Determination of Soil Hydro-Physical Properties of Some Farmlands in Wukari Local Government Area, Taraba State for Sustainable Crop Production

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Abstract
The research work saddled to characterize soil hydro-physical properties of some selected farmlands for sustainable crop production in Wukari LGA, Taraba State. Four locations Akwana ,Rafin Goza, Kente and Gindin Dorowa were selected namely where at each site fifteen (15) soil auger points were sampled using random sampling method at two (2) different soil depths of 0-30 cm and 30-60 cm respectively. At each location thirty (30) soil samples were collected thereby amounting to a total of 120 soil samples for the research work. Soil samples collected were transferred in to the well labeled polythene bags for further physical and hydraulic analysis in the laboratory. The data obtained were analyzed using descriptive statistics. The results of the physical properties revealed that the soil was characterized with loamy sand and sandy loam textures having moderate bulk density (1.64 g/cm^3) with very low to moderate TP (33.91-42.11 %), very low to moderate OM (1.28-1.76 %) and slightly acidic soil pH (6.56) respectively. In addition, the hydraulic properties shows that WHC, FC and PWP were moderate in all the farm locations except at Gindin Dorawa where FC and PWP were low (18.65 % and 7.45 %) meanwhile PAW was high except at Gindin Dorawa found to be moderate (11.18-11.20 %) accordingly. It is therefore, recommends that farmers in the areas especially Gindin Dorawa should adopt the use of soil and water conservation techniques to improve the moisture status of the soil and also effective use of organic manures for effective crop growth and development.

Keywords: *Crop, Farmlands, Hydro-Physical, Soil, Wukari*

INTRODUCTION

Soil, Water and food are fundamental to human life. This is true not only for each separately but also when considering the interrelationships exist among them. Soil quality and Water availability are the prerequisite factors for agriculture and thus for food security for the growing population. To meet the demands of a growing population and per capital consumption, the Food and Agricultural Organization (FAO) (2009) estimates an increase of 70 % in necessary agricultural production by 2050. This increase can be gained by agricultural expansion and/or intensification, both of which affect the hydrologic cycle in different ways, from a local to global scale (Rockström *et al.*, 2014).

Temporal changes of soil physical and hydraulic properties have been the subject of much research to quantify the effects of different management systems within growing seasons (Shahid, 2012). Thus, the resulting variability in soil physical and hydraulic properties is dynamic in space and time. The management of water requires a reliable estimate of soil physical and hydraulic properties for effective predictions and the control of water dynamic in a field. (Oshunsanya, 2013).

Soil is one of the most important natural resources providing life to all kinds of living beings such as plants and animals. Therefore, soil physical properties: soil texture, structure, porespace and soil hydraulic properties: bulk density, available water, permanent wilting point, field capacity and water retention capacity and saturated hydraulic conductivity are essential to be studied. These properties affect soil productivity and the environment. This is because soil properties such as bulk density, texture, porosity and structure are known to affect soil moisture and hydraulic conductivity (Wagner *et al.*, 2001). Still there is usually a connection between these factors since different crops tend to require different soil conditions (Critchley *et al.*, 1991; FAO, 2013).Thus, upon conversion of natural lands to cultivated fields, water retention capacity is strongly influenced (Zhou *et al.* 2008).Similarly**,** Conversion of natural ecosystems to agricultural land can increase runoff and decrease evapotranspiration (Roost*et al*., 2008) as well as change the temporal distribution of these processes (Kashaigili, 2008). The consequences are erosion, sediment and nutrient loss, changes in atmospheric moisture recycling (Rockström *et al*., 2014) and alteration of groundwater recharge (Le Maitre *et al*., 1999). Generally, both the physical and Hydraulic parameters are vitalsoil properties for precision agriculture and essential macronutrient to increase soilfertility required for plant growth and development that is extremely associatedwith soil physical, chemical, and biological processes (Jyoti, *et al.*,2018).

