INTERNATIONAL SYMPOSIUM ON THE ASSESSMENT OF SOIL SURFACE SEALING AND CRUSTING

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EFFECTS OF SOIL MOISTURE AND KINETIC ENERGY ON THE MECHANICAL RESISTANCE OF SURFACE CRUSTS.

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ABSTRACT

A Proctor needle was used in the field to measure the mechanical resistance to penetration of surface crusts formed under simulated rainfall on sandy and clayey soils, at various stages during the tests. In both cases, the measured resistance was found to be correlated to the soil moisture and to the cumulative kinetic energy of preponding rainfall, namely before the soil was protected by a thin water layer from raindrop impact.

INTRODUCTION

Soil surface may present cohesive surface seal due to the impact of raindrops and subsequent drying. The purpose of this study was to determine the influence of soil moisture and kinetic energy of simulated rainfall on crust strength.

MATERIALS AND METHODS

Experiments were carried out on two alluvial soils of a sub-desert region in Niger, near Agadez. The texture of the surface layer (0 - 10 cm) of the first soil was sand, the second was clay loam. The organic matter content was 0.1% and 0.7 % respectively. In both cases, surface seal was destroyed by ploughing the upper 10 cm. Rainfall were simulated on 1-m^2 plots using a sprinkling infiltrometer (Asseline and Valentin, 1978) in reference to the climatic data prevailing in the study area (see Valentin, 1984). Kinetic energy of raindrops were analogous to those of natural rainfall (Figure 1).

In order to assess the variations of resistance to penetration at various stages of crust formation and drying, a Proctor needle was used. It consists of a penetrometer in which compression of a spring is used as a measure of

the pressure required for the penetration of a flat circle probe (1.25 cm^2) into the top 10 mm. There were 10 replications of each measurement. In addition, core samples were collected for moisture determinations.

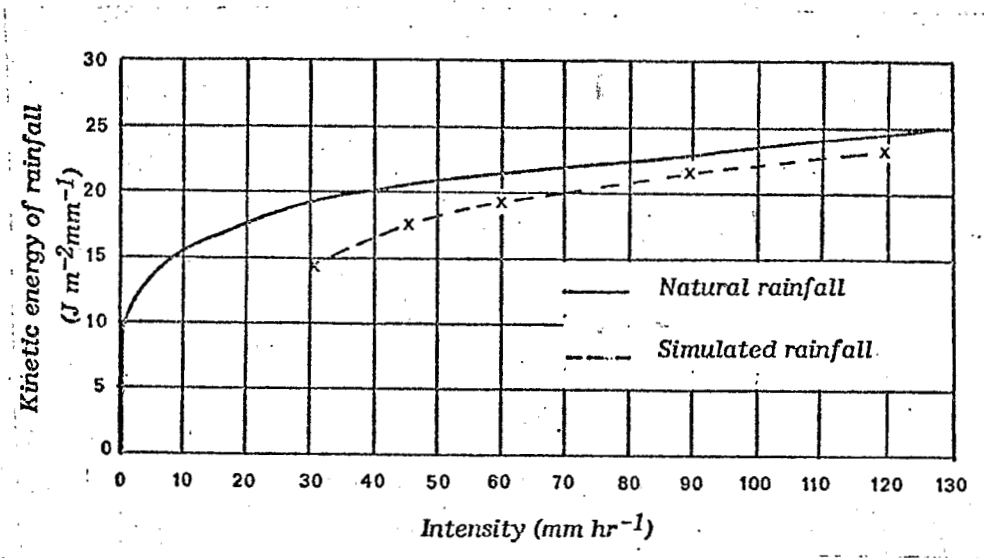

FIGURE 1 Kinetic energy of natural rainfall as compared with the impact energy from the sprinkling infiltrometer. The relationship between kinetic energy (KE) and rainfall intensity (I) was derived from the data collected in Abidjan (Ivory Coast):

$$KE = 10.00\, I^{0.19}, \quad n = 221, \quad r = 0.52$$

RESULTS AND DISCUSSION

The water content alone accounted for only 18 and 57 % of the variation in crust resistance measured on the sandy and the clayey soils, respectively. But stronger correlations existed for both plots if cumulative kinetic energy of preponding rainfall is used as an additional variable (Figure 2). These regression

