International Journal of Academic Research
P-ISSN: 2348-7666: Impact Factor: 6.023
Homepage: https://www.ijar.org.in/
Volume-11, Issue-4, Oct-Dec-2024

Research Article

Zinc Toxicity Impact on Seed Germination and Tolerance Index of Cajanus Cajan (L.) Millspaugh and Sorghum bicolor (L.) Moench

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Abstract

This study investigated the effects of zinc toxicity on seed germination and tolerance index of Cajanus (Red Gram) and Sorghum (Jowar). Increasing concentrations of zinc (50ppm and 100ppm) significantly decreased seed germination and tolerance index in both plants. Cajanus exhibited higher seed germination rates (85% and 63%) compared to Sorghum (70% and 55%) at 50ppm and 100ppm zinc concentrations, respectively. However, Sorghum showed higher tolerance index values (66.6% and 54.4%) than Cajanus (72.9% and 56.9%) at corresponding zinc concentrations. The study suggests that both plants exhibit concentration-dependent responses to zinc toxicity, with significant implications for crop management in zinc-contaminated soils.

Keywords: Zinc, Germination, Tolerance, Concentration, Cajanus, Sorghum.

1. Introduction

Water assumes a vital part in the soil and plant development relationship. Water fills in as the dissolvable and transporter of food supplements for the development of plants. Industrial wastewater can have far-reaching effects on the ecosystem. The water used in various industrial processes comes in contact with toxic chemicals, heavy metals, organic sludge, and even radioactive sludge. So, when such contaminated water is tossed into the sea or other water bodies without any treatment, they become unfit for any human and agricultural use. Zn is one of the important micronutrients. Zinc plays an important role in plants and its deficiency may cause stress in plants and decrease nutritional quality in food crops (Clemens 2006.) Zinc is an essential micronutrient for plant growth and development, playing a crucial role in various physiological processes. However, excessive amounts of Zn can lead to toxicity, causing adverse effects on plant growth. Zn toxicity occurs in soils contaminated by mining and smelting activities, in agricultural soils treated with sewage sludge, and in urban and peri-urban soils enriched by anthropogenic inputs of Zn (Chaney, 1993). Insoluble Zn in soils can contaminate groundwater and excessive applications of Zn contain fertilizers or pesticides and use of Zn contaminated sewage sludge's (Giuffre et al., 2012). Several types of Zn fertilizers are available in the form of chelated Zn that is relatively mobile in the soil. The inorganic fertilizers like zinc oxides, sulphate and nitrates are widely used (chakmak 2008.).

Germination and seedling growth are valuable stages in the life of plants (Vange et al., 2004). In some cultivated species the treatment with Zn reduces seed germination (Sharma et al., 2010). Prasad et al., (1999) studied on effect of Zn metal stress in Brassica juncia. He used three concentrations i.e. 0.007, 0.05, 5 and 10Mm of ZnSo4 Zn at 0.5mm promoted the growth of seedling but at 5and 10mm caused significant reduction in seedling growth. The length of the root, the length of the hypocotyls, and the length of the seedling in the variants of treatment, presented average values lower than in the control, values decreasing with the increase of the concentration of the metal (Michael and Krishnaswamy. 2014).

2. Material and Methods

2.1 Field preparation and experimental design

The district regional climate is Agro-Ecological Sub Region on Eastern Coastal plain, hot sub-humid to the semi-arid Eco region (12.1, 18.4). Agro-Climatic Region East Coast plain and hill region XI). Geographic coordinates of district latitude 16o 58' 60"N longitude 18o 46' 60" E altitude 13m AMSL. Rajahmundry is an industrial area surrounding villages that mainly depend on agriculture. The stone crushers and smaller industries caused heavy metal pollution along with automobile exhausts and affect the agricultural crops. In the East Godavari district, mainly cultivated crops are Rice, Maize, Red gram Sorghum, Sugar cane, and some other vegetable crops.

