CHAPTER SEVEN DISCUSSION OF RESULTS

7.1 Introduction

The infiltration rates soils under various landuses would be compared to each other and related to the physical environment such as the properties of the soils and type of vegetation cover. The pattern of infiltration would be discussed too, in an attempt to explain the characteristics of infiltration of soils of the various landuses.

7.2 Infiltration Rates of Soils of Various Landuses

Based on the results presented in Chapter 5, it was found that infiltration rates of soils under forest were in close agreement to those of 20-year old rubber and 20 year-old oil palm vegetation cover. It was shown that the rate of rainfall application in the calibration of rainfall simulation (ie 21 cm/hr) never exceeded the infiltration capacity of soil under forest and 20-year old rubber vegetation cover. This suggests a very permeable soil structure of the soils.

The higher infiltration capacity of soils under forest condition was noted by Faulkner (1990), who found that under oak woodland and clay loam, infiltration capacity rates were between 15 to 320 cm/hr, whereas at Alkali Creek, the maximum rate in any 5 minute interval was the initial rate of 10 cm/hr, under oak brush.

Lal (1977), stated that the infiltration rate of a majority of the soils in the humid tropics were high in which, equilibration rates of 20 to 25 cm/hr were not uncommon.

In the hardwood stands of West Virginia, Mather (1984), found that the infiltration rates were as high as 50 in/hr, suggesting that forest soils not only have infiltration rates that will exceed essentially all rainfall rates, but that they also have the ability to absorb additional overland flow. Meanwhile, the infiltration rates of soils under 20 year-old rubber vegetation cover were shown as equal to that of forest, ie 21 cm/hr. This value suggests that soils under 20 year-old rubber vegetation cover are very permeable and absorb essentially all simulated rainfall applied.

Soil under 20 year-old oil palm vegetation cover showed that average infiltration rates of 20.5 cm/hr are also in close agreement to those of forest and 20 year-old rubber vegetation cover. This suggests that the soil of 20 year-old oil palm vegetation cover have higher permeability comparable to forest and 20 year-old rubber vegetation cover.

Infiltration rates of soils under 7 year-old rubber and 7 year-old oil palm vegetation cover also showed readings in close agreement with another, in which the former was about 7.99 cm/hr, compared to the latter of about 8.14 cm/hr. This again confirmed the influence of soil's physical properties as a prominent factor in affecting infiltration rates. The characteristics of soil physical properties under rubber and oil palm vegetation cover are shown to be close in this study.

When the infiltration rate of soils under forests and 20-year old rubber and 20 year-old oil palm vegetation cover are compared to the infiltration rate of soil under 7 year-old rubber and 7 year-old oil palm vegetation cover, the former is about 3 times as great as the latter's. The main cause for this difference may be due to the effect of cover density.

It was observed that the amount of ground cover and canopy shading were much more dense in the forest soil, 20 year-old rubber and 20 year-old oil palm vegetation cover. In these landuses, the ground cover is very thick. The effect of the large amount of ground cover on infiltration rates is due to its effectiveness in protecting the soil surface from direct actions of rain drops which eventually halt the compaction process (Stallings, 1959; Wilson 1969; Leopold, 1974; Musgrave and Holtan, 1964).

Stallings (op.cit), stated that rate of water infiltration on the soil is determined by the amount of plant cover on the ground. The rate of infiltration is in proportion to the amount of cover, i.e. the greater the amount of cover, the higher the infiltration rate.

Although soils under 7 year-old rubber and 7 year-old oil palm vegetation cover are sufficiently covered by their canopy, the absence of under-layer vegetation has resulted in unsuccesful protection of the soil surface from rain drop action. The occurance of a compaction process under these landuses is due to the large amount of rainfall which dropped on the soil surface without being intercepted by the canopy.

It has been reported that even in soil under matured oil palm, throughfall is about 69.9% (UPM, 1979). Teoh (1973), reported that for 23 year-old rubber trees, throughfall values from 65 to 81%, while for 6.5 year-old rubber trees, (220 - 250 tree/hectare) a throughfall value of 85-86.4% were recorded.

Large amounts of throughfall and the absence of thick under-layer enable soil compaction to take place to some degree on areas 7 seven year-old rubber and oil palm. This cause the bulk density to increase, which in turn resulted in a decreased infiltration rate.

Infiltration rates as shown under 1 year-old bare soil condition revealed that the main cause of a lower value is due to the near-complete absence of ground cover. In 5 year-old bare soil, although some ground cover was found scattered on the soil surface, the density is insufficient to protect the soil surface.

Lutz and Chandler (op.cit) stated that in a clear-cutting area, if an adequate cover of vegetation fails to develop several years after removal of the stand, the changes most commonly observed were accelerated erosion and increased compactness, resulting from destruction of the soil aggregates and plugging of the non-capillary pores. Rain drops striking bare soil surface tend to disperse the soil aggregates. As the water moves downward, the soil particles held in suspension are filtered out, clogging the pore space. As a result the porosity of the soil surface layer is reduced, and infiltration is greatly decreased. The infiltration rate of 5 year-old bare soil was determined as 4.61 cm/hr, while that of 1 year-old bare soil was 6.4 cm/hr.

