CALCIUM INTERACTION WITH $CdCl_2$ INDUCED EFFECTS ON SEEDLING GROWTH AND METABOLISM OF *VIGNA MUNGO* L. AND *SOLANUM MELONGENA* L.

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Abstract: In the present research work surface sterilized seeds of *Vigna mungo.* L. and *Solanum. melongena* L. were raised to analyzed changes in germination, seedling growth, chlorophyll contents, nitrate and nitrite reductase activity under $CdCl_2$, $CaCO_3$ stress singly and in combination 10^{-2} M+200 ppm, 10^{-4} M +100 ppm 10^{-5} M+50 ppm, 10^{-8} M+25 ppm and control were investigated. Observations were recorded at 3, 5, 7, 10, 30, 45 and 60th day of sowing displayed significant decrease in all the attributes of both crop plants on $CdCl_2$ application However, activity of nitrate and nitrite reductase, seedling growth, and chlorophyll contents were enhanced in lower Cd stress 10^{-8} M. Application of $CaCO_3$ shows the more elevations than $CdCl_2$ singly while combined effect of Cd+Ca is more pronounced in comparison to their individual effects.

Keywords: $CaCO_3$, NR activity, Chlorophyll contents**,** *Vigna mungo.* L. and *Solanum. melongena* L.

INTRODUCTION

Among the heavy metals cadmium (Cd) is a highly toxic and persistent environmental contaminant introduced into the soil, through anthropogenic activity phosphate fertilizers, sewage sludge and atmospheric fallout from industrial and municipal activity (Wagner *et al*., 1993). Although Cd is not essential for plants but because of its mobility in soil and solubility in water it is readily absorbed by plants, where it adversely affects the growth and metabolism and in high concentration it can lead to cell death and destruction of whole plant (Benavides *et al*., 2005). Cadmium enters into the cells due to its similar chemical and physical characteristics to plant nutrients, using Ca channels or Fe, Mn or Zn transporters and reduces the uptake of iron (Fe), nitrogen(N), phosphorus (P), potassium (K), Zinc (Zn), copper (Cu) and sodium (Na) (Wojcik *et al*., 2006). Cadmium is one of the most toxic metals in plants because it is active at concentrations much lower than other heavy metals and it also irreversibly replaces other metal ions in essential metalloenzymes (Jackson *et al.*, 1990). Cadmiun accumulation in plants causes disturbance in membrane function (Hernandez and Cooke, 1997), Enzyme activity (Tamas *et al*., 2006).

Excessive level of HMs in the soil environment adversely affect the germination of seeds, plant height, interfere with the activities of many key enzymes (Ashan *et al.,* 2007 and kuriakosa and Prassad 2008), Nitrate reductase activity (Hernandez *et al.*, 1996), Chlorophyll contents and phytomass (Siddhu *et al.*, 2012). Seed is a stage in life cycle of plant that is well protected against various stresses. However, after imbibition and subsequent vegetative developmental processes, they become stress sensitive (Li *et al.,* 2005). Heavy metals have high affinity to sulfydryl groups and disulfide bond which causes damage to secondary structure of proteins (Siediecka and Kurpa, 2002). The mechanism of action lies in their ability to form strong bonds with base and phosphate of nucleic acids (Tabaldi *et al.*, 2007). Cadmium accumulation in plants causes disturbance in membrane function (Hernandez and Cooke, 1997). Tyler and McBride (1981) and Brown *et al.*, (1983) investigated cadmium to be more mobile in soil than other common trace metals. McBride (1980) found that Cd was sorbed form dilute solution by $CaCO_3$ by chemisorption. Mechanism of Cd immobilization was discussed by Zahan (1986). The effect of combined metal Cd and Ca on *Vigna mungo* L. and *Solanum melongena* L. may be quite different from those of individual metals due to their mitigation to encounter the toxic effect of Cd through cation exchange chemisorpiton. Therefore, in the present study, an attempt has been made to investigate combined effect of Cadmium and calcium on seed germination, seedling growth, Chlorophyll contents & NR activity of *Vigna mungo* L. and *Solanum melongena* L. to encounter toxic effects of cadmium.

