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INVESTIGATION OF IMPORTANT MINERAL NUTRIENTS IN LEAVES OF TWO TREE SPECIES IN A PREMONTANE WET FOREST IN COSTA RICA

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INTRODUCTION

Everybody is fascinated by the biodiversity and the high biomass to be found in tropical forests. One might imagine that a high nutrient content in the tropical soils could account for this. However, in this respect tropical soils are extremly diverse. An example of a paradox is the Amazon Basin where a high species richness and biomass in the primary forest is found despite the extremely nutrient-poor soil. So the question arises as to whether the nutrient contents in the soil and the plant correspond.

In Costa Rica there was and is vulcanic activity accounting for relatively nutrient rich soils. In a primary premontane wet forest the nutrient conditions were investigated. In order to examine these conditions, leaves of two tree species and soil samples were collected as indicators of the nutritional status of trees (VAN DEN DRIESSCHE, 1974) and soils respectively.

LOCATION & EXPERIMENTAL OBJECTIVE

The area of investigation is situated in the Cordillera de Tillarán, in the Reserva Biológica Alberto Brenes (former Reserva Forestal de San Ramon). The Biological station is located at 895 m above sea level. The annual rainfall reaches about 5500 mm (CRUZ, 1989) and the average temperature varies from 19 to 23 °C. The forest is classified as a tropical premontane evergreen rainforest (GÓMEZ, 1986). The soils are Inceptisols of vulcanic origin (TAXONOMÍA DE SUELOS, SMSS,1982); they are sandy but contain a high amount of organic material (10-20% OM).

In this work the macro-nutrient (Ca, K, Mg, P) and micro-nutrient (Mn, Zn) contents in the leaves of two moderatly distributed tree species and the surrounding soil were analyzed.

QUESTIONS OF INTEREST

- What influence does leaf age have on the nutrient content of the leaves?
- Are there any differences between the nutrient contents of the leaves of the two tree species?
- Do the nutrient contents of the leaves and soil correspond?
- How are the nutrients distributed in the soil profile?

MATERIALS & METHODS

During the dry season (March/April) young (same size as mature but light geen and at the end of the twig) and mature leaves (all leaves dark green) were collected. One leaf sample of *Plinia salticola* (Myrtaceae) included 30 leaves and one of *Elaeagia auriculata* (Rubiaceae) included 15 leaves because the latter were much bigger. Altogether 25 individual trees of *P. salticola* and 23 of *E. auriculata* were examined. The soil samples were taken arround the trees to a depth of 10 and 15 cm (A-Horizon). To analyze the contents of the macro-nutrients (Ca, K, Mg and P) and the micro-nutrients (Mn, Zn) the leaves were dried at 70°C and the milled leaf material was treated according to HEINRICHS *et al.* (1986). The soil samples were extracted by ammonium acetate (pH 7, FAO-Unesco, 1990; US-SOIL-TAXONOMY, 1990) in order to determine the content of exchangable cations.

The cations were analyzed by flame atomic absorbtion spectrometry. The contents of phosphorus in the plants were determined by photometry by staining the leaf samples with ammonium molybdate and -vanadate and the soil samples were treated according to the Ca-lactat method (STEUBING & FANGMEIER, 1992).

RESULTS

The nutrient concentrations in the leaves are in agreement with the data for crop plants and trees (MARSCHNER, 1990; BERGMANN, 1992; MENGEL, 1991) with the exception of manganese and phosphorus (Table 1&2) . The concentration of manganese, expecially in *Plinia salticola*, was higher than is usual in plants. Conversely the phosphorus concentration in both species was very low (<0,1% dm, Table 1&2).

The content of exchangable nutrients in the soils is shown in Table 3 and 4. The pH(H_2O) is between 4,7 and 6,1 (4,0-5,1 in 0,1 M KCl) with no differences between the sites.

A correlation analysis did not show any significant connections between the nutrient contents of leaves and soil samples using the described extraction. But there was a statistical difference between the nutrient contents of young and mature leaves. Higher concentrations of Ca, Mg and Mn were found in mature leaves and P and K concentrations were higher in young leaves. For Zinc there was no clear difference between the concentrations of young and mature leaves. However, in general there was a very low Zn concentration in the soil and the plants.

Also, between the tree species there was a difference in the elemetal concentrations. Ca and Mn concentrations were higher in *P. salticola* leaves while the opposite was shown for K, P and Zn which were higher in *E. auriculata* leaves. Both species had a similar Mg concentration.

From analysis of the soil profile (ca. 1m depth) it was clearly shown that the minerals Ca, Mg, K and Mn reached the highest concentration in the upper soil layer (0-15 cm, H-Horizon and A-Horizon).

Table 1: Concentrations of macro-elements in the leaves of *Plinia salticola* and *Elaeagia auriculata*

macro-minerals	**mature leaves**		**young leaves**	
	% dm	**sd**	**% dm**	**sd**
P				
Plinia salticola	0,44	0,05	0,62	0,11
Elaeagia auriculata	0,58	0,10	0,75	0,18
K				
Plinia salticola	5,59	1,69	9,77	2,91
Elaeagia auriculata	9,76	2,95	13,07	3,67
Mg				
Plinia salticola	2,66	0,44	1,88	0,41
Elaeagia auriculata	2,66	0,70	2,02	0,50
Ca				
Plinia salticola	12,12	1,95	7,49	2,50
Elaeagia auriculata	6,64	2,43	4,20	1,77

Table 2: Concentrations of micro-elements in the leaves of *Plinia salticola* and *Elaeagia auriculata*

micro-minerals	**mature leaves**		**young leaves**	
	mg/kg dm	**sd**	**mg/kg dm**	**sd**
Mn				
Plinia salticola	713	252	367	168
Elaeagia auriculata	281	107	205	131
Zn				
Plinia salticola	18	3	20	6
Elaeagia auriculata	34	8	30	9

