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Water Infiltrability as Affected by Topsoil Removal.

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Water infiltrability of an alfisol in the semi humid tropics, as affected by different levels of desurfacing, were investigated using the double ring infiltrometer. Both the initial and equilibrium infiltration rates (IR) varied with level of desurfacing . There were no significant differences between the IR of the contrl and th -2cm depth of desurfacing($p<0.05$). The initial and equilibrium IR for the -5 and -15cm desurfacing differed significantly from the control. The initial IR was in the order 28 > 10 > 9 > 8 $cmhr^{-1}$ for -10, -5, 0 and -2cm depths of desurfacing respectively, while the equilibrium IR was in the order was 9.5 > 5.6 > 3.3 > 2.9cm for -10, -5, 0 and -2cm depths of desurfacing respectively. The higher infiltration rates of the -5 and -10 depth of desurfacing suggests that the decrease in IR as a result of desurfacing by erosion, as reported by previous works, may not primarily be as a result of surface soil removal but the subsequent crusting sealing of the soil pores with the impact of rain drops. The equilibrium IR highly correlated with physical properties of the soil, with correlation coefficient values (r) ranging from 0.79 to 0.89. T he equilibrium IR was multi-regressed with some of the physical properties as follows:

$Y = 2.38.85 - 2.6X_1 - 3.8X_2 - 0.2X_3 + 0.1X_4 - 0.08X_5$, *where* X_1 = *%sand* , X_2 = *% silt,* X_3 = *%clay,* X_4 = *saturated hydraulic conductivity and* X_5 = *total porosity.*

Introduction

Water infiltration into the soil is one of the most important hydrologic processes occurring at the surface soil. It determines the amount of runoff which will form over the soil surface and hence the hazard of erosion during rainstorms, and the entire water economy(Mbagwu and Scott 1984).

In addition to rainfall erosion, some land clearing techniques using mechanized agricultural equipment also result in fertile topsoil being removed from the cleared areas (Couper et. al., 1981). The extent of the damage done to the productivity of the land by surface soil removal in the tropics by these natural and man made disasters abound (Sanders 1985).

The alfisol show a significant clay increase with depth; they have a less stable structure, and are subject to soil compaction and erosion. Lal (1981) reported decreased moisture retention capacity, following several years of erosion. Some of these findings were collaborated by Obi and Asiegbu (1980) in Southeastern Nigeria.

The soil texture, structure and stability are the factors which largely influence infiltrability, and this is through their effect on porosity, pore geometry of the soil profile (Babalola 1987).

A good knowledge of the infiltration process as it relates to soil properties and rainfall intensity is a pre-requisite to efficient soil and water management.

This study, therefore, is aimed at evaluating the effects of surface soil removal on water infiltrability of an alfisol ,in south western Nigeria.

Materials and Method

This study was carried out at he International Institute of Tropical Agriculture, Ibadan (3^0 6^1E and 6^0 8^1 N). Ibadan is located at the northernmost part of the rainforest zone, with an average annual rainfall of 1000-1600mm.

This experiment was carried out the dry season, on loamy sand alfisol , under five years of grass fallow.

The treatments consisted of topsoil manually excavated to depths of 2cm, 5cm, and 10cm with a control of 0cm (no de-surfacing). These were laid out in a randomized complete block design and replicated three times. The entire experimental site was 9m x 12m (0.01ha) , divided into smaller plots of 3m x 3m each.

Infiltration rates (IR) were measured using a double ring infiltrometer. These were made up of two concentric rings, with the inner ring having a diameter of 30cm and the outer 60cm. These were uniformly driven into the soil to a depth of 15cm, using a sheet of hard wood and a sledge hammer. Surface soil of the inner ring was protected with dry grass straw, to avoid soil dispersion while refilling with water. The vertical water movement into the Soil were taken for every minute, for 10mins., then for every 5mins. for 20mins. and for every 15mins. for another 90mins.Data collected were analyzed using analysis of variance tests for the Randomized Complete Block design. Means were separated using F-LSD at $P< 0.05$ according to the procedure outlined by Steel and Torrie (1980).

Results and Discussions

Effects of treatments on infiltration rate

Infiltration rates as affected by the various levels of desurfacing are shown on table 1. The initial infiltration rates(IR) were generally higher than those of the equilibrium IR, owing to the fact that IR decreases with increase in moisture contents(Hillel 1980). The drastic decrease in IR at the 120mins. reading of the -10cm desurfacing also shows that equilibrium IR is dependent on soil structure; with the subsirface having more micropores than macropores. This agrees with previous findings (Babalola, 1993) that total porosity, pore stability and pore continuity not only influence soil water acceptance, but also its transmission through the profile.

Infiltration rates of the -2cm desurfacing, were lower than the control for all times measured, although the differences were not significant. Results also showed significant differences ($P<0.05$) between the -5 and -10cm desurfacing, from the control. This could be as a result of the sandy nature (table 3) and the high gravel concentration of the site (Lal 1989). This suggests that the decrease in IR as a result of desurfacing by natural erosion processes(Mbagwu and Scott 1984), is not primarily as a result of top soil removal. However it could be as a result of compaction, crusting and sealing of the soil pores with subsequent impacts of the raindrops on the desurfaced area. This may imply that manual desurfacing, along with reduced impact of raindrops could enhance water infiltration at he immediate soil surface, and therefore be used to ameliorate very low infiltration rates of highly compacted soils.

Effects of treatments on cumulative infiltration

Cumulative infiltrations were generally low, following the same trend as the IR with respect to treatments. Cumulative infiltration were significantly different for all times for the -5 and -10cm desurfacings (table 2). At the end of 2 hours, the mean cumulative infiltration for all treatments were 8.0, 7.4, 12.2 and 25.8cm for 0, -2cm, -5cm and -10cm desurfacings respectively. This appears to agree with Mbagwu(1995), who recorded ten times higher cumulative infiltration for tilled plots as against continuos pasture. These may be related to higher macroporosity, due to the presence of gravel down the profile.

