Madras Agric. J., 104 (4-6): 136-138, June 2017

Role of Rhizosphere of *Ricinus communis* L. (Castor) on Nickel Phytoextraction

M. Malarkodi
Department of Soil Science and Agricultural Chemistry
Tamil Nadu Agricultural University, Coimbatore - 641 003.

Investigation on the dynamics of the heavy metals in the rhizosphere has been hampered by the lack of reliable methods for sampling rhizosphere soil. The distribution of Ni in the rhizosphere was examined by using rhizobox system, composed of two components namely, central and bulk soil compartments. The rhizobox allows a clear separation of rhizosphere and bulk soil. *Ricinus communis* wild type plants were grown in the central compartment of the rhizobox system containing Alfisols added with 0, 50, 100, 250 and 500 mg Ni kg^{-1} soil. The results showed that the roots decreased the soil pH across the rhizosphere by a factor of around 0.36 units, which cause tremendous increase in DTPA extractable Ni content in the rhizosphere region compared to the bulk soil region. Nickel accumulation by *Ricinus communis* was increased with increasing levels of Ni in the soil.

Key words: Phytoextraction, Nickel, Rhizobox, *Ricinus communis*

Plants are the prime entry points for heavy metals in to the food chains. Understanding the mechanisms implied in the acquisition of trace elements by plant roots is thus a prerequisite for assessing their bioavailability. Rhizosphere soil is the soil adjacent to roots that is directly influenced by rhizodeposites exuded from the roots (Russell, 1977) or the volume of soil influenced by root activity. Dramatic changes in soil chemical properties induced by plant roots such as complexation of metals by root exudates, changes of ionic concentrations, redox conditions, pH and excretion of enzymes which influenced the metal bioavailability (Hinsinger, 2001). Keeping this in view effort has been taken to know the influence of rhizosphere on Ni accumulation by *Ricinus communis* L. using rhizobox system.

Material and Methods

Development of a rhizobox system

Youssef and Chino (1998) designed the rhizobox with several compartments to study nutrient behaviour in the rhizosphere of shallow (fibrous) rooted crops like wheat, barley and maize. Since Ricinus communis has tap root system, some modifications in the rhizobox system designed by Youssef and Chino (1998) has been made. The distribution of nickel in the rhizosphere was examined by the development of a rhizobox system, composed of two components namely, central and bulk soil compartments. Each compartment was made of a plastic frame with a nylon cloth stretched across it as shown in Fig. 1. The size of the plastic frame was 200 x 200 x 1 mm and the nylon cloth was fixed on one side of the frame with dichloro methane. The bulk soil compartment is made of a plastic box of 200 x 200 x 3 mm was attached to each side of the central compartment.

*Corresponding author's email: charmsmalar@gmail.com

Soil treatments

Alfisol was used as a medium in this experiment. The soil was sandy loam in texture with pH 8.26 and electrical conductivity of 0.369 dS m^{-1}. The total and DTPA extractable Ni content of the soil was 32.4 and 1.94 mg kg^{-1}, respectively. The air-dried soil sample was sieved (500 µm) and used. Nickel was added at the rate of 0, 50, 100, 250 and 500 mg Ni kg^{-1} of soil as $NiCl_2.6H_2O$ to 3 kg of soil. The basal fertilizers were added to all the treatments at the rate of 0.098 g N as urea, 0.141 g P_2O_5 as single super phosphate and 0.038 g K_2O as murate of potash. These fertilizers were completely mixed with soil and each treated soil was carefully packed in all compartments of the rhizobox, watered once in three days.

Sowing

The wild castor seeds were pretreated with carbendazim @ 2 g kg^{-1} of seed and soaked in water for 24 hours. After the stipulated time, the seeds were sown in the top of the central compartment. Bulk soil compartment was kept as unsown. The rhizobox was kept under room temperature throughout the study period of one month.

Later, all rhizoboxes were dismantled and the soil was peeled away from the nylon cloth. Soil samples from central compartment were collected and considered to be the rhizosphere soil. Other soil samples collected from the bulk soil compartmental was designated as bulk soil. The soil samples were dried and analyzed for pH (Jackson, 1973), total (Hesse, 1994) and DTPA extractable Ni (Lindsay and Norvell, 1978) content by following the standard procedures as mentioned in the parenthesis. The plants were harvested after one month, plant height and biomass yield were recorded. The total Ni content

in plant parts (shoot, root) was determined after digestion with triacid mixture (HNO_3:H_2SO_4:$HClO_4$ in 9:2:1 ratio; Pratt, 1965) using Atomic Absorption Spectrophotometer model SpectrAA 200.

