Characterization of Infiltration Rates of Kente Farmlands in Wukari Local Government Area of Taraba State, Nigeria

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Abstract
This present study aimed to characterize infiltration rates of Kente farmlands in Wukari Local Government Area of Taraba State. The results revealed that the farmlands were dominated with sandy loam and loamy sand textured soils characterized with moderate to high bulk density (1.42-1.63 g/cm^3) total porosity (34.80-46.24 %). At Kente site the mean IR and CI values were found as 17.63 and 150.12 cm/hr while at Kente site 2 (25.69 and 212.55 cm/hr) and at site 3 (34.02 and 259.43 cm/hr) respectively. To minimize the high rate of IR of the studied soils due to high pore spaces there is need for the adoption of integrated organic manure application by the farmers and also application of minimum tillage practices for improving moisture retention capacity of the soils.

Keywords*: Characterization, Farmlands, Infiltration, Wukari*

INTRODUCTION

Infiltration rates characterization of farmlands is considered as an indispensable tool in defining and evaluating water movement, transmission and storage within the vadoze zone. It is basically affected by different factors fundamental soil physical properties, topography and land use system. Gomez *et al.*, (2002) found that changes in pore-size distribution are highly dependent on soil texture and soil water regime, and did not preclude the use of soil porosity as a monitoring tool for managers. Macropores affect infiltration of water and solutes in soil (Trojan and Linden, 1998). Land use has been suggested as a more important influence on infiltration compared to soil texture (Fischer, 2014). It is known that physical properties such as bulk density aninvestigated water infiltration and soil water content as affected by agroforestry, grass buffers, and row crop management. Generally, hydraulic parameters are vital soil properties for precision agriculture and essential macro nutrient to increase soil fertility required for plant growth and development that is extremely associated with soil physical, chemical, and biological processes. Soil physic-chemical and hydraulic properties are essential to be understood for soil profile development and also for sustainable vegetation growth and development along with water balance in soils (Jyot *et al.*, 2018).

Our knowledge of soil hydraulic and physical processes and the associated changes and the interactions through soil matrices driven by environmental and/or ecological factors needs to be continuously improved to migrate potential adverse impacts of future land modifications on soil functioning. this is because the dynamics of the soil water budget comprise the main components of precipitation, infiltration, capillary rise, evapotranspiration, surface runoff, inter (or soil) flow and groundwater flow (Peck *et al.*, 1977). The interconnection between the water balance elements can have a strong crop farming and cultivation techniques.

Similarly, in Kente farmlands of Wukari local Government Area of Taraba State, Nigeria had been experienced an acute and apparent effect of climate change particularly the reoccurrence of drought spells most farmlands which have 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. In addition, there is no documented research conducted in the area saddled to characterize infiltration rates of soil in the study area. It is therefore based on this backdrop this present study aimed to characterize infiltration rates of Kente farmlands in Wukari Local Government Area of Taraba State.

MATERIALS AND METHOD

Study Area

Kente farmlands are suited in Wukari Local Government of 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 9^o 08′ and 10^o 23′ East (392487.77E, 81642288.39N) of the Greenwich Meridian and Latitude 7^o 35′ and 8^o 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.

