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Effect on uptake of iron and zinc in soybean as influenced by seed priming with iron and zinc in soybean (*Glycine max*)

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Abstract
Field experiment was conducted to assess the uptake of iron and zinc by soybean as influenced by seed priming with iron and zinc in calcareous soil of Rahuri (Maharashtra). Iron and zinc are the most commonly deficient nutrients on calcareous soils. As a result, the crop productivity is decreased. All micronutrients essential for plants are also essential for humans. At present Fe and Zn deficiencies in humans have emerged globally. The most prevalent methods of micronutrient addition are soil and foliar application. But the cost involved and difficulty in obtaining high quality micronutrient fertilizers are major concerns with these in developing countries. Priming is an easy and attractive alternative. The effect of seed priming, or soaking seeds in nutrient solution for 12 hours before drying and sowing them, was undertaken for soybean (Glycine max) during the *kharif* season of 2016 i.e. from 30-6-2016 to 10-9-2016 in M.P.K.V, Rahuri, Maharashtra. There were seven treatments with three replications following RBD design. Including absolute control and GRDF different concentration of Fe and Zn were tried through priming for 12 hrs to the crop soybean along with seed treatment with Rhizobium @ 250 gm10Kg^{-1} seeds. Better results were obtained from priming the seeds compared to the controlled one. The highest significant grain and stover yields of soybean was observed in the seed treatment with 0.02% $FeSO_4.7,H_2O$ and which was at par with the treatment in seed primed with 0.1% Fe-EDTA. Other treatments were significantly lower in grain and stover yield.

Keywords: seed priming, GRDF (general recommended dose of fertilizer), nutrient solution, seed treatment, stover yield

Introduction
Seed priming is a presowing seed treatment method which is simple and inexpensive. This method can increase germination rate and seedling vigour with increase in yield. Seed treatment is a better option from an economical perspective as less micronutrient is needed, it is easy to apply and seedling growth is improved (Singh *et al.*, 2003) [7]. Seed priming was found cost effective compared to soil application with benefit: cost ratio of 8 and 360 from soil application and seed priming, respectively (Harris *et al.*, 2005) [2]. Zinc and iron are a major risk factor to crop production and human health, especially in calcareous soil. Calcareous soils are frequently characterised by their low bioavailability of plant nutrients due to high base status and pH between 7.5 and 8.5 and the presence of carbonate minerals (Marschner, 1995) [5]. In India, analysis of over 2,50,000 soil samples from 20 states show that 48% soils are Zn deficient with DTPA-Zn values below 0.6 mg kg^{-1} (Singh 2009) [8]. The Maharashtra state has about 84 per cent of its total area under black soils. Most of the black soils are calcareous in nature. The presence of calcium carbonate aggravates the problem of nutritional disorders, particularly Fe and Zn in plants growing on them. Iron chlorosis on rice in varying degree of intensity was reported in calcareous soils of north Bihar (Sakal, 1976) [6]. A substantial amount of soluble iron in such soil gets converted into unavailable form. The present study was undertaken to supply the Fe and Zn through seed priming treatment which is cost effective and farmer friendly method. Seed priming is a low cost and attractive alternative to the conventional soil or foliar application.

Materials and Methods
The trial was carried out at post Graduate Research Farm, Department of Soil Science and Agril. Chemistry, M.P.K.V., Rahuri during the *kharif* 2016-17. The experiment was conducted in randomized block design with 3 replications.

