"Utilization of diversity in land use systems: Sustainable and organic approaches to meet human needs"

Influence of Small scale Irrigation on Selected Soil Chemical Properties

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ABSTRACT

The success of soil management to maintain soil quality depends on the understanding of how soils respond to agricultural use and practices over time. The objective of the study was to investigate the effects of small scale irrigation on selected soil chemical properties in sub-humid agroecosystem. Six small scale irrigation farmlands that are located in East Wollega Zone of Oromia National Regional State, western Ethiopia, were selected and the adjacent non-irrigated farmlands were also included for comparisons. A composite soil sample that comprised 25 sub-samples was collected from the plow layer (0–20 cm) for each irrigated and adjacent non-irrigated farmlands. The study indicated that soil pH (H_2O), and exchangeable bases were higher in irrigated farmlands than the non-irrigated farmlands. This attributed to the transportation of soluble cations from the upper slopes to the irrigated farmlands by water erosion. The different soil fertility management practices also contributed to the variation. On the other hands, soil organic matter (SOM), total nitrogen, and exchangeable acidity were lower in irrigated farmlands. Relatively, the lower organic matter and total nitrogen contents in irrigated farmlands attributed to the optimum soil moisture content through out the year that created favorable environmental condition for SOM decomposition. The frequency of cultivation was high in irrigated farmlands as they also used for rain-fed agriculture. This study suggested that soil organic matter and soil acidity management has paramount importance for sustainable production and productivity of irrigated and rain fed agricultural farmlands in western Ethiopia.

Key words: Rain fed agriculture, Small scale irrigation, Western Ethiopia

1. INTRODUCTION

Encouraging small scale irrigation agriculture is vital to enhance production and attain food self sufficiency in Ethiopia. However, monitoring the impacts of irrigation on soil chemical properties is crucial as far as the issue of sustainable crop production and productivity is concerned. The success of soil management to maintain soil quality depends on the understanding of how soils respond to agricultural use and practices over time (Negassa and Gebrekidan, 2004). Irrigation can have adverse effect on soil properties thereby on sustainable productivity if not regularly monitored. Timely monitoring helps to avoid negative effects of irrigation on soil properties so that irrigation could continue its contribution to the diversification of agriculture (Henry and Hogg, 2003). This means Irrigation should be managed so that it could minimize adverse effects on soil quality. The effects of irrigating with waste water on soil chemical properties were reported by many researchers (Itanna et al. 2003; Qian, and Mecham, 2005). Moreover, the effects of irrigation on soil physicochemical properties in arid and semi-arid environments were well documented. However, there is little information on the effects of small scale irrigation on soil physicochemical properties in humid and sub-humid environment.

There are a number of small scale irrigations in Ethiopia in general and in Western Oromia in particular. The lands that are used for small scale irrigations are also utilized for rain fed agriculture. These could lead to nutrient mining and degradation of important soil chemical properties since the practices depend on low input agriculture. Although, most of the irrigation water sources are less likely to have adverse impact on soils in humid and sub-humid agroecosystems, generating scientific information has paramount importance for sustaining the production and productivity of small scale irrigation in western Oromia. Hence the objective of the study was to investigate the effects of small scale irrigation on selected soil chemical properties.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted in 2005 on selected small scale irrigation farmlands that are located in East Wollega Zone of Oromia National Regional State, western Ethiopia. The study area is characterized by sub-humid agroecosystem. Six small scale irrigation farmlands such as Gabar, Kastemach, Basaka, Nagesso, Gibe-Lamu and Lugama were selected for the study. The age of the irrigated farmlands ranged from 11 to 60 years for for Gibe-Lamu, and Negesso, respectively. In addition, the adjacent non irrigated farmlands that used for rain-fed crop production were included for comparison. The soil textural classes were clay loam for Gabar, sandy clay loam for Kastemach while clay for all others.

