DEGRADATION DES PATURAGES NATURELS ET QUALITE DES SOLS DANS LA REGION SOUDANO-GUINEENNE DE L'ADAMAOUA AU CAMEROUN.

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RESUME

L'Adamaoua camerounais connaît depuis un peu plus d'une vingtaine d'années des formes diverses de dégradations de ses parcours. Ces dégradations se traduisent par des formations végétales qui s'éloignent des savanes herbeuses à graminées pérennes, principales sources d'alimentation des herbivores domestiques qui consomment surtout la végétation herbacée tandis que l'apport de la strate ligneuse est de moindre importance. L'analyse phytosociolgique de 76 stations soumis à des charges animales variées, combinée à l'examen du spectre biologique de la strate herbacée de ces parcours, a permis de définir quatre grands faciès de dégradation des pâturages dans la région. Ces quatre faciès de végétation plus deux types de faciès non dégradés ont fait l'objet des analyses physiques et chimiques du sol, puis de la description de l'état de surface. Il ressort de l'analyse que les faciès de dégradation sont pauvres avec des taux faibles à très faibles d'azote et des rapports C/N généralement supérieurs à 15, des taux de phosphore très faibles (inférieur à 30 ppm selon la méthode Bray II), des taux de saturation inférieurs à 30% et des tendances à l'acidité (pH H_2O < 6,5). Les pâturages peu dégradés sont relativement plus riches, avec des rapports C/N inférieurs à 11, des taux de saturation moyens de plus de 30%, des pH (H_2O) tendant vers le neutre de 6 à 7,3, bien que les taux de phosphore soient relativement faibles. Bien que dans l'ensemble on note une bonne stabilité structurale des sols, dans certains pâturages dégradés, on note un compactage de la surface ou une érosion hydrique avec creusement des ravines. La restauration de ses pâturages et l'amélioration de qualité des sols passent par techniques aussi bien simples (mise en défens, rotation de parcours) qu'onéreux (réduction sélective des ligneux et ensemencement des parcours).

Mots clés: Adamaoua, Charge animale, Dégradation, Pâturage, Phytosociologie, Sol.

Introduction

The term "soil conservation" is frequently used to mean a variety of activities by humans to control the rate of degradation, loss of soil, and yield of sediment from the landscape by wind, water and gravity (FAO, 1985). Except under forest conditions, surface horizons of most tropical soils having clay and organic matter contents are generally not well aggregated under cultivation. The soil aggregates are weakly developed and unstable to raindrop impact. On quick wetting during rain, these aggregates slake easily to form a surface seal or crust. Such formations occur when the surface ground is bare or incompletely covered by the vegetative canopy or surface mulch. In addition to sealing and crusting, migration of fine soil particles into underlying layers is often observed especially when the soil surface is disturbed by tillage and/or continuous cropping. The loss of pore continuity at the soil surface by sealing and crusting or at the adjacent soil layers by eluviation of fine topsoil particles causes the reduction of water infiltration. As a result, runoff and soil loss can significantly increase especially on sloppy grounds. Soil erosion is one of the major constraints of agricultural development of the highlands in the tropics. More than 80% of cultivated lands in these regions are prone to severe erosion as a result of improper agricultural practices. Previous workers (Alegre et al., 1986; Lal, 1989; Hulugalle et al., 1990; Babalola et al., 1993) reported the decreases in infiltration due to the loss of pore continuity during cultivation. The poor performance of crop on the surface ground contributes to its effectiveness in soil conservation.(El-Swaity et al., 1988). High runoff and soil loss were also reported in marginally cultivated and bare fallow lands and infiltration invariably decreased as sealing and crusting developed with time (Sabel, 1988). The erodibility factor K of the USLE remains the conventional index to identify lands prone to erosion. However, the long-term knowledge of water infiltration and other soil parameters such as bulk density and pore continuity may be useful to easily estimate susceptibility of soils different management practices to runoff and soil loss. Such a simple approach is needed especially when expertise and equipment for soil erosion studies are the limiting factors. This paper intends to report the importance of water infiltration in characterizing runoff and soil loss in most tropical soils.

Water infiltration, runoff and soil loss.