Six fields (three fields for Cajanus and three for Sorghum) were taken based on the Zn concentration. Out of the six fields, two fields had high Zn concentrations belong to Area-1 (10 km distance from the industries), having ~50 ppm(50ppm) of Zn, and two fields belong to Area-2 (5 km distance from the industries), having ~100ppm of Zn. Remaining two fields were normal area (30-50 km from industries.), having ~ 2ppm Zn, which is located in Rampachodavaram rural areas, is considered as controlled field. Remaining elements all are adequate in range in each field, but only Zn was high level in those four fields. Based on this reason further research was conducted for Zn effect on plant growth and development. Experimental field was ploughed with a tractor and harrowed before seed sowing.

2.2 Plant material

Two types of plants Pigeon pea (Cajanus Cajan (L.) Millspaugh) and Sorghum bicolor (L) were selected for the investigation. The seeds were obtained from agriculture research stations Rampachodavaram and Rajahmundry east Godavari district Andhra Pradesh. The seeds are placed into the furrows at a specific distance manually by a man working behind a plough. In present experimental fields depth of seed sowing is 25mm in Sorghum and 5cm in Cajanus.

2.3 Germination percentage

Seeds of Cajanus and Sorghum were cultivated separately in experimental fields containing ~2 (2ppm), ~50 (50ppm), and ~100 (100ppm) Zn contamination soils. Germinate at natural climatic conditions.

2.4 Tolerance Index (%)

The tolerance index of each concentration against each of the Zn concentration at the end of the research both of the plants Cajanus and Sorghum plants height was calculated as follows:

$$\text{Tolerance index (\%)} = \frac{\text{Mean plant length of plants in contaminated areas}}{\text{Mean plant length of plants in control areas}} X100$$

3. Results

3.1 Per Cent Seed Germination

Percent seed germination of both the plants Cajanus and Sorghum was decreased with increasing concentrations of Zn. The seed germination of controls exhibited 98 percent in Cajanus and 96 percent in Sorghum (Fig.1.1). The 100ppm Zn recorded the lowest percent germination in both of the plants Cajanus and Sorghum. The seeds of Cajanus recorded 85 and

63 percent seed germination 50ppm and 100ppm respectively. The percentage of seed germination Sorghum recorded 70 and 55 percent germination in 50ppm and 100ppm respectively (plate-1, 2, and 3).

Among the two plants, Sorghum exhibited lower percent germination in two Zn contaminated areas than Cajanus. However, greater reduction percent seed germination showed in 100ppm high Zn concentrations than control and 50ppm.

3.2 Tolerance index

The tolerance index of the plants of Cajanus and Sorghum at the end of the season decreased with increasing Zn concentration (Fig. 1.2). Among the two Zn concentrations, plants exposed to 100ppm Zn recorded the lowest index values. The Cajanus recorded 72.9, 56.9 percent tolerance index in 50ppm and 100ppm Zn concentrations respectively. Sorghum resulted in 66.6, 54.4 percent tolerance index at 50ppm and 100ppm Zn concentrations respectively. Greater tolerance index values were recorded in Sorghum than Cajanus.

