Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2017 14(4): 1246-1252. **OPEN ACCESS**

Effects of Chromium on seed germination, growth and yield of pink lentil

Sana Murtaza, Nimra Parveen, Shagufta Murtaza, Muhammad Zafar Iqbal, Muhammad Shafiq*, Muhammad Kabir and Zia-ur-Rehman Farooqi

Department of Botany, University of Karachi, Karachi, 75270, **Pakistan**

.

***Correspondence:** **shafiqeco@yahoo.com** **Accepted:** 18 Nov. 2017 **Published online:** 30 Dec. 2017

The presence of metals in the environment and its effects on plant growth due to anthropogenic, industrial and automobile activities is a worldwide problem. Chromium is toxic heavy metal for plant growth. This paper gives information about the seed germination and seedling growth performance of lentil (*Lens culinaris*) in response to different concentration of chromium (15, 50, 75, 100 ppm) treatment as compared to control (0 ppm). In this study the effects of various concentration of chromium on all growth parameters viz shoot, root, seedling length, seedling dry weight and root / shoot ratio of *L. culinaris* were recorded. There was a significant effect on seed germination percentage of *L. culinaris* at all treatment of chromium. There was a significant ($p<0.05$) reduction in root growth from 9. 65 to 1.52 cm with the treatment of chromium at 100 ppm as compared to control (0 ppm). The shoot growth and seedling length of *L. culinaris* significantly decreased at 25 ppm concentration of chromium, while at 50 ppm chromium significant decrease in seedling dry weight of *L. culinaris* was recorded as compared to control. The reduction in shoot length was more prominent with the increase in concentration of chromium at 100 ppm treatments as compared to control. Tolerance indices and seedling vigor index of *L. culinaris* for chromium treatment decreased with the increase of chromium concentration in the substrate as compared to control. The more reduction in seedling tolerance and seedling vigor indices percentage of *L. culinaris* was recorded at 50 ppm for chromium treatment. There was further reduction in seedling vigor and tolerance indices at 100 ppm chromium concentrations treatments as compared to control.

Keywords: Chromium, phytoxicity, seed germination, seedling growth, tolerance index

INTRODUCTION

Heavy metal pollution is one of the current and most troublesome environmental problems due to mismanagement of pollutants coming out from the industries that contributes to soil, water and air contamination. These pollutants may pose considerable damage to plant and animal health. The introduction of heavy metal in the environment has considered a serious environmental concern for vegetation of the region due to human and industrial activities. A number of elements are taken up by plants and higher concentrations of some are known to be toxic for germination and growth of plants even at low concentrations. These heavy metals are not only toxic to plants but also cause severe human health hazards when leach out into food chain (Kumar et al, 2013). Among the heavy metals chromium is an important heavy metal. The effects of chromium toxicity and tolerance in *Cannabis sativa* L, lentil, soya beans, wheat, fenugreek, in certain vegetables, date palm, pea and alteration in translocation of certain nutrients in Citrullus was reported by several researchers

(Citterio et al, 2003; Dube et al., 2003; Du et al, 2003; Pillay et al, 2003; Pandey and Pandey, 2008; Jotey et al, 2013). Chromium is toxic element and easily absorbed by plants. The results suggested that polyamines and tocopherols activities can contribute to tolerance to 1mM Cr(III) treatment, but not to the highest concentration 5 mM that generated oxidative stress in Quinoa (*Chenopodium quinoa* Willd), an ancient Andean seed crop (Scoocianti, et al, 2016). Chromium stress is found hazardous to seed germination, growth and development of mustard seedling with the reduction in growth, leaf relative water content (RWC), and chlorophyll (chl) content but increased phytochelatin (PC) and proline (Pro) content in *Brassica juncea* L. (Mehmud et al, 2017).

