Role Of Micronutrients in Ensuring Optimum Use of Macronutrients

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Key Words - Presentation Content

- Plant nutrition
- Nutrients
- Micronutrients and macronutrients
- Role of micronutrients
- Experiments in cultivators' fields
- Long term experiments
- Researcher field experiments
- Conclusions

Plant Nutrition

- Growth and development - outcome of several processes
- Growth - mass accumulation of carbon
- Development - morphological, beginning and ending of plant organ differentiation
- Nutrition - sum of processes by which a plant takes and utilizes food for growth and development
- Nutrition determinant of yield

Plant Nutrients

- Several elements constitute plant body
- Seventeen play vital role in plant nutrition
- Present either as constituent of molecules of plant body or are indispensable for a host of enzymatic reactions basic to biological activity
- These are: CHO NPK CaMgS **ZnFeMnCuNi BMoCl**

Plant Nutrients

- **Sub-optimal supply impairs vigorous and healthy plant growth and development**
- **Exclusion of any one, hinders plant to complete life cycle**
- **Primary function of transforming photo-energy into chemical energy and of synthesizing substances that constitute living matter cannot be performed by a substitute**
- **These 17 elements are called 'essential elements'**

Plant Nutrients

- On account of direct involvement in plant nutrition, essential elements are referred to as 'plant nutrients'
- Other than group of 17 elements, some more are useful for some plants but do not benefit others
- Example: Si and rice and Co and N_2 fixation; classified as beneficial elements

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Micro- and Macro-nutrients

- Based exclusively on quantities necessary to produce a unit of plant biomass, essential elements are called either micro- or macro-nutrients
- Micronutrients: ZnFeMnCuNi BMoCl
- Macronutrients: CHO NPK CaMgS

Typical concentrations (mg/kg)of macro- and micro-nutrients

N	15,000	Fe	100
K	10,000	Mn	50
Ca	5,000	Zn	20
P	2,000	Mo	0.1
S	2,000	Ni	0.1

Miconutrients - No way micro in function

- Absence of one atom of Mo or Ni can offset advantage from presence of 10^6 N atoms
- Hence, if all but one nutrient is missing, utility of all other nutrients turns useless
- Deficiency of Zn most prominent
- NPK most attended macronutrients
- Our report, a saga of Zn and NPK

Compound annual growth rates (%) production (P), area (A) and yield (Y)

Variable	Rice	Wheat	Food grains
Period 1980-81 to 1989-1990			
A	3.6	3.6	2.7
P	0.4	0.5	-0.2
Y	3.2	3.1	3.0
Period 1990-91 to 1999-2000			
A	2.0	3.0	2.1
P	0.6	1.5	-0.1
Y	1.35	1.49	2.1

Linear annual growth rates of food grains (FG), gross sown (GSA) and irrigated (GIA) area, NPK use and population

GSA (Mha)	GIA (Mha)	NPK (kg/ha)	Population (M/yr.)
Period: 1980-81 to 1989-90			
0.66	1.23	46.5	16.3
Period: 1990-91 to 1999-00			
0.94	1.50	76.0	17.5

Response to application of NPK fertilizers

Period	Rise in fertilizer consumption (M tons)	Gain in food grain production (M tons)	Response (kg grain kg^{-1} NPK)
1967-1983	3.71	43	12
1984-2000	11.4	66	06

Total dry matter yield (DMY) and uptake of micronutrients by 23 crops gown in succession on a loamy sand soil

DMY	Total nutrient uptake (kg ha^{-1})			
(t/ha)	Zn	Fe	Mn	B
84	1.8	12.8	3.0	1.9
108	2.1	14.6	3.6	2.1
134	2.4	16.3	4.2	2.4

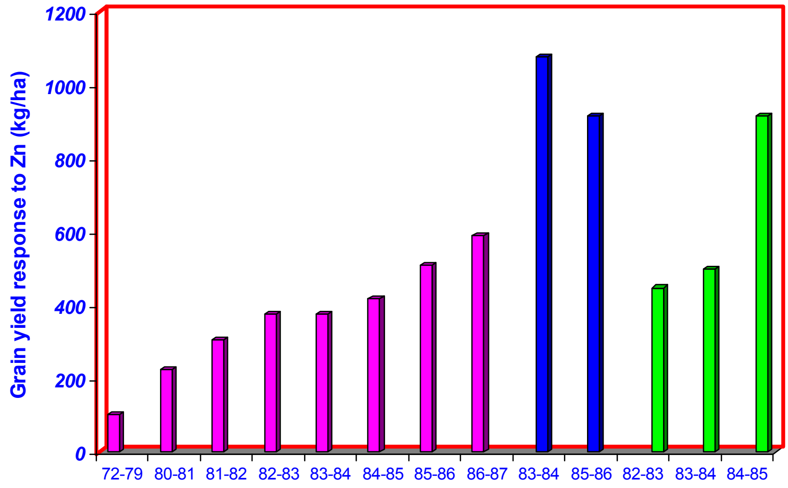
Source: Takkar et al. (1987)

Response of different crops to Zn application from 1967-1983 (4144 farmers' fields experiments)

Crop	Response range (kg/ha)		
	<200	200-1000	>1000
Rice	32	57	11
Wheat	47	46	7
Sorghum	67	33	-
Pearl Millet	63	36	1
Total	42	49	9

Source: Katyal, 1985

Response to Zn over optimal NPK application from 1971 1987



Source: Nambiar and Abrol (1989)

Effect of long-term manuring and cropping on available soil Zn (mg kg^{-1}) following 16 yrs of cropping

