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Effect of zinc on the viability and seedling growth of deteriorated soybean and rice seeds

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ABSTRACT: An investigation was carried out to study the effect of the application of the micro-element Zinc, on the viability and seedling growth of deteriorated soybean (TGX 536-02D) and rice (IR-5) seed.

One batch of the seeds was naturally aged and the other subjected to accelerated ageing. Four levels of $ZnSO_4$ concentration used were 0, 1, 10 and 100 mg l-1. For the naturally aged seed, even though there was no significant effect on soybean and rice seed viability for all the concentration levels tested, there was a beneficial carryover effect resulting in significant enhancement of seedling growth in soybean. On seeds subjected to accelerated ageing, 100 mg Zn/L improved soybean seed viability by about 115% and also had promotive effects on seedling, growth, notably seedling weight and leaf area by 42% and 25% respectively. The implications of Zn application in the invigoration of seeds with depressed viability are discussed.

Key Words: Micronutrients; Zinc; Accelerated ageing; Seed viability; Seedling weight; Invigoration; Soybean; Rice.

Introduction

The application of minerals and chemicals to revive seeds of low viability has been the subject of research in the past three decades or so. Both macro- and micro nutrients as well as growth regulators have been employed by many researchers in seed invigoration experiments.

As early as 17th century, it was established that treatment of seeds with salty water protected them from spoilage. The use of chemical fertilizers at the time of sowing was discovered to have an enhancing effect on germination and growth of seedlings (Ovcharov, 1969). In his study, rye seeds were soaked in different solutions of phosphoric acid and the germination markedly increased from 38% in control to 70% in a 0.05% solution of P2O5. The effect was even more dramatic on oats.

Iodination of mustard seeds demonstrated an appreciable degree of protection against damage under a variety of storage conditions (Basu and Rudrapal, 1980). In their study, seeds treated with iodine retained a germination of approximately 100% while untreated seeds declined to about 75% germination, presumably as a result of lipid peroxidation.

Generally, when microelements are fed to seeds, they do have a very notable influence on many aspects of metabolism (Rogers et al., 1995). Having stored seeds inevitably in an unsuitable environment with its attendant lowered viability, it should be possible to re-invigorate such seeds by chemical application.

The aim of this investigation was therefore to find out the effect of Zinc absorption on the seed viability and seedling growth of soybean and rise seeds.

Materials and Methods

Soybean (cv. TGX 536-02D) and rice (cv. IR-5) seeds were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan. Ambient storage (26-29°C, 65-80% RH) was carried out for the two species, soybean and rice for a period of 2 months and 6 months respectively, and were referred to as 'naturally aged seeds'. Germination percentage was immediately determined before further tests were carried out.

Freshly harvested seeds f the same species and cultivar were procured and also subjected to accelerated ageing conditions (45°C and 95-100% RH, 5 days) before chemical application. The concentrations of the chemical were chosen on the bases of specific responses obtained by other workers (Baertuev, 1965; Simakin, 1966; Adedipe, 1973; Ajala and Adedipe, 1999a; Ajala and Adedipe, 1999b).

For each batch of soybean and rice seeds, ten seeds were weighed and put in Petri dishes after which 10ml. of Zinc Sulphate was added at 0, 1 10 and 100 mg 1-1 concentrations. After 8h., they were then transferred into Petri dishes containing distilled water for another 5 days. The number of seeds germinated was counted and recorded. For seedling growth measurements, after the estimates of the germination percentage, seedlings were transferred into pots containing soil for further observation. On the 10th day, i.e. 15 days after start of seedling growth, measurements were taken on lengths and weights of plumule and radicle, leaf weight and total leaf area. Graphic method, in which leaves outlines were drawn on graph sheets and the squares counted, was used in determining the leaf area.

The experiment was repeated 3 times. The data were subjected to statistical analysis and the Duncan's (1955) New-Multiple Range Tests were used in testing the treatment means where appropriate.

Results

A. Naturally Aged Seeds

Seed viability

Soybean showed no significant effect for all the Zn concentrations tested, although the highest viability was obtained at 100mg Zn/L (Fig. 1) corresponding to the highest response in seedling growth characters (Fig. 3). No significant effect of Zinc was noticed on rice viability (Fig. 1).

