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Balance Sheet of Micronutrient Elements and Rate of Depletion in Four Heterogeneous Soils of Tamil Nadu

G. RAMANATHAN[1], R. NAGARAJAN,[2] M. MOOSA SHERIFF[3] and K.K KRISHNAMOORTHY[4]

A pot experiment was conducted with four heterogeneous soils of Tamil Nadu State to determine the effect of continuous cropping and fertilization on Micronutrient availability in soils. Crops were grown continuously, following a fixed crop rotation under four levels of fertility representing low, medium, high and very high levels classified in accordance with the amounts of fertilizers added.

An assessment of micronutrient balance was determined after ten crops and the data revealed increasing rate of depletion of micronutrients from the total reserve with increasing doses of fertilizers for all the four heterogeneous soils. This established that the use of high levels of fertilizers tended to cause faster rate of depletion of micronutrient elements, irrespective of the nature of soils studied. The rate of depletion of micronutrients followed a set pattern with reference to soils and the sequences of the rate of depletion were arrived at for each one of the micronutrient elements and with reference to soil groups and crops.

With the increasing use of high analysis fertilizers and advent of high yielding varieties, a situation is created where additional stress is laid on available micronutrient status in soils, tending to increase the incidence and extent of micronutrient deficiency. An assessment of the rate of depletion of micronutrient elements under conditions of use of high levels of fertilizers and intensive cropping is therefore of paramount importance and of dire need in the context of exploitive nature of agriculture being currently followed and the present study aims at providing sufficient data on the balance of micronutrients and depletion pattern.

MATERIAL AND METHODS

An experiment was conducted to determine the effect of continuous cropping and fertilization on the micronutrient availability in soils and the rate of depletion of micronutrient elements. Four heterogeneous soils were used for the experiment, namely, the black clay loam of Coimbatore, (2) red sandy loam from Chemmankuzhiyur (Vannapatti series), (3) black clay loam from Thondamuthur (Dasarpatti series) and an alluvial clay loam (Perur series). Six kg of the soil was placed in a polythene lined mud pot. The soils received graded doses of fertilizers. There was an ab-

1 - 4 : Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore-641 003.

solute control with zero levels of N, P and K (low). There were three other fertilizer combinations representing medium level of fertility (50, 25 and 25 ppm), high level of fertility (100, 50 and 50 ppm) and very high level of fertility (200, 100 and 100 ppm of N : P_2O_5 : K_2O respectively). The treatments were replicated six times and the soils received continuously graded doses of fertilizers for every crop. Crops were grown continuously and a fixed crop rotation was followed, the rotation being Co. 7 ragi followed by MCU. 5 cotton and CSH. 1 cholam. The plants were allowed to grow for 45 days and the above-ground portions were cut, dried for recording dry matter production. The plant samples were processed by washing with dilute hydrochloric acid before taking them for analysis for the micronutrient contents. Triacid digestion procedure was adopted for taking up the extracts of the plant samples and the concentrations of the micronutrients namely, Fe, Zn, Mn and Cu in the digest were determined, using atomic absorption spectrophotometer (Model : Varian Techtron AA 120). The fertilizers used were of analar grade and all precautions were taken in regard to uniform mixing of the soils and applied fertilizers, raising of the crops in the corresponding seasons, application of micronutrients-free pesticides and sampling for laboratory analysis etc. After each crop, soil samples were collected from the pots and analysed for the available micronutrient content for determining the change in availability. The initial soil samples were also analysed for the available micronutrient content as also the total micronutrient content following standard procedures (Jackson, 1958). The total nutrient contents were estimated by the method of Homes (1965). The methods described by Shaw and Dean (1951) for available zinc, Cheng and Bray (1953) for available copper, Olsen and Carlson (1950) for available iron and Willard and Greathouse (1957) for manganese were followed for the estimation of the respective nutrients.

A balance sheet has been worked out for each of the four micronutrient elements. For this purpose, the total micronutrient content of the initial soil sample was taken into account. The amount of the micronutrients removed by the first ten crops was calculated for each fertility level and this was deducted from the total to determine the per cent depletion at each fertility level. The data on per cent depletion and change in availability of micronutrients as also other soil characteristics such as E.C., pH and organic carbon are presented in Table I. The rate of depletion of micronutrients with reference to each soil group was also calculated. For arriving at the sequence of depletion, the mean values of per cent depletion for the four fertility levels were considered for each soil group and the results presented in Table IV. The rate of depletion of micronutrients with reference to crops was also determined. For this purpose, only the first nine crops, were considered and these comprised three cotton crops, three ragi crops and three cholam crops. This would give an idea which crop removed a larger proportion of micronutrients. These values are presented in Table V.

