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Chromium Effects on Early Growth of Water Leaf (*Talinum triangulare*) in an Ultisol

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Abstract: The greenhouse experiment was carried out at the Faculty of Agriculture, University of Benin, Benin City to investigate the influence of chromium on some soil chemical properties and some agronomic characters of *Talinum triangulare*. The experiment was organized in a completely randomized design with three replicates. Four rates of 0, 50, 100 and 200 mg Cr per 5kg soil were used. The results revealed that the soil N, P, K, Ca, Na, effective cation exchange capacity and organic carbon decreased at various levels of chromium application whereas the exchangeable acidity, percentage base saturation, Mg and Cr content of the soil increased. The number of leaves was decreased with increasing Cr application with no significant differences among the various treatments whereas the stem girth was decreased significantly with increasing Cr treatments. Plant height, which increased up to 100 mg Cr treatment, also had no significant differences among the various treatments. The shoot dry matter was decreased significantly with increasing Cr levels while the root dry matter had no significant differences among the treatments. The Cr content and the uptake by shoot and root were increased with increasing Cr treatments. However, the Cr content of the root was higher than that of the shoot while the shoot uptake was higher than that of the root. Ca and P content of the plant were decreased and increased respectively with increasing Cr treatments. While K and Na content of the plant increased up to 100 mg Cr treatments and then declined. N and Mg content of the plant however were not consistent with increasing Cr treatments. The application of Cr significantly decreased the uptake of Ca and Mg consistently while K, N, Na and P uptake increased up to 100 mg Cr and then declined at 200 mg Cr treatments.

Key words: Uptake · Chromium · Ultisol · Waterleaf · Accumulation

INTRODUCTION

The implications associated with heavy metals contaminations are of great concern particularly in agricultural production systems [1]. Diverse amount of heavy metals are found as contaminants in agricultural production especially in urban horticultural crop production. The contamination of agricultural soils is often a direct or indirect consequence of anthropogenic activities [2]. Sources of anthropogenic metal contamination in soils include urban and industrial waste, mining and smelting of non-ferrous metals and metallurgical industries. Other sources of anthropogenic contamination include the additions of manure, sewage sludge, fertilizers and pesticides to soils [3]. These metals, once introduced to the environment by one particular method, may spread to various environmental components, which may be caused by the nature of interactions occurring in the natural systems [4].

Crops take up the heavy metal either as mobile ion in the soil solution through the roots [5] or as foliar adsorption [6]. Shaganas *et al.* [7] reported that high Cr associated with the soil components significantly reduced the shoot and root lengths of *Vigna radiatea*. While Subramani *et al.* [8] indicated a gradual decline in growth parameters of *Vigna mungo* with increasing Cr concentration. The chromium has also been reported to affect water status and mineral nutrition of bean plant [9]

However, Cr appears to be essential to man and animals because of its functions in mammalian glucose metabolism [10]. The uptake of these metals by crops results in the bioaccumulation of these elements in plant tissue. The kind of metal, plant species and plant parts however influence the uptake of the metals [11]. Alloway and Davies [12] reported that plants grown on soils possessing enhanced metal concentration due to pollution have increased heavy metal ion content. One of the ways by which heavy metals are consumed is via

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the food chain. If the consumption of these metals through plant sources is not regulated, it may lead to accumulation in man with high potentials for health hazards. The crop such as *Talinum triangulare* is found to grow ubiquitously on soil polluted with toxic heavy metals such as dumpsites, rubbish heaps, mechanical workshops etc in Benin metropolis where it is regularly harvested and consumed This plant has not screened to determine its ability to phyto-accumulate heavy metals. Recent development in environmental pollution calls for studies of the impact of heavy metals on some soil properties with respect to crop production. This study therefore, was carried out to determine the influence of Cr on some agronomic characters of *Talinum triangulare* and some chemical properties of the soil.

MATERIALS AND METHODS

Pot experiment was carried out in the greenhouse at the Faculty of Agriculture, University of Benin, Benin City, Nigeria. The experiment was laid out in a completely randomized design with 3 replicates. Each replicate had 20 pots with 5 pots per treatment. The soil used was collected from 0-15cm depth of uncultivated field left fallow for 5 years. The soil sample was air-dried, sieved and the 5 kg soil filled into the polythene pots. The pots were treated with $Cr(No_3)_2 \cdot 9H_2O$ at rates of 0, 50, 100 and 200 mg and then left for two weeks to allow the Cr equilibrate with soil.. Basal dressing of nitrogen-phosphorus-potassium (N-P-K) at 10 $kgha^{-1}$, 10 $kgha^{-1}$ and 10 $kgha^{-1}$ was applied as urea, single superphosphate and muriate of potash respectively.

