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Short Communications

Effect of sulphur fertilization on biofortification of wheat (*Triticum aestivum*) grains with Fe, Zn, Mn and Cu

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Iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) are essential micronutrients for plants (Prasad and Power 1997) as well as for humans (Gibson 2005). Fe deficiency in humans is widespread in the world, especially in developing countries and also of late Zn deficiency in humans has also drawn considerable attention globally. These micronutrients are required by various metabolic and other processes in human body. Fe and Zn biofortification of cereal grains and other foods has received considerable attention in recent years through genetic improvement of crop cultivars (Graham *et al*. 2001) as well as through agronomic techniques (Prasad *et al*. 2014). Agronomic biofortification mainly focuses on soil or/and foliar fertilization with Fe and Zn fertilizers (Shivay *et al*. 2008, Dhaliwal *et al*. 2010, Shivay *et al*. 2013, Shivay *et al*. 2014, Ram *et al*. 2015). Agronomic biofortification is the easiest and fastest way for biofortification of cereal grains with Fe, Zn, or other micro mineral nutrients in developing Asian and African countries, where cereals are the staple food. Agronomic biofortification is the only way to reach the poorest of the poor rural masses, who will never have money to buy mineral supplements nor can afford to improve the components of their diet by incorporating animal products. The genetic and agronomic approaches are complementary to each other and should progress in tandem (Prasad *et al*. 2014).

Sulphur (S) deficiency in soils is widespread in India and S is now recognized as the fourth major plant nutrient after NPK in fertilizer recommendations for most crops (Tandon 2004) and good responses to S fertilization have been reported (Biswas 2004). However, most studies on S fertilization of crops are generally restricted to yield and S uptake by cereals and pulses and in case of oilseed crops on oil content in seed (Tiwari and Gupta 2006). At present scanty information on the effect of S fertilization on Fe, Zn, Mn and Cu concentration in cereal grains is available and therefore the present study was undertaken.

The present study was taken up on wheat grain samples drawn from the harvest of a field experiment conducted during *rabi* (November-April) season of the crop year 2013-14 to determine the response of wheat (*Triticum aestivum* L.) to sulphur fertilization using sulphur-coated urea (SCU) as a source of S. The SCU used in the present study was made in our research laboratory using prilled urea, commercial grade sulphur dust (90% ash), and natural gum acacia as an adhesive material to provide coatings of 1%, 2%, 3%, 4% and 5% sulphur onto urea. The field experiment was laid out in a randomized block design with 3 replications and 7 treatments [control (no fertilizer), prilled urea and 1%, 2%, 3%, 4%, 5% SCUs each added to supply 130 kg N/ha. All plots of the field experiment were received 26.2 kg P and 41.7 kg K/ha, respectively. The soil of the experimental field was sandy clay loam with a *p*H of 7.8, medium in available NPK and had 8 mg/kg available S (Prasad *et al*. 2006). The DTPA-extractable Zn (Lindsay and Norvell 1978) in the soil was 0.57 mg/kg soil. At harvest, grain yield of wheat was recorded for each plot of the experiment. Also at harvest, the samples of grain were drawn from each plot for the chemical analysis of Fe, Zn, Mn and Cu concentrations. The Fe, Zn, Mn and Cu in grain samples was analysed on a di-acid ($HClO_4$ + HNO_3 in 3:10 ratio) digest on an Atomic Absorption Spectrophotometer (Prasad *et al*. 2006).

Application of N significantly increased Fe, Zn, Mn and Cu concentrations in wheat grain over control (Table 1). Application of S as SCU further significantly increased the concentrations of Fe, Zn, Mn and Cu in wheat grain over N application and the highest values for all the micronutrients were recorded for 5% SCU. However, the increase in the concentration of the 4 micronutrients studied for each percentage of S coating differed in four micronutrients. In the case of Fe, the increase in its concentration in grain increased significantly with each percentage increase of sulphur coating in SCU. As regards Zn, 2 to 5% SCU were

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Table 1 Effect of sulphur fertilization on Fe, Zn, Mn and Cu concentrations in wheat grain

Treatment	Micronutrients concentrations (mg/kg)			
	Fe	Zn	Mn	Cu
Control (no fertilizer)	150	37.3	41.0	5.1
Prilled urea	156	39.2	43.7	5.8
1% Sulphur-coated urea	161	40.9	44.3	6.4
2% Sulphur-coated urea	166	42.8	45.8	6.9
3% Sulphur-coated urea	171	43.2	46.3	7.2
4% Sulphur-coated urea	176	43.8	46.5	7.6
5% Sulphur-coated urea	181	44.5	46.8	7.7
SEm±	1.52	0.62	0.75	0.13
LSD (P=0.05)	4.69	1.90	2.30	0.40

at par and significantly superior to 1% SCU. In the case of Mn, 3 to 5% SCU were at par and recorded significantly more Mn in wheat grain than 1 or 2% SCU. As regards Cu, 4 and 5% SCU were at par and recorded significantly higher Mn in wheat grain than 2 or 3% SCU, which were in turn superior to 1% SCU. Thus, both N and S fertilization increased Fe, Zn, Mn and Cu concentrations in wheat. It could be due to acid forming effect of N (as nitrates) and S (as sulphates) in soil (Prasad and Power 1997), which helped in the dissolution of soil Fe, Zn, Mn and Cu and led to their increased acquisition and absorption by the wheat roots in the rhizosphere. Furthermore, with application of N and sulphur translocation of Fe, Zn, Mn and Cu from source to sink increased which ultimately enhanced the concentrations of these micronutrients in the grains of wheat.

SUMMARY

The highest increase in the concentration of Fe, Zn, Mn and Cu was recorded with 5% sulphur coated urea (SCU), which should be considered as a good source of sulphur along with nitrogen for wheat (*Triticum aestivum* L.). The present study also shows that S fertilization can be helpful in micronutrients biofortification of wheat grains. This study also suggests the need for a linkage between agronomic and human nutrition research in tandem.

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