Results and Discussion

Biomass production and plant height

Ricinus communis seedlings grew well for one month; no visual symptoms of Ni toxicity were observed and the roots developed with high density in the rhizosphere compartment of the rhizobox. Increased Ni concentration in soil drastically reduced the biomass production of *Ricinus communis* (Table 1).

Table 1. Biomass production, plant height and Ni content of *Ricinus communis* as affected by levels of Ni in rhizobox experiment

Treatments	Biomass production (g box^{-1})	Plant height (cm)	Ni content (mg kg^{-1})
T_1 - Control	32.50	32.50	36.85
T_2 - 50 mg Ni kg^{-1}	27.47	28.60	48.47
T_3 - 100 mg Ni kg^{-1}	22.67	27.50	66.85
T_4 - 250 mg Ni kg^{-1}	16.44	22.80	70.67
T_5 - 500 mg Ni kg^{-1}	10.57	17.60	84.68
Mean	21.93	25.80	61.50
CD (0.05)	0.949	1.070	2.764

The percentage reduction over control was 67.5 when 500 mg of Ni kg^{-1} soil was added. Similarly the plant height was decreased with increasing Ni levels in soil (Table 1). The percentage of reduction was 45.8 added with 500 mg of Ni kg^{-1} soil over control. Similar results in drymatter yield and plant height of plants by Ni treatments were also reported (Vijayarengan and Lakshmanachary, 1995).

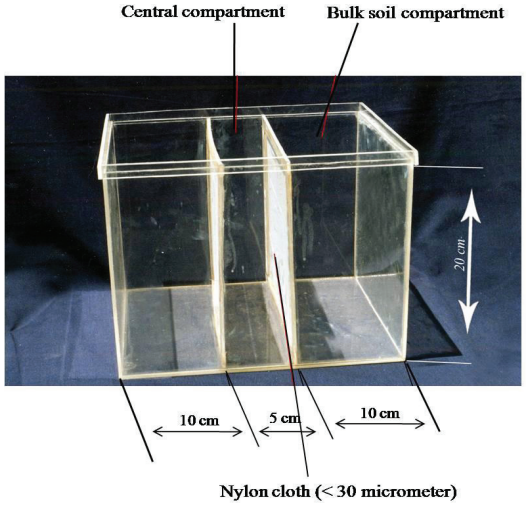

Fig. 1. Rhizobox System

Nickel content

The plant Ni content increased markedly with increasing Ni concentration in the soil. The highest Ni content (84.68 mg kg^{-1}) was detected with 500 mg of Ni kg^{-1} of soil (Table 1). The percentage increase over control was 129.8. The increase in the concentration of Ni in soil significantly increased the Ni content of *Ricinus communis*. The decreased rhizophere pH along with increased availability could be the reasons for enhanced Ni accumulation by *Ricinus communis* as also reported by Gabbrielli *et al*. (1991) and Youssef (1997).

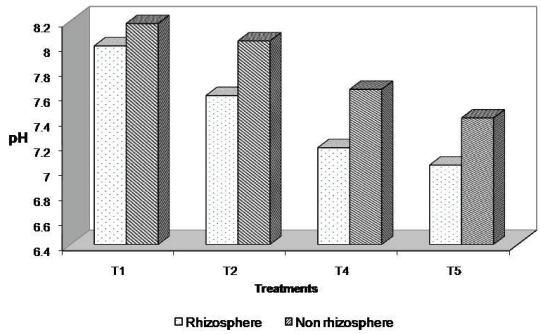

Fig.2. pH rhizophere and non rhizophere region of *Ricinus communis* as affected by different levels of Ni

Soil pH and DTPA extractable Ni content

The roots decreased the pH by about 0.36 units across the rhizophere and the decrease was enhanced with increasing Ni levels in soil (Fig. 2). The reduction of pH was about 10.6 percent in soil added with Ni (500 mg kg^{-1}) compared to control. Youssef and Chino (1991a) found that rhizosphere pH could differ from that of the bulk soil about two units of pH. However, the minor changes in pH in the present experiment might be attributed to a short period of plant growth. The decrease in soil pH might be due to the release of some organic acids under Ni stress condition (Hinsinger *et al*., 2003).

