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Toxic effect of mercury and cadmium on germination and seedling growth of *Cajanus cajan* L (Pigeon Pea)

Aruna Patnaik[1,2]* and B. K. Mohanty[2]

[1]Department of Botany, M. M. Mahavidyalaya, Berhampur, Odisha, India
[2]Department of Botany, P. G. Department of Botany & Biotechnology, Khallikote (Autonomous) College, Berhampur, Odisha, India

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ABSTRACT

The effect of mercury chloride and cadmium chloride on seed germination, root, shoot length and dry biomass of cajanus cajan L. was evaluated under laboratory conditions. The seeds of cajanus cajan L. (Pigeon pea) were germinated in different concentrations of (0,15,10,20,50 mg/L) mercuric chloride and cadmium chloride. The germination parameters like germination percentage, root and shoot length, fresh and dry weight of 10 days seedlings showed a decreasing trend with the increase in concentration of mercuric chloride and cadmium chloride. Hg and Cd showed significant inhibition of root elongation and the inhibition was more pronounced in the seedlings treated with cadmium.

Key words: Mercury, Cadmium, Pigeon Pea, Seedlings.

INTRODUCTION

Soil contains different heavy metals. Metals are continuously released to the soil by volcanoes, natural weathering of rocks and industrial activities such as mining and combustion of fossil fuel, urban waste disposal, surface run off. They present a risk for primary and secondary consumer and ultimately to human beings. Excess accumulation of heavy metals operate as stress factors causing physiological constraints leading to decreased vigour and plant growth. Heavy metals cause pollution after reaching certain concentration in soil. Mercury and cadmium has no essential function but cause toxicity above certain tolerance level. Recently, there was a great concern for mercury as an environmental pollutant. Mercury occurs in organic as well as in inorganic forms and both the forms are highly toxic. Extensive use of mercury containing compounds, fungicides, algaecide, paper pulp industries and in agriculture, create a problem of mercury concentration in soil and water.

Cadmium is considered to be one of the most toxic metal. Cadmium compounds are water soluble. It is used for dye and paint, pigment production batteries, ceramic industries, wooden industries and plastic production. The metal is also used in electroplating, semi conductor, rectifiers, solder for aluminium etc. Industries that are engaged in extraction, refining, electroplating and welding of Cadmium containing materials and also refining copper, lead and zinc etc. are the chief sources of cadmium. Cadmium is the chief constituents of Phosphatic fertilisers. Application of high levels of commercial fertilisers increases cadmium level in the soil. It would accumulate in the soil permanently and also in plant products. Plants uptake is one of the major pathways by which toxic metals enter to human food chain. Heavy metals presence in the atmosphere, soil and water even in trace concentration can cause serious problems to all living being (Chandra Sekhar *et al.*, 2011). Accumulation and exclusion were two basic strategies by which plants respond to elevated concentration of heavy metals (Mikus *et al.* 2005). Treatment of high

concentration of some heavy metals to plants shows in reduction of seed germination and seedling growth (Patra and Sharma 2000, Peralta *et al.* 2001, ‘ Abedin and Meharg 2002, Jeliazkoava *et al.* 2003, Shafiq and Iqbal 2005, Marchial *et al.* 2006, Marques *et al.* 2007, Ashraf and Ali 2007, Hussain *et al.* 2007, Mahmood *et al.* 2007, Singh Sengar *et al.* 2008, Jun *et al.* 2009, Milian *et al.* 2011). Mercury pollution has become an important current issue of its environment (Sharon *et al.* 2012). Seed germination was significantly decreased with mercury treatment. The effect of mercury chloride was found to be highly toxic to seedling growth of *Archais hypogea* L. (Abraham and Damodaran, 2012). Plant grown under different levels of cadmium showed a significant reduction in the length of shoots and roots, yellowing and ultra structural alterations of the leaves and a significant decrease in the essential oil composition (Zheng *et al.* 2010).

Cajanus cajan L. (Pigeon pea) is a multiuse legume crop in the world, especially in Indian subcontinent. Due to its multiple use, pigeon pea is widely grown as inter crop in semi arid regions. It provides the main source of protein for many poorest population and plays important role in reducing malnutrition for millions of people in the world. Pigeon pea is an ideal source of protein and vitamins in human diet, especially in the vegetarian population.

The present study is to assess the effect of different concentrations of mercuric chloride and cadmium chloride on seed germination and seedling growth of *cajanus cajan* L. (Pigeon pea).

MATERIALS AND METHODS

Seeds of *cajanus cajan* L. (Pigeon Pea) was collected from CPR, OUAT, Ratnapur with label UPAS-120.

Test Chemicals: Mercuric chloride ($Hgcl_2$) and cadmium chloride (manohydrate) $cdcl_2$, H_2O) were used as test chemicals. Different concentrations of the compounds were prepared using distilled water as solvent.

Five concentrations of the metals (1,5,10,20,50 mg/L) were prepared using distilled water and for control only distilled water was used. Healthy pigeon pea seeds of uniform size were selected and soaked in different concentrations of mercuric chloride and cadmium chloride solution for 24 hours. Twenty seeds were placed at equidistant in each sterilised petri dish lined with filter paper. The filter paper was moistened with 20 ml of each concentration regularly and for control 20 ml of distilled water was used. Three replicates of each concentrations were taken for study.

The seeds were allowed to germinate in Remi Seed Germinator (R-6C) with relative humidity 90% and 20^{o}C temperature with 12 hours exposure to tube light which was set in auto mode.

