Chapter 6

Chapter 6

Field Experiment: Monoculture *vs.* Mixculture

6.1 Introduction

It has been reviewed that monoculture covers seemingly fail to stabilise and protect slopes (see section 1.3). Although grasses and legumes are effective at low velocity agent of erosion (e.g. a drizzle), their impact decreases as velocity increases (e.g. a heavily downpour). The stems of woody species, on the other hand, are effective at high velocity agent of erosion, but may generate serious problem in terms of tree-falling along the highway. In this regard, the density and diversity of vegetation covers are important consideration factors in the task of slope stabilisation (Thorne, 1990).

This chapter will examine the effects of vegetation covers on slope stabilisation. The study will emphasis on performance of plant community and slope stability. In view of this, RLD of plant community will be measured. Furthermore, the interrelationship amongst soil penetrability, shear strength and water profile of the soil will be investigated.

6.2 Materials and Methods

6.2.1 Plant Materials

All shrubs were propagated at Hulu Langat by stem cutting. After 3 ½ months, the shrubs were planted along with legumes and vetiver on the experimental slope. Vetiver grass was propagated from three tillers. Then, the grass was transferred to the slope after four months at 7-8 tiller stage. Legumes were sown at 1100 seeds per metre length on slopes. The observed germination rate was 27 %.

6.2.2 "Bush-ecosystem" Experiment

Since this "bush-ecosystem" is going to be implemented on a barren slope, the soil quality has to be improved beforehand. Legume has been suggested to be the first species to be grown on slopes as it is the fast growing initial crops and also could adequately fix nitrogen (Butler, 1955). *Pueraria phaseoloides* is used in this project.

Secondly, plant species with good root system is needed to nail soil surface for providing some erosion control. Study has showed that vetiver can be used to reduce erosion due to its extensive root system. It has been proven that vetiver is also tolerant of a large range of soil and ground water conditions. Its base tillers can block the soil from eroding (Grimshaw, 1995). Hence, it can be used to enhance the efficiency of slope stabilisation (Brown and Clark, 1995). Vetiver, namely *Vertiveria zizanioides* was used in the experiments.

Lastly, *Justicia betonica*, *Lantana camara* and *Thunbergia erecta* selected earlier in the previous chapter was planted along with legume and vetiver.

6.2.3 Experimental Design

(a) Six plots have been designed on the experimental slope which had the same soil type and condition. The schematic design has been sketched (Figure 6.1).

(b) Information of the plots have been described and tabulated (Table 6.1).

6.2.4 Measurements

Photosynthesis rates, transpiration rates and leaf area were done by using the same equipment and method described earlier (see 2.2.2a and 2.2.2d). Components of

Table 6.1 : Description of the plots

PLOT	SPECIES	NO. ROWS	SPACING	DATE OF PLANTING (on slope)
PL 2-1 (RVL)	*Pueraria phaseoloides* (legumes) *Vertiveria zizanioides* (vetiver) *Lantana camara* (shrubs)	**2** **3** **2**	**-** **10cm** **40cm**	5-7 Sept. '96 13-15 Oct. '96 30-31 Oct '96
PL 2-2 (RVJ)	*Pueraria phaseoloides* *Vertiveria zizanioides* *Justicia betonica* (shrubs)	**2** **3** **2**	**-** **10cm** **40cm**	5-7 Sept '96 13-15 Oct. '96 30-31 Oct. '96
PL 2-3 (RVT)	*Pueraria phaseoloides* *Vertiveria zizanioides* *Thunbergia erecta* (shrubs)	**2** **3** **2**	**-** **10cm** **40cm**	5-7 Sept '96 13-15 Oct. '96 30-31 Oct. '96
PL 2-4 (RVLJT)	*Pueraria phaseoloides* *Vertiveria zizanioides* *Lantana camara* *Justicia betonica* *Thunbergia erecta*	**2** **3** **mix** **mix** **mix**	**-** **10cm** **40cm** **40cm** **40cm**	5-7 Sept. '96 13-15 Oct. '96 30-31 Oct. '96 30-31 Oct. '96 30-31 Oct. '96
PL 3-1 (RV)	*Pueraria phaseoloides* *Vertiveria zizanioides*	**2** **3**	**-** **10cm**	5-7 Sept. '96 13-15 Oct. '96
PL 3-2 (R)	*Pueraria phaseoloides*	**2**	**-**	5-7 Sept. '96

