Management of Multimicronutrients Deficiencies for Enhancing Yield of Crops

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Abstract
The multi-micronutrient mixture grades for Zn-deficiency (grade-II : Fe-2.0%, Mn-0.5%, Zn-8.0%, Cu-0.5%, B-0.5%), Fe-deficiency (grade-III: Fe-6.0%, Mn-1.0%, Zn-4.0%, Cu-0.3%, B-0.5%) and Zn+Fe-deficiency (grade–IV : Fe-4.0%, Mn-1.0%, Zn-6.0%, Cu-0.5%, B-0.5%) besides normal grade for foliar application (grade-I : Fe-2.0%, Mn-0.5%, Zn-4.0%, Cu-0.3%, B-0.5%) at 1% and soil application grade –V (Fe-2.0%, Mn-0.5%, Zn-5.0%, Cu-0.2%, B-0.5%) at 20 kg/ha were prepared. Efficacy of these mixtures was tested in important food crops by conducting field experiments on different soil type having marginal to deficient Fe and Zn status at various locations in Gujarat state of India. Amongst the foliar grades, Grade-III (for Fe deficient soil) and Grades-IV (For Zn and Fe deficient soils) were found more effective in most of the crops of various groups *viz*., cereals (maize, sorghum, Pearlmillet and wheat), vegetables (potato, cabbage, okra) and pulse like pigeon pea. The soil application Grade-V was found more beneficial in mustard while general foliar grade (Grade- I) was found effective in paddy. Depending upon the soil status for Zn, Fe or Zn+Fe deficiencies, foliar application of corresponding grades @ 1% or soil application @ 20 kg/ha were found effective in increasing yield of different crops and soil types of Gujarat, India.

Key Words
Multimicronutrients mixtures, balanced nutrition, micronutrients efficacy

Introduction

Continuous use of high analysis fertilizers under intensified cropping and neglect of organic manures manifested the occurrence of wide spread micronutrients deficiencies; especially of Zn and Fe in light textured soils of India after 1960. But, later multiple nutrient deficiencies were reported in crops for N, NP, NPFe, NPFeZn, NPFeZnK, NPZnKS, NPZnKSB and NPZnKSMnMo within a time frame of 1960 to 2005. Multinutrient deficiencies are emerging for Zn + Fe in swell- shrink soils, Zn + Mn or Zn + Fe + Mn in alluvial soils of Indo-Gangatic plains, Zn + Fe, Zn + B, Zn + Fe + B in highly calcareous soils of Bihar, Gujarat, Zn + B in acid leached Alfisols, red and Lateritic soils of India (Singh 2006; Singh and Bahera 2007). Despite application of adequate quantity of NPK, the yield remains low due to hidden hunger of micronutrients like Fe, Cu, Mn and B.

The multi-micronutrients mixture facilitate the application of the wide range of plant nutrients in the proportion and to suit the specific requirements of a crop in different stages of growth, and are more relevant under site specific nutrient management practices (Hegde 2007). The low use efficiency of major fertilizers, supplying major nutrient, in large proportion can be improved by their modifications to lessen the negative aspects as well as trying to combine one or two more nutrients so that with the same application effort, crop benefits with multi-nutrient needs. Therefore, there is a need to promote balanced fertilization for which use of appropriate multi-micronutrient mixture grades would play a big role to improve nutrients use efficiency and enhance crops productivity for food and nutritional security.

Methods

Most of the soils of Gujarat have been reported to be deficient in Zn and Fe (Patel 1998). Therefore, the Zn and Fe deficiency is one of the most frequently encountered micronutrient deficiencies besides hidden hungers of other micronutrients in different crops grown in the state. The supplementation of micronutrients through multi-micronutrients mixture under such situations becomes more important to provide balanced nutrition to the crops. Keeping this in view, the multi-micronutrients mixtures were prepared based on prevailing deficiencies of Zn and Fe in soils of Gujarat to provide balanced nutrition of micronutrients in different crops (Table 1); and their efficacy was tested on soils having marginal to deficient status in available (DTPA-extractable) Zn / Fe or Zn+Fe.

Table 1. Composition of multimicronutrients mixture grades

Sr. No.	Grade	Content (%)				
		Fe	Mn	Zn	Cu	B
	For foliar spray					
1.	Grade-I (General)	2.0	0.5	4.0	0.3	0.5
2.	Grade-II (for Zn deficiency)	2.0	0.5	8.0	0.5	0.5
3.	Grade-III (for Fe deficiency)	6.0	1.0	4.0	0.3	0.5
4.	Grade-IV (for Zn & Fe deficiency)	4.0	1.0	6.0	0.5	0.5
	For soil application					
5.	Grade-V (Soil application)	2.0	0.5	5.0	0.2	0.5

The rate of application of the Grades (Sr. No. 1 to Sr. No.4) for foliar spray was kept at 1 % during crop growth period with two to three sprays depending upon the duration of the crop; and the soil application (Sr. No. 5) was @ 20 kg/ha as basal.