The percentage of germination was studied after 48 hrs. and growth of seedling was evaluated after 10 days treatment. Various growth parameters like root length, shoot length, fresh weight of root and shoot, dry weight of root and shoot were measured in triplicates and mean value was calculated. The 10 days old pigeon pea seedlings were taken for recording fresh weight of shoot and root.

They were kept in a hot air oven at 80^{o}C for 48 hours, dry weight of shoot and root were recorded.

Table -1 Seed Germination and Seedling Growth of Pigeon Pea in different Concentrations of mercuric Chloride .

Treatment	Germination percentage	Root Length in cm	Shoot length in cm	Root/shoot Ratio	Fresh weight of Root in gm.	Dry weight of Root in gm.	Fresh weight of shoot in gm.	Dry weight of shoot in gm.
Control	100	6.35	9.25	0.686	0.565	0.053	1.061	0.179
1mg/l	100	6.30 (-0.78)	9.20 (-0.54)	0.684 (-0.29)	0.272 (-51.85)	0.043 (-18.86)	1.064 (+6.28)	0.194 (+8.37)
5mg/l	90	5.02 (-20.94)	8.10 (-12.43)	0.619 (-9.76)	0.200 (-64.60)	0.040 (-24.52)	1..065 (+.037)	0.192 (+7.26)
10mg/l.	80	4.70 (-28.98)	7.60 (-17.84)	0.61 (-9.91)	0.165 (-70.79)	0.029 (-45.28)	0.768 (-25.91)	0.163 (-8.93)
20mg/l.	73	3.00 (-52.76)	7.30 (-21.08)	0.410 (-40.23)	0.130 (-76.99)	0.027 (-49.05)	0.772 (-27.23)	0.158 (-11.73)
50mg/l.	70	2.30 (-63.78)	6.50 (-29.73)	0.353 (-48.54)	0.120 (-78.76)	0.023 (-56.60)	0.641 (-39.58)	0.124 (-30.72)

(The figures in parenthesis are % increase / decrease from the control value)

Table -2 Percent of Germination and Seedling Growth of Pigeon Pea treated with different Concentrations of $Cdcl_2$. The data were recorded in 7-days old seedlings. Figures in parenthesis indicate % increase/ decrease from Control value.

Treatment	Germination percentage	Root Length in cm	Shoot length in cm	Root/shoot Ratio	Fresh weight of Root in gm.	Dry weight of Root in gm.	Fresh weight of shoot in gm.	Dry weight of shoot in gm.
Control	96	6.35	9.25	0.686	0.565	0.053	1.061	0.179
1mg/l	90	3.40 (-46.45)	7.55 (-18.37)	0.450 (-34.40)	0.203 (-64.07)	0.037 (-30.18)	0.868 (-18.19)	0.165 (-7.82)
5mg/l	80	2.85 (-55.11)	6.50 (-29.72)	0.438 (-36.15)	0.152 (-73.09)	0.024 (-54.71)	0.563 (-46.93)	0.098 (-45.25)
10mg/l.	70	1.42 (-77.63)	4.45 (-51.89)	0.319 (-53.49)	0.083 (-85.30)	0.010 (-81.13)	0.400 (-62.29)	0.090 (-49.72)
20mg/l.	68	0.55 (-91.33)	2.80 (-69.72)	0.196 (-71.42)	0.022 (-96.10)	0.002 (-96.22)	0.225 (-78.79)	0.037 (-79.32)
50mg/l.	63	0.50 (-92.12)	2.65 (-71.35)	0.188 (-72.59)	N. A.	N. A.	N. A.	N. A.

N. A. : Data not available due to no development of root and shoot after germination at 50mg/l. $Cdcl_2$ concentration.

RESULTS AND DISCUSSION

The results of germination percentage, root length, shoot length, fresh weight and dry weight of root and shoot with heavy metal treatment to pigeon pea seeds of different concentrations are presented in Table 1 & 2. The germination percentage was maximum (100%, 96%) in control and it declined with the increase in concentration of mercuric chloride and cadmium chloride respectively. The seeds treated with 50mg/L concentration of Mercuric chloride the % of germination was 70% whereas, it was 60% in case of cadmium chloride treatment.

Similarly, the maximum root length and shoot length was 6.35 cm and 9.25 cm respectively in the controlled seedlings which was gradually decreased with the increase in concentration of test chemicals. The maximum fresh weight and dry weight recorded in control plants. There is a gradual decrease in the fresh weight and dry weight with the increase in the concentration of mercuric chloride and cadmium chloride treatment.

The visible symptoms of toxicity of mercuric chloride and cadmium chloride treatment was stunting and chlorosis, browning of leaf tip, reduction in growth ,stunting of seedlings and root were the morphological symptoms of mercury toxicity. Brown margin of leaves chlorosis, necrosis, brown stunted roots, reddish veins and petioles, purple stems are the visible symptoms of cadmium toxicity.

The inhibition of root growth and development of lateral roots are symptoms of toxicity due to mercury which can be attributed in the inhibition of mitosis, reduced synthesis of cell wall components and changes in photo synthetic activity. Similar observations with $Hgcl_2$ treatment to Arachis hyposea seeds were noticed by Damodaran *et al.*, (2012).

CONCLUSION

The effect of Mercury chloride and Cadmium chloride on *cajanas cajan* L (Pigeon Pea) was carried out in the present investigation to find out the toxic effect of Hg and Cd on seedling and germination parameters. In comparison, the toxicity of Cd is more severe than Hg. Further work is required to biochemistry and enzymatic level to evaluate the toxic effect of the heavy metals on the physiology of the test plant.

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