R (runners) = symbol represents legumes

V = symbol represents vetiver

L = symbol represents *L.camara*

J = symbol represents *J.betonica*

T = symbol represents *T.erecta*

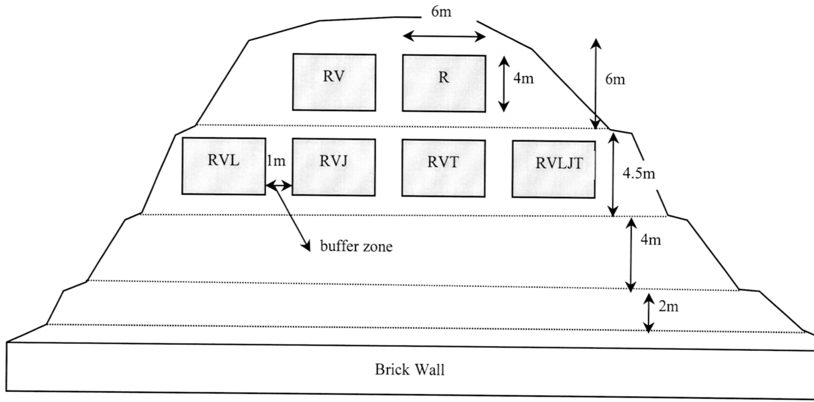


Fig. 6.1 : Six plots at the experimental slope

photosynthesis which comprised light response curve and CO_2 response curve (ACa & ACi) of the shrubs were obtained by using portable photosynthesis system (PPSystem, CIRAS-1, USA). Leaf area index (LAI) was measured in every species studied in both mono and mix-culture plots by using plant canopy analyser (LICOR, model LAI-2000, USA). In addition, five replicates of LAI were measured randomly at each plot. Quadrates (1m x 1m) were used to determine the diversity of the plots. Three replicates were taken randomly at each plot. Quadrates (0.5m X 0.5m) were used to take biomass diagonally across the plot. Four replicates of each plot were taken randomly. Other parameters such as RLD, penetrability, shear strength and water content of soil were carried out as described earlier (see 5.2.2a, 5.2.2b and 5.2.2c).

6.3 Results and Discussion

6.3.1 Physiological Performance of the Shrubs

(a) Photosynthesis Rate

Both *L.camara* and *J.betonica* show highly significant differences between mono and mix-culture treatments (Appendix 2). Photosynthesis rate of *L.camara* in the mix-culture plot was extremely high in which its value was more than twice compared to that of monoculture. Similarly, although not as high as *L.camara*, *J.betonica* showed excellent performance of assimilation rates in the mix-culture plot compared to that of monoculture.

The results imply that, amongst the species, *L.camara* grew very well on slopes as inferred through physiological criteria used when planted in mixed culture system. Though *J.betonica* also grew very well, it did not perform as well as that of *L.camara* adjudged on similar physiological criteria.

However, *T.erecta* did not show any difference between the two treatments. It indicates that this species cannot compete interspecifically with the other species used in the study. This is perhaps due to its small height where shading effect may come from other bigger species.

(b) Transpiration Rate

L.camara and *T.erecta* show highly significant difference in transpiration rates between the two plots (Appendix 2). The results are as expected as in the mixed community, with soil water trapped within the different levels of diverse species. Ultimately, the soil water would be absorbed by the plant. The more water is absorbed, the more it transpires. However, the transpiration rates of both species in the mix-culture plot are not too high (relative to their photosynthesis rates).

In contrast, transpiration rate of *J.betonica* did not show any difference between the plots. This is a good indication that transpiration of neighbouring plants did not influence the transpiration of *J.betonica*.

(c) Leaf Area Index (LAI)

The value of LAI of all species studied were quite low and only *J.betonica* exhibited difference between the two treatments plots (Appendix 2). The LAI of *J.betonica* in the monoculture plot is expected to be higher than that of mix-culture plot because of the lack of competition with other aggressive species for nutrient or water. However, the results show that LAI of *J.betonica* of the mix-culture treatment was about 50% more compared to the monoculture. This indicates that *J.betonica* is induced to grow better when there is competition with other species.

The LAI of *T.erecta* was the lowest of the species studied either in mono- or mix-culture plot. This inherent quality including small height and low RLD (see 2.3a) does not allow this species to compete with other species used in the current studies.

(d) Shrub Performance in the Mix-culture – December 1996 *vs.* December 1997

The increment in photosynthesis rate of *L.camara* was the highest (382%) among the species and between the parameters studied (Fig. 6.2). This results show that *L.camara* did extremely well on slopes and managed to adapt to the mixed culture system. However, its LAI was decreased by 3.7% during the year. It may be due to the decreased value in leaf area since its leaf was easily burnt in intense heat prevailing on the slopes. The increment of LAI of *L.camara* and *T.erecta* was quite low while in *J.betonica* it was relatively higher, 55.6%. Generally, *L.camara* and *J.betonica* seem to grow well and adapted to the mix-culture system as their photosynthesis rates increased more than 100%. However, *T.erecta* was observed to be fairly unsuitable to the mix-culture treatment as its photosynthesis increment was less than 70%. It also implies that *T.erecta* was less aggressive in competing for nutrient, water, light and space when planted with diverse species in the mix-culture plot.

The increment of transpiration rates during the year was significant in all species studied: *L.camara* (253.5%), *J.betonica* (140.0%) and *T.erecta* (215.6%). These results show that the mix-culture system had an effect on transpiration rates. Since transpiration is dependent on stomatal behaviour, this results also imply that stomatal conductance (data was not shown) of shrubs studied was also affected, in this case, possibly they had adapted to the drier environment. The root system that developed after a year would have been significantly more extensive, subsequently allowing more water absorption and transpiration.

