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EFFECT OF CHROMIUM ON MORPHOLOGICAL FEATURES OF TOMATO AND BRINJAL

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SUMMARY

Studies were carried out to investigate the morphological features of tomato and brinjal at different Cr^{6+} concentrations. Chromium caused reduction in root length, shoot length and decreased number of branches. Number of stomata and epidermal cells decreased with increasing level of chromium both in tomato and brinjal except on lower side of leaf in tomato. Number of trichomes increased and size of trichomes and stomata decreased. Deformed and less differentiated stomata were frequently present in the treated plants. There was reduction in leaf area, width of primary vein, secondary vein and areoles.

***Key words*: Areoles, chromium, stomatal index, trichomes, veins.**

INTRODUCTION

Chromium is one of the major metal pollutants like cobalt, copper, zinc, nickel, lead and cadmium in water milieu, in the ecosystem (Schafer 1976, Vander Veen and Huczengal 1980). Even at relatively low concentrations it depresses growth of plants (Anderson and Nilsson 1972, Davies *et al.* 1978, Barcelo *et al.* 1986, Prasad 1995) and their economic yield (Bishnoi *et al.* 1993). The chromium is released during chemical processes such as electroplating, leather tanning, textile printing, textile preservation, metal finishing which is often admixed with industrial effluents for irrigation and of sewage and sludge for fertilizing the soil that adversely affect plant growth and development (Ernst *et al.* 1992, Sheoran and Singh 1992, Prasad 1995). The possible injurious effect of exposure of metals to man, animals and plants has generated a global concern. As the metal pollutants are non-degradable and are readily taken up by plants, these are likely to enter easily into the food chain (Prasad 1995). Many of the heavy metals enters in cereals, vegetables and fruits and cause toxicity to both animals and human beings.

MATERIALS AND METHODS

The present investigations were carried out with tomato (*Lycopersicon esculentum* cv. Sel.-7) and Brinjal (*Solanum melongena* cv. PPL). The plants were raised in earthenware pots in sand. Each pot was supplied with nutrient solution (Wilson and Reisenauer 1963) periodically along with nitrogen 45mg/pot using 30 ml/l, NH_4NO_3. Nutrient solution was given along with Cr treatment using $K_2Cr_2O_7$ at 3 concentrations viz. 0.05, 1.0 and 1.5 mM. Four week old seedlings of tomato and brinjal were transferred into pots in net house. Three seedlings per pot were transplanted and then thinned. For each treatment nearly one hundred plants were raised. Each pot was supplied with appropriate nutrient at an interval of 15 days. The quantity of solution was sufficient to maintain the saturation of the sand.

The root length, stem height number of branches and number of leaves were recorded at the time of transplantation, 25 and 50 day after transplation (DAT). For all foiliar studies, fully expanded leaves from 5th and 6th node were studied. The venation pattern was studied using the leaf clearing technique suggested by Mohan Ram and Nayyar (1978). To calculate the stomatal index the peeling of leaves were taken off mechanically with the help of razor and stained with Delafield's haemotoxylene. The stomatal index was calculated under light microscope using the formulae given by Salisbury (1927). Similarly the trichomes were studied by removing

them mechanically by scrapping and through the leaf peelings as mentioned earlier. The size of stomata and length of trichomes was measured by stage and ocular micrometer.

RESULTS AND DISCUSSION

The deleterious and adverse effect of Cr was observed in the form of reduction in root and shoot length. Reduction in the number of branches was associated with reduction in the number of leaves. The deleterious effect of heavy metal increased with the increase in Cr level.