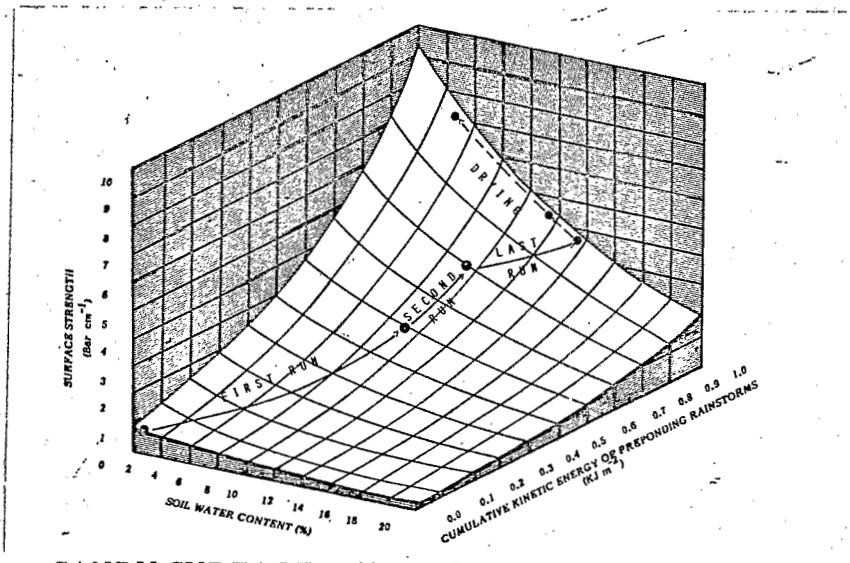

FIGURE 2a SANDY SURFACE. Effect of water content (WC) and cumulative kinetic energy of preponding rainfall ($\sum KE$) on measured resistance to penetration (R): $R = 0.87 \exp(2.37 \sum KE - 0.08\, WC)$, $n = 18$, $r = 0.98$

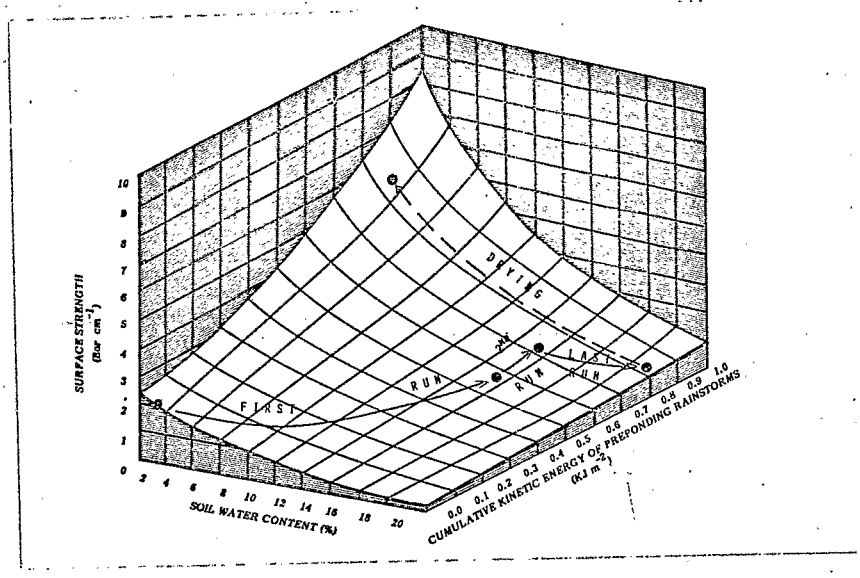

FIGURE 2b CLAYEY SURFACE. Effect of water content (WC) and cumulative kinetic energy of preponding rainfall ($\sum KE$) on measured resistance to penetration (R): $R = 2.01 \exp(1.44 \sum KE - 0.12\ WC)$, $n = 14$, $r = 0.89$

equations suggest that as long as the soil was not covered with a thin water layer, i.e. until runoff occured, impact energy was absorbed by the soft tilled surface, and hence changed into compacting pression. It is worth emphasizing that these increasing surface strength may be related to the sealing processes. On the sandy soil, crust was formed rapidly as the result of sand compaction and clay micro-illuviation (Valentin, 1984). Less dependant on impact energy was sealing on the clay loam soil since it was chiefly due to swelling and slaking.

CONCLUSION

On tilled soils, the variations of surface strength when there are submitted to rainfall are influenced by their textures. Resistance to penetration increases mainly with increasing cumulative kinetic energy of preponding rainfall on sandy soils, whereas clayey surfaces hardened for the most part during drying.

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