

The Nutrient Status of Long Term Fertilized Soils of Coffee Plantation in Southwestern Ethiopia

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SUMMARY

Under highly weathered condition over long periods of time and continuous application of TSP, DAP; sulfate of potash, or ammonium formula, soil nutrients undergoes significant changes both in chemical forms and affect the soil properties. The objective of the study was to study the fate of the micro and macro-nutrients in the soil as a result of continued application of N, P, and K fertilizer on coffee plantation. A laboratory investigation was done in Jimma research Center, Ethiopia. The soil type of the area is Eutric nitosol and clay; deep and well drained, with pH of 5-6, medium to high in exchangeable cations. Soil samples were collected from over 15 years, N-P-K fertilizer trial, and several farm management holding fertilizer plots under coffee production. The result of the study indicated that the available P content increased significantly in all fertilized plots compared to unfertilized sites. The availability and concentration of micronutrients in all cases increased with decreased soil pH ranges in critical level. The Cu contents varied 2.7 to 4.5 ppm and showed higher value in the soil. The iron and manganese contents of the soil are high and tend to be excessive range. The high Mn and Fe concentration in soil were certainly due to the low pH of the soil, which all were below pH 6. In continuous application of P fertilizers, soil phosphorus undergoes significant changes both chemical form and its build up was highly observable. In the long-term mineral fertilized plots demonstrate that organic matter highly significantly correlated to Nitrogen, phosphorus and pH soil reaction. Therefore, a continuous supply of organic materials must be added to maintain soil productivity.

However, continuous application of the same nutrient form for a long time can lead to the occupation of most of the adsorption sites there by creating toxicity problem of the released one. The formula may also contain elements other than the nutrient under study, which will favor the release or fixation of other nutrients. Under highly weathered condition over long period of time and continuous application of fertilizer, soil phosphorus undergoes significant change both in chemical forms and its location in soil profile (Thimma et al., 1991 and Iyengar et al., 1982). The effect of potash application over years significantly increased the amount of K compared to non-fertilized plots with increasing dose of K (Reddy et al., 1993). It is concluded that the applied K has contributed to the luxury consumption of K by the crops and this will still continue to supply K to crops for some more seasons with out reducing yield (Mahendra singh et al., 1982) The purpose of this study was, therefore to study the long-term effect of application of chemical fertilizer on macr-micro nutrient status of the soil. The objective of the present study was to study the fate of the micro and macro-nutrients in the soil as a result of continued application of N, P, and K fertilizer on coffee plantation.

MATERIALS AND METHODS

A laboratory investigation was done at Jima research Center. The soil type of the area is Eutric nitosol and clay; deep and well drained, with pH of 5-6, medium to high in exchangeable cations (Brehanu D.1975, Paulos, 1994). Sixty-four (0-30 cm) soil samples for this study were collected from over 15 years, N-P-K fertilizer trial, and several farm management holding fertilizer plots under coffee production. From these treatments containing different levels of N, P, and K soil samples were collected and studied for the concentration of N, P, K, Fe, Mn, Cu, and Zn. The data were compared with those collected from non-fertilized or intermittently fertilized plots. The changes in concentration of the applied nutrients were also investigated.

The collected soil samples were air-dried, grinded 2 mm meshes. Soil pH was measured 1:2.5 soil H₂O. The available Fe, Mn, Cu, and Zn were analyzed by 0.005M DTPA (Dietylenetriaminepenta-acitic acid) extractant and were read in Atomic Absorption Spectro Photometer (AAS). The total nitrogen and phosphorus were determined colorimetrically using Molybdenum blue and ammonium molybdate method respectively. Potassium was determined by flame photometer. The sources of NPK were Urea, DAP, TSP and Muriate of Potash respectively.

