PRELIMINARY ASSESSMENT OF EXPERIMENTAL PLOTS FOR DRIP IRRIGATION SET UP

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ABSTRACT

With a view to knowing the suitability of selected experimental plots in Makurdi for drip irrigation set up, physicochemical and hydraulic parameters of the soil from the plot were determined. Samples were collected at depths 0-15cm and 16 – 30 cm from five randomly chosen points on three plots each of 7m by 7m. The collected samples were subjected to laboratory analysis. Parameters determined were particle size, pH, organic carbon, organic matter, nitrogen,phosphorus, SAR, hydraulic conductivity, moisture content and total porosity. Results showed that the hydraulic parameters of the soil from the plots make them suitable for drip irrigation though plot two has better hydraulic properties and is expected to have more efficiency under drip irrigation. Inter- elemental correlation revealed some negative and positive correlation among the parameters. For instance, hydraulic conductivity has strong negative correlation with organic matter and bulk density. These are attributed to high clay content of organic matter which tends to block soil pores and reduce the porosity and also closeness of the particle which may inform high bulk density and therefore low porosity. It is recommended that salinity and sodicity of the plots be taken into consideration if repeated drip irrigation will be carried out on the plots.

Keywords: *drip irrigation, hydraulic parameters, coefficient of uniformity, wetting front*

INTRODUCTION

Soil quality has been of increasing concern in recent years. It is usually considered to have three main components: physical quality, chemical quality, and biological quality. Of course, these are not independent because, for example, the biological status of soil depends very strongly on the prevailing physical and chemical conditions (Dexter 2004). However, there is little doubt that an improved measure of soil physical quality could contribute greatly to the overall assessment of soil quality. Soil property is usually considered to have three main aspects: physical, chemical, and biological. All are considered to be important for the assessment of the extent of land degradation or amelioration, and for identifying management practices and to choose the best type of irrigation. Physical properties are however important because they have big effects on chemical and biological process in the soil, and, therefore, it play a central role in studies of soil response to irrigation types. Soil physical quality manifests in various ways, poor physical quality poor water infiltration, run-off of water from the surface, hard-setting, poor aeration, poor rootability, and poor workability (Hu et al., 2009). Soil physical parameter can be considered as an index of soil which control soil compaction, soil organic matter content, which in turn control soil water infiltrability and wetting.

Soil organic matter is considered to be important while describing irrigation methods because it sustains many key soil functions by providing the energy, substrates, and biological diversity to support biological activity, facilitating water infiltration, providing adequate habitat space for soil organisms ensures adequate oxygen supply to roots and soil organisms; and thus preventing soil erosion (Franzluebbers, 2002). Infiltration is an important soil feature that controls leaching, runoff,and crop water availability. Soil hydraulic conductivity (K) and the pore size distribution parameterare important parameters for understanding some aspects of unsaturated soil water flow (Lado and Hur, 2009). They influence infiltration and runoff and the transport of nutrients in soils.

Arid and semiarid regions are characterized by evapo-transpiration that exceeds precipitation during most of the year (Abah, 2012). Therefore, agriculture in these regions relies on supplementary irrigation to enable productive crop growth. At the same time, one of the main environmental problems in these regions is a shortage of freshwater, which is expected to become more severe in the future because of the growing pressure on water resources, as well as climate change (Allaire-Leung, 2001). Therefore, in these regions, one of the challenges facing agriculture, which commonly uses large amounts of water, is to find new sources of water for irrigation.

Drip irrigation has become quite common due to its great potential to use lesswater and to localize chemical applications, thereby enhancing the efficiency of irrigation and fertilization and reducing the risk of pollution. However, these objectives can only be achieved if the emitter spacing, tape lateral spacing, diameter and length of the lateral system are well managed for any given set of soil, crop and climatic conditions. In contrast to surface or sprinkler systems, the frequency of thewater application under drip irrigation is high. This means the infiltration period is a very important stage of the irrigation cycle. A good knowledge of the soil hydraulic and other propertiesis therefore needed to achieve high drip irrigation efficiency. Water extending laterally and vertically away from an emitter is an important criterion for the design of drip systems to ensure efficient irrigation and to avoid the movement of water beyond the root zone (Mubarak et al.,2009).

Having the knowledge of soil hydraulic properties and understanding their temporal variability during the irrigated cropping season are also required to mitigate agro-environmental risks. Soil hydraulic properties are affected by soil texture, bulk density, soil structure, and organic carbon content, many of which are strongly influenced by land use and management. All these have remarkable effect on achieving high drip irrigation efficiency, it is therefore important to determine these properties before setting up drip irrigation project on any farm. The objective of this paper is thus to determine some physical, chemical and hydraulic properties of an experimental plot earmarked for drip irrigation set up.

