J. Phytol. Res. 19(1) : 131-133, 2006

EFFECT OF ALUMINIUM ON THE MINERAL ELEMENT COMPOSITION OF *HYPTIS SUAVEOLENS* (L.) POIT.

S. VASANTHA PILLAY

Department of Botany, P.G. College of Science, O.U. Saifabad, Hyderabad – 500 004, India.

Soil aluminium application to the plant *Hyptis suaveolens* (L.) Poit caused an increase in Mn content in leaves and roots. At 1000ppm Al, the contents of Fe, Cu, and Zn in roots increased. Increasing aluminium applications caused an increase in K, Ca, Mg and N contents in leaves. Other interactions were also noted.

Keywords: Aluminium; *Hyptis suaveolens* (L.) Poit; Mineral element composition.

In acid soils aluminium toxicity is one of the main problem for the growth of plants. According to Broomfield[1], the availability of soil aluminium increases at pH < 5 and causes aluminium toxicity. Some of the manifestations of the toxicity of aluminium are P - deficiency, Ca – deficiency, drought stress, high bulk density, water logging and associated deficiency of oxygen in soil and disturbance in mineral nutrition of plants[2]. The metabolism of the plant in general is altered as a consequence of uptake of toxic metal ions. Toxicity caused by any metal may be due to the specific effect of the element in question or due to its effect on the absorption or uptake of other macro or micro-nutrients. The present investigation was taken up to examine the imbalances and changes in the composition of certain elements, as a result of soil aluminium treatment, to *Hyptis suaveolens*.

Experimental materials and the methods are described in the earlier communication of Pillay[3]. For the estimation of various elements, 0.5 g of dried, powdered sample was ashed in a silica crucible at 550°C in a muffle furnace. The ash was dissolved in 4 ml of 20% HCl V/V and digested for 3 hrs at 90° C. The digests of different samples were made up to 20 ml separately with ion-free water. Calcium and potassium were determined by flame photometry, and Mg, Fe, Mn, Cu and Zn concentrations were analyzed by an atomic absorption spectrophotometer. For the estimation of nitrogen and phosphorus, dried plant material was wet digested. The nitrogen content in the sample was estimated by the micro-Kjeldhal method[4] and phosphorus was estimated by the molybdate-vanadate method[5].

Changes in the levels of micro and macro-nutrients in the roots and leaves of *Hyptis* due to soil aluminium application are presented in Table1 and Table2. Soil aluminium application of 1000ppm to *Hyptis* caused an increase in the Mn content in leaves and roots. Thus, *Hyptis* plants seemed to suffer not only from aluminium toxicity but also due to the effect of increased levels of manganese content. In roots, there was a high accumulation of Fe, Mn, Cu and Zn. The increased levels of the micro-nutrients in the roots is probably due to a break down of selective absorption capacity.

The shoots of the treated plants contained less Fe than the roots. Probably the plants are able to absorb Fe, as evidenced by the high Fe content in roots (Table 1) but is unable to translocated it to the tops.

Treatment of *Hyptis* with 1000ppm aluminium caused enormous increase in the quantity of phosphorus in the leaves. It is quite possible that *Hyptis* plant was able to take more P under aluminium toxicity and the P was forming an insoluble complex with aluminium, as aluminium phosphate, thus countering the toxic effect of aluminium within the tissue. Similar results were found by Clarkson[6] in case of barley seedlings.

At 1000ppm aluminium application, the K, Mg and Ca contents in the roots of *Hyptis* decreased. Many investigators have observed that aluminium toxicity was usually associated with reduced uptake of several macro-nutrients, particularly Ca and P. Johnson and Jackson[7] found that aluminium reduced both the absorption and accumulation of Ca by wheat. But Paterson[8] noted that Ca uptake in corn was affected by aluminium but not the Ca transport to plant tops. In the present study shoot Ca content of *Hyptis* was high while root Ca was low. Bennet *et al.*[9] observed that aluminium interfered with root metabolism, decreased active ion movement and reduced cation retention capacity of root.

Deward and Sutton[10] associated aluminium toxicity in pepper wines with reduced uptake of Ca and Mg, but increased uptake of K and aluminium. Symptoms like death of roots, wilting of foliage were also observed as a result of those changes in the balance of inorganic macro-nutrients. They suggested that the ratio of K: Ca plus Mg in plant tops could be used as an index of aluminium injury. Pepper

Table 1. Micro-nutrient concentration in leaves and roots of *Hyptis* treated with excess of aluminium (Mean of three replicates)

Treatment	Micro-nutreints in leaves µg/gr. dry.wt.				Micro-nutrients in roots µg/gr. dry wt.			
	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn
Control	1140	42	20	40	1300	38	13	27
Al 500ppm	840	56	2	36	2700	76	27	32
Al 1000ppm	1020	286	20	47	2600	70	50	44
* Al 1500ppm	-	-	-	-	-	-	-	-

* Insufficient material due to severe toxicity

Table 2. Macro-nutrient concentration in leaves and roots of *Hyptis* treated with excess of aluminium (mean of three replicates)

Treatment	Macro-nutreints in leaves mg/gr. dry.wt.					Macro-nutrients in roots mg/gr. dry wt.		
	K	Ca	Mg	N	P	K	Ca	Mg
Control	30.00	16.08	4.60	14.82	1.80	15.00	1.00	1.38
Al 500ppm	32.80	19.62	5.29	18.58	1.78	19.00	0.80	2.81
Al 1000ppm	33.60	17.00	5.16	21.40	3.25	10.00	0.620	1.70
* Al 1500ppm	-	-	-	-	-	-	-	-

* Insufficient material due to severe toxicity

wines were slightly affected at a ratio of 1.20 and severely affected at a ratio of 3.89.

