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Effect of Chromium Toxicity on Germination and Early Seedling Growth in Maize (Zea Mays L.)

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Abstract: ***This study was conducted to determine and compare the inhibitory effects of chromium on seed germination and early seedling growth of maize (*Zea mays *L.). Chromium was selected to find out its harmful effects on seed germination and seedling growth of Maize Seeds of the selected plants were grown in Petri dishes and treated with varying concentrations of Chromium solution. Each treatment was replicated three times in a randomized design and observed for 5 days. The developing seedlings were studied for their total rate of germination, length of a radicle, and length of plumule compared to a set of seeds germinated using distilled water as a control. It was observed that the harmful effects of chromium on all the parameters were directly proportional to the concentration of solution employed, with the inhibition of growth being pronounced from 400mg/l onwards. It was found that the level of chromium at and above 100 mg/L proved to be lethal to all the maize cultivars selected based on the comparison of the toxic effect on germination, plumule and radical. Based on the response of the plants to the toxic effect of chromium concentration was seen in the following order, 800mg/L >600mg/L >400mg/L >100mg/L.***

Keyword: Chromium, Seed Germination, Plumule, Radicle, Maize Cultivar, Toxicity.

1. INTRODUCTION

As a result of human activities like domestic, agricultural and industrial sources, heavy metal remains persistently in the environment. Poor waste management and disposal, mining, overused of pesticides, emission from the burning of fossil fuel, used of agrochemical are among other contributory factor that results in the accumulation of persistent heavy metal in

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our environment today. This concern has been reported (Pandey and Pandey, 2008; Paksoy and Acar, 2009). Chromium is among the heavy metals that are found in every component of environment, and has been lethal to living organism, therefore, it can cause ecological imbalance in the environment. It is important to note that the usual range of Cr is from 10 to 50 mg/kg but subject to the originating material (Pandey and Pandey, 2008).

Several studies conducted by researched that plants harbor high level of Cr ranging from 1-5 ppm and identified to be in either as Cr (III) of Cr (VI), in various plant species. Research has shown that plant grown in the chromium cultured solution tends to have chromium in the root since it is difficult to translocate. Hence the plant tissues has found to show higher symptoms of toxicity in high level usually in hundreds ppm. It was found that in barley, corn, oats, and citrus the level is 5ppm and 175ppm in tobacco plant (Sinha et al., 2005). Some of the effects of chromium in plants includes reduced seed germination or early seedling development (Sharma et al., 1995), also hinders root growth, and biomass accumulation, chlorosis, photosynthesis impairing, and finally plant death (Scoccianti et al., 2006). Due to this fact it is important to take into consideration the application of fast and low costly application of agrochemical by farmers in the heavy metal contaminated agricultural land, since germination process may be firstly affected by Cr, if a seed is able to germinated in Cr contaminated land, it shows that the seed can tolerated the effects of the metal.

More also, studies conducted by authors has found that plants that can maintain early growth stages of the seedling is a good indicators that could help in determing the toxicity impacts of heavy metals like chromium on plants (Sharma et al., 1995; Pandey and Pandey,2008). The used of plant can serve as a cheaper alternative means since soil cleanup is expensive using improved technological equipment's and can be realistic only in undersized areas. Recent studies mostly focused on low cost clean up among which the used of microorganism, biomass, and live plants are the first preferential (Peralta et al., 2001). More investigations are being conducted to find solution to the inherent chromium in the environment, and about comparative mechanisms effect of heavy metals chromium on seed germination and seedling growth biomass in early growth stages. (Wierzbicka and Obidzinska, 1998; Seregin and Kozhevnikova, 2005). There is need to explore more plant species that can persist amidst heavy metal pollution in Nigeria. This present study was conducted to determine and compare the inhibitory effects of chromium on seed germination and early seedling growth of some cultivars of maize.

2. MATERIALS AND METHODS

Experimental site

The experiment was conducted at the department of applied ecology screen House located at 10^0 16' N, and 9^0 47' 19^0 E of Abubakar Tafawa Balewa University Yelwa Campus, Bauchi State Nigeria.

Collection and planting of seeds

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Seeds of OBA98 and OBA SUPER, QPM, EVDT, DMR, SAM. 15, SAM. 14 and COM.1 for the experiment were obtained from Bauchi State Agricultural Development Program (BSADP).

