CHAPTER SIX ANALYSIS OF RESULTS

6.1 Introduction

In this chapter the relationship between infiltration rates of soils under various landuses and various physical properties of soil are determined. Since the infiltration rates are mainly governed by the soil's physical properties, it is clear that by examining the relationship between these variables would lead to a better understanding of which factors are most likely to affect the infiltration rates of the soils.

This study, however, excludes the importance of soil chemical properties in relation to its effect on infiltration rates of the soils. Although chemical properties of soil had long been known to have affected the infiltration rates of soils, physical properties, however, are the most and widely quoted by soil scientists, hydrologists, soil conservationists and irrigation experts. Luge-Lopez (quoted by Gavin 1984) stated that among the most important soil properties influencing infiltration rates are the bulk density, total pore space, aggregate stability etc.

Although the effect of these soils properties on infiltration rates are already known, it is always presented in a qualitative form. Mokhtaruddin, Wan Shamsuddin and Jamal (1983) however had attempted to formulate a relationship between soil moisture and soil bulk density mathematically, using simple regression analysis, but found that the relationship was very weak, ie indicated by a correlation coefficient of 0.152.

6.2 Analysis of Data

Analysis conducted on the data of infiltration rates and soil physical properties revealed that almost every variable is closely correlated to the others. Since this study also attempts to examine the relationship between infiltration rates and the physical properties of the soils, the results of data analysis will be incorporated and discussed accordingly in this chapter. The relationship between infiltration rates and soil physical properties are tabulated in Table 6.1 and 6.2 respectively.

Table 6.1: Correlation Coefficient of Inter-relationship Between Infiltration Rates and Soil Physical Properties

	IR	SBD	TPS	OMatter	SIndex
IR	1.00				
SBD	-0.96	1.00			
TPS	0.96	-1.00	1.00		
OMatter	0.89	-0.92	0.92	1.00	
SIndex	0.91	-0.89	0.89	0.86	1.00

IR : Infiltration rate
SBD: Soil bulk density
TPS: Total pore space
OMatter: Organic matter content
SIndex : Soil stability index

Table 6.2: Regression Equations Between IR and Soil Physical Properties

Relationship	Regression equation
IR vs SBD	y = 57.4 - 32x
IR vs TPS	y = 0.85x - 27
IR vs OMatter	y = 9.1x + 2.03
IR vs SIndex	y = 16x - 2.8