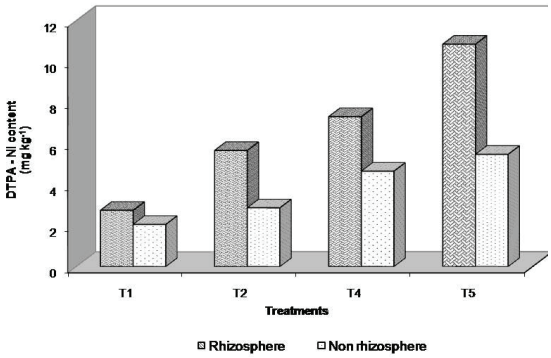

Fig. 3. DTPA - Ni content in rhizophere and non rhizophere region of *Ricinus communis* as affected by different levels of Ni

Tremendous increase in DTPA extractable Ni content of the rhizosphere soil was noticed comparing with the bulk soil (Fig. 3). The DTPA extractable Ni content was two times higher in rhizosphere region than non rhizosphere region (6.69 and 3.71 mg kg^{-1} respectively). Such increase could be due to the different chemistry of the rhizosphere soil from the bulk soil, having lower pH values, which resulted in higher solubility of Ni. Decrease in pH of the rhizoshere strongly increased the availability of

metals in soils (Linehan, 1989). The DTPA extractable Ni content was increased with increasing levels of Ni in the soil and the highest content was recorded by 500 mg of Ni kg^{-1} soil application. Addition of 500 mg of Ni kg^{-1} of soil caused an increase in available Ni content of 193.6 per cent over control is ascribed to their increased Ni bioavailability.

The results revealed that the roots decreased the soil pH across the rhizosphere, which cause tremendous increase in DTPA extractable Ni content in the rhizosphere region compared to the bulk soil region. This may be reason behind the increased nickel uptake by *Ricinus communis* L. plant species.

Acknowledgement

This work was financially supported by Government of India: Ministry of Environment and Forests. New Delhi, India.

References

Gabbrielli, R, C. Mattioni and O. Vergnano. 1991. Accumulation mechanisms and heavy metal tolerance of a Ni hyper accumulator. *J. Plant Nutr.* **14 (10):** 1067 – 1080.

Hesse, R. P. 1994. A Textbook of Soil Chemical Analysis. CBS publishers and distribution, Shahdara, Delhi.

Hinsinger, P. 2001. Bioavailability of Trace Elements as Related to Root Induced Chemical Changes in the Rhizosphere. *In Trace Elements in the Rhizosphere,* G. R. Gobran, W. W. Wenzel and E. Lombi (Eds.), CRC press LCC, Boca Raton, FL, p. 25 – 41.

Hinsinger, P, C.P. Plassard, C. Tang and B. Jaillard. 2003. Origins of root mediated pH changes in the rhizosphere and their responses to environmental constraints: A review. *Plant Soil*, **248**: 43 – 59.

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice – Hall of India Pvt. Ltd., New Delhi.

Lindsay, W. H. and W.A. Norvell. 1978. Development of DTPA soil test for Zn, Fe, Mn and Cu. *Soil Sci. Soc. Am. J.*, **42**: 420 – 428.

Linehan, D. J. 1989. Mobilization of nutrients in the rhizosphere and their uptake by plants. *Asp. Appl. Biol*., **22**: 189 – 190.

Pratt, P. 1965. Digestion with hydrochloric and perchloric acids for total K and Na. *In Methods of Soil Analysis*, Vol, 2., Amer. Soc. Agron. Inc., Madison.

Russel, R. S. 1977. Plant Root Systems: Their Function and Interaction with the Soil. Mc Graw – Hill, Maidenhead.

Vijayarengan, P. and A.S. Laksmanachary. 1995. Effects of Ni on growth and dry matter yield of greengram cultivars. *Indian J. Environ. Hlth*., **37 (2**): 99 – 106.

Youssef, R. A. and M. Chino. 1991a. Movement of metals to plant roots in soil. *Water, Air, Soil Pollut*., **57 – 58**: 249 – 258.

Youssef, R. A. and M. Chino. 1998. Development of a new rhizobox system to study the nutrient status in the rhizosphere. *Soil Sci. Plant Nutr*., **34**: 461 – 465.

Youssef, R. A. 1997. Studies on nickel and manganese dynamic in the rhizosphere. *Soil Sci. Plant Nutr*., **43**: 10121 – 10124.

Received after revision : March 24, 2017; Accepted : April 25, 2017