MATERIALSAND METHODS

This study was carried out in University of Agriculture, Makurdi, Nigeria. The location lies between latitudes 7° 45' and 7°52' N of the equator and longitude 8° 35' and 8° 41' E of Greenwich Meridian. The primary occupation of the people is Agriculture hence the slogan "food basket of the nation" some of the crops grown are potatoes, cassava, soyabeans, guinea corn, groundnut and yam. Makurdi town has a tropical sub humid climate wet and dry type, with double maxima (Ayoade, 1983). The raining season lasts from April to October, with five months of dry season (November to March). Annual ranfall in Makurdi town is consistently high, with an average annual total of approximately 1173mm (Abah, 2012). Temperature in Makurdi is generally high throughout the year, with February and March as the hottest months, it varies from 22.5°C to a maximum of 40°C daily. Geology of Makurdi is basically composed of sedimentary rocks, and sandstones the dominant rock type. The soils in the area reflect the geology. However, it is important to mention that human activities like farming, construction and reclamation have affected the nature of the soils.

Sample Collection and Analysis

Three experimental plots each of 7m by 7m were marked out for drip irrigation set up and therefore five samples were randomly collected from each of the plots using an essential tool for gardeners called stainless steel blade of model 9APH2.The samples were collected in the three different soil types at 0-15cm and 16 – 30 cm depth at five different locations on the same plot.The samples were air dried and sieved through a 2mm diameter sieve and is put in polythene bags, then labelled to be taken for laboratory analysis.Theanalyses were carried out at the Nasarawa State University Agronomy research laboratory. Some standard laboratory procedures used and the parameters that were analysed are as shown in Table 1.

Table 1: Methods of Soil Samples Analysis

S/N	PARAMETER	STANDARD METHODS
1	Bulk density	Core (FAO 2002a).
2	Porosity	Core (FAO, 2002a).
3	Organic matter	FAO (2002b).
4	Field capacity	Egharevba, (2009)
5	Hydraulic conductivity	Falling head permeability
6	Moisture content	Oven dry method
7	SAR	Spectrophotometer and flame photometer
8	Phosphate	Calorimetrically with metrospectrometer.
9	P^H	Glass electrode
10	Particle size distribution	Bouyoucos hydrometer
11	EC	Jenway digital conductivity meter model 4520

AOAC 2005 method was used to determine the chemical properties of soil samples after adopting standard digestion method.

RESULTS AND DISCUSSIONS

The results of particle size distribution of the soil samples and other parameters analysed are as shown in tables 2 and 3.

Table 2: Particles Size Distribution of the Soil Samples.

Site	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural Class
1	0 - 15	60.8	5.4	33.4	Clay Loam
	16 - 30	60.6	3.4	34.0	
2	0 - 15	77.3	3.4	19.4	Sandy loam
	16 - 30	77.0	3.6	19.4	
3	0 - 15	74.2	5.4	20.4	Sandy clay loam
	16 - 30	74.2	5.4	20.4	

The three plots are considered to be suitable for Drip irrigation, considering their sand and silt components in Table 2. Sand and silt composition of all the plots exceeded 60% and 2.5% respectively. Mubarak *et al,* (2009) suggested that soil plot having these compositions can be subjected to drip irrigation since it will give good wetting front. From table 2, there are slight differences between values got at the two depths considered. For instance, pH, organic carbon, organic matter, Sodium Absorption Ratio (SAR) and field capacity have no significant difference in their properties both for the five locations and between the two depths considered. This may point to the fact that if sample plot A is suitable for any particular irrigation type with respect to any of these properties, other two sample plots will also be suitable for such irrigation techniques. However, parameters like phosphorus, nitrogen, electrical conductivity, hydraulic conductivity (HC) and moisture content exhibited some significant difference both for depths and for sample plots. Though SAR and HC are considered to be important while studying suitability of any soil for irrigation (Hu *et al.,* 2009), the change and variation in this particular scenario do not make the plots unsuitable.
Figures 1 and 2 presents variations of some of the parameters, Hydraulic Conductivity (HC) is higher for site 2 than for other sites and this shows that plot two will exhibit more wetting front when water is released from emitters during drip irrigation. Other parameter considered important in this project is total porosity which in turn will determine the effective porosity of the soil (Lado and Hur 2009). Sample from plot 2 also have higher porosity and FC and therefore will be able to withstand the release of more water either by higher irrigation frequency or bigger emitter size when the conceived drip irrigation is set up.

