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SHORT COMMUNICATION

EFFECT OF CADMIUM ON GROWTH, MINERAL COMPOSITION AND ENZYME ACTIVITY OF SUGARCANE

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An attempt has been made to study the effect of differential levels of Cd (0, 5, 10, 100, 200 ppm Cd as cadmium chloride) on growth, cell division, chlorophyll content, and activity of catalase and peroxidase enzymes, foliar anatomical characters and essential nutrient contents in sugarcane (*Sachharum* sp. hybrids CoLk 8102 and CoJ 64) planted under soil pot culture conditions. Very low levels of Cd (5 and 10 ppm) decreased most of the growth attributes studied, *viz*. leaf number, leaf area, plant height, leaf width, fresh and dry weight of different plant parts, reduction being more with an increase in Cd supply. In variety CoLk 8102, the depression was 45, 51 and 71% in leaf number, plant height and leaf area respectively whereas CoJ 64 exhibited 18, 11 and 15% depression at 200 ppm Cd supply. Cytological studies indicated steady decline in mitotic index with increasing Cd dose in both the varieties. Chlorophyll a and b and soluble protein contents decreased with an increase in Cd supply in both the varieties. Peroxidase activity was found high while catalase activity was low in Cd supplied plants. Foliar anatomical studies indicated marked reduction in number of minor veins of LTM leaves but the major veins were not affected due to Cd addition in growth medium. Essential nutrients, *viz*. P, Fe, Mn, Cu and Zn determined in different plant parts revealed lower content of P, Fe, Mn Cu and Zn in leaves and higher content of Fe and P in root tissue at higher Cd levels (100 and 200 ppm Cd). Results obtained indicated that high dosages of Cd (100 and 200 ppm Cd) exerted significant inhibitory effect on shoot and root growth, cell division coupled with changes in mineral composition, activity of catalase and peroxidase enzymes which in turn resulted in reduction in biomass yield of sugarcane. Both the varieties were affected due to excess Cd, effect being less pronounced in variety CoJ 64 in terms of lower decrease in growth attributes.

***Key words*: Cadmium, catalase, nutrients, peroxidase, sugarcane.**

Cadmium (Cd) is one of the most toxic metals which enters into agro-ecosystems through industrial effluents and injudicious use of phosphatic fertilizers. Cadmium is known to cause respiratory, photosynthesis and structural disorders at relatively low concentration (D'Souza and Ramachandran 1996). Sugarcane cultivation in metal polluted fields adjacent to different industries may create the problem of metal toxicity in sugarcane (Jain *et al.*2004). The present investigation was aimed to study the effect of differential levels of cadmium (0, 5, 10, 100 and 200 ppm Cd) as cadmium chloride on growth, cell division, chlorophyll and essential nutrient contents, foliar characters and activity of catalase and peroxidase enzymes in sugarcane varieties CoLk 8102 and CoJ 64 under pot culture conditions.

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Single bud setts of sugarcane (*Sachharum* sp. hybrids CoLk 8102 and CoJ 64) were planted under pot culture conditions at differential levels of Cd (0, 5, 10, 100, 200 ppm Cd as cadmium chloride) along with control. The experiment was conducted in a completely randomized block design with three replications. Plants were sampled at 45th day to determine the growth attributes, fresh and dry weight of different plant parts, biochemical attributes and nutrient analysis. Nutrient contents (P, Fe, Mn, Zn and Cu) were determined in clear digest of oven dried plant material after wet digestion in di- acid mixture (HNO_3:$HClO_4$). Chlorophyll content (Arnon 1949), specific activities of catalase (Euler and Josephson 1927), peroxidase (Luck 1963) and total soluble protein in enzyme extract (Lowry *et al*. 1951) were determined in fresh leaves. For cytological analysis, root tips from germinating setts were fixed as described by Srivastava (1995) and squashed in 45 % acetic acid. Well spread plates from at least 10 meristems were scored for each dose of cadmium.

