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SHORT COMMUNICATION

COMPLIMENTARY EFFECT OF ZINC APPLICATION ON IRON CONTENT IN SORGHUM GENOTYPES

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A field experiment was conducted during *rabi* 2006-07 to study the effect of zinc application on iron content and its translocation in low and high seed zinc type sorghum genotypes raised in calcareous soil. Zinc application @ 10 kg ha^{-1} significantly enhanced the iron content in root, leaf, inflorescence and seeds of high and low seed zinc type sorghum genotypes. Application of zinc to the calcareous soil was complimentary to sorghum plant iron content. Low seed zinc types accumulated more iron in root than in leaf and inflorescence,whereas high seed zinc types accumulated less iron in roots than in leaf and inflorescence which led to higher accumulation of iron in the seeds of high zinc types and were efficient in zinc utilization during growth and iron uptake and translocation than low types.

***Key words*: Iron, sorghum, zinc**

Zinc deficiency is wide spread among plants grown in highly weathered acid soils and in calcareous soils. In latter case zinc deficiency is often associated with iron deficiency(lime chlorosis).The low availability of zinc in calcareous soils results mainly from adsorption of zinc to clay or $CaCO-_3$ rather than formation of sparingly soluble $Zn(OH)_2$ or $ZnCO_3$ (Trehan and Sekhon 1977). In addition, zinc uptake and translocation to shoot are strongly inhibited by high concentration of bicarbonate (Forn *et al*. 1975, Dogar and Vanttai 1980). This effect has striking similarities to the effect of HCO_3 on iron. In neither case, it is well understood. Crops raised in such soils will have low zinc and iron resulting in low productivity as well as lower levels of these in seeds too. Therefore, an attempt was made to enhance the concentration of zinc in rabi sorghum genotypes by zinc application and its effect on iron contents and translocaton was studied. Both zinc and iron are important from the point of sorghum crop nutrition, productivity and human nutrition perspective.

Eight *rabi* sorghum genotypes consisting of four high seed zinc (EC 19, EA 10, DSV 4 and SEVS 23 with seed Zn content from 4.4-5.9 mg 100^{-1} g) and four low seed zinc types (DSV 5, SEVS 22, PU 21 and Gidda Maladandi with seed Zn content from 2.7-3.2 mg 100^{-1} g) were selected from a lot of 35 *rabi* sorghum genotypes analyzed previously for seed zinc content. Two zinc regimes were imposed, one as control (without application of zinc) and another with application of zinc sulphate @ 10 kg ha^{-1} to the soil (calcareous)at the time of sowing along with recommended dozes of NPK. The experiment was laid out at the College of Agriculture, Dharwad during *rabi* 2006-07 following the factorial randomized block design with three replications. The optimum moisture was maintained.The plant samplings was done at flag leaf stage for estimation of zinc and iron content and remaining plants in net plot area were harvested at physiological maturity. The total zinc and iron content in inflorescence, leaf, root and seed were determined from a di-acid extract method of Johnson and

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Ulrich(1959) using Techtron-10 atomic absorption spectrophotometer. The iron content was expressed in mg 100^{-1} g of plant dry weight.

All crops are susceptible to zinc deficiency, but species differ considerably in their ability to tolerate low levels of zinc supply. Sorghum is highly sensitive cereal crop to zinc deficiency (Martens and Westermann 1991). Sorghum grown in calcareous soil faces zinc deficiency and reduction in yield is common without showing deficiency symptoms, which is referred as hidden hunger (Anand *et al*. 2007). Addition of zinc to the sorghum increased zinc content significantly in the root, leaf and grains of sorghum. Increase in the concentrations of zinc in the plants enhanced root, shoot biomass and grain yield too, reflecting increase in overall growth and indicated the soil had inadequate zinc in the soil. Sorghum genotypes of high seed zinc types had higher seed zinc content and low seed zinc types had lower zinc content and maintained the inherent variation of seed zinc content during experimentation and seed zinc content profile was similar to the previously analyzed seed zinc content (Anand *et al.* 2007).

In plants, zinc plays a key role as a structural constituent or regulatory co-factor in a wide range of enzymes in many important pathways (Brown *et al*. 1993). Enhancement of zinc in plants naturally enhances metabolic activities forcing the plant to acquire other minerals from the soil and utilize in the metabolic activities. Iron is also one of the essential elements like zinc, constraints for iron in calcareous are similar to zinc, hence the effect of increased zinc content on iron was analysed.

