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GROWTH AND YIELD PERFORMANCE OF TWO ACCESSIONS OF SOME LEGUMES ON EXPOSURE TO HEAVY METAL IN LAFIA NASARAWA STATE

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ABSTRACT

The aim of the research was to determine the growth and yield performance of some legumes upon exposure to heavy metals. seeds were collected from International Institute for Tropical Agriculture (IITA). Wild beans included TVNU2 and TVUN16, Cowpea: TVU2 and TVU8 while Bambara: TVSU3 and TVSU7. Dried soil collected was filled into 24 plastic buckets. Four (4) grams of lead chloride was measured with the aid of weighing balance and was dissolved into 1 litter of distilled water. Another portion of distilled water without any additive was measured and used as control. The lead solution was used to pollute the soil and allowed to stay for 24hrs before planting in a screen house. 4g of heavy metal was introduced into 8kg of soil in a bucket with each of the legumes having three replicates and was laid in a Randomized Complete Bock Design. The data collected was analyzed using two way (ANOVA) and treatment means were separated by means of LSD where differences exist. At 14 weeks after planting, results revealed that among the Cowpea accessions, TVU8 performed better than the other accession in all the parameters measured. Among the Wild bean, TVNU2 did better in most of the parameters except number leaf and number of pod/plant while in Bambara groundnut, TVSU7 performed best generally.

Keywords: Accessions, Bambara nut, Growth, heavy metals, legumes

INTRODUCTION

Fabaceae/Leguminosae family of angiosperms, which includes legumes, is the third biggest family (Gepts *et al*., 2005). It is evident that they are a necessary component of a diet that is balanced and that regional nutrition techniques are used everywhere in the world (Malaguti *et al*., 2014). Among the most crucial nutrients are protein, low-GI carbohydrates, dietary fiber, minerals, and vitamins. Legumes are distinct because they contain a lot of protein and dietary fiber. Moreover, because legume roots' nodules are home to nitrogen-fixing bacteria, they contain more proteins than other cultivated plants (Kouris-Blazos and Belski, 2016). Furthermore, the synergistic combination of bioactive chemicals may be the source of the noticeable impacts on diseases such as cardiovascular diseases, diabetes, cancer, and obesity.

The yardlong bean (*Vigna unguiculata*) is one of the most important leguminous vegetables. The southern bean, garden bean, lima bean, and common bean are also members of the family (Decoteau, 2000). Other names for it include snap pea, bora, garter bean, Chinese long bean, snake bean, asparagus bean, string bean, and snake pea (Fana *et al*., 2004; Sarutayophat *et al*., 2007). The cowpea (*Vigna unguiculata*) is a major crop on several tropical continents, including Africa, Asia, and South America Walp (Kabulu, 2008).

One of the oldest crops that humans have ever grown is the cowpea. The species was first domesticated in Africa, close to Ethiopia, and afterwards evolved primarily in farms in the African Savannah (Duke, cited by UC SAREP).

The term "heavy metals" refers to metals having a density of greater than 5g/cm3 by Ademoroti, (1994). They included transition metals and metals from groups III through V of the Periodic Table with higher atomic weights. When the amount in a living organism exceeds what is acceptable for the system to function properly, they are considered contaminants. Metals can reach plants in a variety of ways. Examples include the earth's crust, soil erosion, mining, industrial discharge, urban runoff, sewage effluents, air pollution fallout, and pesticides used to manage weeds, insects, or diseases. These heavy metals travel up the food chain and pose a threat to both plants and animals because of bio-accumulation and bio-magnification. The two heavy metals that are most frequently found are Lead and zinc and are pollutants found in soil, sediments, air, and water. Lead can remain in the environment for 150–5000 years.