Experimental Procedure

Uniform seeds of each maize species were sterilized in 10% Na-hypochlorite solution for 20 min to prevent fungal growth, and then washed with distilled water (Di Salvatore, et al. 2008). Seeds were also pre-treated in tap water for approximately 12hrs before initiation of the experiments to accelerate germination (Kummerová, et al. 2012, Benzina, et al. 2013).

Formulation of chromium solution

Accurately weighed 2.828 g of 99.9% analytical grade $K_2Cr_2O_7$ (3800 Buddy Lawrence Drive Corpus Christi TX 78407 United States) was diluted in 1000ml of distilled water to obtain 1000ppm of Cr stock solution. To obtain desired concentrations of 100mg/l, 400mg/l, 600mg/l, 800mg/l for the treatment of seeds of maize, the stock solution was further diluted.

Germination and seedling experiments

The five seeds of each maize species were placed on filter papers (Rundfilter, MN 615, 11 cm) in 110×20 mm glass Petri-dishes in triplicates of each treatment and were arranged in a completely randomized design along with a separate set of control using distilled water. 10ml of each Chromium concentration (100mg/l, 400mg/l, 600mg/l, 800mg/l) was added uniformly to each petri dish, and 10ml of distilled water as a control. The dish was closed and incubated in a dark at 25°C for 5 days (Di Salvatore, et al. 2008, Kummerová, Zezulka et al. 2012). After five days, the seeds were removed from the different chromium concentration, and the control treatments.

Measurements

Germination

The number of seeds germinated was counted manually from the petri-dishes and recorded for each treatment and of each maize cultivar.

Length of plumule and radicle

The seeds were removed from petri-dishes, and placed on filter paper. The measurements were taken by placing a tiny rope from the beginning of longest radicle to the end. The rope was marked with pencil at appropriate place were the radicle ends (tip of radicle). Then the rope was placed on the ruler to get the correct length of the radicle, and it was recorded. Similar approach was applied in measuring the length of plumule.

Data collection

Germination was observed after 24 hours and for further 5 days to record total germination (GT) Abdul-Baki and Anderson,(1973). Total germinated (GT) seeds per each petri-dish were recorded. The length of the radicle (cm) and length of the plumule (cm) of the seedlings were measured after a period of 5 days using a standard centimeter scale.

Statistical Analysis

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The effects of different levels chromium within and between cultivars of maize on the germination, length of the radicle and length of the plumule with the control were determined using analysis of variance with MINITAB 16 statistical package.

3. RESULTS AND FINDINGS

Effect of chromium on maize seed germination

The analysis of variance has shown that seed germination under various chromium solutions (100mg/L, 400mg/L,600mg/L and 800mg/L) was not significantly ($p<0.005$) affected in OBA98, EVDT and SAM.14 maize cultivars when compared with the control. However, there was significant difference in the number of seed germinated in SAM.15 maize cultivars from 100mg/L chromium solution when compared with the control. With increased chromium level to 400mg/L, seed deterioration seen in QPM, DMR, COM.1 maize cultivars when compared with control, only OBA Super has experienced reduction in germination from 600 mg/L chromium solution when compared with control (Table1). Chromium has a lot of negative effects on the metabolic processes, thereby causing toxicity to plants which may results to reduce seed germination or early seedling developments (Sharma et al., 1995), root growth and biomass, chlorosis, photosynthetic impairing and finally, plant death (Scoccianti et al., 2006). In our experiment, it was found that chromium concentration at different level has affected seed germination in five out of the eight maize cultivars under investigation, although the effects varies base on concentration levels of the chromium solution, only two were not affected. Several studies had shown the inhibitory effect with elevated concentrations of chromium on seed germination for different species: chromium reduced the germination from 15 to 55% in alfalfa at 5 to 40 mgl-1 Cr (Peralta et al., 2001); from 2.2 to 100.0% in celery at 0.01 to 10 ml Cr (Scoccianti et al., 2006); and 17 to 44% in pea at 25 to 100 mgl-1 Cr (Pandey and Pandey, 2008) in comparison with control applications.