The data (Table 1) on iron content in different parts at flag leaf stage indicated that root contained maximum amount of iron(57%) followed by leaf(35%) and least

Table 1. Iron content in leaf, root and inflorescence (mg100^{-1}g) at flag leaf stage as influenced by application of zinc sulphate in sorghum genotypes

Genotypes	Leaf			Root			Inflorescence		
	Zn(-)	Zn(+)	Mean	Zn(-)	Zn(+)	Mean	Zn(-)	Zn(+)	Mean
High Zn type									
EC 19	16.25	22.5	19.38	14.22	16.55	15.38	3.25	6.28	4.76
EA 10	12.85	15.51	14.18	17.27	25.27	21.27	2.98	4.5	3.74
DSV-4	12.72	18.61	15.67	12.82	20.45	16.64	2.49	2.96	2.73
SEVS-23	10.74	17.15	13.95	20.38	26.78	23.58	2.77	4.5	3.64
Mean	13.14	18.44	15.8	16.17	22.26	19.22	2.87	4.56	3.72
Low Zn type									
DSV 5	10.33	11.89	11.11	24.91	32.00	28.46	2.19	2.73	2.46
SEVS-22	12.38	15.77	14.08	20.94	30.69	25.81	1.50	2.36	1.93
PU 21	11.51	14.5	13.01	19.32	29.05	24.19	2.58	3.36	2.97
Gidda maladandi	10.48	12.02	11.25	25.91	34.87	30.39	2.10	2.56	2.33
Mean	11.18	13.55	12.36	22.77	31.65	27.21	2.09	2.75	2.42
Grand mean	12.16	16.00	14.08	19.47	26.96	23.22	2.48	3.65	3.07
For comparing		**SEm±**	**CD at 5%**		**SEm±**	**CD at 5%**		**SEm±**	**CD at 5%**
Genotypes(G)		0.34	0.69		0.37	1.07		0.17	0.49
Zinc levels(Zn)		0.03	0.08		0.19	0.53		0.08	0.24
GXZn interaction		0.48	1.38		0.52	1.51		0.24	0.69

Zn (-) = without zinc application, Zn (+) = with zinc application was appeared in the inflorescence(7.6%), while at harvest, seed accumulated more iron than inflorescence (Table 2).Thus root was the immediate sink with maximum iron accumulation and later it translocated to different parts. However, the trend among the genotypes did not remain same but differed significantly. The genotype EC 19 had significantly higher leaf iron content (19.38 mg 100^{-1} g) and DSV 5 contained least (11.11 mg 100^{-1} g). Iron content in root differed significantly among the genotypes and was found higher in the genotype Giddamaladandi (30.39 mg 100^{-1} g) and least in the EC 19 (15.38 mg 100^{-1} g). The inflorescence and seeds of EC 19 had significantly higher iron content. The genotype SEVS-22 which had least iron in inflorescence also had lowest iron content in seeds. Differences in accumulation and translocation were evident among the genotypes in the present investigation. Zinc and iron both are of the variable phloem mobility elements like Cu, Mo, Co and Ni in plants. The degree of phloem mobility of these nutrient elements is highly variable between plant species and even between genotypes within the same species. Additionally, their mobility is dependent not only on genetic variability but also on environmental conditions during development and on plant growth stage (Welch 1986). The iron content in leaf, root, inflorescence and seed increased due to the zinc application showing the zinc dependent uptake and translocation of iron in sorghum raised in calcareous soil (Table 1 & 2). Thus, there was complimentary effect of zinc application on iron content in sorghum. In general, application of zinc sulphate increased root biomass and also utilization efficiency in sorghum. Higher root biomass and higher root volume might have increased the iron content in sorghum plants.

Iron content of Leaf, root and inflorescence of both low and high types increased significantly due to application of zinc. Irrespective of zinc supply, low types contained fairly higher amount of iron in their roots (27.21 mg 100^{-1} g) as compared to the roots of high types (19.22 mg 100^{-1} g), whereas the leaf and inflorescence of high types contained higher iron content. Thus, low types found to accumulate more iron in their roots without translocating much of it to the shoot portion and resulting in reduced iron content in grains (3.45 mg 100^{-1} g) as compared to high types (5.55 mg 100^{-1} g). Whereas, it was quite reverse in high types, which maintained low amount in roots. Therefore, the high types were efficient in translocation of iron and maintained higher iron in grains (Table 2). A similar increase and genotypic difference in zinc accumulation has been reported by Anand *et al*. (2007). Increasing Zn supply to plant roots has been shown to increase (Watanabe *et al*. 1965, Jolley and Brown 1991) or have little effect (Norvell and Welch 1993) on Fe concentration in shoots. However, here in the present investigation zinc application might have enhanced synthesis of auxin from tryptophan and thereby enhanced growth, which might have naturally required more iron content for chlorophyll synthesis and other metabolic activities (Hemantaranjan and Garg 1984).

