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Effect of root feeding of heavy metals on the leaf concentration of P, K, Ca and Mg in coconut (*Cocos nucifera* L.)

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Abstract

The effect of supplying various metals *viz.* Pb, Cd, Al, Bi, Cr, Cu and Ba to the roots of coconut palms on the P, K, Ca and Mg concentration in the leaves of cocnut palms was investigated. The results showed that compared with the control the amount of leaf phosphorus was reduced by all the metals. The K concentration in the leaves was reduced by Al, Cd and Ba but increased by Bi and Cr. Leaf Ca concentration was decreased by Al and Pb treatments and increased by Cd, Cr and Ba. The amount of magnesium in the leaves was low in palms receiving the Al and the Cr but enhanced by Pb.

Introduction

The soils in which coconut is grown in the Kerala State of South India is normally contaminated by the application of large quantities of industrial effluents and sludges which contain high concentration of non-essential toxic elements. X-ray microprobe analysis has shown the accumulation of certain heavy metals in the root tissues of coconut (Biddappa, 1985 and Biddappa and Robert Cecil, 1984). The non-essential elements in the soil are likely to interfere with the nutrition of coconut palm in different ways (Epstein, 1969). The present investigation examined the effect of various noneessential elements on the concentration of P, K, Ca and Mg in coconut leaf.

Materials and methods

Thirty two 15 years old coconut palms at Central Plantation Crops Research Institute farm, Kasaragod were selected for this study. Each treatment (Table 1) had four replications. The soil type at the site was red sandy loam (Arenic Palenstults). Fresh roots all around the base of the coconut palm were exposed sequentially without injuringt the roots. The dilute heavy metal solutions were prepared with distilled water and the roots were placed in these solutions until no more absorption of the solution was observed. Tissue samples were taken from leaves numbering 1, 3, 5, 7, 9, 11, 14, 16 and 21 after a lapse of ten months. Leaf number 1 represents the youngest fully opened leaf, leaf number 14 represents the index (diagnostic) leaf, and the leaf number 21 represents the oldest leaf. The samples were dried and digested in HNO_3 + $HClO_4$ acid mixture and analysed for P (Vanadomolybdate) and K (flame photometry) following Piper (1966). Calcium and magnesium were esti-

Table 1. Quantity of metal feed

Elements	Quantity (mg/palm)	No. of days fed
Pb^{++}	33.5	87
Cd^{++}	47.0	87
Al^{+++}	1043.0	81
Bi^{++}	37.3	81
Cr^{+++}	115.0	52
Cu^{++}	988.0	51
Ba^{++}	50.1	49
Control	00.0	–

mated by atomic absorption spectrophotometer (Varian model AA 975).

Results and discussion

Phosphorus

The results of feeding heavy metals to the roots of coconut palms on phosphorus concentration in the crown indicated that, in general, metal feeding at the roots affectively lowered the leaf phosphorus concentration as compared to control (Table 2). The largest antagonistic effect was in case of Cd and Al followed by Bi and Pb. Jarvis *et al.* (1976) reported a reduction in the mobility of phosphate due to a possible interaction with Cd. They suggested that the Cd-P interaction was similar to the Zn—P-relationship in the plants. For the index leaf (14th leaf), the heavy metal treatments in order of decreasing antagonism to phosphoprus uptake were Cd Al Bi Pb Ba Cr (Table 2), which was similar to the trend observed in the crown. Similar effects of heavy metals on phosphorus concentration have been reported for Al (Rasmussen, 1968; Weisel *et al.* 1970) and for Pb (Baumhardt and Watch, 1972).

Potassium

Leaf potassium concentration in the 14th leaf was enhanced when compared with the control by treatments with Pb, Bi and Cr (Table 2) and although the metals Cd, Al and Ba reduced the leaf K concentration, the differences were not significant. The trend remained the same when the computation was made for the overall crown concentration. In the index leaf, the heavy metal treatments in order of decreasing antagonism to Potassium uptake were Bi Cr control Pb Ba Cd Al.

Table 2. Effect of various heavy metals on tissue concentration of some essential elements

Heavy metal	Index leaf (14th leaf)				In crown (Mean of 32 leaves)			
	P	K (%)	Ca	Mg	P	K (%)	Ca	Mg
Cadmium	0.066	0.89	0.43	0.20	0.073	1.07	0.37	0.22
Aluminium	0.076	0.85	0.17	0.18	0.079	1.00	0.23	0.19
Chromium	0.094	1.37	0.33	0.16	0.095	1.49	0.35	0.17
Barium	0.087	0.90	0.38	0.21	0.092	1.16	0.36	0.23
Bismuth	0.082	1.43	0.37	0.21	0.081	1.81	0.32	0.21
Lead	0.086	1.00	0.30	0.19	0.083	1.26	0.29	0.29
Control	0.120	0.93	0.33	0.23	0.115	1.26	0.31	0.26
CD at 5%	0.007	0.197	0.05	0.04	–	–	–	–

Calcium

The results in Table 2 indicate that treatments with metals Cd, Ba and Bi increased the Ca concentration in the 14th leaf, though it showed significantly only for Cd and Ba. Al treatment reduced the Ca concentration to a considerable extent, while the treatments with Cr and Pb did not result in significant changes when compared with the control. Overall crown Ca concentration also revealed a similar trend. Lower leaf concentration of Ca has been reported by Mengel and Kirkby (1978) was a result of Al toxicity. Al induced Ca deficiency or reduced Ca transport is well documented (Foy *et al.* 1972). Competition between Ca and Pb for exchange sites is also reported (Mengel and Kirkby, 1978).

Magnesium

All the metal treatments resulted in reduced Mg concentration in the 14th leaf when compared with the control (Table 2), though the differences were significant only for the Cr, Al and Pb treatments. Reduced Mg concentration in the leaf was due to Al toxicity. A similar trend was noticed, in general, when the average nutrient concentration in the crown was considered.

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