Effect of chromium on maize plumule length

When Maize cultivars were treated with different levels of concentration (100mg/L, 400mg/L,600mg/L and 800mg/L), the maize plumule length were not decreased in QPM and COM.1 when compared with the control. But significant ($p<0.005$) decreased in length of plumule were observed from 100mg/L chromium solution in OBA Super, EVDT, DMR, SAM.15 and SAM.14 in chromium solution when compared with the control, only OBA98 was affected from 600mg/L chromium solution (Table 2). Our investigation revealed that plumule length were also affected in six maize cultivars out of the eight under investigation, only two showed tolerance under different level of chromium concentration levels. A decrease in plumule could be obvious due to the destruction of root cells by Cr and can result in a decrease in nutrient and water morbidity (Saddique et al., 2015). Our results corroborate with that of Gyawali and Lekhak (2006), they noted that an increase in Cr (VI) concentration 10-800 mgL^{-1} in culture medium negatively limited the seedling growth of rice cultivars. These results also agree with the findings of Jun et al.(2009) who investigated the effects of 0 to 3.3mm Cr on germination and early seedling growth of six pulses and observed that root elongation and coleoptiles growth of six pulse plants were more sensitive than seed germination.

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Effect of chromium on maize length radicle

Significant ($p<0.005$) effects was observed on the radical among all the maize cultivars treated with different chromium concentration (100mg/L, 400mg/L,600mg/L and 800mg/L) when compared with the control (Table 3). The finding of this study showed that Chromium significantly reduced the radicle length of maize seedlings, and their inhibited level increased with the increase of Chromium concentration. Since the plant roots are the first organ to come to contact with toxic elements and they usually accumulate more metal than shoot thus inhibiting the growth and root (Salt et al., 1995; Wojeik and Tukiendorf, 1999; Rout et al., 2001). Also, the roots accumulate the higher amount of chromium than the shoot, it could be due to immobilization of chromium in the vacuoles of the root cells, thus rendering it less toxic, which may be a natural toxicity response of the plant (Shanker, et al., 2004). An experiment was carried out to study plant responses to the addition of 0, 10, 50, and 100 mgkg-1 of chromium, respectively, and radish was used as plant test. Radish was sown after 25 days of incubating the soil with Cr. In Cr, dry matter yield of roots and shoots showed greater values, but these tissues reduced in 100mg kg^{-1} when Cr(VI) was applied (Fernandez et al., 2002).

Table 1: Effects of different levels of Chromium ($K_2Cr_2O_7$) on seed germination of Maize cultivars.

Cr level	**OBA98**	**OBA SUP.**	**QPM**	**EVDT.**	**DMR**	**SAM. 15**	**SAM. 14**	**COM.1**
Control	0.00± 5.00^a	0.00± 5.00^a	2.65± 5.00^a	0.00± 5.00^a	0.58± 5.00^a	1.00± 5.00^a	0.00± 5.00^a	0.00± 5.00^a
100mg/L	0.00± 5.00^a	0.00± 5.00^a	0.58± 4.30a	0.00± 5.00^a	1.15± 4.33^a	0.00± 4.00^{ab}	0.58± 4.33^a	0.00± 5.00^a
400mg/L	0.00± 5.00^a	0.58± 4.33^a	0.00± 3.00^b	0.58± 4.33^a	0.00± 4.0^{ab}	1.16± 4.33^{ab}	1.53± 3.33^a	1.00± 4.00^{ab}
600mg/L	1.00± 4.00^a	0.58± 3.67ab	0.58± 2.33^b	1.15± 3.67^a	0.58± 3.67^{ab}	1.53± 1.67^{ab}	0.58± 2.67^a	0.58± 3.67^{ab}
800mg/L	0.00± 5.00^a	0.58± 2.67^b	0.00± 1.00^c	1.00± 4.00^a	0.58± 2.33^b	1.00± 4.00^b	2.08± 2.67^a	0.58± 2.67^b

Means that do not share a letter are significantly different. OBA98 (Obasanjo Maize bread), OBA Super (Obasanjo maize bread), QPM (Quality protein Maize), EVDT (Early variety drought tolerant), DMR (Downey Mildew Resistant), SAM.15 (Samaru Maize), SAM.14 (Samaru Maize), COM.1 (not found).

Table 2: Effects of different levels of Chromium ($K_2Cr_2O_7$) solution on plumule length of Maize cultivars.