Cultivation practices and land use change affects the physical and hydraulic soil properties causing damage on soil aeration, and soil water dynamics (Emily and Marcos, 2019).
Due to the acute and apparent effect of climate change particularly the reoccurrence of drought spells most farmlands in Wukari area are been affected with low water retention capacity, poor movement and high run-off which are related to the poor soil physical and hydraulic properties. The glaring effect of this menace was apparent on the poor growth and low yield of crops, high cost of management and unprofitable farming activities.

MATERIALS AND METHOD

Study Area

Wukari Local Government is located in the southern part of Taraba State (Figure 1). It is about two hundred kilometers away from Jalingo the state capital. The Local Government is bounded by Plateau State in the North, Benue State in the South and Nasarawa State to the west; it is in the guinea savannah of the middle belt region of Nigeria. Geographically it is located between longitude 9º 08′ and 10º 23′ East (392487.77E, 81642288.39N) of the Greenwich Meridian and Latitude 7º 35′ and 8º 15′ North (500000.00E, 90539916.70N) of the Equator, with an elevation of 200m above sea level. The study area has a land mass of about 4,308km^2 with a population of 241,546 (National Population Commission, NPC 2006) which makes it the second largest and most populated local government in the state. The dry season is characterized by the dry dust laden with harmattan winds coming across the Sahara desert and occurring between November and February of every year. The wet season sets in by April and lasts around October (Iloeje, 1981).

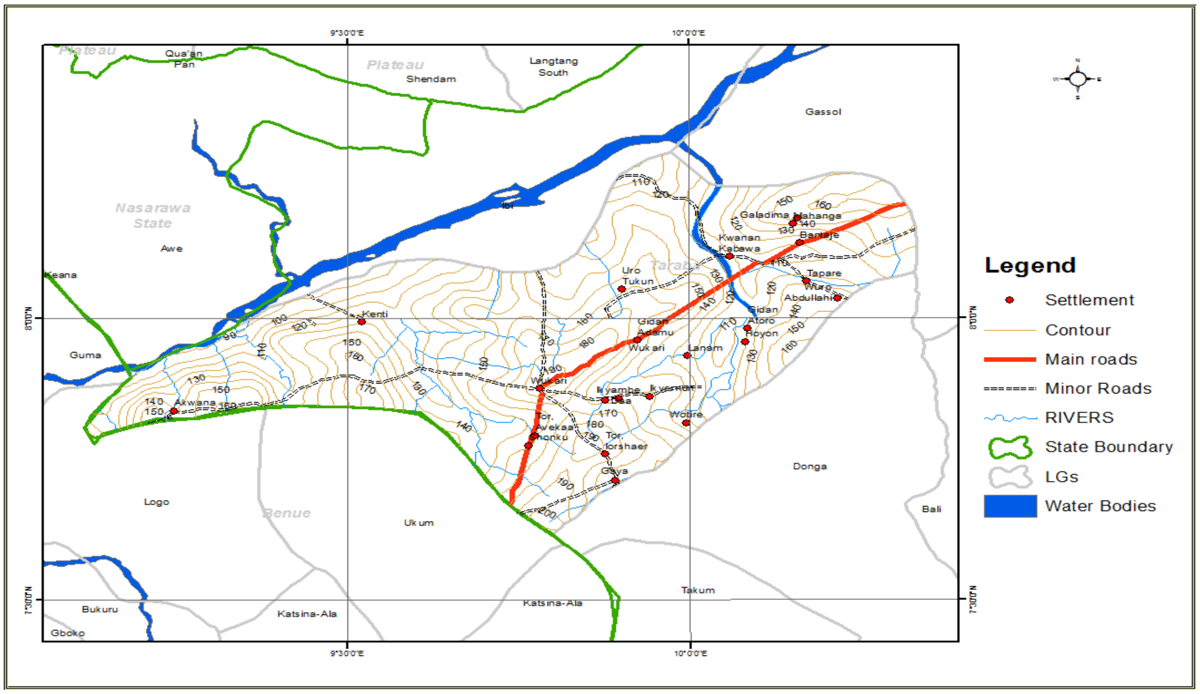

Figure 1. Map of Wukari Local Government Area

Soil Sampling Methods and Techniques

Four (4) arable lands were selected in the study area namely Akwana , Rafin Goza, Kente and Gindin Dorowa farmlands. At each site fifteen (15) auger points were sampled using random sampling method at two (2) different depths of 0-15 cm and 15-30 cm depths of soils. At each location thirty (30) soil samples were collected amounting to a total of one hundred and twenty (120) soil samples for the research work.