RESULTS AND DISCUSSION

The results presented in Table I show that pH values tended to decrease at high levels of fertility. But the decrease in pH was only marginal even after continuous additions for ten crops. These results are in conformity with those of long-term fertilizer experiments and change in pH values was only slight, possibly due to the buffering capacity of the soils. There was distinct reduction in the E.C. values of all the four soils after the 10 crops. With reference to organic carbon content, higher doses of fertilizers tended to deplete the organic matter content. Microbial activity at higher levels of fertilizers had been accelerated, leading to lower organic matter content in soils.

The per cent change in availability did not follow a uniform trend as there was increase in availability of micronutrients in some instances and decrease in others. Readjustment of equilibrium

TABLE I. Effect of continuous cropping on micronutrient availability

Fertility level in ppm			Changes in some chemical characteristics of soils					
			pH		E.C. M. mhos/cm		Organic carbon	
			Initial	After ten crops	Initial	After ten cropss	Initial	After ten crops
				I. Colmbatore — Black clay loam				
0	0	0		6.8		0.42		0.638
50	25	25	7.9	6.9	0.9	0.46	0.710	0.534
100	50	50		7.0		0.41		0.554
200	100	100		7.0		0.39		0.546
				II. Chemmankuzhiyur — Red sandy loam				
0	0	0		7.2		0.29		0.623
50	25	25	7.4	7.3	0.8	0.16	0.480	0.538
100	50	50		7.4		0.23		0.371
200	100	100		7.4		0.24		0.365
				III. Thondamuthur — Black sandy loam				
0	0	0		6.9		0.26		0.370
50	25	25	7.2	6.9	0.4	0.23	0.540	0.277
100	50	50		7.0		0.20		0.349
200	100	100		7.0		0.26		0.328
				IV. Perur — Alluvial				
0	0	0		6.9		0.13		0.651
50	25	25	6.9	6.8	0.8	0.18	0.630	0.630
100	50	50		6.8		0.22		0.630
200	100	100		6.8		0.22		0.445

TABLE II. Balance sheet of Zinc and Manganese

Fertility levels in ppm			Available zinc content in ppm						Available manganes content in ppm					
N	P_2O_5	K_2O	Initial	After 10 crops	Per cent change in availability	Crop removal μ g/pot	Total Zn content (ppm)	Per cent depletion from total Zn	Initial	After 10 crops	Per cent changes in availability	Crop removal μ g/pot	Total Mn content (ppm)	Per cent depletion from total Mn
						I. Coimbatore — Black clay loam								
0	0	0		2.20	— 12.00	1303.23		0.35%		7.20	— 28.0	2369.52		0.075
50	25	25	2.50	2.00	— 20.00	4587.75	60	1.27%	10.0	7.20	— 28.0	6214.84	500	0.199
100	50	50		2.40	— 4.00	6571.18		1.81%		19.20	+ 92.0	10798.08		0.345
200	100	100		6.70	+ 168.00	8834.44		2.45%		24.00	+ 140.0	26782.11		0.857
						II. Chemmankuzhiyur — Red sandy loam								
0	0	0		2.40	+ 700.00	1061.17		0.44%		6.40	+ 28.0	2703.46		0.132
50	25	25	0.30	2.60	+ 766.60	2726.71	40	1.13%	5.0	9.60	+ 90.2	5668.93	340	0.277
100	50	50		3.70	+ 1133.30	4665.95		1.81%		9.60	+ 90.2	8894.69		0.435
200	100	100		3.40	+ 1033.30	52.35		2.18%		32.00	+ 540.0	12730.06		0.623
						III. Thondamuthur — Black sandy loam								
0	0	0		1.00	— 9.90	761.68		0.24%		1.60	— 70.7	1574.71		0.047
50	25	25	1.11	1.00	— 9.90	2624.73	58	0.75%	7.0	3.20	— 54.3	4873.05	580	0.147
100	50	50		1.40	+ 26.10	3853.08		1.10%		3.20	— 54.3	8503.89		0.257
200	100	100		1.70	+ 53.10	6303.95		1.52%		4.00	— 42.8	23456.48		0.710
						IV. Perur — Alluvial								
0	0	0		2.70	+ 80.00	1236.19		0.34%		7.20	+ 10.7	2691.56		0.091
50	25	25	0.30	2.20	+ 63.30	2942.11	60	0.81%	6.5	11.20	+ 73.0	4739.22	490	0.161
100	50	50		3.70	+ 1133.30	3778.87		1.05%		6.40	— 1.5	6862.42		0.233
200	100	100		1.40	+ 36.60	5484.84		1.54%		6.40	— 1.5	9607.23		0.326

