Journal of Experimental Sciences Vol. 1, Issue 8, Pages 03-09 [2010]
www.jexpsciences.com

Regular Article

Impact of Chromium on Morphological, Growth and Yield on *Vigna ungiculata* (L.) Walp.

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ABSTRACT: Heavy metal contaminants in to the aquatic system has various sources, such as smelting processes and fuel combustions via atmospheric fall-outs, pollution from lakes, effluents and dumping activities. With these the run-off water system also takes the atmospheric inputs, sewage materials and leaching of carbages along with it. On the other hand, these polluted water bodies enter the terrestrial ecosystem in many path ways such as irrigation, degrading activities and biota flux.
An attempt has been made to assess the response of cowpea cultivars under the effect of potassium di chromate with special reference to seed germination, seedling growth and yield. Various concentrations of potassium di chromate (Control, 10, 25, 50,100 and 250 mg kg-1 soil) were prepared and used for germination studies. The morphometrical parameters like root length, shoot length, number of leaves, number of root nodules and yield parameters were showed decreasing trend with the increasing of potassium di chromate concentrations. The minimum value was recorded at 250 mg kg-1 soil in the variety (Co-1). It is evident from the results obtained that the increase of potassium di chromate concentrations affected all growth parameters and also yield parameters. The concentration above 250 mg kg-1 soil was found to be completely lethal.

Key words: Cow pea, Biochemicals, Chromium toxicity

Introduction

The increasing demand for food production to feed geometrically growing population is of serious concern. Efforts have been directed by agricultural and plant scientists towards modernizing agricultural and plant scientists towards modernizing agriculture for higher food production. On one hand, the advancements of science and technology have added to human comfort, while on the other hand they have given us one of the serious problems to face namely, the pollution.
Pollution is an undesirable change in physical, chemical and biological characteristics of our environment that may or will harmfully affect the human life and living conditions (Warren, 1971). Pollution problems have arisen recently because of increasing pace of industrialization, urbanization, population explosion and green revolution. The pollution accruing from various industries has reached such an alarming proportion that we are unable to breathe fresh air and drink fresh water. Industrialization, the index of modernization, is believed to cause inevitable problems of pollution of air, water and soil based on the type of industry, nature of raw materials used and the manufacturing process involved (Hodges, 1975).
Among the various types of pollution caused by industrialization, the problems of water pollution due to industrial effluents as well as sewage wastes have attained greater dimensions day by day in India. Water pollution is a state of deviation of pure condition, whereby its normal function and properties are affected. The most important effluent discharging industries are tanneries, textiles, distilleries, electroplating units, paper mills, iron and steel industries, fertilizer units, oil refineries, metallurgical units, pesticide and herbicide industries. Indiscriminately discharged industrial effluents containing organic and inorganic compounds, various forms of heavy metals, suspended solids and other materials which naturally affect the water quality as well as natural ecosystem
Leather industry is one of the major industries that discharges many toxic pollutants like chromium, sulphide, phenolic compounds and other mineral salts, dyes, solvents, etc., chromium contributes a major share to the potentially hazardous nature of tannery effluents (Prasad *et al.,* 1981 and Kimbrough *et al.,*1999). The consumption of basic chromium salts by the Indian leather industry is about 24,000 tonnes per annum. The conventional chrome tanning practices lead only to an uptake of 65-70% leaving behind about 7000-8000 tonnes of chromium salts in the form of effluent annually (Davis and Scroggie, 1973). The various potential sources of chromium pollution other than tanneries are metallurgical and metal finishing, textiles, pigment and dye industries and corrosion inhibitors in cooling and boiler systems.
The legumes have been under cultivation throughout the world since time immemorial. They occupy a significant position among food crops as source of pulses, vegetables, oils, etc., (Khanna and Gupta, 1988). The legumes have a unique property of maintaining and restoring soil fertility through bacterial nodules, which are formed on their roots. India has the distinction of being world's largest producer of legumes (pulses and oil yielding) occupying about 13 % of area under cultivation and producing 22-23 million tones of grains annually (Tiyagi and Alam, 1992).
Among the legumes, cow pea was selected for the present study, due to its wide cultivation in most part of Tamil Nadu and being one of the major oil yielding crops of India. The waste discharges from major industries like tanneries, textiles, fertilizer units, chromate industry, iron and steel, pharmaceutical and battery industries, electroplating units, sugar factories and mining operations contain large quantities of chromium. These waste discharges have been disposed mostly into the nearby water bodies. When these water sources were utilized for irrigation to crops by the farmers, they greatly affect the productivity.