Plate - 1

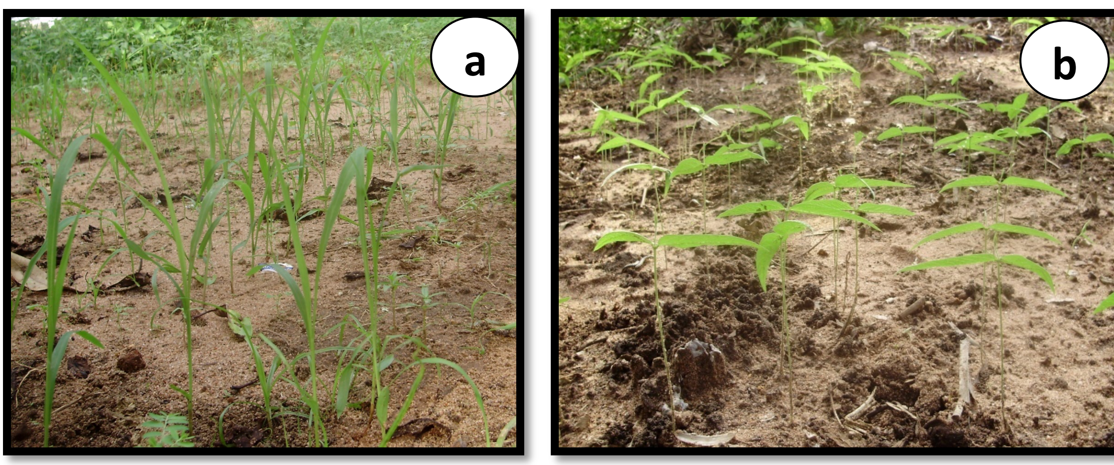


Plate 1: Effect of Zn toxicity on seed germination of Cajanus and Sorghum

a- Cajanus 2ppm Zn concentration was treated as control area

b- Sorghum 2ppm Zn concentration was treated as control area

Plate -2

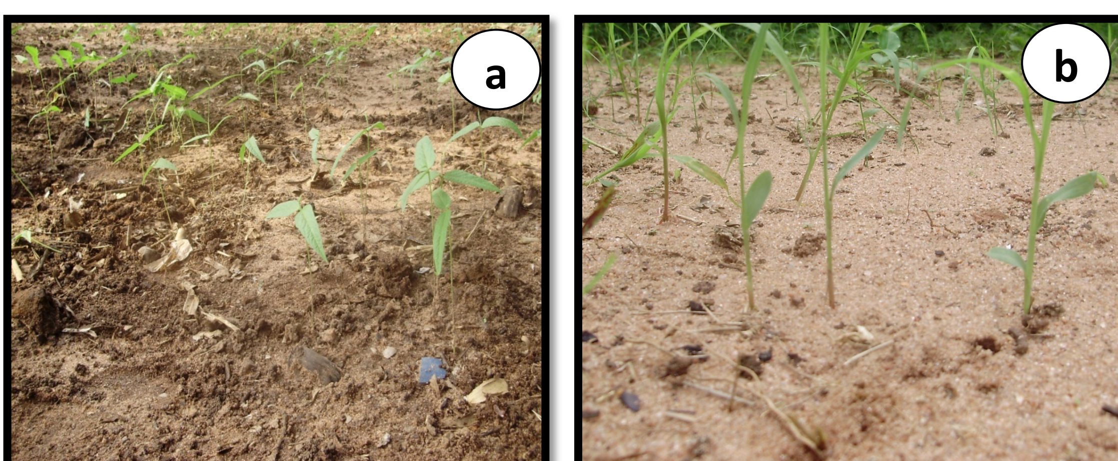


Plate 2: Effect of Zn toxicity on seed germination of Cajanus and Sorghum

a- Cajanus 50ppm Zn concentration was treated as contaminated area-1

b- Sorghum 50ppm Zn concentration was treated as contaminated area-1

Plate – 3

Plate 3: Effect of Zn toxicity on seed germination of Cajanus and Sorghum

a- Cajanus 100ppm Zn concentration was treated as contaminated area-2

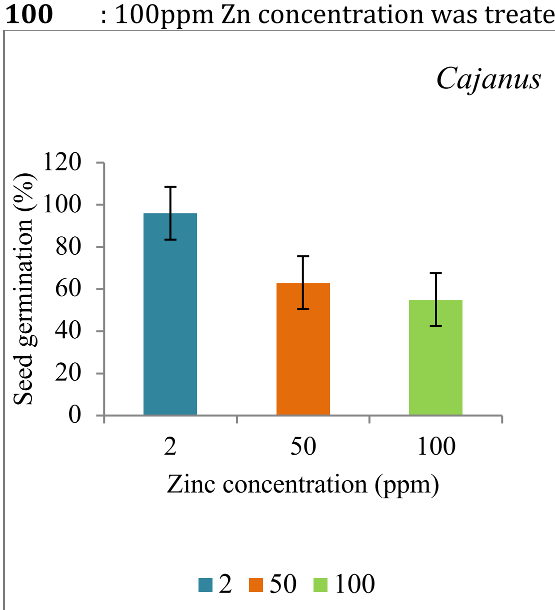
b- Sorghum 100ppm Zn concentration was treated as contaminated area-2

Figure 1.1: The effect of Zn stress on percent seed germination of Cajanus & Sorghum (Vertical lines represent S.E.).