Comparison of infiltration rates of soils of various landuses revealed that infiltration is largely controlled by the characteristics of soil physical properties, ie the bulk density, total pore space, organic matter content and soil aggregate stability. It has been proven too that the amount of ground cover has prominent effects on infiltration , as compared to the types of vegetation.

A dense vegetative cover causes better aeration, porosity, reduce bulk density and ensures a continuous supply of organic matter. It also helps to protect the soil surface from direct througfall which will eventually cause soil compaction. This in turn will promote better permeability of soils, add to its hydraulic conductivity and increase infiltration capacity.

7.3 Infiltration Behaviour Revealed By This Study

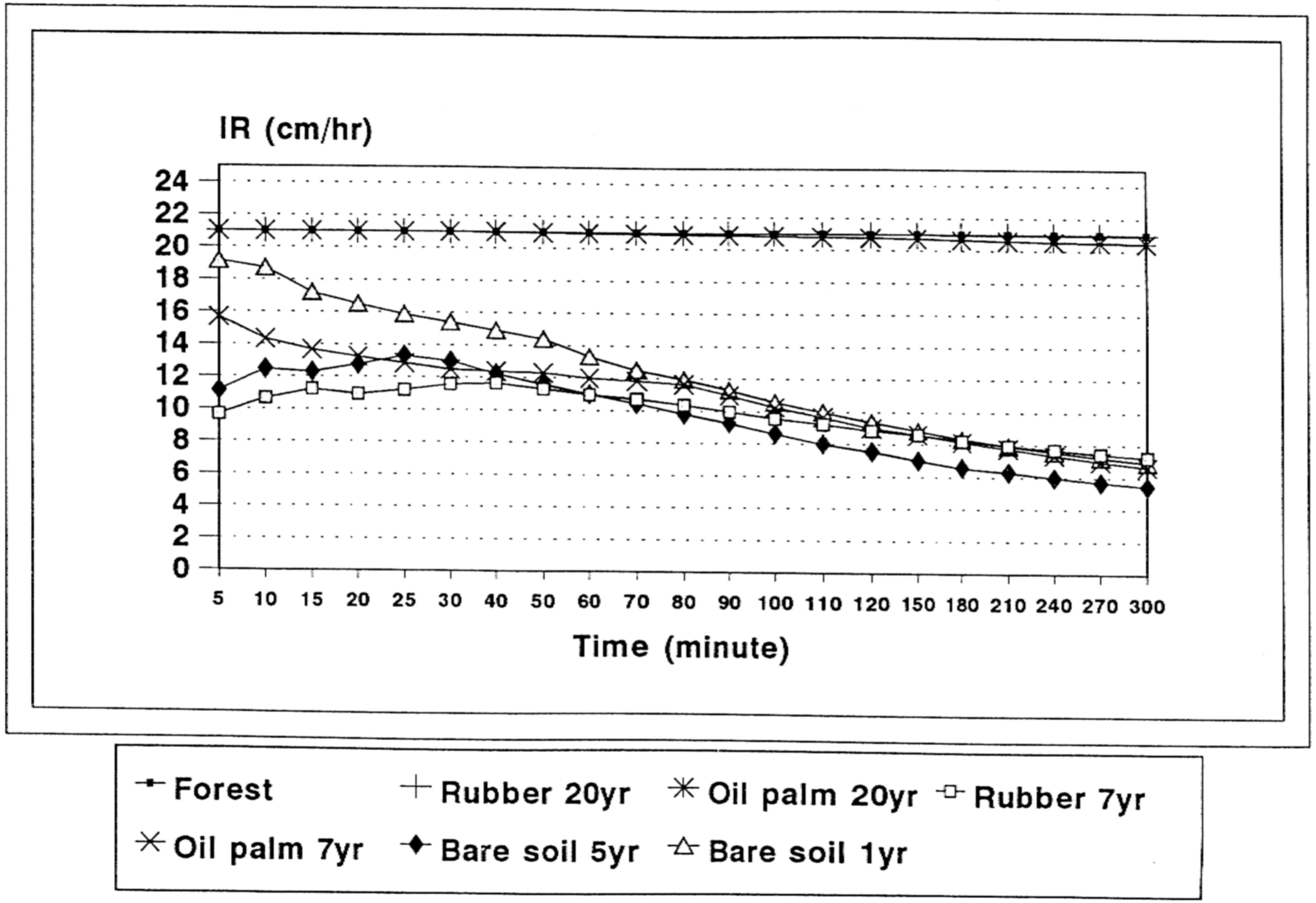
In general, the infiltration behaviour of soils of various landuses follow a normal pattern as described by many researchers including Horton (1940), Philip (1957), and Musgrave and Holtan (1964). In their studies, the normal pattern of infiltration curve is often indicated by a rapid decrease of infiltration rates with time to an asymptotic or steady state, which is a function of the hydraulic conductivity of soil.