Keeping these points of view, the present investigation aims to explore and analyses the extent of damage done by chromium on germination and yield of cowpea (*Vigna ungiculata* (L) Walp) Co - 1 variety.

Materials and Methods

The present investigation has been carried out to assess the effect of chromium on germination and yield of cowpea (*Vigna ungiculata* Walp Co-1 variety).

Seed collection

Cowpea is the major pulse crop cultivated in India. It is essential to achieve the maximum yield with available facilities per unit area. Hence in the present investigation, certain cultivar of the cowpea (*Vigna ungiculata* Walp)
Co-1 variety was selected. The certified seeds of cowpea variety CO-1 was obtained from Pulses Research Station Vamban, Puddukkottai. Seeds of uniform size, colour and weight were chosen for the experiments.

Pot culture

The healthy seeds of cowpea (Co-1 variety) seeds were grown in pot soil (control and in soil to which potassium di chromate have been applied 10, 25, 50, 75, 100 and 250 mg kg^{-1} soil) were prepared and used for pot experiment. Each pot filed with 2kg of soil .The metal (potassium di chromate) was mixed with the soil. Twenty seeds were sown in each pot. All pots were watered

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ISSN: 2218-1768

twice a day. In each pot three plants were taken and measured. Three replicates were maintained for each concentration including control. Various morphometrical parameters like shoot length, root length and number of lateral roots, number of leaves, leaf area and yield parameters were recorded on 15, 30 45, 60 and 75 DAS of treatment. For measurement of seedling growth, three seedlings from each pot were selected at randomly for each concentration and control.

Yield parameters

The yield parameters were recorded at harvest. Three plants were taken for consideration. The following yield parameters (75 DAS) were observed and recorded. Number of pods per plant and seed output per plant were analysed and tabulated.

Results

Shoot length of cowpea at different stages of growth as affected by various concentration of chromium has been represented in the Table 1. The shoot length of cowpea cultivars decreased gradually with the increase in chromium concentration. The maximum shoot length was recorded in the control plants [81.26] of Co-1 cultivar on 75 DAS. The minimum shoot length was observed at 250 mg kg^{-1} [55.26] on 75 DAS. The maximum reduction of percentage over the control occurred at 250 mg kg^{-1} [32.00] of Co-1 variety and the minimum value was recorded [17.99] in 10 mg kg^{-1} of 75 DAS.

Root length (cm $plant^{-1}$)

The root length of cowpea under different concentration of chromium varied significantly [Table.2]. The root length of cowpea declined in proportion to the chromium concentrations. The root length was found to be maximum in control plants (28.94) on 75 DAS. The minimum root length was found to be at 250 mg kg^{-1} soil chromium concentration (19.30) on 75 DAS.

Number of lateral roots [$plant^{-1}$]

The numbers of lateral roots recorded at different stages of growth of cowpea under chromium treatment are furnished in Table3. The number of lateral roots showed a decreasing trend with increase in chromium concentration. The number of lateral roots increased up to 60 DAS and it slightly declined up to the harvest stage. The number of lateral roots were higher in (48.00) in control plants on 60 DAS. While the lateral roots were lower in number (35.40) on 60 DAS at 250 mg kg^{-1} concentration.

Number of root nodules [$plant^{-1}$]

The number of root nodules showed the same pattern of response as in the case of number of lateral roots [Table 4]. The greater number of root nodules [224.40] was recorded on 60 DAS in the control plant. The number of root nodules were lesser in number of [158.80] on 60 DAS at 250 mg kg^{-1} treatment. The maximum percentage of reduction over the control was observed at 250 mg kg^{-1} treatment (31.79) DAS . While the minimum value was recorded at 10 mg kg^{-1} (14.63) concentration on 75 DAS.

Number of leaves [$plant^{-1}$]

The numbers of leaves of cowpea cultivar under chromium treatment at different stages of growth were represented in Table 5. The number of leaves increases up to 60 DAS and it showed a sharp decline up to the harvest stages due to senescence. The number of leaves were found to be higher at control [25.80] on 60 DAS. Lesser number of leaves were observed [18.00] at 250 mg kg^{-1} concentration on 60 DAS. The number of leaves showed a decreasing trend with the steady increase in chromium concentration.

Total leaf area [Cm^{-2} $plant^{-1}$]

The total leaf area of cowpea variety varied significantly in accordance with the number of leaves (Table 6). The leaf area decreased gradually with increase in chromium concentration. The maximum total leaf area was noticed [1173.28] at control. The minimum total leaf area was observed at 250 mg kg^{-1} concentration [816.72] . The leaf area showed a progressive increase up to 60 DAS and there after it decreased as days progressed. The fall in the leaf area at later stages of growth was due to the senescence of the leaves.