Lens culinaris Medikus commonly known as Lentil, Daal or pulse, cultivated in sandy loam soil. It is cool season winter crop. Lentil is the second largest rabi (winter) legume crop grown in Pakistan (Ayub et al, 2001). *L. culinaris* is rich in protein and inexpensive to animal protein. *L. culinaris* has high nutritional value. It belongs to Fabaceaee family and native of sub-continent (Rahim et al, 2010). The lentil is meeting the demand of food requirement for the people all around the world. The data obtained on compositional studies of lentil cultivar Masoor, considered as a significant source of essential amino acids fatty acids and trace minerals to meet the demand of people of Pakistan (Zia-ul-Haq et al, 2011). Lentil is indigenous to central Asia and one of the oldest cultivated legume or pulse. Historians have found archeological evidence of lentil seeds in the Middle East dating back 8,000 years (Gamonski, 2013).

The addition of heavy metal worldwide in immediate environment has been increased and is an important cause of reduction in germination and growth of vegetable due to industrial and anthropogenic activities especially in developing countries likewise Pakistan. Chromium is toxic heavy metal and easily available in air, water and soil. Keeping in view of the ever increase of heavy metals concentrations in environment and its impact on plant growth, there is a need to evaluate the effects of metal like chromium on lentil an important cash crop of Pakistan. Little is known about the effect of chromium on germination and growth performance of an important legume crop (Lentil). The results of the study can be used as selection criteria for cultivation in contaminated areas. The aim of the present study was to evaluate the effects of varying concentration of chromium on seed germination and seedling growth performance of Pink Lentil (*Lens culinaris* Medikus).

MATERIALS AND METHODS

The healthy legume seeds of *Lens culinaris* Medikus (Pink Lentil) were obtained from the local market. The seeds were surface sterilized for one minute with dilute solution of Sodium-hypochlorite to prevent any fungal contamination for one minute. The seeds were washed with double distilled water and placed in Petri dishes (90 mm diameter) on filter paper (Whatman No. 42) at room temperature. Ten seeds were placed in each petri plate and there were three replicates. Solutions of chromium salt as potassium chromate were prepared having five concentrations (0, 25, 50, 75 and 100 ppm). At the start of the experiment, 5 ml of solution of above was applied to each set of respective treatment. After every two day the old solution from every petri plate was sucked and 2 ml fresh solutions of respective treatment was added. All the Petri dishes were kept at room temperature (32±2°C) with 240 Lux light intensity and the experiment lasted for 10 days. The experiment was completely randomized. The rates of the percentage germination, root, shoot, and seedling lengths (cm) and root / shoot ratios were recorded. The seedling dry weight was determined by drying the three largest seedlings from each replicate for each concentration in an oven at 80°C for 24 hours.

All the data were statistically analyzed by Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) to determine the level of significance at $p < 0.05$ on personnel computer using COSTAT version 3.

Seedling vigor index (S.V.I.) was determined as per the formula given by Bewly and Black (1982). Tolerance indices of seedlings were determined with the help of the formula given by Iqbal and Rehmati (1992).

RESULTS

An experiment was conducted to evaluate the effects of chromium on seed germination (%), root, shoot, seedling length (cm), seedling dry weight (g) and root / shoot ratio at different concentrations (0, 25, 50, 75, 100 ppm) of *Lens culinaris* L. (Table 1).

Table 1. Effects of chromium on different growth parameters of *Lens culinaris.*

Treatments (ppm)	Seed Germination (%)	Root Length (cm)	Shoot Length (cm)	Seedling Size (cm)	Seedling dry weight (g)	Root/shoot Ratio
00	100.00±0.00a	9.65±1.28a	4.61±0.45a	14.26±0.99a	0.0266±0.004a	3.02±0.92a
25	100.00±0.00a	5.72±0.41b	2.08±0.37bc	7.86±0.80b	0.0266±0.004a	3.00±0.37a
50	86.60±3.33b	4.10±0.28b	1.46±0.26c	5.57±0.52bc	0.0233±0.004ab	2.92±0.28a
75	63.33±3.33c	0.95±0.45b	2.84±0.08b	3.79±0.54c	0.0131±0.001bc	3.01±0.14a
100	26.33±3.33d	1.52±0.71bc	1.98±0.41bc	2.81±0.40c	0.0100±0.004c	0.46±0.13b
L.S.D.	8.13	2.20	1.25	2.93	0.012	1.56
Values followed by the same letters in same column are not significantly different ($p<0.05$) according to Duncan's Multiple Range Test.						

