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Effect of Lead Polution on the Performance and Protein Content of Two Soybean Varieties

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Abstract: Pollution by lead has been classified as being harmful to plants and animals because it accumulates in organisms and bio-magnifies in the food chain. Excessive concentration of lead in plants results in phyto-toxicity of the cell membrane. It has become necessary to determine the effect of lead, on the yield performance (number of leaves, plant height and yield) and protein content of two soybean varieties, TGX 1485-ID (VI) and TGX 1740-2F (V2). The soybean varieties were planted in 4×2 factorial designs. The experiment consisted: Uncontaminated soil (control) and three contaminated soils containing 300, 600 and 1,800 mg Pb L^{-1}. The soil had the following characteristics: pH 6.1, organic matter 6.68% and CEC 11.24 cmol kg^{-1}. Per cent uptake in lead content of the contaminated soils ranged from 65.25 to 81.94 in V1 and 66.20 to 82.18 in V2 after harvest. This indicated variable decrease in lead levels in contaminated soils while lead was not detectable in the planted and harvested seeds. The mean germination and maturity days of variety TGX 1485-ID were 4.63±0.14 and 110.5±0.11 while it was 4.88±0.13 and 105.5±1.23 in variety TGX 1740-2F, respectively. There were no significant difference in the various lead contamination levels with respect to germination days and maturity days. The mean stem heights of VI were 49.5±1.11, 39.9±0.25, 43.9±1.01 and 44.1±1.21 cm while 43.6±1.31, 47.3±0.42 and 45.3±0.42 cm were obtained in V2 at Control, 300, 600 and 1500 mg L^{-1} treatment levels, respectively. Comparison of the plant height between the TGX 1485-1D variety (V1) and the TGX 1740-2F (V2) variety showed that there was no significant difference ($p>0.05$) between the two varieties with regards to plant height. The mean number of leaves in V1 were 52.4±0.16, 50.6±1.14, 48.4±1.67 and 48.4±0.15 while 51.4±1.26, 48.6±0.33, 45.3±0.25 and 52.3±0.17 were for V2 at the control, 300g L^{-1}, 600 mg L^{-1} and 1800 mg L^{-1}, treatment levels, respectively. However, lead affected the number of leaves significantly between ($p<0.05$) the two soybean varieties. At the four lead treatment levels, the mean pod weights (gram) ranged from 3.55±2.22 to 5.23±1.03 in TGX1485-D and 4.52±1.16 to 5.30±0.41 in TGX1740-2F. There were no significant differences ($p>0.05$) in the number of pods and pod dry weights of the varieties and within their treatments. Spiking of the soil with lead at various concentrations did not have appreciable effect on the soybean protein contents of the two varieties after harvest. This study showed that lead though absorbed from the soil was not accumulated in the leaves and seeds of the two soybean varieties indicating that the risk of lead entering the food chain through these media remains minimal.

Key words: Bio-magnifies, phyto-toxicity, contaminated, germination, soybean, spiking

INTRODUCTION

Soybean (Glycine max) is an important crop particularly in the developing countries such as Nigeria where it is a part of human diet. The crop has a very great potential as source of inexpensive protein for meeting human protein requirements (IITA, 1981). The production level had gradually increased from what it was before the Nigeria civil war as more farmers and new areas are now being involved in its production (Oyekan and Ayeni, 1992). Ashaye Reported that research work in soybean in the western states of Nigeria started with collection and multiplication of seed between 1969-1971and varietal trials started in 1972 which continue to date. In 1975,

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researchers at International Institute of Tropical Agriculture (IITA), Ibadan began to evaluate soybean varieties for seed longevity and by 1982, several lines were developed at the IITA research station that yielded well, had fairly good agronomic characters and produce storable seeds (Kueneman, 1993).

Heavy metals are natural components of the environment, but are of concern lately because they are being added to soil, water and air in increasing amounts. This is because of the rapid growth of population, increased urbanization, expansion of industrial activities and more (Biney *et al*., 1994).

The main sources of lead pollution in the environment are particulates in exhaust fumes from petrol combustion, fossil fuel combustion in soil, paint flakes from old paint containing a percentage of lead, lead pipes for portable water, lead in some traditional cosmetics, lead shot used in guns for game and clay pigeon shooting and use of lead compound as pesticides. However, once lead is released it can be transported through the air as particulate to be taken up by plant through the soil or deposited directly on plant leaves thus it enters terrestrial food chains (Alloway and Ayres, 1993).

Trace levels of some toxic metals have been shown to be hazardous when ingested by humans through inhalation or along the food chain. They are known to have deleterious effects on humans most especially children (Nriagu, 1992). Furthermore, the plucking and eating of plant leaves, raw fruits without washing and food hawkers displaying their food-stuff openly and unwrapped alongside heavy traffic road are common sights in most cities in Africa; therefore the amount of heavy metals ingested in one form or the other can be high if quantified particularly over a long time interval. Lead has been found to be a major pollutant in the environment as it is ubiquitous.