The treatments were: T_1 Control (NPK+ water spray), T_2 Grade-I (General Grade for foliar spray), T_3 Grade-II (for Zn deficiency), T_4 Grade-III (for Fe Deficiency), T_5 Grade-IV (for Zn and Fe Deficiency), Grade-V (General Grade for soil application) and T_7 Soil application as per soil test value (STV).

Experiments were continued for three to five years in different crops with four replications in randomized block design and the data were satisfactory analyzed on pooled basis.

The plant samples (grain / edible parts and straw / leaves) were taken at the harvest of different crops for determination of total contents of micronutrients for computation of micronutrient uptake. The samples were oven dried and finely ground in a S. S. Wiley mill; and digested with di-acid mixture of HNO_3: $HClO_4$ (3:1) as per the standard procedure and the micronutrient contents were determined by atomic absorption spectrophotometer (PE 3110). The soil samples drawn from the experimental field at harvest were analyzed for available micronutrients using 0.005 M DTPA extractant (Lindsay and Norvell 1978).

Results

Effect on crops yield

Amongst the cereals, the maximum improvement in *kharif* paddy grain was up to 766 kg/ha over control due to general foliar grade-I (Table 2). In case of vegetables, potato tuber yield was increased by 8190 kg/ha equivalent to 22.6 % increase over control (362.5 q/ha) due to foliar grade-III. The maximum net realization (Rs. 16129/ha) with CBR (1:2.02) was obtained due to soil application of grade–V (General grade) in okra. The maximum net realization (Rs. 34,439=00/ha) in cabbage was obtained due to the spray treatment of grade–IV (Fe & Zn deficiency) followed by soil application of micronutrients fertilizer as per STV (Rs. 33,425/ha). The CBR value for grade-IV and STV treatments were worked out as 1: 3.19 and 1: 3.17, respectively. The foliar application of grade-III produced the highest tuber yield of potato and recorded maximum net realization (Rs.73,220/ha) and net cost benefit ratio (CBR-1:2.20) among all the treatments. Soil application grade-V also gave comparable net realization (Rs. 63,519/ha) and economic return (CBR Rs.1:2.05). Therefore, use of foliar spray of grade-III and soil application grade-V of micronutrients were found almost equally beneficial in obtaining higher tuber yield and net realization the increase in pigeon pea grain yield was by 436 kg/ha due to grade – IV over control (1250 kg/ha).

The beneficial effects of the multi-micronutrients could be ascribed to the balanced nutrition of the crops and thereby improved crop growth as well as yield. The supplementation of multimicronutrients through foliar feeding during the crops growth period provided balanced nutrition to the crops for improvement in crops yields. Also, the addition of the micronutrients helps in better utilization of the major nutrients to produce higher yield of the crops. The hidden deficiencies of micronutrients are overcome due to their supplementation during the growth period, which results in better crop growth and thereby yield. The beneficial effect on use of multimicronutrients mixture have been reported in different crops for growth and yield of okra (Medhi and Kakati 1994), tomato (Bose and Tripathi 1996), wheat (Nazim 2005; El-Magid 2000), maize (El-nagar 2002) and soybean (Thiyageshwari and Ramanathan 2001).

Table 2. Effect of multi-micronutrients mixture application on yield of different crops (q/ha)

Treatments	Maize Grain (3)	Wheat Grain (3)	*kharif* Paddy Grain (3)	*Bajri* Grain (5)	Okra Fruit (3)	Potato Tuber (3)	Cabbage Head (5)	Mustard Seed (3)	Pigeon pea Grain (3)
Location	Godhra	Vijapur	Navsari	Jamnagar	Anand	Deesa	Anand	S. K. Nagar	Khandha
Soil Type	Medium black	Sandy loam	Clayey	Medium black calcareous	Loamy sand	Sandy	Loamy sand	Sandy	Medium black
T_1 control	16.9	35.9	56.8	21.4	56.3	362.5	228.4	18.1	12.5
T_2 Grade-I	18.8	37.9	64.4	23.4	59.2	366.7	235.7	18.2	15.2
T_3Grade-II	20.6	38.2	60.2	24.2	59.9	378.2	241.0	18.2	15.4
T_4 Grade-III	23.2	37.4	60.9	25.4	60.6	444.4	240.0	18.8	13.6
T_5 Grade-IV	21.1	40.1	62.9	27.0	63.6	389.2	250.7	17.8	16.8
T_6 Grade-V	21.9	35.2	63.6	28.6	63.8	411.7	239.8	18.9	14.6
T_7 STV	21.0	41.4	62.5	28.8	62.7	376.4	244.1	19.8	13.8
LSD(P=0.05)	1.87	2.88	3.5	2.0	2.7	29.5	12.1	0.9	2.1
Y x T	NS	NS	NS	NS	-	NS	NS	-	NS