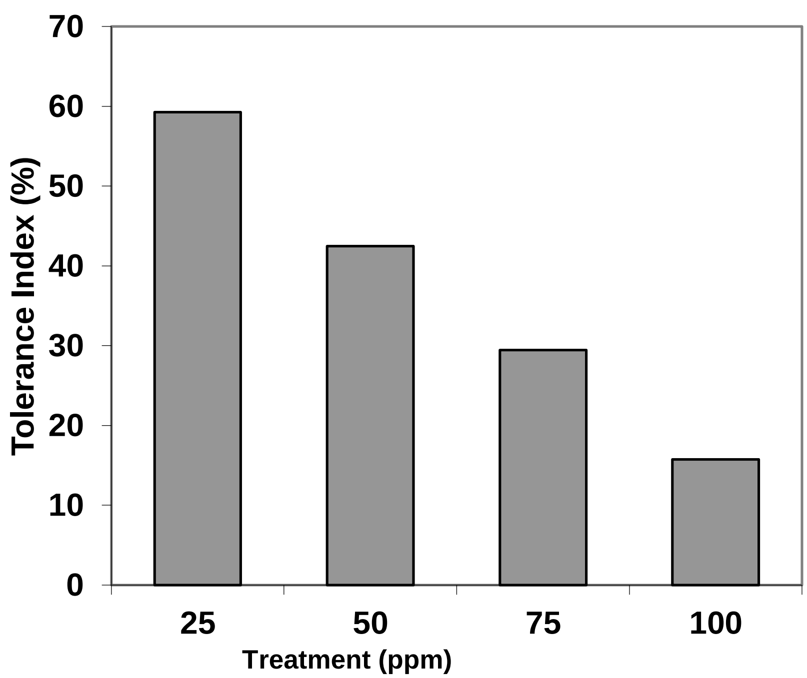

Figure. 1. Percentage of tolerance in *L. culinaris* L. using different concentration (25, 50, 75, 100 ppm) of chromium as compared to control.

Chromium treatment produced harmful effects on seed germination percentage of *L. culinaris* as compared to control. Chromium treatments at 50 and 75 ppm significantly ($p<0.05$) reduced seed germination percentage to 86.66% and 63.33%, respectively. Similarly, the result indicated that root is strongly affected by all concentration of chromium treatments as compared to shoot. With increased in concentration of chromium produced a profound effects on shoot growth of *L*. *culinaris* as compared to control. The results for shoot length showed similar trend as in case of root growth.

Seedling size of *L. culinaris* which includes the length of root and shoot was recorded as 14.26 cm for control and which decreased to 7.86 cm, 5.57 cm, 3.79 cm 2.81 cm when treated with 25, 50, 75 and 100 ppm of chromium solution, respectively. The seedling dry weight of *L. culinaris* was significantly decreased with increase in concentration to 50 ppm of chromium as compared to control. The mean seedling dry weight of *L. culinaris* reduced from 0.0266 to 0.010 g at 25 to 100 ppm chromium solutions treatment.