Laboratory Work, Procedures and Analysis

The collected soils samples were air-dried, crushed using a wooden motar and pestle, and then sieved through a 2 mm mesh. The sieved sample were stored in polythene bags for laboratory analysis of the selected physical and hydraulic properties as portrayed in table 1 and 2 below;

Table 1. Determined soil physical properties of the study area

S/n	Soil physical properties	Methods/ procedures
1.	Soil Texture (Particle Size Distribution)	Bouyocous Hydrometer Method (Bouyoucos, 1962)
2	Soil Available Porosity	Soil core sampler, (Dumitru *et al.*,2009)
3	Soil bulk density	(Dumitru et al., 2009):
5	**Soil pH**	1:2 (soil: water) 0.01M (CaCl). (Page *et al.*, 1982).

6	Soil EC	1:2 (soil: water) 0.01M (CaCl). (Page *et al.*, 1982).
8.	Soil Organic Matter	(Nelson and Sommers, 1982) calculated fraction

Table 2. Determined of soil hydraulic properties of the study area

S/n	Soil hydraulic properties	Methods/ procedures
1	**Water holding capacity**	Soil core samples Zhang *et al.*, (1999) and Haiqiang, *et al*.,(2019)
2	**Field capacity**	Soil core samples Zhang *et al.*, (1999) and Haiqiang, *et al*.,(2019)
3	**Permanent wilting point**	Uttar Pradesh Public Service Commission, UPPSC-AE, 2004).
4	**Plant available water**	Dumitru *et al*.,(2011)

STATISTICAL DATA ANALYSIS

To achieve the stated objectives of the study, the obtained data were analyzed using descriptive statistics where max, min, mean and standard deviation were recorded.

RESULTS AND DISCUSSION
Soil Physical Properties of the Studied Farmlands
Gindin Dorawa Farmlands

The soil physical properties of Gindin Dorawa farmlands at 0-15 cm depth were presented on table 1. The results shows that sand, silt and clay contents were recorded with the corresponding values of 72.59 %, 15.17 % and 12.22 % described as sandy loam textured soil. The bulk density (Bd) and particle density (Pd) and total porosity (TP) were found to be moderate with a mean values of 1.62 g/cm^3 and 2.93 g/cm^3 and 44.63 % . The organic matter (OM) content was very low (1.56 %) with slightly acidic soil pH of 6.46 and 0.13 of Electrical conductivity (EC). At 15-30 cm depth, The results revealed that sandy loam texture dominated the subsurface with values of 73.43 %. 16.47 % and 19.08 % of sand, silt and clay contents with moderate Bd (1.75 g/cm$^{3)}$, Pd (3.08 g/cm^3) and TP (42.81 %) .The OM content of the soil was very low with a mean value of 1.28 % and slightly acidic soil pH (6.69) and EC of 0.14.

It could be noted that sand and silt contents increases at the subsurface while clay decreases. In addition, TP decreased at the subsurface which could linked to increase in Bd. Azooz and Arshad, (1996) explained that tilled soils under continuous cultivation tend to become less porous with time in the plow layer. However, some soils under no-tillage management tend to become more porous with time (Voorhees and Lindstrom 1984). Also OM content decreased at the subsurface which might require addition of organic material. To achieve optimum crop growth and maintaining good soil quality in the area farmers need to improve the OM level of the soil through addition of organic materials such as manures, crop residues incorporation and the use modern organic fertilizers. In general, increasing SOM levels, reducing the extent of soil disturbance, and minimizing compaction and erosion will increase soil porosity and improve structure (Kêsik, *et al.,* 2010: Jalal and Ahmad 2014).

