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IMPACT ASSESSMENT OF NICKEL ON CHICKPEA AND MICROBIAL ACTIVITIES IN ALLUVIAL SOIL OF VARANASI

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SUMMARY

Growth, yield and accumulation of Ni in chickpea (*Cicer arietinum* L.) as well as population & activities of soil microorganisms as influenced by Ni were studied with 0, 1.5, 3, 6 and 12 mg Ni kg^{-1} of soil. Plant growth, nodulation and yield of grain and straw were increased at lower doses up to 3 mg Ni kg^{-1} but decreased at higher doses. At higher level, accumulation of Ni in root was mostly two times greater than in grain. Population of bacteria, fungi and actinomycetes and evolution of CO_2 were drastically reduced by application of >3 mg Ni kg^{-1}. Inhibition of enzymatic activities was more pronounced in dehydrogenase than urease. Microbial cfu and activities progressively declined after ten days of incubation. Nickel @ 3 mg kg^{-1} appeared to be sufficient for good harvest of chickpea.

Key words: **Alluvial soil, chickpea, dehydrogenase, microbial population, nickel, urease**

INTRODUCTION

Nickel is an essential micronutrient for plants (Eskew *et al.* 1983). At low concentrations it is beneficial for growth and development of plant but at higher concentrations results in phytotoxicity (Yang *et al.*1996). Nickel is an important component of urease enzyme which plays an important role in hydrolysis of urea. Excess of Ni decreases microbial population and activities by reducing the enzyme synthesis and changing the configuration of enzymes. In spite of high mobility, distribution and accumulation of Ni in plants varies from crop to crop (Poniedzialek *et al.* 2005). Sewage treatment plants and silk saree printing work in Varanasi discharge >100 million litres of water daily. Farmers utilize this water for irrigation which may elevate the heavy metals including Ni in Varanasi soils. There are some reports on Ni and other heavy metals contamination in vegetable crops (Singh *et al.* 2004) but no systematic investigations were made on impact of Ni accumulation in pulse and its consequence on number and activities of soil microorganisms. Hence, an attempt was made to elucidate the impact of Ni on soil microbial dynamics, growth, yield and accumulation of Ni in chickpea (*Cicer arietinum* L) in alluvium of Varanasi.

MATERIALS AND METHODS

A pot culture experiment was conducted in completely randomized design with five doses of Ni (0, 1.5, 3, 6 &12 mg Ni kg^{-1} of soil) in the form of $NiSO_4.6H_2O$ during rabi season of 2005-2006. Experimental soil was sandy loam with pH 7.14, EC 0.27 dS m^{-1}, organic C 5.7 g kg^{-1}, C EC 10.91 c mol (p^+) kg^{-1}, Ni 0.44 mg kg^{-1}, bulk density 1.32 Mg m^{-3}, particle density 2.55 Mg m^{-3} and water holding capacity (WHC) 46.5%. Twenty kg N and 50 kg P_2O_5 as urea and DAP, respectively were mixed with required quantity of processed soil. Earthen pots lined with polythene were filled with 5 kg of soil. *Rhizobium* treated seeds were

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sown with six replications and three healthy and uniform plants of *Cicer arietinum* were maintained pot^{-1}. After 15 days of sowing, doses of Ni in solution form were applied with irrigation water according to the treatment. Irrigation was given as per the requirement of crop.

Soils of three pots under each treatment were carefully washed with a jet of water at 60 days after sowing to avoid loss and injury to roots and nodules. After separating the nodules, roots were cut from the plants and their volume was measured by dipping them in to partially water filled measuring cylinder. The roots and nodules were oven dried at 65 ± 2^{0}C for 36 hours for assessing their dry weight (DW). Pods pot^{-1} were counted by picking them at maturity (110 days after sowing) and same were manually threshed to record the grain yield. Plants were harvested and after air drying straw yield was recorded. Dried roots and grains were ground separately and analyzed for nickel by the method of tri-acid digestion (Allen *et al*.1986) using atomic absorption spectrophotometer.

A pot culture incubation study was carried out separately with same soil and with same treatments of nickel to assess the impact of Ni on microbial dynamics and activities. Treatments were replicated thrice in three sets. Required quantity of $NiSO_4.6H_2O$ in solution form, for each treatment was thoroughly mixed with 900 g of processed soil and equally filled in nine small plastic pots. Pots were brought to 50% WHC and incubated for 10, 20 and 30 days at 28 ± 2^{0}C. Evaporation loss of water was recouped routinely. At each stage of incubation, soils of three pots under each treatment were analyzed for urease (Zantua and Bremner 1975), dehydrogenase (Casida *et al.* 1964) and CO_2 evolution (Anderson 1982). Microbial population (bacteria, fungi and actinomycetes) were also assessed employing the serial dilution and plate count technique (Schmidt and Caldwell 1967).

