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Changes in nutrient contents of radish under cadmium toxicity

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SUMMARY

In the pot culture experiment, radish (*Raphanus sativus* L.) plants were grown up to 60 days, in soil amended with various levels of cadmium (*viz*, 10, 20, 30,40 and 50 mg kg^{-1}). The inner surface of pots was lined with a polythene sheet. Each pot contained 3kg of air dried soil. Six seeds were sown in each pot. All pots were watered to field capacity daily. Plants were thinned to a maximum of two per pot, after a week of germination. Control plants were maintained separately. Cadmium at all levels (10-50 mg kg^{-1}) tested, decreased the macro (nitrogen, phosphorus and potassium) and micro (copper, iron, manganese and zinc) nutrient contents of treated plants compared to untreated plants. Cadmium content of the radish plants increased with an increase of cadmium level in the soil.

Key words : Cadmium, Toxicity, Radish and nutrients

Cadmium is a non-essential element that negatively affects plant growth and development. It is released into the environment by power stations, heating systems, metalworking industries and urban traffic. Increase in the cadmium concentration of soils is generally caused by the application of cadmium-rich phosphate fertilizers and mining (Nolan *et al.*, 2003). It can alter the uptake of minerals by plants through its effects on the availability of minerals from the soil, or through a reduction in the population of soil microbes (Moreno *et al.*, 1999). Cadmium accumulation in the soil and crop plants is an increasing concern affecting human health and crop production (Hall, 2002). The present study was aimed to find out the extent of changes in macro and micro nutrient contents and uptake and accumulation of cadmium by radish plants due to cadmium toxicity.

MATERIALS AND METHODS

The certified seeds of *Raphanus sativus* (L.) cultivar, Pusa Chetki were purchased from Tamil Nadu Agricultural University, Agricultural Research Station, Paramakudi, Ramanathapuram district. Seeds with uniform size, colour and weight were chosen for the experimental purpose. The soil used in the experiment was sandy loam in nature and the pH of the soil was 7.1. It contains 118 kg available N, 28.8 kg available P and 10.9 kg available K/ha. The cadmium chloride ($Cd\ Cl_2$ 2½ H_2O) was used as a cadmium source.

The seeds were grown in pots containing untreated soil (control) and in soil mixed with cadmium (*viz*, 10, 20, 30, 40 and 50 mg kg^{-1} of soil). The inner surfaces of pots were lined with a polythene sheet. Each pot contained 3 kg of air-dried soil. The cadmium was applied to the soil, as cadmium chloride ($CdCl_2$ 2½ H_2O). Six seeds was sown in each pot. All pots were watered to field capacity twice a day. Plants were thinned to a maximum of two per pot, after a week of germination. Each treatment including the control was replicated five times.

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Sampling:

The plant samples were collected on 60th day after sowing. The contents of macro nutrient such as nitrogen, phosphorus and potassium were estimated from dried and powdered plant samples of leaves of treated and control plants by using (Peach and Tracey, 1956), (Black, 1965), (Yoshida, 1972) and (Williams and Twine, 1960) methods and contents of micro nutrients such as copper, iron, manganese and zinc were estimated by (De Vries and Tiller, 1980) method. The cadmium contents of dried and powdered root and shoots of treated and control plants were estimated by using (Khan, 1972) and (Slavin, 1983) methods.

RESULTS AND DISCUSSION

Increasing cadmium levels (10, 20, 30, 40 and 50 mg kg^{-1}) in the soil, gradually reduced the nitrogen, phosphorus and potassium contents of the leaves of radish plants (Table 1). The minimum nitrogen (21.88), phosphorus (4.85) and potassium (30.34) content were estimated at 50mg kg^{-1} cadmium level of the soil. The maximum of all macro nutrients were observed in control plants. The macro nutrient contents decreased significantly ($P< 0.01$) with increase in the cadmium levels (10, 20, 30, 40 and 50 mg kg^{-1}) of the soil.

When compared to control plants, the estimation of micro nutrient contents of treated plants showed a decreasing trend with an increase (10-50 mg kg^{-1}) in cadmium level in the soil (Table 1). The maximum copper (25.0), iron (875), manganese (40.0) and zinc (65.2) contents were recorded in control plants and the minimum value of all micronutrient contents were recorded in 50 mg kg^{-1} cadmium level of soil. The micro nutrient contents of leaves of treated plants decreased significantly ($P< 0.01$) with increase in the cadmium levels (10, 20, 30, 40 and 50 mg kg^{-l}) of the soil.

The concentration of cadmium in the radish plants grown in different cadmium treatments of soil are presented (Table 1). Increasing cadmium level (*viz.*, 10,20,30,40 and 50 mg kg^{-1}) in the soil increased the uptake and accumulation of cadmium contents in root and shoot of treated plants. Maximum cadmium content (26.4) was recorded at 50 mg kg^{-1} cadmium level in the soil in the root of radish. The minimum accumulation was observed in shoot (5.0) at 10 mg kg^{-1} cadmium in the soil. Cadmium contents of root and shoot increased significantly ($P< 0.01$) with increase in the cadmium levels of the soil. The uptake and accumulation of cadmium was higher in roots than the shoots.

