Research Journal of Chemical Sciences ______________________________ ISSN 2231-606X
Vol. **4(10),** 30-32, October **(2014)** *Res. J. Chem. Sci.*

Effect of variation in Nickel concentration on Growth of Maize plant: A comparative over view for Pot and Hoagland culture

Gopal Rathor[1*], Neelam Chopra[1] and Tapan Adhikari[2]
[1]Department of Chemistry, Government M.V.M. Bhopal (M.P.) INDIA-462008
[2]Division of ESS, Indian Institute of Soil Science, Bhopal (M.P.) INDIA-462038

Availableonline at: www.isca.in, www.isca.me
Received 24th September 2014, revised 3rd October 2014, accepted 17th October 2014

Abstract

Nickel is essential element in low concentration for maize plant growth while at high concentration it is toxic. The level of nickel toxicity on root, shoot length and dry biomass of maize was studied, compared to control. A pot (60days) and solution culture experiment (20 days) were conducted to study the effect of nickel concentration on maize plants. Seeds of maize were exposed to a range of nickel levels (0, 10, 20, 30 and 40 mg L^{-1}) prepared in Hoagland nutrient solution and in pot experiments black soil were spiked with the (0, 50, 100, 150, 500 and 600 mg kg^{-1}) metal solution of different concentrations of nickel. The study revealed that dry matter yield of maize was decreased at 10 mg L^{-1} nickel in solution culture, while in pot culture study, 50 mg kg^{-1} nickel concentration recorded reduced dry matter weight and also chlorosis symptom was observed at nickel dose above 100 mg kg^{-1}. The aim of this study was to determine how to nickel reduces maize growth. We examined Ni accumulation and distribution in maize plants and the effects of toxic concentrations on growth and biomass.

Key words: Nickel, toxicity, chlorosis, Hoagland

Introduction

Nickel is essential element for plant in low concentration but high concentration is toxic. Nickel is naturally occurring in soil and surface water with concentration lower than 100 and 0.005 ppm, respectively[1, 2]. Nickel is released into the environment from various anthropogenic activities, like metal mining, smelting, vehicle emissions, fossil fuel burning, and disposal of household, industrial and municipal wastes, fertilizer and organic manures[3, 4]. In soil or culture solution, nickel is usually absorbed in ionic form (Ni^{++}). There are a number of reports that nickel is easily absorbed by the plants when supplied in the ionic form and is not as strongly absorbed when chelated[5,6]. Turina investigated that the absorption of nickel by roots is through the root caps in some monocots like rye (*Secale cereale* L.), wheat and corn *(Zea mays* L.)[7]. Soil pH values to favor the absorption of nickel is below 5.6 seem, while values above 5.6 do not. Increases the exchangeable nickel content of the soil with the increasing soil acidity[8,9]. The main toxic symptom produced by nickel is the chlorosis or yellowing of leaves usually followed by necrosis. Other toxic symptoms of nickel include deformation of various plant parts, short growth of root and shoot, unusual spotting and a host of other growth abnormalities. At extreme cases nickel may cause the death of the whole plant. Kucharski *et al.,* found that the soil contamination with nickel had a negative impact on the activity of soil enzymes[10].

Material and methods

Pot experiment: To study the effect of nickel on plant growth of Maize, pot culture experiments were conducted in the net house. Plastic pots initially rinsed with dilute hydrochloric acid to remove mechanically adhering metals, followed by through washing with water. 15 cm plastic pots were filled with 8 kg black soil (Vertisol). Before seeds sowing 3000 mL metal (Ni) solution of different concentrations (0, 50, 100, 150, 500, 600 mg kg^{-1}) was added separately in each pot. It was found the amount (3000 mL) was sufficient for the homogenous distribution of metal solution in 8 kg of soil. Pots receiving distilled water in place of metal solution served as a control. 6 seeds of maize were sown in each pot. All treatment was replicated two times. The pots were placed on greenhouse stands. Plants were thinned to 4 in each pot after one week. After two months when plant were completely or fully grow it was harvest and then plant growth (root and shoot length), biomass (fresh and dry weights of shoot and root) and yield were determined.

Hoagland culture experiment: ***A*** solution Culture experiments were conduct to study the effect of nickel on growth of maize plants. Seeds of maize were germinated in Petri plate for about 4 days after sterilization and water soaking. Uniform seedlings were selected and transplanted to test tube containing deferent concentration of nutrient solution after 4 days plants were transferred in 1500mL plastic container containing 1200mL of nutrient solution[11]. Composition of the nutrient solution (1 strength Hoagland solution and Ni 0, 10, 20, 30 and 40 mg L^{-1} from $NiCl_2$). In order to eliminate iron deficiency, 1mL 0.5% Iron tartarate was added in nutrient solution. The final solution pH was 6.5.