When there is a good vegetative cover such as forests, there is abundant biotic life, such as earthworm and other faunal activities. These faunal organisms create channels which increase porosity and thus improve water infiltration. In newly cultivated lands prior to a complete soil coverage by crop canopy or in continuous cultivated lands with noticeable decline in soil fertility status, soils develop both surface seal and crust. Fine soil particles clog the soil pores, rending them permeable to water and air and thus favoring runoff and erosion of important quantities of fine earth. Sealing and crusting occurred mostly on soils exhibiting sparse vegetation and thus are exposed to intense solar radiation and high intensity rains. Among the management practices, slash-and-burn agriculture exhibits a higher hazard of surface sealing and crusting because of the low plant population density characterizing this system. With modern agriculture, sealing and crusting often occur on newly cultivated lands when the soil surface is yet to be completely covered by crop canopy. Such phenomena also develop on harvested fields depending on the quantity and the management of crop residues on the soil surface.

Water infiltration is linked to the vegetation cover on the surface ground. Vegetation acts as surface mulch by protecting the soil surface from impacting raindrops and by affecting more or less surface runoff velocity. The more the soil is protected by vegetation cover or by mulch, the higher the infiltration. This is because vegetation cover serves as barriers to raindrop impact which otherwise can break soil structure. Investigations from previous workers (Sabel, 1988) indicated that surface sealing is high when the soil surface is not well protected from impacting raindrops by a sufficient crop cover. Fig.1 illustrates the development of crop cover, soil loss ratio (SLR) and infiltration rates during 1984 on plow plot in western Nigeria (Sabel, 1988). SLR decreased only when the crop cover reaches 30%' and approached zero when the crop cover reached 100% crop cover.

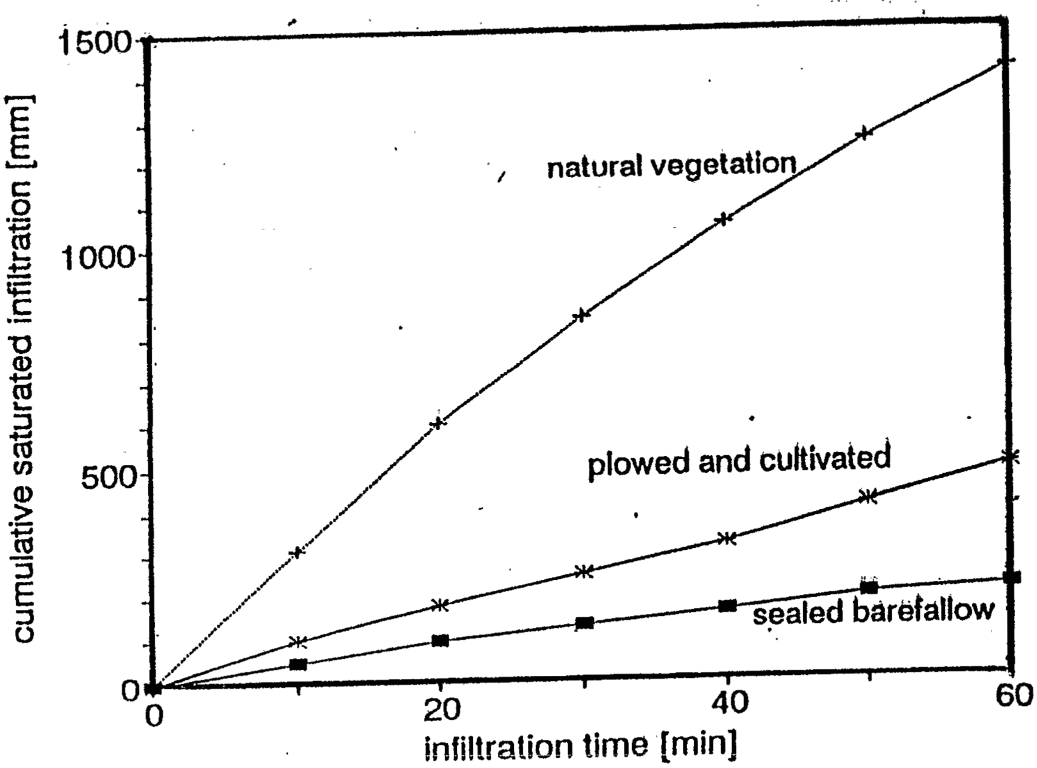

Fig. 1. Infiltration as influenced by management and vegetation. (Source: Sabel – Koschella, 1988).

