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Effect of cadmium on the growth of tomato

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Abstract
The present experiment was conducted to test the effect of cadmium (Cd) on the vegetative and reproductive growth of *Lycopersicon esculentum* cv. Navodaya (tomato). The selected plant species was treated 4 times with 10, 20, 30 and 40 µg cadmium. The plant was treated twice at pre-flowering stage at 10 days interval and twice at post-flowering stage. Almost all selected growth parameters were sensitive to all or at least high doses of Cd. In the present study, the total chlorophyll content increased in the plants treated with Cd. The plant biomass decreased significantly on treatment with higher doses of Cd. The leaf number and leaf area was negatively correlated with the concentration of cadmium.

Keywords: Cadmium; chlorophyll pigment; tomato; heavy metal.

Introduction

Several heavy metals are naturally present in the environment. Their occurrence, however, has gradually been increasing with the increase in industrialization (Forstner, 1995). Copper and Zn are important micronutrients if present in low concentration, while in high concentration, these two metals become toxic to plants. The role of Cd and Pb as nutrients is not yet well known. Plants readily accumulate them in their system (Jeliazkova and Craker, 2001). The ability of plants to accumulate toxic heavy metals may prove to be useful in phytoremediation. During the last few decades, the toxicity of heavy metals has drawn attention of many environmental scientists. Heavy metal accumulation leads to the loss of agricultural yield and hazardous health effect. Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in biosystem through contaminated water, soil and air. Therefore, a better understanding of the sources, accumulation, and uptake of heavy metals and their effects on plant systems seem to be an important issue of present day research on risk assessments (Sharma *et al*., 2004; Lokeshwari and Chandrappa, 2006).

Cadmium enters into the environment through weathering of rocks, forest fires and volcanic eruptions. It may be naturally present in air, water, soil and foodstuffs. Rapid industrialization has increased the natural limit of cadmium to a toxic level. The present work has been conducted to study the effect of cadmium on the growth of tomato (*Lycopersicon esculentum* cv. Navodaya) of the family Solanaceae. Tomato is the most popular and widely cultivated seasonal fruit vegetable crop.

Materials and Methods

The earthen pots of 22x18 cm (height x diameter) were filled with garden soil and compost (4:1 ratio). The pots and compost mixed soil was autoclaved at 15 p.s.i for 15 min at 121^{o}C before filling. For each treatment including control, 6 pots were used as replicates. In each pot, 50 healthy seeds (pre-sterile by soaking for 1 min in 1% KOH and washed with DDW) of *Lycopersicon esculentum* cv. Navodaya were sown. The seeds germinated within 7-8 days after sowing. The thinning of each pot was done to leave 1 plant of equal growth vigour in each pot. The pots of each treatment were randomly placed at a fixed distance in rows (30 cm pot to pot and 60 cm line to line). The pots were maintained with adequate waters.

Five sets each in replicates of six pots of the selected cultivar of tomato were treated separately with aqueous solution of 0, 10, 20, 30 and 40 µg of cadmium. The treatments were given twice before the flowering and twice after the flowering stage. The first two treatments were given at 30 and 40 days old stage (from the date of sowing) before the flowering and later two doses at 73 and 83 days stage (post-flowering). AR grade cadmium nitrate [$Cd(NO_3)_2.4H_2O$] was used as source of cadmium. The stock solution of Cd was prepared by dissolving 2.717 g of $Cd(NO_3)_2.4H_2O$ in double distilled water to make 100 ml of solution. One ml of the solution contained 1000 µg of Cd. Each pot with single tomato plant was treated by soil application.

Seven days after the last dose, the shoot and root length, leaf number, leaf area, flower and fruit number, above ground biomass, fruit biomass, stomatal frequency and chlorophyll content were recorded in 90 days old tomato plants. Chlorophyll in fresh leaf tissues was estimated following the method of Arnon (1949). The data collected on different parameters were statistically analyzed using SPSS (version 10.0).

