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Influence of lead on growth and nutrient accumulation in Black gram (*Vigna mungo.* L)

S. Ravikumar*, P. Thamizhiniyzn

Department of Botany, Annamalai University, Annamalai Nagar - 609 002, India

*E-mail address: drsrk74@gmail.com

ABSTRACT

This study was conducted to investigate toxic effects of Pb on growth and nutrient uptake in Black gram. Black gram was subjected to seven (5, 10, 25, 50, 75, 100 & 200 kg^{-1}) levels of lead. Due to Pb toxicity, plant growth was adversely affected and relatively a severe reduction in root biomass was recorded. The Pb accumulation increased with the increase in lead concentrations. The uptake of different nutrients, *i.e.,* N, P, K, Ca and Mg was reduced in black gram due to the lead treatment.

***Keyword*: Lead; Black gram; Nutrients; Growth; Dry weight**

1. INTRODUCTION

Although the major causes of accumulation of high levels of heavy metals in soils are a variety of man-made activities including manufacturing, agricultural, mining, and waste removal practices (Uwah *et al.,* 2009) they are also brought due to the use of metal-enriched fertilizers and pesticides (Nouri *et al.,* 2008). These metal ions dissolved in irrigation water contaminate the cultivated soils and can have toxic impact on living system, if present in excessive amounts (Nriago,1990). Lead (Pb) is one of the most important heavy metals frequently available in the environment and its most common sources are vehicles and automobiles (Sezgin *et al.,* 2003).In plants, its accumulation has been reported in stem, leaves, roots and seeds, which increases with increase in Pb levels in the growth medium (Yilmaz *et al.,* 2009). It detrimentally influences plant growth (Wang *et al.,* 2007) by hampering a variety of physiological processes including nutrient uptake (Sinha *et al*., 2006)

Plant injuries caused by Pb are very frequent and drastic, especially on the rooting system, which results into severe reduction in plant productivity (Uveges *et al.,* 2002). Lead toxicity alters the normal metabolic pathways in plants including photosynthesis, respiration, and other such key metabolic processes by disrupting specific cellular enzymes (Ruley *et al.,* 2004). Crop yield is also reduced due to Pb-induced inhibition in metabolic processes in plants. Since most crops can frequently accumulate high levels of Pb, they serve as a source of heavy metal supply in the food of humans and animals which ultimately cause health hazards in them. So, an attempt were made on the impact of Lead on Black gram growth and nutrient accumulation.

2. MATERIALS AND METHODS

Black gram (*Vigna mungo* (L) Hepper) seeds were obtained from the Regional Rice Research station, Aaduthurai, Tamil Nadu, India. Uniform seeds were selected and surface sterilized with 0.01 % $HgCl_2$ solution for 2 minutes. Uniform sized pots were filled with three kilograms soil and mixed with different concentrations (control, 5, 10, 25, 50, 75, 100 and 200 mg kg^{-1} soil) of Lead. Three replicates were maintained. Plant Growth were measured by using centimeter scale and recorded. The same plant samples were taken for morphological studies were also used for the determination of dry weight by using electrical single pan balance. Their dry weights were determined by keeping the plant materials in a hot air oven at 80 °C for 24 hrs and recorded. Similarly the accumulation of Lead was measured followed by the method of Piper, 1966 and the mineral elements such as Total nitrogen (Jackson, 1958), Phosphorus (Black, 1965), Potassium (Williams and Twine, 1960), Calcium and magnesium (Yoshida *et al.,* 1972)was also measured.

3. RESULTS AND DISCUSSION

Due to the application of Pb, Plant growth and biomass was significantly reduced in Blackgram (Table 1). However, the most severe effect was noted on roots and shoots of plants growing under the highest level of Pb (200 mg kg^{-1} soil). The effect of Pb toxicity was more severe on roots than on shoots in blackgram both in shoots and roots increased with increase in external Pb level. Lead accumulation in the roots was higher than that in the shoots.

In the present study, plant growth, root and shoot biomass was reduced due to Pb toxicity in Blackgram. However, the decrease in root biomass was more marked than that in shoot biomass. It is now widely known that heavy metals in soil or water can adversely affect the growth and ionic concentration in different tissues of plants (Sanchez *et al.,* 1999; Ali *et al.,* 2009). As the roots contained higher amount of Pb than that of shoots, which might have antagonistically disturbed the uptake of essential nutrients and water absorption resulting into reduced root growth, as observed in the present investigation.