Yield parameters

The yield parameters like number of pods $plant^{-1}$ and seed output $plant^{-1}$ increased gradually up to the harvest stage (Table 7). The maximum number of pods ($plant^{-1}$) and seed output ($plant^{-1}$) were recorded [viz., 15.60, 249.60] at control. The minimum number of pods $plant^{-1}$ and seed output $plant^{-1}$ were recorded at 250 mg kg^{-1}concentration [viz., 9.32 and 141.83].

Discussion

Shoot and root length

The shoot and root length decreased the steady increase in chromium concentrations. It was found that the shoot and root length decreased in proportion to the increase in chromium concentrations. Similar trend was noticed Aery and Sarkar (1991). Several workers noted the reduction in shoot and root length under different metal treatments in various plant species, such chromium and mercury on rice and wheat (Varshney, 1992), nickel on greengram (Vijayarengan and Lakshmanachary, 1995) , cadmium on ground nut (Saravanan. 1997) , chromium on cowpea (Joshi *et al.,* 1999), bavistin and monocrotopos on Trigonella (Kamble and Sabale 1999), chromium on blackgram (Lakshmi and Sundaramoorthy 2003), zinc on three seeds (Mahalakshmi and Vijayarengan 2003), lead on *Pisum sativum* (Ahmed and Basumathy 2004) and cobalt on sunflower (Jayakumar *et al*., 2006).

Number of lateral roots and root nodules

The number of lateral roots and number of nodules were found to decrease with progressive increase in chromium concentration. The maximum number of lateral roots occurred in control plants. The 250 mg Kg^{-1}soil chromium treatment produced minimum number of lateral roots. Similar reduction in number of lateral roots was also observed by a number of workers Turner (1973) and John and Laerhovan (1976) with increase in metal concentration.

Nodules are active sites of biological nitrogen fixation and supplement the needs of the crop Nodule number was decrease that it was also observed by Aery and Sarkar (1991) due to high levels of zinc and cadmium. Haung *et al.,* (1974) have also recorded decrease in nodule number, weight and nitrogenous activity in soybean plants when stressed under high doses of cadmium and lead. This would be evident from the study who suggested that most of the metal ions are toxic to soil microorganisms, even in small quantities which resulted in the reduction of nodulation and this confirms the results of the present study also.

Number of leaves and total leaf area

The number of leaves and total leaf area declined with an increase in chromium concentration. The responses among the cultivars varied significantly. The number of leaves and total leaf area also varied in proportion with the chromium concentration. Similar reduction in the number of leaves and total leaf area was observed earlier in wheat (*Triticum aestivum*) due to chromium by Sharma (1993), cadmium and lead Khan and Frankland, (1983) , mercury Ravimycin (1995), nickel Vijayarengan and Lakshmanachary (1992), Selvaraju (1999) zinc , Zeid (2001) chromium and cobalt and Sharavanan *et al.,*(2007) cadmium.

The reduction in leaf area and total number of leaves are in agreement with the findings of Varshney (1990) in greengram (Sharma *et al*., 1995). A steady decrease in leaf area at higher concentrations can be attributed either to reduction in the number of cells in the leaves stunted by stalinization or due to reduction in cell size (Nieman, 1965).

In general, an overall decrease in different growth parameters due to toxic effects of chromium at higher concentrations might be due to the reason that the stressed plants, have to spent more energy for survival in the hostile environment, which otherwise would be available for their other growth processes, which lead to a decrease in the overall growth of the stressed plants.

Yield parameters

The various yield components like number of pods and seed output were decreased with an increase in chromium concentration. The maximum reduction in yield was observed at 250 mg Kg^{-1}soil concentration. Several workers have recorded a similar reduction in yield and yield components due to chromium by Sharma and

Sharma (1993) ,cadmium by Moral *et al.,* (1994) , cadmium and lead Juwarkar and Shende (1986) , mercury by Varshney (1992), nickel by Piccini and Malavolta (1992) cadmium, copper and zinc by Kalyanaraman and Sivagurunathan (1993). The reduction in yield parameters due to metal treatment was also observed by Gupta and Singh (1972), Ohki, (1978) and Vijayarengan and Lakshmanachary (1992).

Inhibition of growth and yield components due to chromium may be due to the blockage of nitrogen which is similar to the observations of Sortberg (1974) in oats, Root *et al.,* (1975) in cor n and bean and Varshney (1990) in greengram.