RESULT AND DISCUSSION:

Initially 64 Soil samples were collected from over 15 years fertilized experimental plots. The results of analysis in Table 1 indicated that average soil pH was 4.57. The total nitrogen content was ranged from 0.20 to 0.36% and the average value was 0.25%. The organic carbon content ranges from 2.1% to 3.6 % and the average organic carbon content was found to be 2.96%. The available P content ranges from trace to 22 ppm and the average available P content was 5 ppm. Available P content increased significantly in all fertilized plots compared to unfertilized sites. Unlike N, which is highly liable to mineralization, leaching and volatilization the residual effect and build up of P in the long term fertilized plot is highly observable. In general, the availability of P increased with the high dose of fertilizer in all treated plots.

The analysis of fertilized plots indicated that there were significant effects of the application on the concentration of available P in soil. Particularly P₂ (66 kg^{-ha}) compared with control. Therefore, P fertilization was able to raise the P status of the soil. According to analysis K-fertilization increased potassium concentration of the soil K₂ (134 kg^{-ha}) and K₃ (201 kg^{-ha})

compared with control. This was also confirmed in the earlier work (Paulos Dubale, 1994 and Höfner and Schmiitz, 1994).

Table 1. Some descriptive statistical on indicator parameters of soil samples collected from over 15 years fertilized experimental plots.

Parameters	Mean	Std. Error	Std. Deviation	Variance
Nitrogen (%)	0.25	0.00	0.03	0.00
Organic Carbon (%)	2.96	0.04	0.30	0.09
Phosphorus (ppm)	5.00	0.74	5.90	34.86
pH	4.57	0.06	0.45	0.20

Soils were analyzed for pH, CEC, Organic carbon and NPK (Table 2). As a result it was observed that soil pH in the fertilized soils showed a decreasing trend (acidity increased) and available Phosphorus in fertilized soils increased significantly owing to its low mobility.

Table 2. Physical and chemical properties of long term fertilized and unfertilized plots.

Lab. No	Site Description	PH	N (%)	P (ppm)	K (me/100g)	C (%)	CEC
1	Fertilized 15 to 20 years	6.0	0.18	7.2	0.93	1.8	34.60
2	“ “ “	5.2	0.22	23.8	1.13	2.7	26.60
3	“ “ “	4.8	0.21	15.8	0.53	2.8	32.40
4	“ “ “	4.9	0.21	24.1	0.50	2.5	30.00
5	“ “ “	5.5	0.27	36.6	1.08	3.0	28.00
6	“ “ “	4.7	0.22	82.4	0.71	3.9	23.60
7	“ “ “	5.5	0.21	65.3	0.66	3.5	28.20
8	“ “ “	6.1	0.22	40.6	0.89	3.5	27.60
9	From unfertilized adjacent fields	5.7	0.22	3.6	0.67	3.6	27.00
10	“ “ “	6.1	0.18	2.8	0.78	3.3	29.60
S.D		0.53	0.03	26.72	0.24	0.63	3.10
S.E		0.17	0.01	8.06	0.10	0.2	0.98

The total nitrogen content of the soils was generally low to medium 0.18 to 0.27%. The exchangeable potassium in soils was high. However, the level of K did not show significant differences compared to unfertilized sites. CEC value was medium to high and there was no significant different between long-term fertilized and unfertilized plots. This may be due to the relatively high organic matter in this heavy textured soil.

The results of laboratory analysis (Table 3) showed that the availability and concentration of micronutrients in all cases increased with decreased soil pH ranges in critical level. The Cu contents varied 2.7 to 4.5 ppm and showed higher value in the soil. The iron and manganese contents of the soil are high and tend to be excessive range. The high Mn and Fe concentration in soil were certainly due to the low pH of the soil, which all were below pH 6. Therefore, by raising the soil pH the availability of Mn and Fe could be reduced and possibility of its toxic effects eliminated.

From Table 3, it was evident that application of fertilizer increased the availability of micronutrients available Zn, Cu, Fe and Mn in all case compared to unfertilized plots. Similar results had been reported (Prasad. B. nad Jinna N.P, 1982). These results indicated that the solubility of these micronutrients was generally found to increase in decrease soil pH.

