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Strategies of micronutrient management for food security

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Abstract

Micronutrients requirement of various crops through chemicals varied from 1kg (Mo) to 50 kg (Fe) per ha. Very less part of these nutrients is taken up by the crops and the rest are lost. Nutrient use efficiency of micronutrients is extremely low. Huge amount of micro nutrients either fixed in the soil or losses by other means. Effect of micronutrient deficiency can be very severe in terms of stunted growth, low yield, dieback and even plant death. Very small application of micronutrients may produce dramatic results. The chief sources of micronutrients are organic materials available in agriculture farms which are good alternative of micronutrient fertilizers. These include FYM, poultry manure, green manure, compost, animal dungs, and crop residues. Efficiency of micronutrient applied through fertilizers in soil is only 2-10% whereas availability of micronutrients reported more than 10% when applied through organic sources and supply is continuous. Macro plant nutrients require supplementation from inorganic fertilizers, whereas the micronutrients supplied through organics do not need supplementation of micronutrient fertilizers. If these micronutrients are added through organic sources, these are slowly available to the crops as per requirement and larger part is retained by soil for the next crop.

Key words- Source of nutrieents, use efficiency, nutrients uses, deficiency

Introduction

Soil is a very important natural source of the socio-economic development of the country. Maintenance of soil health is the key to ensure food security of the nation. With introduction of green revolution, use of chemical fertilizers although contributed 40% of crop production, continuous use of chemicals in agriculture seriously jeopardized the soil health and environment. Cultivation of HYVs, increase in irrigation facility, increased use of fertilizers and adoption of improved agronomic practices could bring about green revolution and pulled the country to self sufficiency in food grain production. Limited recycling of plant residues and gap between the removal and supplementation of nutrients have resulted in widespread multiple plant nutrient deficiencies. The term micronutrient and trace elements must not be construed to imply that these nutrients are somehow less important than macronutrients. Micronutrients play a vital role for the

growth and development of plants. Fertilizers will be the kingpin of agriculture and to be the best hope for meeting the future challenge of food production of the country. The noble laureate Norman E. Borlaug even prophesized that without chemical fertilizers India would have required two to three times more area to meet the food grain to meet the requirement of its population. Recently long-term sustainability of agricultural productivity and environmental safety due to continuous use of chemical fertilizers is being questioned. Thus the most logical way to manage soil fertility and productivity of soil is integrated use of inorganic, organic and biological sources of plant nutrients.

Discussions

1- Micronutrient requirement of crops: Micronutrients requirement of various crops through chemicals varied from 1.0 kg (molybdenum) to 50.0 kg (iron) ha^{-1}. Since the beginning of agricultural research in India, a lot of efforts have gone into making nutrient management practices optimum to the requirements of the crops/ cropping systems and soils under various agro-climatic regions of the country (Table 1).

Table-1: Micronutrients requirements of different crops (g t^{-1} dry matter)

Crops	Iron	Manganese	Boron	Zinc	Copper	Molybdenum
Wheat	32	26	18	21	8	0.87
Potato	60	12	50	9	9	0.80
Maize (Fodder)	17	74	-	30	31	-
Sorghum (Jowar)	60	27	27	36	3	0.98
Cotton	06	14	15	16	8	0.77
Guar	1	15	29	15	9	1.14
Castor	23	41	31	14	2	1.01
Pearl millet (Bajra)	49	44	-	50	12	-
Brinjal	20	36	45	23	12	0.23
Groundnut	99	39	44	9	5	1.32
Cow pea	60	89	53	17	11	1.31
Green gram	70	18	32	13	11	1.05
Cabbage	05	28	25	21	8	0.98
Tobacco leaves	92	132	96	21	11	0.60
Lucerne	20	41	36	21	10	2.59
Hybrid Bajra		23	**72**	22	9	0.84

Source: Fertilizer Statistics, 1999-2000. The Fertilizer Association of India, New Delhi

2- Micronutrient deficiency in Indian soils: Deficiencies of essential elements in Indian soils and crops started emerging since 1950s' and as food grain production increased with time the number of essential elements becoming deficient in soils and crops also increased. Intensive cropping systems are heavy feeders of plant nutrients and are bound to absorb the nutrients from the soil. Hence nutrient deficiencies are inevitable unless steps are taken to restore fertility levels. Micro nutrient deficiencies in soils are also emerging as yield limiting factors. Analysis of huge number of soil samples indicated wide spread of micronutrients deficiencies viz. Zn (49%), Fe (12%), Cu (3%), Mn (5%) and B (33%) and Mo (7%) (Table 2).