Location	Initial value of available Zn	Available Zn after 16 yr NPK	NPK+Zn	NPK+FYM
Ludhiana	1.10	0.61	0.94*	1.25
Delhi	1.10	1.30	2.90	1.30
Coimbatore	2.60	0.34	2.76	0.38
Jabalpur	0.60	0.44	4.82	0.90
Pantnagar	2.54	0.83	1.05**	1.04

*Zn @ 10 kg ha^{-1} every 4 to 5 years; ** Foliar spray; In all other locations annual application of 5-10 kg Zn ha^{-1}. Source: Nambiar (1994)

Effect of long-term manuring and cropping on available soil Fe, Mn and Cu (mg kg^{-1}) over the years (1971-86)

Location	Initial value of available micronutrients			Available micronutrients corresponding to optimum NPK after 16 years		
	Fe	Mn	Cu	Fe	Mn	Cu
Ludhiana	4.8	5.1	0.4	5.4	6.1	0.3
Delhi	10.6	20.0	1.4	24.2	9.2	2.4
Coimbatore	2.8	27.4	1.4	2.8	8.5	1.5
Jabalpur	6.5	8.3	1.0	15.1	12.0	1.4
Pantnagar	29.0	---	2.9	41.3	25.8	4.4

Source: Nambiar (1994)

Total Micronutrient contents

Micronutrient	India	World
Zn	20-97	17-125
Fe	13 to 18000	-
Mn	38-1941	60-1300
Cu	11-141	6-80
B	2.8-630	9-85
Mo	Traces-12.3	1-3

Available micronutrient content of Indian soils and critical limits

Nutrient	Mean	Critical limit
Zn	0.54	0.6
Fe	20.5	4.5
Mn	26.0	2.5
Cu	1.7	0.2
B	1.7	0.5
Mo	Tr.-2.8	0.2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Response of crops to micronutrients over and above NPK application

Crop	Soil	Response
Boron		
Safflower	Vertisol (HWS B 0.11 ppm)	100 kg seed and 70 kg oil yield ha^{-1} over 75 kg N ha^{-1}
Blackgram	B deficient calcareous	30% increase in yield over 30 kg K ha^{-1}
Iron		
Groundnut	Alfisol calcareous	30% increase in yield over recommended NPK
Chickpea	Entisol calcareous	500 kg ha^{-1} increase in grain yield
Sorghum	Vertisol calcareous	1.9 t ha^{-1} increase in yield over NPK

Compiled from various sources

Response of crops to micronutrients over and above NPK application

Crop	Soil	Response
Manganese		
Wheat	Sandy loam (DTPA Mn 2 ppm)	Drymatter yield and N uptake increased in presence of Mn over applied N
Rice	Alluvial sandy DTPA Mn 2.15 ppm)	Increased yield by 430 kg/ha over 100 kg P_2O_5 ha^{-1}
Molybdenum		
Pigeon pea	------	Increased grain yield by 400 kg ha^{-1} over applied P
Trifolium	------	20% increase in fodder yield over applied P

Compiled from various sources

Interactive Effect of micro- on uptake of macro-nutrients

- PxZn interaction - Zn deficiency interferes with P metabolism. Application of Zn corrects it; a typical case of nutrient imbalance
- Ni associated with N nutrition of higher plants. Usefulness in urease functioning
- Maximum response to urea-N with Ni treatment

Interactive Effect of micro- on uptake of macro-nutrients

- Mo influences N_2 fixation
- Influence of B on P nutrition well established; legumes and oilseed crops
- Progressive rise in P uptake by *Trifolium* in the presence of B
- Joint application of P and B maximize productivity of soybean, safflower and castor

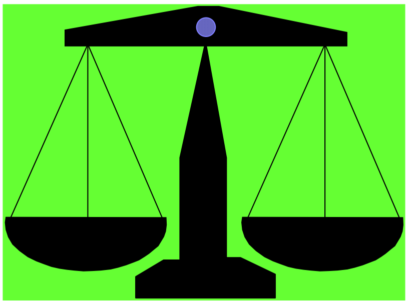
Extent and regions of micronutrient deficiency

- Analysis of some 200,000 soil and 50,000 plant samples place Zn deficiency ahead of all other micronutrients. Nearly 50% samples found Zn deficient compared to less than 10% with other micronutrients
- Several factors responsible for it:

  i. Native level of micronutrients

  ii. More removals, less additions

Zinc supply-demand balance



- Annual additions - 8000 tons Zn
- Removal estimate range between 14,000 and 60,000 tons/year
- Annual crop uptake equals 25,000 tons
- Half turned back; net deficit 4,500 tons/year

Extent and regions of micronutrient deficiency

iii. Deficient soils and inefficient crops need supplementation with Zn to ensure optimum response from uptake of macronutrients

iv. Deficiency provoked by some soil characteristics: soil aridity, OM depletion, alkaline reaction, calcareousness, light texture

v. Submergence and inefficient types


CAUVERY

Conclusions

- Micronutrients play vital role in sustaining economic and agronomic efficiency
- Deficiency capable of accentuating fertilizer related environmental pollution
- Zn deficiency most widespread
- Remains a creeping sickness due to low native levels and inadequate additions
- Sustainable benefits from NPK not possible without equalizing removals - additions

Conclusions

- Enhancing Zn use necessary - use fully installed capacity, enhance efficiency of use
- Development of micro-macro nutrient fertilizer combinations
- Infuse organic manure use in soil fertility management scheme
- Harness genetic potential, a practicable and economically viable option