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EFFECT OF ZINC ON EARLY SEEDLING GROWTH OF SORGHUM AND BAJRA

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The effect of different concentrations of zinc (0,2.5,5.0,7.5mM) on the morphology, growth, dry matter accumulation, phytotoxicity and chlorophyll content under normal laboratory conditions was studied to determine the possible influence of zinc in ten day old seedlings of sorghum (CSH-9) and bajra (HHB-94) . The presence of zinc drastically decreased all the parameters compared to the control plants. The percentage of inhibition increased with increasing concentration of zinc.

Keywords: Chlorophyll; Dry matter; Phytotoxicity; Zinc.

Introduction

World wide large areas of land are contaminated with heavy metals, mainly due to industrial activity. Metal concentration in the soil ranges from less than 1mg/kg to as high as 1,00,000 mg/kg[1] . Some heavy metals, at low concentrations are essential micronutrients for plants, but at higher concentrations may prove toxic leading to growth inhibition and metabolic disoders. Zn is an essential micronutrient and a constituent of metalloenzymes or a co-factor for several enzymes such as anhydrase, dehydrogenase, oxidases and peroxidases[2] and plays an important role in regulating nitrogen metabolism, cell multiplication, photosynthesis and auxin synthesis[3] in plants but at elevated levels is highly phytotoxic, since it is assimilated early by plants[4]. The aim of the present study is to understand the growth inhibition and percent phytotoxicity at elevated levels of Zn in sorghum and bajra.

Material and Methods

Seeds of widely used variety of sorghum and bajra were procured from Agricultural University (ANGRAU) and National Seed Corporation (NSC), Hyderabad,A.P., respectively. Both the seeds were soaked for two hours in distilled water and were surface sterilized with 0.01M mercuric chloride for two minutes and thoroughly washed with distilled water several times. The seeds of uniform size were spread in a petri plate lined with two layers of Wattman No.1 filter paper containing 10ml of varying concentrations of zinc. Twenty seeds of sorghum and thirty seeds of bajra were placed in each plate. The different concentrations of zinc selected for the present experiment was 2.5,5.0,7.5mM, given in the form of zinc sulphate. The seeds grown in distilled water served as control. For each treatment five replicates were maintained. The experiment was carried out under normal laboratory conditions with a photoperiod of 8hrs per day and a temparature of approx. 30±2°C during the day and 22±2°C during the dark period. The seeds were allowed to germinate for 10 days. They were then removed, separated into individual parts for further analysis. Different parameters like morphological changes, root and shoot length, percentage phytotoxicity, dry weight, relative growth index (RGI), chlorophyll a, chlorophyll b, total chlorophylls and chl a/b ratio were analyzed.

Growth parameters: Morphological changes: During germination seedlings were observed for morphological changes. The visual symptoms of toxicity if any were noted on the 10th day.

Root and shoot length: The seedlings were separated into roots and shoots and the length of each part was measured using a graph paper.

Percent phytotoxicity: It was calculated following the standard technique of Chou *et al.*[5].

$$\text{Percent phytotoxicity} = \frac{\text{Root length of control - root length of test}}{\text{Root length of control}} \times 100$$

Dry weight : The seedlings were separated into roots and shoots and immediately their fresh weight was recorded, the same were dried in a hot air oven at 80°C for 48 hrs to obtain constant dry weights.

Relative growth index (RGI): It was calculated for each treatment both for root and shoot on the basis of dry

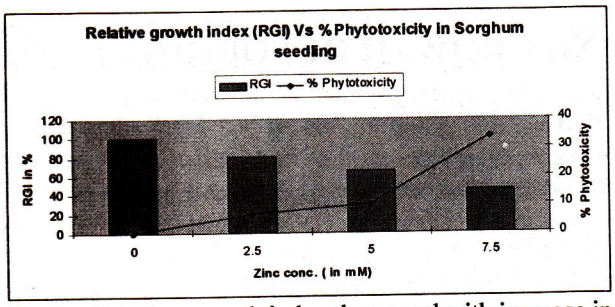

Fig.1a. Relative growth index decreased with increase in percent phytotoxicity in sorghum seedlings.