Cr Level	**OBA 98**	**OBA SUP**	**QPM**	**EVDT**	**DMR**	**SAM. 15**	**SAM. 14**	**COM.1**
Control	0.60± 5.68^a	1.24 $\pm7.29^a$	6.56± 6.61^a	1.41± 5.85^a	0.91± 5.56^a	1.05± 7.59^a	1.05± 7.59^a	0.94± 4.57^a
100mg/L	0.32±	0.44±	0.63±	0.58±	0.28±	0.31±	0.33±	0.45±

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	4.19ᵃ	3.15ᵇ	3.37ᵃ	4.10ᵃᵇ	2.81ᵇᶜ	3.90ᵇ	3.71ᵇ	3.75ᵃ
400mg/L	0.97± 2.30ᵃ	0.78± 2.51ᵇ	0.45± 2.72ᵃ	0.91 ±2.42ᵇᶜ	1.02± 2.85ᵇᶜ	0.64± 1.71ᶜ	1.05± 2.79ᵇᶜ	1.63± 2.68ᵃ
600mg/L	0.59± 1.71ᵇ	0.40± 1.73ᵇ	0.42± 2.18ᵃ	0.17± 1.40ᶜ	1.54± 4.77ᵃᵇ	0.75± 0.84ᶜ	0.50± 3.71ᶜ	0.54± 2.34ᵃ
800mg/L	0.16± 1.20ᵇ	0.22± 2.06ᵇ	0.17± 1.30ᵃ	0.43± 1.62ᶜ	0.53± 0.93ᶜ	0.21± 2.04ᶜ	0.51± 1.24ᶜ	0.14± 2.24ᵃ

Means that do not share a letter are significantly different. OBA98 (Obasanjo Maize bread), OBA Super (Obasanjo maize bread), QPM (Quality protein Maize), EVDT (Early variety drought tolerant), DMR (Downey Mildew Resistant), SAM.15 (Samaru Maize), SAM.14 (Samaru Maize), COM.1 (not found).

Table 3: Effects of different levels of Chromium ($K_2Cr_2 O_7$) solution on radical length of Maize cultivars.

Cr Level	OBA 98	OBA SUP.	QPM	EVDT	DMR	SAM. 15	SAM. 14	COM.1
Control	0.76± 6.28a	1.58± 6.41ᵃ	2.56± 9.19ᵃ	1.30± 7.31ᵃ	1.13±6.33ᵃ	0.94± 8.53ᵃ	0.94± 8.53ᵃ	2.16± 6.00a
100mg/L	0.93± 4.90ᵃ	0.40± 3.28ᵇ	0.63± 3.45ᵃᵇ	0.59± 3.30ᵇ	1.34± 5.56ᵃ	0.45± 3.45ᵇ	1.13± 2.95ᵇ	0.89± 3.92ᵃᵇ
400mg/L	0.98± 2.49ᵇ	0.54± 2.26ᵇᶜ	1.82± 2.11ᵇ	0.55± 1.39ᵇ	0.62±4.21ᵃᵇ	1.14± 1.32ᵇ	0.56± 1.61ᵇ	2.01± 2.92ᵃᵇ
600mg/L	0.28± 1.44ᵇ	0.76± 1.58ᶜ	0.42± 0.90ᵇᶜ	0.17± 2.11ᵇ	0.07± 1.73ᵇᶜ	1.38± 1.28ᵇ	0.39± 0.92ᵇ	0.23± 1.54ᵇ
800mg/L	0.75± 1,41ᵇ	0.47± 0.65ᶜ	0.56± 0.50ᵇᶜ	0.84± 1.21ᵇ	0.95± 0.99ᶜ	1.13± 0.73ᵇ	0.61± 1.51ᵇ	1.03± 1.21ᵇ

Means that do not share a letter are significantly different. OBA98 (Obasanjo Maize bread), OBA Super (Obasanjo maize bread), QPM (Quality protein Maize), EVDT (Early variety drought tolerant), DMR (Downey Mildew Resistant), SAM.15 (Samaru Maize), SAM.14 (Samaru Maize), COM.1 (not found)

4. CONCLUSION

The results of this study showed that chromium at all concentrations harmed all the growth parameters in comparison to control. It can be concluded that the level of chromium at and above 100 mg/L proved to be lethal to all the maize cultivars selected based on the comparison of the toxic effect on germination, plumule and radical.

