EFFECT OF LEAD (PB^{+2}) ON SEED GERMINATION OF SESAMUM (*Sesamum indicum L. Var YLM-11*) IN SOLUTION AND POT CULTURES AT DIFFERENT TEST CONCENTRATIONS OF LEAD

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ABSTRACT

The present study deals with the effect of lead (Pb^{+2}) on seed germination in Sesamum (*Sesamum indicum* L. Var YLM - 11) in solution as well as pot experimental studies. Three test concentrations of lead (Pb^{+2}) 23.6 ppm, 236 ppm, 2360 ppm are taken in a solution as well as a pot (soil) culture besides a test control to grow the sesamum species. Effect of lead on germination success and seedling characteristics were studied in test species grown in above test concentrations of lead, besides control.

Keywords: lead, seed germination, sesamum, toxicity, seedling, growth.

INTRODUCTION

Contamination of soils by heavy metals is a wide spread occurrence as a result of human, agricultural and industrial activities. Among the heavy metals lead is a potential pollutant that readily accumulates in soils and sediments by anthropogenic activities including mining and smelting of lead ores, burning of coal, effluents from storage battery industries, automobile exhausts, metal plating and finishing operations, fertilizer pesticides and from additives in pigments and gasoline (Sharma and Dubey, 2005). Lead is not only toxic element but also can be accumulated into plant organs and agricultural products (Burzynski, 1987; Mahmoud and el - beltagy, 1998) consequently enter in human food chain (Waner, 1993). Lead is extremely toxic to all the intermediates of food chain (Brunet *et al*., 2008) and human beings (Estrella - Gomez *et al*., 2009). In recent decades, enhanced industrial and mining activities have contributed to the increasing occurrence of heavy metals in ecosystems. It has been reported that plants could accumulate considerable amount of toxic metals, and could tolerate toxic amount of metals by inducing different enzymes, stress proteins and synthesise enzymetically phytochelatins (Ali *et al*., 2003)

Soils contaminated with Pb cause sharp decrease in crop productivity there by posing a serious problem for agriculture (Johnson and Eaton, 1980) Although Pb is not an essential nutrient for plants, majority of lead is easily taken up by plants from soil and accumulated in root while only a small fraction was translocated upward to the shoots (Patra *et al*., 2004)

The effect of Pb depends on concentration, type of soil, soil properties and plant species. Pb toxicity leads to decrease germination percent, length and dry mass of root and shoots (Munzuroglu and Geekil, 2002), disturbed mineral nutrition (Paivoke, 2002) reduction in cell division (Eun *et al*., 200).

Pb contamination in soil and vegetation in many countries has increased with rapid developments of agriculture and industry in recent decades. Earlier studies demonstrated that agricultural crop species like maize variety are tolerant to several heavy metals such as Cu, Cd and Pb (Malkowski *et al*., 1996; Heidari *et al*., 2005) The uptake, transport and accumulation of Pb by plants are strangely depend on soil type and plant species.

So present study is undertaken to study the effect of lead on germination percent, root and shoot lengths of seedlings is studied in the crop variety sesamum (*Sesamum indicum* L., Var YLM - 11) which is widely cultivated oil seed crop in India.

MATERIALS AND METHODS

a) **Soil:** The red sandy loam soil suitable for groundnut crop is collected from near the agricultural fields of Visakhaptanam;
b) **Lead nitrate:** lead nitrate of analytical reagent (qualifiers) is used to spike the soils to prepare test concentrations;
c) **Seeds:** Seeds of test crop *Sesamum indicum* L., Var YLM- 11 was collected from regional agricultural research station Anakapalle, A.P. India;
d) **Germination studies:** To investigate the effect of lead on germination, seed of test crop variety were surface sterilized with 30% (V/V) sodium hypochlorite solution for 20 mins. Then later were washed and placed in control, 23.6 ppm, 236 ppm, 2360 ppm concentration of Pb in solution as well as spiked soil. Effect of lead on germination of seeds in solution state was observed by placing the seeds in filter paper placed in solutions of test concentrations and Distilled Water as control. 3 ml of each test concentrations was taken into petri dishes and at every third day the old solution was sucked out and replaced with 2 ml of new solution. The control received only 3 ml of distilled water. There were five replicates per each test concentrations and control. Petri dishes were kept at room temperature with 4 hr light period provided by 200 watt bulb and the germination was recorded. Similarly effect on germination was studied in pot experiments by soil spiked with test concentrations of Pb;

