AVAILABILITY OF MANGANESE, COPPER AND ZINC AS AFFECTED BY NITROGEN AND PHOSPHORUS FERTILIZATION

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Excessive quantities of superphosphate induced reduction of Cu and Zn availabilities to sorghum crop from soil, while the Mn supply was increased due to the formation of manganous phosphate. Ammonium sulphate was found to depress the Mn uptake but has generally very slightly increased the availability of Cu and Zn.

The effect of the combined use of nitrogen and phosphorus on the Mn, Cu and Zn availability showed that there was a positive correlation of +0.62 for Mn and negative correlations −0.15 and −0.57 for Cu and Zn respectively.

INTRODUCTION

The importance of micro-nutrients in the metabolism of plants has recently been realized. It was in the later part of the nineteenth century and in the early twenties that a larger number of reports were published on the role played by the micro-nutrients in the nutrition of plants and animals. Subsequently, research on the relation of micro-nutrients to the plants turned from the highly practical qualitative and descriptive phase towards the fundamental quantitative type of investigation. From the standpoint of micro-nutrient requirements of plants, the most important factor in crop production is not the total amount but the availability, specially in those soils where major nutrients have been adequately supplied.

Application of fertilizer material affect the availability of many trace elements. Bingham and Martin (1956) found that Cu and Zn availability in soils was adversely affected by large applications of superphosphate. Bingham and Garber (1960) studied availability of B, Fe, Cu, Mn, Mo and Zn in relation to excess of superphosphate with sour orange seedlings as indicator plants. Regardless of the source of P_2O_5, excess of phosphorus resulted in acute Cu deficiency and in acid soils it reduced the uptake of B and Zn. Similarly, Burleson *et. al.* (1961), on the basis of field and greenhouse experiments, found that phosphorus fertilization may induce Zn deficiency in some crops under certain soil and climatic conditions.

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In some cases, phosphorus addition has contributed to zinc deficiency and an increase in severity of zinc deficiency symptoms was noted when the nitrogen supply was increased regardless of the nitrogen source used (Thorne, 1957).

Millikan (1950) found that with nitrate and urea as the sources of nitrogen, severe symptoms of injuries due to Mn toxicity were noted. Such injuries were absent, when ammonium nitrate and ammonium sulphate were used as sources of nitrogen. On the basis of pot experiments, Viets *et. al.* (1957) were of the view that nitrogen application generally increased the uptake of both applied and native Zn, and this uptake by and large depended on the changes in pH that was brought about by the respective nitrogen carriers.

Amongst the various fertilizers, nitrogen and phosphorus fertilizers have found increasing popularity in Pakistan for enhancing the yield of cultivated crops and as such, their effect on the uptake of micro-nutrients like Cu, Zn and Mn by the plants seems a very important aspect of soil fertility for investigation.

MATERIAL AND METHODS

Soil sample of 0-9 inches depth was collected from the University Campus, air-dried, powdered and sieved through coarse muslin cloth and then thoroughly mixed. The physical and chemical composition of the soil were determined and the data are presented in Table 1. Glazed pots were filled with this soil at the rate of 30 pounds per pot. The requisite amount of superphosphate was added to the soil in pots before sowing sorghum crop and ammonium sulphate with first irrigation water. The following ten treatments (figures are on acre basis) with three replications were compared:

1.	0 lb. N+0 lb. P_2O_5 (check)	6.	500 lb. N+100 lb. P_2O_5
2.	0 „ N+100 lb. P_2O_5	7.	100 „ N+0 lb. P_2O_5
3.	60 „ N+100 lb. P_2O_5	8.	100 „ N+60 lb. P_2O_5
4.	100 „ N+100 lb. P_2O_5	9.	100 „ N+200 lb. P_2O_5
5.	200 „ N+100 lb. P_2O_5	10.	100 „ N+500 lb. P_2O_5

The sorghum plants were harvested at preflowering stage and dried in air-oven at the initial temperature of 70°C, and gradually raised to 100°C, till the samples were brittle. The samples were then powdered and stored in plastic bottles.