2 : 2ppm Zn concentration was treated as control area

50 : 50ppm Zn concentration was treated as contaminated area-1

100 : 100ppm Zn concentration was treated as contaminated area-2



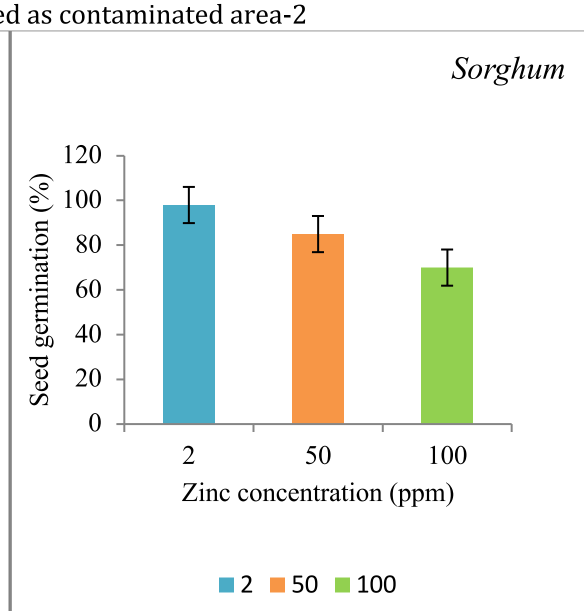
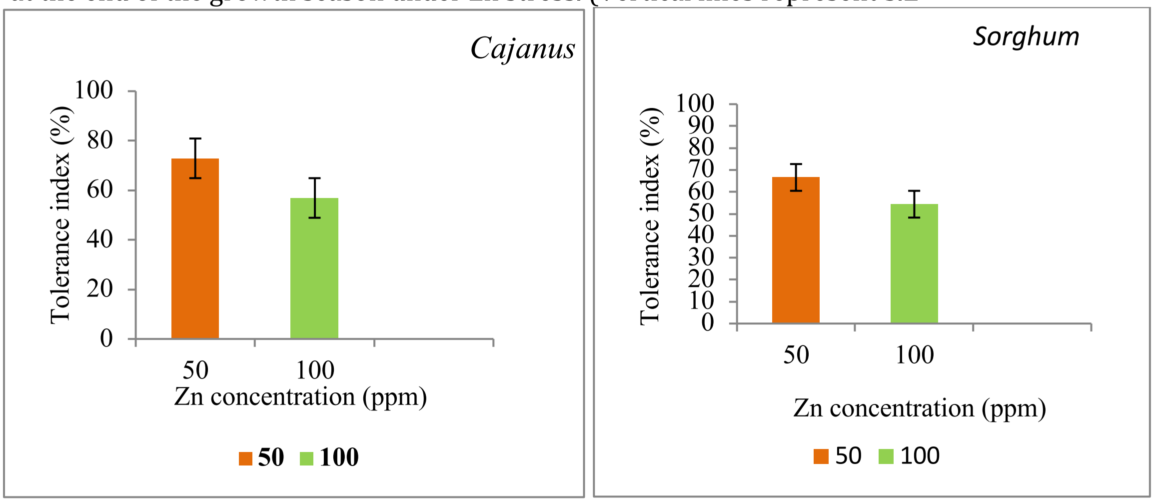


Figure 1.2: Tolerance index (per cent of control) of Cajanus & Sorghum at the end of the growth season under Zn stress. (Vertical lines represent S.E