2.2. Soil Sampling and Analysis

A composite soil sample that consisted of 25 sub-samples was collected from the plow layer (0-20 cm) of each irrigated and adjacent non-irrigated farmlands. The collected soil samples were air dried and sieved < 2 mm size for different soil chemical analysis, whereas ground into 0.5 mm size for the total nitrogen, total carbon and the total phosphorus analyses. Standard laboratory procedures were followed to analysis the selected soil chemical properties. Soil pH (H_2O) was determined in 1: 2.5 (w/v) soil to solution ratio. The exchangeable bases were extracted with 1.0 *M*-ammonium acetate at pH 7. The exchangeable Ca and Mg were determined by atomic adsorption spectrophotometer, whereas the exchangeable K and Na were determined by flame photometer from the extracts. The exchangeable acidity was determined by extracting the soil samples with 1 *M* KCl solution and titrating with NaOH as described by McLean (1965). Effective cation exchange capacity (ECEC) was estimated by summation of exchangeable bases and exchangeable acidity. Organic carbon was determined following the wet digestion method as described by Walkley and Black (1934). Total nitrogen was determined by the Kjeldahl procedure as described by Jackson (1958). Available P in the soil samples was extracted by using Bray-II method (Bray and Kurtz, 1945). Total P was extracted using NaOH fusion technique. The extracted available P and total P was determined colorimetrically following the procedure of Murphy and Riley (1962).

3. RESULTS AND DISCUSSION

3.1 Organic Mater, Total Nitrogen, Total and Available Phosphorus

Soil organic matter (OM), total nitrogen (TN), total phosphorus (TP), and available phosphorus (AP) for the irrigated farms and the adjacent non-irrigated farmlands are presented in Table 1. The results showed that the OM contents in all irrigated farmlands were lower than the non-irrigated farmlands. The OM contents ranged from 4.19 to 6.37% in small scale irrigated farmlands where the lowest and the highest OM were observed in Nagesso, and Kastemach, respectively. On the other hands, the OM contents of the non irrigated farmlands ranged 4.83 to 7.01% that were recorded from Gibe-Lamu, and Kastemach, respectively. The trend of TN was similar to that of the OM as there is strong association between OM and TN. However, TP and AP were higher in the irrigated farmlands than the non-irrigated farmlands.

Table. 1. Organic matter, total nitrogen, total and available phosphorus irrigated and non-irrigated farms

Location	OM (%)		TN (%)		TP (mg kg^{-1})		AP (mg ka^{-1})	
	Irrig	Adj	Irrig	Adj	Irrig	Adj	Irrig	Adj
Gabar	5.75	6.97	0.40	0.39	1166.14	1011.36	14.41	4.16
Kastemach	6.37	7.01	0.37	0.4	1381.33	1173.11	6.75	3.52
Basaka	4.44	5.31	0.23	0.29	1009.34	1098.74	1.19	1.12
Nagesso	4.19	5.03	0.24	0.27	1020.84	1488.49	1.50	1.58
Gibe Lamu	4.69	4.83	0.22	0.22	929.01	901.24	1.22	1.00
Lugama	5.08	5.87	0.26	0.24	1111.04	995.00	12.62	6.06

Irrig. : Irrigated, Adj.: Adjacent

The lower values of OM and TN in small scale irrigated farmlands are attributed to the continuous cultivation throughout the year. Moreover, relatively optimum soil moisture content throughout the year created favorable condition for OM oxidation. The frequency of cultivation was high in irrigated farmlands as they also used for rain-fed crop production. The small scale irrigation farmlands were also used for rain-fed agriculture during the rain season and used for irrigation during the dry season. Moreover, crop residues were immediately removed from farmlands used for small scale irrigation and rain-fed agriculture. This implies that little above ground crop residues remained on the land for decomposition as compared to the adjacent lands used only for rain-fed agriculture. There were also variations among the irrigated farmlands in OM, TN, TP and AP. This could be due to the variations in the ages of the small scale irrigation, topography, climatic factors, slope, soil type and the soil management practices adopted for the land management. This was true for the counter non-irrigated farmlands. The higher TP and AP in irrigated farmlands could be due to the application of fertilizer P in each cropping cycle i.e. in rain fed and irrigated crops on the same land.

