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Effects of Lead on Performance and Nutrient Quality of Two Cowpea Varieties

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ABSTRACT: The effects of lead on plant growth, yield and nutrient quality of two cowpea varieties (IT94K-4403 and IT93KZ-8-21-23-3) were studied. Soil and seeds analyses for lead before planting and after harvest revealed variable decreases in lead levels in contaminated soil after harvest, while lead was not detectable in the planted and harvested seeds. There were no significant differences in the various lead contamination levels with respect to germination days and maturation days. Lead contamination was found to have adverse effects on the yield of cowpea. The variety IT94K-4403 showed no variation in protein content after harvest with the different levels of lead contamination. IT93KZ-8-21-23-3 on the other hand showed variable decreases in protein content.

Key words: (Please supply 5 relevant key words)

Introduction

Addition of sewage sludge to soil, atmospheric fallout of lead from fossil fuels, oil spillage, amongst others, result in increase in concentration of lead in soils (Alloway and Ayres, 1995). Long-term studies have shown that heavy metals are ploughed into near-neutral agricultural lands and they do not leach appreciably (McGrath and Cegarra, 1994).

Excessive lead concentration in plants results in phyto-toxicity of the cell membrane due to changes in permeability. Lead can occur naturally in soils, but often occurs at enhanced levels due to additions from motor vehicle emissions, sewage sludge applications, metal mining, smelting and scrap metal processing (Thornton, 1991). Lead may be adsorbed on the surfaces of negatively charged colloidal particles and organometallic complexes (Ellis and Mellor, 1995). Also, industrial pollutants in the form of heavy metals (including lead) often lead to soil pollution/contamination and may result in toxic accumulation in arable produce and in herbage for grazing animals, thus having important implications for human health (Thornton, 1991).

Lead is readily mobilised in acidic soils resulting in toxicity to life forms, both flora and fauna (Ellis and Mellor, 1995). In man, lead replaces calcium in bone, cause infertility and menstrual disturbances, depressions, lack of co-ordination and brain damage, amongst others.

Considering the toxicity of lead and many sources of lead contamination in the environment, there is the need to investigate the accumulation in tissues of plant food since there is tendency for bioaccumulation along the food chain.

Cowpea, being a major source of plant protein for humans and fodder for livestock was used in this study to determine how much of lead could be absorbed by plants on lead contaminated soil. The study aimed at monitoring the effect of lead on growth and yield patterns and protein content of cowpea.

Materials and Methods

Soil samples were collected from experimental farms of Faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Nigeria. The soil and seeds were analysed for lead prior to planting using Atomic Absorption *Spectrophotometry*. Two cowpea varieties IT94K-4403 and IT93KZ-8-21-23-3 were planted in plastic pots and each variety was subjected to the following four treatments:

I - Uncontaminated soil (Control)
II - Soil contaminated with 300 mgPb/l
III - Soil contaminated with 600 mgPb/l
IV - Soil contaminated with 1,800 mgPb/l

Lead nitrate was used as the source for lead and the various levels were obtained as follows:-

Molecular mass of Lead Nitrate $[Pb(NO_3)_2]$ = 331.20
Molecular mass of lead = 207.20
Lead in 1mg of lead Nitrate = 207.20/331.20 = 0.63mg
Hence 0.63mg lead (Pb) is equivalent to 1mg $Pb(NO_3)_2$
Then, 300mg Pb = 300/0.63 = 476.19mg $Pb(NO_3)_2$ per litre

Table 1: Lead Levels in the Soil Prior to Planting and After Harvest of cowpea in soils treated with lead nitrate.

Soil Sample	Lead Concn. (mg/l)	% Residue in Soil	% Reduction
	Before Planting		
All soils	66.70	100	-
	After Harvest		
IT94K-4403 (V_1)			
0 mg/l	28.00	41.98	58.02
300 mg/l	122.50	33.41	66.59
600 mg/l	198.00	29.70	70.30
1,800 mg/l	335.50	17.97	82.03
IT93KZ-8-21-23-3 (V_2)			
0 mg/l	45.00	67.47	32.53
300 mg/l	122.00	33.27	66.73
600 mg/l	154.50	23.14	76.86
1,800 mg/l	335.50	17.97	82.03

Hence, 476.19 mg, 952.38 mg and 2857.15 mg $Pb(NO_3)_2$ were weighed separately, dissolved in distilled water and made up to one litre for treatments II, III and IV respectively.

The experimental design used was split-plot in a randomised complete block. The two studied varieties formed the main block while the four lead concentrations formed the subplots.