Excessive lead concentration in plants results in phytotoxicity of the cell membrane due to changes in permeability (Thornton, 1991). In man, lead replaces calcium in bone marrow where red blood corpuscle formation occurs, it causes kidney damage, infertility and menstrual disturbances, depressions, neo-natal mortality, abortion and brain retardation (Peter, 1993).

The current efforts and campaign being made by government of developing countries to improve standard of living through the production and utilization of soya bean can possibly be realized if adequate research attention is directed towards devising solutions to the environmental and biological constraints hampering production and good yield of the crop (Ononuju and Fawole, 2000). Considering the toxicity of lead and its many sources in the environment coupled with the cultivation of Soybean in urban agriculture, there is the need to investigate its accumulation in plant tissues and food since there is tendency for bioaccumulation along the food chain.

The objectives of this study therefore, were to investigate the effect of lead on growth yield of two soybean varieties, assess lead residue in the harvested leaves and seeds and evaluate the effect of lead on the protein content of soybean.

MATERIALS AND METHODS

Soil samples were collected from the farms of University of Agriculture, Abeokuta Nigeria. The soil samples were analyzed for pH, organic matter content lead and Cation Exchange Capacity prior to planting. The soil and soybean seeds were analyzed for lead prior to planting using Atomic Absorption Spectrophotometer. The two soybean varieties used were TGX 1485-lD and TGX 1740-2F obtained from the Generic Laboratory of International Institute for Tropical Agriculture, Ibadan. The two varieties were planted in plastic pots and each variety subjected to the following four treatments:

A - Control
B - Soil contaminated with 300 mg Pb L^{-1}
C - Soil contaminated with 600 mg Pb L^{-1}
D - Soil contaminated with 1800 mg Pb L^{-1}

Lead nitrate ($Pb(NO_3)_2$) was used as the sources for lead of which 476.19, 952.38 and 2857.15 mg ($Pb(NO_3)_2$) were weighed separately, dissolved in distilled water and made up to one liter for 300, 600 and 1800 mg L^{-1} treatments, respectively.

The experimental design used was split plot in a randomized complete block. The main plot was the two soybean varieties while four lead concentrations formed the subplots. Each of the treatments and control had five replicates. One hundred mL of the various lead standards were added to each pot except controls and labeled appropriately. Germination dates, growth and yield data of the plants were recorded. The pods were harvested at maturity. After harvest, soil, leaves and seeds were analyzed for lead to determine residual lead content in soil and plant tissues using atomic absorption spectrophotometer. The protein content of seeds prior to planting and after harvesting was also determined by colorimetry using adapted auto-analyzer method.

For residual lead content in seed and plant tissues, 0.5 g samples of plant material was taken in a kheljahl flask and 5 mL of 2:1 nitric per^{-1} chloric acid was added. It was heated at a temperature of 150°C for 1.5 h till complete digestion. The residue was dissolved in redistilled water and final volume was made up to mark in a 100 mL volumetric flask. The dissolved materials were filtered through Whatman filter paper No.42. A blank was also run in the same way without plant materials. The reading was taken with atomic absorption spectrophotometer (GBC 902) at 283.3 nm. Data generated from the study were subjected to Analysis of Variance (ANOVA) (SAS, 1997) and New Duncan's Multiple Range Test (Duncan, 1959) for means separation at 95% level of probability for the growth and yield parameters.

RESULTS AND DISCUSSION

The experimental results are presented in Table 1-5. Soybean grows in nearly all types of soils but the best results are obtained in sandy and clay loam soils, containing a fair amount of potash (Lai *et al*., 1996). Willet *et al*. (1994) reported that the mobility and availability of metals is considerably greater in acidic soils than in near neutral or alkaline soils.

The result of the soils analysis for lead before simulated contamination showed that lead was present at 68.30 mg L^{-1}. This agrees with the reports of Ellis and Mellor (1995) that less than 100 mg L^{-1} background levels are found in uncontaminated soil. The levels of lead in the soil after harvest were reduced for both varieties. For TGX1485-ID, the corresponding percentage reductions for the treatments A, B, C and D were 34.85, 65.25, 70.22 and 81. 94, respectively. This trend is similar for TGX 1740 -2F. The plants in the control treatment had the least uptake while those treated with the highest lead level of 1800 mg L^{-1} l also had the highest uptake (Table 2). The result showed that percentage lead uptake by plants depends on the availability in the soil. This result is in consonance with the findings of Arvind *et al*. (1999) who observed similar reduction when soybean and wheat were planted on lead contaminated fly ash.

The results of germination pattern are presented in Table 3 and this showed that lead contamination had no significant effect on germination among the treatments. The germination pattern is in conformity with three to six days reported by Ndimande *et al*. (1981). Fadina and Annih (2000) also reported that germination of soybean seeds was not affected by contamination with spent lubricating oil.

Analysis of variance of the data set revealed that there is a significant difference between the stem heights and the number of leaves of the two soybean varieties. However, there were no significant differences in the yields of the two varieties and within their treatments.