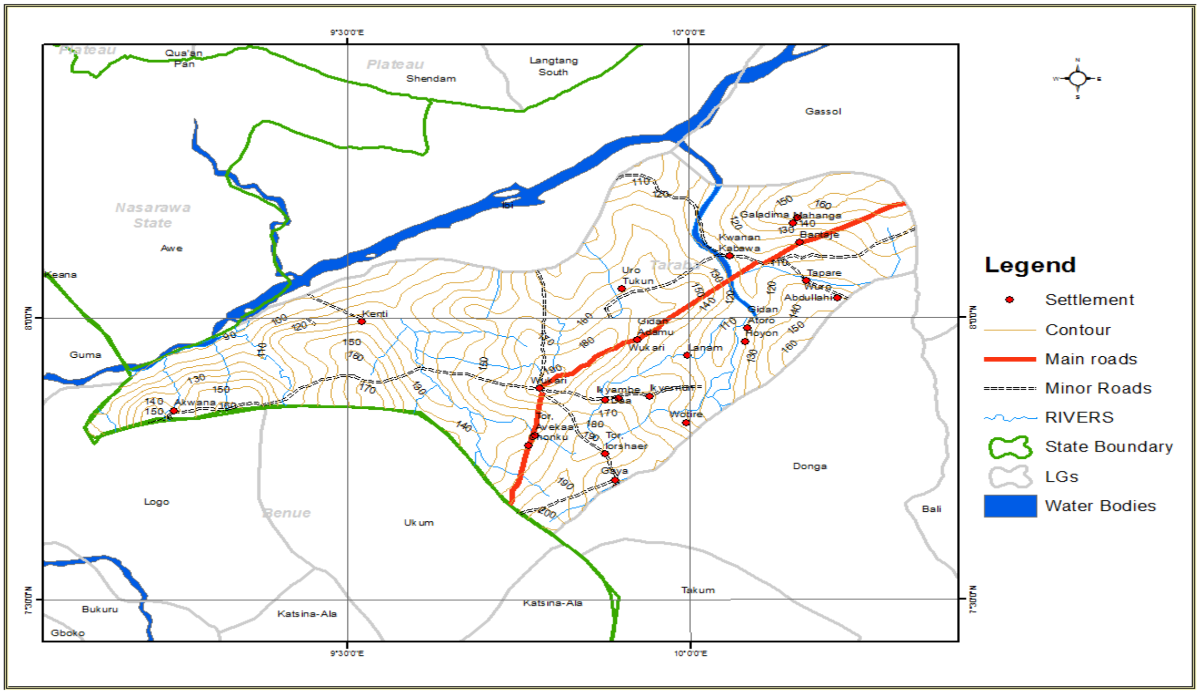


Figure 1. Map of Wukari Local Government Area

Soil Sampling Methods and *Techniques*

In addition, three (3) standard profile pits were dug randomly at different sites where infiltration tests were carried out near to each profile pit using double ring infiltrometer method (Reynolds and Erick, 2002) for the period of three (3) hours.

The infiltrometer rings were driven into the ground by hammering a wooden bar placed diametrically on the rings to prevent any blow out effects around the bottom of the rings. Some areas with grasses were trimmed to a near surface level with a cutlass so that the float could be free movement and care was taken not to uproot that grasses. The infiltrometer both the outer and inner rings were filled with water and for inner ring the water filled at 0 cm point to the fixed meter rule and read and local time was taken. Repeated readings were taken at intervals of 2, 4,6, 8, 10, 15, 20, 30, 40, 70, 130 and 190 minutes. The double ring cylinder compartment was refilled from time to time when the water level dropped. Two Infiltration measurements were conducted at each location of the study site.

Infiltration rate was determined using the formular I= **Q/At**

Where Q is the quantity or volume of water absorbed or infiltrated by unit A of soil surface per unit time t.

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 properties described were soil texture (Particle Size Distribution) by Bouyocous Hydrometer Method (Bouyoucos, 1962), total porosity (TP) and bulk density (Bd) were both determined as described by Dumitru *et al.*, (2009).

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

Soil texture is an intrinsic attribute of the soil and the one most often used to characterize its physical make-up, having a bearing on such soil behaviors as nutrient and water holding capacity, organic matter (OM) level and decomposition, aeration, infiltration rate, drainage and/or permeability and workability (Hillel, 1998). The physical properties of the soil of Mubi north LGA are presented in Table 2. The result showed that the sand content was generally high ranging from 61 % to 88 % with the highest value in the Ap horizon of Kente 1 (61 %), Kente 2 (68 %) and Kente 3 (88 %) areas respectively. The presence of high sand content in all pedons particularly at upper horizons indicates the soil to have high water permeability. In consequence reducing the affinity of the soil to reserve or retain nutrient due to low CEC and OM of the soil. The coarse texture of sandy loam control the variability of nutrient storage capacity, limit the water holding capacity and roots may grow under sub-optimal soil water due to water deficits (Gachene and Kimaru, 2003; Anne, *et al.*, 2015).

The bulk density of the soil ranges from (1.46-1.63 g/cm^3) with the highest (1.63 g/cm^3) at last horizon (C) of Kente site 1, followed by Kente 2 (1.57 g/cm^3) in Bw1 horizon and (1.54-1.62 g/cm^3) in Ap horizon of Kente 3 respectively. It could be explained that the high bulk density of the soil at the upper layer at Kente 3 could be connected to the agronomic activities such as intensive tillage practices using tractors which tends to increase the compaction of the soil, thus, reducing porosity and infiltration. This assertions concords with the findings of Azooz and Arshad, (1996) who explained that tilled soils under continuous cultivation tend to become less porous and more dense with time in the plow layer. Therefore, long-term conventional tillage and no-tillage systems can alter bulk density, aggregate stability, total porosity and organic carbon content (Singh *et al.,* 1994).