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e) **Pot experiment:** Pots of 1ft x 1ft x 1ft dimension are taken, with 6 kg of soil spiked with lead nitrate to get 23.6ppm, 236 ppm, 2360 ppm concentrations and control of unspiked soil. In the pot experiment three seeds were sown in each pot at the distance and depth prescribed by ICAR in the hand book of agriculture. Pots were placed in net house shaded with transparent polythene sheet to protect from rain water leaching. Fertilizers and manure were not added to enhance growth or metal uptake. Observations were done daily for metal toxicity on test crop and growth parameters were studied in seedling state;

f) **Seedling growth parameters:** On the 7th day seed lings were removed from pots, washed thoroughly with water and studied in their growth parameters of root length, shoot length in control and test concentrations of lead.

RESULTS

Table-1. Soil characteristics.

Parameters	
Physical characteristics	
Color	Brownish yellow
Gravel (%)	7.8
Sand (%)	87.5
Silt (%)	2.0
Clay (%)	10.5
Texture	Sandy loam
Bulk density (g/cc)	1.52
Particle density (g/cc)	2.62
Porosity (%)	41.98
Hydraulic conductivity (cm/h)	16.42
Water content at saturation (% wt)	13.88
pH (1:25)	7.05
EC (m mhos/cm)	0.24
CEC (c mol/kg)	4.78
Chemical characteristics	
Organic carbon (%)	0.95
Available nutrients	
N (% wt)	0.2580
P (% wt)	0.350
K (% wt)	0.0146
Ca (% wt)	0.11
Mg (μg/g)	245.60
Na (μg/g)	86.80
Fe (μg/g)	28.4
Mn (μg/g)	34.30
Cu (μg/g)	11.0
Zn (μg/g)	20.80
Mo (μg/g)	2.95
Sulphate (μg/g)	31.50
Cl (% wt)	0.4250
Available lead (Pb) (μg/g)	2.36
Total lead (μg/g)	17.133

Table-2. Germination successes, root length, shoot length and R/S ratio Sesamum seedlings (day-7) in different test concentrations of lead.

Test concentrations	Germination success %		Root length (cm)	Shoot length (cm)	R/S ratio
	Petri dish culture	Pot experiment			
Control	95	78	2.07	5.87	0.354
TC_1	93.33	57.5	2.04	6.57	0.310
TC_2	90	50.78	2.01	6.76	0.298
TC_3	58.33	42.92	1.64	7.9	0.208

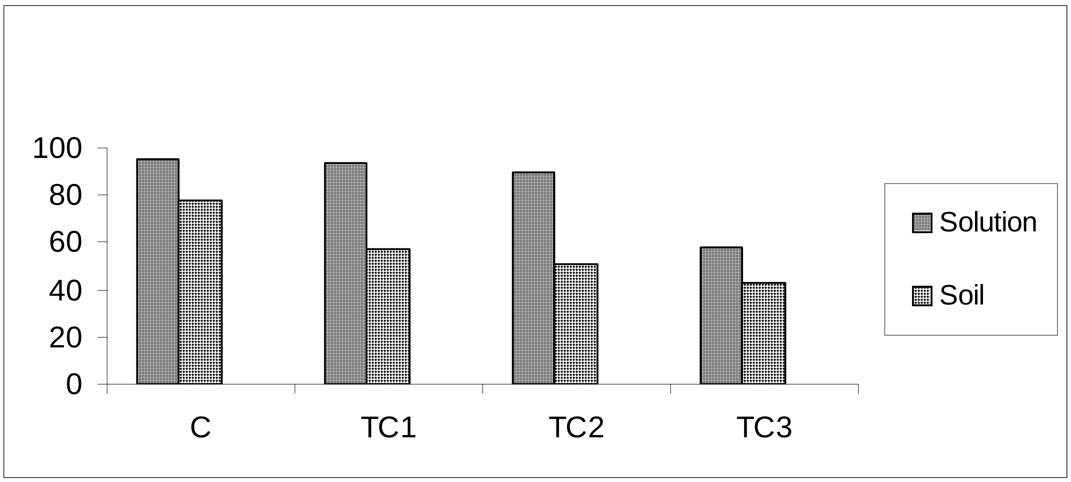

Figure-1. Germination percent of Sesamum in various test concentrations in solution and spiked soils.