Increasing cadmium levels (10, 20, 30, 40 and 50 mg kg^{-1}) in the soil gradually reduced the nitrogen, phosphorus and potassium contents of the leaves of radish plants. The minimum nitrogen, phosphorus and potassium content were estimated at 50mg kg^{-1} cadmium level of the soil. The maximum of all macro nutrient contents were observed in the control plants. Similar decrease in the nutrient contents was observed (Gussarsson, 1994) in the *Betula pendula* (Sugar beet) seedlings. Nitrogen metabolism is disturbed in many ways due to heavy metals. The heavy metals sharply decrease the N03 uptake by roots, incorporation of nitrogen into organic compounds and translocation of nitrogen to shoots as stated by Berezovskii and Klimashevskii (1975). The blockage in mobilization of phosphorus from soil and root system to the aerial system due to cadmium as stated by Lin *et al.* (1975). The cadmium application at higher concentrations inhibited the uptake of potassium by inhibiting ATP levels and ATPase activity as stated by Lindberg and Wingstrand (1985) in *Beta vulgaris*.

When compared to control plants, the estimation of micro nutrient contents of treated plants showed a decreasing trend with an increase (10-50 mg kg^{-1}) in cadmium level in the soil. The maximum copper, iron, manganese and zinc contents were recorded in control plants and the minimum value of all micronutrient contents were recorded in plants treated with 50 mg kg^{-1}cadmium level of soil. This investigation lends support to the findings of (Rio *et al.*, 1991) who reported similar reduction of Cu, Fe, Mn and Zn uptake by Cd treated plants. The decrease in copper content of the plant may be due to close association of copper with nitrogen ligands. There was a close parallel relation in the movement of copper and nitrogen out of the old leaves of wheat as stated by Hill *et al.* (1979). The decrease in iron at higher concentration of cadmium may be also due to the changes in conducting xylem tissues and blockage of xylem elements as stated by Hagemeyer *et al.* (1993). The distinctive decrease in manganese content may be due to competition of manganese with cadmium for transport across plasmalemma (Bottrill *et al.*, 1970). The manganese deficiency results in the reduction of

Table 1 : Effect of cadmium on nutrient contents and uptake and accumulation of cadmium contents of *Raphanus sativus* (L.) on 60th day

Cadmium added in the soil (mg kg^{-1})	N	P	K	Cu	Fe	Mn	Zn	Cd (μg g^{-1} dry weight)	
	mg g^{-1} dry weight			μg g^{-1} dry weight				Root	Shoot
0	29.61	7.94	38.66	25	875	40	65.2	-	-
10	28.13	7.68	35.11	25	615	36	52.1	6.3	5.0
	(-4.9)	(-3.2)	(-9.1)	(-0.0)	(-29.7)	(-10.0)	(-20.0)		
20	28.02	5.62	33.86	20	595	32	50.8	15.2	11.3
	(-5.3)	(-29.2)	(-12.4)	(-20.0)	(-32.0)	(-20.0)	(-22.0)		
30	25.67	5.16	33.08	15	545	28	47.3	19.0	14.6
	(-13.3)	(-35.0)	(-14.4)	(-40.0)	(-37.7)	(-30.0)	(-27.4)		
40	24.21	5.08	32.01	12	540	24	43.6	22.6	19.4
	(-18.2)	(-36.0)	(-20.7)	(-52.0)	(-38.2)	(-40.0)	(-33.1)		
50	21.88	4.85	30.34	10	530	22	40.2	26.4	21.2
	(-26.1)	(-38.9)	(-21.5)	(-60.0)	(-39.4)	(-45.0)	(-38.3)		
C.D. (P = 0.01)	0.0577	0.0056	0.0049	0.6582	0.6824	1.9746	0.7099	0.1042	0.1044

Average of five replications

Figures in parentheses represent per cent reduction (–) over control chlorophyll content also. The reduction of zinc content may be due to existence of a competitive relationship in the mechanisms controlling the uptake and translocations of the zinc and cadmium as stated by Bjerre and Schierup (1985).

Increasing cadmium level (*viz.*, 10, 20, 30, 40 and 50 mg kg^{-1}) in the soil, increased the uptake and accumulation of cadmium contents in root and shoot of radish plants. Similar observations were reported by Gussarsson and Jensen (1992). Present results are in agreement with the findings of (Vazquez *et al.*, 1992) who reported that the cadmium accumulation in the roots was due to compartmentation of cadmium in the vacuoles.

Conclusion:

The present study shows decrease in nutrients contents of cadmium treated radish plants, when compared to untreated plants. The loss of these may be due to inhibition in the uptake of mineral nutrients from the soil. Uptake and accumulation of cadmium increased in the root and shoots of treated plants with an increase in the cadmium level in the soil. So there was a consequent reduction in macro (nitrogen, phosphorus and potassium) and micro (copper, iron, manganese and zinc) nutrient contents of radish plants. The uptake and accumulation of cadmium was higher in roots than the leaves.

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