

## Micronutrient deficiencies in Indian soils and field usable practices for their correction

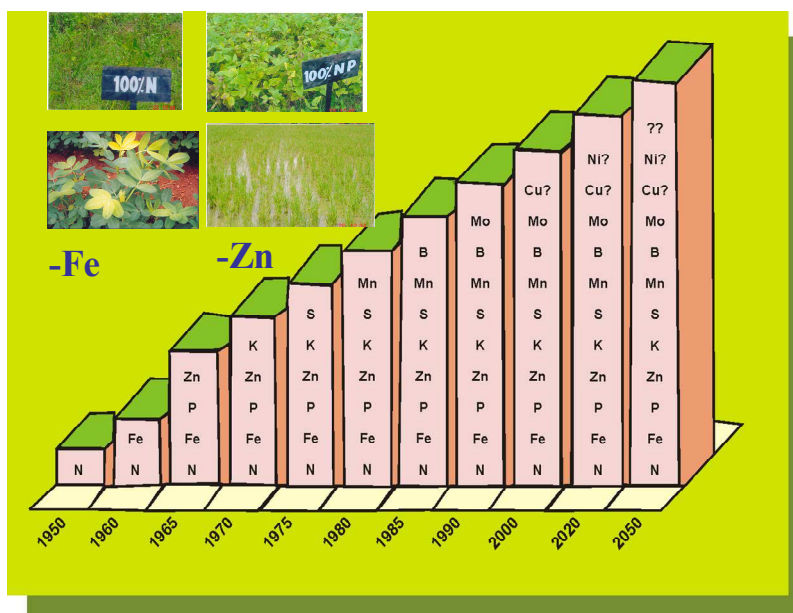
M. V. Singh

Project Coordinator ( Micronutrients)

\*Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal-462 038

(E.mail: [drmvssingh@yahoo.com](mailto:drmvssingh@yahoo.com), [mvs@iiss.ernet.in](mailto:mvs@iiss.ernet.in))

Micronutrients are essential for the normal growth of plants. Deficiencies of micronutrient drastically affects the growth, metabolism and reproductive phase in plants, animal and human beings. Wide spread deficiencies of micronutrients has been found in Indian soils. About 3 billion people in the world are affected with micronutrient malnutrition.

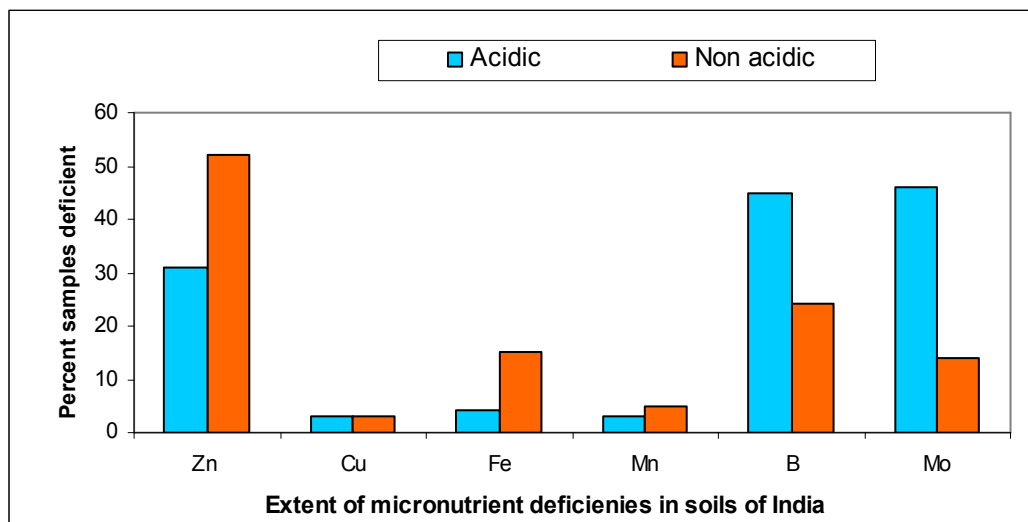
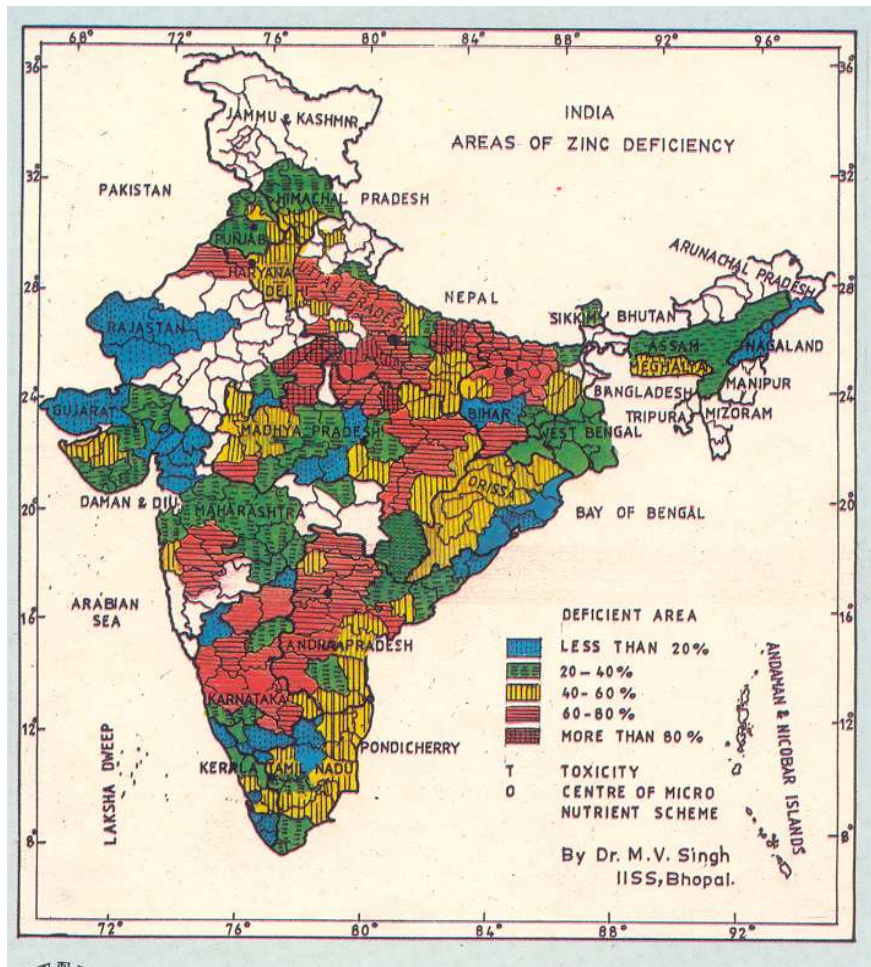