Seeds *Talinum triangulare* obtained locally were sown in the nursery, left for 4 weeks before transplanting at one plant per pot. The seedlings were watered regularly with distilled water. Weeding was carried out regularly. The experiment lasted for 50 days when the plant height, number of leaves and stem girth were determined. Thereafter, the plants were harvested, separated into shoot and root parts and then oven dried at 78°C for 48 hours to obtain a stable dry weight used in calculating the nutrient uptake.

Soil Analysis: Soil pH was determined by using a pH meter while the soil particle size was done by methods of Day [13]. The organic carbon was determined by chromic acid wet methods of Black [14]. The total N was determined by micro-kjeldal procedure as described by [15] whereas the available P was extracted by using Bray No 1 P solution and the P in the extract assayed colorimetrically by molybdenum blue colour method of Jackson [16]. The exchangeable bases were extracted using 1 N neutral ammonium acetate solution. The Ca and Mg content of the extract were determined volumetrically by EDTA titration procedure Black [14]. The K and Na were determined by flame photometry and Mg content obtained by difference. The exchangeable acidity was determined by methods of Mclean [17] while the Cr was determined by methods of Soon and Abboud [18]. The data generated were analyzed by the genstat statistical package (Genstat statistical version 6.1.0 234) [19].

Plant Analysis: The plant materials were ground (< 1 mm) and then digested with a mixture of HNO_3, H_2SO_4 and $HClO_4$ acids [20]. The mineral ions (Na, K, Ca, Mg and Cr) were determined by the use of atomic absorption spectrophotometer. For P content [21] perchloric acid, digestion (wet oxidation) method was used while the micro-kjeldal method of Jackson [16] was used for N determination.

RESULTS AND DISCUSSION

Pre-Trial Soil Properties: The properties of the soil used before the trial are shown in Table 1. The chemical properties of the soil used showed that the soil is moderately acidic with low percentage base saturation typical of ultisols and the soil was low in fertility. The N value was less than the critical level of 1.5 gkg^{-1} as reported by Enwenzor *et al.* [22]. The available P value was less than the critical level of 10-16 $mgkg^{-1}$ reported by Adeoye and Agboola [23] while the K value was less than the critical level of 0.18-20 $cmolkg^{-1}$ recorded by Agboola and Obigbesan [24]. The Cr level of the soil was less than the critical level of 0.3 $mgkg^{-1}$ [25].

The Post-trial Soil Chemical Properties: The properties of the soil after the trial are shown in Table 1. The organic carbon, N, available P, Ca and Na declined significantly at various levels of Cr treatments except soil pH, K, percentage base saturation which recorded no significant differences among the various treatments. The Mg, exchangeable acidity, effective cation exchange capacity and Cr content of the soil however recorded a significant increase among the various Cr concentrations. The fluctuations of these nutrients may be tied up with the uptake by the plant at various levels of Cr concentrations as earlier reported by Orhue [26] in *Telfairia occidentalis*.

Table1: Some chemical properties of the soil used in the trial

Treatment mg/5kg soil	Soil:H_20(1:1)	Org $Cgkg^{-1}$	$Ngkg^{-1}$	Av $Pmgkg^{-1}$	K	Mg	Ca	Na	Exch acidity	ECEC acidity	Base saturation (%)	Cr $mgkg^{-1}$
					---- $cmolkg^{-1}$ ----							
Before	Cr	Treatment										
	5.71	21.1	1.30	6.19	0.12	0.12	0.76	0.12	1.21	2.32	28.00	0.01
After		Harvest										
0	5.06a	0.91b	0.06b	4.01a	0.06a	0.16b	0.48a	0.09b	1.94b	2.73b	28.93a	0.07d
50	5.07a	1.07a	0.08a	3.29b	0.05a	0.18a	0.42c	0.09b	1.95a	2.69c	27.51a	8.61c
100	5.11a	1.07a	0.08a	2.38c	0.05a	0.18a	0.48a	0.10a	1.96a	2.77a	29.24a	18.92b
200	5.06a	1.07a	0.08a	2.38c	0.05a	0.17ab	0.45b	0.09b	1.91c	2.67c	28.46a	44.55a

Mean values with the same letter in the column are not significantly different from one another at $P < 0.05$

ECEC: Effective Cation Exchange Capacity

Table 2: Effect of Cr on some mineral content (%) of and uptake by Talinum triangulare ($mgkg^{-1}$)

Treatment mg/5kg soil	Minerals ions Content						Mineral ions Uptake					
	N	P	K	Mg	Ca	Na	N	P	K	Mg	Ca	Na
0	3.04d	0.22d	2.56c	0.41a	1.27a	5.43c	16.20c	1.17c	13.66b	2.19a	6.77a	28.96c
50	4.05a	0.25c	2.80b	0.27b	0.83b	7.12b	17.55b	1.08c	12.13c	1.17c	3.60b	30.85b
100	3.46c	0.32b	2.87a	0.28b	0.66c	9.31a	19.26a	1.78a	16.19a	1.41b	3.69b	48.10a
200	3.54b	0.38a	2.01d	0.17c	0.55d	2.08d	13.33d	1.33b	7.58d	0.64d	2.07C	7.84e