This high initial rate of infiltration decreases with time as a result of sealing of entry pores by the washing-in of fine particles or the shrinkage of their walls (Miller, 1977). Wilson (1969), stated that when subject to wetting, very fine soils, containing particles fine enough to be classified as colloids, actually swell slightly. This swelling tends to reduce the size of the micro-voids through which infiltration takes place and is a reason for the reduction of infiltration with time, in continuous rain.

However, in a forested condition (which is taken as a control to other measurements of infiltration rate in this study), and in areas under 20 year-old rubber and 20 year-old oil palm vegetation cover, the expected patterns of infiltration discussed earlier were not detected throughout the study (Figure 7.1). The patterns of infiltration curves under these landuses are shown to resemble straight lines, although a slight variation can be seen in soil under 20 year-old oil palm vegetation cover.

This suggests a higher infiltration capacity of soils under these landuses. In the simulation process of determining the infiltration rates of these landuses, it was found that only trace amounts of runoff were collected during each 5 hours of rainfall simulation, even though large amounts of water was applied.

Figure 7.1: Infiltration Rates of Soils of Various Landuses (comparison)



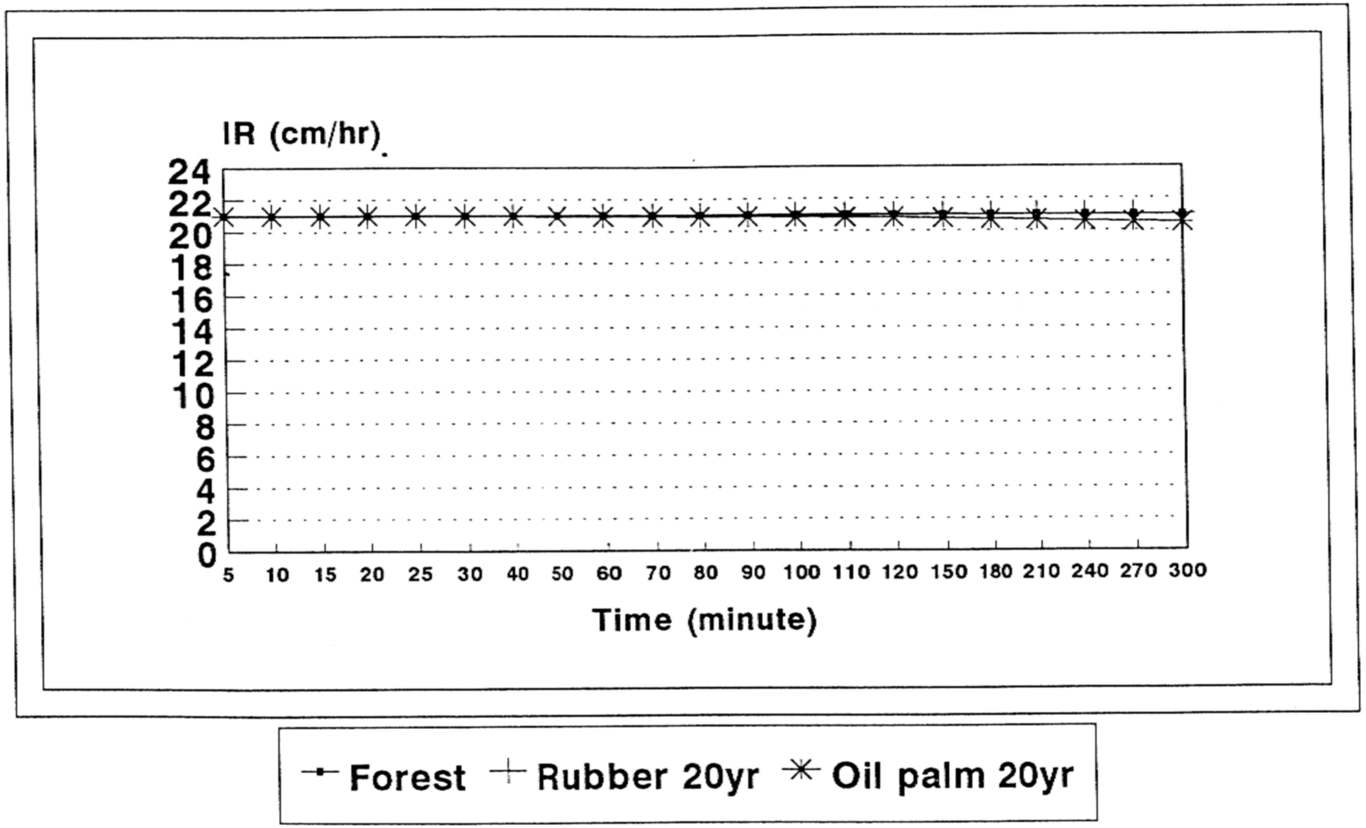
A close observation on the pattern of infiltration rates of soil of various landuses are shown in Figure 7.2 , Figure 7.3 and Figure 7.4. In Figure 7.2, the pattern of infiltration rates of soils under 20 year-old rubber and 20 year-old oil palm vegetation cover are compared to that of forest which was a control. A slight reduction of infiltration rates was observed within 40 to 180 minutes after rainfall simulation in oil palm. However, a steady state of infiltration rates was observed after that.