The total porosity of the soil was highest at Kente 1 (Bw2 and Ap horizons), with the corresponding values of 46.24 % and 45.11 respectively. Meanwhile the lowest total porosity was recorded at last horizon (C) of Kente 1 (34.80 %). These variations of total porosity could be attributed to the bulk density of the soil. For any given soil, the higher the bulk densities, the more compacted the soil is and the lower the pore space (Anne *et al.,* 2015). By implication the general variability of the TP could leads to high rate of infiltration which inconsequence reducing the run-off capacity of water in the studied area.

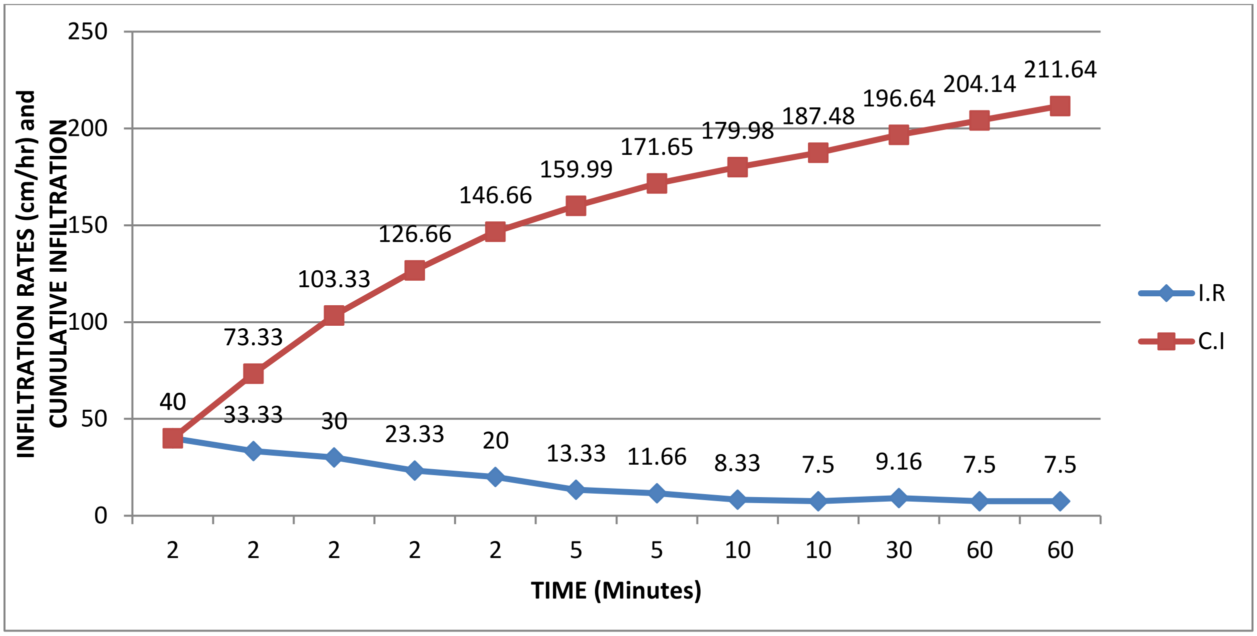
Table 1. Selected Soil Physical Properties of the study area

STUDY SITE	Depth (cm)	Horizon Designation	Sand	Silt	Clay	Textural Class	Bd (g/cm^3)	Pd (g/cm^3)	TP (%)
	0-25	Ap	61	20	19	SL	1.46	2.66	45.11
	25-60	Bw1	64	14	12	SL	1.42	2.35	39.57
KENTE 1	60-120	Bw2	80	7	13	LS	1.43	2.66	46.24
	120-190	C	88	4	8	LS	1.63	2.50	34.80
	0-20	Ap	68	16	16	SL	1.49	2.50	40.40
KENTE 2	25-95	Bw1	64	16	20	SL	1.57	2.50	37.20
	95-124	C	72	12	16	SL	1.50	2.45	38.77
	0-23	Ap	88	5	7	LS	1.54	2.66	42.10
KENTE 3	23-68	Bw1	84	6	10	LS	1.42	2.35	39.57
	68-123	Bw2	72	12	16	SL	1.50	2.50	40.00
	123-187	C	68	20	12	SL	1.50	2.65	43.39

