Evaluation of Two Wheat Varieties for Phytotoxic Effect of Mercury on Seed Germination and Seedling Growth

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Summary

Two varieties of wheat (*Triticum aestivum* var. Blue Silver and *T. aestivum* var. Punjab 85) were tested for the phytotoxic effect of mercury on seed germination and seedling growth. Seed were treated with 25, 50, 75 and 100 ppm of $HgCl_2$ solution. Both varieties showed enhanced seed germination at all levels of mercury compared to untreated control. However, shoot, root, and seedling length was significantly ($P<0.05$) reduced in both wheat varieties at all the levels of mercury treatments particularly at 100 ppm of mercury. The highest reduction was observed in root length rather than shoot and seedling length. The tolerance indices for both varieties showed that that var. Blue Silver was more tolerant to mercury toxicity than var. Punjab 85.

Key words

Mercury toxicity; seed germination; plant growth; wheat varieties; Blue Silver; Punjab 85

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Introduction

Mercury is one of the best known toxic metals discharged from human activities. The global rise in mercury pollution by anthropogenic activities may have risen by three to four folds in this century, but the seriousness of the problem at local levels is many times greater. The environmental protection agencies have expressed increasing concern over the release of mercury to the environment in the past couple of years. There are studies about the response of crop species to heavy metals reporting mechanisms that are responsible for their tolerance or sensitivity (Ernest 1996, Hall 2000, Mahmood et al. 2005, Shriapanahi and Anderson 1986, Vitorello et al. 2005, Watanabe et al. 2002, Williams et al. 2000). $HgCl_2$ is dominant among all mercury forms. Shriapanahi and Anderson (1986) found elevated levels of cadmium, lead and mercury in the upper layer of soil following long term application of municipal wastewater which resulted in the accumulation of toxic levels of these metals in the vegetables grown in these areas. The toxic effect of mercury on germination, growth and yield has been studied on different plants (Mukherjee and De 1996, Varshney 1991, Vizarova et al. 1985).

Wheat (*Triticum asetivum* L.) is the staple food for a large part of the world population including Pakistan. Wheat is grown in Pakistan on 8.141 million hectares with an average yield of 2.28 tons per hectare with a total production of 18.535 thousand tons (Agricultural Statistics of Pakistan 2003-2004). The average yield is below than most wheat producing countries like Germany (7.9 tons per hectare), France (6.6 tons per hectare) and Egypt (6.4 tons per hectare). With increasing population, the over-demanding production of wheat can be increased either by bringing more area under wheat cultivation or by introducing high yielding wheat varieties which are resistant against biotic and abiotic environmental stresses. The aim of this research is to investigate the effects of $HgCl_2$ on seed germination and seedling growth of two varieties of wheat (*Triticum asetivum* var. Blue Silver and *T. aestivum* var. Punjab 85) commonly cultivated in Pakistan. The effect of mercury was tested at germination and seedling growth of wheat as these are the key events for the establishment of plants under any prevailing conditions.

Materials and methods

Healthy seeds of two wheat varieties (*Triticum asetivum* var. Blue Silver and *T. aestivum* var. Punjab 85) were obtained from the Pakistan Agriculture Research Council, Karachi. Seeds were stored at room temperature under air tight conditions before treatments with metal solution. Seeds were washed with distilled water and were placed on the filter papers in 90-mm diameter glass petri dishes. Each petri dish contained 20 seeds per treatment replicated three times. Mercuric chloride ($HgCl_2$) solution was prepared as 25, 50, 75 and 100 ppm of Hg. Each Petri dish was supplied with 2 mL of mercury solution at alternate day replacing the old solution with the fresh solution. All the petri dishes were kept at room temperature (30 ± 2 ^{0}C) with 12 hourly light period provided by three mercury tubes (120W). Seed germination, root, shoot and seedling length were recorded after 10 days and the data were analyzed statistically.

Results

The results showed that seed germination of both varieties was enhanced at all concentrations of mercury as compared to untreated control (Table 1). Highest germination was observed at 25 ppm of $HgCl_2$ treatment, 80% in var. Blue Silver and 70% in var. Punjab 85, respectively which was significantly ($P<0.05$) different from the control. Shoot length of both wheat varieties showed significant results at different treatments of mercury. Highest reduction in shoot length (5.80 cm) was observed in var. Blue Silver at 75 ppm of mercury which was significantly ($P<0.05$) different as compared to control (11.26 cm). At 75 and 100 ppm of mercury, the difference in shoot length in var. Blue Silver was

Table 1.
Effect of mercury on seed germination and growth of wheat varieties Blue Silver and Punjab 85

Treatments	*Triticum aestivum* var. Blue Silver				*Triticum asetivum* var. Punjab 85			
	Seed germination (%)	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Seed germination (%)	Shoot length (cm)	Root length (cm)	Seedling length (cm)
Control	50.00±10.00	11.26±1.39	9.63±0.18	20.89±1.57	43.33±8.81	12.06±0.97	9.01±1.05	21.07±2.02
25 ppm	80.00±11.54	5.83±1.45	9.03±1.94	14.86±3.39	70.00±11.59	9.20±0.62	6.36±1.63	15.56±2.25
50 ppm	76.67±3.34	8.46±0.55	6.56±1.61	15.02±2.16	63.33±14.52	8.76±0.59	7.10±0.64	15.86±1.23
75 ppm	76.67±6.63	5.80±1.51	5.26±0.84	11.06±2.35	60.00±8.81	6.56±0.78	4.33±1.14	10.89±1.92
100 ppm	66.67±14.52	6.03±0.91	3.90±1.50	9.93±2.41	53.33±20.27	5.00±1.40	3.23±0.39	8.23±1.79±