( ) Figure in parenthesis indicates experimental duration (years)

Table 3. Effect of multimicronutrients mixture application on micronutrients uptake (g/ha) by different cereals

Traetments	Wheat Grain (3)	Maize Grain (3)	Okra Fruit (3)	Cabbage Head (5)	Mustard Seed (3)	Wheat Grain (3)	Maize Grain (3)	Okra Fruit (3)	Cabbage Head (5)	Mustard Seed (3)
Location	Vijapur	Godhra	Anand	Anand	S. K. Nagar	Vijapur	Godhra	Anand	Anand	S. K. Nagar
Soil Type	Sandy loam	Medium black	Loamy sand	Loamy sand	Sandy	Sandy loam	Medium Black	Loamy sand	Loamy Sand	Sandy
	Fe Uptake					**Zn Uptake**				
T_1 control	216	36.9	30.0	260.9	89	56.9	35.2	12.5	32.2	38.2
T_2 Grade-I	192	39.9	34.7	296.6	30	64.4	38.4	13.4	35.2	46.6
T_3Grade-II	233	44.0.	32.8	338.7	36	71.3	46.9	13.7	40.2	54.1
T_4 Grade-III	177	52.8	34.8	312.8	39	65.0	51.4	16.0	40.1	53.1
T_5 Grade-IV	233	46.2	35.9	319.9	47	70.3	45.0	16.5	39.7	50.5
T_6 Grade-V	212	49.4	37.3	318.2	110	64.3	43.9	15.6	41.8	60.0
T_7 STV	228	51.6	37.5	270.9	35	74.4	45.9	13.5	43.3	66.0
LSD(P=0.05)	33	6.6	NS	29.0	2	9.9	5.1	NS	5.9	3.6

( ) Figure in parenthesis indicates experimental duration (years)

Uptake of Micronutrients

The data on total uptake of micronutrients for some of the important crops (Table 3) revealed that the treatments of foliar as well as soil application of multi-micronutrients mixture enhanced the uptake of micronutrients in edible portion of the different crops over control. It has therefore, indicated an increase in the micronutrients use efficiency by different crops due to use of multi-micronutrients mixture application over control. The improvement in the nutrients use efficiency could be attributed to an enhancement in absorption and assimilation of the micronutrients which provided balanced nutrition to the crops for higher growth; and thereby nutrients uptake which ultimately resulted into higher yield of the crops. The increase in content of micronutrients and their uptake by different crops due to use of multi-micronutrients fertilizers have also been reported by several workers as mentioned earlier.

The overall results indicated superiority of different grades in increasing crop yields. Amongst the foliar grades, Grade-III (for Fe deficient soil) and Grades-IV (For Zn and Fe deficient soils) were found more effective in most of the crops of various groups *viz*., cereals (maize, sorghum, pearlmillet and wheat), vegetables (potato, cabbage, okra) and pulse like pigeon pea. The soil application Grade-V was found more beneficial in oilseed like mustard; while the general foliar grade (Grade- I) was found effective in paddy. Thus, in general, the use of multimicronutrients mixture foliar grades depending upon the soil deficient condition for either of Fe, Zn or Fe and Zn, the foliar application of corresponding grades @ 1% and soil application @ 20 kg/ha have shown their better effectiveness in increasing yield of different crops and various soils types of Gujarat.

In general, the average contents of DTPA-extractable Fe and Zn of the soil improved due to application of multimicronutrients through soil application at the end of the experiment. However, the improvement in DTPA- micronutrients was not that alarming to adversely affect the soil health.

Conclusion

Field crops are generally sensitive to micronutrients stress and suffer due to hidden hunger of multi-micronutrient deficiencies. Therefore, correction of hidden hungers or deficiencies of micronutrients are necessary for balanced nutrition to get higher yield of crops on sustainable basis. The multi micronutrients fertilizers mixture grades prepared on the basis of micronutrients deficiency status of Gujarat soils proved beneficial in increasing yield of different crops under varied agro-climatic conditions and different types of soils. In general, the multi micronutrients mixture (grade-V) having Fe 0.2%, Mn 0.5%, Zn 5%, Cu 0.2% and B 0.5% for soil application at 20 kg/ha and foliar application grade-III (for Fe deficiency) having Fe 6%, Mn 1%, Zn 4%, Cu 0.3% and B 0.5% as well as grade-IV (for Fe and Zn deficiency) at 1% having Fe 4%, Mn 1%, Zn 6%, Cu 0.5% and B 0.5% for spraying at 15, 30, 45 / 60 days after sowing were found beneficial to get higher yield of different crops and net realization. The improved content of micronutrients in food parts help correcting malnutrition problems of Fe and Zn in human.

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