4.Discussions

Percent seed germination of Cajanus and Sorghum decreased with increasing concentrations of Zn. The seed germination of controls exhibited 98 percent in Cajanus and 96 per cent in Sorghum (Fig 1.1). Zn at higher quantity it abridged the germination percentage (Sudarshana Sharma et al., 2010). Treatment of lead and cadmium with 25, 50, 75 and 100 ppm of showed in Leucaena leucocephala gradual reduction in seed germination and seedling growth (Shafiq et al., 2008). Higher concentrations of Zn considerably reduce the germination of plants, including Vigna unguiculata, Cassia angustifolia, and Glycine max (Basha et al., 2015 and Gupta et al., 2016)

We observed control areas at sufficient level of Zn (2ppm) showed a significant increase in germination, plant growth, whereas in contaminated areas are affected at high level of Zn (50-100ppm) showed grater reduction of seed germination and plant growth (plate.2,3). Notably germination in 48, 74 hours delay in 50ppm and 100ppm Zn concentrations respectively when compared to the controls. They exhibited late seed germination and always shown very slow seedling growth rate when compared to the controls in both of the plants. Among the three areas Sorghum always exhibited highest reduction of germination than Cajanus.

100ppm Zn exhibited greatest reduction of seed germination may be due to the excess amount of Zn in both of the plants Cajanus and Sorghum. The excess amount of Zn uptake through the root can be considered an important cause for variation in seedling growth performance of Cajanus and Sorghum seedlings. The decrease in seed germination of Cajanus and Sorghum due to Zn treatment is in conformity with the previous findings (Mahalakshmi et al., 2003; Mahmood et al., 2005; Rahman et al., 2011).

Tolerance index of Cajanus and Sorghum plants studied increase up to post flowering stage. Sorghum registered greater tolerance index values than Cajanus (Fig.1.2). Rengel (2000) reported that the response of the plants to high Zn concentration was related to their tolerance capacity of Zn. The decrease of the relative yield at higher concentrations could be due to the toxic effect of Zn that damages plant growth (Atici et al., 2005). Increasing Cu, Pb and Zn had significant adverse effects on metal toxicity tolerance all crop seedlings (Tariq Mahmood et al., 2007.). TI decreases progressively with the increase of Zn concentration in solution tolerance index values lower than 50 % were recorded at concentrations between 200 mg/l and 600mg/l (Anişoara Stratu and Naela Costica 2015).

Notably lowest tolerance index values were noticed at 100ppm in both of the plants Cajanus and Sorghum when compared to their respective controls. The increase in copper and Zn concentrations decreased vigor and tolerance indexes of tomato seedlings compared to control, treatment (Ashagre et al., 2013)

5.Conclusion

The study reveals that increasing zinc concentrations significantly impact seed germination and tolerance index of Cajanus and Sorghum. Cajanus exhibits better seed germination rates, while Sorghum shows higher tolerance index values under zinc stress. These findings suggest that both plants have different mechanisms to cope with zinc toxicity. The results of this study can be useful for developing strategies to manage zinc-contaminated soils and improve crop productivity.

References:

1. Anişoara Stratu, Naela Costica., (2015). The Influence of Zinc on Seed Germination and Growth in The First Ontogenetic Stages in the Species Cucumis Melo L. Pesd, Vol. 9, No. 2, 2015.
2. Ashagre H., Almaw D., Feyisa T., (2013). Effect of copper and zinc on seed germination, phytotoxicity, tolerance and seedling vigor of tomato (Lycopersicon esculentum L. cultivar Roma VF), International Journal of Agricultural Science Research, 2, (11), 312-317.
3. Atici O, Agar G, Battal P., (2005) Changes in phytohormone contents in chickpea seeds geminating under lead or Zinc stress. Biol plant. 49 (2): 215-222.
4. Basha S.A., Selvaraju M. Toxic effect of Zinc on growth and nutrient accumulation of cow pea (Vigna unguiculata L.) Int. Lett. Nat. Sci. 2015;43 Doi: 10.18052/www.scipress.com/ILNS.43.48. [DOI] [Google Scholar].
5. Cakmak, I. (2008) Enrichment of Cereal Grains with Zinc: Agronomic or Genetic Biofortification? Plant Soil, 302, 1-17.
6. Chaney R L., (1993). Plant uptake of inorganic waste constituents. Land treatment of hazardous wastes. Park Ridge, NJ, USA: Noyes Data Corporation, PP: 50-76.
7. Clemens, S. (2006) Toxic Metal Accumulation, Responses to Exposure and Mechanisms of Tolerance in Plants. Biochimie, 88, 1707-1719.
8. Giuffer L., R. I. Romaniuk, L. Marban, R.P Rios and T.P Garciaa Torres., (2012). Public health heavy metal in urban and peri urban horticulture. Emir. J. Food Agric. 24(2): 148-154.
9. Gokak I., Taranath T. Seed germination and growth responses of Macrotyloma uniflorum (Lam.) Verdc. exposed to Zinc and Zinc nanoparticles. Int. J. Environ. Sci. 2015; 5:840. [Google Scholar]
10. Gupta S., Meena M., Datta S. Effect of selected heavy metals (Lead AND Zinc) on seedling growth of Soybean Glycine Max (L.) MERR'. J. Pharm. Pharm. Sci. 2016; 8:302–305. [Google Scholar].
11. Ivanov Y.V., Kartashov A.V., Ivanova A.I., Savochkin Y.V., Kuznetsov V.V. Effects of zinc on Scots pine (Pinus sylvestris L.) seedlings grown in hydroculture. Plant Physiol. Biochem. 2016; 102:1–9. Doi: 10.1016/j.plaphy.2016.02.014. [DOI] [PubMed] [Google Scholar].
12. Mahalakshmi, G. and P. Vijayarengan., (2003). Effects of zinc on germinating seeds of three plants species. Nature Environ. Pollut. Tech. 2:117-119.
13. Mahmood, S., A. Hussain, Z. Saeed and M. Athar., (2005). Germination and seedling growth of corn (Zea mays L.) under varying levels of copper and zinc. Int. J. Environ. Sci. Tech. 2:269-274.

14. P.I. Michael and M. Krishnaswamy., (2014). Membrane damage and activity of antioxidant enzymes in response to zinc and high irradiance stress in Cowpea plant. International journal of current research and academic review 2014; 2(10):112-128.
15. Patel Kailas P, Vyas Milvee K, Patel Parimal M and Patel Kalpesh M., (2014). Effect of Zinc on seed germination, seedling growth and nutrient contain of Rauvolfia serpentin. Environmental science and technology 2014 vol.1.
16. Rehman F, Khan F, Varshney D, Naushin F, Rastogi J., (2011) Effect of cadmium on the growth of tomato. Biol Med 3:187-190.
17. Rengel Z., (2000). Ecotypes of Holcus lanatus tolerant to zinc toxicity also tolerate zinc deficiency. Ann Bot 86:1119-1126.
18. Shafiq, M., I. M. Zafar and M. Athar., (2008). Effect of lead and cadmium on germination and seedling growth of Leucaena leucocephala. J. Appl. Sci. Environ. Manage. 12:61- 66.
19. Sharma RK, Agrawal M, Agrawal SB., (2010). Physiological and biochemical response in cadmium and zinc accumulation in carrot plants. J Plant Nutrition 33:1066–1079.
20. Sharma S., Sharma P., Datta S. P., Gupta P., (2010). Morphological and biochemical response of Cicer arietinum L. var. pusa-256 towards an excess of zinc concentration, Life Science Journal, 7, 1, 95 - 98.
21. Tariq Mahmood, K.R. Islam and S. Muhammad. 2007. Toxic Effects of Heavy Metals on Early Growth and Tolerance of Cereal Crops. Pak. J. Bot., 39(2): 451-462, 2007.
22. Vange, V., Hevchand, I., vandvik, V., 2004. Does seed mass and family affect germination and juvenile performance in Knautia arvensis L. A study using failure time methods. Acta Oecol.25: 169-178.

Citation: A. Satya Gowri Parvathi, Y. Baby. “Zinc Toxicity Impact on Seed Germination and Tolerance Index of Cajanus Cajan (L.) Millspaugh and Sorghum bicolor (L.) Moench”. International Journal of Academic Research, 11(4): 109-115.