The soil was medium black calcareous soil (*Typic Haplustept*) and had the following characteristics: pH 8.13 (1:2.5), organic carbon (OC) 0.55 %, electrical conductivity (EC) 0.26 dS m^{-1}, calcium carbonate 10.29 %, DTPA- Fe 4.30 mg kg^{-1}, DTPA-Zn 0.43 mg kg^{-1}, available N 246.11 kg ha^{-1}, available P 12.49 kg ha^{-1} and available K 335.72 kg ha^{-1}. The treatments comprised of *viz.,* T_1- control, T_2- GRDF (50:75:45 $N:P_2O_5:K_2O$ kg ha^{-1} + 5 t ha^{-1} FYM), T_3- T_2 + seed priming with distilled water, T_4- T_2 + seed priming with Zn EDTA @ 0.2 %, T_5- T_2 + seed priming with $ZnSO_4.7H_2O$ @ 0.02%, T_6- T_2 + seed priming with Fe EDTA @ 0.1% and T_7- T_2 + seed priming with $FeSO_4.7H_2O$ @ 0.02%. Full dose of N, P, and K were applied at the time sowing soybean seeds. Seed treatment with *Rhizobium* @ 25 g kg^{-1} seeds were common to all except treatment T_1 after priming. Recommended agronomic practices were followed. Iron and zinc uptake at harvest stage was recorded. Fresh plant samples were collected and processed with following standard procedure of washing, drying and grinding. Ground material (0.2 g) was digested with 5 ml of di-acid mixture ($HNO_3:HClO_4$ in 9:4). It was kept in digestion chamber till complete digestion of the sample. The residue was dissolved in double-distilled water and after filtration, final volume was made to 50 ml. The iron and zinc content in grain and straw of soybean were determined with the help of atomic absorption spectrophotometer.

Results and Discussion

Grain and Straw Yield

The grain yield of soybean was significantly higher (29.18 q ha^{-1}) in the seed treated plots compared to untreated plot with significantly highest recorded in seed priming with $FeSO_4.7H_2O$ @ 0.02 % along with recommended dose of fertiliser. This might be due to increase in germination percent, vigour index and Fe enrichment of soybean seed due to seed priming with $FeSO_4.7H_2O$ @ 0.02%.

Similar results were obtained by Huang *et al*., (2002) [4] who stated that germination percentage of primed and air-dried seeds at 30^0C increased by 51 % and GT_{50} was reduced by 21 % compared to the control. In the field, primed seeds emerged faster and had higher yield than non-primed seeds. Primed spinach yield was 1213 kg per 0.1 ha at 45 days after planting, while that of control was 633 kg per 0.1 ha. The highest stover yield (34.89 q ha^{-1}) was recorded, when seeds were treated with $FeSO_4.7H_2O$ @ 0.02% along with recommended dose of fertilizer. Farooq *et al*., (2012) [1] reported that seed treatment with micronutrients has the potential to meet crop micronutrient requirements and improve seedling emergence and stand establishment, yield and grain micronutrient enrichment.

Table 1: Grain and straw yield of soybean in calcareous soil

Tr. No.	Treatment	Yield (qha^{-1})		Percent increase over T_2 treatment	
		Grain	Stover	Grain	Stover
T_1	Absolute control	21.31	26.35	-	-
T_2	GRDF (50:75:45 $N:P_2O_5:K_2O$ kg ha^{-1} + 5 t ha^{-1} FYM)	25.57	29.21	-	-
T_3	T_2 + seed priming with distilled water	25.74	30.09	0.66	3.01
T_4	T_2 + seed priming with ZnEDTA@ 0.2 %	26.53	31.18	3.75	6.74
T_5	T_2 + seed priming with $ZnSO_4$. $7H_2O$ @ 0.02%	26.47	30.19	3.52	3.35
T_6	T_2 + seed priming with Fe EDTA@ 0.1%	27.73	32.50	8.45	11.26
T_7	T_2 + seed priming with $FeSO_4.7H_2O$ @ 0.02%	29.18	34.89	14.12	19.45
	SE±	0.80	1.12		
	CD at 5%	2.51	3.51		