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MATERIAL AND METHOD

Uniform healthy seeds of *Phaseolus mungo* L. cv.T-9 and *Solanum melongena* L. cv.Pusa uttam were obtained from Indian Agricultural Research Institute, New Delhi-12 and were made surface sterilized with 0.1 % $HgCl_2$ solution. Cadmium solution was prepared by dissolving the molecular weight of cadmium chloride (228.35) in one liter of Hoagland's nutrient solution. This solution was known as 1M solution of cadmium and served as a stock solution (S.S.), other molar conc. were prepared from this 1M (one molar) solution.

In the present investigation, there were two methods of cadmium treatment employed i.e. presoaking and irrigation. For presoaking treatment sterilized seeds of *Phaseolus mungo* L. and *Solanum melongena* L. were imbibed upto 12 hrs in the different molar conc. of cadmium viz. (10^{-2}M, 10^{-4}M, 10^{-5}M, 10^{-8}M, $CaCO_3$ as 25,50,100,200 ppm and in combination as 10^{-2}M+200 ppm, 10^{-4}M+100 ppm, 10^{-5}M+50 ppm, 10^{-8}M+25 ppm, & control) and for irrigation process metal was also given to soil in the form of above molar conc. before sowing. The surface sterilized seeds were sown in polythene bags in triplicate containing 10 kgs. of sandy loam soil (pH 7.45). The experiment was conducted at Environmental Science Laboratory during the year 2004, 2005 and 2006. Observations on seedling growth, morphological and biochemical attributes were recorded. Data were analysed statistically and significant value critical difference at 5 % level were calculated. Seedling vigour index was calculated according to (Abdulbaki and Anderson, 1973) and phytotoxicity percentage of root and shoot was measured by the formula derived by Chou and Muller (1972). Chlorophyll contents were estimated by adopting the method of Smith and Benetiez (1955). Nitrate and nitrite reductase activity, soluble sugar and protein contents of seeds were estimated the method given by Sadasivum and Manickam (1992).

RESULT AND DISCUSSION

Seeds of *Phaseolus mungo* L. and *Solanum melongena* L. were germinated in different. conc. of cadmium singly(10^{-2}M, 10^{-4}M, 10^{-5}M, 10^{-8}M, $CaCO_3$ as 25,50,100,200 ppm and is combination as 10^{-2}M+200 ppm, 10^{-4}M+100 ppm, 10^{-5}M+50 ppm, 10^{-8}M+25 ppm, & control) in petriplates polythene bags in triplicate. Results on Germination percentage, seedling vigour index (S.V.I) and number of lateral roots shows -10.52%, -54.97% and -31.97% reduction in 10^{-2} M $CdCl_2$ singly while interaction of both metal shows a decrease in percent of reduction (-7.36%, -47.33%, and -16.57%). However $CaCO_3$ and 10^{-8}+25 ppm show significant stimulations in these parameters. These observations are in the conformation with that of Siddhu *et al.* (2008). (Table -1 & 2.)

It is obvious from the results of present investigation that seed germination under the different treatments were reduced significantly in 10^{-2} M of $CdCl_2$ while application $CaCO_3$ along with $CdCl_2$ shows a remarkable increase. Peusal of data on seedling growth the *Vigna mungo* L. and *Solanum melongena* L. in $CdCl_2$ shows (-44.22%, -53.11%, -44.438%, -64.805%, -36.64% and -14.93%, -43.87%, -46.11%, -30.65% & -28.7%) reduction oven control in radical & plumule length & dry wt. and shoot root ratio respectively in 10-^{2}M at 10th day however percentage of reduction decrease (-37.39%, -47.27%, -3535%, -6093%, -39.61% and -8.14%, .36-57%, -45.57%, -22.96%, -41.51%) due to interaction of $CdCl_2$ and $CaCO_3$ in (10^{-2} M + 200 ppm) (Table-1 & 2). The inhibition was none in root than shoot because plant roots are finest point of contact with heavy metals in nutrient media (Zhang *et al.,* 2009). The reason for reduced seedling growth under metal treatment could be the reduction in meristematic cells present in the region and some enzymes present in cotyledons and in endosperm.