The detachment of soil particles was reduced by increasing crop cover and consequently the soil loss was also reduced independently of infiltration. The surface seal developed before the crop cover developed, persisted until when the crop cover exceeded 90% and was then penetrated by roots and soil animals (Kladivko et al., 1986), thereby increasing the infiltration rate to more than 100mm/h. The destruction of the surface seal is time taking and can only occur under a high crop cover when the soil surface is protected from repeated sealing. Investigating the impact of natural vegetation, tilled or cultivated land and bare fallow on water infiltration, Sabel (1988) found that soil covered by vegetation generally infiltrated more water than uncovered soil. In this study, a natural savannah grass fallow (1410 mm/h) infiltrated 7 times more water than sealed bare fallow (210 mm/h) (Fig.2). If plowed and cultivated, the same soil infiltrated 450 mm/h. In contrast to high water infiltration under crop cover, lowest runoff and soil loss were reported by Alegre and Cassel (1994) on similar management practices in a peruvian Ultisol (Table 1). Variations in runoff and soil loss were in the order Bare plot > Continuous cropping > Alley cropping > Secondary forest, indicating a mean annual soil loss 57 times greater under continuous cropping than under alley cropping. The above results show that improvement of water infiltration when the soil surface is protected usually corresponds with none or less runoff and soil loss. Whereas exposed soil surfaces such as bare fallows experience low infiltration and high runoff and soil loss. Other bulk density and pore size and continuity are of great importance as they affect the infiltration rates. It is well established that pore continuity, as infiltration, varies inversely with bulk density. Compacted soils will probably generate less conductive media resulting in low water infiltration and high runoff and soil loss. High infiltration and low runoff will be expected in porous soils. Comparison of water infiltration under different management practices at different times can give the insight of the general trend of land susceptibility to erosion hazard before detailed and at often complicated studies can be carried out.

Two typical examples taken from an Ultisol in Cameroon show variation of the pore