In tomtao there was reduction in root length from 20.9 (control) to 3.5 cm (1.5mM) at vegetative stage and 31.3 (control) to 5.1 cm at flowering stage (Table 1). Similary, in brinjal root length declined gradually from 9.3 (control) 4.1 cm (1.5mM) at vegetative stage and 20.1 (control) to 8.3 (1.5mM) at flowering stage (Table 4). In tomato, shoot length gradually declined from 14.5 (control) to 6.0cm at vegetative stage and 22.8 (control) to 8.1 cm (1.5mM) at flowering stage (Table 1). Similarly, in case of brinjal, shoot length decreased from 14.5cm to 6.0 cm at vegetative stage and 22.6 cm to 8.1 cm at flowering stage, respectively. The number of branches also showed the similar trend, which decreased from 14.5 (control) to 5.2 (1.5mM) in tomato at vegetative stage and 20.1 (control) to 6.3 (1.5mM) at flowering stage. Similarly, in brinjal number of branches decreased from 8.4 (control) to 2.1 cm (1.5mM) at vegetative stage and from 11.4 (control) to 3.9cm (1.5mM) at flowering stage. These reports tally with the reports of Mahadeswaraswamy (1996) in *Vigna mungo* where Cr causes retardation of growth up to 90 per cent both in root and shoot. Banu *et al.* (1997) also found a significant reduction in root and shoot length in Cr treated plants of *Vigna radiata*. At higher concentrations, a reduction in shoot length is possibly due to accumulation of Cr in the plant tissues and its interaction with the minerals. Baetjer *et al.* (1974) reported surface injury of roots and ascribed it the oxidation of the cell wall and membrane components causing tissue lesions similar to described as corrosive reactions in animals or human epidermis.

The chromium not only reduced the number of leaves but also accelerated the rate of senescence. The number of leaves reduced from 70.0 (control) to 10.1 (1.5mM) at vegetative stage and from 80.0 (control) to 13.5 (1.5mM) at flowering stage (Table 1). Similarly, in brinjal, the number of leaves decreased from 18.9 (control) to 4.3 (1.5mM) at vegetative stage and 30.5 (control) to 11.3 (1.5mM) at flowering stage (Table 4). The difference in the frequency of epidermal cells also prevailed between lower and upper epidermis, which was directly related to the size of cells. In tomato, on the upper surface of leaf the number of epidermal cells per unit area were more than the lower surface (Table 2) while in the brinjal the frequency of epidermal cells was more on the lower surface of leaf than on the upper surface (Table 5).

Table 1. Effect of chromium+ on morphological features of tomato (*Lycopersicon esculentum* L.).

Treatment	Root length (cm)		Shoot length (cm)		Number of leaves		Number of branches	
(mM)	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT
Control	20.9±1.2	31.3±1.7	15.3±1.3	25.3±1.8	70.0±2.1	80.0±12.9	14.5±1.1	20.1±1.3
0.5	11.4±1.7	19.2±1.9	9.6±1.1	16.6±1.4	34.1±2.5	41.3±2.5	6.5±0.4	8.3±0.5
	(45.4)	(38.6)	(37.2)	(34.3)	(51.2)	(48.3)	(55.1)	(58.7)
1.0	6.5±1.3	14.3±1.5	7.2±0.9	10.1±0.7	25.1±1.6	28.1±1.8	6.1±0.2	8.1±0.3
	(68.8)	(54.3)	(53.9)	(60)	(64.1)	(64.8)	(57.9)	(59.7)
1.5	3.5±0.8	5.1±0.5	5.1±0.3	6.4±0.4	10.1±0.4	4.2±0.1	5.2±0.2	6.3±0.1
	(83.2)	(83.7)	(66.6)	(74.7)	(85.5)	(83.1)	(71)	(74.1)
* At transplantation	4.3		5.2		8.9		2.1	

Values in parenthesis show per cent reduction.

Table 2. Effect of chromium on foliar epidermal features of brinjal (*Solanum melongena*) var. PPL

Treatment		Number		Epidermal	Trichome	Stomata size		Stomatal
		Stomata	Trichome	cell	length (μ)	length (μ)	breadth (μ)	index
Control	U	20.5±0.8	9.2±0.4	100.2±2.9	428.6±4.6	20.2±1.0	13.2±0.9	16.9
	L	30.5±0.7	14.1±0.8	133.5±3.1	433.2±5.2	21.3±0.5	13.8±0.8	18.5
0.5	U	19.1±0.3	123±1.1	80.1±2.1	40.55±3.9	20.1±0.7	13.0±0.5	19.2
	L	28.8±1.1	18.5±0.5	110.3±3.4	410.3±5.6	20.6±0.6	12.9±0.7	20.7
1.0	U	17.8±0.5	18.3±1.0	60.9±2.5	385.6±4.9	192.±0.5	12.0±0.4	22
	L	25.3±0.9	24.6±0.9	90.8±3.2	393.2±6.2	17.2±0.3	12.0±0.3	21.7
1.5	U	15.1±0.6	20.2±1.1	50.3±3.2	375.7±4.5	18.9±0.4	12.1±0.2	23.1
	L	20.1±0.5	30.2±0.7	75.1±3.9	380.2±5.2	17.0±0.3	11.9±0.2	21.3

U-Upper surface of leaf.