Table 3. Status of Micronutrient of soil on long term fertilized fields of coffee.

Lab. No	Site Description	DTPA- Soluble micronutrients (ppm)			
		Fe	Mn	Zn	Cu
1	Fertilized 15 to 20 years	32.8	148.2	2.8	3.2
2	“ “ “	58.1	124.5	3.3	3.7
3	“ “ “	46.5	131.5	2.3	3.7
4	“ “ “	49.8	155.9	2.7	3.1
5	“ “ “	52.8	101.8	2.9	3.1
6	“ “ “	63.2	219.1	5.5	4.5
7	“ “ “	61.9	131.9	3.0	2.7
8	“ “ “	68.4	172.6	3.3	4.2
9	From unfertilized adjacent fields	32.4	157.2	1.9	3.2
10	“ “ “	48.9	109.1	2.1	3.3
S.D		3.8	10.8	0.34	0.74
S.E		12.1	34.1	1.1	0.6

Table 4. Correlation coefficient (r) for relationship between organic carbon and available micronutrients, pH and available micronutrients.

	r- value
Organic carbon and Fe	0.674**
Organic carbon and Mn	−0.288*
Organic carbon and Zn	0.248
Organic carbon and Cu	0.131
pH and Fe	−0.159
pH and Mn	0.161
pH and Zn	−0.371**
pH and Cu	0.068

* and ** = significant at *p* 0.05 and 0.01 respectively.

Table 5. Correlation coefficient (r) for relationship between organic carbon and available macronutrients, pH and available macronutrients.

	r- value
Organic carbon and Nitrogen	0.621**
Organic carbon and Phosphorus	0.292*
Organic carbon and Potassium	0.161
Organic carbon and pH	−0.354**
pH and Nitrogen	−0.115
pH and Phosphorus	−0.368**
pH and Potassium	0.395**

* and ** = significant at *p* 0.05 and 0.01 respectively.

Relation between available micronutrients and organic carbon, pH and available micronutrients are presented in Table 3. It was shown that available Iron positively correlated with organic carbon (OC). The available Manganese was also correlated negatively, however the relation was not significant in Zinc and Copper. Presumably organic matter promotes the availability of these nutrients. Further, the available copper, iron and manganese did not correlate significantly with the soil pH. But, it was negatively significant with zinc.

According to the classification of the limiting value on DTPA soluble Zn, Fe, Cu and Mn, in soil solution the concentrations found to be not below the limiting value. Therefore, deficiencies are rare in soils (Höfner and Schmitz, 1984).

The available micronutrients increased with soil pH and percent organic matter. The total Nitrogen and phosphorus positively correlated with soil organic matter. Exchangeable potassium positively was not correlated with soil organic matter. The available P and exchangeable potassium highly correlated with soil pH; hence, the total nitrogen content did not correlate with soil pH (Table 5).

CONCLUSION

Chemical fertilizers applied long term to the soil can provide crops specific ingredient elements, but not with all essential elements they need. Hence this long-term application of chemical fertilizer might cause some plant nutrients to be depleted and other to be deposited in excess in the soil, and consequently the acidity of the soil increased.

The application of P- fertilizer was effective in every case, while K application had a positive effect only at higher application rate. In continuous application of P fertilizers, soil phosphorus undergoes significant changes both chemical form and its build up was highly observable. In the long-term mineral fertilized plots demonstrate that organic matter highly significantly correlated to Nitrogen, phosphorus and pH soil reaction. Therefore, a continuous supply of organic materials must be added to maintain soil productivity.

RECOMMENDATIONS

The total effect of continuous cropping with various soil fertility treatments have contributed towards improving the macro and macronutrients status of soil. The form and application of Nitrogen fertilizer should be considered the soil reaction with lower pH values below 5. It is advisable to use Ca- containing N and P fertilizers, which are able to correct the soil reaction.

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