TABLE III. Balance sheet of Iron and Copper

Fertility levels in ppm			Available iron content in ppm						Available copper Content in ppm					
N	P_2O_5	K_2O	Initial	After 10 crops	Per cent change in availability	Crop removal μ g/pot	Total iron content in ppm	Per cent depletion from total Fe	Initial	After 10 crops	Per cent change in availability	Crop removal μ g/pot	Total copper content in ppm	Per cent depletion from total Cu
					I. Coimbatore — Black clay loam — Coimbatore series									
0	0	0		1.50	— 37.5	7131.39		0.0141		0.660	— 26.60	322.02		0.09
50	25	25	2.40	1.25	— 47.9	20346.31	8300	0.0408	0.90	0.550	— 38.80	980.96	55	0.30
100	50	50		1.25	— 47.9	29146.36		0.0585		0.330	— 63.30	1721.49		0.52
200	100	100		1.75	— 27.1	41751.77		0.0834		0.770	— 14.40	2993.79		0.90
					II. Chemmankuzhiyur — Red sandy loam — Vannapatti series									
0	0	0		1.00	— 28.6	5818.79		0.0014		0.330	+ 26.94	279.19		0.11
50	25	25	1.40	1.25	— 10.1	15396.05	65500	0.0391	0.26	0.440	+ 69.20	625.68	40	0.26
100	50	50		1.00	— 28.6	22493.82		0.0572		0.440	+ 69.20	1077.03		0.44
200	100	100		1.25	— 10.7	21945.13		0.0812		0.165	+ 36.20	1352.24		0.56
					III. Thondamuthur — Black clay loam — Dasapatti series									
0	0	0		0.50	— 90.4	5834.95		0.0016		0.660	+ 65.00	145.90		0.06
50	25	25	5.25	0.50	— 90.4	12398.60	59000	0.0350	0.40	0.385	— 3.75	552.76	40	0.23
100	50	50		0.50	— 90.4	14930.45		0.0421		0.387	— 3.25	876.71		0.36
200	100	100		0.50	— 90.4	21731.16		0.0613		0.330	+ 17.50	1269.14		0.52
					IV. Perur — Alluvial — Perur series									
0	0	0		1.00	— 28.6	5867.64		0.0009		0.385	+ 6.10	473.35		0.12
50	25	25	1.40	0.75	— 46.4	17221.96	1000000	0.0287	0 30	0.825	+ 175.00	2484.45	65	0.63
100	25	50		0.75	— 46.4	21091.43		0.0351		0.275	— 8.30	3460 29		0.88
200	100	100		0.50	— 64.3	28988.52		0.0401		0.275	— 8.30	4121.10		1.05

conditions changed with the environment and it was obviously different at different periods.

The results show that there was a consistent trend with regard to the depletion of the micronutrient, zinc (Table II). There was progressive increase in the per cent depletion with progressive rise in fertility levels and this trend was uniformly the same for all the four major heterogeneous soils. The per cent depletion of zinc from the total micronutrient content ranged from 0.24 to 2.45 for all soils considered together. This indidicated that the rate of depletion increased with increased doses of fertilizers but however, attained a maximum value of only 2.45 per cent for the first ten crops.

The depletion of manganese showed an exactly similar trend (Table II). Increased doses of fertilizers tended to cause a higher rate of depletion of manganese from soils. But the values of per cent depletion ranged from 0.047 to 0.857.

With reference to iron, the per cent depletion from the total was still of the lower order, the values ranging from 0.0009 to 0.0834 (Table III). But increasing rate of depletion with increasing levels of soil fertility was once again evident. The total iron content was high in all soils and hence the per cent depletion was of very low order.