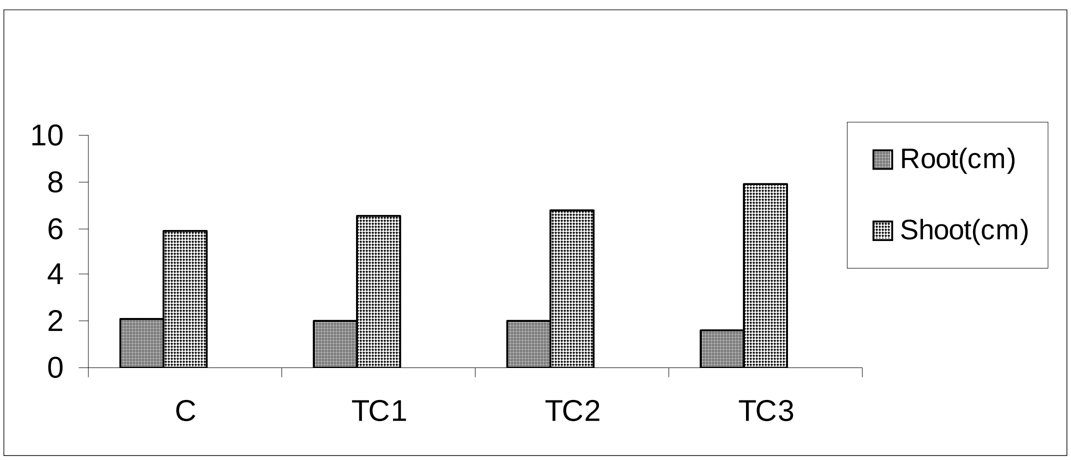

Figure-2. Effect of lead in root and shoot lengths of seedlings (Day-7).

DISCUSSIONS

The soil used for present experiment on sesamum was sandy clay loam with 10.5%clay, 87.5%sand and 2% silt content. The soil was near neutral with PH 7.05 and electrical conductivity (EC) was 0.24 mmho/cm. The chemical constituents such as organic carbon and available nutrients were examined and results are presented in Table-1. The soil has a cation exchange capacity (CEC) of 4.78 C mol/hg the dominants being calcium with 0.110% and magnesium with 245 μg/g which the dominant anion being chloride with 0.4250%. The soil has a lead content of 17.133 μg/g of which 2.36 g/g was in available form. The soil was spiked with lead nitrate to get logarithmic increasing test concentrations of 23.6ppm, 236ppm, and 2360ppm.

Germination success in seed sprouting is observed from day 4 in case of control and TC_1 soils, while in case of the remaining two TC_2 and TC_3 it was day

6, indicating delayed germination at high soil Pb concentrations. Germination precent was also reduced with increasing Lead (Pb+2) concentrations in test concentrations in solution and also in spiked solutions. The effect is more in spiked solutions than in the solution as due to additional factors in soils. Details of germination percent were given in the Table-2. The size of root and shoot variation in the germinated sprouts was observed and data indicate that increased soil Pb concentrations, the sizes of roots and shoots have declined gradually. Decrease in root length is 1.5% in TC_1, 2.90% in TC_2 and 20.29%in TC_3 with respect to control where as increase in shoot length was increased by 11.73% in TC_1, 15.14% in TC_2, and 20.29% in TC_3 with respect to control soil. But after 30 days shoot length declined in all test the concentrations than in the control. Root shoot ratio declined as 13% in TC_1, 20% TC_2 and 28% in TC_3 with respect to that in control soils.

The experimental soils collected from the crop fields had their physical and chemical characteristics similar to those reported by several authors (Etheringtom 1976; Farooq *et al*., 1999). These characteristics include PH, EC, hydraulic conductivity, bulk density and several other parameters. The general ranges reported for these parameters are well comparable with others indicating the soils used for experiments on groundnut are of uncontaminated by lead (Pb) and ideal for lead amendments. Rooney *et al*. (1999) reported that neutral concentrations of Pb in soils to range between 10-30 μg/g and in case of soils in the present studies it was 17.133 μg/g total lead and 2.36 μg/g is in plant available fraction. This confirm with the observations of Brady (1994) who opined that soil lead is largely unavailable to plants. However it is important to note that correlations between soil metal fractions and bio availability is still an unresolved problem (Quian *et al*., 1996) and these anomalities perhaps depend upon various factors like the source, route and land type or land user, species types etc.