Table 1. Soil physical properties of Gindin Dorawa farmlands at the depth of 0-30 cm

Depth	Statist,	Bd (gcm^{-3})	Pd (gcm^{-3})	TP (%)	Sand (%)	Silt (%)	Clay (%)	OM (%)	pH (1:2)	EC (dSm^{-1})
0-15 cm	MAX	2.11	3.78	58.36	76.23	18.22	17.54	2.23	7.34	0.17
	MIN	1.12	2.39	32.74	70.11	12.33	6.32	1.14	5.68	0.11
	MEAN	1.623	2.93	44.63	72.59	15.17	12.22	1.56	6.46	0.13
	SD	0.28	0.25	7.27	1.69	1.84	2.90	0.34	0.44	0.01
	SKEW	-0.32	1.19	0.38	0.42	0.02	-0.00	0.69	0.46	0.38
15-30 cm	MAX	2.23	3.97	53.47	78.90	18.78	13.34	1.88	7.45	0.40
	MIN	1.23	2.27	34.60	70.11	14.32	6.78	0.88	5.34	0.11
	MEAN	1.75	3.08	42.81	73.43	16.47	10.08	1.28	6.69	0.14
	SD	0.24	0.42	5.33	2.24	1.23	1.77	0.29	0.61	0.06
	SKEW	-0.60	0.28	0.59	0.73	-0.26	0.180	0.57	-1.05	3.70

Keys: **Bd**: Bulk Density, **Pd**; Particle Density, **TP**: Total porosity, **OM**: Organic matter, **pH**: Percent Hydrogen, **EC**: Electrical Conductivity

AKWANA FARMLANDS

The soil physical properties of Akwana farmlands at 0-15 cm depth were presented on table 2. It was revealed that the soil texture was dominated with loamy sand having 83.87 %, 6.92 % and 9.2 % of sand, silt and clay contents characterized with moderate Bd (1.73 g/cm^3), Pd (2.65 g/cm^3) and very low TP (33.91 %). The soil is slightly acidic (6.52) with low OM (1.78 %) content respectively. At the subsurface (15-30 cm) horizon, the sand content decreases to 72.76 % while both the silt and clay contents increases with a mean values of 14.75 % and 12.48 % characterized as sandy loam textural class as presented on Table 2. The Bd, Pd and TP were found to have increases at the subsurface level with mean values of 1.95 g/cm^3 , 3.04 g/cm^3 , and 36. 11 % correspondingly.

However, despite the increase of these parameters the TP was very low to favour effective root growth and development of crops which might need conventional tillage practices to improve the pore spaces of the soil. In contrast, OM content decreases at the subsurface to 1.39 % described as low to effectively support crop growth. This could be the fact that there is now receiving intensive cultivation than any other arable lands in the study area which led to reduction of OM content of the soil. It is therefore suggested that peasant farmers in the area should improve the moderate OM level before reaching below the threshold level. Moraru *etal.*,(2020) was early revealed that intensive land cultivation and diminishing of the amount of organic matter in upper soil horizons by complete release of vegetation after harvesting are the precursors of erosion phenomenon installation and intensification

Table 2. Soil physical properties of Akwana farmlands at the depth of 0-30 cm

Depth	Statist,	Bd (gcm^{-3})	Pd (gcm^{-3})	TP (%)	Sand (%)	Silt (%)	Clay (%)	OM (%)	pH (1:2)	EC (dSm^{-1})
0-15 cm	MAX	2.12	3.48	45.30	87.21	11.23	14.27	2.50	7.52	0.67
	MIN	1.23	2.11	23.26	80.20	3.70	4.12	1.23	5.12	0.11
	MEAN	1.73	2.65	33.91	83.87	6.92	9.20	1.78	6.52	0.26
	SD	0.24	0.43	6.82	2.20	2.15	3.12	0.40	0.73	0.12
	SKEW	-1.97	0.81	0.03	-0.16	0.59	-0.16	0.43	-0.51	2.15
15-30 cm	MAX	2.56	3.78	49.67	77.34	18.89	17.55	2.33	7.23	0.43
	MIN	1.23	2.11	23.67	69.99	11.76	6.66	0.99	5.34	0.11
	MEAN	1.95	3.04	36.11	72.76	14.75	12.48	1.39	6.28	0.21
	SD	0.39	0.48	6.59	2.03	2.62	3.08	0.38	0.51	0.08
	SKEW	-0.06	-0.44	-0.07	0.91	0.47	-0.31	1.32	-0.13	1.21