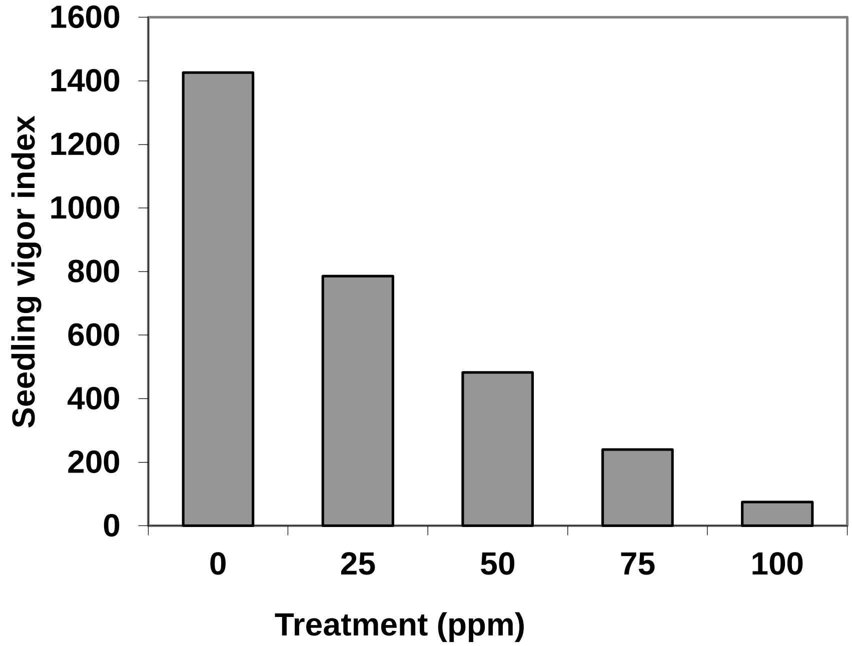

Figure. 2. Seedling vigor index for *Lens culinaris* L. using different concentration (0, 25, 50, 75, 100 ppm) of chromium.

The result also showed that root / shoot ratio significantly ($p<0.05$) affected by chromium treatments at 100 ppm as compared to control.

The seedlings of *L. culinaris* showed different percentage of tolerance to chromium treatment as compared to control (Fig. 1). A high percentage of tolerance (59.27%) to chromium treatment at 25 ppm for *L. culinaris* as compared to control was recorded. The better percentage of chromium tolerance indices (42.48%) for *L. culinaris* seedlings was recorded at 50 ppm. The lowest percentage of seedling tolerance indices (15.75%) for *L. culinaris* was recorded at 100 ppm for chromium treatment.

A direct relationship between seedling vigor index and different chromium treatment (0, 25, 50, 75, 100 ppm) in seedlings of *L. culinaaris* was recorded. An increase in chromium concentration from 25 to 100 ppm decreased seedling vigor index of *L. culinaris*. The seedling Vigor Index (S.V.I.) for *L. culinaris* was highest (1425) at control treatment and gradually declined with the increase in concentration of Cr treatments from 25 to 100 ppm (Fig. 2). Similarly, the seedling vigor indices of *L. culinaris* for chromium treatment was recorded 786, 482, 240 and 75 at 25, 50, 75 and 100 ppm, respectively.

DISCUSSION

Heavy metal pollution is of great concern in developed and developing countries. A huge proportion of human population in Pakistan is exposed to it. These toxic metals are making their way from water bodies to soil where it not only interferes with plant growth and development but also initiates serious health issues in human consuming the produce of such soils (Zahoor et al,2017). Germination and seedling establishment are critical stage in the plant life cycle and negatively affected in the presence of high level of metals. Toxic elements have specific function and role in plant growth. It was observed that chromium was toxic at higher level. The plant under stress conditions are most likely to be adversely affected by heavy metals treatments. In present studies the toxicity to varying concentration of chromium 25, 50, 75 and 100 ppm on germination, seedling growth and yield performances of *L. culinaris* were found significantly affected. The treatments of Cr solution at 100 ppm was found responsible lowest rate of seed germination (26.77%) of lentil. Similarly, the toxic effect of $PbCl_2$ at 1.00 mM on the seed germination and root growth of *L. culinaris* was observed by Kiran and Sahin, (2005). Prodgers and Inskeep (1981) reported that the excessive amount of toxic element usually caused reduction in seedling growth and the damage may occur at any stage of plant growth. Heavy metals are known to pose a potential threat to terrestrial and aquatic biota (Agoramoorthy et al, 2008). Effects of lead chloride stress at 4.5 mM concentration on seed germination of *Lens culinaris* Medic was investigated (Cokkizgin and Cokkizgin, 2010).

When *L. culinaris,* was subjected to different concentrations of chromium it was found that that the growth of root growth was more reduced as compared to shoot growth. Roots of *P. oleracea* seedlings were more sensitive to the studied heavy metal in comparison with shoot (Naz et al. 2013). A significant inhibition in root length of *L. culinaris* was found at 100 ppm as compared to control. The results for shoot length showed similar trend as in case of root growth. Shoot length deceased with the reduction in root length might be due to decreased in nutrients and water uptake stress from the substrate. Seedling size which includes the length of root and shoot was highly decreased when treated with 100 ppm solution of chromium as compared to control.