When Cd-Ca on Cd-Zn interactions are considered, the absorption of Cd decreased in vegetative parts of the plants. Such interactions can be accounted by antagonism process. It is presumed that Ca^{+2} compete with Cd ions or exchange sites on the roots because the radius of Calcium is similar to that of cadmium. Increase significance has been observed in radical & plumule length & dry wt. and shoot root ratio in 10^{-8}M + 25 ppm. The observed significance is (7.22%, 3.15%, 10.14%, 10.75%, -1.23% & 1.58%, 2.80%, 5.93%, 11.17% & 5.01%) respectively. However, Ca Singly increased the length and dry wt. of radical and plumule. Similar trend of observation have been reported with $CaCO_3$ by Salim and Nair (1982). Cadmium reduced the root growth by decreasing Ca in root, calcium being a requirement for root growth development is affected (Greger and Bertell, 1992) (Table-1 & 2).

In our experiment on *Vigna mungo* L. it has been observed that Cadmium alone decreased the germination and seedling growth but along with Ca. the toxic effect of cadmium are reduced to some extent. The combine application of both the elements increases the germination and seedling growth while Ca alone increased the germination and growth of seedlings. Similar observations have been reported by Mohan and Saran (1999). He reported that soaking of $CaCl_2$ and KNO_3 alleviated the effects of Cd toxicity to some extent.

The synergistic effects of cadmium and calcium on the chlorophyll contents at the age of 30th, 60th days of *Vigna mungo* L. and *Solanum melongena* L. in 10^{-2}M +200 ppm of Ca + Cd and in 25 ppm of $CaCO_3$ have been observed. Cadmium treatment caused a significant reduction in the leaf chlorophyll contents of both the crop plants compared with their controls. The maximum decline -34.88%, -44.54%, -51.48% & -46.24% in proto. Chlorophyll. Chl a. chl b. and total chlorophyll contents of *Solanum melongena* L. over control were observed (Table). Destruction of chlorophyll pigments reported due to the instability of pigment-protein complex which may be correlated to the indirect effects of Na and Cl^- ions and also due to impaired uptake of Mg, Fe and Ca by plants (Jaleel *et al.*, 2008). On the contrary, combined treatments of 10^{-2} M + 200 ppm could reduces proto. Chlorophyll. Chl a. chl b. and total chlorophyll contents only by -64.05%, -58.49%, -45.74%, -62.52% & -45.74%, -33.36%, 38-49% and -45.74% in *Solanum melongena* L. *and Vigna mungo* L. respectively. The extend of percent of reduction was less in 10^{-8} M +25ppm of Cd + Ca treatment, thus showing a remedial effects CdCl2 treatment. Observation on CaCO3 singly shows the same trend. Calcium might prevent the damage from cellular dehydration by balancing osmotic strength of cytoplasm (Arshi, *et. al.*, 2006 ab). CSI result shows the stimulation in 10^{-2}M + 200 ppm and 200 ppm of $CaCO_3$ however, 10^{-8}M +25 ppm, 25ppm & 50ppm revealed significant reduction (Table-3).

Nitrate and nitrite reductase activity of *Vigna mungo* L. and *Solanum melongena* L. revealed its inversely proportional to the conc. of cadmium (10^{-2}M, 10^{-4}M, 10^{-5}M, 10^{-8}M). These observations are in the conummeration with that of Mehindirata *et al.* (1999) and Ali khan and Siddhu (2006). Combined result on effect of $CaCO_3$ and $CdCl_2$ levels in nitrate and nitrite reductase activities showed increase in 10^{-8}M +25 ppm at 45th and 60th day. Observed promotion is 3.81%, -15.60% & -33.75%, -9.23% in nitrate reductase enzyme activity and -8.57%, -8.35% & -89.56%, -65.45% in nitrite reductase enzyme activity however, significant reduction -42.85%, -43.13%, -51.74%, & -39.46% in 10^{-2}M+200ppm of Cd + Ca at 45th & 60th day. Activity of nitrate reductase enzyme is increased with increasing $CaCO_3$ concentration. Nishi *et al.* (1996) reported that $CdCl_2$ could recover the loss of in vivo NRA in roots caused by either of the metal combination whereas the salt could recover the loss in leaf NRA caused only by Pb^{2+}, Cd^{2+} (1.0 mM each) and organic N contents of root and leaf however, increased significantly with $CaCl_2$ alone and with the metals supplied in various combinations (Table-4).

Concluding thoughts

In present is study combined effect of Cd+Ca on *Vigna mungo* L. *and Solanum melongena* L. have been observed quite different from those of individual metal pollutant due to their mitigation to encounter the toxic effects of cadmium through cation exchange chemisorptions. Results due to application of both metals revealed more pronounced than $CdCl_2$ singly, however $CaCO_3$ results shows the slight alleviations in all plants attributes in comparison to cadmium.