Human exposure to heavy metals has significantly grown due to the growing usage of industrial goods, processes, and chemicals in both processed and unprocessed foods as well as irrigation water for planting. Certain vital plant functions, such as photosynthesis, mitosis, and water absorption, may be hindered by extremely low concentrations of lead, which can cause toxic symptoms like dark green leaves, withering elder leaves, stunted foliage, and brown short roots. High soil lead levels, for instance, may have a negative impact on soil productivity (Bhattacharyya *et al*., 2008). Because they can cause chlorosis, poor plant development, and low yield, heavy metals can be harmful. They may also be connected to abnormal metabolism, decreased nutrient intake, and deficits in plants' capacity to fix molecular nitrogen. The aim of this present study was therefore to determine the growth and yield performance of two accessions of some selected legumes on exposure to heavy metal in Lafia, Nasarawa State

MATERIALS AND METHODS

Experimental site, soil collection, and seed material

Experimental site

The research was carried out at Botanical Garden of the College of Agriculture, Lafia, Nasarawa state which lies between latitude 8°25' 40"N to 8°34' 15"N and longitude 8°24' 25"E to 8°39' 19"E in the Guinea savannah region of northern Nigeria.

Soil collection
Composite soil samples were collected in clean dried polythene bag for pre and post analysis from 0-15cm depth according to (Agbenin, 1995), from the Faculty of Agriculture, Nasarawa State University Shabu, Lafia campus and taken to the laboratory for soil physicochemical analysis.

Seeds collection
Two (2) different accessions each of cowpea, Bambara groundnut and wild Vigna were collected from International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria. They are: Wild beans included TVNU2 and TVUN16, Cowpea: TVU2 and TVU8 while Bambara: TVSU3 and TVSU7.

Seeds viability test
10 Seeds each of the various accessions were sown in Petri dishes containing distilled water to observe germination. The seeds were observed daily until maximum germination was attained on the 7th day after sowing (DAS).

Preparation of Lead chloride (PdCl2)
Using a weighing balance, four (4) grams of lead chloride were weighed and dissolved in one litter of distilled water. As a control, a different volume of additive-free distilled water was used.

Pre-treatment of soil
The dissolved lead chloride was introduced into the 24 buckets each containing 8kg of dried soil to pollute the soil and was allowed to stay for 24hrs in the screen house before sowing.

Sowing of seeds
The seeds of the cowpea, Bambara, and wild beans were planted directly into the contaminated ground. Planting was done in the evening just after dusk using protocol proposed by Ikhajiagbe (2004). Three wild bean, cowpea, and Bambara seeds per bucket, including the control sections, were sowed. Throughout the trial, continuous morning irrigation was carried out until full maturation and yield was reached.

Experimental design
The experiment was laid out in a Randomized Complete Blocked Design (RCBD) with each treatment consisting of 3 replicates. The buckets were properly labeled for easy. In other to avoid bias and misidentification, treatments bags were properly labeled according to a given treatment name and replicate number. Treatment bags were then randomized over the whole plot, each bearing an identification tag.

Statistical Analysis
The data collected was critically and statistically analyzed using two-way (ANOVA) and treatment means was separated by means of LSD method.

Heavy Metals Analytica Methods
Heavy metal was analyzed using Atomic Absorption Spectrophotometer according to the method of A.O.A.C (William and George,2003).

Soil Physicochemical Analysis
Soils were dried at ambient temperature (22-25 ºC), crushed in a porcelain mortal and sieve through a 2-mm (10 meshes) stainless sieve. Air-dried < 2 mm samples were stored in polythene bags for subsequent analysis. The 2 mm fraction was used for the determination of selected soil physicochemical properties and the heavy polyaromatic hydrocarbons (PHC). Soils were than analyzed for total hydrocarbons and heavy metal contents (Fe, Mn, Zn, Cu, Cr, Cd, Ni, V) by Atomic Absorption Spectrophotometry (AAS model No 240 FSAA) was used to determine the concentration levels of heavy metals in the samples.

RESULTS AND DISCUSSION
Soil characteristics were comparable across the soil depths (Tables 1). Soil pH ranged 5.75 – 6.86, as well as other variables considered.