Generally the studies on Pb and plant response are studies adopting pre determined media amendments (Solutions and soil). The concentrations chosen for Pb amendments in solutions usually ranged up to 1000 μg/ml (Huang *et al*., 1974; Malone *et al*., 1974; John, 1977; Burton *et al*., 1983; Godbold and Huttermann, 1986; Kumar *et al*., 1993; Anita Mishra *et al*., 1997; Xiong, 1998. Present study used the Pb^{+2} in the range of 23.6 to 2360 μg/ml.

In the present studies, germination percent showed reduction from control to TC3 soils both in petri dish culture and in experimental pots. The results are in agreement with certain studies by Kumar *et al*., 1993 who reported concentration dependent inhibition of seed germination in *Sesamum indicum* Var HT-1 treated with 0.04 to 1.9 mM Pb^{+2} on the first day of planting, however the effect was reduced as function of time and on 4^{th} day after planting all the seeds germinated even at 1.9 mM. Inhibition of seed germination by Pb^{+2} is reported in Spartina alterniflora by Morzek Funicelli 1992, in Pinus halepensis by Nakos 1979 and in Lupinis by Worzny *et al*., 1982. Inhibition / delay of germination may be due to interference with some important enzyme involved in the process (Mukerji and Maitra, 1976). Inhibitory effect of Pb^{+2} on germination was also reported by Anita Mishra *et al*., 1997 on rice varieties IR-36 and Ratna. They reported 100% germination in control, 84% in Pb^{+2} solutions in IR-36, 25% in Ratna variety at 2 ppm of lead. They concluded that Pb^{+2} inhibited germination and seedlings growth through inhibition of hydrolysis of endosperm starch due to inhibition of alpha amylase. Xiong (1998) reported decrease in seed germination in *Brasica perkenensis* Rupr in a pot experiment with sand culture treated with Pb $(NO_3)_2$ solution to produce concentrations in range of 0 - 1000 μg/g He reported decreased seed germination as Pb increased in the growing media and percent germination in 125μg/g Pb was similar to that of control while at 1000 μg/g it was 43.3% that of control.

In the present studies it was observed that germination success in soil medium was significantly low when compared with that of solution culture and the difference widened with increased Pb concentrations in the soil.

Xiong (1998) while experimenting with *Brassica perkenensis* under pot culture, found decreased root and shoot lengths as Pb concentrations increased in the soils. These studies reported that at 1000 μg/g of Pb, roots were 10% of the length of control. In the present study also 11% decline in root length was decreased at 2360 ppm of lead than that of control.

Abdul Ghani (2010) also demonstrated that exposure of maize varieties to Pb stress resulted in significant inhibition of root growth though shoot growth remained less effected, however the extent of inhibition varied in different varieties.

Le investigated lead pollution near road side soils range from 23-90mg/kg with an average value of 37.11 mg/kg. Khan *et al*., (2010) reported that motor vehicles resulted in deposition of lead as particulate matter along road side surface soils, concentration of lead vary from place to place. Present study also revealed the soils's back ground total lead as 17.133 μg/g and available fraction as 2.36 μg/g.

Srinivas J. *et al*., (2013) found that seed germination and growth of three vegetable plants Coccinia, Mentha and Trigonella were reduced in all the treatments (100, 300, 500 ppm) of lead as compared to control and also found that lead at 500 ppm produced adverse effect on seed germination when compared to control. The inhibitory effect of toxic metals on germination is due to affecting the amylase activity in seed and inhibiting the radical and plumule growth (Godbold D.C *et al*., 1991; Shanifah BA *et al*., 1992). Inhibition of germination and retardation of plant growth are commonly observed due to heavy metal toxicity (Fisher N.S *et al*., 1981; Singh K.P and Singh K, 1981).

CONCLUSIONS

Our present studies on the effect of lead on seed germination and growth parameters seedlings of sesamum

(*Sesamum Indicum L.* Var YLM - 11) revealed delayed germination and inhibition in germination percent, and reduced root length of seedlings, in test concentrations of lead ranging from 23.6-2360 ppm. So, agricultural soils on sides of highways and industrial areas should be checked for lead contamination periodically before their use for cultivation.

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