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Table 1. Effect of cadmium chloride on seedling growth of *Vigna mungo L.*

CdCl2treatment	DAS	Germination percentage	Germination relative index (G.R.I.)	Seedling vigour index (S.V.I.)	Shoot: Root ratio	Dry weight of root	Dry Weitht of shoot	Number of lateral roots	Root length	Root length	Phytotoxicity percentage of root length	Phytotoxicity percentage of root length
Control	3	75.00	855.00	505.950	3.240	4.500	14.583	12.050	4.930	1.816	0.000	0.000
	5	91.66	1008.15	1048.040	3.803	7.361	28.000	17.000	5.480	5.954	0.000	0.000
	7	95.00	1007.00	1866.180	3.699	8.130	30.077	17.855	7.420	12.224	0.000	0.000
	10	95.00	950.00	2051.810	3.569	8.756	31.255	18.000	8.344	13.254	0.000	0.000
$CdCl_2$+$CaCO_3$												
10^{-2} M + 200ppm	3	70.00*	798.00*	213.360*	4.126*	2.100*	8.666*	8.655*	1.847*	1.201*	62.535*	33.865*
	5	83.00*	916.30*	599.059*	2.272*	4.201*	9.545*	12.055*	3.244*	3.945*	40.802*	33.742*
	7	88.00*	935.98*	902.202*	2.208*	4.980*	11.000*	12.428*	4.345*	5.869*	41.442*	51.987*
	10	88.00*	883.00*	1080.540*	2.155*	5.666*	12.211*	12.631*	5.245*	6.988*	37.140*	47.276*
10^{-4} M+ 100ppm	3	73.00*	835.62*	322.514*	3.381*	3.121*	10.555*	9.000*	2.954*	1.464*	40.811*	19.383*
	5	88.33*	971.30*	827.387*	3.464*	5.323*	18.442*	15.625*	4.222*	5.145*	22.956*	13.587*
	7	91.66*	971.49*	1075.721*	3.802	6.124*	20.242*	15.798*	5.212*	6.524*	29.757*	46.629*
	10	91.66*	916.50*	1325.036*	3.000*	7.000*	21.000*	15.912*	6.232*	8.224*	25.311*	37.950*
10^{-5} M+ 50ppm	3	74.00	850.62*	427.760*	3.263	4.245	13.852*	12.445	3.885*	1.576	21.196*	13.215*
	5	90.00	990.00*	951.120*	3.848	6.898*	26.545*	16.675	5.022*	5.546*	8.357*	6.852*
	7	93.33*	998.98*	1293.180*	3.679	7.844	28.864*	16.875	5.644*	8.212*	23.935*	32.820*
	10	93.33*	933.00*	1529.678*	3.527	8.345*	29.440*	17.033*	6.545*	9.845*	21.560*	25.720*
10^{-8} M+ 25ppm	3	81.66*	930.81*	661.364*	3.023	5.622*	17.000*	14.000*	5.245	2.854*	-6.389*	-57.158*
	5	95.00*	1026.30*	1230.630*	4.062	7.876*	32.000*	18.122*	6.000	6.954*	-9.489*	-16.795*
	7	98.33*	1041.98*	2112.128*	3.844	8.643*	33.224*	18.724*	8.245	13.235*	-11.118*	-8.270*
	10	98.33*	983.00*	2307.500*	3.525*	9.644*	34.000*	19.011*	9.255	14.212*	-10.918*	-7.228*
$CaCO_3$												
25 ppm	3	61.66*	702.81*	213.096*	4.357*	2.300*	10.022*	9.000*	2.000*	1.456*	59.432*	19.823*
	5	68.33*	751.30*	464.029*	3.263*	4.545*	14.834*	12.345*	2.559*	4.232*	53.302*	28.921*
	7	81.66*	865.49*	884.622*	3.143*	5.700*	17.916*	12.745*	4.500*	6.333*	39.353*	48.192*
	10	81.66*	816.50*	1058.598*	3.023*	6.200*	18.745*	13.142*	5.684*	7.255*	31.879*	45.261*
50ppm	3	66.66*	759.81*	317.634*	3.921*	3.400*	13.333*	9.445*	3.221*	1.544	34.665*	14.977*
	5	75.00*	825.00*	735.750*	4.027*	5.555*	22.375*	15.755*	4.566*	5.244*	16.678*	11.924*
	7	83.33*	882.98*	1063.624*	4.270	6.666*	28.466*	15.862*	5.765*	6.999*	22.304*	42.743*
	10	83.33*	833.00*	1286.615*	3.906*	7.455*	29.122*	16.054*	6.666*	8.774*	20.109*	33.801*
100ppm	3	68.33*	778.62*	391.804*	3.140	4.342*	13.636*	12.454*	4.122*	1.612	16.389*	11.233*