Table 1: Physicochemical characteristics of the soil sample Lafia

Soil depths (cm)	Soil depths (cm)		p-value
	0-15	15-30	
pH (H_2O)	5.75	6.86	0.42
pH ($CaCl_2$)	4.55	5.43	0.14
O.C. (%)	1.47	1.75	0.53
TOM (%)	2.52	3.01	0.32
N (%)	0.45	0.53	0.84
Avail. P (ppm)	3.82	4.56	0.14
K (Cmole/kg)	0.44	0.52	0.62
Ca (Cmole/kg)	4.18	4.99	0.18
Mg (Cmole/kg)	2.16	2.58	0.74
Na (Cmole/kg)	0.34	0.41	0.47
(Cmole/kg)	0.14	0.16	0.57
TEB (Cmole/kg)	7.05	8.42	0.19
ECEC (Cmole/kg)	7.19	8.58	0.17
Sand (%)	63.39	75.69	0.07
Silt (%)	3.35	4.24	0.16
Clay (%)	13.09	15.63	0.52

O.C. organic carbon; TOM total organic matter;N (%) percentage nitrogen; K exchangeable potassium, Ca calcium, Avail P available phosphorus; Na sodium, E.A. exchangeable acidity; TEB total exchangeable bases; ECEC cation exchange capacity

Among the wild mung bean, there was increased in plant height in TVNU2 upon exposure to lead solution (144.4) compared to the control level (113.6) (Table 2). Reserve was the case however when compared to TVNU16. Same trend was seen in cowpea where Tvu2 performed better in lead polluted soil compared to the control. TVU8 however performed better in the control compared to the lead polluted soil. In both Bambara nut accessions, their performance was best in the lead solution.

Table 2: Effect of Lead on plant heights in Wild *Vigna*, Cowpea and Bambara groundnut

Crop	Control	PbCl2	Mean	LSDv	LSDt
Wild Vigna					
TVNU2	113.6	144.4	127.5[a]	99.55	89.42
TVNU16	198.3	45.8	122.05a		
Mean	155.95[a]	93.60[a]			
Cowpea					
TVU2	0	17.03	8.52a	9.77	11.8
TVU8	22.6	15.9	19.25b		
Mean	11.30a	16.47b			
Bambara					
TVSU3	0	3.53	1.77a	3.49	2.48
TVSU7	0	3.47	1.73a		
Mean	0a	3.50b			

Means followed by same superscripts within same column or row are not significantly different

There was no significant difference in stem girth between the control and the lead treated soils among the wild bean (Table 3). However, there was increase in stem girth in TVU2 upon exposure to lead solution. The same observation was seen among Bambara nuts where there was notable increase.

Table 3: Effect of Lead on stem girth in Wild *Vigna*, Cowpea and Bambara groundnut

Crop	Control	PbCl2	Mean	LSDv	LSDt
Wild Vigna					
TVNU2	1.3	1.33	1.32a	0.6	0.61
TVNU16	1.3	0.83	1.07a		
Mean	1.3a	1.08a			
Cowpea					
TVU2	0	2.27	1.13a	1.18	1.19
TVU8	2.29	1.9	2.09a		
Mean	1.15a	2.08a			
Bambara					
TVSU3	0	3.53	1.77a	3.49	2.48
TVSU7	0	3.47	1.73a		
Mean	0a	3.50b			

Means followed by same superscripts within same column or row are not significantly different

TVNU2 recorded increase in number of branches in lead solution compared with control while TVNU16 recorded a decline (Table 4). Cowpea had varying increase with no significant difference among the accessions considered. In both accessions of Bambara however, there was increase in the number of branches compared with the control.