Key:, **Bd**: Bulk Density, **Pd**; Particle Density, **TP**: Total porosity, **OM**: Organic matter, **pH**: Percent Hydrogen, **EC**: Electrical Conductivity

RAFIN GOZA FARMLANDS

At Rafin Goza farmlands, loamy sand textured soil predominated at the surface (0-15 cm) having a corresponding mean values of 82.81 %, 8.60 % and 8.58 % of sand, silt and clay as shown on Table 3 . The Bd and Pd were found to be 1.67 g/cm^3 and 2.74 g/cm^3 considered as moderate with low TP (37.53 %). OM content was moderate (1.71 %) having slightly acidic soil (6.43) and 0.18 dS/m^3 of EC content respectively. The soil physical properties at subsurface (15-30 cm) depth presented on table 3 shows clear variation of sand, silt and clay contents compared with the surface layer with mean recorded values of 72.50 %, 15.40% and 12.09 % characterized as sandy loam texture having 1.62 g/cm^3 of Bd, 2.79 g/cm^3 and moderate TP 42.11 % . In addition, OM content was moderate (1.27 %) and slightly acidic soil condition of 6.49 and 0.12 dS/m of EC.

Textural variation was observed from loamy sand to sandy loam might be attributed to deposition of finer particles through illuviation process. According to Geetha and Naidu, (2013) explained in their findings that textural variation was ascribed to differences in composition of parent material, topography, *in-situ* weathering and translocation of clay by eluviation and age of soils. The TP also increased from low to moderate which might be Bd of the soil. This might be attributed to the influence of root penetration and concentration of shrubs coupled with low mechanical effects and crusting caused by raindrops. Thus, TP is directly related to the Bd. Since porosity is calculated from the relation between bulk density and particle density of soil, it is very much influenced by the soil bulk density as the particle density is not greatly altered by agricultural manipulations (Lal and Shukla, 2004). For any given soil, the higher the bulk densities, the more compacted the soil is and the lower the pore space (Anne *etal.*,2015) as also observed in this profile. Furthermore, OM decreases with an increasing depth which might be attributed to low or absence of vegetation at the subsurface. Thus, Liu *etal.*, (2017) and Liu, *etal.*, (2019) have suggested that larger above-ground and underground plant biomass in native vegetation land provided leaf litter and root exudates that can increase soil organic matter (SOM). Concomitantly, abundant SOM improved microbial activity because of required energy substances for microbial metabolism. Therefore, to realize proper growth and development of crops and maintaining soil quality, OM content of the soil must be improving to a sustainable range which can be achieved through integrated organic management strategies, the use of available local sources and plant biomass incorporation in to the soil should be adopted by the farmers.