Table-2: Extent of micronutrient deficiency in Indian soils

Zn	B	Fe	Mn	Cu	Mo
Maharashtra (86%)	West Bengal (68%)	Karnataka (35%)	Meghalaya (23%)	Tamil Nadu (6%)	Haryana (28%)
Karnataka (72%)	Bihar (38%)	H.P. (27%)	Assam (20%)	Karnataka (5%)	M.P. (18%)
Haryana (60%)	Karnataka (32%)	Maharashtra (24%)	Karnataka (17%)	Gujarat (4%)	Gujarat (10%)
Tamil Nadu (58%)	U.P. (24%)	Haryana (20%)	U.P. (3%)	Bihar (3%)	-
Orissa (54%)	M.P. (22%)	Tamil Nadu (17%)	Punjab (2%)	Haryana (2%)	-
Bihar (54%)	Tamil Nadu (21%)	Punjab (14%)	Bihar (2%)	U.P. (1%)	-
U.P. (45)	Punjab (3%)	Bihar (6%)	-	-	-
All India (49%)	All India (33%)	All India (12%)	All India (5%)	All India (3%)	-

Source: Singh (2001)

Table -3**:** Symptoms of micronutrients deficiency in crop plants

Micronutrients	Symptoms
Zn	Deep yellowing of whorl leaves (cereals). Dwarfing (rosette) and yellowing of growing points of leaves and roots (dicot).Rusting in strip on older leaves with yellowing in mature leaves. Leaf size reduced. Main vein of leaf or vascular bundle tissue becomes silver-white and marked strips appear in middle of leaves.
Cu	Yellowing of young leaves. Rolling and dieback of leaf tips. Leaves are small. Tillering is retarded. Growth is stunted.
Fe	Inter veinal yellowing of younger leaves with distinct green veins. Entire leaves become dark yellow or white with severe deficiency and leaves border turns brown and die.
Mn	Inter veinal tissue becomes light green with veins and surrounding tissue remaining green on dicot (Christmas tree design) and long interveinal leaves streaks on cereals. Develop necrosis in advance stage.
B	Death of growing points of roots and shoots. Failure of flower buds to develop. Blackening and death of tissues especially the cambium tissues.
Mo	Mottled pale appearance in young leaves. Bleaching and withering of leaves and sometime tip death. Legumes suffering molybdenum deficiency have pale green to yellowish leaves. Growth stunted. Seed production is poor.
Cl	Reduce leaf size. Yellowing, bronzing and necrosis of leaves. Root reduced in growth and without hairs.
Ni	Chlorosis of newest leaves. Ultimately leads to necrosis of meristems .Reduced

	germination and seedling vigor (low seed viability).
Co	Diffuse yellowing in leaves. Young shoots and younger leaves have severe localized marginal scorching.

Source: Fageria *et al.* (2002)

3- Low nutrient use efficiency: Nutrient use efficiency of micronutrients in the country is quite low (Table 4). Huge amount of micro nutrients either fixed in the soil or losses by other means. Nutrient use efficiency of micronutrients further decreased in salt affected and acid soils because these are converted into insoluble compound.

Table -4: Nutrient use efficiency of micronutrients

S. No.	Nutrient	Efficiency (%)
1	Zn	2-5
2	Fe	1-2
3	Cu	1-2

4- Micronutrient content in soils of NE states: Several studies revealed that soils of NE states are sufficient in available Fe, Mn and Cu. In case Nagaland soils, 13.3 and 6.6 percent samples were marginal and deficient and rest of the samples were sufficient in DTPA extractable zinc respectively. Soils of Senapati district of Manipur are medium in Zn & Cu and high in Fe & Mn. Shifting cultivation is old age practice in North Eastern states. Cleaning and burning of biomass reduced available micronutrient cations in the soils (Table 5, 6 & 7).