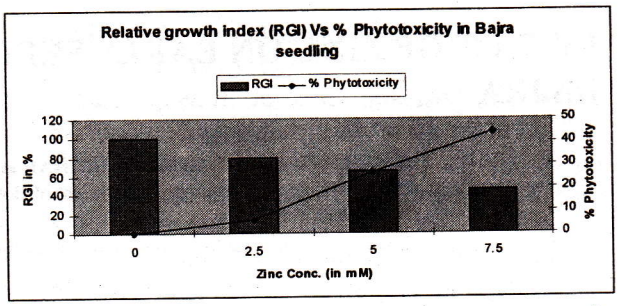

Fig.1b. Relative growth index decreased with increase in percent phytotoxicity in bajra seedlings.

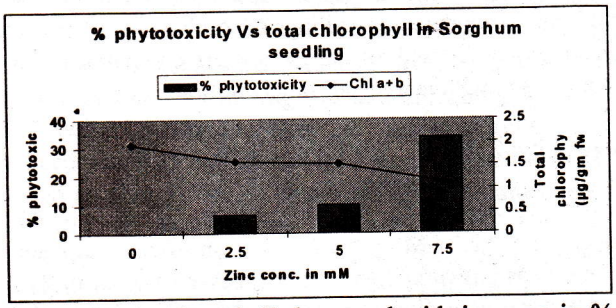

Fig.2a. Total chlorophyll decreased with increase in % phytotoxicity in sorghum seedlings.

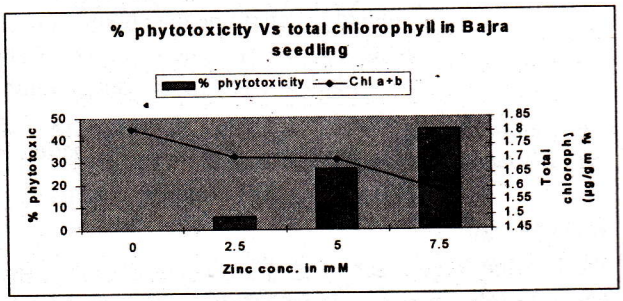

Fig.2b. Total chlorophyll decreased with increase in % phytotoxicity in bajra seedlings.

weight[6].

$$RGI = \frac{\text{Average dry weight in metal}}{\text{Average dry weight in control}} \times 100.$$

Chlorophylls : Chlorophyll content was measured according to Arnon's method[7]. Fresh leaf material (200mg) was harvested from the plant for each concentration, washed with distilled water and the moisture was removed with blotting paper. The leaf material was ground thoroughly in mortar with 5ml of 80% acetone. The green slurry was centrifuged at 3000 rpm for 10 min. The supernatant was then transferred into a clean test tube. The residual pigment was re-extracted with 10ml of 80% acetone. This process is repeated till a white pellet is obtained. The total volume was made up to 25ml using 80% acetone in a 25ml volumetric flask. The OD was recorded at 645nm and 663nm against blank (80% acetone).

Results and Discussion

Morphological changes: In both sorghum and bajra seedlings stunting of shoots was observed after 4 days of germination. At higher concentrations of metal treatment rolling of leaves was observed in sorghum. The root in sorghum were reduced, brittle and appeared blunt. The tips of roots became brown at concentration of 7.5mM of zinc. In bajra the roots were curled, brown in colour with feathery root hair. Inhibitory effect of zinc at higher concentrations was also reported in a number of leguminous plants[8].

Root and shoot length: Data pertaining to root and shoot length of both sorghum and bajra is represented in Table 1. Increasing concentration of zinc caused linear decrease in the root and shoot length in both sorghum and bajra seedlings. At 7.5mM the percent decrease in the root length was 34% in sorghum and 44% in bajra. Where as the shoot growth reduced by 47% in sorghum and 29% in bajra. Reduced growth of root and shoot due to zinc treatement was also observed by other workers in *Vigna radiata* and *Sorghum bicolor*[9], *Phaseolus munga*[10], *Bacopa monniera*[11], *Cajanus cajan*[12]. Reduction in shoot growth at higher concentration in the present experiment could be due to the interference of zinc with certain important metabolic process as suggested by Tripathy and *Mohanty*[13] and Alia *et al.*[14]. It may also be due to inhibition of cell division and cell elongation[12,15].