Table 3: Concentrations of macro-elements in the soil on sites of *Plinia salticola* and *Elaeagia auriculata*

macro-minerals	**10 cm deep**		**20 cm deep**	
	mg/kg dm	**sd**	**mg/kg dm**	**sd**
P				
Plinia salticola	27,9	18,7	15,2	7,7
Elaeagia auriculata	26	10,6	13,9	4,9
K				
Plinia salticola	55	42	40	41
Elaeagia auriculata	67	85	43	57
Mg				
Plinia salticola	50,6	69,2	42,8	74,1
Elaeagia auriculata	46,6	45,7	26,3	18,9
Ca				
Plinia salticola	246	450	223	469
Elaeagia auriculata	190	195	120	86

Table 4: Concentrations of micro-elements in the soil on sites of *Plinia salticola* and *Elaeagia auriculata*

micro-minerals	**10 cm deep**		**20 cm deep**	
	mg/kg dm	**sd**	**mg/kg dm**	**sd**
Mn				
Plinia salticola	8,9	5,6	6,7	3,8
Elaeagia auriculata	12,2	8,2	8,2	5,5
Zn				
Plinia salticola	0,34	0,28	0,27	0,15
Elaeagia auriculata	0,40	0,34	0,27	0,20

Table 5: Concentrations of the six elements Ca, K, Mg, Mn, P, Zn [mg/kg dry matter] in tree leaves from eight different rainforests

investigated area	Ca	K	Mg	Mn	P	Zn	comments
rainforest near San Carlos, Venezuela (GOLLEY *et al.*, 1980b)	1090 ± 681	3799 ± 1316	1054 ± 419	153 ± 89	570 ± 132	11 ± 3	average (28 species)
„terrȧ firme" forest in brazil (GOLLEY *et al.*, 1980a)	4537 6576	6567 4043	3855 4201	87 154	469 450	13 15	Myrtaceae Rubiaceae
central amazone, brazil (KLINGE, 1985)	1000-7000	2000-9000	1500-3500	-	300-900	-	depending on trees-species (altogether 14 species)
mountain rain forest in New Guinea (GRUBB & EDWARDS, 1982a)	15000 ± 1500	7700 ± 700	3100 ± 400	-	860 ± 40	-	average of 8 tree species
rainforest in NO Columbia (GOLLEY *et al.*, 1978)	3905 3550	1210 11520	3175 5630	31 27	593 561	229 125 (high!)	canopy leaves brushwood
secondary forests in Guatemala and Panama (SNEDAKER & GAMBLE, 1969)	1000-20000	1000-20000	3000-13000 (high)	10-200	100-200	20-50	depending on tree-species (18 species, including brushes)
mountain rainforests on Jamaica (TANNER, 1977) „mull ridge forest"	15300 5100	23300 9500	6700 2100	610 60	900 800	-	*Palivourea alpina* *Eugenia virgultosa*
premontane wet forest in Costa Rica (own results)	5390 ± 2430 9700 ± 3230	11490 ± 3700 7780 ± 3180	2320 ± 670 2250 ± 570	243 ± 124 536 ± 273	667 ± 167 531 ± 126	30 ± 8 19 ± 5	*Elaeagia auriculata* *Plinia salticola*

DISCUSSION

The nutrient content in the leaves of the two tree species were in a similar range compared with data of crop plants and trees in other tropical forests (Table 5 and Table 5.4.13 in BERGMANN, 1992). The lack of connection between the nutrient concentrations in the soil and the leaves, determined in this work, can be interpreted in different ways: The trees are well supplied with nutrients and capable to storing these and/or the concentrations in the soil lie above the minimum requirement of the plants and/or the extraction methods for the soil are not able to mimic plant uptake. The latter point is always a problem for plant analyses. GLASER & DRECHSEL (1991) for example screened different phosphorus extraction methods in soils and looked for a correlation with P-concentrations in plants. They found no correlation between P-concentration in soil and leaves when measured with the Ca-lactat method. Also GOLLEY *et al.* (1978) found no connection between these parameters in their investigation in Colombia.

In the detected pH range most plant nutrients are easily available and aluminium toxicity should not be a serious problem. And according to BERTSCH (1987) the content of exchangable cations in the soil can be described as moderately fertile.The high content of organic material in the upper soil layer contributes to the high binding capacity and this is probably the reason for the accumulation of minerals in that soil profile and the latter causes the high root density.

It is not clear as to whether the low P-content in the leaves indicates a deficiency as the trees showed no visible P-deficiency symptoms and the soil was well supplied with P. Leaves of trees in other rain forests have similar low P-concentrations (Table 5). It is reasonable to assume that these tropical trees are adapted to this low P-concentration. Conversely the element Mn is highly concentrated in the leaves of *P.salticola* and possibly this species is an Mn-accumulator or even Mn-tolerant.

From the literature, K, Mg and P are known to be mobile in the phloem but Zinc and Ca are not, while Mn seems to have limited mobility. From our results we conclude that K and P are remobilized from older to younger leaves and that these elements are perhaps growth limiting. This is in aggreement with findings of GRUBB & EDWARDS (1982a) in New Guinea; TANNER (1977) in Jamaica and VENEKLAAS (1991) in Colombia who found a high remobilization of K into younger leaves and CHAPIN (1980) who found a high remobilzation of P before abscission. Mg is not supposed to be a limiting factor. Because the two species are not specific for location, pH or soil nutrient content there are probably other factors which contribute to the difference in nutrient concentrations, like competition for light, space or physiological differences.

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