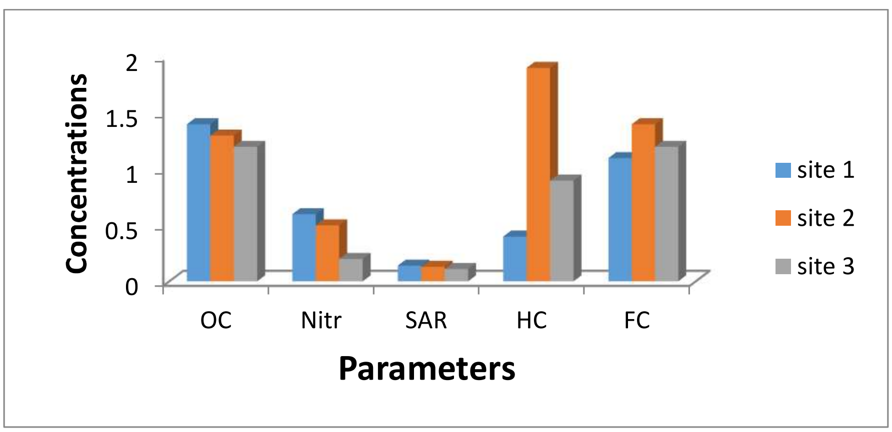

Figure 1: Variations in soil physicochemical and hydraulic parameters.

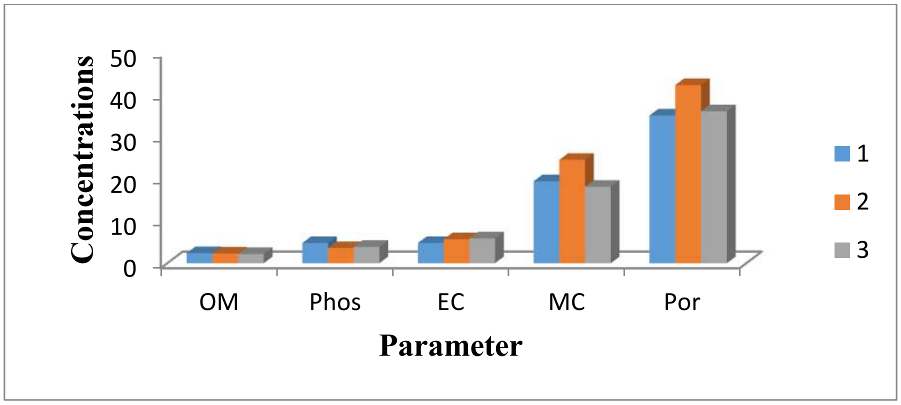

Figure 2: Variations in Soil Physicochemical and Hydraulic Parameters.

Table 2: Physicochemical and Hydraulic properties of the soil samples

Site	Depth (cm)	pH	OC (%)	OM (%)	N (mg/g)	P (mg/g)	EC (μs/cm	SAR (Meq/100g)	FC (%)	HC (r
1	0 - 15	$6.3^{a} \pm 0.4$	$1.4^{c} \pm 0.5$	$2.4^{b} \pm 0.1$	$0.6^{e} \pm 0.0$	$4.8^{g} \pm 1.0$	$4.8^{h} \pm 0.7$	$0.14^{r} \pm 0.3$	$1.1^{t} \pm 0.2$	0.35^{v}±
	16 -30	$5.9^{a} \pm 0.4$	$1.4^{c} \pm 0.6$	$2.4^{b} \pm 0.4$	$0.3^{d} \pm 0.1$	$4.4^{g} \pm 1.1$	$4.5^{m} \pm 0.3$	$0.18^{r} \pm 0.0$	$0.9^{t} \pm 0.3$	0.33^{v}
2	0 - 15	$6.4^{a} \pm 0.4$	$1.3^{c} \pm 0.5$	$2.2^{b} \pm 0.0$	$0.5^{e} \pm 0.2$	$4.8^{g} \pm 0.3$	$5.7^{m} \pm 0.4$	$0.13^{r} \pm 0.0$	$1.4^{t} \pm 0.2$	1.86^{x}
	16 -30	$6.5^{a} \pm 0.6$	$1.3^{c} \pm 0.2$	$2.3^{b} \pm 0.5$	$0.5^{e} \pm 0.2$	$3.6^{f} \pm 0.1$	$4.7^{n} \pm 0.2$	$0.07^{r} \pm 0.0$	$1.2^{t} \pm 0.3$	1.98^{x}
3	0 - 15	$6.5^{a} \pm 0.3$	$1.3^{c} \pm 0.2$	$2.2^{b} \pm 0.1$	$0.3^{d} \pm 0.0$	$3.9^{f} \pm 0.2$	$5.9^{n} \pm 0.3$	$0.07^{r} \pm 0.0$	$1.2^{t} \pm 0.0$	0.78^{v}
	16 -30	$6.4^{a} \pm 0.2$	$1.2^{c} \pm 0.2$	$2.1^{b} \pm 0.2$	$0.2^{d} \pm 0.0$	$3.6^{f} \pm 0.2$	$5.9^{n} \pm 0.3$	$0.10^{r} \pm 0.0$	$1.1^{t} \pm 0.1$	0.92^{v}