Seedling growth responses

There was significant enhancement of seedling growth in soybeans at 10 and 100 mg Zn/L (Fig. 3). With the exception of radicle fresh weight in which there was no significant increase, all the other growth parameters recorded significant increases. Similarly, with the exception of radicle fresh weight which was significantly increased at 1mg/L in rice, all other growth parameters were not significantly different from the control (Table 1).

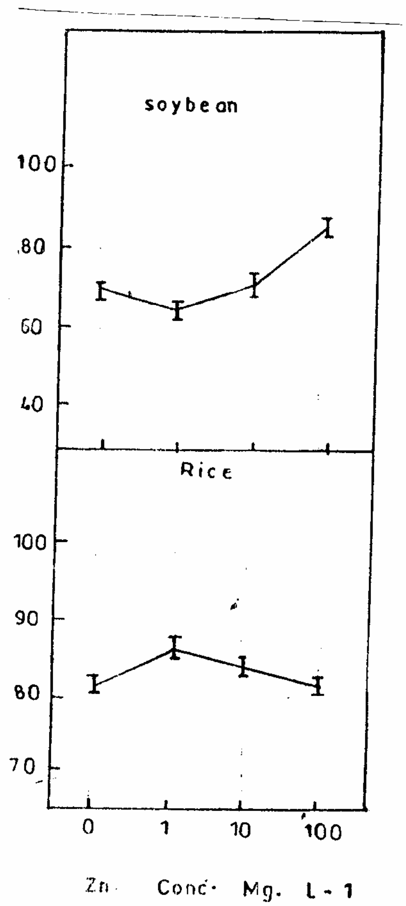

Fig. 1: Effect of Zn absorption on the viability of naturally aged soybean and rice seeds.

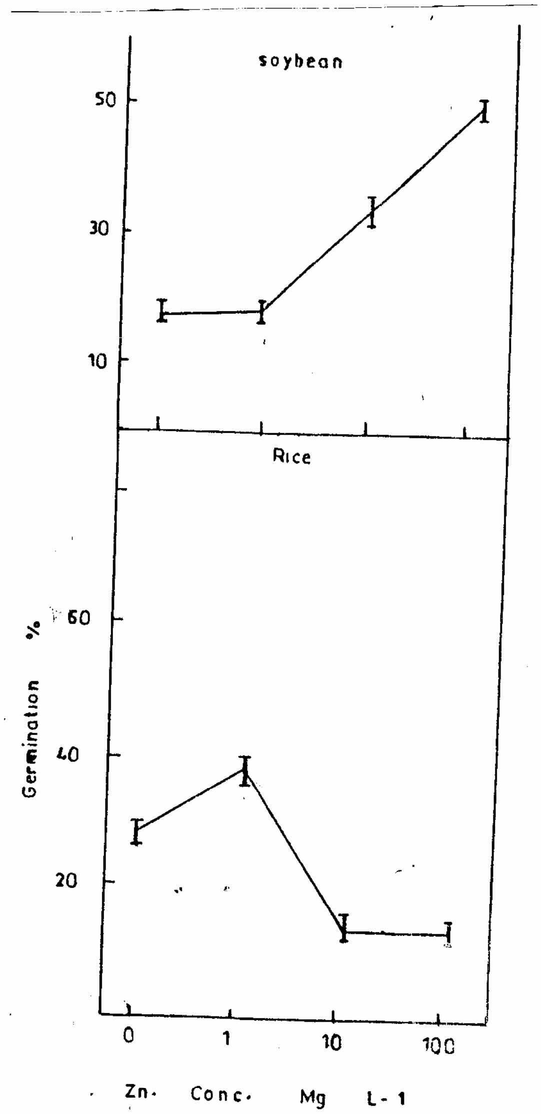

Fig. 2: Effect of Zn absorption on the viability of deteriorated soybean and rice seeds.