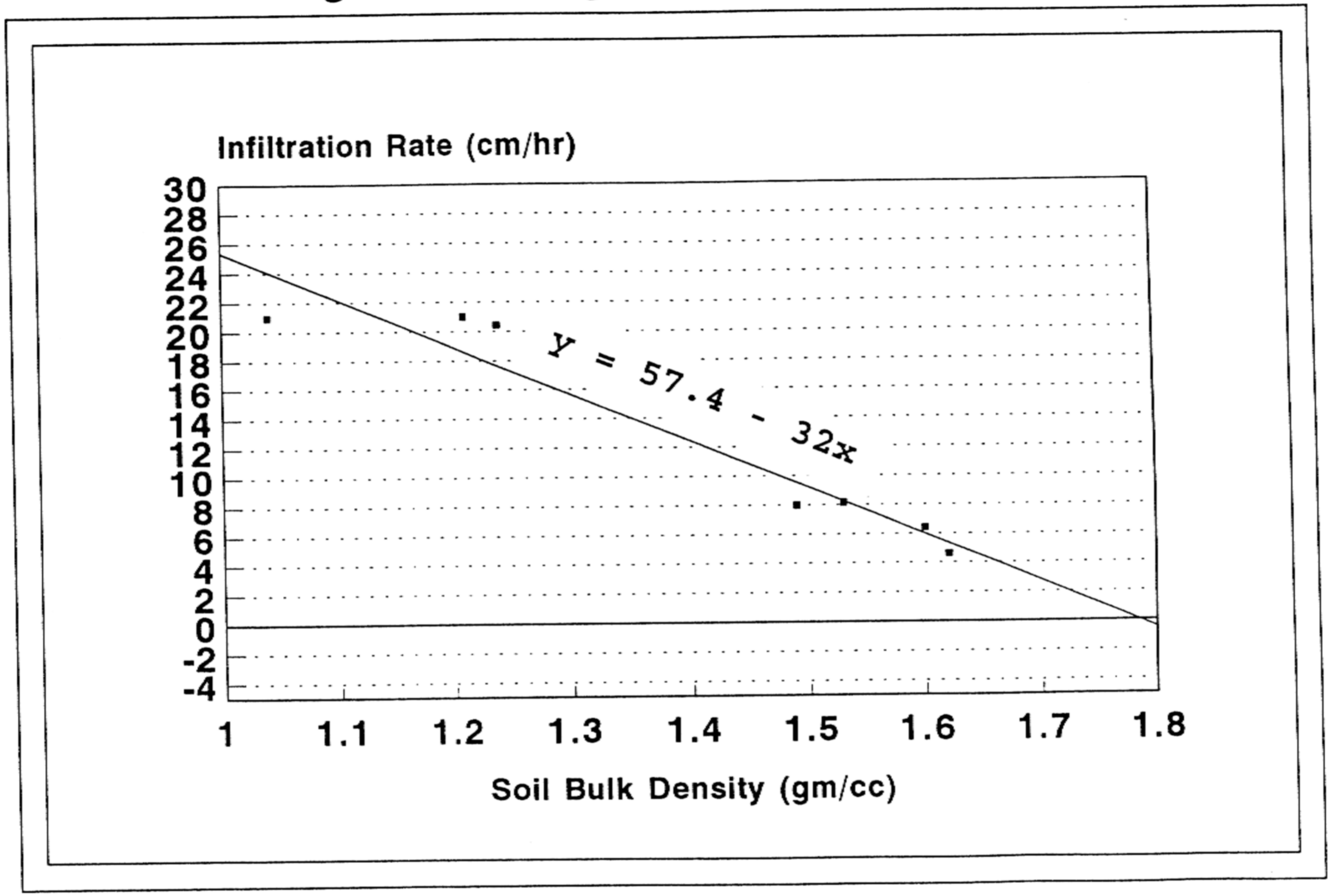
6.3 Effect of Soil Bulk Density on Infiltration Rate

The correlation coefficient of relationship between the infiltration rate and soil bulk density was -0.96. This relationship is represented by a linear regression equation:

$$y = 57.4 - 32x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.1)$$

The relationship between the infiltration rate and soil bulk density is very significant and highly correlated to each other. The relationship between the infiltration rate and soil bulk density is shown graphically in Figure 6.1. It indicated that the relationship is in an inversely proportional order, ie an increase in bulk density is followed by a decrease in infiltration rate. The effect of soil bulk density has been widely quoted. Wilson (1983) stated that exposed soil can be rendered almost impermeable by the compacting impact of large drops coupled with the tendency to wash fine particles into the voids. The surface tends to become puddled and the infiltration value drops sharply.

Figure 6.1: Regression of IR vs SBD



IR = Infiltration Rate
SBD = Soil Bulk Density

Lutz and Chandler (1957), stated that in a clear cutting area, in which an adequate cover of vegetation fails to develop for several years after removal of the stands (forest), the changes most commonly observed are accelerated erosion and increased compactness (indicated by a higher value of bulk density) of the soil. This compacted soil will lead to decreased infiltration rates.

An increase in soil bulk density with depth of soil has been noted by Tanuoe (1982), Wong (1972) and Maesschalck (1983). This partly explains why a sharp decrease in infiltration rates is encountered in the soil of a newly cut area.

In Table 5.2 in Chapter 5, the bulk density is recorded as highest in a bare soil, in which the means are between 1.6 to 1.62 gm/cc. These values are close to that reported by Baharuddin (1989), for soils of skid trails and logging roads, which are 1.49 gm/cc to 1.60 gm/cc, respectively.

The mean bulk density value of forest soils is 1.04 gm/cc. This value is close to that reported by Peh (1978), ie 1.12 gm/cc and also by Baharuddin (op.cit), ie 1.13 gm/cc.

Bulk density of higher value encountered in the bare soils are apparently caused mainly by compaction due to the impact of rain drops on the soil surface or because of traffic movement by tractors and also by man.

6.4 Effect of Soil Total Pore Space on Infiltration Rates

The effect of soil total pore space on infiltration rates has been found to be very significant. With a correlation coefficient of 0.96, it is suggested that total pore space of soils is very closely correlated to infiltration rates.