Table 4: Effect of Lead on number of branches in Wild *Vigna*, Cowpea and Bambara groundnut

Crop	Control	PbCl2	Mean	LSDv	LSDt
Wild Vigna					
TVNU2	18.99	24.33	21.67a	16.69	60.48
TVNU16	35.99	6	20.99a		
Mean	27.49a	15.17a			
Cowpea					
TVU2	0	4	2.00a	2.55	3.14
TVU8	6.01	3.33	4.67b		
Mean	3.01a	3.69a			
Bambara					
TVSU3	0	8.33	4.17a	13.64	10.69
TVSU7	0	17.33	8.67a		
Mean	0a	12.83b			

Means followed by same superscripts within same column or row are not significantly different

In both Wild bean and Bambara accessions, there was significant increase in number of leaves per plant upon exposure to lead solution compared to the control (Table 5). Cowpea however showed different response where TVU2 had increased in number of leaves per plant.

Table 5: Effect of Lead on number of leave in Wild *Vigna*, Cowpea and Bambara groundnut

Crop	Control	PbCl2	Mean	LSDv	LSDt
Wild Vigna					
TVNU2	70.01	193.67	131.84a	165.51	163.78
TVNU16	305	59.67	182.34a		
Mean	187.50a	126.67a			
Cowpea					
TVU2	0	63.67	31.83a	38.18	50.82
TVU8	101.01	60.67	80.84b		
Mean	50.5a	62.17a			
Bambara					
TVSU3	0	29.67	14.83a	37.68	28.22
TVSU7	0	42.33	21.17a		
Mean	0a	36.0b			

Means followed by same superscripts within same column or row are not significantly different

Both cowpea and Bambara accessions had decrease in leaf area upon exposure to lead solution which is significant different from the concentration (Table6). Among Wild bean however, TVUN2 had increase in leaf area compared to control while TVUN16 had decrease upon exposure to lead concentration compared to the control.

Table 6: Effect of Lead on leaf area in Wild *Vigna*, Cowpea and Bambara groundnut

Crop	Control	PbCl2	Mean	LSDv	LSDt
Wild Vigna					
TVUN2	16.5	26.57	21.53a	9.14	14.07
TVNU16	10.4	2.23	6.32b		
Mean	13.45a	14.4a			
Cowpea					
TVU2	0	83.37	41.73a	50.59	65.96
TVU8	130.4	76.57	103.48b		
Mean	65.2a	79.92a			
Bambara					
TVSU3	0	6.63	3.22a	19.59	17.31
TVSU7	0	26.37	13.18a		
Mean	0a	16.40a			

Means followed by same superscripts within same column or row are not significantly different

TVNU16 in the control had an increased number of pods per plant compared to the control while among the Cowpea, TVU82 had an increase in number of pods per plant upon exposure to lead solution (Table 7).

Table 7: Effect of Lead on number of pods in Wild *Vigna*, *Cowpea* and Bambara groundnut

Crop	Control	PbCl2	Mean	LSDv	LSDt
Wild Vigna					
TVNU2	0	0	0a	1.49	1.49
TVNU16	2.99	0	1.49a		
Mean	1.49a	0a			
Cowpea					
TVU2	0	9.87	5.83a	8.44	7.62
TVU8	6.99	5.67	6.32a		
Mean	3.49a	8.67a			
Bambara					
TVSU3	0	0	0.0a	0.37	0.37
TVSU7	0	0.33	0.17a		
Mean	0.a	0.17a			

Means followed by same superscripts within same column or row are not significantly different

Discussions

The study's findings demonstrated that the TVU8 cowpea accession performed better than the TVU2 accession with increased exposure to the lead-polluted soil. As indicated in Table 2, TVU8 had a higher plant height (19.25) than TVU2 (8.52), one of the parameters measured. The similar pattern was seen for additional characteristics such as plant girth, branch count, leaf count, leaf area, and pod count per plant.

While not considerably different from the other accessions, TVNU2 accession recorded the maximum plant height in the case of the wild *Vigna*. Finally, among the Bambara, TVSU3 had the tallest plant height (3.53cm). As a result, their findings differ from those of Tomar *et al*., (2000), who from his findings of this study revealed that the TVU8 cowpea accession stated that a significant drop in plant height, root-shoot ratio, dry weight, nodule per plant, and chlorophyll content in *Vigna radiate* was induced by a higher level of lead in the soil.

