Scenario of Zinc Deficiency in Indian Soils and Its Influence on Zinc Enrichment in Crops for Improving Human and Animal Health

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INTRODUCTION

Zinc deficiency in crops is the common micronutrient problem world over, therefore zinc malnutrition has become a major health burden among the resource poor people (Takkar et al 1990, Singh 2006, 2011). One third of the world population is reported at the risk of zinc malnutrition due to inadequate dietary intake of zinc (Cakmak 2009). Singh (2010) reported wide spread hidden hunger of zinc in seeds and feeds which is affecting a large segment of resource poor families whose food comes mainly from cereals grown on zinc deficient soils. Continuous intensive cropping of high yielding crop varieties has further aggravated the depletion of soil zinc leading to low zinc concen-tration in edible grains. This paper therefore, aims to present the latest scenario of zinc deficiency in Indian soils and best agricultural management practices influencing zinc enrichment in seed and fodders for addressing zinc nutrition, yield improvement for reducing zinc malnutrition in India.

METHODS AND MATERIALS

Survey data for soil available zinc status generated in India by analysis of 300000 surface samples in past four decades was systematically processed to assess the effect of soil-crop-zinc fertilization- management practices on periodic changes in zinc deficiency in India. The data of 7500 field response trials and 220 site zinc concentration in soil, grain and stover were compared to assess the impact of zinc deficiency on grains, human and animal plasma zinc concentration. Economic losses due to zinc deficiency were worked out for maize, rice and wheat crop as suggested by Singh (2010).

RESULTS AND DISCUSSION

Continuous cropping over past four decades has caused much change in zinc status in most soils and crops 9Table 1). A wide range of inter and intra variations in zinc deficiency have been recorded among the soils, states and agroecological zones (AEZ). Zinc deficiency was found less than 40% in AEZ 1, 2, 5, 15, 16, 18, 19; 40-50% in AEZ 9, 11, 12; 50-55% in AEZ 4, 7, 13 and > 55% in remaining areas of country.The extent of zinc deficiency was found 55, 47, 36% in trans-northern, central and eastern parts of Indo-Gangetic alluvial plains (IGP) (Singh 2001, 2009). Zinc deficiency in northern states before 1980 was a dominant problem as 77, 69 and 53% soil samples were tested low in zinc in Haryana, Punjab and Uttar Pradesh state which has come down to 19, 22.6 and 39% by the year 2007-08 due to regular application of zinc sulphate in paddy-wheat systems. A reverse trend was however, observed for zinc status in southern states deficiency of zinc showed an increase from 42% tested in 1975 to 70% found in 2006-7 as the farmers in these states are often using micro-nutrient mixtures which left much less residual effect in soils compared to zinc sulpahte (Table 1). In middle India, multinutrient deficiencies are widely causing poor crop yields. Overall zinc deficiency in country has increased from 42% to 49% in past four decades and it is expected to increase upto 63% by 2025 (Singh 2009). Detrimental effect of zinc deficiency on crop yields was estimated to be US $ 1.5 billion (Singh et al 2010) which is leading to increased disease burden worth of US$ 2.5 billions as reported by world bank depending upon nature of crop (Singh 2006).

Zinc application at 5-10 kgha^{-1} increased the grain response by 0.2-2.6 t ha^{-1} in rice-wheat, rice-rice,maize-wheat or rice-pulse cropping systems (Singh 2006, Takkar et al 1990). But zinc concen-tration in seed still found low. Zinc enrichment in seed through agronomic biofortification has not received much focus in India (Singh 2010). Studies conducted to assess the impact of zinc deficiency on mineral zinc content in seed, humans and animals by collecting 220 soil, grain and straw samples of wheat, maize and paddy fields and their respective families in Nalgonda, East Godavary, Karnal, Sirsa, Panchmahal, Vadodara, Ludhiana districts indicated need for soil-crop specific zinc manage-ment options to enrich seeds. In Haryana and Punjab regular zinc fertilization has increased zinc in paddy, wheat and maize grains ranging from 12 to 29, 14 to72, 28 to 47 mg kg^{-1} (Singh 2010, 2011).

Table 1. Changes in percent zinc deficiency (PSD) in north, central and southern states of India

States	1968-83		1983-89		1988-97		1997-2008	
	No. of soil Sample	PSD	No. of soil Sample	PSD	No. of soil sample	PSD	No. of soil sample	PSD
Northern	33906	66	25561	50	30551	35	6751	24.2
Central	40416	41	33759	38	41817	53	3468	55.0
Southern	11945	42	22737	49	6300	55	5266	70.1

Two foliar sprays of 0.5% zinc sulphate unneutralized at blooming and milk stages increased the zinc enrichment by 3 to 4 times higher compared to zinc in seed found in zinc deficient sites or had basal application alone (Singh 2009a). Rice had low zinc than maize, wheat and pulses. Concentration of zinc increases as density of wheat seeds increases. Zinc concentration increases in seeds and stover with balanced application of 5 kg Zn, 100-120 kg N and 40 kg S ha^{-1} than either N or P application alone. In similar studies level of zinc soil fertility also influenced the zinc enrichment in pigeon pea, gram and wheat. High status of zinc in soils of Haryana and Andhra Pradesh led to high zinc concentration in blood plasma samples in human and animals above the critical content (Singh and Sampath 2011). Zinc sulphate sprays at heading and milk stage were found beneficial as that of zinc chelates while zinc chloride spray caused deleterious effect on major cereal and pulse crops.

CONCLUSIONS

Zinc deficiency in Indian soils is expected to increase from 42% in 1970 to 63% by 2025 due to continuous depletion of soil fertility. A direct yield loss is estimated US $1.5 billion/yr besides huge loss due to disease burden in the country. Only about one third of the country is consuming adequate zinc sulpahte which has increased zinc concentration in soil, grain and fodders but much focus is needed in central and southern India. Several site and crop specific zinc management options are available for enhancing zinc enrichment efficiency in paddy, wheat, pulses and maize. Zinc concentration ranged from 12 to 29, 14 to72, 28 to 47 mg kg^{-1} in seed in major crops. Two foliar sprays of 0.5% zinc sulphate at blooming and milk stages increased the zinc enrichment by 3 to 4 times than that in zinc deficient condition or crops received only basal dose of 5 kg $Znha^{-1}$. Balanced use of NPSZn increased the zinc enrichment more than inadequate and imbalanced use. Areas having high zinc status in soils has direct effect on zinc concentration in seed and so on blood plasma in human and animals, thereby reduces zinc malnutrition, disease burden and yield economic losses.

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