In soil under 20 year-old rubber vegetation cover, the pattern of infiltration was found to be in close agreement with those of soil under forest, suggesting a higher infiltration capacity of the soil.

In Figure 7.3 the pattern of infiltration rates of soils under 7 year-old rubber and 7 year-old oil palm vegetation cover was compared to that of soil under forest. A rapid decrease of infiltration rate was observed during the first 45 minutes after rainfall simulation. It then became slower before reaching steady state after about 2 hours of rainfall simulation. It was also shown that infiltration rates of soil under 7 year-old oil palm vegetation cover proceeded at a lower rate compared to that of soil under rubber of the same age during the 5 hours of rainfall simulation.

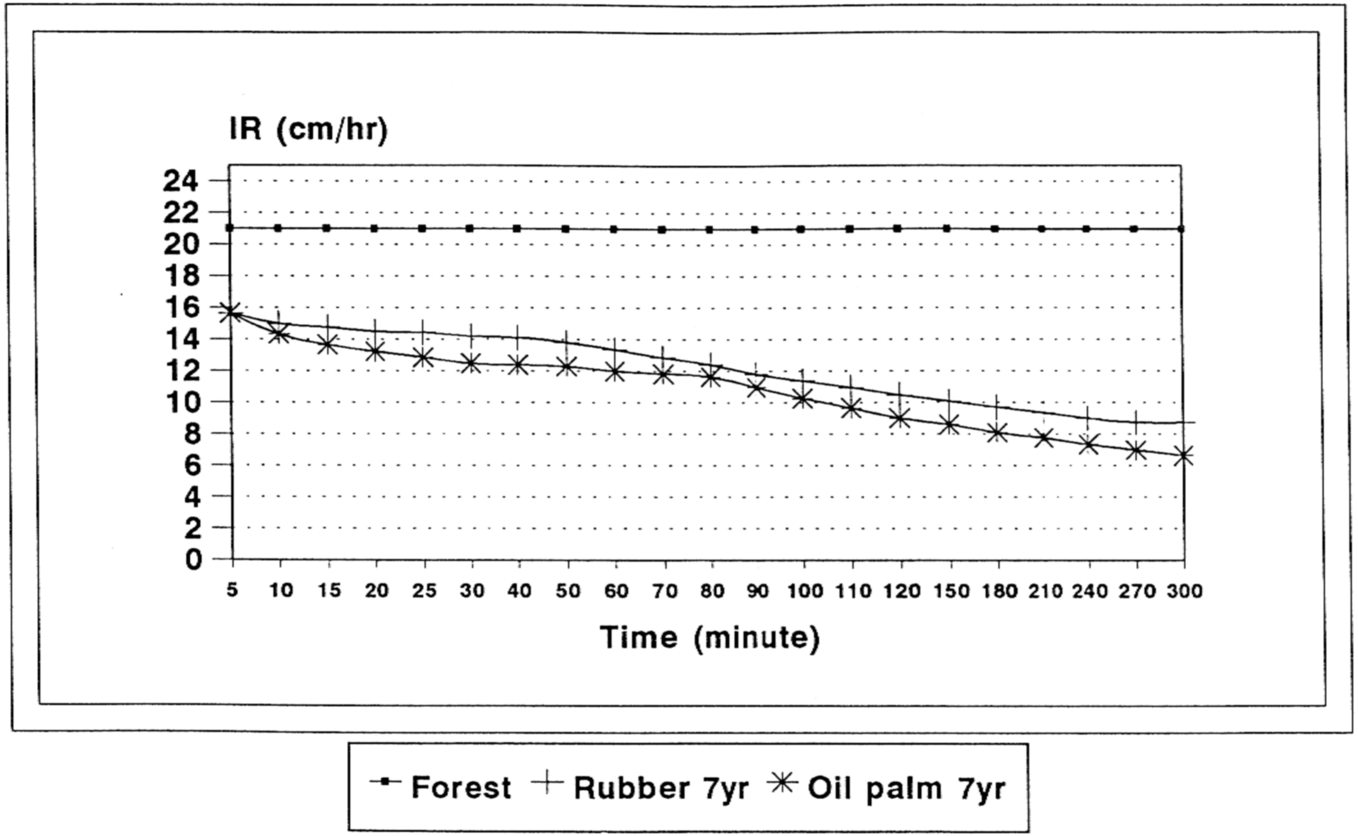
In Figure 7.4, the pattern of infiltration rates under barren soil condition was compared to that of soil under forest. It was shown that in the first one and a half hours