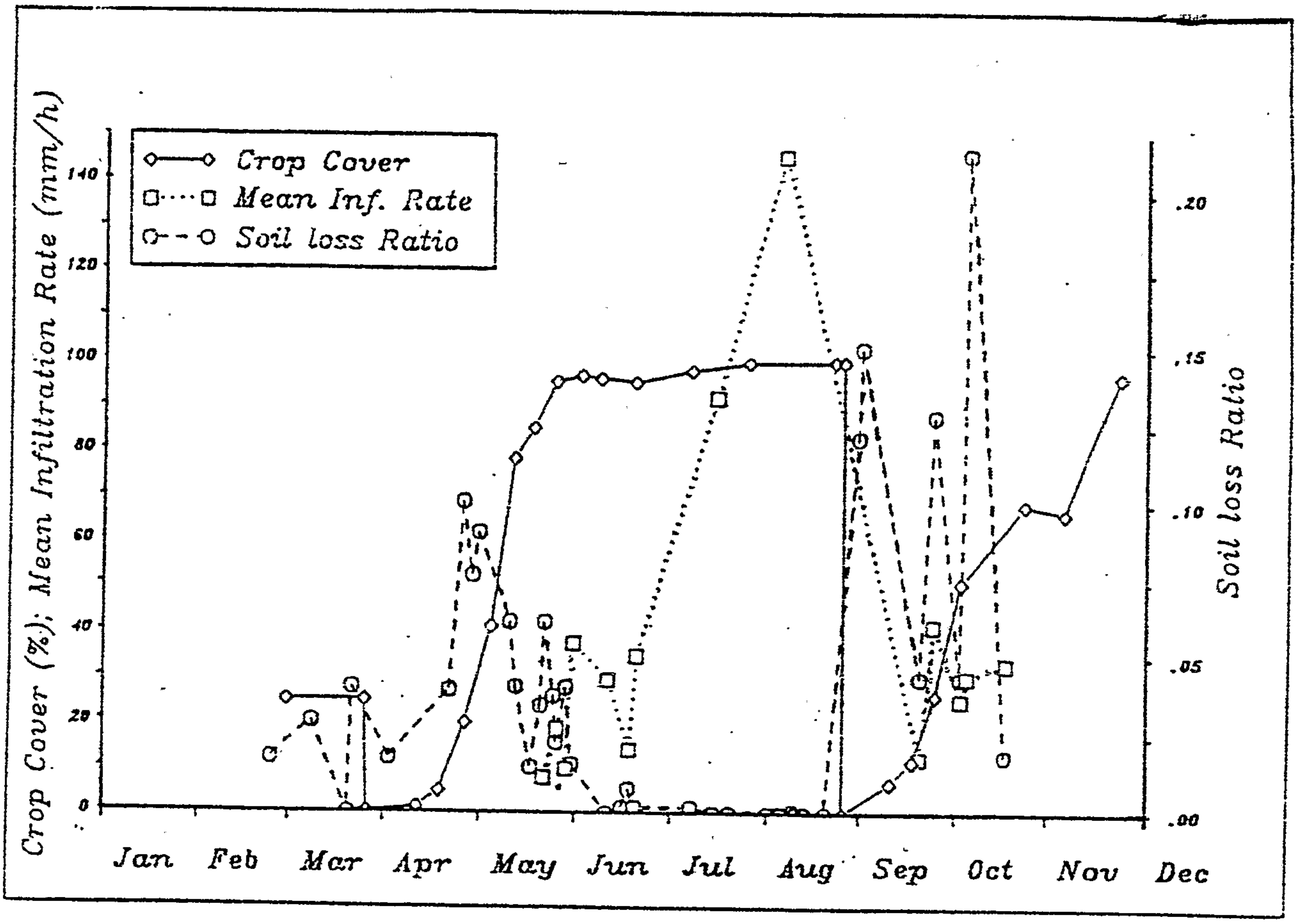

Fig2: *Crop Cover, Mean Infiltration Rate and Soil loss Ratio*
(Plow (3), 1984)

(Source: Sabel, 1988)

Table 1: Effect of management systems on runoff and soil loss from December 1988 to March 1993 and annual means.

	Runoff		Soil loss	
Treatment	Total (mm)	Mean (mm/yr	Total (Mg/ha)	Mean (Mg/ha/yr)
Continuous croppin(	1080	249	228.5	52.77
Alley cropping	133	31	4	0.92
Secondary forest	16	4	0.83	0.19
Bare plot	2865	6.62	505.4	116.72

Total rainfall: 8710 mm in 52 months.

(Source: Alegre and Cassel, 1994)

continuity and water infiltration as function of time (Nyobe et al. in preparation). In the first example, two infiltration tests were carried out between 1995 and 1996 on four different levels of burning under slash-and-burn practice. The four levels were: Unburned (NB), slightly burned (SB), moderately burned (MB) and heavily burned (HB) dry biomass. The first cropping season was characterized by high crop yield on HB because of readily available nutrients released by ash. As a result, good crop canopy protected the soil surface from raindrop impact, thus enhancing high porosity and infiltration. However, with a decline in soil fertility during the second year, crop cover was sparse and the soil surface exposed to high intensity rains. Results showed 30, 20, 19 and 16% decreases in silt contents respectively on NB, SB, MB and HB between 1995 and 1996, indicating the eluviation of these fine particles from the top into the subsoil layers. Total porosity also decreased between the same period, the decreases being highest in HB (32%) and lowest in NB (14%) (Fig. 3). As a result, water infiltration higher immediately after burning and cultivation, gradually decreased in HB plot by 18.5% because of the clogging of the soil pores (Fig.4). The decrease in pore continuity and infiltration on HB predicted less vertical flow of water into the soil whereas horizontal flow and thus high runoff and soil loss could be expected, although not measured in this study.

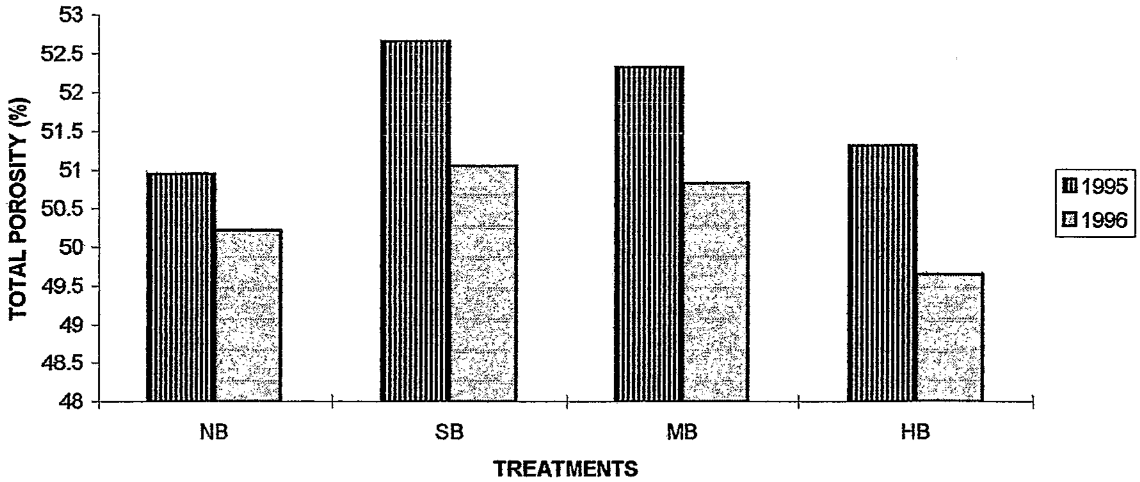

Fig.3. Effect of the levels of burning on total porosity (%) under slash-and-burn practice. (NB=no-burn; SB= Slight burn; MB= moderateburn; HB= heavy burn)