Different factors that were examined in Wild Vigna responded differently when exposed to the heavy metal lead. For instance, TVUN 16 did better in terms of number of leaves and number of pods per plant, with 182.34 to 131.84 in TVUN2 and 1.49 and 0.00 for each, respectively (Table 5 and 6). However, TVUN2 outperformed TVUN16 in terms of metrics including plant height, plant girth, branch count, and leaf area. The greatest Pb and Zn concentrations examined, according to Oladele *et al*. (2013), caused 92.3% and 30% percentage chromosomal abnormalities in Bambara groundnut, respectively. This variation in the response to the heavy metal utilized in this investigation could be caused by chromosomal abnormality. Severe reductions in the enzyme activity involved in seed metabolic processes related to germination have been linked to Cu-induced oxidative stress (Mahmood, 1995, Ayaz and Kadioglu, 1997). This is thought to be the cause of the various wild beans' responses to lead.

In addition, Bambara nuts exposed to lead-contaminated soil revealed that TVSU3 had the maximum number of leaves (1.77) compared to TVSU7 (1.73) despite this difference not being statistically significant. In accordance with other findings, TVSU7 had superior plant height, plant girth, leaf number, leaf area, and pod number per plant. Lead exposure can have negative impacts on plant germination and growth, even at micromolar levels (Kopittke *et al*. 2007). There were obvious indications of growth retardation in plants subjected to high lead poisoning levels, including fewer, smaller, and more brittle leaves with dark purplish abaxial surfaces. (Islam *et al*. 2007; Gupta *et al*. 2009). According to Kopittke *et al*. (2007), and disrupted photosynthesis, nutrient metabolic abnormalities may be responsible for lead exposure-related plant growth retardation (Islam *et al*. 2008). It is most likely due to interspecies variations in seed coat structures that control metal absorption that Pb and Zn have not consistently deleterious impacts on seed germination. According to reports, plant seeds are naturally capable of selectively absorbing metals from the environment (Stefanov *et al*., 1995).

This implies that in order to lessen their detrimental effects on germination, Pb and Zn absorption from the solution may have been selectively lowered in the seed coat structures of wheat, rice, and barley. A variety of seed germination inhibitors result from different levels of seed coat permeability to metals (Wierzbicka and Obidziniska, 1988). Lead may accumulate in the root system after penetrating it or it may go to aerial plant components. According to reports on Vicia faba, Pisum sativum, and Phaseolus vulgaris (Piechalak *et al*., 2002; Malecka *et al*., 2008), the majority of the absorbed lead (about 95% or more) accumulates in the roots of most plant species.

Although many metals exhibit the translocation limitation phenomenon described above, not all heavy metals exhibit this behavior. Nevertheless, this behavior in plants is unique to lead and is highly strong.

Because to the increased use of industrial processes, goods, and chemicals in both raw and processed foods, as well as the use of irrigated water for planting, human exposure to heavy metals has increased dramatically. A very low lead concentration may inhibit some essential plant processes, such as photosynthesis, mitosis, and water absorption, resulting in toxic symptoms such as dark green leaves, wilting of older leaves, stunted foliage, and brown short roots (Bhattacharyya *et al*., 2008). Elevated lead levels in soils, for example, may decrease soil productivity. Potentially harmful, heavy metals can cause chlorosis, stunted growth, and low yield. They can also cause problems with plant metabolism, decreased nutrient uptake, and a decreased capacity to fix molecular nitrogen in legumes (Guala *et al.*, 2010).