Table 3. Soil Physical properties of Rafin Goza farmlands at various depth

Depth	Statist,	Bd (gcm^{-3})	Pd (gcm^{-3})	TP (%)	Sand (%)	Silt (%)	Clay (%)	OM (%)	pH (1:2)	EC (dSm^{-1})
0-15 cm	MAX	2.56	3.78	61.68	87.23	11.23	13.54	2.34	7.21	0.56
	MIN	1.23	2.11	20.24	79.11	4.56	1.54	1.11	5.56	0.10
	MEAN	1.67	2.74	37.53	82.81	8.60	8.58	1.71	6.43	0.18
	SD	0.38	0.59	11.73	2.35	1.92	3.40	0.35	0.53	0.13
	SKEW	0.76	0.60	-0.07	0.58	-0.67	-0.49	-0.24	0.12	2.06
15-30 cm	MAX	2.11	3.45	60.77	77.23	18.87	16.44	1.67	7.23	0.15
	MIN	1.22	2.11	16.11	70.34	12.33	6.80	0.98	5.60	0.11
	MEAN	1.64	2.79	42.11	72.50	15.40	12.09	1.27	6.49	0.12
	SD	0.29	0.40	11.05	1.62	2.05	2.58	0.16	0.44	0.01
	SKEW	0.08	-0.15	-0.56	1.60	-0.16	-0.31	0.24	-0.33	0.27

Key: **Bd**: Bulk Density, **Pd**; Particle Density, **TP**: Total porosity, **OM**: Organic matter, **pH**: Percent Hydrogen, **EC**: Electrical Conductivity

KENTE FARMLANDS

Result on soil physical properties at surface (0-15 cm) depth of Kente farm location were presented on table 4. It was found that loamy sand texture dominated the area with percent sand, silt and clay of 82.88 % , 7.76 % and 9.34 %. Both the Bd and Pd were moderate with mean values of 1.74 g/cm^3 and 2.92 g/cm^3 having low TP (39.55 %). The OM of the soil was moderate (1.76 %) having slightly acidic pH (6.56) and 0.15 dS/m respectively. At the subsurface horizon (15-30 cm) the texture of the soil varied to sandy loam having corresponding values of 73.24 % sand, 8.78 % silt and 17.96 % clay. The Bd, Pd and TP were moderate having mean values of 1.44 g/cm^3, 2.67 g/cm^3 and 45. 22 % correspondingly. The OM content was low (1.40 %) with pH of 6. 44 considered as slightly acidic and EC of 0.13 respectively.

The textural variation could be due to sedimentation process and illuviation of finer soil particles leading to decrease of coarser particles and increase of finer particles down the horizons. This result agreed with the finding of Geetha and Naidu, (2013). It is imperative to note that TP increases at the subsurface from low to moderate which could be linked to the decreased in both Bd and Pd as the depth increases. Plant growth will be facilitated easily due to the adequate porosity within the subsurface horizons through effective root growth and accessibility of water and nutrients in deeper layers. Alabi, (2011) noted that porosity is the most important physical property of porous medium, which is a measure of the ability of a material to transmit fluid through it. It could be observed that OM content decreases at subsurface horizon from moderate to low which could be attributed. To improve the OM content farmers in the area should adopt incorporation of organic materials in to the soil through the use of minimum tillage.

Table 4. Soil physical properties of Kente farmlands at various depth

Depth	Statist,	Bd (gcm^{-3})	Pd (gcm^{-3})	TP (%)	Sand (%)	Silt (%)	Clay (%)	OM (%)	pH (1:2)	EC (dSm^{-1})
0-15 cm	MAX	2.12	3.89	55.75	87.11	12.34	14.27	2.34	7.20	0.19
	MIN	1.23	2.11	26.06	79.88	4.33	1.79	1.23	5.67	0.11
	MEAN	1.74	2.92	39.55	82.88	7.76	9.34	1.76	6.56	0.15
	SD	0.25	0.53	7.35	2.27	2.43	3.50	0.31	0.47	0.02
	SKEW	-0.40	0.36	0.44	0.46	0.52	-0.61	-0.17	-0.51	-0.45
15-30 cm	MAX	1.89	3.71	55.75	76.34	12.11	24.32	1.89	7.22	0.17
	MIN	1.21	2.11	20.85	70.12	4.45	12.99	0.99	5.66	0.11
	MEAN	1.44	2.67	45.22	73.24	8.78	17.96	1.40	6.44	0.13
	SD	0.23	0.39	8.32	2.02	1.90	2.76	0.30	0.36	0.02
	SKEW	0.46	0.81	-1.49	0.23	-0.53	0.42	0.15	-0.11	0.59