3.2 Cation exchange Capacity and Exchangeable Bases

The Effective cation exchange capacity (ECEC) of the irrigated farmlands and their adjacent non irrigated farmlands were more or less similar (Table 2). However, the exchangeable bases were higher for the irrigated farmlands than their counter non-irrigated farmlands. This attributed to different soil fertility management practices. Farmers apply farmyard manure, and use crop rotations for the irrigated farms while they usually use only inorganic fertilizers for the adjacent non-irrigated farmlands. The high exchangeable bases and ECEC in the irrigated farmlands could be attributed to the transportation of exchangeable cations by erosion as most of the small scale irrigation farmlands located at the lower slope.

Table. 2. Cation exchange capacity and exchangeable bases in irrigated and non-irrigated farmlands

Location	ECEC ($cmol_c$ kg^{-1})		Ca		Mg		K		Na	
	Irrig	Adj	Irrig	Adj	Irrig	Adj	Irrig	Adj	Irrig	Adj
Gabar	22.12	22.68	9.50	8.10	3.97	2.76	4.70	3.97	0.20	0.10
Kastemach	32.49	29.59	19.29	18.18	4.00	3.13	6.11	5.74	0.09	0.04
Basaka	19.47	18.37	11.88	10.55	4.69	3.93	0.98	1.24	0.17	0.15
Nageso	24.68	23.29	14.96	9.69	4.99	3.03	2.21	3.06	0.02	0.01
Gibe Lamu	18.48	17.49	10.77	10.09	3.55	3.41	1.84	1.67	0.07	0.07
Lugama	32.65	29.28	19.28	17.89	5.62	4.89	5.46	4.73	0.04	0.02

Irrig. : Irrigated, Adj.: Adjacent

3.3 Soil pH, Exchangeable Acidity and Aluminum

Higher soil pH was observed in the irrigated farmlands than their counter non-irrigated farmlands (Table 3). The higher pH could also be attributed to the different management practices. Although the ECEC was similar for irrigated and counter non-irrigated farmlands, their exchangeable acidities were different. The value

Table. 3. Soil pH, available P, and exchangeable acidity in irrigated and adjacent farmlands

Location	pH (H_2O)		Ex. Acidity $cmol_c kg^{-1}$		Ex.Al $cmol_c kg^{-1}$		EAP (%)	
	Irrig	Adj	Irrig	Adj	Irrig	Adj	Irrig	Adj
Gabar	4.98	4.67	3.75	7.75	2.00	4.00	16.95	35.04
Kastemach	5.53	5.32	3.00	2.50	1.50	1.00	9.23	7.69
Basaka	5.54	5.38	1.75	2.50	1.00	1.50	8.99	12.84
Nageso	5.54	4.69	2.50	7.50	1.25	4.50	10.13	30.39
Gibe lamu	5.30	5.30	2.25	2.25	1.25	1.50	12.18	12.18
Lugama	5.85	5.50	2.25	1.75	1	0.50	6.89	5.36

Irrig. : Irrigated, Adj.: Adjacent, Ex; exchangeable acidity, EAP ; exchangeable acidity percentage

of exchangeable acidity was lower in the irrigated farmlands than the adjacent non-irrigated farmlands that agree with established facts where the soil pH and exchangeable bases are negatively associated with exchangeable acidity. The highest exchangeable acidity percentage was observed in the non-irrigated farms of Gabar (35%) and Nagesso (30%), which were two and three times greater than their respective irrigated farmlands. The dominant proportion of the exchangeable acidity was exchangeable Al.

4. CONCLUSION

The selected soil chemical properties were affected by the different land use systems. Soil organic matter soil acidity and P management are very crucial for the sustainable production and productivity of small scale irrigation and rain-fed agricultural farmlands in western Ethiopia.

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