Table 1: The characteristic of the experimental soil

pH	% Organic matter	K^+	Na^+	Ca^{2+}	Mg^{2+}	Exch. Acidity	CEC
		(cmol kg^{-1})					
6.1	6.86	0.4	0.31	8.2	1.98	0.35	11.24

Table 2: Levels of lead in the soil (Prior to planting and after harvest of soybean)

Soil sample	Lead conc. (mg L^{-1})	% Residue in soil	% Decrease
All soils	Before planting		-
	68.30	100	-
TGX 1485-ID (VI)	After Harvest		
0 mg L^{-1}	44.50±0.01	65.15±0.22	34.85±0.31
300 mg L^{-1}	128.00±1.10	34.75±0.14	65.25±1.01
600 mg L^{-1}	199.00±0.30	29.78±0.21	70.22±0.32
1800 mg L^{-1}	337.50±1.00	18.06±0.25	81.94±1.02
TGX 1740-2F (V2)			
0 mg L^{-1}	31.00±0.46	45.39±1.01	54.61±0.44
300 mg L^{-1}	124.50±0.41	33.80±1.20	66.20±0.32
600 mg L^{-1}	195.00±0.32	29.18±0.51	70.82±0.25
1800 mg L^{-1}	333.00±1.12	17.82±0.21	82.18±0.16

Table 3: Germination days of soybeans varieties

Variety	Treatment	Mean germination day
TGX 1485-ID	0 mg L^{-1}	4.5±0.11
	300 mg L^{-1}	4.6±0.21
	600 mg L^{-1}	4.5±0.11
	1800 mg L^{-1}	4.9±0.12
TGX 1740-2F	0 mg L^{-1}	5.0±0.13
	300 mg L^{-1}	5.0±0.13
	600 mg L^{-1}	4.5±0.12
	1800 mg L^{-1}	5.0±0.14

Table 4: Growth parameters of two soybeans varieties grown on soil treated with varying levels of lead nitrate

	No. of leaves		Stem height		No. of pod		Pod weight (g)	
Treatment	V1	V2	V1	V2	V1	V2	V1	V2
0 mg L^{-1}	52.4^a	51.4^a	49.5^a	43.6^a	7.0^a	6.60^a	5.23^a	5.0^a
300 mg L^{-1}	50.6^a	48.6^a	47.3^a	5.00^a	5.00^a	6.00^a	4.49^a	5.30^a
600 mg L^{-1}	48.4^a	45.3^a	48.3^a	9.30^a	9.30^b	6.60^a	5.87^a	4.87^a
1800 mg L^{-1}	48.4^a	52.3^a	45.3^a	6.00^a	6.00^a	5.57^a	3.55^a	4.52^a

Figure followed by the same letter within a column do not differ significantly ($p = 0.05$) using DMRT. VI = (TGX 1485-ID) V2 = (TGX 1740-2F)

Though, the variety TGX1485-ID planted on contaminated soil produced greater number of pods than corresponding treatments in TGX 1740-2F.

The pod weight for TGX 1740-2F was relatively more than that for TGX 1485-ID. Since yield of leguminous crops is measured in terms of weight, TGX 1740-2F may be preferred. This result agrees with the findings of Lai *et al*. (1996) who observed a substantial yield improvement in soybean at 4% level of lead contaminated fly ash.

Lead was not detected in the leaves and seeds of the harvested soyabeans. This is in similarity to the reported work of Fadina and Opeolu, (2003) in which, lead was also not detected in the seeds and leaves of cowpea planted on lead contaminated soil. However, the result was not in agreement with the findings of Kao *et al*. (1999) who though not working on soyabean observed a substantial accumulation of cobalt, nickel and lead in wheat seed.

Table 5: Effect of lead on protein contents of seeds

Variety	Treatment	Protein content
TGX 1485-ID	Before planting	34.4%
	After Harvest	
	Control (0 mg L^{-1})	34.4%
	300 mg L^{-1}	34.4%
	600 mg L^{-1}	34.4%
	1800 mg L^{-1}	34.81%
TGX 1740-2F	Before planting	31.6%
	After planting	
	Control (0 mg L^{-1})	31.6%
	300 mg L^{-1}	31.61%
	600 mg L^{-1}	31.59%
	1800 mg L^{-1}	31.60%

Analysis of seed for protein revealed that there was no variation in protein contents of the two-soybean varieties (Table 5). This result is in agreement with the findings of Singh and Simpah (1996) who observed no variation in protein contents of soybean planted on lead and nickel amended soil. Similarly, the result agrees with the findings of Abdel and Abo El (1996) who also reported no variation in protein contents of seed planted on sandy soil amended with sewage sludge.

CONCLUSION

Generally the study showed that lead was absorbed from the soil but not accumulated in the leaves and seeds of the two soybean varieties. It is either locked up in the roots or stems of the plants. Lead pollution had no effect on the yield and protein contents of soyabean. Since lead was not detected in the leaves and seeds, the risks of lead entering the food chain through the leaves and seeds consumption is very minimal.

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