**Emerging deficiencies of multi-micronutrients in Indian crops in Indian soils due to depletion in fertility during Green Revolution**

### Delineation of micronutrient deficient areas

In India, analysis of 2.52 lakhs surface soil samples collected from different parts of the country revealed the predominance of zinc deficiency in divergent soils. Of these samples 49, 12, 4, 3, 33% and 41% soils are tested to be deficient in available zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), boron (B) and sulphur (S), respectively (Table 1). The magnitude of zinc deficiency varied widely among soil types and within the various states. Coarse textured, calcareous, alkaline or sodic soils having sandy texture, high pH and low in organic matter are generally low in available zinc.

Calcareous soils of Bihar, Vertisols and Inceptisols of Andhra Pradesh, Tamil Nadu and Madhya Pradesh and Aridisols of Haryana showed extensive deficiency of zinc resulting low crop yields. Zinc is a crucial component of the package of the practices recommended sodic soils reclamation. Deficiencies of Fe, Mn and Cu are much less extensive than that to zinc. The deficiency of Fe was found to be largest 26% in Sierozem of Haryana followed by 18% in Tamil Nadu, 12% in Punjab and 8 to 9% in calcareous soil of Gujarat and Uttar Pradesh. Acid soils are more deficient in B and Mo than zinc, iron and manganese.



Agroecological zone (AEZ) wise, extent of zinc deficiency was found less than 40% in zone no. 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 other zones (Table 1). Among 90419 surface soil samples analyzed for AEZ 4, 9, 13, 16 mainly representing

Indo-Gangetic alluvial plain (IGAP) showed 55, 47 and 36% zinc deficiency in trans-northern, central and eastern parts of West Bengal while reverse trend was found for boron showing 8, 37, 68% deficient soils, respectively.

**Table 2. Extent of micronutrient deficiencies in different Agro-Ecological Zones of India**

SNo	Agroecological zones name	Soil type	No. of sample	Per cent deficient samples			
				Zn	Cu	Mn	Fe
1	Western Himalayas	Hill	138	21.0	-	-	-
2	Western plains and Kutch Peninsula	Desert & Saline	12136	36.0	3.6	8.3	16.6
3	Deccan Plateau	Red and black	485	57.5	0.1	0.6	4.8
4	Northern Plain and Central Highlands	Alluvial derived	24936	54.6	2.4	4.3	9.6
5	Central (Malwa) highlands and Kathiawar Peninsula	Medium & deep black	8569	64.2	0.7	1.9	3.0
6	Deccan Plateau	Shallow & medium black	3865	64.6	0.5	1.9	11.8
7	Deccan Plateau and Eastern Ghats	Red & medium black	5573	51.6	0.1	2.6	4.0
8	Eastern Ghats (TN uplands) and Deccan Plateau	Red loam	12688	57.0	17.6	8.4	19.9
9	Northern Plain	Alluvium derived	13793	44.2	2.4	5.4	9.4
10	Central highlands (Malwa & Bundelkhand)& Deccan Plateau	Medium black clay Red soil	6659 6898	76.5 58.0	0.3 1.0	0.7 0.6	6.1 2.5
11	Eastern Plateau (Chhatisgarh)	Red and yellow	8067	44.5	0.7	0.1	0.9
12	Eastern (Chhota Nagpur) Plateau and Eastern Ghats	Red loam	18675	49.1	0.9	1.8	0.5
13	Eastern Plain	Alluvium derived	10221	54.7	1.6	17.6	19.6
14	Western Himalayas	Brown hill & forest	490	45.0	18.0	17.6	16.4
15	Assam and Bengal plains	Alluvium derived	18712	34.0	0.5	0.2	0.3
16	Eastern Himalayas	Brown red and hill	52	20.0	0.4	1.0	0.6
17	North-Eastern hills (Purvanchal)	Alluvial derived	95	57.0	2.1	2.3	0.2
18	Eastern Coastal Plains	Alluvium derived	8152	15.0	4.2	3.6	4.0
19	Western Ghats & Coastal Plains	Red, lateritic and Alluvium	720	36.0	24.0	1.0	0.8
20	Islands of Andaman-Nicobar and Lakshadweep	Red loamy	8	20	-	-	-
All	All	All	148782	45.4	3.3	4.5	8.3

Source : Singh (1999, 2001) AICRP Micronutrients

Boron deficiency varies from 2% in AER 2; 24-48% in highly calcareous soils of AEZ 2, 9 and 14 but most widespread (39-68%) in red and lateritic soils of AEZ 6, 13, 16, 17, 19. Deficiency of boron occurs widely in highly calcareous soils of Bihar, parts of Gujarat and Tamil Nadu. Calciorthent soils of Samastipur and Muzzaffarpur showed 52% B deficiency, 44% in Gandak command area and 32% in Vertisols of Sone command area. About 22-24% calcareous and sandy soils of Uttar Pradesh and 2-4% samples of swell-shrink soils of Madhya Pradesh, inceptisols of Haryana and Punjab tested to be deficient in available boron. Soil fertility maps have been prepared for wider use. **Maps showing micronutrient deficiencies** have been developed for common use as given below.