The growth attributes, *viz*. leaf number, area, plant height, leaf width and dry weight of different plant parts decreased with increase in Cd supply (Fig. 1). The maximum reduction was found at 200 ppm Cd supply. In variety CoLk 8102, the depression was about 45, 51 and 71% in leaf number, plant height and leaf area, respectively, while variety CoJ 64 exhibited lower level of depression *i.e*, 18, 11 and 15% in leaf number, plant height and leaf area, respectively. Similar effect of growth reduction was observed in maize due to Cd toxicity (Lagriffoul *et al.* 1998). Cytological studies indicated steady decline in mitotic index with increasing Cd dose from 16.91 % in control to 1.54% at 200 ppm Cd in CoLk 8102 and from 14.25% in control to 2.19% at 200 ppm Cd in CoJ 64, which may be attributed to enhanced disturbance of spindle function with increase in Cd supply (Table 1). Chlorophyll a and b contents decreased with an increase in Cd supply in the growing medium in both the varieties which may indicate the inhibitory effect of Cd on chlorophyll biosynthesis (Assche and Clijsters 1990, Bayçu *et al.* 1999) (Table 2). Similar effects of decreased root and shoot biomass, leaf area, leaf mass, chlorophyll a and b contents due to Cd presence in growing medium was reported in wheat plants by Jalil *et al*. (1994). Foliar peroxidase activity increased, while

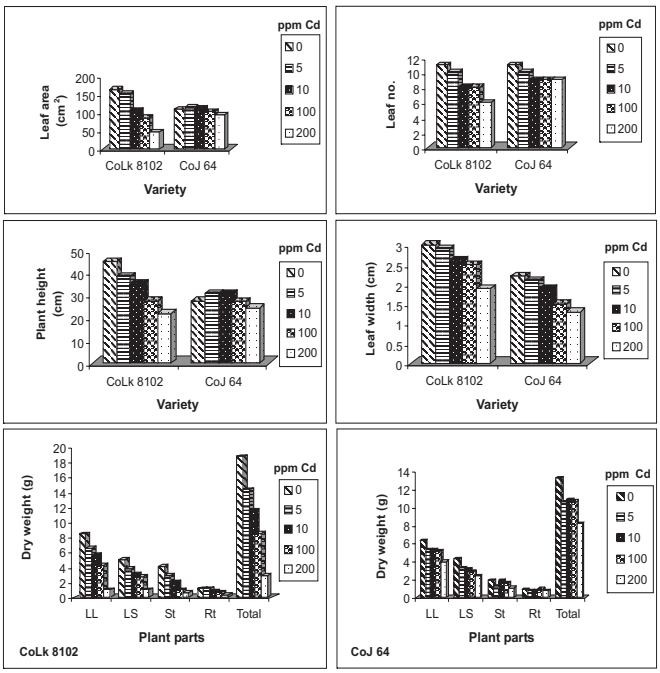

Fig. 1. Effect of cadmium on growth attributes of sugarcane

Table 1. Effect of cadmium on cell division in sugarcane roots.

Variety	Cd concentration (ppm)	Mitotic index (%)	Decrease over control (%)
CoLk 8102	0	16.91	–
	5	15.0	-11.3
	10	13.0	-23.1
	100	5.0	-70.4
	200	1.54	-90.9
CoJ 64	0	14.25	–
	5	11.01	-15.7
	10	9.24	-45.3
	100	6.05	-64.2
	200	2.19	-87.0

catalase activity decreased due to Cd in the growing medium (Table 2). Several reports showed that excess supply of heavy metals causes decrease in catalase activity and an increase in peroxidase activity (Tandon and Srivastava 2004). Increase in peroxidase activity due

Table 2. Effect of cadmium on biochemical and foliar attributes of sugarcane.