The depletion pattern of copper followed an exactly similar trend, the rate of depletion increasing with increasing levels of added fertilizers (Table III). The minimum values for depletion was 0.09% and the maximum 1.05%.

The sequence of depletion of micronutrients with reference to each one of the micronutrients and the soil groups is represented in Table IV. The pattern of changes revealed that there was a faster rate of depletion of micronutrients (Zn, Fe and Mn) in black clay loam of Coimbatore and the least rate of depletion in alluvial soil for the same nutrients. Red sandy loam and black clay loam of Thondamuthur ranked second and third positions in the descending order of depletion of micronutrient elements. In respect of copper, the pattern of depletion had been considerably altered and higher rate of depletion was observed only in alluvial soil.

With reference to crops too, a distinct trend of changes of depletion of micronutrients was revealed. CSH 1 sorghum removed a larger proportion of micronutrients (Cu, Fe and Mn) followed by Co. 7 ragi and then MCU. 5 cotton. However, the zinc requirements for Co.7 ragi appeared to be greater than even for CSH 1 sorghum and their relative positions in the descending order had been interchanged. Similar studies were made in Gujarat and the results were broadly in agreement with those reported here (Anon, 1975). From the data it was clear that the per cent depletion was considerably low. The rate of depletion from the soil for some micronutrient elements was also indicated in the experiments conducted at Rothamsted by Williams *et al.* (1960). Thay have compared the amounts of micronutrients removed by five successive crops with the total reserves of four micronutrient elements Cu, Mn, Mo and Zn. The percentage depletion as calculated

TABLE. IV. Rate of depletion of micronutrients with reference to soil groups

Zinc	:	Black clay loam Coimbatore	>	Red sandy loam	>	Black clay loam	> Alluvial
		(1.47)		(1.39)		(0.98)	(0.93)
Copper	:	Alluvial	>	Black clay loam Coimbatore	>	Red sandy loam	> Black clay loam Thondamuthur
		(0.67)		(0.45)		(0.34)	(0.29)
Iron	:	Black clay loam Coimbatore	>	Red sandy loam	>	Black clay loam Thondamuthur	> Alluvial
		(0.0492)		(0.0447)		(0.0350)	(0.0282)
Manganese	:	Black clay loam Coimbatore	>	Red sandy loam	>	Black clay loam Thondamuthur	> Alluvial
		(0.369)		(0.366)		(0.290)	(0.202)

Figures in parentheses represent the mean values of per cent depletion for four fertility levels.

TABLE V. Rate of removal of micronutrients with reference to crops

Zinc	:	Co. 7 Ragi	>	CSH. 1 Sorghum	>	MCU. 5 Cotton
		(332.99)		(265.21)		(216.47)
Copper	:	CSH. 1 Sorghum	>	Co. 7 Ragi	>	MCU. 7 Cotton
		(285.82)		(250.59)		(58.96)
Iron	:	CSH. 1 Sorghum	>	Co. 7 Ragi	>	MCU. 5 Cotton
		(3727.45)		(1603.74)		(1336.95)
Manganese	:	CSH. 1 Sorghum	>	Co. 7 Ragi	>	MCU. 5 Cotton
		(1966.83)		(1174.75)		(375.40)

Figures in parentheses represent amounts in μ g/pot of the respective micronutrient removed by 3 crops grown in three seasons of successive years.

from their data was observed to be 0.52, 0.80, 0.37 and 0.72 per cent for Cu, Mn, Mo and Zn respectively. The figures reported by the workers at Rothamsted were in close agreement with the data obtained in the present studies. It may be noted that while the above study was confined to five successive crops the data reported in this paper were for ten successive crops on four heterogeneous soils of Tamil Nadu State. Despite the heterogeneous nature of soils and continuous cropping, the trend of results were consistently the same for all the four heterogeneous soils. It was markedly evident that the per cent dep-

letion increased with increase in levels of added fertilizers but could reach a maximum of just two per cent, when the first ten crops were taken into consideration. The work of Williams *et al*. (1960) lends support to the above observations. There were no deficiency symptoms manifested even under the highest level of fertility for the tenth crop. A set pattern of removal of micronutrients with reference to soils and crops was however, evidenced. Increased rate of depletion of all the four micronutrients was distinctly manifest with increase in doses of applied fertilizers and a similar consistent trend of results was revealed for all the four heterogeneous soils.

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