Key: **Bd**: Bulk Density, **Pd**; Particle Density, **TP**: Total porosity, **OM**: Organic matter, **pH**: Percent Hydrogen, **EC**: Electrical Conductivity

Soil Hydraulic Properties of the Studied Farmlands
Gindin Dorawa Farmlands

The results on hydraulic soil properties of Gindin Dorawa farm location were portrayed on table 5. At surface horizon WCH (48.37 %) and PAW (11.18 %) were found to moderate. Meanwhile, FC and PWP were low with mean values of 18.65 % and 7.45 % respectively. Similar trends were identified at the subsurface horizon where the WHC and PAW (42. 05 % and 11.20 %) were moderate with low content of water at FC and PWP (18.67 % and 7.46 %). These results revealed poor moisture characteristics of the soils that will insufficiently support effective crop growth and development in the area. This could be connected to the sandy loam textured soils at the 0-15 cm depth coupledvery high aeration porosity (32.32 %). Moraru *et al.*, (2020) have highlighted that soils with coarse textures (sandy loam) have a reduced field water capacity while soils with fine textures (clay loam, clay) may store a larger amount of water. However, sandy loam soils are considered wet, but unable to provide plants with the water they need

Table 5. Soil Hydraulic properties of Gindin Dorawa farmlands at various depth

Depth	Statistics	WHC (%)	FC (%)	PWP (%)	PAW (%)
0-15 cm	MAX	59.88	26.12	10.44	15.67
	MIN	32.12	7.09	2.83	4.25
	MEAN	48.37	18.65	7.45	11.18
	SD	16.84	5.83	2.33	3.50
	SKEW	-0.65	-0.46	-0.46	-0.46
15-30 cm	MAX	55.32	24.56	9.82	14.74
	MIN	24.56	7.89	3.15	4.74
	MEAN	42.05	18.67	7.46	11.20
	SD	8.51	4.13	1.65	2.47
	SKEW	-0.93	-1.42	-1.42	-1.42

WHC: Water Holding Capacity, **FC**: Field Capacity, **PWP**: Permanent Water Holding, **PAW**: Plant Available Water

Akwana Farmlands

Results on hydraulic properties of Akwana farm location at surface level of 0-15 cm were presented on Table 6. It was revealed that the water holding capacity (WHC), field capacity (FC) and permanent wilting point (PWP) were generally moderate with the mean corresponding values of 53.43 %, 24.88 % and 9.95 %. Meanwhile, plant available water (PAW) was found to be high with 14.93 % mean value. This further explains suitability of crop production in the area. At subsurface horizon of 15-30 cm depth, the WHC and PWP were moderate while FC and PAW were high. These results shows increase in water content at FC and PAW with increase in soil depth which could link to presence of finer particles (Silt and Clay) at the subsurface horizon. The PAW might support cropping farming most especially the deep-rooted crops. This finding agreed with the result of Anne, *et al.*, (2015).

Table 6. Soil Hydraulic properties of Akwana farmlands at various depth

Depth	Statistics	WHC (%)	FC (%)	PWP (%)	PAW (%)
0-15 cm	MAX	59.59	30.10	12.04	18.06
	MIN	37.60	19.01	7.60	11.41
	MEAN	53.43	24.88	9.95	14.93
	SD	5.79	3.46	1.38	2.07
	SKEW	-1.64	-0.55	-0.55	-0.55
15-30 cm	MAX	65.67	38.00	15.20	22.80
	MIN	34.50	11.23	4.49	3.41
	MEAN	51.82	26.21	10.48	15.06
	SD	9.27	6.81	2.72	5.09
	SKEW	-0.51	-0.28	-0.28	-0.74

WHC: Water Holding Capacity, **FC**: Field Capacity, **PWP**: Permanent Water Holding, **PAW**: Plant Available Water

