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Effect of Long-term Fertilization and Cropping on Micronutrient Cations of Soils in Bangladesh

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Abstract: The effects of intensive fertilization and cropping on micro nutrients content of soil, solution and plant samples were studied. The treatments selected for this study were control, N, NP, NS, NPK and NPKSZn. The samples were analyzed to see the concentration of Zn, Cu, and Mn. Application of N showed an increase only in available Fe and Mn over control. The long-term application of P (TSP) increased available, total and soil solution content of Zn, Cu, Fe and Mn and uptake by crops. Fe and Mn content of soil solution was high in wet period than in dry period while a reverse was noted in case of Zn and Cu.

Key words: Fertilizers, Zn, Cu, Fe, Mn

Introduction

Micronutrients are the nutrients, essential for plant growth but are needed in very little quantity. An essential nutrient element sometimes may be toxic when its concentration rises above a safety level. This phenomenon is eventually common for micronutrients. The micronutrient cations (Fe, Mn, Zn, Cu) are influenced in a characteristic way by the soil environment e.g. the micronutrient cations are the most soluble and available under acid conditions. As all micronutrients are required in very small quantities, they are harmful when present in the soil in larger amounts (Brady, 1990).

Pollution of soils by heavy metals may repress microbial enzyme activity and reduce the diversity of populations of microorganisms and soil fauna (Tyler, 1981). Uptake of metals by plants reflects increasing levels of metals in soils, especially those metals that are more mobile. Above certain critical concentrations of heavy metals in plants, yield and/or crop quality and animal or human health may be affected (Tiller, 1989). Pollution of soil generally refers to an elevated concentration of natural or man-made chemicals in the soil profile as a result of human activities. Plants not only take up nutrient elements and molecules, necessary for their normal development but also other compounds that are present in growth medium in a so-called available form (Verloo, 1993). The accessibility of any element to plants in a given soil is determined by its chemical form and its location within the soil. Kausar *et al.* (1976) stated that flooded soils appeared responsible for Cu and Zn deficiency for rice in calcareous soils of Pakistan. Availability of manganese greatly affected by other nutrient status, organic matter and drainage. Faber (1987) stated that balanced fertilization specially application of micronutrients increased the uptake of these nutrients.

Nambiar and Ghosh (1984) conducted a long term fertilizer experiment and reported an increased uptake of micronutrients with a jute-rice-wheat cropping pattern under optimum NPK application. These facts led us to see the effect of long-term fertilization and cropping on micronutrient cation concentration in soil and plant.

Materials and Methods

A laboratory experiment was carried out in the Department of Soil Science, Bangladesh Agricultural University (BAU) during the period of 1997-98. Soil samples were collected from a permanent manurial experimental field of the Department of Soil Science, BAU Farm, Mymensingh, Bangladesh. The area is above the recent flood level while short time water stagnation occurs during the rainy season. The soils of the plots developed on the alluvial deposits of the Old Brahmaputra, which originated from the south of 'Kailas range'. Texturally the soil was silt-loam. It belongs to the Sonatola Series under the general soil type of non-calcareous dark grey 'floodplain alluvium' and the AEZ Old Brahmaputra Floodplain. This may be correlated with 'Aeric Haplaquept' of USDA Soil Taxonomy and 'Eutric Gleysols' of FAO-UNESCO soil unit.

This manurial experimental plot was started in the year 1978. The initial soil was silt loam in texture having pH 6.8, organic matter 2.16%, total nitrogen 0.06%, available phosphorus 9.0 mg kg^{-1}, available potassium 0.20 cmol kg^{-1}. The treatments include control, N, NP, NPK, NS, NPKSZn, NFYM and NPKFYM. The fertilizer doses used in the experiments were 60 kg N ha^{-1} from urea, 20 kg P ha^{-1} from TSP, 15 kg K ha^{-1} from MP and 30 kg S from gypsum.

For determination of Zn, Cu, Mn and Fe, the soil and soil solution were extracted with 0.024M Na_2EDTA solution. Zinc, Fe, Cu and Mn in extract were determined directly by atomic absorption spectrophotometer following the procedure by Mc Laren *et al.* (1984). Uptake of Zn, Cu, Mn and Fe were determined from grain and straw analysis directly by atomic absorption spectrophotometer following the procedure of McLaren *et al.* (1984).

Results and Discussion

Intensive fertilization and cropping for a period of 2 decades have brought a remarkable change in available Fe, Zn, Cu and Mn status of soils (Table 1). The treatments control, N and NS were identical and did not show any effect on these nutrients. However, the addition of P significantly increased their concentration in soils of respective plots (Khan, 1995). Among the P containing treatments, the effects of NPKSZn was significantly higher than NP and NPK in case of soil Zn content because of its application. The concentration of all micronutrient cations in subsurface soil decreased over surface soil in NP, NPK and NPKSZn treatments while in control, N and NS treatment it tended to increase over the control.