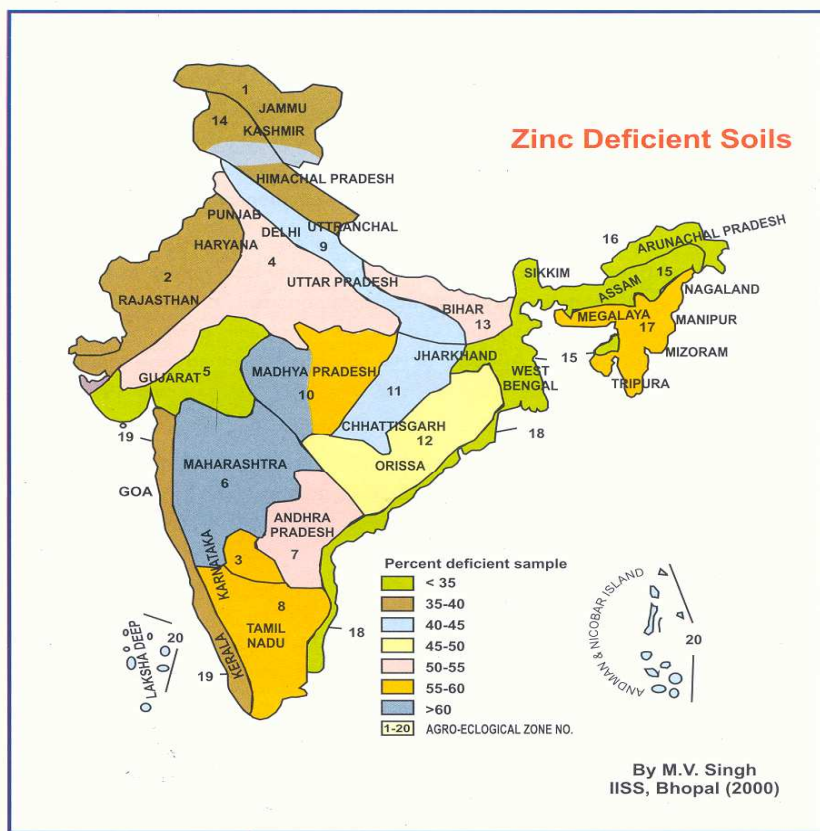


Fig. 1 Extent of zinc deficient soils in different agro-ecological zones of India



Fig 5. Extent of manganese deficiency in Indian soils

## 2. Amelioration technology for correcting micronutrient deficiencies

### 2.1 Amelioration of zinc deficiency

#### 2.1.1 Sources of zinc

- Among various inorganic sources, zinc sulphate hepta hydrate ( $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ) containing 21-22% Zn is found the most efficient, commonly available, economically cheapest zinc source for correcting Zn deficiency in most of the crops and diverse soils as compared to sparingly soluble Zn sources, chelates and mixtures. Mono hydrated zinc sulphate (33%) and hepta hydrated zinc sulphate containing (21% Zn) were found equally efficient for correcting zinc deficiency either through soil and foliar application.
- Regular application of farm yard manure (FYM) at 10-15 tonnes /ha if applied , it helps in mitigating deficiencies of all the micronutrients in long run. However if farm yard manure is not applied annually, one should apply on alternate year to prevent emerging micronutrient deficiencies. When adequate FYM is not available, and 4-5 t/ha is added then one may reduce 50% of the recommended dose of FYM.
- Application of 2.5 t/ha poultry manure or piggery manure is efficiently correct the zinc deficiency in different crops.
- If biogas slurry is applied then application of 2.5 kg Zn/ha is adequate to get good yield in highly deficient soils. Green manuring is found helpful in enhancing availability of native micronutrients of soil and enhances yield.
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- Synthetic Zn-EDTA chelates were found better than zinc sulphate in combating Zn deficiency in crops in non calcareous loamy sand soils but at par in calcareous and Aridisols soils. However, their high cost than zinc sulphate made it chetated fertilizers most uneconomical and less effective for common use.
- The efficiency of sparingly soluble Zn sources such as  $\text{ZnO}$ ,  $\text{ZnCO}_3$ , zinc fritts in fine textured high Zn fixing soils was at par to highly soluble  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ , however, when sparingly soluble and soluble zinc sources were compared in coarse textured soils, it was soluble zinc sources which gave best performance.
- Micronutrient blended macronutrients sources such as zincated urea, zincated super and boronated super were found initially inferior to zinc sulphate or chelates in highly Zn or B deficient soils as they mismatched with the nutritional requirements of crops but long term effect of zincated urea, boronated super became as efficient as that of soluble sources in controlling hidden /emerging micronutrient deficiencies in several crops.

- Zinc oxide was found effective for roots dipping and seed coating before transplanted crops than zinc sulphate. Zinc phosphate was found efficient source for seed coating to control hidden hunger and cheaper than ZnO. Zinc frits release Zn slowly in soil.

#### 2.1.1.1 Micronutrient sources notified in fertilizer control order (FCO) for farmers use :

Deficiency of a micronutrient can be corrected through addition of chemical fertilizers (off farm inputs), organic manures/residues (on- farm inputs) and by cultivation of tolerant plants. Several inorganic salts, synthetic chelates, natural organic complexes, mixtures are notified by the Government of India under FCO, 1985 as micronutrient fertilizers which vary considerably in their nutrient content, ameliorative efficiency, residual effect and for economic effectiveness for different soil-cropping systems. Apart from the specifications of single micronutrients, some major nutrient fertilizers fortified with micronutrients have also been notified under FCO, 1985 such as boronated single super phosphate and zincated urea. The fortified fertilizers, which may have one or two major nutrients like N or N and P with a specific micronutrient may have special advantage in areas of wide spread deficiency in soils. Zinc phosphate is also notified based its better performance to seed treatment.