Percent phytotoxicity: It was calculated on the basis of root length and is shown in Fig.1. A linear relationship was observed between the percentage of phytotoxicity and the concentration of zinc treatement in both the plants. At 7.5mM, percent phytotoxicity of zinc was maximum. It was more for bajra as compared to sorghum. Similar trend in percent phytotoxicity as a result of cadmium treatment was observed in black gram[16]. A marked correlation was

Table 1. Effect of zinc on root and shoot length of sorghum and bajra.

Metal conc.	Sorghum		Bajra	
	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length cm
0	7.9 ± 0.32	5.9 ± 0.54	6.5 ± 0.27	9.7 ± 0.07
2.5 mM	5.5 ± 0.27	5.5 ± 0.50	6.0 ± 0.08	9.2 ± 0.06
5.0 mM	4.8 ± 0.17	5.3 ± 0.21	5.7 ± 0.32	7.1 ± 0.13
7.5 mM	4.2 ± 0.27	3.9 ± 0.10	4.6 ± 0.17	5.4 ± 0.14

Table 2. Effect of zinc on dry matter accumulation (in mg) and relative growth index (RGI in %) of sorghum and bajra seedlings.

Metal conc. (mm)	Sorghum				Bajra			
	Root	RGI	Shoot	RGI	Root	RGI	Shoot	RGI
Control	4.46	100%	8.66	100%	2.0	100%	3.3	100%
2.5	3.68	83%	6.88	79%	1.3	65%	3.1	94%
5.0	2.4	54%	5.6	65%	1.0	50%	2.6	79%
7.5	1.8	40%	4.6	53%	0.6	30%	2.0	61%

Table 3. Chl a, chl b, total chlorophyll (µg/gm fw) and chl a/b ratio of zinc treated sorghum and bajra seedlings.

	Sorghum				Bajra			
Zinc conc.	Chl a	Chl b	Chl a+b	Chl a/b	Chl a	Chl b	Chl a+b	Chl a/b
0	1.24	0.73	1.97	1.69	1.46	0.351	1.811	4.1
2.5 mM	1.23	0.35	1.58	3.51	1.42	0.297	1.717	4.7
5.0 mM	1.20	0.34	1.54	3.52	1.42	0.300	1.700	4.7
7.5 mM	0.90	0.23	1.13	3.91	1.33	0.268	1.598	4.9

observed between percent phytotoxicity and relative growth index in both the plants. Increase in percent phytotoxicity has resulted in decrease in the relative growth index (Fig.1a & b).

Dry weight: The data on dry weight of root and shoot is shown in Table 2. The dry weight of both roots and shoots decreased with increase in zinc treatement. At 7.5mM the root and shoot dry weight in sorghum showed a reduction of 60% and 47%, respectively where as the decrease in bajra was 70% and 39%. Inhibition of growth at toxic levels of zinc was shown by Balashouri[9], Chaoui *et al.*[10], Shesty and Madhava Rao[12] also reported a decrease in dry weight of roots and shoots of pea at higher levels of zinc.

Relative growth index (RGI): The RGI was calculated from the dry weight of roots and shoots of sorghum and bajra and is depicted in Table 2. The RGI of roots and shoots of both sorghum and bajra decreased with increasing concentration of metal treatement. Similar results were obtained for zinc and nickel treated pigeon pea cultivars[12]. At a concentration of 7.5mM of zinc, the RGI was 40% in sorghum roots where as it was 30% in the roots of bajra.

Chlorophylls: The effect of zinc on the chlorophyll pigments is represented in Table 3. Chl a, chl b and total chlorophylls decreased with increasing concentration of

zinc in both plants (Fig.2a & b). Decrease in total chlorophylls was more due to a decrease in chl b. Nag *et al.*[17] observed decrease in chl a and chl b content in rice seedlings,as a result of high levels of zinc treatment. Chlorophylls a/b ratio increased with increasing zinc concentration for both plants. Stiborova *et al.*[18] observed an increase in chl a/b ratio in barly seedlings treated with Cu, Pb or Zn.

Zinc shows an inhibitory effect on the root and shoot growth of sorghum and bajra. Elevated zinc concentrations caused an increase in phytotoxicity which resulted in decrease in RGI. The decrease in growth led to a decrease in dry matter accumulation in the zinc treated plants as compared to the control. Total chlorophyll content showed a gradual decrease in metal treated plants.

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