L-Lower surface of leaf.

Vazquez *et al.* (1987) found that Cr caused plasmolysis in peripheral cells, which indicates that Cr damages the plasmalemma causing leakage of the cell content. This phenomenon may be considered as a primary toxic effect of Cr and may explain the inhibition of water uptake by Cr. Similar observations were made in potato tuber slices by Mukherji and Roy (1977). A noticeable difference in the stomatal frequency prevailed in nature between the upper and lower epidermis. It was more on lower leaf surface both in tomato and brinjal (Table 5). There was a significant decrease in the number of stomata both in tomato and brinjal under the influence of chromium (Table 4). There was a increase in stomatal index on upper as well as lower side of leaf with increasing level of chromium except in case of tomato on lower side, where decrease in the stomatal index occurred (Table 2 and 5). Leaf surface in chromium treated plants of both tomato and brinjal showed an increase in number of trichomes (Table 2 and 4). Increase in the number of trichomes may be an adaptation towards physical protection and reductions in transpiration as these are known to offer outer line of physical defence against pollutants (Levin 1973). Trichome length as well as stomata size showed reduation with the increasing level of chromium in both tomato and brinjal (Table 2 and 4). In case of Cr treated plants in tomato, degenerated and poorly differentiated stomata were frequently present. Vazquez *et al.* (1987) also found an increase in number of trichomes on lower surface of chromium treated plants. Occasionally the stomata were less differentiated in the leaves and in some cases these were disintegrated. Molas (1997) found that in cabbage, both stomatal differentiation and functioning were affected by Ni. Similar findings were noted by other studies where at higher concentrations, chromium causes chlorosis and necrosis of leaves (Barcelo *et al.* 1986); inhibits photosynthesis causes perturbations in mineral

Table 3. Effect of chromium on morphological features of tomato (*Lycopersicon esculentum* L.) var. Sel. 7

Treatment (mM)	Leaf area (cm^2)	No. of areoles per unit area	No. of veinlets entering/areole	No. of vein ending/areole	Width of prim. vein (μ)	Width of sec. vein (μ)
Control	73.0±2.1	43.2±1.2	1	2	70.8±0.8	39.8±0.4
0.5	65.0±1.9	39.1±0.9	1	2	65.1±0.7	36.3±0.5
1.0	50.7±2.5	29.8±1.0	1	1	58.3±0.9	25.4±0.7
1.5	30.8±0.8	21.1±0.7	1	1	30.2±0.8	15.3±0.3

Table 4. Effect of chromium on on morphological features of brinjal (*Solanum melogena* L.)

Treatment (mM)	Root length (cm)		Shoot length (cm)		Number of leaves		Number of branches	
	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT	25 DAT	50 DAT
Control	9.3±0.8	20.1±1.2	14.5±1.2	22.6±1.7	18.9±2.5	30.5±2.3	8.4±0.3	11.4±0.4
0.5	6.4±0.7	15.1±1.1	10.2±0.8	16.2±1.3	10.2±1.9	22.3±1.3	5.2±0.1	7.3±0.2
	(33.1)	(24.8)	(29.6)	(28.9)	(56.6)	(26.8)	(38)	(35.9)
1.0	5.3±0.9	10.2±0.4	8.5±0.7	10.3±1.5	5.1±0.2	15.8±1.7	3.2±0.1	4.6±0.1
	(43)	(49.7)	(41.3)	(54.8)	(46)	(48.1)	(61.9)	(59.6)
1.5	4.1±0.1	8.3±0.1	6.0±0.2	8.1±0.2	4.3±0.1	11.3±0.9	2.1±0.2	3.9±0.1
	(55.9)	(58.7)	(58.6)	(64.4)	(77.2)	(62.9)	(75)	(65.7)
*At transplantation	3.2		5.1		3.5		2.1	

Values in parenthesis show per cent decrease.

