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# Cowpea emergence response to cadmium stress

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## Abstract

*Cadmium been the utmost prominent and extensively distributed heavy metal in Nigeria soils. This study investigated the emergence of cowpea accessions (TVu-91,92,93,95 and 96) to cadmium stress in Nigeria soils. The experimental setup consisted of 3 treatments namely 0ESV, 2.5ESV and 5ESV (Ecological Screening Value) and the following parameters were taken; time to 50% emergence, height of emergence, hypocotyl length, terminal leaf breadth and length, fresh and dry weight matter. Cadmium caused a significant decrease in the studied parameter. In TVu-91, cadmium pollution resulted to 2-days delay in time to 50% emergence between the control and 5ESV. The emergence height of TVu-93 sown in Cd-5ESV was 10.67cm as compared to 12.10cm in the control, the hypocotyl length was also reduced from 3.7 to 2.3cm with increased concentration. Terminal leaf length and breadth followed similar trend of reduction. However, the various accessions responded differently as there were insignificantly difference observed in the emergent height of TVu-93 between the treatments. In conclusion, although cadmium pollution reduced the emergence productivity of cowpea accession, however its effect varied within the accessions. This suggests that the presence of the genetic makeup of the individual accessions have the ability to withstand cadmium stress.*

**Keywords:** Pollution, heavy metal, germination, soil toxicity, plant physiology.

## Introduction

The environmental and human health implications of heavy metal is owing to their prevalent existence, tenacious in ecosystems, and noxious properties[1]. Some of this heavy metals e.g. copper and zinc are necessary elements in plants growth and development. Zinc is significant to plant for production of seeds and in disease resistibility while Cu is importance in the metabolic processes of most plants. Nonetheless, some heavy metal existing in little concentrations are detrimental to plants. One of such heavy metal is cadmium and is commonly found as a contaminant in Nigerian soils[2]. Cadmium is extremely poisonous to all biota and is mainly one of the greatest toxic metal in plants' because of its great dissolvability in $H_2O$ and phytotoxicity[3]. Cadmium is has no relevance in the nutrient cycle of plants and when in high amount impedes growth[4]; even when comparatively minute, it modifies plants metabolism[5].

There are various natural and anthropogenic sources that adds heavy metals in to the environment. In natural processes, volcanic upsurges is one of the main source of Cd, however the quantity of the metal released is relatively in significant in contrast to anthropogenic processes. While anthropogenic sources includes; industrial waste, fossil fuel combustion, waste ignition, phosphate fertilizers, among others are the largest contribution of Cd to the environment. A great consideration has been given to cadmium in both plant nutrition and soil science because of its phytotoxic effect which varies from growth reduction[4], wilting, chlorosis[6] and cell death[7].

They are ubiquitous, persistence, non-biodegradable and accumulate in the environment. This implies that living organisms are continuously exposed to Hms[8] throughout their life cycle, resulting in toxicity[9]. Plants however, depend on some mixture of nutrients found in soil and air, as well as the solar energy, $CO_2$, and water for photosynthetic processes[10]. Food chain pollution by metal is a burning concern in recent years due to their impending build up in bio system through polluted soil, $H_2O$ and air[4]. The existence of plants is hinged on their capacity to identify the impetus, transmit signals and initiate defense mechanisms that regulate their metabolism accordingly[11].

Cowpea, *Vigna unguiculata* (L.) Walp, also popularly called 'beans' in Nigeria is an essential food crop (legume) and resourceful plant, mainly nurtured in the dry savannas regions of tropical Africa, including south America and Asia, spanning over 12million ha with a yearly production surpassing 3milliontones[12]. Around 64% of the cultivated areas used for cowpea is in Central and West Africa where the crop is mainly planted in combination with sorghum, millet and maize usually in Sahelian and Sudan savanna region. Cowpea serve as a source of cash income and protein supplement in the daily life of people in Nigeria.