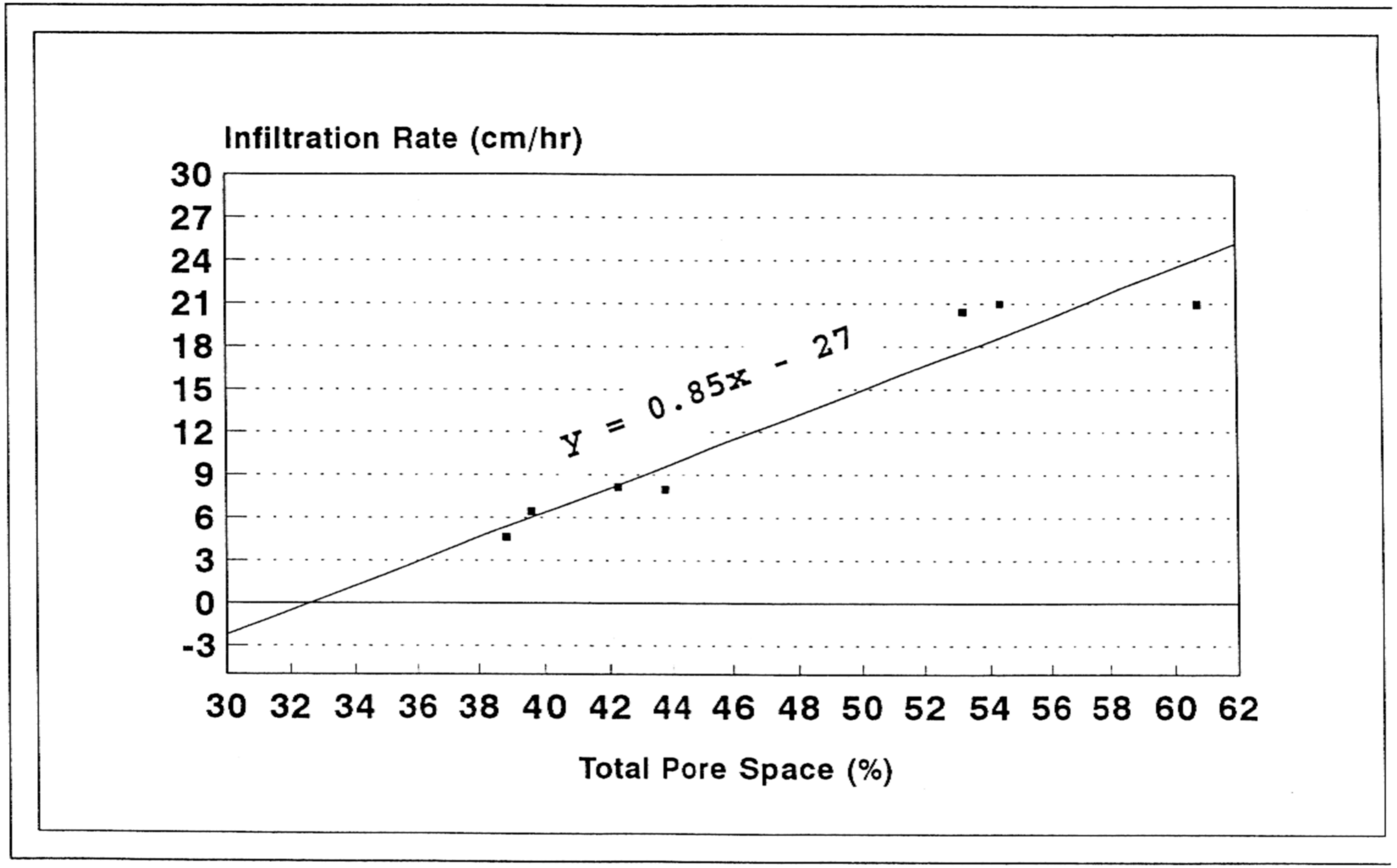
The relationship between the infiltration rate and soil total pore space is represented by a linear regression equation,

$$y = 0.85x - 27 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6.2)$$

and indicated graphically in Figure 6.2. In Figure 6.2, it was indicated that the relationship between infiltration rates and soil total pore space occured in a directly proportional manner, in which an increase in soil total pore space was followed by an increase in infiltration rates.