Rafin Goza Farmlands

Results on the hydraulic properties of Rafin Goza farm location at the surface horizon (0-15 cm) were depicted on Table 7. The WHC, FC and PWP were revealed to be moderate with mean values of 44.88 %, 23.99 % and 9.59 % accordingly. The PAW was high (14.40 %) that might sustain crop production throughout the cropping season. The trend remained same at the subsurface level with moderate WHC (51.74 %), FC (21.78 %) and PWP (8.70 %) with high PAW (13.05 %) as were presented on Table 7 respectively. These results expressed the suitability of moisture condition towards effective crop growth and development in the without any supplementary requirement. This might result from the transportation of fine soil particles from topsoils to deep soils through soil macropores, particularly in arable lands. (Su *et al.*, 2010; Hishe *et al.*,2017).However, this finding was not consistent with observations by Wang *et al.*, (2012, 2013) and the recent result of Li *et al.,* (2019) who found a general decrease in the FC and WHC with the soil depth which was attributed due to higher Bd of the black soils

Table 7. Soil Hydraulic properties of RAFIN GOZA farmlands at various depth

Depth	Statistics	WHC (%)	FC (%)	PWP (%)	PAW (%)
0-15 cm	MAX	60.78	36.67	14.66	22.01
	MIN	19.88	11.23	4.49	6.74
	MEAN	44.88	23.99	9.59	14.40
	SD	11.58	7.89	3.15	4.73
	SKEW	-0.64	-0.08	-0.08	-0.08
	MAX	63.20	29.12	11.64	17.48
	MIN	32.22	11.67	4.66	7.01

15-30 cm	MEAN	51.74	21.78	8.70	13.05
	SD	9.08	5.63	2.25	3.35
	SKEW	-1.012	-0.30	-0.30	-0.30

WHC: Water Holding Capacity, **FC**: Field Capacity, **PWP**: Permanent Water Holding, **PAW**: Plant Available Water

Kente Farmlands

The hydraulic properties of Kente farmlands at the depth of 0-15cm (surface level) were presented on Table 8. The results shows that all the defined hydraulic properties (WHC, FC, PWP and PAW) were moderate to support the growing of crops in the area with the corresponding values of 44.07 %, 21.22 %, 8.48 % and 12.74 % accordingly. Similarly, at the subsurface horizon of 15-30 cm the results expressed same trend of moderate hydraulic properties except PAW which increases to 14.73 % characterized as high. However, it could observe that moisture content of all identified parameters increases with increasing depth. This could explain due to textural variation between the two horizons with finer particles at the subsurface coupled with moderate TP compared with the surface horizon. High or moderate TP has the ability to retained more water and moisture than the low TP which has less available pore space to absorb and retain water. The presence of adequate moisture requirement for the plants could be attributed to the textural class of the soils with high aeration and total porosity. Hence, total porosity is directly relating to the water storage capacity (Reynolds *et al.*, 1995).

Table 8. Soil Hydraulic properties of KENTE farmlands at varoius depth

Depth	Statistics	WHC (%)	FC (%)	PWP (%)	PAW (%)
0-15 cm	MAX	59.88	35.56	14.22	21.34
	MIN	19.55	9.78	3.91	5.87
	MEAN	44.07	21.22	8.48	12.74
	SD	11.47	7.46	2.98	4.47
	SKEW	-0.59	0.24	0.24	0.24
15-30 cm	MAX	62.12	29.12	11.64	17.48
	MIN	25.56	19.88	7.95	11.93
	MEAN	49.86	24.55	9.816	14.73
	SD	10.33	3.04	1.21	1.82
	SKEW	-0.97	0.08	0.08	0.08

WHC: Water Holding Capacity, **FC**: Field Capacity, **PWP**: Permanent Water Holding, **PAW**: Plant Available Water

CONCLUSION

The research work analyzed the hydraulic and physical properties of some arable lands of Wukari LGA, Taraba State. Based on the information obtained of the studied farm locations characterized with moderate physical and hydraulic properties, it is therefore concludes that soil of the farmlands are suitable for effective crop growth and development. However, Gindin Dorawa area there is need for the farmers to improve the physical and hydraulic properties of the soil in the area for optimum yield.

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