Keys: **SL**: Sandy loam, **LS**: Loamy sand, **Bd**: Bulk density, **Pd**: Particle density, **TP**: Total porosity

Infiltration Characteristics of the Studied Soils

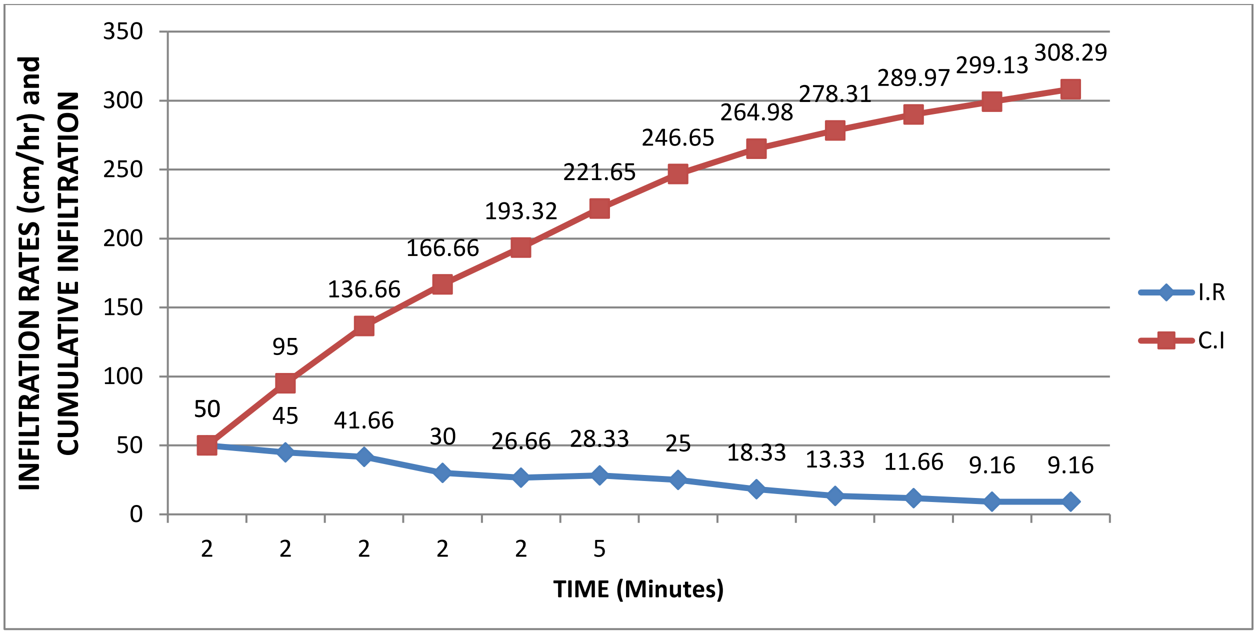
Results on the infiltration characteristics for Kente site 1 were presented on table 1 and the diagrammatic illustration was depicted on figure 1. It was revealed that IR was 40 cm/hr at the initial time of 2 minute which reduces to 33.33cm/hr and 30 cm/hr at 4 and 6 minutes respectively. This trend of infiltration rates could be linked to the textural class of sandy loam soil at the upper horizon coupled with low initial water content of the soil at the time of the experiment. The trend of infiltration rates decreased rapidly to 23.33 cm/hr at 8 minutes and continuously to 20.00 cm/hr at 10 minutes of the test. The drastic increased of the IR might be attributed to the textural variation at the second horizon which dominated by sandy loam as depicted on Table 1.In addition, it could be noticed that as the time interval increases (at 5 minutes) an abrupt changes was of IR was observed (13.33 cm/hr) and suddenly rates to 11.66 cm/hr respectively. Meanwhile, at time interval of 10 minutes the IR maintained increase of almost 2 cm/hr (8.33 and 7.5 cm/hr). Conversely, slight increase of IR (9.16 cm/hr) was recorded at time interval of 30 minute which consistently maintained the trend to 7.50 cm/hr at 60 minutes interval signifying the steady state of IR within the soil horizons respectively. Thus, it could be asserted that high rate of infiltration will reduce the run-off capacity of the soil thereby reducing the susceptibility of the soil to erosion. This assertion conformsthe report of Cooperative Research Centre for Viticulture (CRCV, 2006) which explained that high infiltration capacities will reduce run-off and risks of waterlogging, however very high infiltration capacities, often found in sands soils.