Considerable changes in the "Physiological effect" have been observed in crops grown in soils contaminated with even moderate levels of some industrial effluents. In order to obtain a better understanding the basis of the "physiological effect", the effect of chromium has been reported. Since the germination, and yield are more vulnerable to pollution stress. The net result of chromium uptake and accumulation resulted in the reduction of growth and yield on cow pea.

Table 1: Influence of chromium on shoot length (Cm plant^{-1}) of cowpea variety (Co-1)

Concentration (mg kg^{-1})	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
Control	13.60	25.62	46.80	69.52	81.26
10	13.00 (-4.41)	23.58 (-7.96)	41.46 (-10.98)	59.81 (-13.97)	66.64 (-17.99)
25	12.70 (-6.62)	23.10 (-9.84)	40.72 (-12.99)	58.42 (-15.97)	64.20 (-20.99)
50	12.46 (-8.38)	22.29 (-13.00)	39.24 (-16.15)	55.00 (-20.89)	60.96 (-24.98)
75	12.01 (-11.69)	21.53 (-15.96)	37.91 (-19.00)	53.55 (-22.97)	59.82 (-26.38)
100	11.76 (-3.53)	20.76 (-18.97)	36.00 (-23.08)	51.96 (-25.26)	57.78 (-28.89)
250	11.35 (-16.54)	20.00 (-21.94)	35.57 (-24.00)	50.67 (-27.11)	55.26 (-32.00)

*Per cent over control values are given in parentheses

Table 2: Root length (Cm plant^{-1}) of cowpea cultivars (var .Co-1) as affected by chromium treatment

Concentration (mg kg^{-1})	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
Control	8.62	12.18	19.35	25.43	28.94
10	8.19 (-4.99)	11.45 (-5.99)	18.00 (-6.98)	23.14 (-9.01)	25.76 (-10.99)
25	8.10 (-6.03)	11.33 (-6.98)	17.41 (-10.03)	22.38 (-11.99)	24.74 (-14.51)
50	7.76 (-9.98)	10.84 (-11.00)	16.83 (-13.02)	21.36 (-16.00)	23.56 (-18.59)
75	7.59 (-11.95)	10.47 (-14.04)	16.06 (-17.00)	20.09 (-21.00)	21.47 (-25.81)
100	7.33 (-14.97)	9.99 (-17.98)	15.29 (-20.98)	18.82 (-25.99)	20.72 (-28.40)
250	6.98 (-19.03)	9.44 (-22.50)	14.32 (-25.99)	17.80 (-30.00)	19.30 (-33.31)

*Per cent over control values are given in parentheses

Table 3: Efficacy of chromium concentration on number of lateral roots (Plant^{-1}) of cowpea (var. Co-1) cultivar

Concentration (mg kg^{-1})	**15DAS**	**30DAS**	**45 DAS**	**60 DAS**	**75 DAS**
Control	20.20	33.60	45.40	48.00	43.80
10	19.60 (-2.97)	31.60 (-5.95)	41.80 (-7.93)	42.60 (-11.25)	38.80 (-11.42)
25	19.20 (-4.95)	31.20 (-7.14)	40.00 (-11.89)	41.40 (-13.75)	37.40 (-14.61)
50	18.40 (-8.92)	29.60 (11.90)	39.20 (-13.66)	39.90 (-16.88)	35.20 (-19.63)
75	17.80 (-11.88)	29.00 (-13.69)	37.80 (-16.74)	38.70 (-19.38)	34.40 (-21.46)
100	17.20 (-14.85)	27.60 (-17.86)	36.00 (-20.70)	36.40 (-24.17)	32.40 (-26.03)
250	16.80 (-16.83)	26.60 (-20.83)	34.60 (-23.79)	35.40 (-26.25)	31.00 (-29.22)

*Per cent over control values are given in parentheses

Table 4: Number of root nodules (Plant^{-1}) of cowpea (var.Co-1) cultivar as affected by chromium concentrations

Concentration (mg kg^{-1})	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
Control	82.00	135.60	215.80	224.40	198.20
10	78.20 (-4.63)	125.60 (-7.37)	195.80 (-9.27)	197.00 (-12.21)	169.20 (-14.63)
25	76.80 (-6.34)	123.80 (-8.70)	188.80 (-12.51)	191.20 (-14.80)	161.00 (-18.77)
50	75.60 (-7.80)	120.00 (-11.50)	183.00 (-15.20)	183.40 (-18.27)	156.40 (-21.09)
75	73.40 (-10.49)	115.60 (-14.75)	175.40 (-18.72)	176.20 (-21.48)	149.20 (-24.72)
100	71.00 (-13.41)	113.20 (-16.52)	166.40 (-22.89)	167.40 (-25.40)	143.60 (-27.55)
250	68.20 (-16.83)	108.00 (-20.35)	157.80 (-26.88)	158.80 (-29.23)	135.20 (-31.79)