Nutritionally, the pods, leaf and green peas are eaten as food, with the green including the dry haulms used as livestock fed. Nigeria been the biggest producer and consumer of cowpea in the world[13].

In Nigeria, cowpea is mostly grown in the north which characterized with the savanna type of vegetation and light rainfall, with Borno State being the major producer[14]. Owing to several limitations the amount of cowpea produce in West Africa was shown to be below 358kg/ha[15] however Singh *et al.*[16] projected 240kg/ha cowpea produce as an average in Nigeria. Some of these constraints include; insect pests infestation,[17] diseases[18], heavy metals[19], insufficient information of ideal ethnical practices and great yielding varieties causing reduced yields[20]. Studies showed the efficiency of cowpea to produce in such structures can be improved over the use of better-quality varieties, suitable date of planting, sophisticated plant population, enhanced soil richness, and appropriate spatial arrangements[21]. Recently, the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria developed some enhanced cultivars of cowpea for the savanna ecological zones. These cultivars are said to be superior to the local cultivars in many aspects (high yielding, earlier maturity, resistant to major pests and diseases). Attention is now being given to developing cultivars that can resist environmental stress. Therefore, the aim of this study was to examine the effects of cadmium stress on emergence parameters of 5 cowpea accession (TVu91, TVu92, TVu93, TVu95 and TVu96) obtained from IITA.

## Materials and methods

**Seed collection:** The cowpea seed and its respective accession namely; TVu91, TVu92, TVu93, TVu95 and TVu96 were procured from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

**Metal:** The experimental cadmium used was cadmium chloride procured from Pyrex chem. Lab. in Benin, Nigeria.

**Experimental setup:** The experimental setup was performed in the Botanic farm of the Dept. Plant Biology and Biotech., UNIBEN, Benin city. The soils were also collated here from ten random spots and mixed together to obtain composite sample. Soil samples were collected randomly in the site at a 0–30cm depths by the use of a soil auger. The soil samples were mixed together into a composite sample, sun-dried, grind to pass through a 2mm sieve before sending to the laboratory for physic-chemical examination using to standard techniques. The soils were afterward contaminated with cadmium based on its ecological screening value (ESV). Three concentrations were obtained; 0 ESV, 2.5ESV and 5 ESV.

**Sowing:** This comprised of 3 blocks with 15 treatments per block, 1 plant per polybag resulting to 45 plants organized in a random complete block design (RCBD). The experimental setup was left for 14weeks and parameters taken. The height of emergence, hypocotyl length, petiole length, terminal leaf length and breadth were measure using a meter rule in centimeter while stem width was measured in millimeters, the fresh weight was by weighing in grams while the dry matter was oven dried at 70˚C according to Ekpo and Ebeagwu[22]. Time to 50% emergence (T50) is the days needed for 50% emergence of the total number of seeds[23].

**Table-1:** Treatment designations for metal concentrations.

| Designations | Description | Replications |
|---|---|---|
| 0 ESV | Control (unpolluted soil) | 3 |
| 2.5 ESV | 0.15g of cadmium chloride diluted in 2L of water and mixed in 15kg soil | 3 |
| 5 ESV | 0.30g of cadmium chloride diluted in 2L of water and mixed with 15kg soil | 3 |

**Statistical analysis:** The data was subjected using statistics to one way analysis of variance (ANOVA). The least significant difference (LSD) were used to separate any difference in their means. Results were presented as means and standard error (n= 7). The significance of the results was ascertained at $p<0.05$. The SPSS-20® software was employed to run analyses of data.