Keys: **IR**: Infiltration Rates, **CI**: Cumulative Infiltration

Figure 1. Shows Infiltration Rates and Cumulative Infiltration of Kente site A

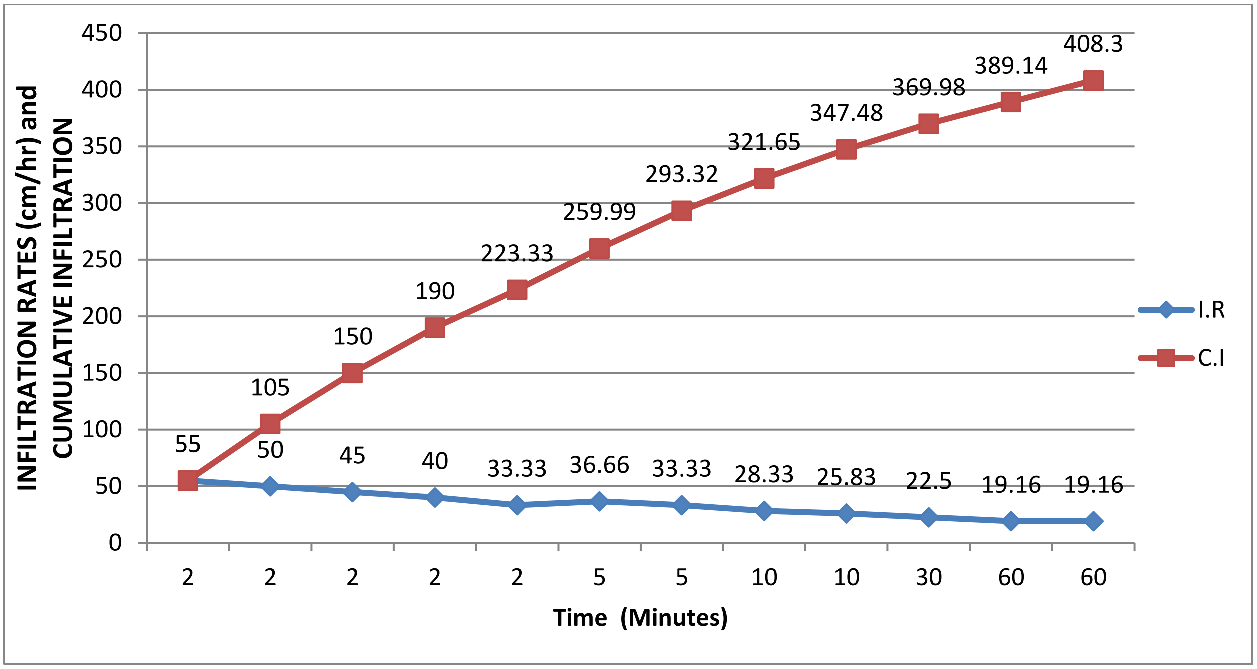
At site B of the experimental site, the results revealed that the IR was recorded at initial time (2 minutes) having value of 50.00 cm/hr, gradually decreased to 45.00, 41.66 cm/hr, 30.00 cm/hr and 26.66 cm/hr at 4, 6, 8 and 10 minutes interval respectively. It could be noted that there was decreased in IR with an increase in time intervals of 2 minutes ranges from 4-9 cm/hr which might be connected to coarse textural soil type of sandy loam at the upper layer of the profile. As the time interval increases to 5 minutes an increase of 2.33 cm/hr was recorded (28.66 cm/hr) and drastically decreased to 25.00 cm/hr after 5 minutes. In contrast, the IR continue to decreased down the profile despite the increase in time interval of 10 minute (18.33 cm/hr and 13.33 cm/hr), 30 minutes (11.66 cm /hr) and at 60 minutes interval (9.16 cm/hr) which attained the steady state of the downward movement of water. This similar trend could be connected to uniformity of sandy loam texture in all the identified horizons allowing regularity of water transmission within the horizons. Generally, at the commencement of infiltration, the rate is usually high (i.e., theoretically infinite at the initial stages of the process) when the soil is unsaturated and the suction gradient across the soil surface is very high and predominating, but decreases to approach a constant quasi-steady-state value. Therefore, the results of this study with high initial infiltration decreasing to low constant or asymptotic at final infiltration toward the end of the cumulative time of three (3) hours are in agreement with the theoretical concept of infiltration as also explained by Ogban, (2017).