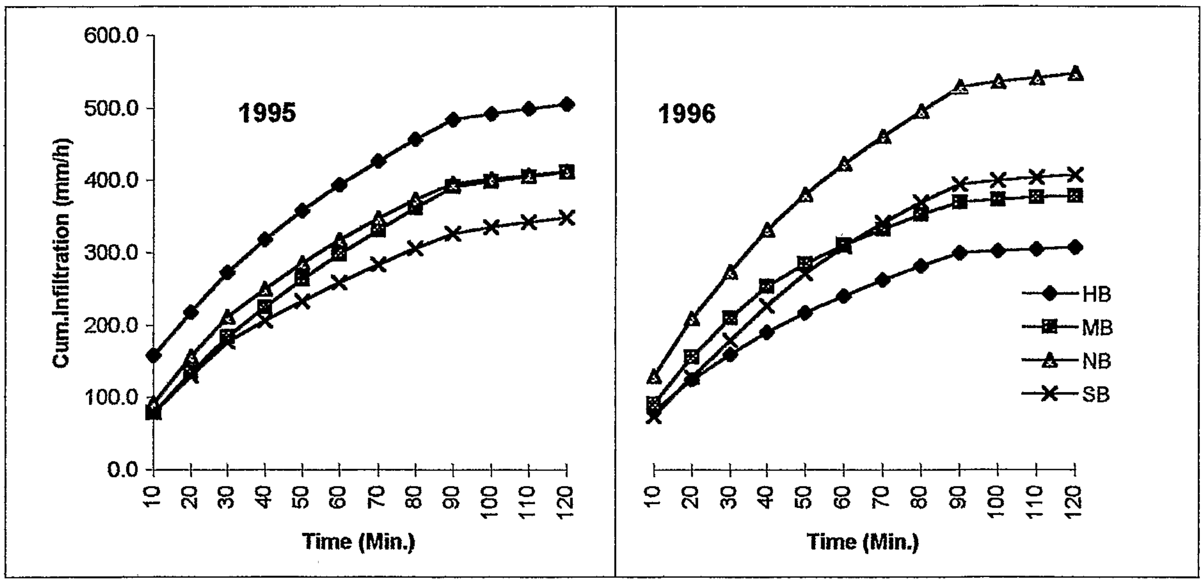

Fig.4. Effect of the levels of burning under slash-and-burn practice on water infiltration.(NB=no-burn; SB= Slight burn; MB= moderateburn; HB= heavy burn)

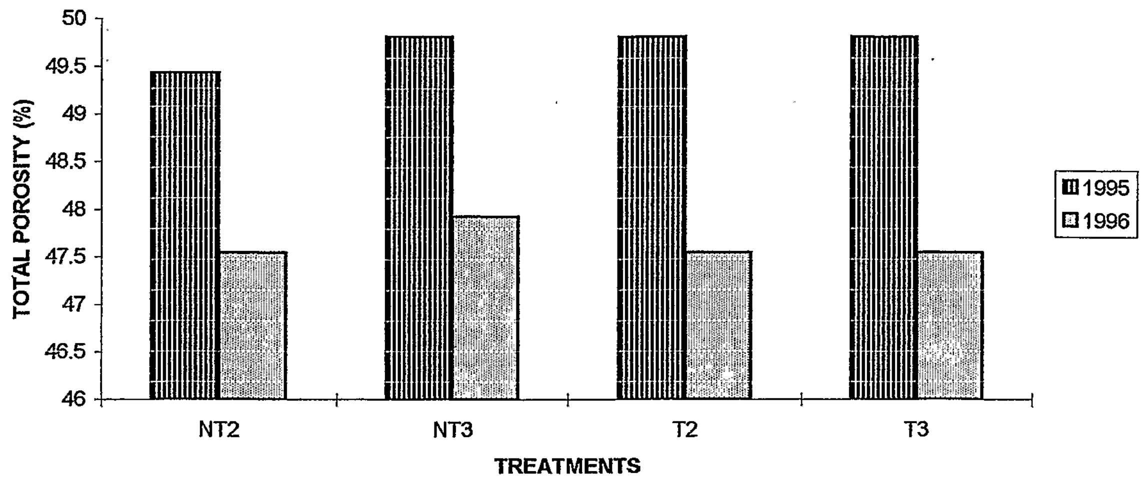

Fig.5. Effects of tillage and no-tillage with or without *Senna* hedgerows on total porosity. (NT2=no-tillage without *S*. hedgerows; NT3=no-tillage w ith *S*. hedgerows; T2=tillage without *S*. hedgerows; T3=tillagewith *S*.hedgerows).