Relating equilibrium infiltration rates to soil physical properties

Some physical properties of the soil is as shown on table 3. The soil texture of 0-10cm depth was loamy sand. Percent sand decreased while percent clay increased with depth. Bulk densities were generally high ranging from 1.62 to 1.81 kgm^{-2} . Table 4 shows simple correlation coefficients and regression equation between equilibrium IR and various soil physical properties. All the soil physical properties were highly correlated with equilibrium infiltration rate. The correlation coefficients ranged from 0.79 to 0.84.

The equilibrium IR was multi-regressed with some of the physical properties as follows:

$$Y = 238.85 - 2.6X_1 - 3.8X_2 - 0.2X_3 + 0.1X_4 - 0.08X_5.$$

where X_1 = sand, X_2 = silt, X_3 = clay, X_4 = saturated hydraulic conductivity and X_5 = total porosity.

Conclusion

In conclusion,, the results presented, show that surface soil removal will significantly affect water infiltrability into the soil, and the magnitude will depend on the level of desurfacing. It also suggests that decreased infiltration rates recorded by other researchers, as a result of desurfacing may be as a result of sealing, crusting and compaction from raindrop impacts and not necessarily the desurfacing. It is also suggested that manual removal of topsoil could be used to ameliorate the effect of hardpans and sealing of hard pans when combined with other management practices that will reduce the direct impact of rain drops.

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Table 1: Effects of Treatments on Infiltration Rates ($cmhr^{-1}$) , over Time

Depth of Desurfacing (cm)	Elapsed Time(mins.)						
	5	10	15	30	60	90	120
0	9.0	7.0	4.2	4.3	3.2	3.2	3.3
- 2	8.0	8.0	3.6	3.7	3.0	3.0	2.9
- 5	10.0	10.0	12.8	7.5	6.6	5.7	5.6
-10	28.0	27.0	17.8	16.2	11.1	9.8	9.5
Mean	13.8	13.0	9.6	7.9	6.0	5.4	5.3
$LSD_{(0.05)}$	6.2	5.3	4.5	2.9	1.3	2.3	1.7
CV(%)	73.2	65.3	76.1	58.5	33.8	69.8	51.3

CV- Coefficient of variability

Table 2: Effects of Treatments on Cumulative Infiltration (cm), over Time

Depth of Desurfacing (cm)	Elapsed Time(mins.) 5	10	15	30	60	90	120
0	0.9	1.5	1.8	3.0	4.4	6.2	8.0
- 2	0.7	1.2	1.5	2.6	4.1	5.7	7.4
- 5	0.8	1.6	2.6	4.4	7.3	9.6	12.2
-10	3.7	5.5	6.1	10.2	14.9	21.0	25.8
Mean	1.3	2.4	3.0	5.1	7.7	10.6	23.4
$LSD_{(0.05)}$	0.3	0.7	1.0	1.8	2.5	3.3	4.3
CV(%)	42.4	44.5	54.0	56.0	52.6	50.7	29.65

CV- Coefficient of variability

***Table 3: Mean values of some physical properties of the soil under study.**

Parameters	Depth (cm)	% Sand	% Silt	% Clay	Ks (cmh^{-1})	Bulk Density (kgm^{-3})	Macro-Porosity (%)	Total Porosity (%)	Textural Class
X		82.3	9.6	8.1	3.6	1.62	15.4	39.1	LOAMY
σ	0-5	8.1	0.006	7.6	0.4	0.004	2.4	5.5	SAND
CV		3.7	0.8	19.8	27.7	3.4	12.6	6.8	
X		77.9	11.2	11.8	1.4	1.72	12.0	34.8	LOAMY
σ	5-10	0.4	0.5	1.1	0.2	0.0001	0.02	0.04	SAND
CV		0.6	7.4	7.4	19.6	0.6	1.2	0.58	
X		77.1	9.0	15.1	3.5	1.81	12.1	31.6	SANDY
σ	10-20	0.1	0.1	0.4	0.4	0.001	0.01	2.0	LOAM
CV		0.3	3.9	4.5	26.8	2.0	0.8	4.1	
X		75.9	8.2	23.0	2.2	1.77	9.6	33.3	SANDY
σ	20-30	0.1	0.6	20.9	0.002	0.0002	1.8	0.3	CLAY
CV		0.5	8.0	33.0	33.0	0.9	11.0	1.6	LOAM
X		69.9	10.8	11.3	0.7	1.77	12.4	33.4	SANDY
σ	30-60	11.3	0.2	1.6	0.62	0.0002	0.003	0.3	LOAM
CV		4.4	5.3	9.2	34.6	0.9	0.4	1.5	

X is mean, σ is variance, CV is coefficient of variability(%) and Ks is sat. hydraulic conductivity.

* (From Mbonu 2005)

Table 4: Regression equation and correlation coefficients (r) of equilibrium infiltration rates with some soil physical properties.

Dependent Variable (Y)	Independent Variable (X)	Equation	r
	Sand	82.7 - 1.03X	0.79
IR	Silt	-13.8 + 1.92X	0.82
	Clay	-19.5 + 1.60X	0.84
	Ks	1.6 + 1.16X	0.84
	Mp	13.6 - 0.74X	0.78
	Tp	23.7 - 0.56X	0.79
	BD	48.05 - 24X	0.89

IR =Equilibrium infiltration rate, Ks = Saturated hydraulic conductivity, Mp =Macroporosity,
Tp =Total porosity, BD = Bulk density.