## Results and discussion

**Effects of cadmium on Time to 50% Emergence:** In this study, the effects of cadmium on 50% emergence time of cowpea accession (TVu91, TVu92, TVu93, TVu95 and TVu96) have been reported (Figure-1). TVu-95 sown in the control soils had a 50% mean emergence time speed of 4.20 days as compared to a delay of 6.30 days in TVu-95 sown in Cd-5ESV soil. The prolonged delayed difference of 3.00 days also reported in time to 50% emergence of TVu-93 between the Cd-5ESV and control conforms to those observed by other researchers[24]. For example, Rahman[25] detected a reduced germinated seed and seedling development in chickpea exposed to 50, 100, 200 and 400ppm of nickel and cobalt. Singh et al.[26] reported a decline in germination percent and initial growth period of wheat exposed to copper at different levels. This shows that cadmium polluted soils affects time to 50% emergent of cowpea accessions, though there was no significant difference (P=0.17). Metal toxicity is a vital issue governing sprouting and growth of plants. Energy generation is vital for seed emergent and any impediment can disturb protein, DNA and RNA production including mitosis due to the fact that energy is a prerequisite for these processes to occur[27].

**Effects of cadmium on height of emergent:** The effects of cadmium pollution on cowpea resulted in a reduction in emergent height (Figure-2). Germination and initial seedling sprouting evaluation is regarded as an elementary experiment for assessing the toxic effects of any heavy metal or element type on plants[28,29]. There was a decrease in seedling emergence height with increased metal concentration. Take for instance, TVu-93 sown in Cd-2.5ESV and Cd-5ESV had an emergent height value of 11.47cm and 10.67cm respectively as compared to 12.10cm in the control. Seedling growth is agreed as a relevant pointer of metal effect on plants' capacity to existence. However, TVu-92 was more resilient to Cd pollution than the other studied accessions. Hence, cadmium pollution was highly significantly different (P=0.000). Some researchers has stated the decline of emergence and seedling growth of difference crops exposed to metals toxicity. This was not far from the present study were the emergence height and hypocotyl length reduced with increase in Cd concentration. Take for instance, TVu-91 reduced from 11.62 to 10.30cm with increased metal toxicity. This can be due to the noxious effects of ions on the emergence process[30,31].