The Cu content of soils from P containing plots was remarkably higher than the remaining three treatments (Table 1) although the amount varied slightly. The content of all plots decreased in the lower depth and become almost 50% of surface soil (0-10 cm).

The Fe and Mn content of control plot ranged from 39-45 mg kg^{-1} and 8.3-9.3 mg kg^{-1} soil respectively irrespective of depths where lower amount was found in subsurface soil (Table 1). Application of TSP-P with other fertilizers also increased their level in both surface and sub-surface soils. Like Cu, the soils of NP and NPK treated plots contained almost equal and higher amount of Fe and Mn over other treatments. It appeared from the results in Table 1

Table 1: Concentration of Zn, Cu, Fe and Mn (mg kg^{-1}) in soils of surface and subsurface layer after 20 years of fertilization in long-term experiment.

Treatments	Zn		Cu		Fe		Mn	
	0-10 cm	10-20 cm	0-10 cm	10-20 cm	0-10 cm	10-20 cm	0-10 cm	10-20 cm
Control	1.4	1.6	4.5	9.2	45	39	9.3	8.3
N	1.4	1.6	5.3	3.4	50	39	12.1	11.2
NP	2.5	2.1	6.2	5.7	96	56	26.0	20.2
NS	1.5	1.9	4.3	2.9	45	37	9.6	5.6
NPK	2.8	2.5	6.3	4.9	84	67	32.1	20.2
NPKSZn	3.5	3.0	4.9	3.9	57	43	16.1	7.7

Table 2: Soil solution concentration (g l^{-1}) of micronutrients during dry and wet periods (0-10 cm)

Treatments	Zn		Cu		Fe		Mn	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Control	11	10	8	5	68	90	10	20
N	12	12	7	6	68	90	11	25
NP	16	14	10	7	130	175	55	95
NS	10	14	9	7	140	160	10	20
NPK	20	22	12	8	140	260	50	100
NPKSZn	20	23	10	9	190	290	30	90

Table 3: Micronutient uptake by rice (T.aman and boro)

Treatments	Uptake mg m^{-2}			
	Zn	Cu	Fe	Mn
Control	22	2.2	238	190
N	23	2.5	240	200
NP	24	3.0	260	210
NS	24	3.0	255	209
NPK	24	3.0	249	216
NPKSZn	64	6.0	823	622

that except Zn, the Fe, Mn and Cu contents of soil from NPKSZn treated plots were lower than NP and NPK treated plots. The higher status of Zn in the NPKSZn treated plot was possible for long continued fertilization, whereas the low content of Fe, Mn and Cu was possibly the effect of sulfur and Zn fertilization. Application of S and Zn with NPK helped increasing the biomass production and hence withdraws higher amount of nutrient compared with other nutrients. As a consequence the status decreased remarkably. The higher amount of nutrients in the surface layer is mainly associated with the higher organic matter content than sub-surface soils (Prasad and Singh, 1980 and Takkar, 1996).

Application of P with other nutrients increased the total soil reserve of Zn and Cu while in case of Fe and Mn almost no effect was found although the available content increased to some extent (Table 1). It appears from the results that the level of Zn and Cu decreased with depth but the level of Fe and Mn increased. In addition to uptake by growing crops, the leaching losses under reduced condition in wet season (Ponnamperuma, 1972, Tian-ren, 1985) probably made such a variation between surface and subsurface layers.

The mean concentrations of Zn, Cu, Fe and Mn in soil solutions from dry and wet periods have been given in Table 2. The results showed that the concentration of Zn and Cu showed no difference between dry and wet period where as the availability of Fe and Zn increased remarkably in wet period. The concentration of Zn increased when fertilizer management was proper i.e. when balanced fertilizer was used. Ali (1992) revealed almost the same result.

Uptake of micronutrient was the highest in case of NPKSZn treatment (Table 3) and it was very much higher than all other treatments. Uptake of all micronutrient cations are very much high when all common fertilizers (NPK) and additionally S and Zn are applied. This indicates that balanced fertilization can greatly influence the uptake of micronutrient cations. Nambiar and Ghosh (1984) reported an increased uptake of micronutrients when these are applied with a jute-rice-wheat cropping pattern under optimum NPK application. Ali (1992) reported a significant uptake of micronutrients and yield increase in rice and wheat after Zn application over NPK. Tandon (1995) and Faber (1987) also reported almost the same results.

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