Copper, Zinc and Manganese were determined colorimetrically in the nitric, sulphuric and perchloric acids extracts of the soil and plant materials. Dithizone method was used for Cu, and Zn and Periodate method was used for Mn (Atkinson, *et al.*, 1949). Total P_2O_5 in soil and plant was determined

TABLE 1.—*Physical and chemical characteristics of the soil used*[a]

Mechanical Analysis:	Sand	60 %
	Silt	24 %
	Clay	14 %
	Textural class	Sandy loam
Chemical Analysis:	Organic matter	0.89 %
	Nitrogen	0.14 %
	Total P_2O_5	0.23 %
	Available P_2O_5	0.12 %
Other characteristics:	pH	7.5
	Ecx10^3 mmhos/cm[3]	3:1[b]
	Cation exchange Capacity	16.1 me/100 g. of soil
	Exch. Na	0.53 me/100 g. of soil
	Exch. K	0.65 me/100 g. of soil
	Exch. Ca+Mg.	14.92 me/100 g. of soil
Trace elements content	Mn	456 ppm.
	Cu	44 ppm.
	Zn	50 ppm.

(a) Data presented on oven-dry basis.
(b) Ec stands for electrical conductivity of saturation paste extract.

following perchloric acid treatment according to method proposed by USDA Staff (1954) and available P_2O_5 in the soil was determined by molybdate-$SnCl_2$ method (Olsen *et. al.*, 1954). Nitrogen in the soil was determined by Macro-Kjeldahl method (A.O.A.C., 1955) and in plant by Micro-Kjeldahl method (Jackson, 1958).

RESULTS AND DISCUSSION

Statistical analysis of data presented in Table 2 indicated that Mn showed negative correlation for nitrogen and positive correlation for phosphorus applications. However, the combined effect of nitrogen and phosphorus on Mn availability gave a positive correlation of +0.62. For Cu and Zn, the correlation values were positive for nitrogen and negative for phosphorus applications. The combined effect of nitrogen and phosphorus fertilizations on Cu and Zn availabilities showed negative correlations of 0.15 and 0.57 respectively. Similar results were reported by Bingham *et. al.* (1958), Bingham and Martin (1956), Bingham and Garber (1960) and Viets *et. al.* (1957).

TABLE 2.—*Nitrogen, phosphorus, manganese, copper and zinc contents of sorghum plants receiving different doses of nitrogen and phosphorus fertilizers.**

Fertilizer treatments to soil in pots (per acre basis)	Nitrogen (%)	Phosphorus (%)	Trace-elements in PPM		
			Manganese	Copper	Zinc
0 lb. N + 0 lb. P_2O_5	0.10	0.08	44	9.1	22.5
60 lb. N +100 lb. P_2O_5	0.40	0.21	48	10.8	22.0
100 lb. N +100 lb. P_2O_5	0.61	0.25	50	9.8	23.7
200 lb. N +100 lb. P_2O_5	1.02	0.31	50	10.8	27.5
500 lb. N +100 lb. P_2O_5	2.86	0.33	48	12.5	28.3
100 lb. N + 0 lb. P_2O_5	0.35	0.09	42	10.8	23.7
100 lb. N + 60 lb. P_2O_5	0.42	0.19	46	10.8	25.0
100 lb. N +200 lb. P_2O_5	0.52	0.42	55	7.5	20.2
100 lb. N +500 lb. P_2O_5	0.58	0.48	59	4.1	18.1
0 lb. N +100 lb. P_2O_5	0.12	0.16	51	6.2	21.6

*Results are average of three determinations.

The slight reduction in Mn availability when ammonium sulphate was added as source of nitrogen may be due to depressing effect of ammonium ions on Mn uptake. In case of soils receiving superphosphate, Mn uptake by plant has increased. This may be due to the formation of manganous phosphate which is a soluble compound and also due to the lowering of soil pH by the application of superphosphate. Under these conditions, trivalent Mn is converted to divalent form which is readily available (Reuther *et. al.*, 1949).

When nitrogen and phosphorus fertilizers are applied together, it is most likely that the soil pH is lowered by several degrees and the trivalent manganese gets converted to divalent form and becomes available to the plants.

The Cu and Zn availability has increased by application of ammonium sulphate but the extent of availability is not so profound. This slight increase of availability may be due to the calcareous nature of our soils. With the application of superphosphate, Cu and Zn availabilities have been decreased. Possibly this is due to the formation of phosphates of these metals and also due to the antagonistic effect of P on Cu and Zn (Boawn *et. al.*, 1965). The results obtained also show that nitrogen and phosphorus uptake by plants increases with the increase in the rate of nitrogen and phosphorus, but these increased absorptions are not proportionate to the amount of the fertilizers applied to the soil.

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