The effect of soil total pore space on the infiltration rate was noted by Baharuddin (op.cit). He stated that uncompacted soils, with about 18.2 and 11.4% of total porosity (total pore space) are classified as transmission and fissures pores, (which enhance infiltration rates), respectively, while in the compacted soils, such as skid trails the values were 6.2 and 4.9% and for the logging roads, 6.4 and 2.6%.

Figure 6.2: Regression of IR vs TPS



IR = Infiltration Rate
TPS = Total Pore Space

He concluded that, the infiltration process took place more readily in undisturbed areas, which have a comparatively higher percentage of total porosity.

The influence of total pore space on infiltration rates has also been observed by Bennet (1939), who stated that the rate of infiltration for different types of soils were closely correlated with the total amount of pore space.

Lutz and Chandler (1957), stated that soil porosity under vegetation tended to be higher because of the relatively large amount of organic matter added annually, and this favoured the infiltration of water. They also stated that if the porosity of the surface soil layer was reduced, infiltration greatly decreased.

Table 5.3 in Chapter 5 showed that total porosity is highest in soil under forest, followed by areas under 20 year-old rubber and 20 year-old oil palm vegetation cover. The total pore space of the three landuses ranged from 53% to 61%. In soil under 7 year-old rubber and 7 year-old oil palm vegetation cover, the total pore space are between 44% and 42% respectively, while of under bare soil conditions, it is between 38% and 40%. This suggests that under forest, 20 year-old rubber and 20 year-old oil palm vegetation cover, the soils are most permeable and serve as a porous media which enhances infiltration rates. In a bare soil condition, total pore space recorded was the lowest. This explains why infiltration rates were severely reduced in such areas.

6.5 Effect of Organic Matter Content on Infiltration Rates

The effect of organic matter content of soils on infiltration rates has been widely quoted by researchers involved in soil conservation. Lutz and Chandler (op.cit), in their investigation in the Boise National Forest, Idaho, showed that the rate of absorption of water increased greatly with increased content of organic matter.

Absorption, in term of inch/hr, averaged 1.67 for soil having less than 2% organic matter and 9.81 cm/hr for soil having over 5% of organic matter. A decline in the permeability of soil is commonly associated with a decrease in the content of organic matter.

Kolar (1991), stated that physical properties, including bulk density and hydraulic conductivity, improved with increasing organic matter content, which suggested the importance of these properties in affecting the infiltration rates of soils.

Spencer (1990), related the effect of organic matter content on infiltration rates by saying that organic material on the floor of a humid temperate forest varies considerably, but where it is reasonably thick, it has an extremely high permeability which allows water to move into the soil freely.

Kubota (1977), found that mulching of organic matter such as rice straw was very effective in holding the soil's available water. The effect of soil organic matter content on infiltration rates has been conclusively proven in this study. It was found that the infiltration rates of soils under various landuses were found to be highly correlated to their organic matter content(r = 0.89).

Table 5.4 presented in Chapter 5 showed that organic matter content is highest in soils under forest, ie 2.27%. This value is about the same as the one found by Baharuddin (op.cit), under the same condition, ie 2.8%. However, these values are considered higher than those stated by Lutz and Chandler (op.cit) which gave the comparable value for forest soil (organic matter content) as 1.93%.

Meanwhile, the organic matter content under bare soil condition is noted as the least, ie between 0.09 to 0.67. This value is much lower than the one stated by Baharuddin (op.cit) on logging roads, ie 2.6%.

The organic matter content on unshaded areas was found to be 0.62% (Biot, 1990), and this value is similar to that of 1 year-old bare soil. The organic matter content under 20 year-old rubber and 20 year-old oil palm vegetation cover are shown as ranging from 1.39 to 1.93. The organic matter content under 7 year-old rubber and 7 year-old oil palm vegetation cover are shown as ranging from 1.00 to 1.02. (Refer to Table 5.4, Chapter 5).

Figure 6.3 shows a linear regression line which represents a relationship between infiltration rates and organic matter content of soils. It shows that an increase in soil organic matter content is appropriately followed by an increase in infiltration rates.