**Table –2 Nutrient contents of fertilizers approved under FCO**

S.No	Materials	Element/Forms	Content (%)
1.	Zinc sulphate.	Zn	21.0
2.	Manganese Sulphate*	Mn	30.5
3.	Ammonium Molybdate	Mo	52.0
4.	Borax (For soil application)	B	10.5
5.	Solubor (Foliar spray)	B	19.0
6.	Copper Sulphate*	Cu	24.0
7.	Ferrous Sulphate*	Total Fe Ferrous & Ferric	19.5 19.0 & 0.50
8.	Zinc Sulphate mono-hydrate	Zn	33.0
9	Zinc Phosphate $Zn_3(PO_4)_2 \cdot 4H_2O$	Zn + P	19.5
10	Chelated Zn (EDTA form)	Zn	12.0
11	Chelated Fe (EDTA form)	Fe	12.0
12	Boronated super phosphate	B+P <sub>2</sub> O <sub>5</sub>	0.18B +16.0 P <sub>2</sub> O <sub>5</sub>
13.	Zincated urea	Zn+N	2.0 Zn + 43.0 N

\*Mean S % content in (i)  $ZnSO_4 \cdot 7H_2O$  15% (ii)  $MnSO_4 \cdot 4H_2O$  17%

(iii)  $CuSO_4 \cdot 5H_2O$  13% (iv)  $FeSO_4 \cdot 7H_2O$  19%

#### 2.1.2 Rate of zinc application

- Amount of zinc required for alleviating zinc deficiency varied with severity of deficiency, soil types, nature of crops and cultivars. In majority of instances 5.5 kg zinc ha<sup>-1</sup> was found to be ideal dose. Zinc deficiency can be best alleviated with the use of 11 kg Zn ha<sup>-1</sup> to wheat, rice and maize; 5.5

kgZn ha<sup>-1</sup> to soybean, mustard, raya, sunflower and sugarcane and with 2.5kg Zn ha<sup>-1</sup> to groundnut, ragi, gram, linseed, green gram, lentil etc.

- Soils testing very low, low and marginal needs 50, 25 and 12.5 kg zinc sulphate /ha to get optimum yields. Initially higher doses of zinc application are useful but in subsequent crops only 12.5 kg zinc sulphate /ha to each crop is enough to meet the zinc requirement of crops.
- Alkali soils are generally deficient in Zn and Ca. So higher yields of rice, wheat, berseem and other crops in such soils can't be achieved unless the toxicity of Na/ deficiency Ca and Zn are corrected simultaneously. Use of 9-10 kg Zn ha<sup>-1</sup> to highly alkaline soil and 4.5 kg Zn ha<sup>-1</sup> in reclaimed alkali soils for rice-wheat/mustard/barley was found optimum.
- Zinc requirement of crops in alkali soils is reduced substantially by 25-75% depending upon the levels of amendments added (25-100%GR) or reducing level of sodicities.
- Fertilizer Zn requirement of crops was found to be double in coarse textured loamy sand soil than in fine textured loam or clayey soil for wheat and rice.

### 2.1.3 Frequency of zinc application

- Zinc leaves marked residual effect so it is not necessary to apply Zn to every crop. The residual effect of 11 kg Zn ha<sup>-1</sup> added to soil persisted on four crops in calcareous and on six crops in non-calcareous soils.
- In sandy loam alkaline alluvial soil 5.5 kg Zn ha<sup>-1</sup> for first four crops and repeat application of 5.5 and 2.75 kg ha<sup>-1</sup> for next 8 and 12 crops, respectively gave the largest grain response and were found optimum.
- Under brackish water irrigation in a highly sodic soil (pH 10.4) amended with gypsum @ 50% of the gypsum requirement (GR) the residual effect of 22 kg Zn ha<sup>-1</sup> could last for four crops of rice-wheat sequence and the fifth crop required repeat application of Zn .
- Alkali soil (pH 10.45 ) when irrigated with normal quality water, the yield with fresh application of 2.25 kg Zn ha<sup>-1</sup> continuous to each crop was not different from a single initial application of 18 kg Zn ha<sup>-1</sup> after the seventh crop, suggesting that residual effectiveness of Zn applied once had not diminished.
- The beneficial effect of FYM alone or in combination of zinc was higher compared to Zn application. Integrated nutrient management proved better than zinc alone.

- Organic manures 12 t ha<sup>-1</sup> FYM, 5 t ha<sup>-1</sup> poultry manure and 2.5 t ha<sup>-1</sup> of piggery manure were as efficient as 11.2 kg Zn ha<sup>-1</sup> in meeting the Zn requirements of maize-wheat rotation. Also half or even less rates of these manures proved equally efficient or better when amended with 5.6 kg Zn/ha for maize-wheat rotation.
- Application of 12 kg Zn ha<sup>-1</sup>, 8-16 t FYM ha<sup>-1</sup> and 4 t FYM + 3 kg Zn ha<sup>-1</sup> were found equally efficient for enhancing soybean-wheat productivity in Vertisols. Application of 12 kg Zn ha<sup>-1</sup> left residual effect for 2-3 cropping cycles in medium to deep vertisols.

#### **2.1.4 Methods of application**

- Basal application of Zn to soil through broadcast and mixed or its band placement below the seed proved superior to top dressing, side dressing or band placement, foliar sprays or soaking or coating of seeds /seedling in Zn solution/slurry as well as transplanting Zn enriched nursery because of later led delayed cure of Zn deficiency than basal use.
- Foliar feeding of crops with application of 0.5 to 2.0% ZnSO<sub>4</sub>.7H<sub>2</sub>O solution is the supplement of soil application but it is not a substitute. In field crops it proved inferior in case of zinc and boron; however, in horticultural and plantation crops foliar feeding of crops with repeated foliar sprays of or boron generally excelled to their soil application.
- Seed coating of Zn materials like concentrated zinc Zn; zinc phosphate was found good in correcting Zn deficiency in bold size seed crops in marginally deficient soils. But these are ZnO proved superior but inferior to soil application of Zn in highly Zn deficient soils. However, seed treatment to potato with ZnSO<sub>4</sub>.7H<sub>2</sub>O solution proved equally effective as that of its foliar sprays or soil application.
- Dipping of rice seedlings in 2-4% ZnO slurry before transplanting proved less effective with other sources in combating Zn deficiency and could not catch up with the farmers because of certain limitations as that of zinc. Dipping of vegetable seedlings in ZnO suspension and sugarcane sets could not meet full Zn requirement of these crops.

#### **2.1.5 Time of application**

- Time of zinc application mainly depends upon its content in seed or severity of its deficiency. Best time of zinc addition is prior to sowing or transplanting of crops because maximum zinc absorption by plants takes place upto tillering or preflowering stages.
- Split application of zinc sulphate in rice is recommended as 50% at the time of sowing or transplanting and remaining 50% before or upto tillering stage.

