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Soil Fertility Assessment of The Lugu Main Canal Of Wurno Irrigation Project, Sokoto State, Nigeria, Five Years After Rehabilitation.

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ABSTRACT: A study was conducted during the 2000/2001 irrigation season to assess the soil fertility and the pattern of its variation with depth in the Lugu main canal of Wurno Irrigation Project. Soil samples were collected from four randomly chosen transects across the field at two sampling spots in each transect. The samples were taken at 0 - 15, 15 - 30 and 30 - 45 cm depths from each spot. Soil chemical properties such as pH, total N, available P, CEC and exchangeable bases were determined. The soils had average pH of 7.09, 6.92 and 6.87 at the 0-15, 15-30 and 30-45 cm depths, respectively. The CEC, available P, and total N were very low at all depths. CEC and total N decreased with depth. Ca and K were also very low while Mg was moderate at all depths. Na on the other hand, was high at the surface and moderate at lower depths. The % base saturation was high at all depths. The soils were low in fertility and need the adoption of proper management in terms of organic and inorganic fertilizer application and quality irrigation practices to resuscitate and sustain the soil fertility.

Key words: Soil fertility, Soil chemical properties, Wurno Irrigation Project, Lugu main canal.

INTRODUCTION: Global drive for sustainable agricultural systems involves optimizing agricultural resources to satisfy human needs and at the same time maintaining the quality of the environment and conserving natural resources (FAO, 1989). The establishment of irrigation agriculture is vital to enhance crop production to attain food sufficiency, especially in arid and semi arid regions. The success of soil management to achieve productivity and maintain soil fertility depends on the undersrtanding of how the soil responds to agricultural use and practices (Negassa and Gebrekidan, 2004). Irrigation agriculture could have adverse effects on soil chemical properties, fertility and sustainable productivity if not well monitored. The chemical properties of a soil give a strong indication of its fertility. Cation exchange capacity (CEC) for instance, do not only help to evaluate soil fertility, but also to classify it (Hesse, 1971). It determines the capacity of a soil to hold nutrients and eventually release them for plant uptake. The quantity of nutrients to be applied to complement soil fertility and the relative level of nutrients in the soil (O'Hoore, 1992). Agbenin and Goladi (1997) reported rapid decline of organic matter, followed by extensive leaching of basic cations and rapid development of acidity when most savanna soils undergo continous cultivation. Soils with >50% base saturation indicates eutric (more fertile) while those with <50% base saturation are dystic (less fertile) as indicated in the FAO soil map of the world classification. Low levels of soil nitrogen as a result of losses through various processes such as leaching, denitrification to gaseous forms such as, nitrous oxide, nitrogen gas, nitric oxide and ammonia volatilization which lead to permanent loss of nitrogen to the atmosphere as a result of biochemical reactions taking place in the soil is common in irrigated areas (Landon, 1991). The reactions

are normally favoured and could be aggravated by irrigation activities, especially with poor soil management practices, such as existance of poor drainage, leading to anaerobic conditions. Available phosphorus levels are generally low in tropical soils, since phosphorus in native phosphorus compounds is unavialable for plant uptake due to high insolubility of these compounds, even when soluble sources of P such as those in fertilizers and manures are added to the soils they are easily fixed or changed to unavilable forms and with time react to become highly insoluble (Brady, 1990). This could be due to high levels of other elements such as Fe, Al and Mn under acid conditions and Ca under alkaline conditions. Soil pH also strongly indicates the availability of essential nutrients to plants most of which become available at pH 6 - 7 (Brady and Weil, 1999; Olaitan and Lombin, 1984).

Timely monitoring is necessary to minimize and properly manage the negative effects of irrigation practices on soil chemical properties so that irrigation could continue with its contribution to the diversification of agriculture (Henry and Hogg, 2003). This is to ascertain the level of nutrient mining and degredation of important soil chemical properties, since the farmers practices depend on low input agriculture.

Wurno Irrigation Project area constitute fadama soils, poorly or imperfectly drained in relatively flat topography (Graham and Singh, 1997). The soils are also prone to seasonal water logging which prompted Sokoto state government to request for the intervention of European Economic Community (EEC) for its rehabilitation, which was completed in 1995. Over the years, it has been involved in growing rice in the wet season and vegetables, such as onions and garlic in the dry season. It is worrisome that only scanty studies have been conducted on the chemical properties of the soils as affected by the irrigation activities in the area, mostly before the rehabilitation.This necessitated a study to understand the chemical properties of the soils especially as they relate to fertility being a pre-requisite for efficient use of soil resources (Khan *et al.*, 1998; Mustapha *et al.*, 2001). This could form a basis for monitoring the fertility status of the soils at regular intervals. The study had the objectives of determining some chemical properties as they relate to fertility status of the soils in Lugu main canal of the irrigation scheme five years after rehabilitation, the pattern of variation of these properties across the area and with depth.