Figure 7.2: Infiltration Rates: (Forest,20 Year old Rubber, 20 Year-old Oil Palm)



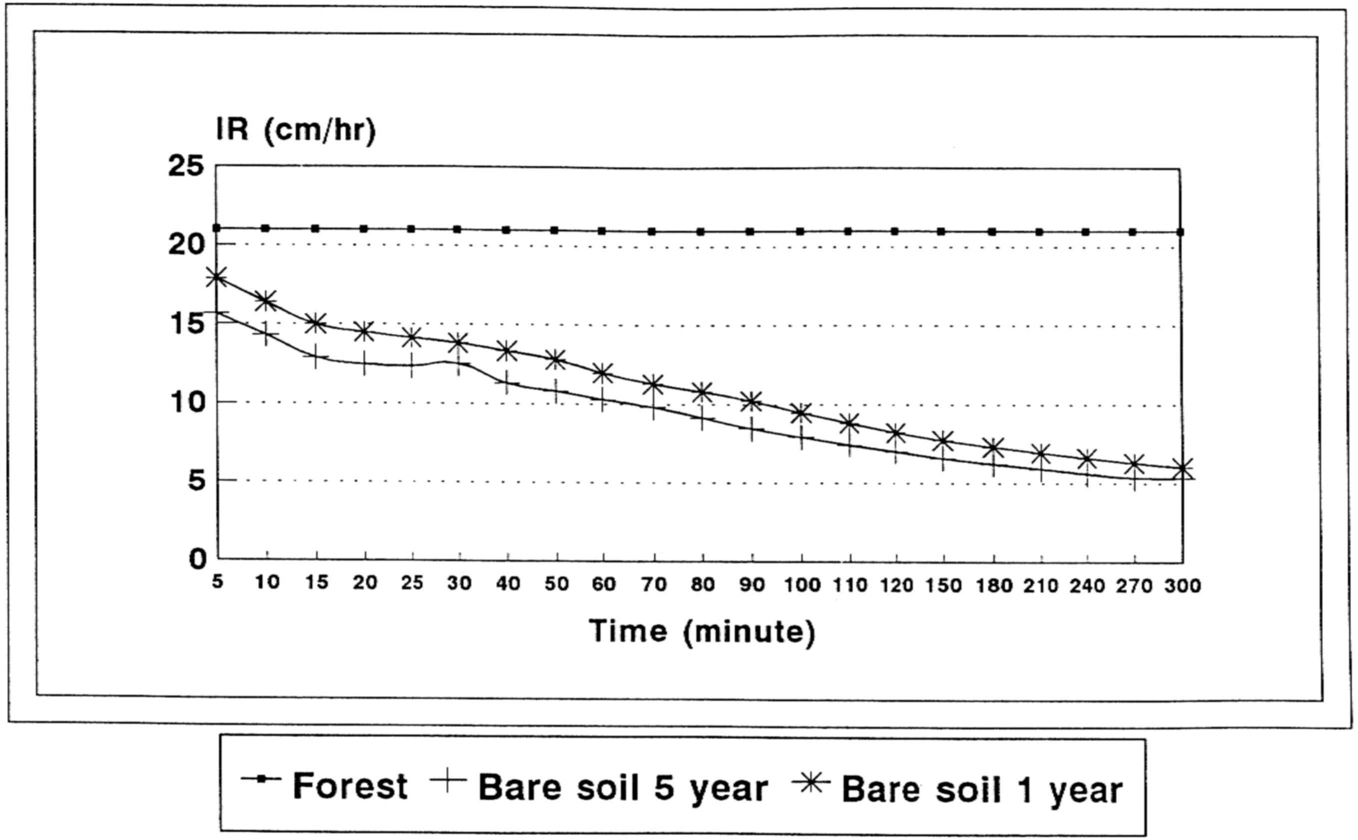
(Forest = Control)

Figure 7.3: Infiltration Rates: (Forest, 7 Year-old Rubber, 7 Year-old Oil Palm)



(Forest = Control)

Figure 7.4: Infiltration Rates: (Forest, 1 Year-old Bare Soil, 5 Year-old Bare Soil)



(Forest = Control)