	5	78.33*	861.30*	854.580*	3.757	6.984	26.245*	16.855*	5.244	5.666	4.306*	4.833*
	7	88.33*	935.98*	1295.447*	3.641	7.844	28.567*	16.925*	5.955*	8.711*	19.740*	28.738*
	10	88.33*	883.00*	1538.885*	3.448	8.656*	29.854*	17.062*	7.000*	10.422*	16.107*	21.367*
200ppm	3	70.00*	798.00*	589.190*	3.014	5.712*	17.220*	14.455*	5.433*	2.984*	-10.202*	-64.317*
	5	81.00*	898.15*	1110.410*	4.097	7.942*	32.545*	18.322*	6.500*	7.000*	-18.613*	-17.568*
	7	90.00*	954.00*	1997.280*	3.885	8.754*	34.011*	19.000*	8.550*	13.642*	-15.229*	-11.600*
	10	90.00*	900.00*	2158.920*	3.416	10.211 *	34.885*	--	9.422*	14.566*	-12.919*	-9.898*

* Significant at 5% level.
DAS = Days after sowing

Table 2. Effect of cadmium chloride on seedling growth of Solanum melongena L.

CdCl2treatment	**DAS**	**Germination percentage**	**Germination relative index (G.R.I.)**	**Seedling vigour index (S.V.I.)**	**Number of lateral roots**	**Radicle length**	**Plumule length**	**Phytotox-icity percentage of radicle length**	**Phytotoxi-city percentage of plumule length**	**Shoot root ratio (SRR)**	**Dry weight of radicle**	**Dry weight of plumule**
Control	3	23.33	265.62	-	-	-	-	-	-	-	-	-
	5	85.00	935.00	444.805	-	5.233	-	-	-	-	0.538	-
	7	96.66	1024.49	1123.189	5.482	7.676	3.945	-	-	3.378	0.740	2.500
	10	96.66	966.50	1320.955	7.524	7.886	5.780	-	-	3.129	0.926	2.900
$CdCl_2$+$CaCO_3$												
10^{-2} M + 200ppm	3	6.66*	37.62*	0.0*	-	-	-	-	-	-	-	-
	5	70.0*	421.3*	267.68*	-	3.824*	-	36.955*	-	-	0.363*	-
	7	88.33*	901.0*	746.39*	2.445*	5.453*	3.00*	28.951*	23.954*	3.985*	0.426*	1.7*
	10	88.33*	850.0*	963.68*	2.622*	7.244*	3.66*	8.141*	36.564*	4.428*	0.504*	2.234*
10^{-4} M+ 100ppm	3	11.66*	57.0*	0.0*	-	-	-	-	-	-	-	-
	5	73.33*	476.3*	281.88*	-	3.844*	-	26.543*	-	-	0.454*	-
	7	91.66*	935.98*	905.32*	3.256*	6.666*	3.211*	13.138*	18.60*	3.910*	0.514*	2.012*
	10	91.66*	883.0*	1066.55*	3.578*	7.324*	4.312*	7.126*	25.397*	3.467*	0.676*	2.346*
10^{-5} M+ 50ppm	3	13.33*	75.81*	0.0*	-	-	-	-	-	-	-	-
	5	83.3	495.0*	404.33*	-	4.854*	-	7.242*	-	-	0.489*	-
	7	93.33*	954.0*	988.36*	3.624*	6.945*	3.645*	9.394*	7.604*	3.875*	0.598*	2.320
	10	93.33*	900.0*	1152.90*	4.625*	7.585*	4.768*	3.816*	17.508*	2.958	0.892*	2.640*