MATERIALS AND METHODS

Description of the study site: Wurno Irrigation Project is located on latitute 13^{o} 20´N and longitude 4^{o} 55´E, within the Sudan savanna ecological zone. The climate consists of a long dry season (October to May) and a short wet season (June to September) (Graham and Singh, 1997). The mean annual rainfall in the area is about 500 mm, poor in distribution, scanty in quantity and erratic in behaviour with its peak in August (Graham and Singh, 1997). The tempreture ranges from a minimum of 17^{o}C recorded in December/January to 40^{o}C in April/May. The project comprises of a storage reservoir with design capacity of 19,501,200 m^{3} supplied from Goronyo dam. The reservoir is linked to two main canals, namely; Lugu main canal that passes through Lugu village (the site of this study) and Tutudawa main canal that passes through Tutudawa village, a main drain and a number of secondary canals.

Soil sampling, Preparation and Analyses: Soil samples were taken in the dry season during the 2000/2001 irrigation season from Lugu main canal of the project in order to obtain detailed information. Four transects were randomly chosen and two sampling spots were identified in each transect. Soil samples were taken at 0 - 15, 15 - 30 and 30 - 45 cm depths from each sampling spot, making a total of 24 samples. These were taken to the laboratory, air dried, ground using a stainless steel mill and sieved through 2 mm sieve mesh. The samples were stored for subsequent analyses to determine various chemical properties.

The following chemical properties were determined; pH using 1:1 soil : water ratio by pH meter, total N by micro kjedahl method (Jackson, 1962), available P by Bray no. 1 method (Bray and Kurtz, 1945), CEC by ammonium saturation method (Black, 1965) and exchangeable bases from CEC

determination extract. Potassium and sodium were determined by flame photometry and Ca and Mg by EDTA titration method. Percentage base saturation was then calculated from the relation; Percentage base saturation (PBS) = Σ Exchangeable bases/CEC x 100.

RESULTS AND DISCUSSION

The results of the chemical properties of the soils in the Lugu main canal of Wurno Irrigation Project five years after rehabilitation at different soil depths is shown in Tables 1 - 3.

Table 1. Effect of irrigation on soil chemical properties at Lugu main canal of Wurno Irrigation Project five years after rehabilitation (0 - 15 cm)

Transects	**Sampling spots**	**pH**	**Total N g kg^{-1}**	**Avail. P mg kg^{-1}**	**CEC ←**	**Ca**	**Mg cmol kg^{-1}**	**K**	**Na→**
A	1	5.42	0.30	0.47	5.92	0.40	1.75	0.21	0.90
	2	7.74	0.30	0.60	3.85	0.40	2.15	0.26	0.52
B	1	6.80	0.30	0.39	4.72	0.70	1.45	0.24	1.27
	2	7.96	0.40	0.36	4.20	0.55	1.50	0.30	1.47
C	1	6.80	0.20	0.38	6.24	0.50	2.20	0.24	1.16
	2	7.29	0.30	0.40	4.45	0.85	1.00	0.16	1.15
D	1	7.08	0.20	0.37	2.32	0.70	0.55	0.14	0.52
	2	7.67	0.20	0.53	3.60	0.85	0.70	0.11	0.78
Mean		**7.09**	**0.28**	**0.44**	**4.41**	**0.62**	**1.41**	**0.21**	**0.97**

Table 2 Effect of irrigation on soil chemical properties at Lugu main canal of Wurno Irrigation Project five years after rehabilitation (15 - 30 cm)

Transects	**Sampling spots**	**pH**	**Total N g kg^{-1}**	**Avail. P mg kg^{-1}**	**CEC ←**	**Ca**	**Mg cmol kg^{-1}**	**K**	**Na →**	**BS %**
A	1	5.90	0.20	0.90	5.88	0.70	1.55	0.20	0.83	56
	2	7.83	0.30	0.36	3.65	0.55	1.90	0.12	0.59	87
B	1	6.17	0.20	0.37	4.82	1.05	1.45	0.21	0.31	63
	2	8.17	0.30	0.38	3.12	0.95	1.30	0.15	0.43	91
C	1	5.84	0.20	0.38	5.20	0.95	1.35	0.15	0.15	50
	2	6.75	0.20	0.36	5.31	1.70	0.95	0.15	0.50	62
D	1	7.28	0.10	0.45	3.21	1.15	0.16	0.12	0.31	54
	2	7.21	0.20	0.49	3.56	0.90	0.65	0.11	0.71	67
Mean		**6.89**	**0.21**	**0.46**	**4.34**	**0.99**	**1.28**	**0.15**	**0.48**	**66**

Table 3 Effect of irrigation on soil chemical properties at Lugu main canal of Wurno Irrigation Project five years after rehabilitation (30 - 45 cm)