Collection of plant samples: After harvesting of the crop through washed Plants were dried in a hot air oven at 70-80°C for 24 hr and dry matter was recorded. Leaves and roots were grinded separately in a stainless steel grinder to a make coarse powder.

Analysis of plant sample: In a 100 ml conical flask 0.5 gram of plant dry matter was taken. Using a pipette 5mL of HNO_3 was added and swirled to thoroughly wet the sample. 25 mm reflux funnels were placed over samples and allowed to predigest over night. Next day added the mixture of HNO_3 and $HClO_4$ (3:1, vv) and conical flask were placed into a digestion block port for 3 hours at 200ºC after the HNO_3 fumes have evolved. The funnels were removed 10 minutes before the end of the digestion. The flasks were taken out of the digestion block, left for 20 minutes in a hood. Thereafter 10mL deionized water was added in the flask on hot plate (90ºC). The contents of the conical flask were mixed, cooled and quantitatively transferred into 50mL volumetric flask and diluted to the final volume, and the Ni contents of plant digest were made using ICP-OES (Perkin Elmear Optima DV 2100)

Results and Discussion

Pot experiment: Plant growth: The effect of dry-matter production to Ni application generally decreased with increasing rate of Ni dose applied in soil (r= -0.975) (table 1). Higher level of Ni decreased the crop growth as compared to control. Ni also decreased the shoot length with the increasing the Ni concentration in soil (r= -0.874) (table 1) [3,4].

Nickel content in shoot: Nickel concentration in shoots of maize grown in spiked soil range from 32 to 62 mg kg^{-1} dry weight (table 1). Addition of nickel to soil with normal background level markedly increased the Ni content in plants (r=0.898). Application of higher dose of Ni (600 mg kg^{-1}) in soil increased shoot Ni concentration up to 62 mg kg^{-1}.

Hoagland culture experiment: Plant growth: The effect of dry-matter production to Ni application generally decreased with increasing rate of Ni dose applied in water (table 2). Higher level of Ni decreased the crop growth as compared to control (figure 1 and 2). Also decreased the shoot and root dry weight with the increasing the Ni concentration in water (r= -0.832 and r= -0.944 respectively) (table 2). Similar observations in crops had been observed by Barceló and Poschenrieder[12, 13].

Nickel content in shoot and root: Nickel concentration in root and shoot of maize grown in spiked water range from 39.5 to 4139.4 mg kg^{-1} and 19.1 to 1445.3 mg kg^{-1} dry weight respectively (table 2). Addition of Nickel increased the Ni content in plants. Application of higher dose of Ni in water increased root and shoot Ni concentration (r= 0.983 and r= 0.979 respectively). Hewitt showed the nickel toxic for maize plant[14]. A Ni-induced reduction of mitotic activity in root tips was observed in *Zea mays*[15].

Conclusion

Nickel is essential element for plant in low concentration but high concentration is toxic. Green house study revealed that dry matter yield of maize was decreased at 10 mg L^{-1} nickel in Hoagland solution culture, while in pot culture study conducted in black soil (Vertisol) with maize crop, 50 mg kg^{-1} nickel recorded reduced dry matter weight and chlorosis symptom was also observed at nickel dose above 100 mg kg^{-1}. This reduction could come either from a decrease in the sink root effect or from an inhibition in the leaves of starch degradation into sucrose and then of the transport of this later to the root.

Acknowledgement

The authors would like to express thanks to the Department of Chemistry, Govt. M. V. M. Bhopal for providing financial assistance. Authors are also grateful to Department of ESS, Indian Institute of Soil science (ICAR), Bhopal for ICP-OES analysis.

Table-1
Pot experiment: Effect of Ni on maize crop

S. No	Treatment of Ni (mg kg^{-1})	Shoot length (cm)	Dry wt. of shoot (g)	Ni content in shoot (mg kg^{-1})
1	Control	40	18.35	28
2	50	36	18.01	32
3	100	31	17.18	38
4	150	28	16.26	42
5	500	26	13.87	44
6	600	23	10.84	62

Table-2
Hoagland experiment: Effect of Ni on maize crop

S. No	Treatment of Ni (mg L^{-1})	Dry wt. of Shoot (g)	Dry wt. of root (g)	Ni content in Shoot (mg kg^{-1})	Ni content in Root (mg kg^{-1})
1	Control	0.460	0.168	19	39
2	10	0.196	0.124	287	1514
3	20	0.165	0.100	509	1637
4	30	0.150	0.096	1164	3311
5	40	0.120	0.012	1445	4139