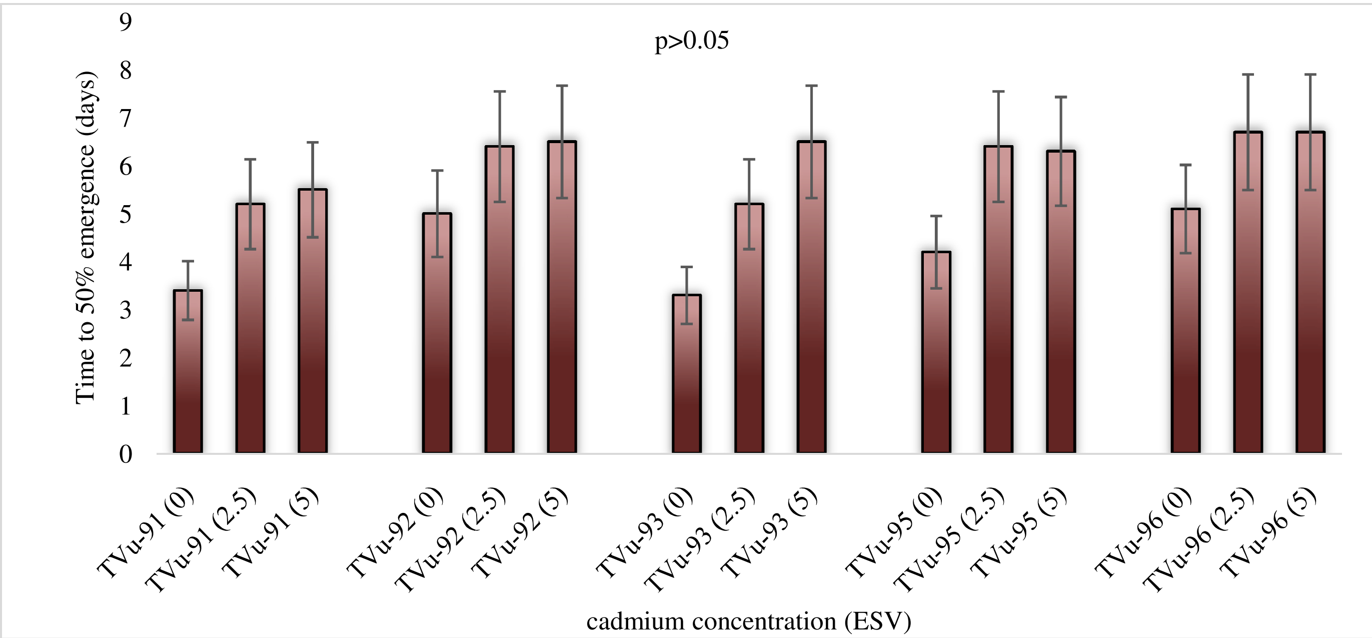



**Figure-1:** Time to 50% emergence (days) of cowpea.

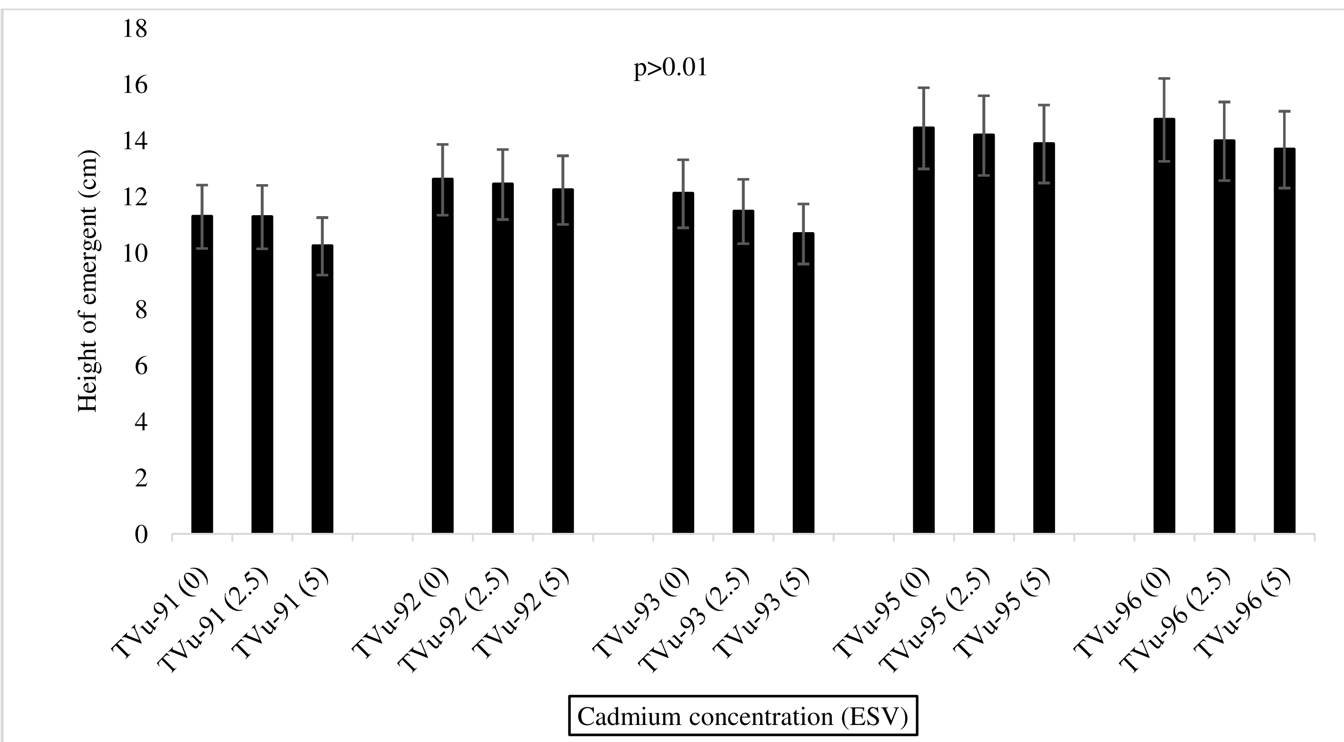



**Figure-2:** The height of emergent of cowpea.

**Effects of cadmium on fresh and dry weight of emergent:** Figure-3 shows the fresh weight performance of emerged cowpea accessions to various concentration of cadmium. In this study, Cd significantly reduced both fresh and dry weight of emergence over the control. Fresh weight of emergent in TVu-91 sown in Cd-5ESV was 0.65g as compared to an increased 1.35g in TVu-91 in the control. The existence of inhibitory compounds in greater concentrations of the metal may be the cause for the various performance of the extracts and extreme reduction in the emergence parameter[32]. The plant dry weight matter followed similar trend of reduction with increase in metal concentration. TVu-91 was more susceptible to cadmium pollution than TVu-92. This decline in biomass can be credited to the inhibition of chlorophyll synthesis and photosynthesis by the metal. These results is in line with Singh *et* al.[26].

**Effect of cadmium on hypocotyl length:** The hypocotyl length of cowpea accession to cadmium pollution has been reported (Figure-4). Cadmium pollution resulted to a decrease of 1.4cm in the hypocotyl length of TVu96 between Cd-5ESV and control. This indicated that increased Cd concentration, decreases the hypocotyl length of the cowpea accessions. However, cadmium pollution has no significant difference (P=0.07) on the hypocotyl length of various cowpea accessions. The process of germination like emergence height and hypocotyl length will be suppressed. This findings is in agreement with previous studies carried out[4,6].

**Effects of Cd on Terminal leaf length and breadth:** Figure-5 shows the consequence of cadmium pollution on the terminal leaf length and breadth of cowpea accessions. There was a reduction in terminal leaf breadth in all treatments with TVu-96 sown in Cd-5ESV having a value of 3.9cm as compared to 4.9cm in TVu-96 sown in the control soils. Growth decrease in Cd environments was observed for several species tested[33-35]. In this study, a significant reduction was reported for the hypocotyls, terminal leaf length and breadth particularly in the 50% emergence time radicles. Hence, the findings provide further backing to the previous research. Hence, a significant difference (P=0.009) exist on the terminal leaf breadth of the studied accessions to cadmium pollution.

## Conclusion

From the findings, Cd pollution induce growth inhibition in cowpea seedlings, especially at 50% emergence time. However, the various accessions responded differently as there was little to no difference in the height of emergence of TVu-95. The observed variation in the cowpea seedlings response is strongly dependent on the intrinsic characteristics inherent within the accessions type.

