

EFFECTS OF HEAVY METAL TOXICITY ON MAIZE SEEDLINGS GROWTH TRAITS

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Abstract: *Maize is an edible cereal crop that belongs to family Gramineae and use as an energy source for human and animals. In our country the industrial and municipal wastewater has been being used for irrigation purposes that contain heavy metals. These heavy metals affect production of maize crop and soil quality. The purpose of this study was to investigate the affect of different heavy metals on maize growth and to asses more tolerant and more sensitive maize variety. Different concentrations of Mn and Cr (0, 0.25Molar, 0.50Molar) were applies in combined form and individually. Total three replicates were carried out during research. Analysis of variance (ANOVA), Tukey's rang test ($p \leq 0.05$) were applied as statistical tool among treatment means. ANOVA indicated the differences among five different genotypes and 9 different treatments for all parameters were significant. Tukey's test indicated that higher toxic effect was shown under treatment 0.5M Mn + 0.25M Cr while less toxic effect was observed under treatment 0.50M Mn in maize plant. The genotype 31R88 was more sensitive for metal toxicity because most of 31R88 traits were affected under heavy metal treatments while more tolerant variety was Neelum. Hence the results of our study have suggested that the genotype Neelum may be used for the improvement of grain yield and productivity under heavy metal stress conditions.*

Keywords: maize, heavy metals, analysis of variance, Tukey's rang test, 31R88, Neelum, tolerant variety

Introduction

Most of the heavy metals are occurred in fertilizers, pesticides, municipal and compost wastes and naturally in earth crust but when they are released in excess concentration into the environment due to anthropogenic activities they affect plant growth and human health (Rakesh *et al.*, 2013). Industrial and municipal wastewater contain less concentration of heavy metals but long term use of these wastewaters for irrigation purposes can affect the plant growth and restrict soil function. Most of the plant roots help in immobilization of heavy metals but excess concentration of heavy metals such as Cd, Cr, Cu, Co, Ni, Zn become toxic for plant growth (Ashfaq *et al.*, 2016). Now a days heavy metal accumulation is a big problem in our world. These heavy metals accumulated into the plant bodies directly or indirectly. They inhibit the physiological processes. High concentration of heavy metals in our atmosphere might be resulted from agricultural activities, industrial processes, mining activities and emission from vehicles (Salt and Rauser, 1995). Maize is considered as main food source for living organisms and main energy source in developing countries (Chaudhary, 1983; Ali *et al.*, 2014ab; Ali *et al.*, 2015; Ali *et al.*, 2016; Ali *et al.*, 2017; Ashraf *et al.*, 2020). Most of the metals are very toxic in low

concentration like As, Pb, Hg, Cd. But most of the metals are require in small amount for plant growth, excess concentration can inhibit physiological processes (Raskin *et al.*, 1994). Essential metals like Fe, Cu, Zn, Mg are involved in biochemical processes. Most of the heavy metals are occurred in industrial wastewater, when they discharge into surface water they cause serious health damages (Mohnish and Kumar 2015; Zubair *et al.*, 2016). In Benin city most of the dump sites are used for agriculture purposes. Some farmers used decomposed materials from dump sites and apply them on crops as manure which contains heavy metals. Plants uptake these metals that are unfit for plant growth and human consumption (Demirevska *et al.*, 2004). Metals like mercury, lead, cadmium and arsenic are toxic at very low concentrations (Nkansah *et al.*, 2010). Though most heavy metals are needed in trace amounts by growing plants, their excess can result in plant intoxication. The occurrence of heavy metals in industrial wastewater is of interest because they are often present at significant levels and if discharged into surface waters can have severe effects on the environment and public health. Thus the presence of concentrations of heavy metal in plant tissues brings about poisoning problems in human beings and other animals feeding on specific plant tissues (Mazhar *et al.*, 2020; Saif-ul-Malook *et*

al., 2014; Tahir et al., 2020; Zubair et al., 2016; Shan et al., 2014; Sheng et al., 2008). These heavy metals have the potential hazardous effect, not only in compounds but also on human health. This is due to their cumulative properties and toxicity although they are generally present in agricultural soils at low levels. Increasing industrialization has been accompanied throughout the world by the extraction and distribution of mineral substances from their natural deposits. However, there are large scale industries in Pakistan, both privately and publicly owned. These include cement, pharmaceuticals, paint, ceramics, roofing sheets, agro allied, beverages and so on. The auditing and monitoring of metals in the environment (soil, water and foods) is fast becoming an essential aspect of pollution studies, particularly in industrialized area.

Material and method

Seeds of five different maize accessions were sown during summer season in soil filled plastic pots.



Figure 1. Pot experiment for heavy metal stress studies in maize seedlings

Results and discussion

It was persuaded from results given in table 1 that there were significant difference among maize genotypes, treatments of heavy metals and interactions between genotypes and treatments of heavy metals. It was found that there was very low coefficient of variation for all growth parameters indicated that there was higher consistency for all these growth parameters. The results from table 2 indicated that there was high number of leaves per plant, leaf area, fresh stem weight, dry leaf weight and diameter of root was found for genotype Neelum while low plant height, leaf area, dry stem weight, dry root weight, dry leaf weight, fresh stem weight, fresh root weight, fresh leaf weight and diameter of stem was found in genotype 31R88. The high number of leaves per plant, leaf area, fresh stem weight, dry leaf weight and diameter of root indicated that there were higher photosynthetic compounds in the leaves which may be helpful for the improvement of organic compounds accumulation in the leaves and provides resistance against various abiotic stresses (Ali et al.,