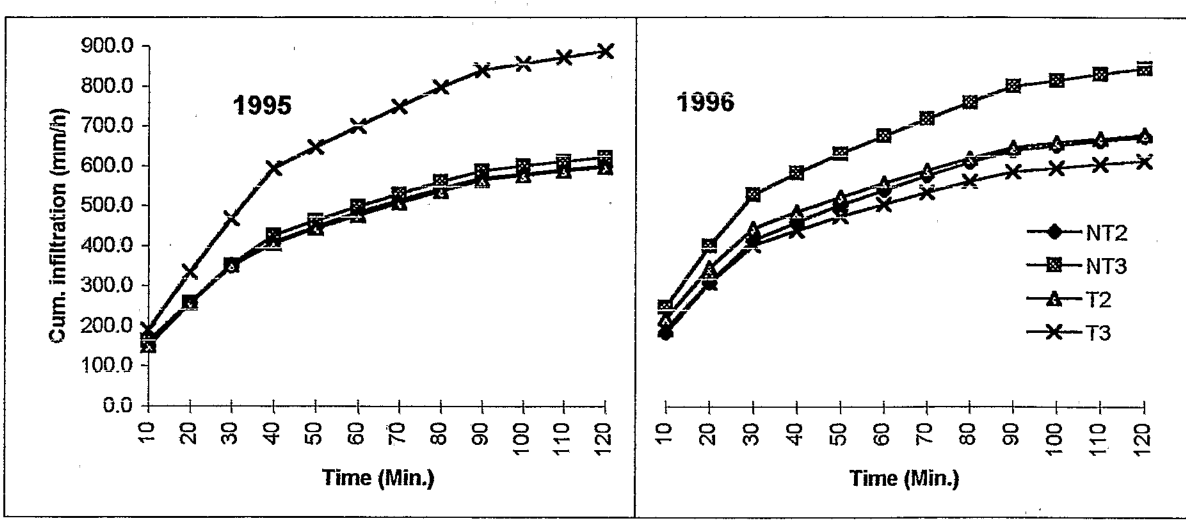

Fig.6. Effects of tillage and no-tillage with or without *Senna* hedgerows on water infiltration. (NT2=no-tillage without *S*. hedgerows; NT3=no-tillage w ith *S*. hedgerows; T2=tillage without *S*. hedgerows; T3=tillagewith *S*.hedgerows).

Another example, illustrated by a two factorial experiment involving 2 cropping systems (*Senna* hedgerows vs no *Senna* hedgerows) and two tillage systems (manual tillage vs no tillage) showed decreases in silt contents between 1995 and 1996. The percent decreases were 77.2, 22.0, 20.3 and 22.0, respectively on T2, T3, NT3 and NT2, indicating the downward migration of silt particles (Nyobe et al., 1998, in preparation). This migration resulted in decreases in total porosity in tilled (4.6%) and untilled (3.8%) plots (Fig.5). The water infiltration consequently decreased during that period on tilled plots (Fig.6). Such variations in infiltrations invariably result in increase in runoff on tilled plots.

Conclusion

The knowledge of infiltration between different periods may be of great usefulness in roughly estimating the susceptibility of a given area to runoff and soil loss. Perhaps most importantly the nature, nutrient status and preparation of soil and the ground cover are determinant of the effectiveness of infiltration. The intensity of infiltration more or less influences the quantity of water that flows over the soil surface causing loss of arable soils. Bare fallows and continuous cropping had low water infiltration that resulted in high runoff and soil loss because of high soil compaction and therefore low pore size and continuity. However, similar observations are often made on newly cultivated or harvested fields where the soil surface is exposed to impacting raindrops resulting in high surface sealing and crusting. It is suggested that appropriate measures of soil surface protection should be taken especially at the early stage of crop establishment and after harvesting the land. Management of crop residues should be more integrated in the farmers' policies that include soil fertility and conservation.

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