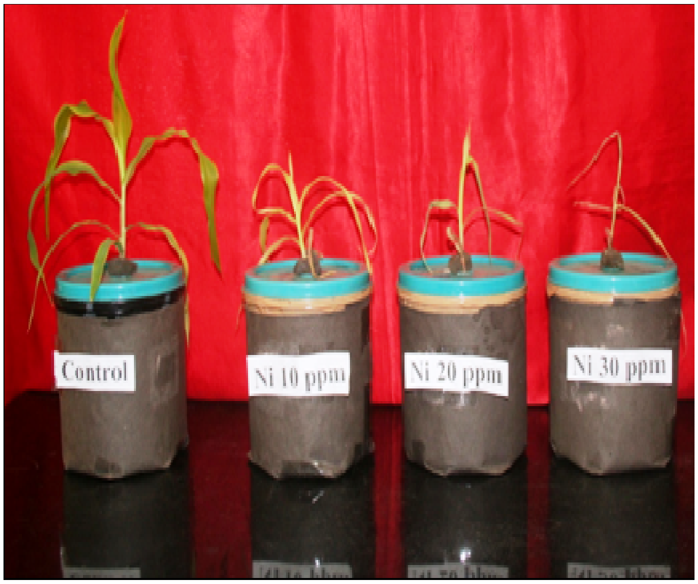

Figure-1
Effect of Ni on shoot (Maize)

Figure-2
Effect of Ni on root (Maize)

References

1. McIlveen W.D. and Negusanti J.J., Nickel in the terrestrial environment, *Sci. Tot. Environ.*, **148,** 109-138 **(1994)**
2. McGrath S.P., Heavy Metals in Soils (Ed: B.J. Alloway) 2nd ed., Blackie Academic and Professional, London, 152 - 174 **(1995)**
3. Alloway B.J., Heavy Metal in Soils (Ed: B.J. Alloway) 2^{nd} ed., Blackie Academic and Professional, London, 25-34 **(1995)**
4. Salt D.E., Phytoremediation of Contaminated Soil and Water (Eds: N. Terry, G. Banuelos) Lewis Publishers, Boca Raton, FL,189-200 **(2000)**
5. Kock De P.C., Heavy metal toxicity and iron chlorosis, *Annals of Botany* (London), **20,** 133-141 **(1956)**
6. Kock De P.C. and Mitchell R. L., Absorption of metal chelates by plants, *Soil Sci.,* **84,** 55-62 **(1957)**
7. Turina B., Absorption of selenium, sulfur, tellurium, potassium, magnesium, iron, nickel and chromium ions by plant roots, *Agronomy Glasgow*, **30,** 919-950 **(1968)**
8. Mizuno N., Chemical characteristics of serpentine soil in Hokkido. I. The difference of contents of nickel and molybdenum in plants and soils, *Hokkaido-ritsu Nagyo Shikensho Shuho*, **15,** 48-55 **(1967)**
9. Masuda T. and Sato R., Crops grown on serpentine soil. I. Mutual relations between Ni, Ca, and Mg, *Nippon Dojo Hiryokgku Zasshi*, **33,** 201-204 **(1962)**
10. Kucharski J., Boros E. and Wyszkowska J., Biochemical Activity of Nickel-Contaminated Soil, *Polish J. Environ. Stud*, **18 (6),** 1039-1044 **(2009)**
11. Hoagland D.R. and Arnon D.I., The water-culture method for growing plants without soil, California Agricultural Experiment Station Circular, **347,** 1-32 **(1950)**
12. Barceló J. and Poschenrieder C., Fast root growth responses, root exudates, and internal detoxification as clues to the mechanisms of aluminium toxicity and resistance: a review, *Environ. Exp. Bot.,* **48,** 75-92 **(2002)**
13. Ezenwa L.I., Awotoye O.O. and Ogbonna P.C., Spatial Distribution of Heavy Metals in Soil and Plant in a Quarry Site in Southwestern Nigeria, *Res. J. Chem. Sci.,* **4(8),** 1-6 **(2014)**
14. Hewitt E.J., Iron metabolism in plants. I. Some effects of metal induced iron deficiency, Annual Report of Agriculture and Horticulture Research State Bristol, 66-80 **(1948b)**
15. Robertson A.I., The poisoning of roots of ***Zea*** *mays* by nickel ions, and the protection afforded by magnesium and calcium, *New Phytol.*, **100,** 173-189 **(1985)**