± Standard error

Table 2.
Percentage reduction in seed germination and growth of wheat varieties Blue Silver and Punjab 85

Treatments	*Triticum aestivum* var. Blue Silver				*Triticum asetivum* var. Punjab 85			
	Seed germination (%)	Shoot length	Root length	Seedling length	Seed germination (%)	Shoot length	Root length	Seedling length
25 ppm	60.00+	48.22	6.23	27.23	61.55+	23.71	29.41	26.56
50 ppm	53.34+	24.84	31.87	28.36	46.15+	27.36	21.19	24.28
75 ppm	53.34+	48.49	45.37	46.93	38.47+	45.6	51.94	48.77
100 ppm	33.34+	46.44	59.50	52.97	23.07+	58.54	64.15	61.35

+ = Percentage increase

not significant. In var. Punjab 85, the highest reduction in shoot length (5.0 cm) was recorded at 100 ppm of mercury, which was significantly ($P<0.05$) different compared to control (12.06 cm). Highest reduction in root length in wheat var. Blue Silver (3.90 cm) and var. Punjab 85 (3.23 cm) was found at 100 ppm of mercury which was significantly ($P<0.05$) different as compared to control. Both wheat varieties also showed significant ($P<0.05$) reduction in seedling length at 75 and 100 ppm of mercury treatment as compared to other applications. Highest reduction in seedling length in var. Blue Silver (9.93 cm) and var. Punjab 85 (8.23 cm) was found at 100 ppm of mercury treatment.

Table 3.
Percentage tolerance of mercury by two wheat varieties

Treatments	Percentage tolerance	
	T. aestivum var. Blue Silver	*T. aestivum* var. Punjab 85
25 ppm	93.76	70.58
50 ppm	68.12	78.80
75 ppm	54.62	48.05
100 ppm	40.49	35.84

The results showed that the seed germination was enhanced while other variables such as shoot, root and seedling length showed reduction at all treatments of mercury in both varieties (Table 2). The highest reduction was observed at 100 ppm of mercury treatment. The tolerance indices showed mercury toxicity of elevated levels of mercury in both wheat varieties (Table 3). Blue Silver was comparatively more tolerant than the var. Punjab 85 at most of levels of mercury treatment. At 100 ppm of mercury, var. Blue Silver showed 40.49% tolerance as compared to 35.84% in var. Punjab 85.

Discussion

Seed germination of var. Blue Silver and var. Punjab 85 was not affected by elevated levels of mercury rather it enhanced the seed germination in both varieties compared to control. This means that mercury treatment could break the seed dormancy and enable seeds to germinate. The seedling growth on the other hand was reduced at all levels of mercury treatment in both varieties, which demonstrated that mercury reduces the seedling growth, particularly the root length. The root length of both wheat varieties was significantly reduced as compared to shoot length. This indicates that roots are sensitive parts of the plants and more damage occurred to roots as compared to the shoot since metal was absorbed through roots (Sattelmacher et al. 1993). Vizarova et. al. (1985) found negative effects of mercury on young barley root growth as compared to above ground parts. Excessive mercury ions in soil also decreased the chlorophyll contents of maize seedlings as shown by Vizarova et al. (1985).

Kaslimuthu and Subramanian (1990) found reduction in seed germination, seedling growth and protein contents of maize seedlings while Mukherjee and De (1996) reported the injurious effects in biochemical nature of tomato seedlings. Present study revealed that both varieties are sensitive to mercury as for seedling growth and root length. Varshney (1991) studied the phytotoxic effects of mercury on development of chlorophyll in cotyledons of two cucurbits and found that *Luffa aegyptica* was more sensitive to mercury treatment than *Citrullus valgaris*.

Plants have evolved several mechanisms to prevent the toxic action of metals. These include reduction of uptake into the root cells by changes in the kinetic properties of transporters and exudation of complexing agents into the rhizosphere (Watanabe and Osaki 2002). Once metals have entered the plant they induce the synthesis of the glutathione containing peptides phytochelatins and high cysteine containing proteins, the metallothioneins, which are able to bind the metal ions (Cobbet and Goldsbrough 2002, Hall 2002, Quartacci et al. 2000, Voskaoboinik et al. 2002). Ultimately the metals are stored in the vacuole in a relatively non-toxic form (Williams et al. 2000). There have been a number of attempts by different laboratories to construct novel plants using genetic manipulation technologies that may have a greater tolerance to the presence of toxic metals (Belouchi et al. 1997, Macnair et al. 2000, Sasaki et al. 2004, Vitorello et al. 2005). These plants are currently under intensive study to establish the mechanisms involved and for their possible use in pytoremediation (Faisal and Husnain 2004, Igwe and Abia 2006, Igwe et al. 2005).

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