Table-5: DTPA extractable micronutrient cations status of Nagaland soils

Sampling site	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
1	1.30	94.8	34.9	2.34
2	3.20	240.6	48.9	4.00
3	1.88	165.4	42.4	3.10
4	0.95*	90.0	46.2	2.98
5	2.95	275.2	55.6	4.43
6	1.72	172.8	51.6	3.85
7	2.40	110.0	44.9	3.21
8	6.00	290.0	57.0	4.34
9	3.50	194.8	50.8	3.76
10	2.15	105.4	29.1	2.40
11	5.50	270.6	42.5	3.35
12	3.37	180.6	36.8	2.90
13	1.00*	96.2	31.2	2.16
14	3.65	280.6	40.5	3.00
15	2.15	160.2	35.3	2.56
16	0.60*	66.0	33.2	2.00
17	3.50	170.0	41.5	2.81
18	1.10*	104.2	37.6	2.34
19	0.10**	88.2	44.6	2.43
20	3.24	230.6	59.8	3.14
21	1.20	148.8	52.8	2.78

22	0.92	92.4	39.0	2.76
23	2.80	265.0	49.9	3.66
24	1.93	174.6	45.5	3.04
25	1.15	94.4	30.8	1.32
26	4.50	240.2	45.8	2.55
27	2.85	184.2	38.2	1.98
28	0.16**	74.8	23.6	1.67
29	5.10	215.4	36.0	2.54
30	2.04	152.4	29.8	2.04

Source: Sharma et al, (2012), *Marginal, ** Deficient, samples without * are sufficient in respective nutrients

Table 6: Micronutrient cations status of the soils of Senapati district of Manipur

S.N	Sampling site	Zinc (mg kg^{-1})	Iron (mg kg^{-1})	Copper (mg kg^{-1})	Manganese (mg kg^{-1})
1	Song Song	1.46	66.41	1.03	29.05
2	Tadubi	1.29	49.98	0.73	31.42
3	New Makhan	1.06	69.95	0.73	22.35
4	Tungjoy	0.94	57.52	0.84	30.25
5	Laii	1.05	68.28	1.46	32.91
6	PhaibungKhullen	0.96	52.87	0.92	25.44
7	Purul	1.09	68.15	0.80	29.30
8	Taphou Onaeme	0.98	55.63	1.00	26.43
9	Shangkhumai	1.32	72.38	1.70	30.93
10	Karong	1.18	62.08	0.95	28.31
Nutrient index		2.00	3.00	2.30	3.00
Nutrient index class		Medium	High	Medium	High

Source: Saya (2021)

Table 7: Effect of biomass burning on micronutrient content of soils of Nagaland under shifting cultivation

Micronutrient	Before burning	After burning
Zn (mg kg^{-1})	1.00	0.78
Mn (mg kg^{-1})	29.36	25.13
Fe (mg kg^{-1})	58.4	50.3
Cu (mg kg^{-1})	0.68	0.54

Source: Jamir (2019)

5- Manures-excellent source of micronutrients: Mostly micronutrients are available in synthetic forms and these chemical micronutrients are costly and impart adverse effect on soil health. The chief sources of micronutrients are organic materials available in agriculture farms which are good alternative of micronutrient fertilizers. These include FYM, poultry manure, green manure, compost, animal dungs, and crop residues. The manures supply essential micronutrients viz. Fe, Mn, Zn, Cu, B, Mo, Cl in sufficient quantities (Table 8).

Table -8: Micronutrient content in organic sources (mg kg^{-1})

S. No.	Organic source	Zn	Cu	Fe	Mn	Mo	B
1	FYM	34	2.5	1788	137	2.1	4.6
2	Pig Manure	50	8.9	1200	70	1.4	3.5
3	Poultry Manure	90	7.1	1400	210	3.1	5.0
4	Rural compost	85	14	3600	200	2.0	10.0
5	City compost	400	150	7000	560	9.0	15.0
6	Goat/Sheep manure	2570	61	6500	150	3.5	4600
7	Sewage sludge	2459	643	8000	262	6.0	9.0
8	Green Manure	17	3.2	140	80	0.2	20.0
9	Rice Straw	30	4.5	225	700	0.1	8.0
10	Wheat Straw	25	3.4	190	90	0.1	5.0

Source: Adhikari, 2009

6- Response of crops to micronutrient: It was observed that zinc application improved herb yield of palmarosa by 9.1 to 17.7% over control, irrigated with boronated saline – sodic water. A remarkable improvement in grain and straw yield of rice was observed in saline environment. Zinc application @ 50 kg $ZnSO_4$ ha^{-1} increased grain yield up to 44.26% while application of 75 kg $ZnSO_4$ ha^{-1} enhanced straw up to 66.66%. Application of boron along with major nutrients enhanced the yield of green gram and available B content of soil. Omission of Zn and B reduced growth and yield of maize. (Table 9, 10 & 11).