RESULTS AND DISCUSSION

The results revealed that lower doses of nickel up to 3 mg kg^{-1} enhanced growth and yield of chickpea and above this level root volume, nodule weight, pods pot^{-1} and yield were suppressed significantly (Table 1). Nickel application @ 3 mg kg^{-1} increased 22.5, 22.7, 26.4 and 13.8%, respectively the root volume, nodule weight, pods pot^{-1} and grain yield. However, nickel @ 12 mg kg^{-1} decreased 15.4, 21.0, 32.3 and 53.3%, respectively the above variables. Highest grain yield and nodulation at 3 mg Ni kg^{-1} has also been reported by Kumar and Mukherjee (1992) and Prasad *et al*. (2005). Reduction in growth and yield of rabi pulses at higher level of Ni has also been reported by Gupta *et al*. (1996). Nickel application non significantly influenced shoot weight and straw yield of chickpea. Lower doses of nickel increased root volume which resulted in more surface area for nodulation and greater nodular mass. Nitrogen metabolism during reproductive phase of growth was enhanced by lower doses of nickel consequently increasing urease activity which attributed to increase

Table 1. Effect of nickel application on growth, nodulation and yield of chickpea

Nickel (mg kg^{-1})	Root volume (cm^3)	Root weight (g/pot)	Shoot weight (g/pot)	Nodule wt (g/pot)	Pods pot^{-1}	Grain yield (g/pot)	Straw yield (g/pot)
0.0	51.66	3.13	7.46	0.517	34	5.06	7.45
1.5	53.33	3.89	7.48	0.643	37	5.50	7.49
3.0	63.33	3.93	7.55	0.669	43	5.76	7.54
6.0	55.0	3.49	7.15	0.432	30	2.85	7.20
12.0	43.33	2.97	6.87	0.408	23	2.36	6.86
SEM ±	5.57	0.21	0.42	0.105	2.12	0.14	0.38
C.D(P= 0.05)	12.4	0.51	NS	0.233	4.72	0.30	NS

NS = Non significant

in grain yield (Walker *et al*. 1985). High production of dehydrogenase enable more availability of electrons to the nitrogenase and resulted in more grain yield through increase in nitrogen fixation (Hausinger 1987). Higher doses of nickel showed phytotoxic effect on nodulation as well as reproductive phase of chickpea which reflected on reduced grain yield of the crop. Reduction in grain yield and number of nodules at higher dose may be attributed to the decreased enzyme synthesis associated with inhibition of enzyme activities due to the masking of active groups, protein denaturation or change in enzyme configuration as has been suggested by Dar (1995).

Nickel content in grain was significantly correlated with its doses of application (r=+0.96). Application of Ni @ 6 and 12 mg kg^{-1} showed 35.4 and 54.0% increase of Ni in grain, respectively but at 1.5 mg kg^{-1} this increase was only 1.1%. Nickel accumulation in root was much higher than grain (Fig. 1). Accumulation of Ni in root was 15.5 to 104.6% more than control. At higher doses, accumulation of nickel was mostly two times higher in root than in grain (Parida *et al*. 2003).

Fig. 1. Effect of soil applied nickel on its content in root and grain of chickpea

Nickel application adversely influenced the microbial population and their activities (Fig. 2). Nickel even @ 1.5 mg kg^{-1} reduced 17.2-38.8, 3.9- 22.2 and 8.4-24.9 % of bacterial, fungal and actinomycetes population, respectively. The degree of Ni toxicity on microorganisms increases with increase in doses of Ni and incubation period has also been reported by Dar (1995). The inhibitory effect on microbial population was

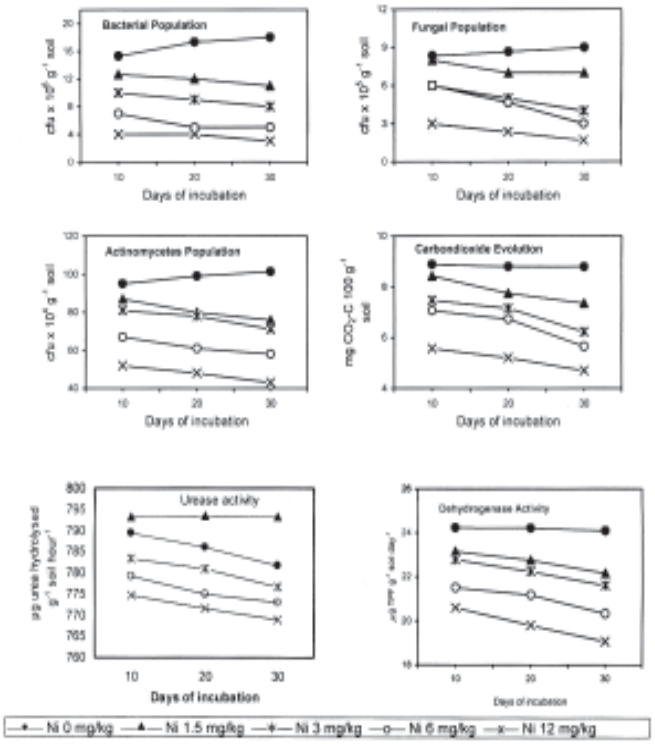

Fig. 2. Effect of nickel on microbial population and their activities in alluvium of Varanasi

highest on bacteria followed by fungi and actinomycetes. Irrespective of the Ni doses and days of incubation, CO_2 evolution depressed significantly. The maximum inhibitory effect on CO_2 evolution was recorded with 12 mg Ni kg^{-1} at 30 days of incubation. Dehydrogenase activity was inhibited more than urease. Dehydrogenase activity decreased with increase in doses of Ni in soil and ranged from 21.3-14.7%. However, in comparison to control, urease activity enhanced from 0.5-1.5% only at 1.5 mg Ni kg^{-1} (Singh 2002), higher dose of Ni beyond 1.5 mg kg^{-1} caused toxic effect. Inhibition of these activities may be associated to the decreased microbial population, their activities and alteration of enzyme configuration in conformity with the Bertrands *et al.* (2001).

The present investigation indicated that Ni @ 3 mg kg^{-1} was enough for growth, yield and nodulation of chickpea. Dehydrogenase activity exhibited higher sensitivity to nickel and was much adversely affected. Application of Ni @1.5 mg kg^{-1} was quite enough to achieve good microbial biomass and their activities in soil.

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