- Basal application of zinc to soil is found the best. However, if it is missed, zinc deficiency can be corrected by top dressing of zinc upto 45 days. Seed coating with ZnO, Teprosyn zinc, zinc phosphate slurry successfully corrected deficiency in marginally deficient soils.
- Foliar sprays of 0.5% zinc sulphate two to three times at 7-10 days interval just after appearance of its deficiency can control zinc deficiency more efficient and effectively. If deficiency persists then continue more sprays.

### **2.1.6 Use of organic manures**

- Fertilizer use efficiency zinc applied to soil seldom exceed 5 percent Organic manures were found to increase the efficiency of soil applied Zn.
- Among organic materials, poultry manure proved most effective and twice efficient to FYM/compost. Zinc use- efficiency increases twice on combined application of 10 t ha<sup>-1</sup> of either FYM or compost with 2.5 –5 kg Zn ha<sup>-1</sup>. Poultry manure @ 5 t ha<sup>-1</sup> alone was as much efficient as 25 kg zinc sulphate ha<sup>-1</sup> > 10-15 t ha<sup>-1</sup> FYM > 10-15 t ha<sup>-1</sup> Compost.
- IPNS options for applying 0, 4, 8 and 16 t FYM ha<sup>-1</sup> in conjunction of 100, 50, 25 and 0 % of zinc requirements were found optimum for soybean–wheat, rice-wheat, maize- wheat and other cropping systems. When 8-10 t ha<sup>-1</sup> FYM is added annually then micronutrient deficiencies does limit the crop productivity. Excessive use of organics mainly under organic farming may cause emergence of zinc, copper deficiencies in the growing crops.
- Relative efficiency of organic wastes on equal quantity of Zn supply was in the order of: poultry manure > FYM > compost > biogas slurry > sewage sludge> municipal waste > presumed. Residual effect of Zn amended organic wastes with respect to soil available Zn was much higher than zinc sulphate alone.

### **2.1.7 Relative tolerance of crops and cultivars**

- The relative susceptibility of wheat cultivar to the stress was in the order of UP-262 = K-8804 > HP-1102 > RW-346 > DL-784-3 > HUW-206 > K-7410 > HP-1633 > Sonalika

## **2.2 Amelioration of iron deficiency**

### **2.2.1 Sources of iron**

- Iron deficiency or its chlorosis is a serious constraint to crops production in many upland alkaline , calcareous. coarse textured soils low in organic matter .
- A number of inorganic, synthetic and other sources available to combat iron chlorosis are ferrous sulphate (19-20.5%Fe), Fe-EDTA (9-12%Fe), Fe-EDDHA (10% Fe), pyrites, biotite and organic

manures (FYM 0.15% Fe), poultry and piggery manure (0.16% Fe), sewage sludge are also used as sources of Fe to correct Fe chlorosis in crops.

- Application of Fe-EDTA or  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  were found equally efficient and effective in increasing rice yield when seeds were coated with 2%  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  solution/slurry. Among various sources, pyrites and biotite proved inferior to ferrous sulphate Ferrous ammonium sulphate in increasing rice yield and Fe uptake in Vertisols.
- Since iron applied to soil through inorganic Fe carriers is susceptible to transformation into unavailable forms, therefore its deficiency in crops is one of the most difficult micronutrient deficiencies to manage. Ferrous sulphate, Fe-EDTA and FYM, green manures are most commonly used to correct iron deficiency in most crops.

### **2.2.2 Iron chlorosis in nursery**

- Iron chlorosis in rice seedlings can be effectively controlled by raising them under puddled nursery beds supplemented with requisite dose of FYM or compost. Ponding of water in nursery beds during dry spell is essential to mitigate Fe chlorosis.
- Foliar sprays of 1-2%  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  solution unutilized at weekly interval at early stage of deficiency are quite successful to control Fe chlorosis. Foliar sprays proved more effective than soil application of iron carriers. As soil application, pyrite proved better than  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  in alkaline calcareous coarse texture upland and saline-sodic soils.

### **2.2.3 Correction of iron deficiency using soil management**

- Iron chlorosis in rice is encountered in upland soils or highly permeable coarse textured soils because of less mobilization of  $\text{Fe}^{2+}$  as the desired degree of reduction does not occur. So puddling markedly reduces the extent of Fe-chlorosis in rice.
- Iron chlorosis in rice, pearl millet, groundnut, soybean, sugarcane, citrus and horticultural crops is a serious problem. Foliar sprays of 1-2% un-neutralized ferrous sulphate three to four times efficiently correct the iron chlorosis. Soil application is inferior and less profitable than foliar sprays.

### **2.2.4 Use of organic manures**

- Combination of green manure (GM) or organic manures with foliar spray of unneutralized 1%  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  solution is more beneficial in increasing crop yield than GM/ sprays.
- Green manuring, use of FYM and compost helped in mobilisation of inherent soil iron resource in available forms during its decomposition.

### 2.2.5 Method of application

- Iron deficiency can be corrected by application Fe sources to soil or foliar sprays. Foliar sprays of ferrous sulphate or chelates are found to be more effective and efficient than soil application in correcting Fe-chlorosis in rice, wheat, soybean, groundnut and sugarcane, citrus and several other crops.
- Efficiency of ferrous sulphate increases with citric acid during foliar sprays soybean, groundnut, rice, sugarcane yield by 16-24% .

### 2.2.6 Optimum rate

- Fertilizer requirement for basal soil application of Fe is very high ( 50-150 kg FeSO<sub>4</sub>) compared to 1-2% ferrous sulphate solution for foliar application and as such soil application uneconomical.
- Iron chalets are more efficient than inorganic sources in combating Fe deficiency but due to high cost of synthetic carriers farmers do not prefer using chelate except in cash crops.
- The dose of pyrite ranged from 5-10 q ha<sup>-1</sup> and that of FeSO<sub>4</sub>. 7H<sub>2</sub>O from 50-100 kg ha<sup>-1</sup> in soil. The efficiency of soil applied Fe could be enhanced when applied in conjoint with 10 t ha<sup>-1</sup> organic wastes.
- The relative efficiency of iron source was : sewage sludge > municipal waste > poultry manure > pressmud > FYM > FeSO<sub>4</sub> 7H<sub>2</sub>O. Sewage sludge as a source of Fe was more efficient than poultry manure and other organic wastes.
- Spreading groundnut varieties (GAU6.10, Punjab-1, G 6-11) were more tolerant to Fe chlorosis than erect ones: MH-1, MH-2, GG-2, JL24, PKV68.