Table 5. Effect of chromium on foliar epidermal features of tomato (*Lycopersicon esculentum* L) var. Sel.7

Treatment		Number		Epidermal	Trichome	Stomata size		Stomatal
		Stomata	Trichome	cell	length (μ)	length (μ)	breadth (μ)	index
Control	U	16.5±1.2	8.0±1.9	110.3±2.1	153.6±1.9	25.6±0.4	19.0±0.9	13.0±1.3
	L	25.2±1.9	8.0±1.4	56.3±1.9	120.0±3.5	32.0±0.6	22.0±0.3	30.8±1.2
0.5	U	14.0±0.9	12.0±2.1	78.0±1.5	98.0±2.1	25.0±0.5	17.0±0.7	15.2±1.9
	L	23.6±1.2	12.2±1.9	46.6±2.2	99.0±1.7	30.6±0.7	20.0±0.3	33.5±1.7
1.0	U	12.0±2.1	14.2±2.2	62.5±1.4	64.0±1.7	24.0±0.4	16.0±0.4	16.1±1.7
	L	16.2±1.8	13.9±1.8	39.8±0.8	63.1±1.8	26.4±0.8	16.4±0.5	34.1±2.1
1.5	U	14.0±2.0	16.2±0.9	65.7±2.1	48.2±2.1	24.0±0.8	16.4±0.7	17.5±1.6
	L	37.3±1.9	16.5±1.5	100.3±3.1	44.8±2.0	22.0±0.5	15.2±0.4	26.1±1.3

U-Upper surface of leaf.

L-Lower surface of leaf.

nutrition (Turner and Rust 1971, Misra and Jaiswal 1982, Barcelo *et al.* 1985, Otabong 1989) and eventually results in diminished growth. There was a gradual decrease in epidermal cells frequency with increase in consecutive Cr level. There was an abnormal increase in number of epidermal cells (50%) at 1.5mM Cr concentration in tomato on lower side (Table 2) which may be due to expansion of epidermal cells. Molas (1997) also found a decrease in number of stomata both on upper as well as on lower side of leaves in cabbage.

Under the various treatments of chromium there was no major shift or change in venation pattern. Leaf area decreased with increasing level of Cr, both in tomato and brinjal (Table 3 and 6). The basic architecture of venation remained the same except the sizes of the primary veins, secondary veins and areoles. Width of primary vein and secondary vein got reduced with increasing level of chromium both in tomato and brinjal (Table 3 and 6). The reduced cell size and decreased intercellular spaces were largely responsible for reduction in leaf area. Vazquez *et*

Table 6. Effect of chromium on morphological features of brinjal (*Solanum melogena* L.) var. PPL

Treatment (mM)	Leaf area (cm^2)	No. of areoles per unit area	No. of veinlets entering/areole	No. of vein ending/areole	Width of prim. vein (μ)	Width of sec. vein (μ)
Control	260.0±4.5	41.5±0.9	1	2	78.2±2.1	45.2±1.3
0.5	195.0±3.9	36.7±1.6	1	2	67.1±1.7	32.6±1.7
1.0	115.3±5.1	29.3±1.3	1	1	59.2±1.9	26.1±1.5
1.5	90.2±2.1	26.4±1.9	1	1	41.7±1.5	20.2±1.6

al. (1987) found that trifoliate leaves in bush bean plants treated with 9.6×10^{-5} mM Cr had much smaller cells and more reduced intercellular spaces than control which resulted in decrease of leaf area. Width of primary and secondary vein reduced with increasing level of chromium both in tomato and brinjal. The variation in size of areole is another feature, which was markedly affected by different concentrations of chromium. The size of the areoles decreased in plants treated with chromium and this may be due to the decrease in the leaf area. Reduction in all these factors affected the process of translocation and transportation of water, mineral salt and other minerals accounting for the reduced growth.

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