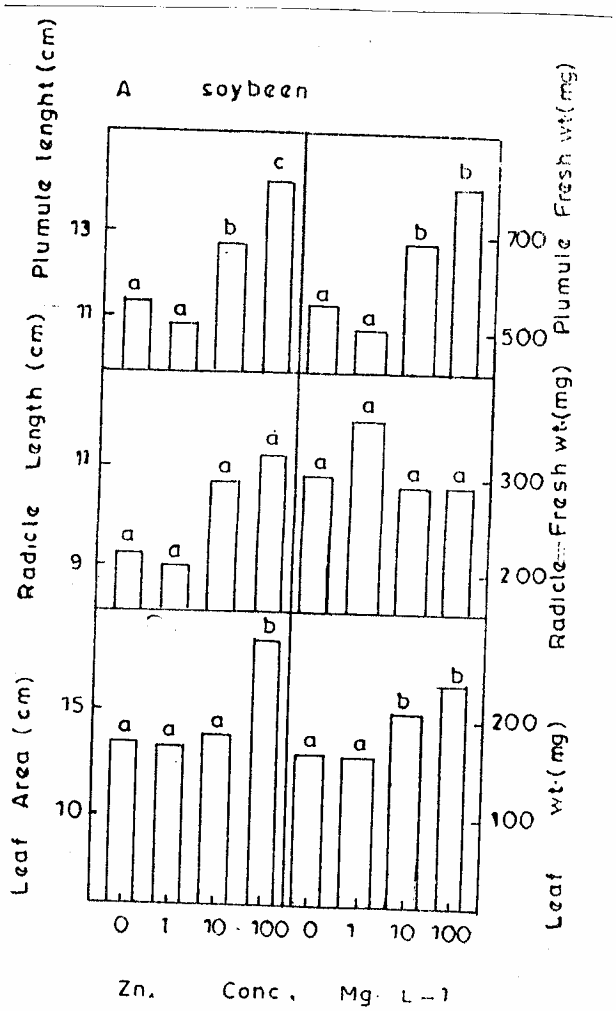

Fig. 3: Effect of Zn absorption on seedling growth of naturally aged soybean and rice seeds.

Table 1: Effects of zinc absorption on seedling growth in naturally aged rice seeds.

Zinc conc. (mg/l)	Seedling weight (g)		Leaf weight (g)	Leaf area (cm^2)	Seedling length (cm)	
	Plum.	Rad.			Plum.	Rad.
0	0.12 ± 0.003a	0.125 ± 0.01a	0.06 ± 0.003a	9.44 ± 0.4a	17.54 ± 0.3a	6.3 ± 0.8a
1	0.18 ± 0.01a	0.23 ± 0.01b	0.11 ± 0.01a	13.5 ± 0.7a	18.0 ± 0.6a	7.8 ± 1.5b
10	0.11 ± 0.003a	0.10 ± 0.01a	0.05 ± 0.003a	9.0 ± 0.17a	16.2 ± 0.6ab	10.5 ± 1.0a
100	0.12 ± 0.002a	0.11 ± 0.01a	0.06 ± 0.004a	9.0 ± 0.25a	15.5 ± 0.5c	8.2 ± 0.9a

Each point is the mean of three replicates ± S.E.

B. Seeds Subjected to Accelerated Ageing

Seed viability

Seed viability of soybean was significantly enhanced by 115% at 100mg Zn/L (Fig. 2). Rice on the other hand showed a significant reduction in its viability at higher concentrations (10 and 100mg Zn/L).

Seedling responses

In soybeans, seedling growth characteristics, especially plumule fresh weight and leaf area were significantly enhanced at 100mg Zn/L (Table 2). Its enhancing effect on seedling growth characteristics is worthy of note. Seedling weight was distinctly increased by 42% while lead area was improved by 25%. Also there were significant differences in radical weight and length occuring at 1mg/l but not at higher concentrations. In rice, apart from plumule weight which show a significant increase at 1mg/l no significant effect was observed for the growth parameters except seedling weight which became depressed at 100mg Zn/L (Table 2).

Discussion

This study describes the effects of zinc on rice and soybean seed viability and seedling growth following natural and accelerated seed ageing. In naturally aged seed, the microelement, Zn, studied has not been particularly promotive on soybean and rice seed viability, although seedling growth was significantly enhanced in soybeans at 10 and 100mg Zn/L. It is interesting to note that some chemicals may not influence seed viability but can still exert their influence on subsequent seedling growth. In the studies carried out by Masev and Kutacek (1966), soaking of barley seeds in a solution of $ZnSO_4$ led to an increased content of growth substances particularly IAA but Bewley and Black (1984) later stated that there is no substantial evidence that IAA participates in germination process and that later events of seedling growth may be controlled by the hormone. Hence Zn may have no stimulating effect on naturally aged soybean seed viability, it has resulted in enhanced seedling growth, bearing a close resembleance to Bewley and Black's observation.