Table 2. Seed iron content (mg 100^{-1} g) as influenced by zinc application in *rabi* sorghum genotypes

Genotypes	Zn(-)	Zn(+)	Mean
High Zn type			
EC 19	5.12	8.23	6.68
EA 10	4.92	6.31	5.62
DSV-4	3.76	5.11	4.44
SEVS-23	4.52	6.41	5.47
Mean	4.58	6.52	5.55
Low Zn type			
DSV 5	2.96	3.46	3.21
SEVS-22	2.46	3.41	2.94
PU 21	3.81	5.35	4.58
Gidda maladandi	2.26	3.87	3.07
Mean	2.87	4.02	3.45
Grand mean	3.73	5.27	4.50
For comparing	**SEm±**	**CD at 5%**	
Genotypes	0.18	0.53	
Zn	0.09	0.26	
GXZn	0.26	0.75	

Zn(-)=without zinc application ,Zn(+)= with zinc application

Grain iron content is most important from human nutrition perspective. The high types were observed to have 38 per cent higher iron than low seed types. In zinc supplied condition, it further increased significantly by 62 percent, whereas, the low types could increase 23 percent only. As there was increase in the in zinc and iron contents in plants due to zinc application ,there was concurrent increase in sorghum yield also (Anand *et al*. 2007).

From the discussion it could be inferred that agronomic fertigation of zinc not only enhances zinc in sorghum but also increases iron content in sorghum. Genotypic differences were also significant emphasizing the genetic control of mineral nutrient accumulation and translocation. The genotype EC 19 belongs to high seed zinc type had significantly higher iron content with higher translocation efficiency and was considered superior among the genotypes in the present study.

REFERENCES

Anand, A. (2007). Evaluation of *rabi* sorghum genotypes for seed zinc content and zinc use efficiency. M.Sc (Agri.) thesis, University of Agricultural Sciences, Dharwad.

Brown, P.H., Cakmak, I. and Zhangi, Q. (1993). Form and function of zinc in plants. In: A.D. Robson (ed.), Zinc in Soils and Plants, pp. 90-106. Kluwer Academic Publishers, Dordrecht.

Forno, D.A.,Yoshida, S. and Asher, C.J. (1975). Zinc deficiency in rice. I. Soil associated with the deficiency. *Plant* S*oil* **42:** 537-550.

Hemantaranjan, A. and Garg, O.K. (1984). Effect of zinc fertilization on the senescence of wheat varieties. *Indian J. Plant Physiol.* **27:** 239-245.

Johnson, C.M. and Ulrich, A. (1959). Analysis of Micronutrients in Plant Samples. Bulletin No. 766-778. California Agricultural Experiment Station.

Jolley, V.D. and Brown, J.C. (1991). Factors in iron-stress response mechanism enhanced by zinc deficiency stress in Sanilac, but not Sainaw navy bean. *J. Plant Nutr.* **14:** 257-266.

Martens, D.C. and Westermann, D.J. (1991). Fertilizer applications for correcting micronutrient deficiencies In: J.J. Mortvedt, F.R. Cox, L.M. Shuman and R.D. Welch (eds.), Micronutrients in Agriculture (2nd edition), pp. 549-592. Soil Science Society of America Inc, Madison, Wisc.

Nayyar, V.K. and Takkar, P.N. (1980). Evaluation of various zinc sources for rice grown on alkali soil. *Pflanzenernachr. Bodekd* **143:** 489-493.

Norvell, W.A. and Welch, R.M. (1993). Growth and nutrient uptake by barley (*Hordeum vulgare* L. cv. Herta): Studies using an N-(2-hydroxyethyl) ethylenedinitrilotriacetic acid buffer nutrient solution technique I. Zinc ion requirement. *Plant Physiol*. **101:** 619-803.

Trehan, S.P. and Sekhon, G.S. (1977). Effect of clay, organic matter and $CaCO_3$ content of zinc adsorption by soils. *Plant Soil.* **46:** 329-336.

Welch, R.M. (1986). Effect of nutrient defiencies on seed production and quality. *Advan. Plant Nutr.* **14:** 49-82.

Watanabe, F.S., Lindsay, W.L. and Olsen, S.R. (1965). Nutrient balance improving phosphorus, iron and zinc. *Soil Sci. Soc. Amer. Proc*. **29:** 562-1512.