## 2.3 Amelioration of manganese deficiency

### 2.3.1 Sources of manganese

- Manganese deficiency occurs sporadic. Its deficiency in wheat has emerged and is on the increase in Punjab as a result of the adoption of intensive cultivation of rice-wheat system in place of maize-wheat or groundnut-wheat system for a period of 7-10 years on highly permeable coarse-textured alkaline soils low in organic matter.
- Soils application of MnSO<sub>4</sub>.4H<sub>2</sub>O proved 1.5 and 10 times more effective than Mn-frits and MnO<sub>2</sub>, respectively in increasing the grain yield of wheat in sandy textured soils.

### **2.3.2 Method of application**

- Both soil and foliar application of Mn significantly increased the yields, but the rates of soil applied Mn (40-50 kg ha<sup>-1</sup>) are uneconomical than its foliar sprays due to more reversion of soil applied Mn to higher oxide in alkaline soils.

### **2.3.3 Rate of application**

- Foliar sprays 3-4 times of 0.5-1.0% MnSO<sub>4</sub> solution (7.5-15 kg Mnha<sup>-1</sup>) are equally or more efficient than basal soil application of 25-75 kg Mn ha<sup>-1</sup> to wheat in sandy soils.

### **2.3.4. Time of application**

- Foliar sprays of MnSO<sub>4</sub> solution one before and two after first irrigation gave maximum wheat yield response in alkaline sandy soils.

### **2.3.5 Tolerant cultivars**

- Among large number of wheat cultivars the magnitude of response to Mn application decreased successively as the rating of the tolerance increased and there were no significant responses in the most tolerant categories.
- The tolerant cultivar HD 2329 needed only one foliar spray ( 1.6 kg Mn ha<sup>-1</sup> ) as compared to 2 to 3 sprays (3.2-4.8 kg Mn ha<sup>-1</sup>) to moderate or least tolerant cultivars like HD 2329 so later is being sown on a large scale by the farmers on Mn-deficient soils.
- Durum wheat genotypes are more susceptible to Mn deficiency than aestivum wheat.
- Relative susceptibility of crops to Mn stress was in the order of oat > lentil > Lucerne > gobhi sarson > senji > maize fodder crops to the order of berseem > shaftal = metha.

## **2.4 Amelioration of boron deficiency**

### **2.4.1 Sources of boron**

- Borax, granubor & boric acid proved equally efficient in combating B deficiency in crops .

### **2.4.2 Method of application**

- Basal soil application of B proved superior and corrected its deficiency more efficiently than to foliar sprays. Sprays controlled its deficiency in standing crops but less effectively.
- In case of hidden deficiency sprays of 0. 2% boric acid or borax at pre flowering or flower head formation stages enhanced the crop yields.

- Boron helps in pollination and seed formation so foliar sprays are helpful in better pollination, seed setting and yield even in few soils tested adequate in soil available B.

### 2.4.3 Rate of application

- Boron deficiency in crops grown in calcareous or non-calcareous (coarse textured) soils can be corrected by its soil application more efficiently.
- Optimum dose of boron in calcareous soils of Pusa, Bihar and Junagarh (Gujarat) ranges between 1.5-2.0 kg B ha<sup>-1</sup> and 1.0-1.5 kg B ha<sup>-1</sup> in non-calcareous sandy, lateritic soils. Maize, wheat groundnut, sugarcane, cotton, sunflower, safflower and various vegetable crops showed high B requirements than soybean, green gram and mustard & oilseeds.
- Maize, rice, wheat, sunflower, groundnut, cotton, cabbage, cauliflower need 1.5-2.0 kg B ha<sup>-1</sup> in calcareous soils of North Bihar, West Gujarat, red and lateritic soils, 0.5 kg ha<sup>-1</sup> to gram, pearl millet in sandy soils of western Haryana and 0.5 kg Zn ha<sup>-1</sup> in soybean/wheat/mustard,/gram sequence in swell-shrink soils of Central India. Sensitive crop needs two to three times more boron than tolerant crops in B deficient soils.

### 2.4.4 Frequency of application

- Boron leaves residual effect to the succeeding crops. Effect of 1.6 kg B ha<sup>-1</sup> in calcareous soil persists on two to three crops in sequence.
- The optimum dose of B in lateritic soils of Bihar plateau ranged between 1.0-1.5 kgB ha<sup>-1</sup> for cereals and 1.5-2.0 kg B ha<sup>-1</sup> for pulses and oilseeds at a interval 3-4 crop.
- Application of more than 2.0 kg B ha<sup>-1</sup> caused toxicity to maize, grain and other crops even in calcareous alkaline soils.

### 2.5 Copper deficiency

- The deficiency of Cu is found sporadic, response of Cu fertilization is assessed only at few locations . Copper sulphate is mostly used carrier in soil and/or for foliar sprays.
- Application of 5 kg Cu ha<sup>-1</sup> increases wheat grain yield in loamy sand soil .