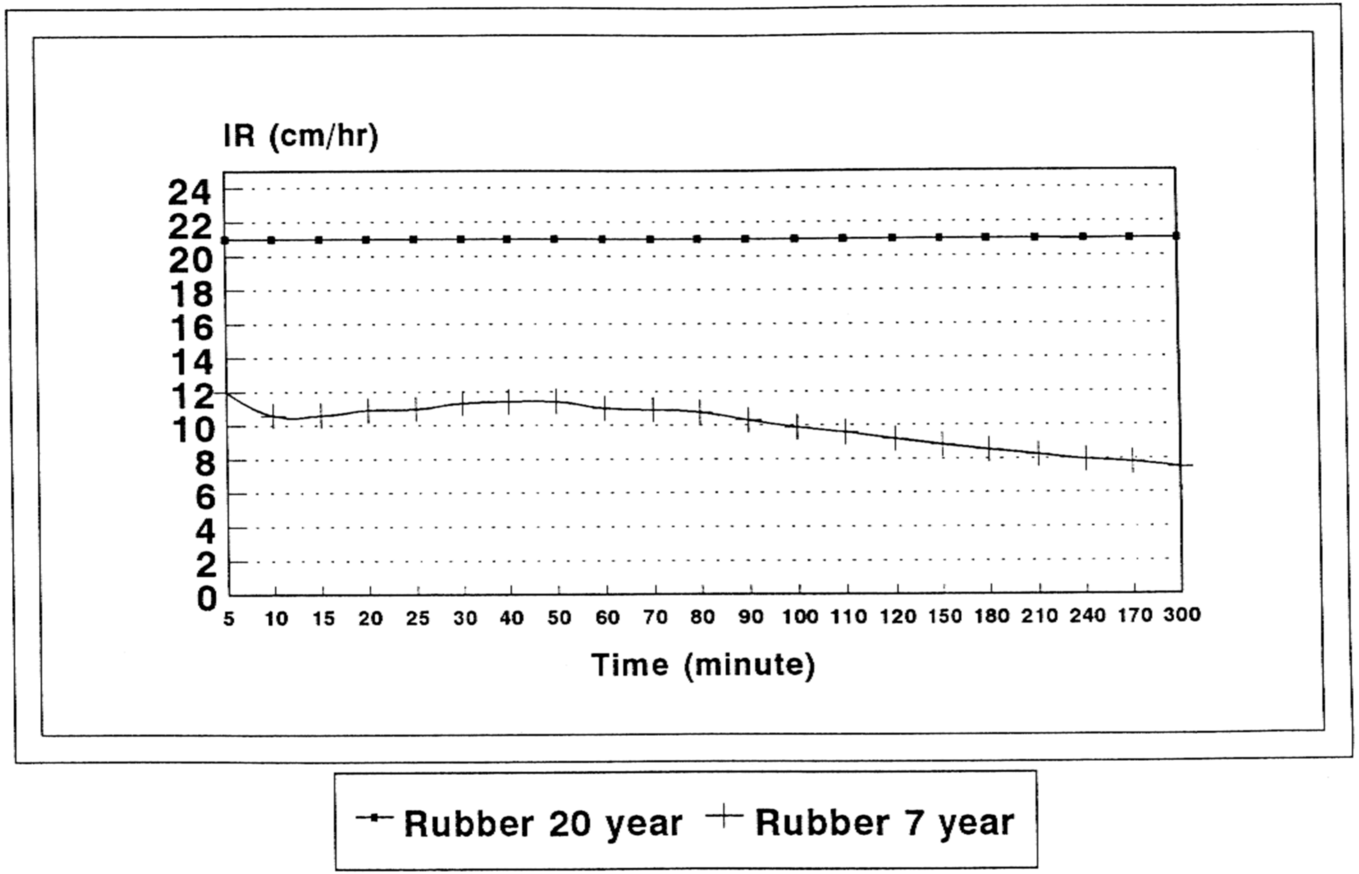
of rainfall simulation, infiltration rates decreased rapidly with time before coming to a steady state. The figure also indicates that infiltration rates under 5 year-old bare soil are almost in every situation, lower than those of 1 year-old bare soil.

A comparison of infiltration pattern between landuses of the same type but of different ages revealed that infiltration capacity is highly influenced by vegetation cover, rather than the age of the landuse. Infiltration curves of landuses of the same type are compared in accordance to their age as shown in Figures 7.5, 7.6 and 7.7.

In Figure 7.5, it is shown that in 20 year-old rubber plantation, the infiltration capacity of the soil is approximately equal to the rate of rainfall application, ie 21 cm/hr. This higher infiltration capacity is actually due to the dense under-layer vegetation which completely covered the soil surface.

A dense cover of vegetation on the soil's surface encourages better aeration, porosity, reduces bulk density and ensures a continuous supply of organic matter,besides protecting the soil from direct throughfall which would eventually cause soil compaction.In a younger rubber plantation (seven year-old), it is shown that infiltration rates are reduced rapidly initially before reaching a steady state. The rates of infiltration are shown as lower in the young plantation , suggesting a lower infiltration capacity of the

Figure 7.5: Comparison of Infiltration Rates (7 Year-old Rubber and 20 Year-old Rubber)



soils. This is due to light vegetal cover on the soil surface , which was not able to successfully protect the soil surface from direct throughfall. This eventually lead to a compaction of the soil surface, hence reducing its infiltration capacity.