6.6 Soil Stability Effect on Infiltration Rate

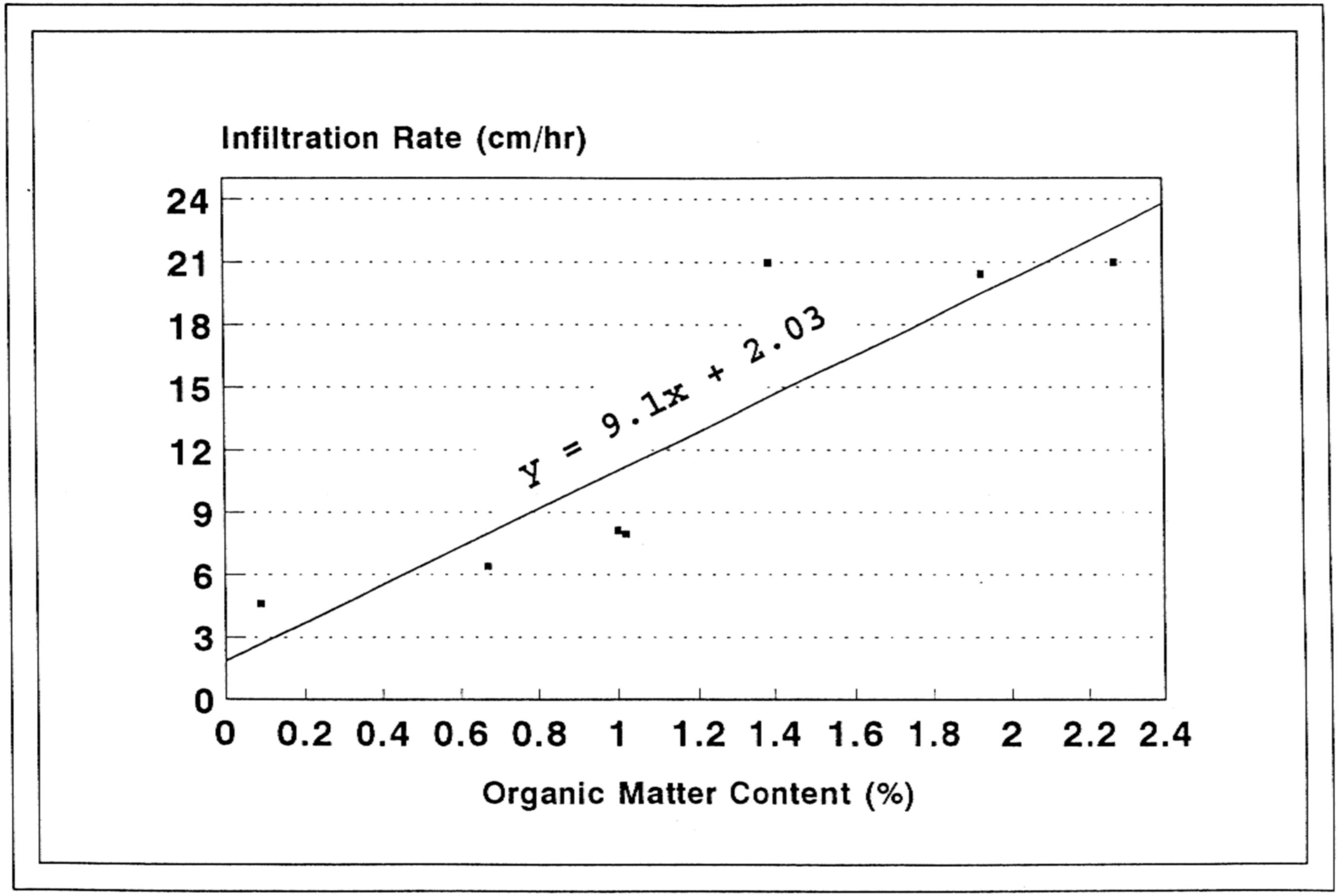
The aggregate stability of soils is most influenced by their content of organic matter, which holds the soil particles firmly (Fitzpatricks, 1971). The effect of soil stability on infiltration rates has been noted stated by Luge-Lopez (op.cit).