Variety	Cd concentration (ppm)				
	0	**5**	**10**	**100**	**200**
			% Soluble protein		
CoLk 8102	3.85±0.13	3.81±0.026	3.61±0.11	3.34±0.06	3.30±0.09
CoJ 64	1.67±.06	1.64±0.04	1.55±0.13	1.22±0.03	1.20±0.05
			Peroxidase (Change in OD/mg protein / min)		
CoLk 8102	1.39±0.08	1.49±0.06	1.61±0.01	1.83±0.05	2.18±0.17
CoJ 64	3.75±0.05	4.61±0.04	4.52±0.07	5.67±0.16	5.96±0.16
			Catalase (µmol H_2O_2 decomposed/mg protein / min)		
CoLk 8102	56.7±1.57	29.9±0.85	29.8±1.71	26.97±1.52	26.0±1.52
CoJ 64	101.9±3.15	82.1±1.01	81.8±1.71	80.2±1.31	71.1±1.01
			Chlorophyll a (mg/g fw)		
CoLk 8102	2.50±0.13	2.26±0.05	2.23±0.26	2.20±0.09	2.0±0.13
CoJ 64	2.00±0.05	1.95±0.04	1.80±0.23	1.73±0.09	1.60±0.05
			Chlorophyll b (mg/g fw)		
CoLk 8102	0.75±0.04	0.70±0.04	0.65±0.01	0.59±0.09	0.53±0.04
CoJ 64	0.60±0.05	0.58±0.07	0.55±0.01	0.52±0.06	0.50±0.04
			Major veins number		
CoLk 8102	13.5±1	14±1.3	14±1	13±1	14±0.9
CoJ 64	18±1	16±0.5	16±0.6	17±0.5	16±0.9
			Minor veins number		
CoLk 8102	88±3.6	83±1.7	78±1	72±2.6	70±1
CoJ 64	92±2	87±1.7	77±1.7	46±2.6	42±1

to Cd may indicate general response of heavy metal stress as a result of *de novo* protein synthesis (Reddy and Prasad 1992, Lagriffoul *et al*. 1998). Besides, peroxidase (POD) is widely distributed in all higher plants and one of its function is known as the detoxification of the activated oxygen forms (Reddy and Prasad 1992). Soluble protein content was found to decrease in Cd supplied plants (Table 2). Excess cellular concentrations of heavy metals either inhibit the utilization of amino acids or promote protein hydrolysis , thus affecting the normal balance of cellular proteins (Tandon and Srivastava 2004). Foliar anatomical studies indicated a marked reduction in leaf width and number of minor veins of LTM leaves but the major veins were not affected due to Cd supply (Table 2). Reports are not available on cell division and foliar aspects in relation to Cd in sugarcane and thus it needs further exploration. Essential nutrients determined revealed lower content of Fe, Mn Cu, Zn, and P in leaves due to high Cd application (Table 3). Reports are available on decreased concentration of Fe, Mn, Zn and Cu in leaves of crops other than sugarcane due to Cd addition in growing medium (Bjerre and Schierup 1985, Jalil *et al.* 1994).

Above findings suggested that lower level of Cd was inhibitory to sugarcane growth but very high level (100 and 200 ppm Cd) exerted toxic effect on shoot and root growth coupled with changes in mineral composition, mitotic cell division and enzyme activity, chlorophyll contents and foliar attributes which in turn causes reduced biomass yield of sugarcane at early stages of growth. Var. CoLk 8102 was affected by cadmium more than CoJ 64.

Table 3. Effect of cadmium on Fe, Mn, Zn, Cu and P contents in sugarcane leaves.

Variety	Cd concentration (ppm)				
	0	**5**	**10**	**100**	**200**
			Fe (µg/g dwt)		
CoLk 8102	294.5±5.8	288.8±7.8	270.3±5.0	261.4±3.1	244.6±5.6
CoJ 64	272.6±3.7	264.4±4.1	260.0±5	256.0±3.6	242.4±2.5
			Mn (µg/g dwt)		
CoLk 8102	68.0±2.6	66.6±1.5	64.0±1.0	60.0±4.6	56.8±2.8
CoJ 64	52.6±2.2	36.4±2.2	36.2±1.0	35.3±3.0	31.9±1.8
			Zn (µg/g dwt)		
CoLk 8102	19.9±1.1	17.8±1.7	17.1±1.7	14.9±0.8	14.8±1.0
CoJ 64	23.8±3.7	20.2±0.7	19.8±1.7	19.0±1.0	16.8±1.7
			Cu (µg/g dwt)		
CoLk 8102	9.0±0.87	7.0±0.5	6.8±0.26	6.7±0.26	6.2±0.26
CoJ 64	7.9±0.85	7.0±0.8	6.4±0.8	6.2±0.26	5.9±0.4
			P (%)		
CoLk 8102	0.242±0.01	0.235±0.03	0.216±0.01	0.187±0.04	0.123±0.01
CoJ 64	0.147±0.01	0.145±0.01	0.138±0.01	0.110±0.01	0.124±0.01

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