In Figure 7.6, the infiltration rate of soil under 20 year-old oil palm vegetation cover is shown as higher than that of soil under 7 year-old oil palm vegetation cover. This indicated that a higher infiltration capacity is also caused by a dense cover of under layer vegetation on the soil surface. In younger oil palm plantations, this under-layer vegetal cover is limited, due to proper agricultural management.

In Figure 7.7, it is shown that the infiltration rate of 5 year-old bare soil is lower than that of 1 year-old bare soil (and the lowest compared to other soils of different landuses).

In this comparison, it seems that both types of landuses had shown similar patterns of infiltration rates which decreased rapidly initially before reaching a steady state. However, at the middle and final stage of simulation, it was obvious that infiltration rate under 1 year-old bare soil proceeded steadily at a higher rate compared to that of 5 year-old bare soil.

Figure 7.6: Comparison of Infiltration Rates (7 Year-old Oil Palm and 20 Year-old Oil Palm)

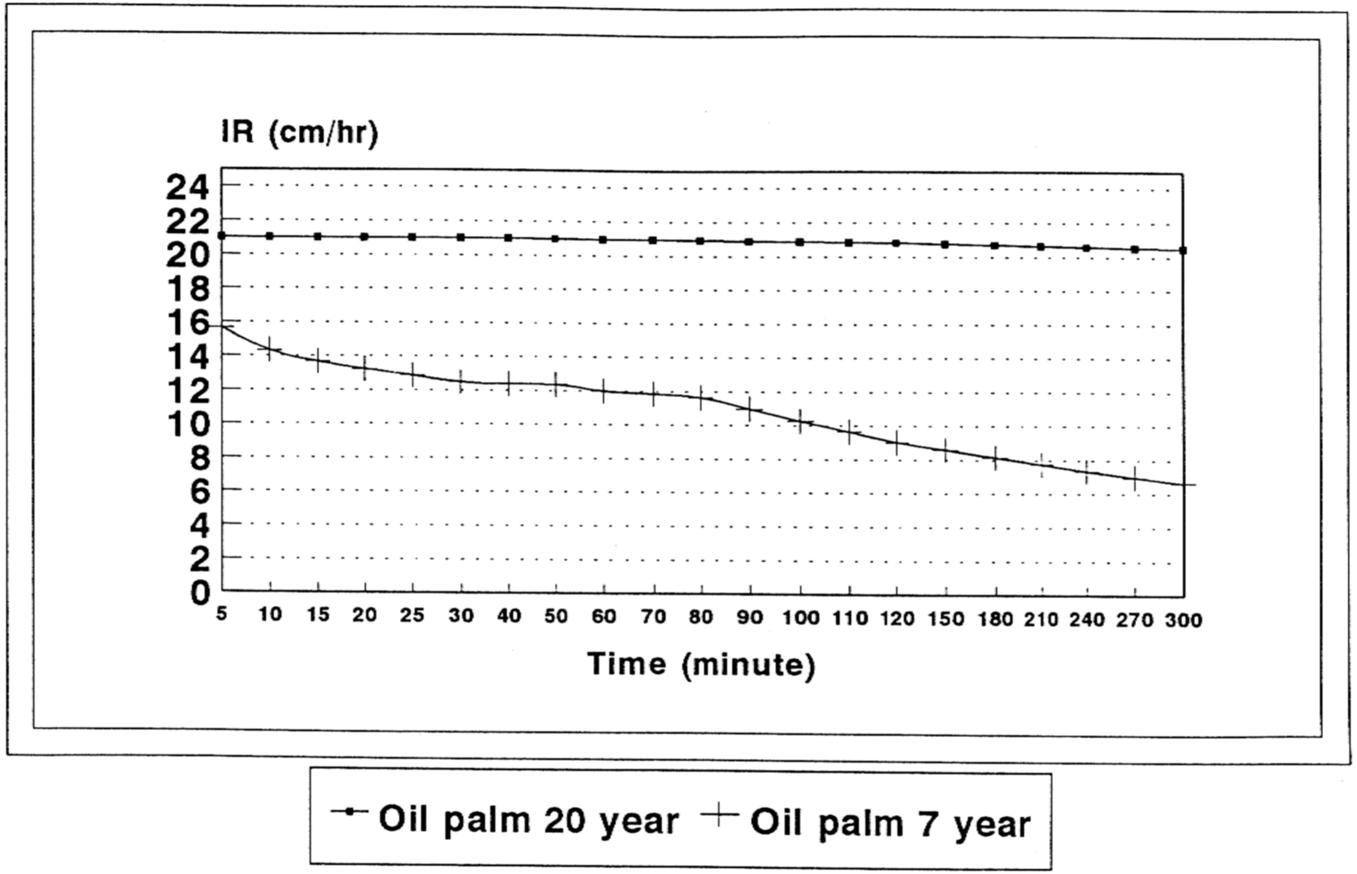
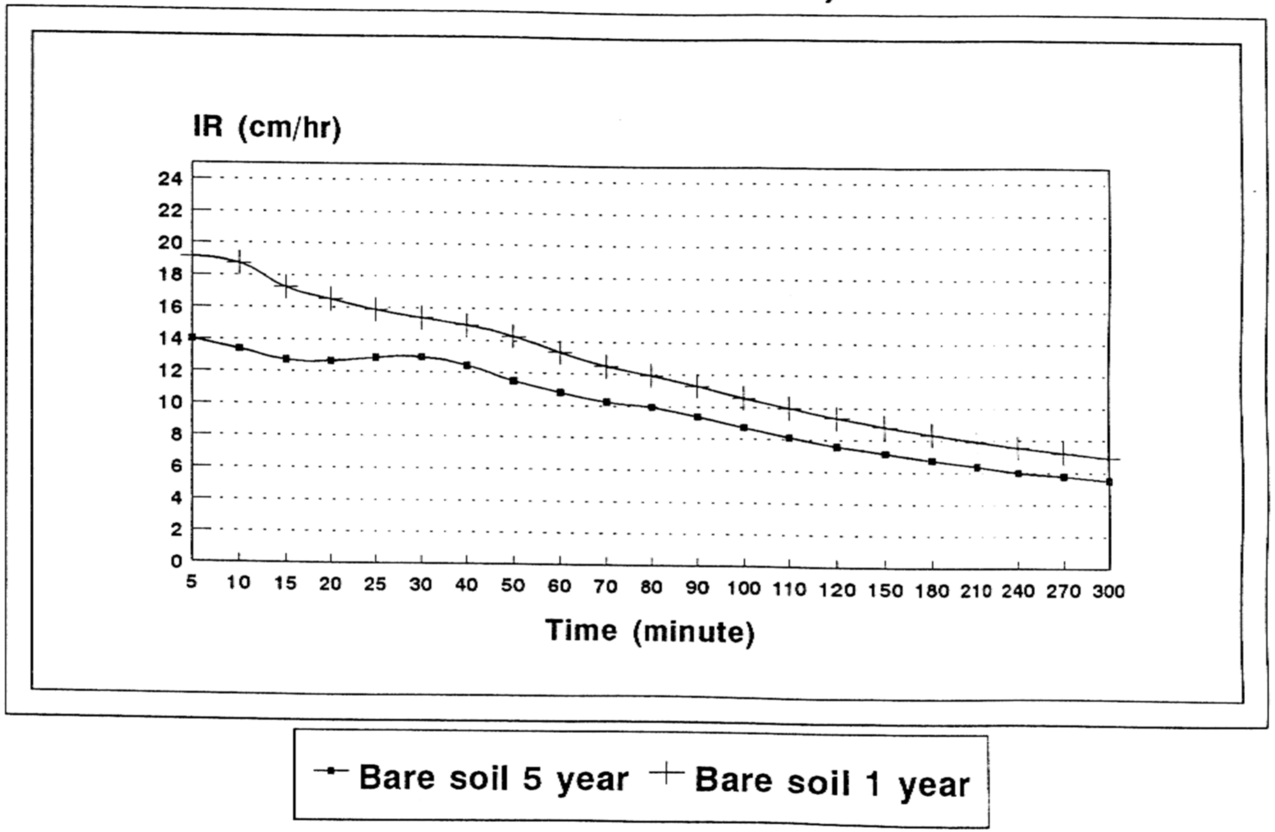