Result from this research showed that TVU8 cowpea accession had the best performance compared to TVU2 accession with increased exposure to the lead polluted soil. Parameters measured such as plant height, TVU8 had the highest plant height (19.25) compared to TVU2 (8.52) as shown in Table 2. The same trend was observed for other characters like plant girth, number of branches, number of leaves, leave area and number of pods per plant. In the case of the case of the wild Vigna, TVNU2 accession recorded the highest plant height though not significantly different from the other accession. Finally in the case of Bambara nut, TVSU3 had the highest plant height. These results are hence in variance with work done by Increased levels of lead in soil were found to significantly lower plant height, dry weight, nodule per plant, root-shoot ratio, and chlorophyll content (Tomar *et al*., 2000) in *Vigna radiate.* The different response to the two different accessions of cowpea to exposure to lead polluted soil is believed to be based on varietal difference at this stage. TVNU2 had the highest stem girth and number of branches (Table 3 and 4).

Considering Wild Vigna, different parameters measured showed different response upon exposure to the lead heavy metal. For example, in terms of number of leaves and number of pods per plant, TVUN 16 performed better with 182.34 to 131.84 in TVUN2 and 1.49 and 0.00 for number of leaves and number of pods per plant respectively (Table 5 and 6). TVUN2 however recorded better results than TVUN16 in features recorded like plant height, plant girth, number of branches and leave area. The highest doses of Pb and Zn that were evaluated caused 92.3% and 30% percentage chromosomal abnormalities in Bambara groundnut, respectively, according to Oladele *et al*. (2013). This variation in the reaction to the heavy metal utilized in this investigation could be attributed to chromosomal abnormality. Cu-induced oxidative stress has been found to cause a significant decrease in the activity of enzymes involved in the metabolic pathways connected to germination in seeds. (Mahmood, 1995, Ayaz and Kadioglu, 1997). This is suspected to be the reason for the response of the different wild bean to lead

Furthermore, Bambara nuts upon exposure to lead polluted soil indicated that TVSU3 had highest number of leaves (1.77) compared to TVSU7 (1.73) though not significantly different. Other results showed that TVSU7 had better plant height, plant girth, number of leaves, leave area and number of pods per plant. Lead exposure can have negative effects on germination and growth, even at micromolar levels (Kopittke *et al*. 2007). Plants under severe lead poisoning stress showed clear signs of growth inhibition, with darker purplish abaxial surfaces on fewer, smaller, and more brittle leaves (Islam *et al*. 2007; Gupta *et al.* 2009). Lead exposure-related growth retardation in plants may be related to disruptions in photosynthesis and nutrition metabolism (Kopittke *et al*. 2007; Gopal and Rizvi 2008; Islam *et al*., 2008). The lack of consistent detrimental effects of Pb and Zn on seed germination is probably because different species' seed coat architectures regulate how much metal is absorbed. Plant seeds are said to possess an innate ability to selectively absorb metals found in the environment (Stefanov *et al*., 1995). This implies that in order to lessen the negative effects of Pb and Zn on germination, the seed coat structures of barley, rice, and wheat may have preferentially decreased their absorption from the solution. Different levels of metal permeability in seed coats result in different inhibitions of seed germination (Wierzbicka and Obidziniska, 1988). Lead may accumulate in the root system after it has entered there or it may go to aerial plant components. *Pisum sativum*, *Phaseolus vulgaris*, and *Vicia faba* have all been shown to collect the majority of absorbed lead (about 95% or more) in their roots, with only a little portion moving to the aerial parts of the plant (Piechalak *et al*. 2002; Małecka *et al*. 2008). While the translocation restriction phenomena have been observed in many metals, not all heavy metals exhibit this effect. Nevertheless, this behavior in plants is unique to lead and quite strong.

CONCLUSION

The response of the three (3) underutilized legumes to heavy metal revealed different response due to varietal differences. TVUN 16, TVSU7 and TVU8 had the best performance in terms of yield upon exposure to the lead polluted soil. Therefore, when considering the accessions for the purpose of cultivation in a lead polluted soil, TVUN 16, TVSU7 and TVU8 are recommended based on the results found.

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