Results also showed that seedling dry weights of *L. culinaris* were also declined with increased concentration of chromium treatment. Essential and non-essential heavy metals generally produce common toxic effects on the production of low biomass, photosynthesis, alteration in water balance and nutrient assimilation (Singh et al. 2016). The effects of Cr have been reported in several studies over the last few years. At the cellular level, oxidative stress has been reported as a common mechanism (Smeets, et al, 2009). *L. culinaris* treated with different concentration of chromium showed reduction in seedling growth and vigor indices of *L. culinaris* and agreed with the findings of other researchers. Chromium treatment at 100 mg kg^{-1} in pot adversely affected seed germination, seedling growth, and seedling vigor index and biochemical attributes of *Hibiscus esculentum* L. (Amin et al, 2013).

CONCLUSION

The present study reveals some useful information about the effects on chromium on an important crop *L. culinaris*. It was concluded that the treatment of different concentration of chromium at higher concentration produced toxic effects on seed germination and seedling growth of *L. culinaris* along with significant reduction in yield production as compared to control treatment. Similarly, the tolerance to chromium treatment at 100 ppm decreased the highest percentage of tolerance indices and seedling vigor index for *L. culinaris* seedlings as compared to control. The difference in tolerance to metal toxicity should be considered while *L. culinaris* plantation in chromium contaminated areas and to cover the risk of bio magnification with reference to its role in food chain. This preliminary baseline information will be useful for future comparison in other contaminated localities. Percentage of growth of lentil as a test plant was taken as indicator of chromium tolerance and toxicity. These results suggest that development of tolerance indices of chromium could be used as a suitable bio indicator for metal pollution studies in the ecosystem.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

The cooperation of the Charmian, department of Botany for providing the experimental facilities during research work is gratefully acknowledged.

AUTHOR CONTRIBUTIONS

The authors contributed as follows.
SM, NP and SM performed the experiment and collected the data. MZI designed and supervised the experiment, MS statistically analysed the experimental data and draft the manuscript. MK AND ZF reviewed the manuscript.

REFERENCES

Agoramoorthy, G.F., Chen. and Hsu, M.J. Threat of heavy metal pollution in halophytic and mangrove plants of Tamil Nadu, India. Environmental Pollution, 155 (2): 320-326. 2008.

Amin, H., Arain, B., Amin, F. and Surhio, M.. Phytotoxicity of chromium on germination, growth and biochemical attributes of *Hibiscus esculentus* L.. *American Journal of Plant Sciences*, 4 (12): 2431-2439. 2013.

Ayub, K., Rahim, M. and Khan, A. Performance of exotic lentil varieties under rain fed condition in Mingora (NWFP). Pakistan. J. Biol. Sci. 1: 343-344. 2001.

Bewly, J.D. and Black, M.B. 1982. Germination of seeds. In: Physiology and biochemistry of seed germination. Ed: A.A. Khan, Springer Verlag, NewYork, pp. 40-80.

Citterio, S., Santagostino, A., Fumagalli, P.P., Ranalli, N.P. and Sgorbati, S. Heavy metal tolerance and accumulation of Cd, Cr and Ni by *Cannabis sativa* L. Plant and Soil, 256 (2): 243-252. 2003.

Cokkizgin, A. and Cokkizgin, H. Effects of lead ($PbCl_2$) stress on germination of lentil (*Lens culinaris* Medic) lines. African Journal of Biotechnology, 9(50): 8608-8612. 2010.

Du, Y., He, J.H., Chen, J.J., Wei, X.G., Yang, X.Q., Wang, S.Y. and He, W.B. Effects of heavy metals of Pb, Cd and Cr on the growth of vegetables and their uptake," Acta Horticulturae Sinica, 30 (1):51-55. 2003.

Dube, B.K., Tewari, K., Chatterjee, J. and Chatterjee, C. Excess chromium alters uptake and translocation of certain nutrients in Citrullus. Chemosphere, 53 (9): 1147-1153. 2003.

Gamonski, W. 2013. Lentils: The elite legume. Life Extension Magazine. http://www. Life extension.com/magazine/2013/9/lentils-the-elite-legume/page-01. Visited on 28th May, 2017.