Results

The shoot length of tomato plants treated with 10-30 µg of Cd did not vary significantly from control plants. However, higher dose (40 µg Cd) reduced the shoot length of tomato plant significantly. The root length of tomato plant treated with 40 µg of Cd also reduced significantly. There was a consistent decrease in leaf number of tomato plant with the increase in the dose of Cd with minor variation (Table 1). The most significant impact of Cd was recorded in the leaf size (area). The leaf area reduced with increase in the concentration of Cd. All selected cadmium doses reduced flower number per plant from 12 in control plants to almost as less as 4 flowers per plant in cadmium treated pots. The photosynthate partitioning to above ground stem, branches, leaf and root also varied in response to Cd treatments. The total biomass initially increased in response to 10 µg of Cd but decreased on treatments with higher doses (20-40 µg). The total chlorophyll content increased as chlorophyll 'a' increased in response to Cd treatments. The stomatal frequency on both the leaf surfaces decreased in proportion to dose of Cd. As shown in Figure 1, the regression line and correlation coefficients of leaf number and leaf area had significant negative relationship with the dose of cadmium. But, shoot length and root length did not show linear relationship with varying doses of cadmium. Cadmium treatment induced variations in the carbon partitioning to the leaf mainly at the cost of root (Table 1). The highest dose of Cd (40 µg) reduced carbon partitioning to leaf and root and increased the proportion of carbon partitioning to the stem of the tomato plant.

Discussion

In the present study, the shoot length of tomato plant did not decrease in response to Cd treatment. It is reported that plant have their own threshold level to different types and concentration of heavy metals (Babich and Stotzky, 1980; Babich *et al*., 1982). The impact of Cd on the shoot length was not linearly related with the dose. Leaf number and leaf area had linear negative relationship with the dose of cadmium. The growth of radish has been found related with Cd concentration (Salim *et al*., 1993). Similarly, Cd and Al reduced the growth of soybean in proportion to their doses (Imran *et al*., 2007).

Table 1. Effect of various doses (µg) of cadmium on the growth of *Lycopersicon esculentum* cv. Navodaya.

Parameters	Control	µg Cadmium (Cd)				LSD	
		10	20	30	40	5%	1%
Shoot length (cm)	57.27±2.86	55.30±2.77	54.37±2.72	60.10±3.01	47.53±2.38	5.439	7.913
Root length (cm)	17.30±0.86	14.17±0.71	21.93±1.10	18.67±0.93	15.43±0.77	1.733	2.521
Leaf number	178.00±4.00	157.67±4.51	151.00±2.65	136.33±7.37	144.33±7.02	2.865	4.169
Leaf area (cm^2)	7.81±0.36	6.70±0.33	4.80±0.24	3.60±0.18	1.53±0.08	0.546	0.795
Flower number ($plant^{-1}$)	12.00±0.60	4.00±0.20	4.33±0.27	4.00±0.20	4.67±0.23	0.638	0.928
Fruit number ($plant^{-1}$)	5.67±0.28	5.67±0.28	4.67±0.18	4.33±0.22	6.00±0.30	0.507	0.738
Above ground biomass(g)	9.56±0.48	14.07±0.70	9.34±0.47	7.77±0.39	6.75±0.34	1.006	1.464
Leaf biomass(g)	4.25±0.21	4.98±0.25	4.56±0.23	3.78±0.19	2.48±0.12	0.414	0.602
Root biomass(g)	1.41±0.07	1.52±0.08	1.13±0.06	1.19±0.06	0.76±0.04	0.125	0.181
Total biomass(g)	10.97±0.55	15.59±0.78	8.90±0.45	10.53±0.53	7.52±0.38	1.130	1.644
Chlorophyll a (mg g^{-1} fresh leaf)	0.083±0.004	0.209±0.010	0.219±0.011	0.169±0.008	0.141±0.007	0.018	0.025
Chlorophyll b (mg g^{-1} fresh leaf)	0.272±0.014	0.321±0.016	0.251±0.013	0.339±0.017	0.224±0.011	0.028	0.041
Total chlorophyll (mg g^{-1} fresh leaf)	0.354±0.018	0.530±0.027	0.558±0.028	0.519±0.021	0.365±0.018	0.046	0.066
Stomatal frequency (adaxial) upper surface	7.90±0.39	7.80±0.39	6.40±0.32	4.40±0.22	2.80±0.14	0.635	0.925
Stomatal frequency (abaxial) lower surface	6.40±0.32	5.60±0.28	5.20±0.26	4.00±0.20	2.00±0.10	0.496	0.721