Earlier work carried out by Ajala and Adedipe (1999a) revealed that ascorbate had anti-oxidant properties which were responsible for lowering the rate of lipid auto-oxidation in stored seeds. Hence

Table 2: Effects of Zinc absorption on seedling growth in deteriorated* soybean and rice seeds.

Zinc. Conc. ($mg\ l^{-1}$)		Seedling wt. (g)		Leaf Wt. (g)	Leaf area (cm^2)	Seedling length (cm)	
		Plum.	Rad.			Plum.	Rad.
Soybean	0	0.63 ± .03a	0.28 ± .02a	.16 ± .01a	12.33 ± .20a	12.0 ± .58a	8.33 ± .33a
	1	0.62 ± .02a	0.40 ± .02b	.18 ± .01a	13.67 ± .58ab	12.0 ± .58a	12.0 ± .58b
	10	0.65 ± .03a	0.38 ± .03b	.20 ± .03a	14.5 ± 29ab	11.33 ±.88a	11.67 ± .33b
	100	0.79 ± .06b	0.40 ± .03b	.23 ± .03a	15.47 ± 1.5b	13.67 ± .88a	11.0 ± 1.15b
Rice	0	0.089 ± 0.012a	0.108 ± 0.02ab	0.044 ± 0.01a	6.33 ± 1.39a	13.67 ± 0.88a	8.33 ± .067a
	1	0.127 ± .006b	0.151 ± 0.035a	0.059 ± 0.006a	9.4 ± 0.4a	15.83 ± 0.6a	6.83 ± 0.73a
	10	0.10 ± 0.005ab	0.135 ± 0.007ab	0.052 ± 0.005a	6.77 ± 1.23a	14.33 ± 1.45a	7.33 ± 1.33a
	100	0.048 ± 0.006c	0.076 ± 0.003b	0.032 ± 0.003a	5.57 ± 0.38a	12.5 ± 1.26a	6.17 ± 0.6a

*Seeds were subjected to accelerated ageing conditions (95% RH. 45°C for 5 days) before chemicals were applied.
Each value is the mean of 3 replicates ± standard error.

deteriorated seeds of rice benefitted from ascorbic acid treatment at 10 and 100 mg/l and resulted in significant improvement in viability and seedling growth characters.

On seeds subjected to accelerated ageing, the effect of Zn had been quite striking. Along with the enrichment of deteriorated soybean seeds with Zn at 100mg/L came a favourable effect of an increase in seed germination and growth vigour of seedlings (Fig. 2, Table 2). It is interesting to note that both germination and seedling vigour were enhanced at the same concentration of 100mg Zn/L. It is pertinent to note that soybean seed which had suffered storage calamity had its viability dramatically improved by 115%. Besides, seedling growth characters, notably seedling weight and leaf area increased by 42% and 25% respectively. Therefore, the possibility cannot be excluded that Zn may not be particularly effective on fresh soybean viability (Fig. 1), but its functions of the rehabilitation of the substandard soybean seed are hereby established. This is particularly important with respect to seeds that have suffered one form of disaster or another which has resulted in a sudden drop in viability.

Rice viability became depressed at Zn concentrations of 10 and 100mg/L. Even though most of the seedling parameters were not affected, seedling weight was distinctly lowered at 100mg Zn/L to about 38%. This shows that rice may not have suffered low levels of endogenous auxin and may therefore not be benefitted by Zn treatment. On the other hand, the chemical level required for effect may fall outside the range used in this study.

The present study, however, indicates that Zn is implicated in soybean viability. Even though there was no substantial evidence to prove that viability improvement through zinc pplication was IAA mediated, Zn had been particularly effective in the enhancement of viability and modification of seedling growth behaviour of soybean. This is to say that there is no ambiguity to the role of this micronutrient on soybean seed viability. Although no stimulating effect on naturally aged soybean seed viability was reported, its seedling growth was enhanced by Zn nutrition. Further studies should test changes in 1AA concentrations in order to determine whether the observed effects of Zn are 1AA mediated or not. This is without prejudice to the fact that the application of this microelement (Zn) has proved beneficial in the modification of viability and seedling growth behaviour of soybean seed subjected to accelerated ageing.

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