Keys: **IR**: Infiltration Rates, **CI**: Cumulative Infiltration

Figure 2. Shows Infiltration Rates and Cumulative Infiltration of Kente site B

The results of IR at C were characterized at figure 3 and presented at Table 2. The results shows that the initial IR at 2 minutes with zero initial water content was 55.00 cm/hr which reduces uniformly with 5 .00 cm/hr at regular intervals of 4, 6 and 8 minutes with corresponding values of 50.00 cm/hr, 45.00 cm/hr and 40.00 cm/ hr respectively. This regularity pattern could link to the loamy sand homogeneity of the soil texture within the upper layers (Ap and Bw1 horizons) as show on Tale 1. The high (55 cm /hr) infiltration rate measured initially might be due to little or no initial water content in the soil which produce greater water matric potential gradients to permeate rapidly and fill the pores spaces drive by gravitational and capillary forces. In contrast, despite the fact the top layer of the profile (0-20 cm) has a higher bulk density (1.54 g/cm^3) coupled with 42.10 % porosity still the water infiltrates exponentially due to high vertical gravitational driven forces at the initial time due to the drier status of the soil. As the time increased to 5 minutes slight increase was also observed from 33.33 to 36.66 cm/hr, however there were no any increased in IR due to increase in time interval from 10, 30 and 60 minutes intervals respectively. Even though decreased in IR was observed with corresponding values of 25.85, 22.50 ad 19.16 cm/hr as its reaches the steady state accordingly. It is imperative to explain that the trends follow the homogeneity of the sandy loam at the last two horizon of the soil profile. Thus, Infiltration rates were at their highest values at the beginning of the experiments, but decreased steadily at different rates. Generally, it is obviously ascertained that IR was measured as high in the area which could be linked to the nature of the soil properties such as texture, structure, bulk density and porosity degradation due to an intensive disturbance caused by agronomic practices (tillage) in the area. These results also demonstrate that the effect of soil texture on infiltration rate was probably masked by the land use practices and soil management, which agrees with the fact that water infiltration into the soil is highly sensitive to land use and soil management, as also observed by Lal and van Doren (1990).



Keys: **IR**: Infiltration Rates, **CI**: Cumulative Infiltration

Figure 3. Shows Infiltration Rates and Cumulative Infiltration of Kente site

Table 2. Shows Actual Infiltration, Infiltration Rates, Cumulative Infiltration of the studied soils

	KENTE 1			KENTE 1			KENTE 1		
Time (Minutes)	**AI**	**IR**	**CI**	**AI**	**IR**	**CI**	**AI**	**IR**	**CI**
2	24.00	40.00	40.00	30.00	50.00	50.00	33.00	55.00	55.00
2	20.00	33.33	73.33	27.00	45.00	95.00	30.00	50.00	105.00
2	18.00	30.00	103.33	25.00	41.66	136.66	27.00	45.00	150.00
2	14.00	23.33	126.66	18.00	30.00	166.66	24.00	40.00	190.00
2	12.00	20.00	146.66	16.00	26.66	193.32	20.00	33.33	223.33
5	8.00	13.33	159.99	17.00	28.33	221.65	22.00	36.66	259.99
5	7.00	11.66	171.65	15.00	25.00	246.65	20.00	33.33	293.32
10	5.00	8.33	179.98	11.00	18.33	264.98	17.00	28.33	321.65
10	4.50	7.50	187.48	8.00	13.33	278.31	15.50	25.83	347.48
30	5.50	9.16	196.64	7.00	11.66	289.97	13.50	22.50	369.98
60	4.50	7.50	204.14	5.50	9.16	299.13	11.50	19.16	389.14
60	4.50	7.50	211.64	5.50	9.16	308.29	11.50	19.16	408.30
Mean Values	**10.58**	**17.63**	**150.12**	**15.41**	**25.69**	**212.55**	**20.41**	**34.02**	**259.43**

Keys: **AI**: Actual Infiltration, **IR**: Infiltration Rates, **CI**: Cumulative Infiltration

CONCLUSIONS

Characterization of infiltration rates of farmlands is a tool use to evaluate the water transmission, run-off and storage for sustainable management. Kente farmlands were evaluated for infiltration characteristics in this present study, where in all the three sites selected the results revealed high rates of infiltration which could be linked to soil properties particularly sandy textured soils (Sandy loam and loamy sand) dominated the soil horizons characterized with moderate to high total porosity. To minimize the high rate of infiltration and to improve the retention capacity of the soils there is need for integrated application of organic materials coupled with adoption of minimum tillage practices by the farmers in the area.

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