### 2.6 Molybdenum deficiency

- Application of ammonium molybdate (54% Mo) and sodium molybdate (39% Mo) are common sources of Mo to rectify its deficiency in soils and crops.
- Vegetables, pulses, legume oilseed are more responsive to Mo than cereals.
- Crop need varied from 0.4-0.5 kg Mo ha<sup>-1</sup> in Mo deficient red acid soils. Wheat variety Sonalika exhibited 38% grain yield response with application of 0.5 kg sodium molybdate

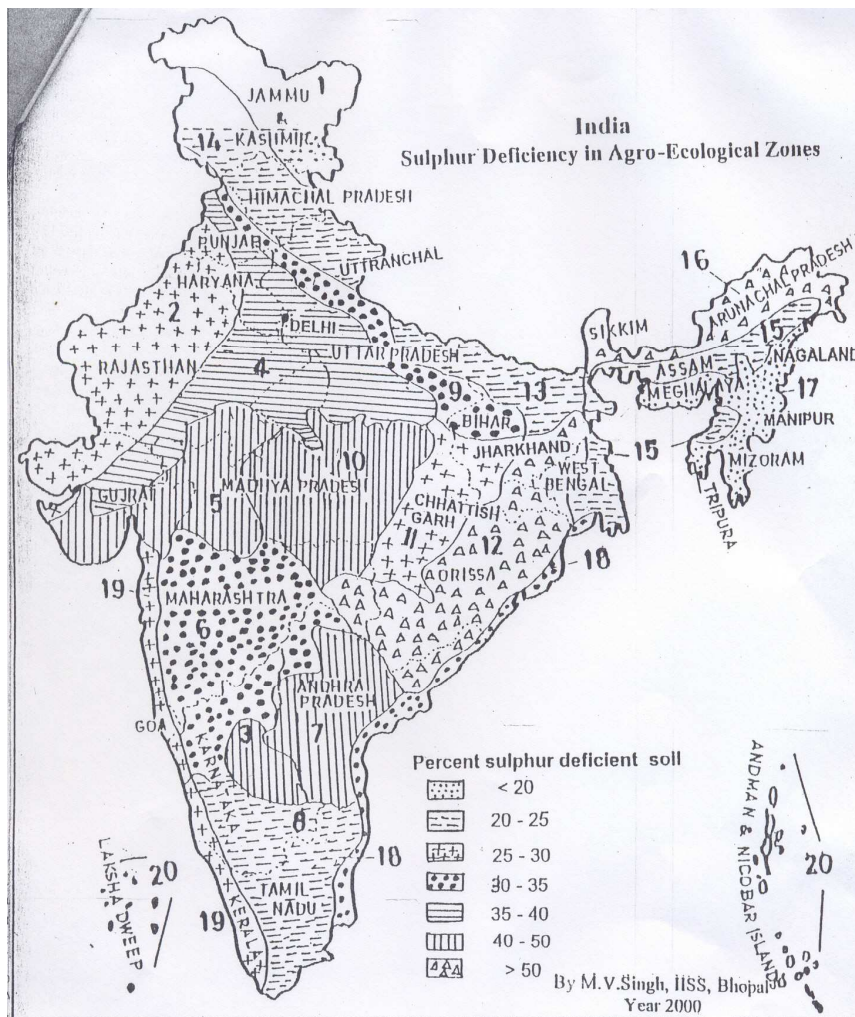
- Mixing of ammonium or sodium molybdate with phosphatic fertilizers proved very effective to increase Mo use efficiency.

### **2.7 Relative tolerance of crop species or cultivars**

- Marked variations in the relative susceptibility of a number of varieties of rice, wheat, maize, chickpea, lentil, potato, pearl millet, finger millet, mustard and linseed for Zn; of rice, chickpea and lentil for Fe; of wheat, maize chickpea, pigeon pea lentil, sesame, mustard and linseed for B and sesame and mustard for S have been noted.
- In general, the varieties of rice, maize are more susceptible to Zn deficiency than wheat. Susceptible varieties being mostly dependent on readily available forms of native micronutrients in soil are more responsive to applied micronutrients than the tolerant one under stress condition.
- Genotypes of wheat HUW-12, NP-852 and Sonalika; lentil varieties L-12, Pant 406 and DL 77-2, finger millet BR-12 and RAU-7 and linseed variety NP-5 were found tolerant to Zn stress.
- A number of pulses, oilseeds and cereals varieties have been found tolerant to B deficiency which can safely be grown under stress condition.
- Application of B to tolerant crops or cultivars has produced negative response.

### **3. Sulphur deficiency in Indian soils and its amelioration**

- Sulphur (S) deficiency is fast emerging in areas under oilseeds and pulses due to higher removal of S by crops. Survey of Indian soil under AICRP Micronutrients revealed that on an average, 41 per cent of Indian soils are deficient in S and it is widespread in coarse textured alluvial, red and lateritic, leached acidic and hill soils and black clayey soils. The deficiency of sulphur is emerging fast in areas where continuously sulphur free fertilizers like DAP, urea etc are being used. Sulphur deficiency is also found more in alkaline, coarse textured, low organic matter soils.



### Amelioration technologies

- Sulphur removal by one tonne cereals, pulses and oilseeds grain is about 4, 8 and 12 kg. Oilseeds show high response to sulphur fertilization than cereals. Visible symptoms of sulphur deficiency in most of the oilseed and pulse crops appear on young foliage in the form of pale chlorotic leaves, thin slender stem, stunted growth, poor branching and bushy appearance.
- Among different sources, single super phosphate, gypsum, phospho-gypsum, pyrites, ammonium sulphate, bentonite S pastilles were found better for S fertilization. Basal application of S was found beneficial but in oilseed its application can be made in at 25-30 days of crop growth. Pyrite should be applied in moist soil through surface broadcast.
- Application of 8-10 t/ha organic manure efficiently correct sulphur deficiency and gave equal yield as that of inorganic sources. Sulphur should be preferably applied to oilseed and pulses to achieve higher benefits in oilseed/pulse based cropping systems.

### **Effect of sulphur application on groundnut crop growth under front line demonstrations**

- Among pulses, chickpea, field pea, pigeon pea require 40 kg S ha<sup>-1</sup>, while lentil, green gram, black gram and cluster bean need 20 kg S ha<sup>-1</sup> to produce optimum crop yields. Regular use of 40 kg S ha<sup>-1</sup> to soybean, groundnut, mustard, gobhi sarson, raya, safflower, castor and 20 kg S ha<sup>-1</sup> to sesame, linseed, niger was found optimum.
- Application of 20-40 kg S ha<sup>-1</sup> gave economic seed response of 204 to 640 kg ha<sup>-1</sup> in oilseed crops, and 176 to 592 kg ha<sup>-1</sup> in pulse crops amounting to Rs.9/- to 82/- benefit for each rupee spent on sulphur.
- Crops irrigated with high sulphate containing waters generally do not respond to external supply of sulphur. Also oilseeds and pulses show high response than cereal crops.