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5. REFERENCES

1. S. K. Pandey and S. K. Pandey, 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. J. Am. Sci. 4(3): 28-40, 2008
2. M. Paksoy and B. Acar,. Effect of organic fertilizers on yield components of some tomato cultivars. Asian J. Chem. 21(8): 6041- 6047, 2009
3. P. Sinha, B. K. Dube, and C. Chatterjee, Amelioration of chromium phytotoxicity in spinach by withdrawal of chromium or iron application through different modes. Plant Sci. 169: 641-646, 2005.
4. D. C. Sharma, C. Chatterjee, and C. P. Sharma,. Chromium accumulation by barley seedlings (Hordeum vulgare L.). J. Exp. Bot. 25: 241-251, 1995.
5. V. Scoccianti, R. Crinelli. B, Tirillini, V. Mancinelli, and A. Speranza, Uptake and toxicity of Cr(III) in celery seedlings. Chemosphere, 64: 1695-1703, 2006
6. J. R. Peralta, J. L. Gardea-Torresdey, K. J. Tiemann, E. Gomez, S. Arteaga. E. Rascon, and J. G. Parsons, Uptake and effects of five heavy metals on seed germination and plant growth in Alfalfa (Medicago sativa L.). Bull. Environ. Contam. Toxicol. 66: 727-734, 2001.
7. M. Wierzbicka, and J. Obidzinska, The effect of lead on seed imbibition and germination in different plant species. Plant Sci. 137: 155-171. 1998,
8. V. Seregin, and A. D. Kozhevnikova, Distribution of Cadmium, Lead, Nickel, and Strontium in Imbibing Maize Caryopses. Russian J. Plant Physiol. 52(4): 565-569. 2005
9. M. Di Salvatore, A. M. Carafa, and G. Carratù, Assessment of heavy metals phytotoxicity using seed germination and root elongation tests: a comparison of two growth substrates. Chemosphere, 73(9), pp.1461-1464, 2008.
10. M. Kummerová, Š. Zezulka, L. Váňová, and H. Fišerová, Effect of organic pollutant treatment on the growth of pea and maize seedlings. Open Life Sciences, 7(1), pp.159-166, 2012.
11. O. Benzina, D. Daâssi, H. Zouari-Mechichi, F. Frikha, S. Woodward, L. Belbahri, S. Rodriguez-Couto, and T. Mechichi, Decolorization and detoxification of two textile industry effluents by the laccase/1-hydroxybenzotriazole system. Environmental Science and Pollution Research, 20(8), pp.5177-5187, 2013.
12. A., Adul-Baki,and J. D. Anderson,Vigor determination in soya bean seed by multiple criteria. Crop science. 1973:13(6), 1973.
13. Z. Saddique, A. Farooq, and F. Khan, Effects of chromium (VI) on plant growth and biochemical parameters of wheat (Triticum aestivum L) seedlings. Biologia (Pakistan)2015; 61(2):219-26, 2015.
14. R. Gyawali, and H. D. Lekhak, Chromium tolerance of rice (Oryza sativa L.) cultivars from Kathmandu Valley, Nepal. Scientific World, 4(4): 102-108, 2006.
15. R. Jun, T, Ling and Z. Guanghua, Effects of Chromium on seed germination, root elongation and coleoptile growth in six pulses. Int. J. Environ. Sci. Technol. 6(4): 571-578, 2009.
16. D. E. Salt, R. C. Prince, I. J. Pickering, Mechanisms of cadmium mobility and accumulation in Indian mustard. Plant Physiol. 1995; 109:1427-33, 1995.

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17. M. Wojeik, and A. Turkiendorf, Cd-tolerance of maize, rye and wheat seedlings. Acta Physiol Plant. 1999; 21 (2):99-107, 1992.
18. G. R. Rout, S. Samantaray, and P. Das, Differential lead tolerance of rice and black gram genotypesin hydroponic culture. Rost Vyroba (Praha)2001;47:541-8, 2001.
19. Shanker, A. K, Djanaguiraman, M, and R. Sudhagar, Differential antioxidative response of ascorbate glutathione pathway enzymes and metabolites to chromium speciation stress in green gram (vigna radiate L.) R. Wilczek, cv. CO4 roots. Plant Physiol.5 44-52, 2004.
20. M. L.V. Fernandez, F. Calouro, M. M. Abreu, (2002). Application of chromium to soils at different rates and oxidation states. I. Effect On Dry Matter Yield and Chromium Uptake by Radish. Commun. Soil Sci. Plant Anal. 33(13-14): 2259-2268.