Transects	Sampling spots	pH	Total N g kg^{-1}	Avail. P mg kg^{-1}	CEC ←	Ca	Mg cmol kg^{-1}	K	Na →	BS%
A	1	5.74	0.20	0.51	5.24	0.65	1.65	0.16	0.71	60
	2	7.63	0.20	0.42	2.68	0.50	1.15	0.16	0.45	84
B	1	5.97	0.20	0.36	5.06	0.90	1.05	0.13	0.38	47
	2	7.78	0.20	0.42	2.56	1.10	0.90	0.04	0.24	89
C	1	6.28	0.20	0.46	6.36	0.80	1.35	0.12	1.12	54
	2	6.97	0.20	0.42	2.40	0.95	1.00	0.05	0.17	90
D	1	7.42	0.10	0.45	4.00	0.85	1.80	0.02	0.17	71
	2	7.16	0.20	0.58	3.68	0.80	1.45	0.07	0.48	76
Mean		**6.87**	**0.19**	**0.45**	**3.99**	**0.82**	**1.2**	**0.09**	**0.47**	**71**

The soil pH values were moderately acidic to slightly alkaline and ranged between 5.42 and 7.96 with a mean of 7.90, 5.84 and 8.17 with a mean of 6.92 and between 5.74 and 7.78 with a mean of 6.87 at the 0 - 15, 15 - 30 and 30 - 45 cm depths of the soil respectively. This indicates a slight decrease in pH with depth which could be attributed to continous accumulation of salts due to poor soil management, fertilization and poor quality irrigation water, whose effect is more pronounced at the surface. Similar pH values were reported by Ibrahim and Dikko (1998), Graham and Singh (1997). The optimum pH for best performance of most tropical crops was reported to be 6 - 7 when most essential nutrients are available at adequate amounts (Brady and Weil, 1999; Olaitan and Lombin, 1984). The total N and CEC were very low at all soil depths and slightly decreased with depth. Average values of 0.29 g kg^{-1} and 4.41 cmol kg^{-1} at 0 - 15 cm depth (Table 1) 0.21 g kg^{-1} and 4.34 cmol kg^{-1} at the 15 - 30 cm depth (Table 2) and 0.19 g kg^{-1} and 3.41 cmol kg^{-1} at the 30 - 45 depth (Table 3) were obtained. This may be due to lack of return of crop residues common with the farmers practice in the study area, also the total N and CEC are directly linked to 1:1 clay mineral inherent in the soils, being sandy (Jones and Wild, 1975; Agbenin and Goladi, 1997). The results obtained agrees with reports of Agboola (1990) that tropical soils are intrinsically low in N. The CEC values were also similar to those reported by Graham and Singh (1997). In addition, the findings confirm the fact that total N and CEC decrease with soil depth (Brady and Weil, 1999). The total N values observed, an average of 0.29, 0.21 and 0.19 g kg^{-1} for the 0 - 15, 15 - 30 and 30 - 45 cm depths respectively, were much lower than those reported by Graham and Singh (1997) who reported values of total N as high as 0.40 - 0.6 g kg^{-1} at the surface (0 - 15 cm) soils. This decrease in N could be linked to continous cultivation of the soils for up to five years without proper soil management, having been managed by local farmers with little or no assistance from extension workers, which could have led to the observed decline, reported to be more rapid at the first year and gradually continous with time (Olaitan and Lombin, 1984). Nitrogen is also easily loss through various processes such as leaching, crop removal, denitrification and

volatilization, especially at high tempretures as obtainable in the study area. Available P was also very low, however, it did not follow the same trend as the total N and CEC, but rather not consistent with a slight increase with depth. The slight increase in available P with depth could be explained by the slight decrease in pH from an average of 7.09 at the surface to 6.92 and 6.87 at the 15 - 30 and 30 - 45 cm depths respectively, at which P compounds are more soluble and therefore, higher available P were obtained. Relatively high levels of exchangeable bases were observed with average values of 0.62, 1.42, 0.20 and 0.97 cmol kg^{-1}at 0-15 cm, 0.99, 1.16, 0.15 and 0.48 cmol kg^{-1} at 15 - 30 cm and 0.82, 1.30, 0.09 and 0.47 at 30 - 45 cm depths for Ca, Mg, K and Na respectively (Tables 1- 3), with Mg being the dominant cation in the exchange complex of the soils similar to what was previously observed in the Sokoto - Rima river basin at Dundaye District, Sokoto state (Singh *et al.*, 1996; Singh, 1997) and in fadama soils of Jos, Plateau state (Mustapha and Nnalee, 2007). The results of the exchangeable bases supports the soil pH values obtained and explains the high average base sturation values obtained; 75, 66 and 71% for the three respective depths.

Conclusion: The soils at the Lugu main canal of Wurno Irrigation Project are low in fertility. The pH was neutral at the surface and slightly decreased with depth, attributed to higher concentration of salts at the surface. The CEC, available P and total N were very low at all depths, the CEC total N were higher at the surface and decreased with depth. Ca and K were very low at all depths, Mg was moderate but Na was high at the soil surface and moderate at the lower depths. The base saturation was moderate throughout the soil depths. The low fertility level of the soil could be improved by adopting proper management practices such as application of manure and inorganic fertilizers as well as using adequate quality irrigation water.

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