Iqbal, M.Z. and K. Rahmati. Tolerance of Albizia lebbeck to Cu and Fe application. Ekologia (CSFR). 11:427-430. 1992.

Joutey, N.T., Bahafid, W., Sayel, H. and El-Ghachtouli, N. Phytotoxic effects of hexavalent chromium on germination and seedling growth of different plant species. Journal of Agricultural Technology,9(2): 361-372. 2013.

Kiran, Y. and Sahin, A. The effects of the lead on seed germination, root growth, and root tip cell mitotic divisions of *Lens culinaris* Medik. G.U. Journal of Science, 18(1): 17-25. 2005.

Kumar, S., Asif, M.H., Chakrabarty, D., Tripathi, R.D., Dubey, R.S. and Trivedi, P.K. Expression of a rice Lambda class of glutathione S-transferase,*OsGSTL2*, in *Arabidopsis* provides tolerance to heavy metal and other abiotic stresses. J. of Hazardous Materials, 248-249, 228-237. 2013.

Mahmud, J.A., Hasanuzzaman, M., NAhar, K., Rahman, A., Hossain, M.S. and Fujita, M. γ-aminobutyric acid (GABA) confers chromium stress tolerance in *Brassica juncea* L. by modulating the antioxidant defense and glyoxalase systems. Ecotoxicology, 2017 Apr 13. doi: 10.1007/s10646-017-1800-9.

Naz, A., Khan, S., Qasim, M., Khalid, S., Muhammad, S. and Tariq, M. Metals toxicity and its bioaccumulation in purslane seedlings grown in controlled environment. Natural Science, **5:** 573-579. 2013

Pandey, S.K. and Pandey, S.K. Germination and seedling growth of field Pea *Pisum sativum* Malviya Matar-15 (HUDP-15) and *Pusa Prabhat* (DDR-23) under varying level of copper and chromium. American Journal of Science, 4 (3): 28-40. 2008.

Pillay, A.E., Williams, J.R.M. O., Mardi, E.L., Al-Lawati, S.M.H., Al-Hadabbi, A.L. and Al-Hamdi, A. Risk assessment of chromium and arsenic in Date Palm leaves used as livestock feed. Environment International, 29 (5): 541-545. 2003.

Prodgers, R.A. and Inskeep, W.P. Heavy metals tolerance of inland salt grass Distichlis spicata. Great Basin Naturalist, 51: 271-278. 1981.

Rahim, S., Dawar, S. and Tariq, M. Mycoflora associated with lentil (*Lens culinaris* L.). Pakistan Journal of Botany, 42(6): 4345-4352. 2010.

Scoocianti, V., Bucchini, A.E., Iacobucci, M., Ruiz, K.B. and Biondi, S. Oxidative stress and antioxidant responses to increasing concentrations of trivalent chromium in the Andean crop species *Chenopodium quinoa* Willd. Ecotoxicol. Environ. Saf., 133: 25-35. 2018

Singh, S., Parihar, P., Singh, R., Singh, V.P. and Prasad, S.M.Heavy metal tolerance in plants: role of transcriptomics, proteomics, metabolomics, and ionomics. Front. Plant Sci. 6:11- 43. 2016.

Smeets, K., Opdenakker, K., Remans, T., Sanden, S.V., Belleghem, F.V., Semane, B., Horeman, B., Guisez, Y., Vangronsveld, J. and Cuypers, A. Oxidative stress-related responses at transcriptional and enzymatic levels after exposure to Cd or Cu in a multipollution context. J of Plant Physio, 166(18):1982-1992. 2009.

Zahoor, M., Irshad, M., Rahman, H., Qasim, M., Afridi, S.G., Qadir, M. and Hussain, A. Alleviation of heavy metal toxicity and phytostimulation of Brassica campestris L. by endophytic Mucor sp. MHR-7. Exotoxicol Environ. Saf. 142: 139-149. 2017.

Zia-ul-Haq, M., Ahmad, S., Shad, M.A., Iqbal, S., Qayum, M., Ahmad, A., Luthria, D.L. and Amarowicz, R. Compositional studies of lentil (*Lens culinaris* Demik) cultivars commonly grown in Pakistan. Pakistan Journal of Botany, 43(3): 1563-1567. 2011,