In the present study increasing aluminium applications to *Hyptis* caused an increase in K and Mg contents in leaves, and at 500ppm aluminium the ratio of K: Ca + Mg was 1.3 and at a higher level of 1000ppm aluminium the ratio was 1.48, which was well correlated with aluminium injury.

At 1000ppm aluminium additions, *Hyptis* plants were severely affected. The leaves contained high concentrations of N and P. Similar increased concentrations of N and P in plant tops, were observed by Ota[11] in rice plants affected by aluminium toxicity.

Aluminium toxicity to *Hyptis* plants, caused an increase in the content of Fe, Mn, Cu and Zn in the roots and decreased K and Ca levels. Lee[12] found that aluminium inhibited the transport of P to potato plant tops; decreased the absorption of Ca, Mg and Zn by roots; and caused the accumulation of P, Al, Mn, Cu and Fe in plant roots.

Ouelletted and Dessureaux[13] found that aluminium tolerant alfalfa clones contained higher concentrations of aluminium and Ca in their roots than aluminium sensitive clones. They suggested that Ca reduced aluminium toxicity by reducing aluminium uptake and transport to plant tops. Chamura and Hoshi[14] found that the greater aluminium sensitivity of sorghum as compared to corn was associated with a greater reduction in K uptake. Many investigators[15-18] observed an enhancement in the concentration of K due to aluminium treatment in different plants.

Hyptis plants exhibited phytotoxic symptoms at 1000ppm aluminium and at this level a decrease in the root K, Ca and Mg concentrations was observed. No such decrease in the macronutrients was observed at 500ppm aluminium treatment and plants were healthy with normal green leaves. It is suggested that probably the macro-nutrients (K and Mg) played an important role in mitigating the inhibitory effects of aluminium.

References

1. Broomfield S M 1987,Simple tests for the assessment of aluminium and managenese levels in acid soils. *Aust. J. Exp. Agric.* **27** 399-404
2. Foy C D, Sadeghi A M, Ritchie J C, Krizek D T, Davis J R and Kemper W D 1999, Aluminium toxicity and high bulk density; Role in limiting shoot and root growth of

selected aluminium indicator plants and eastern gamagrass in a acid soil. *J. Plant Nutr.* **22** 1551-1566

3. Pillay S V 2006, Some effects of aluminium toxicity on *Hyptis sauveolens* (L.) poit. *J. Phytol. Res.* **19** (In press)
4. AOAC, Official Methods of Analysis, 7th Ed. Washington D C, 1950, p.910
5. Johnson A D 1970, Effect of manganese on tobacco leaf quality and on the inorganic cation levels of the leaves. *Aust. J. Exp. Anin. Husb.* **10** 118-123
6. Clarkson D T 1966, Effect of aluminium on the uptake and metabolism of phosphorous by barley seedlngs. *Plant Physiol.* **41** 165-172
7. Johnson R E and Jackson W A 1964, Calcium uptake and transport by wheat seedlings as effected by aluminium. *Soil Sci. Soc. Amer. Proc.* **28** 381-386
8. Paterson J W 1965, *The effect of aluminium on the absorption and translocation of calcium and other elements in young corn.* Ph.D. thesis, Pennsylvania State University.
9. Bennet R J, Breen C M and Foy M V 1985, The primary site of aluminium injry in the root of *Zea mays. South African J. Plant Soil* **2** 8-177
10. Deward P W F and Sutton C D 1960, Toxicity of aluminium to black pepper *(Piper nigrum* L.) *Nature* (London) **188** 1129-1130
11. Ota Y 1968, Studies on the occurrence of the physiological disease of rice called "bronzing" *Bull. Nat. Inst. Agr. Sci.* Nishigahara Tokyo, Japan, Ser. D No. 18
12. Lee C R 1971, Influence of aluminium on plant growth and mineral nutrition of potatoes. *Agron. J.* **63** 604-608
13. Ouelletted G J and Dessureaux L 1958, Chemical composition of alfa alfa as related to degree of tolerance to manganese and aluminium. *Can. J. Plant Sci.* **38** 206-214
14. Chamura S and Hoshi A 1960, Studies on the relation between the tolerance of crops to soil acidity and that to low pH on the uptake of K ions in passive and active processes. *Crop Sci. Soc. Jap. Proc.* **31** 108-111.
15. Lidon F C, Barreiro MG, Ramalho J C and Lauriano J A 1999, Effect of aluminium toxicity on nutrient accumulation in maize shoots : Implications on photosynthesis. *J. Plant Nutr.* **22** 397-416
16. Lidon F C, Azinherira H G and Barreiro M G 2000, Aluminium toxicity in maize : Biomass production and nutrient uptake and translocation. *J. Plant Nutr.* **23** 151-160
17. Ramachandran V, Patel D V and Kumar S C 2004, Influence of aluminium on mineral nutrients of rice seedlings grown in solution culture. *Indian J. Plant Physiol.* **9** 348-353
18. Smalley T J, Lasseigne F T, Mills H A and Hussey G G 1993, *J. Plant Nutri.* **16** 1375-1384.