Table- 9: Effect of $ZnSO_4$ on herb yield of palmarosa

$ZnSO_4$ levels (kg ha^{-1})	Herb yield (g pot^{-1})					
	1997-98			1998-99		
	I cutting	II cutting	III cutting	I cutting	II cutting	III cutting
Control	38.32	41.43	47.05	34.24	43.14	42.28
15	40.68	43.90	49.36	36.27	44.50	43.56
30	43.92	47.08	53.51	37.30	46.80	45.65
45	45.10	48.31	54.53	38.00	47.06	47.37
SEm±	0.44	0.45	0.43	0.21	0.32	0.20
CD *(P=0.05)*	1.26	1.28	1.22	0.58	0.91	0.56

Source: Sharma and Pal, 2001

Table-10: Effect of $ZnSO_4$ on yield of rice

$ZnSO_4$ levels (kg ha^{-1})	Grain yield (g pot^{-1})		Straw yield (g pot^{-1})	
	I year	II year	I year	II year
Control	5.06	5.21	14.93	14.45
25	5.95	5.93	17.53	15.75
50	7.30	7.34	21.20	18.96
75	7.14	7.30	24.88	21.53
CD *(P=0.05)*	0.153	0.131	0.519	0.492

Source: Singh *et al.* (2013)

Table -11: Effect of fertility levels on growth and yield of green gram

Fertility levels	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Available B(mg kg^{-1})

F_1- Control	438.59	512.96	0.31
F_2- N	471.45	527.03	0.32
F_3- N + P	490.52	558.00	0.32
F_4- N + P + K	509.27	610.53	0.32
F_5- N + P + K + B	553.05	671.09	0.44
F_6- N + L	608.03	789.45	0.32
F_7- N + P + L	744.48	834.69	0.34
F_8- N + P + K + L	775.03	977.60	0.34
F_9- N + P + K + B + L	782.92	994.04	0.46
SEm ±	10.52	8.64	0.008
CD (P=0.05)	30.10	25.91	0.02

N = 20 kg N ha^{-1}, P = 50 kg P_2O_5 ha^{-1}, K = 40 kg K_2O ha^{-1}, B = 2 kg B ha^{-1}, L= 10% lime of LR (656 kg ha^{-1})

Source: Odyuo and Sharma (2020)

Table-12: Effect of nutrient omission on growth and yield of maize

Treatments	Plant height (cm)	Cob length (cm)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1: N_{120} P_{60} K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}	227.0	20.1	3.975	5.107
T_2: N_0 P_{60} K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}	202.6	16.3	2.996	3.940
T_3: N_{120} P_0 K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}	212.5	17.1	3.140	4.160
T_4: N_{120} P_{60} K_0 Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}	219.4	18.9	3.435	4.482
T_5: N_{120} P_{60} K_{60} Zn_0 $B_{0.5}$ + 300 kg lime ha^{-1}	216.7	18.1	3.656	4.730
T_6: N_{120} P_{60} K_{60} Zn_{10} B_0 + 300 kg lime ha^{-1}	217.5	18.3	3.612	4.768
T_7: N_{120} P_{60} K_{60} Zn_{10} $B_{0.5}$ + 0 kg lime ha^{-1}	211.5	17.6	3.283	4.210
CD(p=0.05)	7.66	1.88	0.101	0.173

Source: Marry and Sharma (2021)

Hence, it may be conclude that a less part of micronutrients is utilized up by the crops and the rest are lost. Huge amount of micro nutrients either fixed in the soil or losses by other means. Effect of micronutrient deficiency can be very severe in terms of stunted growth, low yield, dieback and even plant death. The chief sources of micronutrients are organic materials available in agriculture farms which are good alternative of micronutrient fertilizers. These include FYM, poultry manure, green manure, compost, animal dungs, and crop residues. Macro plant nutrients require supplementation from inorganic fertilizers, whereas the micronutrients supplied through organics do not need supplementation of micronutrient fertilizers. If micronutrients are added through organic sources, they are slowly available to the crops as per requirement.

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