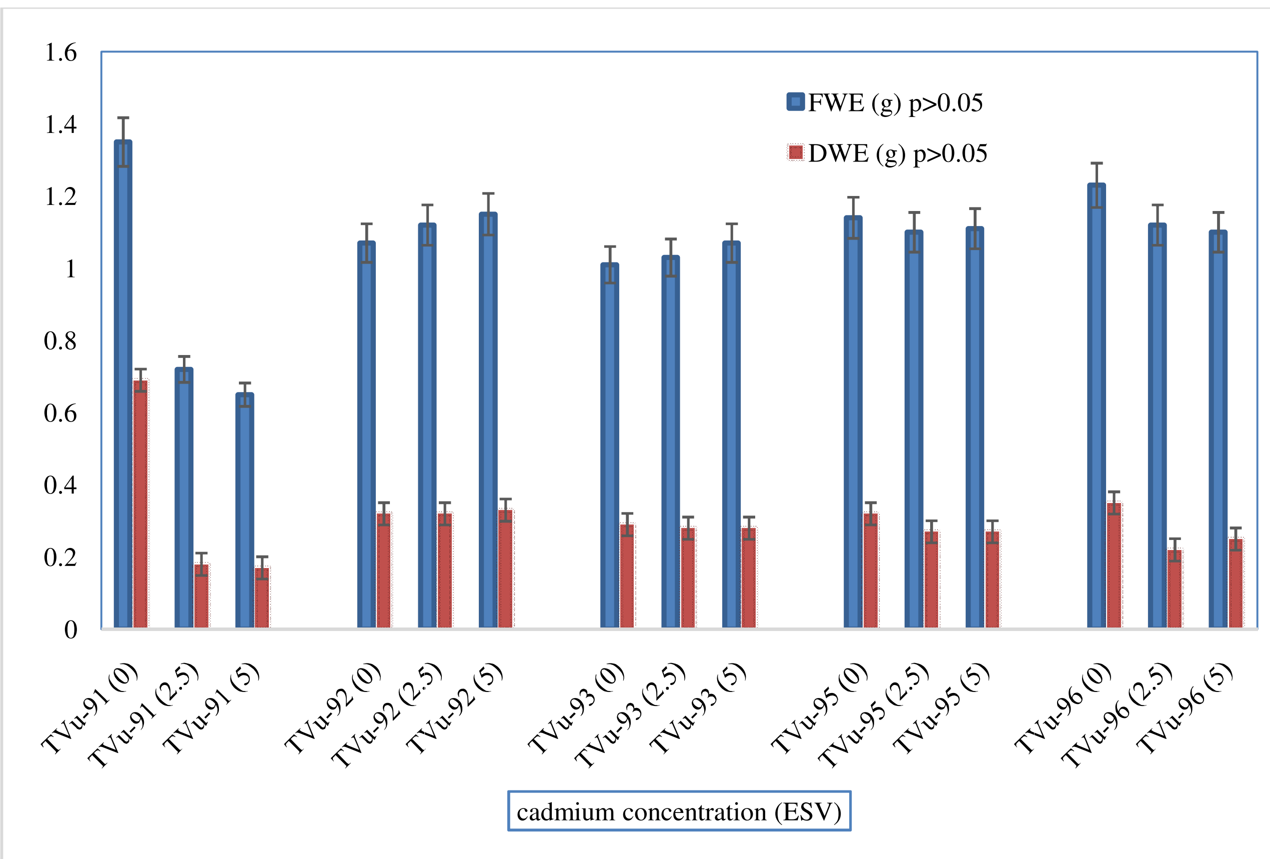



**Figure-3:** Fresh weight of emergent (FWE) and dry weight of emergent (DWE) of cowpea.

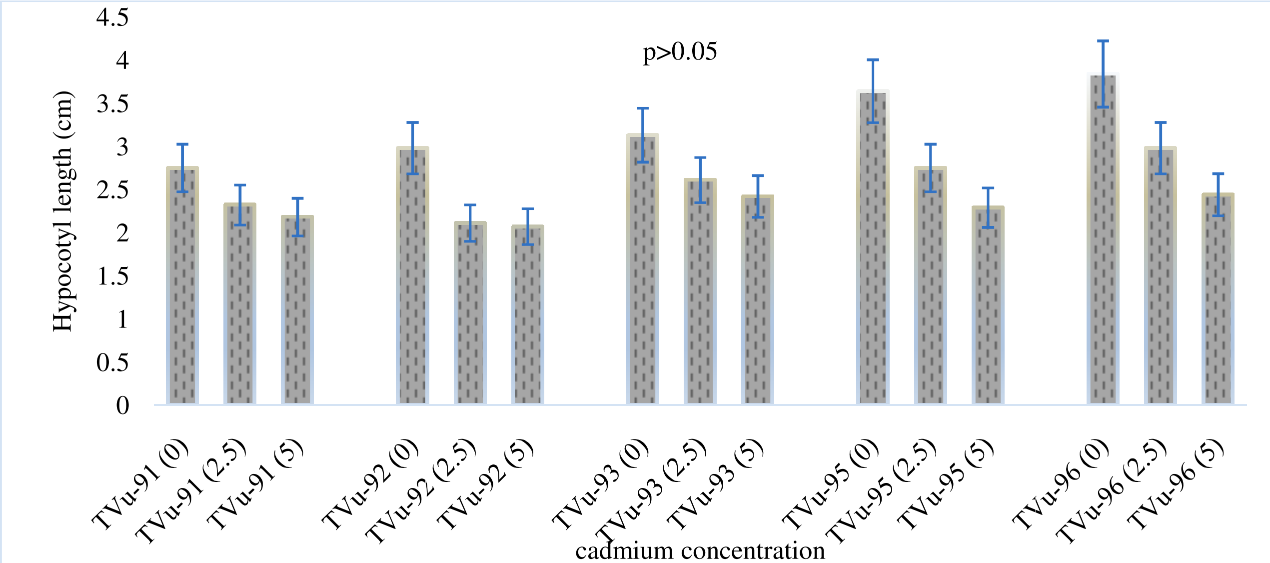
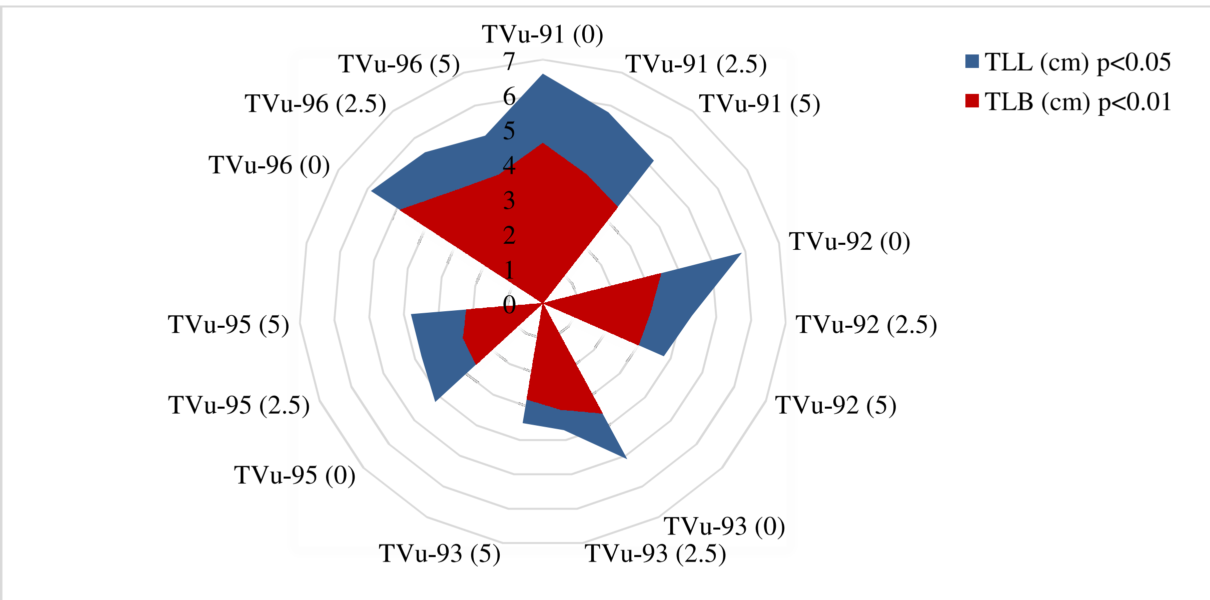



**Figure-4:** Hypocotyl length of cowpea accession in cadmium polluted soils 7 days after sowing.




NB: TLL - Terminal leaf length (cm), TLB - Terminal leaf breadth (cm)

**Figure-5:** TLL and TLB of cowpea accessions to cadmium polluted soils 14 days after sowing.

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