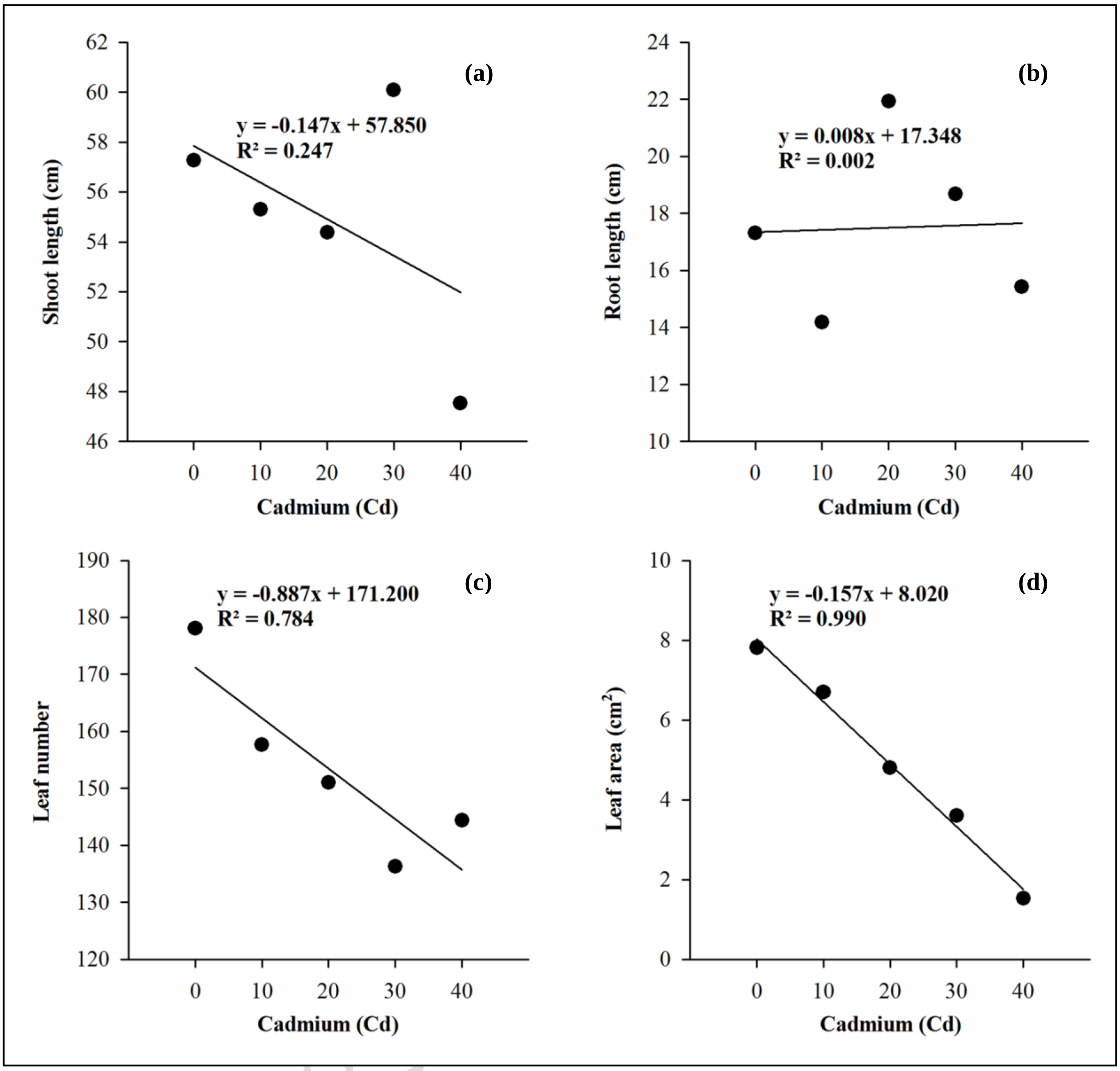

Figure 1: Correlation coefficient (square), linear regression line and equation between cadmium concentration and shoot length (a), root length (b), leaf number (c) and leaf area (d) of *Lycopersicon esculentum* cv. Navodaya.

In the present study, the higher doses of Cd reduced biomass but lower dose of Cd (10 µg) enhanced. In a similar study, hydroponically cultured woody seedlings of four Mediterranean plants showed increase in biomass at intermediate concentration but reduction at higher doses of Ni (Fuentes *et al*., 2007). No reduction in plant height and shoot dry biomass was noted when the plants were grown at Cd concentration of <25 mg/kg soil (Sun *et al*., 2008). In another study, 10, 20, 30 and 40 µg of Cd and Ni reduced the overall growth of *Cichorium intybus*. The chlorophyll content and total plant dry weight were also recorded to be more sensitive to Cd than to Ni (Ayub *et al*., 2009).