The nutrient contents in the shoots and roots were imbalanced by the high quantity of Pb present in the soil. Essential macro- nutrients like N, P and K in the shoots decreased with increased levels of Pb from 0 to 200 mg Pb kg^{-1} soil, but reduction in K and N was more marked in the roots of blackgram (Table 2). This clearly shows that Pb presence in the growth medium inhibited the absorption of N and K as already observed in sugar beet (Larbi *et al.,* 2002). As these both elements are mobile so whatever quantity of K and N is absorbed by the roots, it is ultimately translocated to the shoot, because these nutrients are required in large amount to maintain the plant metabolic activities (Kaya *et al.,* 2003). Although P content decreased significantly in both shoots and roots, the roots accumulated more amount of P than that of shoots. It has been earlier reported that nutrient uptake by roots also depends on the plasma membrane selective properties. Thus Pb may perturb the normal uptake of nutrients by changing the permeability of the plasma membrane as well as by affecting all the processes involved in nutrient transport across the membrane (Gussarsson, 1994). Calcium and Magnesium concentrations in the roots were increased slightly due to increase in external Pb from 0 to 200 mg kg^{-1} of soil, while their amount was significantly decreased in the shoots of blackgram (Table 3). Since Ca is an integral component of cell wall as well as it is usually bound to the exterior surface of the plasma membrane, it plays a vital role in maintaining the integrity of both cell wall and membrane (Wensheng *et al.,* 1997). An increase in Ca concentration under Pb contamination in the roots could be a putatitve mechanism of minimizing the toxic effects of Pb and a decrease in Ca concentration in the shoots under Pb toxicity may have been an indication of a damaged intercellular defense system. Magnesium contents decreased in the shoots while they increased in the roots due to Pb application. This suggests that uptake of Mg was not affected due to Pb present in the growth medium; however, its translocation to the shoots was inhibited. The reduction in shoot Mg might have been one of the factors for causing reduction in chlorophyll content (Wensheng *et al.,* 1997)..

Table 1. Effect of Lead on the Plant height (cm/p) and Dry weight (g/p) of root and shoot of Black gram (*Vigna mungo* (L) Merr).

Lead conc. (mg/kg)	Plant height			Dry weight in Shoot			Dry weight in Root		
	20	**40**	**60**	**20**	**40**	**60**	**20**	**40**	**60**
Control	30.621	42.354	50.712	0.927	1.478	1.826	0.517	0.718	0.847
10	27.854 (-9.036)	39.218 (-7.404)	45.422 (-10.431)	0.812 (-12.405)	1.117 (-24.424)	1.427 (-21.851)	0.474 (-8.317)	0.624 (-13.091)	0.785 (-7.319)
25	25.527 (-16.635)	34.422 (-18.727)	42.495 (-16.203)	0.754 (-18.662)	1.056 (-28.552)	1.218 (-33.296)	0.437 (-15.473)	0.611 (-14.902)	0.744 (-12.160)
50	21.396 (-30.128)	30.139 (-28.840)	39.854 (-21.411)	0.622 (-13.901)	0.827 (-44.046)	1.147 (-37.188)	0.396 (-23.404)	0.575 (-19.916)	0.695 (-17.945)
75	17.412 (-43.137)	26.622 (-37.144)	36.217 (-28.582)	0.506 (-45.415)	0.796 (-46.143)	0.932 (-48.959)	0.352 (-31.914)	0.527 (-26.601)	0.627 (-25.974)
100	14.396 (-52.986)	25.363 (-40.116)	33.422 (-34.094)	0.417 (-55.016)	0.725 (-50.947)	0.754 (-58.707)	0.317 (-38.684)	0.491 (-31.615)	0.594 (-29.870)
200	10.448 (-65.879)	21.125 (-50.134)	31.398 (-38.085)	0.325 (-64.940)	0.628 (-57.510)	0.628 (-65.607)	0.298 (-42.359)	0.452 (-37.047)	0.544 (-35.773)

Percentage over control is expressed in parentheses
F values are significant at 1 % level.

Table 2. Effect of Lead on accumulation of Nitrogen (ppm), Phosphorus (ppm) and Potassium (ppm) content of Black gram (*Vigna mungo* (L) Merr).