Since the stability of soil is closely associated with its organic matter content, the effect of soil stability on infiltration rates is also vital. The correlation coefficient of 0.91 showed that the relationship between infiltration rates and soil stability, which is represented by the equation

$$y = 16x - 2.8 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Eq.6.4)}$$

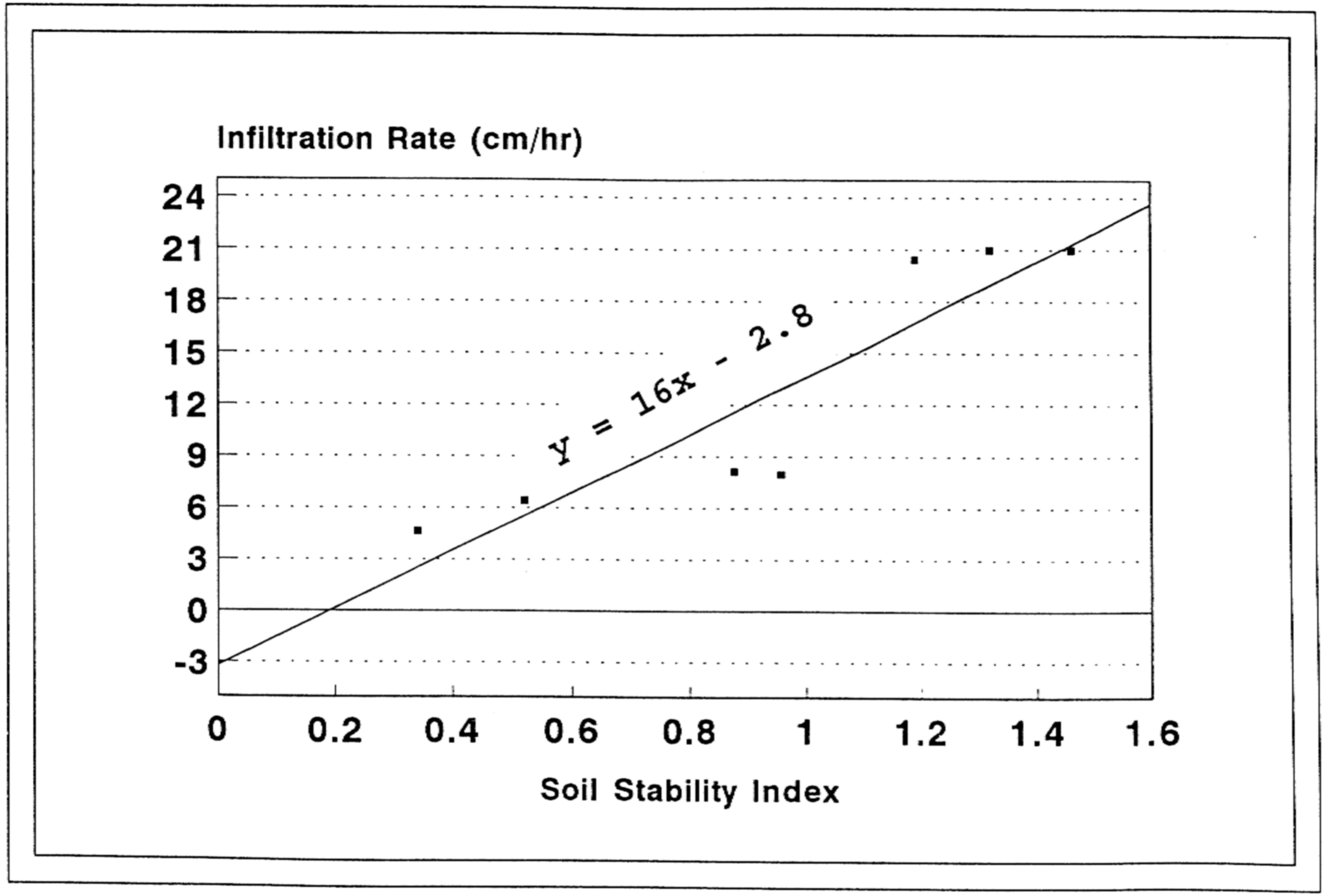
as highly significant. The stability index of soils of various landuses are represented in Table 5.5, Chapter 5. Figure 6.4 indicated that the more stable the soil aggregate, the more readily the infiltration process takes place.

Figure 6.3: Regression of IR vs OMatter



IR = Infiltration Rate
OMatter = Organic Matter Content

Figure 6.4: Regression of IR vs SIndex



IR = Infiltration Rate
SIndex = Stability Index

6.7 Conclusion

Primary data obtained from the field were analysed using simple regression analysis. The relationships between infiltration rates and soil physical properties were shown by their respective correlation coefficient values. In general, it has been shown that most values suggest highly correlated relationships between infiltration rates and soil physical properties.