*Per cent over control values are given in parentheses

Table 5: Influence of chromium on number of leaves (Plant^{-1}) of cowpea (var. Co-1) cultivar

Concentration (mg kg^{-1})	**15DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
Control	5.20	9.40	19.60	25.80	17.20
10	5.00 (-3.85)	8.60 (-8.51)	17.40 (-11.22)	22.40 (-13.18)	14.40 (-16.28)
25	4.80 (-7.69)	8.40 (-10.64)	16.80 (-14.29)	21.60 (-16.28)	13.80 (-19.77)
50	4.60 (-11.54)	8.00 (-14.89)	16.00 (-18.37)	20.60 (-20.16)	13.00 (-24.42)
75	4.40 (-15.38)	7.80 (-17.02)	15.60 (-20.41)	19.60 (-24.03)	12.40 (-27.91)
100	4.20 (-19.23)	7.40 (-21.28)	15.00 (-23.47)	19.00 (-26.36)	12.00 (-30.23)
250	4.00 (-23.08)	7.00 (-25.53)	14.00 (-28.57)	18.00 (-30.23)	11.40 (-33.72)

*Per cent over control values are given in parentheses

Table 6: Changes in total leaf area (cm^{-2} Plant^{-1}) of cowpea (var. Co-1) cultivar due to chromium treatments

Concentration (mg kg^{-1})	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
Control	105.71	312.35	821.02	1173.28	788.92
10	99.71 (-5.68)	278.49 (-10.84)	702.38 (-14.45)	951.41 (-18.91)	620.17 (-21.39)
25	95.53 (-9.63)	273.03 (-12.59)	683.75 (-16.72)	930.18 (-20.72)	606.29 (-23.15)
50	94.39 (-10.71)	262.66 (-15.91)	667.74 (-18.67)	909.76 (-22.46)	581.38 (-26.31)
75	92.64 (-12.36)	261.06 (-16.42)	654.27 (-20.31)	873.98 (-25.51)	562.34 (-28.72)
100	90.50 (-14.39)	251.88 (-19.36)	634.16 (-22.76)	852.51 (-27.34)	547.43 (-30.61)
250	87.33 (-17.39)	244.51 (-21.72)	611.50 (-25.52)	816.72 (-30.39)	516.58 (-34.52)

*Per cent over control values are given in parentheses

Table 7: Effect of chromium on number of pods ($Plant^{-1}$) and seed out put ($Plant^{-1}$)of cowpea (var. Co-1) cultivar

Concentration ($mg\ kg^{-1}$)	Number of Pods $Plant^{-1}$			Seed output $Plant^{-1}$		
	45 DAS	60DAS	75 DAS	45 DAS	60 DAS	75 DAS
Control	8.40	12.40	15.60	100.80	173.60	249.60
10	8.23 (-2.02)	11.90 (-4.03)	14.50 (-7.05)	97.71 (-3.07)	164.87 (-5.03)	229.14 (-8.20)
25	7.91 (-5.83)	11.36 (-8.39)	13.71 (-12.12)	93.67 (-7.07)	156.00 (-10.14)	217.06 (-13.04)
50	7.52 (-10.48)	10.77 (-13.15)	13.04 (-16.41)	88.52 (-12.18)	145.15 (-16.39)	202.10 (-19.03)
75	6.99 (-16.79)	9.90 (-20.16)	11.78 (-24.49)	81.89 (-18.76)	135.21 (-22.11)	184.41 (-26.12)
100	6.46 (-23.10)	9.01 (-27.34)	10.53 (-32.50)	75.12 (-25.48)	123.06 (-29.11)	164.24 (-34.20)
250	5.88 (-30.00)	8.15 (-41.27)	9.32 (-40.26)	67.84 (-32.70)	109.11 (-37.15)	141.83 (-43.18)

*Per cent over control values are given in parentheses

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Please Cite This Article As:

S. James, P.S. Sharavanan and M. Noorunisha Begam. 2010. Impact of Chromium on Morphological, Growth and Yield on Vigna ungiculata (L.) Walp. J. Exp. Sci. 1(8):3-9.