OC – Organic Carbon, OM – Organic matter, N – Nitrogen, P – Phosphorus, EC – Electrical conductivity, SAR – Sodium Absorption HC – Hydraulic Conductivity, MC- Moisture Content. Results are mean of three replicates ± SEM; Mean with similar superscripts alor significant difference (p< 0-.5) while mean with different superscripts along same column have significant difference.

Table 3: Correlation Matrix for Soil Parameters

	pH	*OC*	*OM*	*Nitr*	*Pho*	*Pot*	*Cal*	*Sod*	*Mag*	*EC*	*SAR*	*FC*	*HC*	*MC*	*TP*	*BD*
pH	1															
OC	-0.14	1														
OM	-0.12	**0.99***	1													
Nitr	-0.08	0.06	0.11	1												
Pho	0.19	**0.53***	0.52	0.13	1											
Pot	-0.08	-0.17	-0.16	-0.31	-0.07	1										
Cal	0.30*	-0.60	**-0.57***	-0.01	**-0.49**	0.22	1									
Sod	-0.18	0.30	0.27	-0.27	0.35	0.16	-0.20	1								
Mag	-0.13	-0.41	-0.39	0.57*	-0.21	-0.28	0.37*	-0.30	1							
EC	0.21	-0.24	-0.22	0.19	0.03	0.05	**0.64***	0.14	**0.46***	1						
SAR	-0.18	0.35	0.33	-0.21	0.37	0.14	-0.29	**0.92***	-0.25	0.10	1					
FC	-0.43	-0.17	-0.18	0.30	-0.18	-0.34	-0.04	-0.10	**0.64***	0.19	-0.13	1				
HC	-0.17	-0.38	**-0.40***	0.29	-0.06	-0.26	0.08	0.13	**0.66***	**0.40***	0.08	0.72	1			
MC	0.02	0.08	0.07	0.23	**0.54***	-0.26	-0.27	0.37	0.29	0.28	0.38*	0.39	0.67*	1		
TP	-0.19	-0.29	-0.30	0.02	0.00	-0.24	-0.16	0.34	0.28	0.06	0.30	0.43*	0.77*	**0.58***	1	
BD	0.18	0.31	0.32	-0.02	0.02	0.25	0.14	-0.32	-0.30	-0.06	-0.30	**-0.43***	**-0.78***	**-0.58***	-1.00	1

**correlation is significant ($p < 0.05$) at 2- tailed*

Table 3 presents inter-elemental correlation among the parameters tested. Both negative and positive correlation existed. For instance pH exhibit negative correlation with other parameters except phosphorus, bulk density and moisture content though the correlation are not so significant. Correlation between hydraulic conductivity and percentage organic matter is a strong significant one and this may be interpreted that increased organic matter in a soil sample may lead to reduced HC; reason Franzluebbers (2002) attributed to this was higher clay content of organic matters which can seal up the pores in the soil samples. Similarly, bulk density and HC also exhibited strong significant correlation which may also be as a result of aforementioned points. And also that high bulk density can be as a result of well parked soil particles, reduced soil pores and therefore less HC.

CONCLUSION

From this project, it can be concluded that

(i).The three experimental plots used for this work are suitable for drip irrigation set up having considered values of their physicochemical and hydraulic properties.
(ii) Samples from plot 2 exhibited better hydraulic properties and will therefore conduct water faster, hence, more water can be released and the plot can also be planted with crop with more reference evapo-transpiration (ET_e)
(iii). There is no significant difference between the parameters of samples taken from depth 0-15 cm and from samples taken from depth 16 – 30cm. Therefore crop that can tap water or nutrient up to 30 cm depth can be established on the plot.
It is however recommended that SAR, percentage magnesium and sodium of the plots should be considered if repeated drip irrigation will be carried out on these plots as this may lead to salt build up and sodicity of the experimental plots.

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