Each of the treatments and control had five replicates. 100 ml of lead standards were added to each pot, except control, and labeled appropriately. Lead standard was not added to the controls. Observations were made on germination dates, growth and yield parameters of the plants. At harvest, soil, leaves and seeds were analysed 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 harvest was also determined by Colorimetry using Adapted auto-analyzer method. Standard was prepared from Ammonium Sulphate in 8% conc. Sulphuric acid. 4.719 g of Ammonium sulphate was washed and dissolved in 100 ml flask with 8% sulphuric acid to make 1000 mg/l of Nitrogen. 100 mg/l was prepared from stock standard. Working standards of 10, 15, 20, 25, 30 mg/l were also prepared from the 100 mg/l. 1ml of either standard or sample was measured. 4.0 ml of diluent was added to it, followed by mixing it with 1.5 ml of potassium phosphate tartrate. 2.5 ml of alkaline phenate was added and mixed thoroughly and finally, 1.5 ml of commercial bleach was added to the mixture and thoroughly mixed. The tubes were left for at least 30 minutes and read on Spectronic 20 at 630 nm. The blank contained all reagents. Calibration curve was used to determine protein content.

Data generated from the study were subjected to Analysis of Variance (ANOVA) (SAS, 1997) and Duncan's Multiple Range Test (Duncan, 1959) for means separation at 95% level of probability for the growth and yield parameters.

Results and Discussion

For IT94K-4403, the levels of lead in the soil after harvest were reduced. The corresponding percentage reductions for the treatments I, II, III and IV were 58.02, 66.59, 70.30 and 82.03 respectively. The results revealed that percentage lead uptake by plants depended on the availability in the soil. This trend is similar for IT 93KZ-8-21-23-3. The plants in the control treatment had the least uptake while those in the highest level (1,800 mg/l) treatment had the highest lead uptake (Table 1).

The results of germination pattern showed that lead contamination had no significant effect on germination among the treatments (Table 2). Germination pattern is in conformity with three to five days reported by Pandey (1987). Fadina and Annih (2000) also reported that germination of soyabean seeds was not affected by contamination with spent lubricating oil.

The difference between yields of the two cowpea varieties was not significant. Though the variety IT94K-4403 planted on contaminated soil produced greater number of pods than corresponding treatments in IT93KZ-8-21-23-3, the pod weight for IT93KZ-8-21-23-3 was relatively more than that for IT94K-4403. Since yield of cowpea is measured in terms of weight, IT93K-8-21-23-3 may be preferred for cultivation by farmers.

Lead was not detected in the leaves and seeds of the harvested cowpeas. This agrees with the report of Ibrahim *et al* (1992) that increasing years of application of sewage water for irrigation did not produce any accumulation of heavy metals in tested parts of citrus trees. Narwal *et al* (1990) reported that cadmium, a more mobile heavy metal, was retained in the root of maize planted on cadmium contaminated soils, therefore lead, a comparatively less mobile metal, was probably retained in the roots of cowpea.

Analysis of seeds for protein showed that there was no variation in protein contents of IT94K-4403 while IT93KZ-8-21-23-3 showed slight decrease in protein contents (Table 2). The result is in contrast to the work of Ibekwe *et al* (1997) who reported increase in protein content of *Rhizobium leguminosarium* and heavy metal contents of soils. However, working on other heavy metals, Quariti *et. al* (1997) reported that cadmium and copper adversely affected the lipids composition of tomato seedlings grown in nutrient solutions containing cadmium and copper.

TABLE 2: Effects of Lead on Protein Contents and Mean Germination Days of two Cowpea Varieties.

Treatments	% Protein Content		Mean Germination Days	
	IT94K-4403 (V_1)	IT93KZ-8-21-23-3 (V_2)	IT94K-4403 (V_1)	IT93KZ-8-21-23-3 (V_2)
Before Planting	17.60	19.40	-	-
After Harvest				
0 mg/l	16.90	18.40	4.80	4.50
300 mg/l	19.40	18.40	5.00	4.50
600 mg/l	12.60	15.66	5.00	4.50
1,800 mg/l	21.06	18.09	5.00	4.90

Table 3: Means of Growth and Yield Parameters of two Cowpea Varieties Grown in Soils treated with varying levels of lead nitrate.

	Number of Leaves		Stem Height		Number of Pod's		Pod Weight (g)	
Treatments	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
0 mg/l	30.80^{a}	23.00^{a}	13.40^{a}	16.76^{a}	6.00^{ba}	4.60^{ba}	3.32^{a}	3.10^{a}
300 mg/l	24.60^{a}	20.00^{a}	14.46^{a}	15.12^{a}	3.00^{b}	4.00^{ba}	2.94^{a}	3.20^{a}
600 mg/l	23.80^{a}	21.40^{a}	14.44^{a}	15.88^{a}	7.40^{a}	4.60^{ba}	3.94^{a}	2.98^{a}
1,800 mg/l	25.67^{a}	24.00^{a}	13.87^{a}	15.58^{a}	4.00^{ba}	3.75^{b}	2.77^{a}	2.80^{a}

Figures followed by same letter within a column do not differ significantly according to DMRT at 5% level of probability. V_1 = Variety IT94K-4403 V_2 = Variety IT93KZ-8-21-23-3

This study showed that lead pollution had slight adverse effect on the yield of the two cowpea varieties (Table 3). Lead also had slight adverse effect on the protein content of cowpea. Therefore, due to economic implications, it is better to plant on soils free of lead for good yields. Also, if protein is to be derived optimally from cowpeas, lead-contaminated sites should be avoided for its cultivation.

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