10^{-8} M+ 25ppm	3	26.66*	301.81*	0.0*	-	-	-	-	-	-	-	-
	5	86.66	981.75*	518.66*	-	5.985*	-	-14.37*	-	-	0.567*	-
	7	98.33	1052.58*	1220.17*	6.885*	7.989*	4.42*	-4.091*	-12.040*	3.795*	0.761	2.888*
	10	98.33	993.0*	1371.99*	8.678*	8.011	5.942	-1.833*	-2.802*	3.286	0.981*	3.224*
$CaCO_3$												
25 ppm	3	0.0	0.0*	0.0*	-	-	-	-	-	-	-	-
	5	30.0*	330.0*	120.75*	-	4.025*	-	23.084*	-	-	0.384*	-
	7	85.0*	901.0*	740.94*	2.566*	5.68*	3.037*	25.993*	23.016*	4.789*	0.454*	2.176*
	10	85.0*	850.0*	924.8*	2.8*	6.898*	3.982*	11.488*	31.107*	4.571*	0.538*	2.461*
50ppm	3	0.0*	0.0*	0.0*	-	-	-	-	-	-	-	-
	5	50.0*	550.0*	241.4*	-	4.828*	-	7.739*	-	-	0.477*	-
	7	86.66*	918.49*	892.16*	3.455*	6.875*	342*	10.423*	13.307*	4.00*	0.555*	2.222*
	10	86.66*	866.5*	1094.42*	3.756*	7.754	4.765*	1.673*	17.560	3.538*	0.769*	2.722*
100ppm	3	1.66*	18.81*	0.0*	-	-	-	-	-	-	-	-
	5	58.33*	641.3*	298.70*	-	5.121	-	2.140*	-	-	0.512	-
	7	88.33*	935.98*	1070.11*	3.757*	7.35*	3.588*	4.234*	9.049*	3.678*	0.666*	2.452
	10	88.33*	883.0*	1115.51*	4.8*	7.765	4.875*	1.534*	15.657*	3.16	0.900	2.844
200ppm	3	3.33*	37.62*	0.0*	-	-	-	-	-	-	-	-
	5	65.00*	715.0*	392.88*	-	6.044*	-	-15.505*	-	-	0.600*	-
	7	96.66	1024.49*	1266.43*	7.00*	8.137*	4.965*	-6.026*	-25.855*	3.471	0.777*	2.7*
	10	96.66	966.5*	1392.19*	8.898*	8.414*	5.898*	-6.695*	-3.615*	3.260*	1.012*	3.4*

* Significant at 5% level.
DAS = Days after sowing

Table 3. Effect of $CdCl_2$ + $CaCO_3$ on chlorophyll contents (mg/g. f. wt.)of *Solanum melongena* L. and *Vigna mungo L*.

		Solanum melongena				***Vigna mungo***			
Treatment	**DAS**	**P. chl.**	**Chl. a**	**Chl. b**	**Total chl.**	**P. chl.**	**Chl. a**	**Chl. b**	**Total chl.**
$CdCl_2$									
Control	30th	1.735	0.5788	0.168	0.7468	1.827	0.453	0.1770	0.630
10^{-2} M		1.258*	0.242*	0.0145*	0.256*	0.930*	0.209*	0.092*	0.302*
10^{-4} M		1.380	0.325	0.056*	0.409	1.691	0.293	0.108	0.401*
10^{-5} M		1.627*	0.381*	0.068*	0.448*	1.708*	0.308*	0.112	0.421
10^{-8} M		1.702*	0.422*	0.072*	0.494*	1.718*	0.356*	0.115*	0.471*
Control	60th	1.1797	0.36038	0.0986	0.459	1.388	0.292	0.099	0.391
10^{-2} M		0.638*	0.0701*	0.0281*	0.099*	0.741*	0.098*	0.036*	0.135*
10^{-4} M		0.733*	0.213*	0.0290	0.242	0.887	0.106	0.040	0.147