Seeds were washed with distilled water before sowing to remove contamination. Total seven seeds were sown in each pot. Metals (Cr and Mn) were applied individually and in combined form. One set was treated as control. Water was applied according to requirement.. Soil was turned over on regular basis. Three replicates were carried out at a time. Plants were harvested with the interval of ten days. Data was recorded carefully. Plant height and leaf area was measured with the help of meter rod. Diameter of root and diameter of stem was measured with vernier caliper. Fresh weight t of root, stem, leaf was measured by using electric balance. After weighing the fresh weight of root, stem and leaf, they were kept in oven at 40°C for 48h at biotechnology lab of The University of Lahore, Lahore. After it, dry weight of root, stem and leaf was measured in grams by using electric balance.

2014ab; Ali et al., 2015; Ashraf et al., 2020; Khalil et al., 2020). The genotype Neelum may be selected as heavy metal tolerance genotypes in maize. The treatments of heavy metals caused higher damaging effects on genotype 31R88 (Misra and Jaiswal, 1982; Shankar *et al.*, 2005). It has been shown from results given in table 3 that the high plant height, fresh leaf weight, fresh root weight and dry leaf weight was found under treatment 0.5M $MnCl_2$ indicated that there were very low toxic effects of this treatment. The photosynthetic rate was not affected due to applications of this treatment as compared with the applications of other treatments. While low plant height, dry stem weight, dry leaf weight and diameter of root was found under treatment 0.5M $MnCl_2$ +0.25M $CrCl_3$ and 0.25M $CrCl_3$ which indicated that there were very high toxic effect of this treatment. The photosynthetic rate was affected due to applications of this treatment as compared with the applications of other treatments. The selection of genotypes under heavy metal treatment of 0.5M $MnCl_2$ may be helpful for the improvement of crop

production and productivity (Doncheva *et al.*, 2006; Barcelo *et al.*, 1985).

Table 1. Analysis of variance for different growth parameters of maize seedlings under heavy metal treatments

Growth parameters	Average	Coefficient of variation	Statistical analysis
Plant height	8.1459±3.151	0.27	Significant
L/P	3.3674±0.0103	0.84	Sig.
Leaf are	18.441±0.3900	0.79	Sig.
Fresh root weight	0.2789±0.065	0.24	Sig.
Fresh stem weight	0.4640±0.049	0.12	Sig.
Fresh leaf weight	0.2684±0.063	0.11	Sig.
Dry root weight	0.0252±0.005	1.75	Sig.
Dry stem weight	0.0200±0.013	1.66	Sig.
Dry leaf weight	0.0174±0.0013	2.43	Sig.
Diameter of root	0.5218±0.044	0.55	Sig.
Diameter of stem	1.3709±0.086	0.38	Sig.

Probability level=5%

Table 2: All pairwise comparison among different maize accessions for different growth parameters (p ≤ 0.05)

Growth parameters	Maize accessions				
	30Y87	31R88	Neelum	Pak afghoi	White corn
Plant height		-		+	
L/P			+	-	
Leaf area		-	+		
Fresh root weight		-			+
Fresh stem weight		-	+		
Fresh leaf weight		-			+
Dry root weight	+	-			
Dry stem weight	+	-			
Dry leaf weight		-	+		
Diameter of root			+		-
Diameter of stem		-			+

Negative sig (-)= Highly affected

Positive sig(+)=Less affected

Table 3: All pairwise comparison among different heavy metal treatments for different growth parameters

Growth parameters	Heavy metal treatments				
	Control	0.5M MnCl ₂	0.25M MnCl ₂	0.5M CrCl ₃	0.25M CrCl ₃
Plant height		+			
L/P			+		-
Leaf are			+	-	
Fresh root weight		+	-		
Fresh stem weight					-
Fresh leaf weight		+		-	
Dry root weight		-			
Dry stem weight					
Dry leaf weight		+			
Diameter of root			+		
Diameter of stem					
Growth parameters	0.5M MnCl ₂ + 0.5M CrCl ₃	0.5M MnCl ₂ + 0.25M CrCl ₃	0.25M MnCl ₂ + 0.5M CrCl ₃	0.25M MnCl ₂ + 0.25M CrCl ₃	
Plant height		-			
L/P					
Leaf are					
Fresh root weight					
Fresh stem weight				+	
Fresh leaf weight					

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Dry root weight			+
Dry stem weight	-	+	
Dry leaf weight	-		
Diameter of root	-		
Diameter of stem			-

Negative sig (-) = Highly affected

Positive sig (+) = Less affected

Conclusion

Analysis of variance indicated the differences among five different genotypes and 9 different treatments for all parameters were significant. Tukey's test indicated that higher toxic effect was shown under treatment 0.5M Mn + 0.25M Cr while less toxic effect was observed under treatment 0.50M Mn in maize plant. Variety 31R88 was more sensitive for metal toxicity because most of the traits were affected in 31R88 under heavy metal treatments which indicates through negative sign while more tolerant variety was Neelum which indicates through positive significant. Positive sign indicates that plant growth was less affected under heavy metal treatments. Plant growth and photosynthetic rate will be high under heavy metal treatment, while negative sign indicates that growth parameters were highly affected under heavy metal treatments. Plant growth and photosynthetic rate will be low under heavy metal treatments.

Conflict of interest

The authors have declared absence of any type of conflict of interest.

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