Figure 7.7: Comparison of Infiltration Rates (1-year old Bare Soil and 5-year old Bare Soil)



7.4 Conclusion

There is a significant relationship between the infiltration rate and soil's physical properties, namely the soil bulk density, total pore space, organic matter content and soil aggregate stability. With a coefficient correlation of more than 0.86, the findings suggest that above-mentioned physical properties of soils are the main factors which affect the infiltration rate. It was also found that the higher rate of infiltration is greatly affected by the nature of vegetation. A dense cover of vegetation such as under forest, 20 year-old rubber and 20 year-old oil palm vegetation cover greatly enhance the infiltration capacity of soil.

Soils under forest, 20 year-old rubber and 20 year-old oil palm vegetation cover had better physical properties due to the dense vegetal cover and thick under-layer which enhance the infiltration capacity of the soils.

Infiltration rates of soils under 7 year-old rubber and 7 year-old oil palm vegetation cover were found to be lower than those of forest and 20 year-old rubber and 20 year-old oil palm vegetation cover. This was partly due to the absence of thick under-layer, which is important in preventing soil compaction as a result of rain drop action on the soil surface.

The infiltration rates of five year-old bare soil was found to be the lowest.This is clearly due to total absence of vegetal cover on five year-old bare soil. Due to the thin but scattered vegetal cover on 1 year-old bare soil the infiltration rate recorded was also low. The compacted soil surface, sometimes with the formation of crusts lead to the destruction of soil's physical properties. The soil becomes hard and bulky, with less or non-existent organic matter, bad soil aeration and lower hydraulic conductivity due to the decreased porosity - which in turn reduced greatly the infiltration capacity of the soils.