock (1970), found that high P increased the mobility of Fe. In the present study, accumulation of Fe in the midribs of P-deficient plants, may be construed to indicate the immobilisation of Fe under conditions of P-deficiency.

Manganese

The analytical data for manganese show that plants deprived of N and Ca have accumulated Mn in all leaf components. An inverse relationship between Ca and Mn, in which Ca has been found to reduce Mn toxicity has been observed by Hewitt (1945, 1946, 1948) and by Ouellette and Dessureaux (1958). The reciprocal relationship may also be true in which Ca deficiency increases the uptake of Mn as observed in the present investigation.

The increased uptake of Mn by plants starved of nitrogen appears unusual. It may be relevant to note that at the amputation stage too it was observed that a relatively greater quantity of Mn was taken up by the shoots of seedlings deprived of nitrogen. Whether this observation reflects an inverse relationship is not clear. However, it is possible that a deficiency of nitrogen disrupts the mechanism controlling the metabolic movement of Mn in the plant, thus causing an increased uptake of Mn through non-metabolic processes.

The reduced uptake of Mn by phosphorus deficient plants is in accordance with the observation made by other workers (Morris and Pierre, 1947 Vlamis and Williams, 1962).

Copper and Zinc

The data presented in Figs. 3 and 4 show that plants deprived of all nutrients had high contents of Cu in laminae and midribs. The concentration of Cu was 34.5 ppm. in the laminae, and 23.4 ppm. in the midribs. The value for laminae was at least 5 times greater than the highest found in the other treatments. The plants receiving this treatment showed retarded growth with severe chlorosis and drying of leaf margins. It was likely that the Cu levels in laminae and midribs have exceeded the upper tolerance limit, and some of the observed characteristics may in fact represent symptoms of Cu toxicity.

The frequently observed inverse relationships of P-Zn and of P-Cu (Bingham *et al.* 1958, Bingham and Garber 1960, Bingham 1963 and Peterson *et al.* 1969), were not shown distinctly in this investigation. The absence of magnesium apparently facilitates increased uptake and accumulation of Zn in the rachis, as observed in the plants of minus Mg and minus all treatments.

The high levels of Zn in the rachis of amputated minus Ca plants is not clear; so is the high content of Cu in the rachis of amputated minus Mg plants.

Boron

As was observed in the case of iron, the contents of boron in all leaf components of 'plus all' plants are strikingly high when compared with those of other treatments. In plants deficient in potassium and magnesium, accumulation of boron occurred in the laminae. The physiological significance of this observation is not clear.

The above discussion clearly shows the complexities that arise when one or more of the essential plant nutrients are found deficient in the growth medium. It is hardly necessary to emphasize the importance of studies of this nature both for a better understanding of the nutrition of the plant and also for diagnostic studies.

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