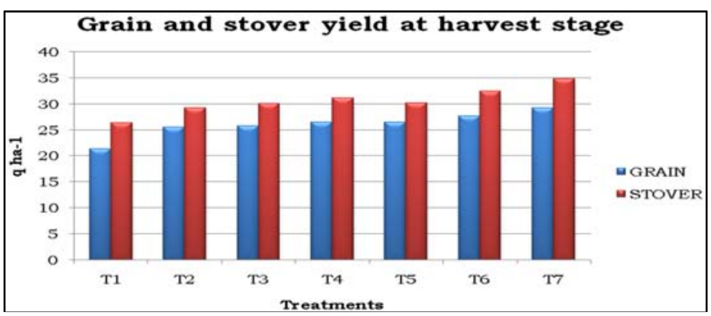

Fig 1: Effect of seed priming with iron and zinc on grain and stover yield at harvest stage of soybean

Total Fe and Zn Uptake by Soybean

Table 2: Total uptake of iron and zinc by soybean crop at harvest stage

Tr. No.	Treatment	Total uptake (g ha^{-1})	
		Fe	Zn
T_1	Absolute control	1770	891
T_2	GRDF (50:75:45 $N:P_2O_5:K_2O$ kg ha^{-1} + 5 t ha^{-1} FYM).	2567	1098
T_3	T_2 + seed priming with distilled water	2644	1200
T_4	T_2 + seed priming with Zn EDTA @ 0.2 %	3030	1674
T_5	T_2 + seed priming with$ZnSO_4$. $7H_2O$ @ 0.02%	3142	1499
T_6	T_2 + seed priming with Fe EDTA @ 0.1%	3934	1322
T_7	T_2 + seed priming with $FeSO_4.7H_2O$ @ 0.02%	5330	1436
	SE±	354.05	67.42
	CD at 5%	1090.94	207.74

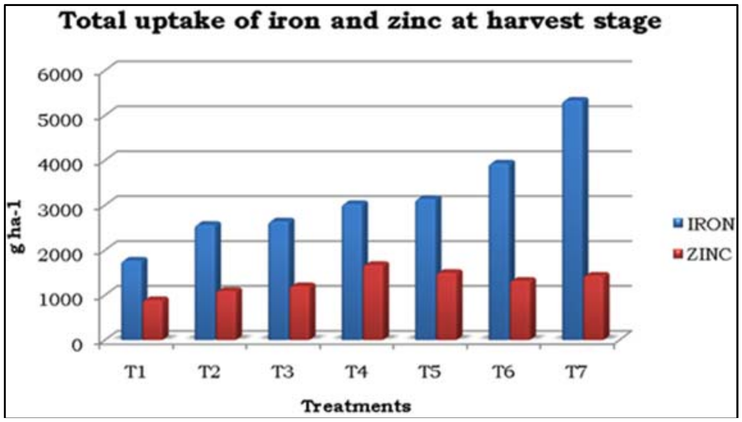

Fig 2: Effect of seed priming with iron and zinc on total uptake of iron and zinc at harvest stage of soybean

Highest uptake of Fe (5370.17 g ha^{-1}) and Zn (1674.17 g ha^{-1}), respectively, were found in seeds primed with $FeSO_4.7H_2O$ @ 0.02 % and seeds primed with Zn-EDTA @ 0.2% along with recommended dose of fertilizer. Seed priming effectively increased the micronutrient content of grain and stover compared to the control. This increase in micronutrient might be due to supply from the nutrient imbibed at the time of seed soaking. Similar results were obtained by Harris *et al*., (2007) [3], who stated that priming maize seeds in 1 % w/v $ZnSO_4$ solutions for 16 hrs. significantly increased seed Zn concentration, and the seedlings derived from these seeds showed greater biomass and significantly greater grain yield.

Conclusions

Seed priming has been found effective in supplying the micronutrient requirement of seeds at the time of sowing as well as during the entire life cycle of plant. Higher micronutrient content at the time of harvest was found in plot primed with micronutrients compared to the control. Also there was no requirement for extra supplement of micronutrients through other method. This method is cost effective since very less micronutrient is required for soaking of the seeds. Considering all this, seed priming should be promoted among farmers for better yields, micronutrient content of the grain as well as for its low cost.

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