10^{-5} M		0.784	0.218	0.0364*	0.254	0.928*	0.117	0.046	0.163*
10^{-8} M		0.928*	0.226*	0.0423*	0.268*	1.081*	0.134*	0.056*	0.190*
$CdCl_2$+$CaCO_3$									
10^{-2} M + 200ppm		1.2582*	0.2424*	0.1450*	0.2569*	0.956*	0.216*	0.096*	0.312*
10^{-4} M+ 100ppm	30^{th}	1.3805	0.3254	0.0564	0.4096	1.709	0.303	0.102	0.406
10^{-5} M+ 50ppm		1.627*	0.3801*	0.0682	0.4483	1.765	0.318	0.108	0.427*
10^{-8} M+ 25ppm		1.702*	0.4223	0.0723*	0.4946*	1.780*	0.386*	0.117*	0.504*
$CdCl_2$+$CaCO_3$									
10^{-2} M + 200ppm		0.6386*	0.07018*	0.0290*	0.0992*	0.753*	0.105*	0.041*	0.146*
10^{-4} M+ 100ppm	60^{th}	0.7335	0.2133	0.2956	0.2428	0.895	0.112	0.045	0.160*
10^{-5} M+ 50ppm		0.7842*	0.2185*	0.0364	0.2549*	1.078*	0.128	0.048	0.176
10^{-8} M+ 25ppm		0.9285*	0.2265*	0.0423*	0.2688*	1.182*	0.141*	0.067*	0.209*
$CaCO_3$									
25 ppm		1.338*	0.392*	0.033*	0.426*	0.967*	0.231*	0.099*	0.330*
50 ppm	30^{th}	1.459*	0.421	0.086	0.507	1.721	0.312	0.112	0.425
100 ppm		1.752	0.484*	0.088	0.573*	1.769	0.325*	0.114	0.440*
200 ppm		1.775*	0.512*	0.090*	0.602*	1.789*	0.406*	0.119*	0.525*
$CaCO_3$									
25 ppm		0.659*	0.188	0.0335*	0.221*	0.762*	0.112*	0.044*	0.156*
50 ppm	60^{th}	0.749	0.223*	0.0338	0.257	0.905*	0.120	0.049	0.169
100 ppm		0.807*	0.235	0.0428*	0.278*	0.930	0.135*	0.053*	0.187*
200 ppm		0.946*	0.253*	0.0495*	0.302*	1.087*	0.149*	0.069*	0.218*

DAS=Days after sowing
*Significant at 5% level

Table 4. Effect of cadmium chloride on Nitrate (µg. NO_2^{-}prod/min/gm f.w.t) and nitrite (µg. NO_2^{-}red/min/gm f.w.t) reducatase activity of leave at 45th and 60th day (in parentheses), of *Vigna mungo L.* and *Solanum melongena L.*

Treatment	Nitrate reductase activity		Nitrite reductase activity	
$CdCl_2$	**Vigna mungo**	**Solanum melongena**	**Vigna mungo**	**Solanum melongena**
Control	4.642 (7.920)	2.45 (5.35)	3.50 (5.627)	1.677 (2.446)
10^{-2} M	2.00* (4.747)*	0.324* (1.343)*	1.33* (2.895)	0.125* (0.326)*
10^{-4} M	3.332* (4.933)*	1.122 (2.23)	1.882 (3.983)	0.135 (0.456)
10^{-5} M	3.885 (5.287)	1.253 (2.501)	2.00 (5.164)	0.148 (0.624)
10^{-8} M	4.544* (5.600)*	1.376* (4.770)*	2.892* (5.373)*	0.165* (0.695)*
$CdCl_2$+$CaCO_3$				
10^{-2} M + 200ppm	2.245* (4.794)*	0.565* (1.435)*	1.55* (3.22)*	0.133* (0.563)*
10^{-4} M+ 100ppm	3.55 (5.122)	1.340 (2.356)	2.00 (4.176)	0.140 (0.622)
10^{-5} M+ 50ppm	4.00 (5.395)	1.476 (2.621)	2.35 (5.265)	0.160 (0.752)
10^{-8} M+ 25ppm	4.465* (6.684)*	1.623* (4.856)*	3.200* (5.558)*	0.175* (0.845)*
$CaCO_3$				
25 ppm	2.125* (4.765)*	0.600* (1.564)*	1.25* (3.00)*	1.019* (1.465)*
50 ppm	3.245 (4.954)	1.455 (2.466)	1.88 (3.55)	1.342 (1.636)
100 ppm	3.955 (5.255)	1.562 (2.855)	1.22 (5.18)	1.421 (1.784)
200 ppm	4.352* (6.255)*	1.755* (5.245)*	3.00* (5.412*)	1.485* (1.944)*

* Significant at 5% level

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