Mean values with the same letter in the column are not significantly different from one another at $P < 0.05$

Table 3: Effect of Cr levels on some growth parameters and dry matter yield of *Talinum triangilare*

Treatment mg/5kg soil	Plant height (cm)	Stem girth (cm)	No of leaves	Shoot dry weight (g)	Root dry weight (g)
0	17.30a	1.83a	19.00a	0.56a	0.11a
50	19.00a	1.53b	15.00a	0.53b	0.11a
100	19.70a	1.47c	14.70a	0.43c	0.10a
200	18.30a	1.30d	13.30a	0.38d	0.01b

Mean values with the same letter in the column are not significantly different from one another at $P < 0.05$

Table 4: The Cr content and its uptake by *Talinum triangulare*

Treatment mg/ 5kg soil	Shoot Cr content (%)	Shoot Cr uptake gkg^{-1}	Root Cr content (%)	Root Cr uptake gkg^{-1}
0	0.13d	0.001a	1.61c	0.002b
50	1.51c	0.007a	2.60b	0.003a
100	1.81b	0.04a	2.61b	0.003a
200	2.56a	0.07a	2.70a	0.0003c

Mean values with the same letter in the column are not significantly different from one another at $P < 0.05$

Mineral Ions Content (%) and Their Uptake by *Talinum triangulare:* The mineral ions and their uptake are shown in Table 2. The N and Mg content of the were not consistent with increasing Cr levels whereas the P and Ca increased and decreased respectively with increasing Cr treatments. K and Na components of the plant increased consistently up to 100 mg Cr treatments and then declined. However, significant differences were recorded among the various Cr treatments. Similarly, the uptake of P, K, Mg and Ca were not consistent with increasing Cr concentration but significant differences were found among the various Cr concentrations. The uptake of N and Na however significantly increased consistently up to 100 Cr mg treatments. The highest Cr dosage may have caused inbalances in mineral content of the plant especially in high Cr dosage leading to reduction in most of the essential macronutrients needed for growth. Similar results have earlier been reported by Azmat and Haider [27] in *Phaseolus mungo* and Orhue [26] in *Telfairia occidentalis.*

Effect of Cr Levels on Some Growth Parameters and Dry Matter Yield of *Talinum triangulare:* Table 3 shows the effect of Cr levels on some growth parameters and dry matter yield. As the Cr concentrations increased, stem girth significantly decreased consistently with increasing Cr treatments. Number of leaves was also decreased consistently but no significant differences recorded among the various Cr levels. Plant height was increased consistently up to 100 mg Cr and then declined with no significant differences recorded the various Cr treatments. In addition, as Cr concentrations increased, the shoot and root dry matter yield decreased consistently with significant differences detected among the various Cr treatments in shoot dry matter yield. There was however no significant differences recorded among the Cr treatments in root dry matter yield. The reduction in shoot and root dry matter yield with high Cr dosage may be attributed to the toxicity or Cr antagonism of other nutrients. This result further strengthens the results of Azmat and Khanum [9].

Chromium Content and its Uptake by *Talinum triangulare:* Table 4 depicts the chromium content and uptake. As the Cr levels increased, the shoot and root Cr components increased consistently with the 200 mg Cr treatment significantly higher than other treatments. The uptake of Cr by the shoot also increased consistently as the Cr concentration increased with however no significant differences recorded among the Cr levels whereas the uptake of Cr by the root significantly increased up to 100 mg Cr. Higher Cr was however found to accumulate in the root than the shoot. High accumulation in root makes the plant a metal excluder as earlier reported by Raskin *et al.* [28].

CONCLUSION

The high Cr dosage altered the mineral ions uptake, synthesis and translocation in *Talinum triangulare*. In growth parameters, the plant height was increased with increasing Cr treatments up to 100 mg Cr while the stem girth, number of leaves and dry matter yield were decreased with increasing Cr application. In addition, high Cr accumulation was found in the root than the shoot with the control level having the least Cr value. The accumulation of Cr in the 0 mg Cr treated plant was low compared to WHO [25] maximum acceptable level of $0.3 mgkg^{-1}$ for most leafy vegetables whereas the Cr content of the plants treated with Cr exceeded the WHO [25] acceptable level thereby making it hazardous to health when consumed. The Cr content of the soil increased with increased Cr application and there was however, no negative influence of Cr treatments on the soil nutrient components.

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