### **Crop responses to micro and secondary nutrient application:**

Spectacular response to iron, manganese and boron application has been recorded in cereal, oilseed, pulse, vegetable and cash crops (Table,5). Average responses of maize, wheat and rice to 1-2 kg B ha<sup>-1</sup> were 480, 370 and 310 kg ha<sup>-1</sup>. Chickpea, pigeon pea, and groundnut gave 430, 340 and 370 kg ha<sup>-1</sup> and sesame, mustard, linseed and sunflower gave 90, 210, 150 and 320 kg ha<sup>-1</sup>, respectively. In front line demonstrations, chick pea, lentil and mustard responded to higher rates 1.5 to 2 kg B ha<sup>-1</sup>. Boron application gave 350, 750, 300 kg seed kg<sup>-1</sup> B in highly B deficient calcareous soils. Response of onion was 5300 kg ha<sup>-1</sup> and that of sugarcane 8700 kg ha<sup>-1</sup> to the application of 1-2 kg B ha<sup>-1</sup>.

Field studies on rates and frequency of boron application to rice - wheat, maize - mustard and sesame - chickpea sequences indicated that economic returns to the application of 1.6 kg B ha<sup>-1</sup> to every third crop or 0.8 kg B ha<sup>-1</sup> to each crop were as much as B:C ratio of Rs.14-48:1 without inducing any deleterious effect on soil and plants. On the other hand, regular application of B fertilizer more than 2 kg ha<sup>-1</sup> annually or application of irrigation water high in B leads to B toxicity in plants and reduced crop yields. Mean response of rice was recorded 403 kg ha<sup>-1</sup> in 49% of the trials in deltaic alluvium soils which was far more than 187 kg ha<sup>-1</sup> obtained in 27 trial on red alluvium soils. Red and lateritic soils are highly deficient in boron and application of 0.5,1.0,1.5 and 2.0 kg boron ha<sup>-1</sup> increased the rice yield by 460 to 150 kg ha<sup>-1</sup> over no boron treatment. Rabi rice responded more to boron than kharif rice in Orissa.

**Table 3 Response of crop to zinc fertilization in few states of India**

Crop	No. of expt..	Range of response t ha <sup>-1</sup>		Average response, t ha <sup>-1</sup>
		Individual expt.	Mean of expt.	
Wheat	2447	0.00-4.70	0.01-1.47	0.42
Rice	1652	0.00-5.47	0.14-1.27	0.54
Maize	280	0.01-3.09	0.11-1.37	0.47
Barley	17	0.11-1.18	0.49-0.73	0.5
Sorghum	83	0.07-1.35	0.21-0.65	0.36
Pearl millet	236	0.00-1.17	0.17-0.46	0.19
Finger Millet	47	0.00-1.25	0.08-0.42	0.36
Lentil	16	0.03-0.58	0.08-0.39	0.22
Chickpea	15	0.10-1.01	0.23-0.56	0.36
Blackgram	10	0.07-1.12	0.11-1.12	0.24
Groundnut	83	0.04-0.60	0.21-0.47	0.32
Soybean	12	0.08-0.69	0.16-0.39	0.36
Mustard	11	0.02-0.34	0.14-0.26	0.27
Linseed	5	0.12-0.21	0.15-0.20	0.16
Sunflower	8	0.01-0.67	0.15-0.20	0.24
Onion	3	1.36-8.70	1.70-4.91	5.13
Potato	45	0.10-7.60	2.40-3.90	2.96
Sugarcane	6	8.00-4.30	1.72-2.40	37.70
Tea	1		0.02	0.02
Turmeric	2		3.98	3.98
Cotton	27	0.01-0.78	0.06-0.24	0.22

Source: M.V. Singh (1997, 1999a), AICRP Micronutrients, IISS, Bhopal.

**Table 4 Responses of crops to Fe, Mn and boron application**

Crop		No. of Expt.	Response t ha <sup>-1</sup>	
			Range	Mean
Wheat	<b>Iron</b>	81	0.0-2.50	0.82
Rice		31	0.20-4.40	1.39
Sorghum		23	0.03-2.9	0.06
Lentil		7	0.00-1.01	0.43
Chickpea		7	0.05-0.82	0.33
Groundnut		10	0.05-0.70	0.89
Sunflower		3	0.46-0.80	0.55
Soybean		3	0.21-1.00	0.34
Potato		37	1.1-6.90	3.40
Sugarcane	10	2.40-12.80	11.00	
Wheat	<b>Manganese</b>	69	0.0-3.78	0.64
Rice		110	0.40-1.78	0.49
Sorghum		5	0.29-0.51	0.83
Soybean		2	0.03-1.03	0.31
Potato		35	1.00-3.90	1.90
Wheat	<b>Boron</b>	35	0.03-1.19	0.39
Rice		107	0.00-1.67	0.32
Maize		5	0.17-1.05	0.57
Chickpea		7	0.09-0.90	0.35
Lentil		4	0.04-0.49	0.24
Pigeonpea		2	0.03-0.32	0.19
Groundnut		11	0.05-0.42	0.21
Linseed		2	0.11-0.14	0.12
Sunflower		4	0.22-0.62	0.42
Mustard		2	0.21-0.31	0.26
Onion		4	3.87-7.30	4.47
Cotton		2	0.06-0.35	0.21

Source: Singh (2000)

**Correct citation : Singh, M.V.(2004) Micronutrient deficiencies in Indian soils and field usable practices for their correction. IFA International Conference on Micronutrients, Feb. 23-24, 2004, at New Delhi.**



**His Excellency Governor of Bihar inaugurated the AICRP- Micronutrient workshop at RAU, Pusa**

**For further details please contact followings**

**Dr. M.V.Singh, Project Coordinator (Micronutrients)  
AICRP Micronutrients, Indian Institute of Soil Science,  
Nabibagh, Berasia Road, Bhopal 462038  
Ph. 0755-2734487, 270970 -312, Fax 0755 2733310,  
[drmvsingh@yahoo.com](mailto:drmvsingh@yahoo.com), [mvs@iiss.ernet.in](mailto:mvs@iiss.ernet.in)**