Lead conc. (mg/kg)	Nitrogen			Phosphorus			Potassium		
	20	**40**	**60**	**20**	**40**	**60**	**20**	**40**	**60**
Control	162.46	176.82	167.42	23.62	37.91	26.10	105.41	162.32	112.37

10	151.62 (-6.67)	161.59 (-8.61)	152.81 (-8.60)	20.74 (-15.31)	34.39 (-9.28)	22.63 (-13.29)	98.36 (-6.68)	137.32 (-15.40)	102.29 (-8.97)
25	147.62 (-9.13)	158.76 (-10.21)	148.75 (-11.15)	18.37 (-22.22)	32.92 (-13.16)	20.55 (-21.26)	88.96 (-16.80)	126.51 (-22.06)	89.65 (-20.21)
50	138.82 (-14.55)	152.39 (-13.81)	139.82 (-16.48)	15.92 (-32.59)	28.76 (-24.31)	17.92 (-31.34)	81.82 (-22.37)	110.52 (-31.91)	83.27 (-25.89)
75	132.65 (-18.34)	144.28 (-18.40)	130.49 (-22.05)	14.43 (-38.90)	26.95 (-28.91)	15.56 (-40.38)	72.39 (-31.32)	104.37 (-35.70)	74.52 (-33.68)
100	126.46 (-22.15)	141.38 (-20.04)	121.52 (-27.41)	12.87 (-45.51)	24.48 (-35.42)	12.39 (-52.52)	58.62 (-44.38)	96.82 (-40.35)	70.32 (-37.42)
200	119.51 (-26.43)	135.46 (-23.39)	103.39 (-38.24)	10.42 (-55.88)	21.52 (-42.23)	10.79 (-58.65)	46.37 (-56.09)	87.65 (-46.00)	65.46 (-41.74)

Percentage over control is expressed in parentheses
F values are significant at 1 % level.

Table 3. Effect of Lead on accumulation of Calcium (ppm), Magnesium (ppm) and Lead (ppm) content of Black gram (*Vigna mungo* (L) Merr).

Lead conc. (mg/kg)	**Calcium**			**Magnesium**			**Lead**		
	20	**40**	**60**	**20**	**40**	**60**	**20**	**40**	**60**
Control	52.36	59.46	55.42	34.56	48.32	34.92	43.41	88.32	122.37
10	49.52 (-5.233)	54.82 (-7.803)	52.92 (-4.511)	31.41 (-9.11)	44.26 (-8.40)	31.16 (-10.76)	65.36 (-6.68)	97.32 (-15.40)	132.29 (-8.97)
25	44.37 (-15.259)	49.37 (-16.969)	46.35 (-16.365)	28.39 (-17.85)	40.46 (-16.26)	28.34 (-18.84)	78.96 (-16.80)	111.51 (-22.06)	149.65 (-20.21)
50	38.62 (-26.241)	42.27 (-28.910)	40.39 (-27.120)	25.52 (-26.15)	36.29 (-24.89)	27.56 (-21.07)	91.82 (-22.37)	121.52 (-31.91)	153.27 (-25.89)
75	31.49 (-39.858)	35.62 (-40.090)	33.36 (-39.805)	22.96 (-33.56)	34.82 (-27.93)	24.83 (-28.89)	112.39 (-31.32)	132.37 (-35.70)	174.52 (-33.68)

100	24.72 (-52.788)	29.82 (-49.848)	27.62 (-50.162)	20.84 (-39.69)	31.62 (-34.56)	21.49 (-38.45)	138.62 (-44.38)	146.82 (-40.35)	200.32 (-37.42)
200	19.56 (-62.643)	26.31 (-55.751)	21.82 (-60.627)	16.39 (-52.57)	28.72 (-40.56)	18.24 (-47.76)	146.37 (-56.09)	187.65 (-46.00)	265.46 (-41.74)

Percentage over control is expressed in parentheses
F values are significant at 1 % level.

4. CONCLUSION

From the present investigation, it can be concluded that the level of Lead above 200 mg/l is proved to be lethal to Black gram. However, Lead contaminated water can be properly treated and then discharged into nearby water bodies in order to prevent water pollution. Both government and public sector should join hands in the creation of a clean and green environment.

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