The soil properties also influence the uptake of heavy metals. The Cd in presence of Cu reduced the growth of tomato plant (Mediouni *et al*., 2006). Addition of 23 mg cadmium in 1 kg of soil reduced the plant growth, chlorophyll content in chickpea (Wani *et al*., 2007). However, in the present study, the chlorophyll in tomato plant treated with Cd increased considerably (Table 1). In the present finding, the addition of Cd reduced the flower number severely but not the fruit setting (Table 1). The cadmium treatment is also known to delay the flowering (Wani *et al*., 2007).

The minor statistically non-significant variations in selected parameters within varying doses may be due to the minor-microclimatic variation. The minor variations in the properties of garden soil led to minor variations in the growth parameters irrespective of the dose (Salim *et al*., 1993).

Conclusion

The selected cultivar of tomato (*Lycopersicon esculentum* cv. Navodaya) is sensitive to higher concentration of cadmium. The flowering is more sensitive than the rate of fruit setting. The vegetative growth (shoot length) was affected only at high dose of cadmium.

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References

Arnon DI, 1949. Copper enzymes in isolated chloroplast, polyphenol oxidase in *Beta vulgaris*. Plant Physiology, 24: 1-15.

Ayub S, Khan FA, Varshney D, 2009. Effect of heavy metals on a medicinally important plant. Proceeding of International Conference on Emerging Technologies in Environmental Science and Engineering, October 26-28, 2009, Aligarh Muslim University, Aligarh, pp. 1028-1033.

Babich H, Stotzky G, 1980. Environmental factors that influence the toxicity of heavy metal and gaseous pollutants to microorganism. CRC Critical Reviews in Microbiology, 8: 99-145.

Babich H, Schiffenbauer M, Stotzky G, 1982. Comparative toxicity of trivalent and hexavalent chromium to fungi. Bulletin of Environmental Contamination and Toxicology, 28: 193-202.

Forstner U, 1995. In: Metal speciation and contamination of soil (AE Herbert, CP Huang, GW Bailey, AR Bowers), London, Lewis, pp. 1-33.

Fuentes D, Disante KB, Valdecantos A, Cortina J, Vallejo VR, 2007. Sensitivity of Mediterranean woody seedlings to copper, nickel and zinc. Chemosphere, 66: 412-420.

Imran HS, Wei K, Jilani G, Zh G, 2007. Interactions of cadmium and aluminium toxicity in their effect on growth and physiological parameters in soybean. Journal of Zhejiang University of Science, 8: 181-188.

Jeliazkova EA, Craker LE, 2001. Heavy metals and seed germination in some medicinal and aromatic plants (Department of Plant and Sciences, University of Massachusetts, Amherst, MA, 01003, USA). http://www.cprm.gov.br/pgagcm/manuscripts/Jeliazkova.htm

Lokeshwari H, Chandrappa GT, 2006. Impact of heavy metal contamination of Bellandur Lake on soil and cultivated vegetation. Current Science, 91(5): 622-627.

Mediouni C, Benzarti O, Tray B, Ghorbel MH, Jemal F, 2006. Cadmium and copper toxicity for tomato seedlings. Agro Sustainable Development, 26: 227-232.

Salim R, Al-Subu MM, Attallah A, 1993. Effect of root and foliar treatment with lead, cadmium and copper on uptake, distribution and growth of radish plants. Environment International, 19: 393-404.

Sharma RK, Agrawal M, Marshall FM, 2004. Effect of wastewater irrigation on heavy metal accumulation in soil and plants. Paper presented at a national seminar, Bangalore University, Bangalore. Abstract No. 7, p. 8.

Sun Y, Zhou Q, Chunyan D, 2008. Effect of cadmium and arsenic on growth and metal accumulation of Cd-hyperaccumulator *Solanum nigrum* L. Bioresource Technology, 99: 1103-1110.

Wani PA, Khan MS, Zaidi A, 2007. Impact of heavy metal toxicity on plant growth symbiosis, seed yield and nitrogen and metal uptake in chickpea. Australian Journal of Experimental Agriculture, 47(6): 712-720.