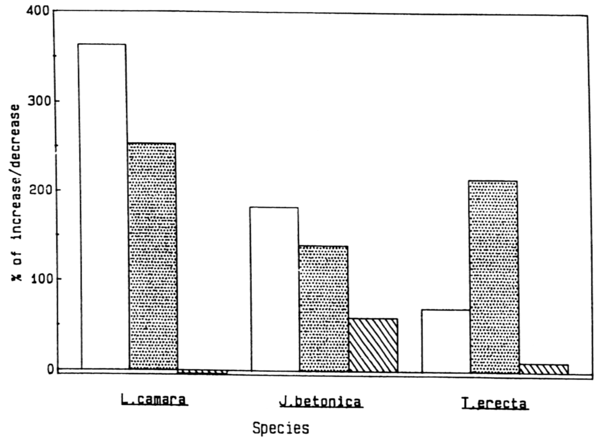
(e) Component of Photosynthesis

(ii) Light Response Curve

All shrubs studied showed the typical curve which has two phases : linear and horizontal line (Long and Hallgren, 1987). The linear phase is a light limiting, meaning the effect of carbon dioxide on photosynthesis process was influenced by the amount of

Fig. 6.2 : Performance of the shrubs in the mix-culture treatment (December 1996 – December 1997). The percentage (%) is the increment of the parameters studied. (□ photosynthesis rate, ⊡ transpiration rate, and ▨ LAI).

Fig.6.2: Performance of the shrubs in the mix-culture treatment (December 1996-December 1997)



light, which is in turn, influenced by leaf resistance (Farquhar and Sharkey, 1982). In addition, quantum efficiency (QE) can be obtained from the slope of the linear phase (Appendix 4). In this observation, QE of *J.betonica* and *L.camara* are similar and *T.erecta* are about 30% lower (Table 6.2). It is suggested that these two species had slightly higher efficiency of light utilisation compared to *T.erecta*. Meanwhile, *T.erecta* showed the best light compensation point compared to other species. It indicates that this species needs light as low as 31 $\mu E\ m^{-2}\ s^{-1}$ to affect a positive carbon balance. Moreover, the range of light compensation point of all the species, 31.0 – 55.9 $\mu E\ m^{-2}\ s^{-1}$, indicates that all the shrubs studied have a good potential as carbon sink.

At the second phase of the curve, carbon dioxide was a limiting factor to carboxylation process in dark reaction (Appendix 3). At this saturation level, increase of light does not increase the photosynthesis rate. The A_{max} or light saturated assimilation rate was obtained from this line and *J.betonica* was observed to have the highest A_{max} (Table 6.2). The results indicate that *J.betonica* had high CO_2 absorption capacity to turn it into organic matter. It implies that this species serves as a good potential as carbon sink to reduce the ever increasing CO_2 concentration in atmosphere, the most discussed global issues currently. Light saturation at ambient CO_2 (360 ppm) occurred at PAR 2001 μE $m^{-2}\ s^{-1}$ in *L.camara*, followed by *J.betonica* (1100) and *T.erecta* (500). Furthermore, all the shrubs studies did not show any photo-oxidation (Appendix 3).

(ii) Carbon Dioxide Response Curves (ACa and ACi)

Carbon dioxide response curves or relationship between photosynthesis rates and CO_2 concentration, whether ambient (Ca) or in the substomatal cavity (Ci), showed a typical hyperbolic rectangular relationship in all shrubs studied (Appendix 3). Similar to light response curve, ACa and ACi have two phases : (1) linear and (2) horizontal line. The linear phase is CO_2 limiting related to the function and activity of RuBP carboxylase. Whereas, the horizontal line is where the CO_2 assimilation rate equals the RuBP regeneration rate. This rate can be increased with increase in level of light (Von

Table 6.2 : Some parameters related to photosynthesis components of the species studied.

Species	Light Response Curve				Carbon Response Curve (ACa & ACi) (at PAR 1000 μE $m^{-2}s^{-1}$)				Cummulative rank
	QE (μE $m^{-2}s^{-1}$)	Γ_l (μE $m^{-2}s^{-1}$)	A_{max} (μmol $m^{-2}s^{-1}$)	Light at 360 ppm (μE $m^{-2}s^{-1}$)	A_{max} (μmol $m^{-2}s^{-1}$)	A_{360} (μmol $m^{-2}s^{-1}$)	g_m (μmol $m^{-2}s^{-1}$)	Γ_{CO2} (ppm)	
J.betonica	1 (0.06)	2 (42.8)	1 (12.6)	2 (1100)	1 (37.6)	1 (16.2)	1 (0.11)	2 (70.0)	11
L.camara	1 (0.06)	3 (55.9)	2 (9.3)	1 (2001)	3 (16.7)	2 (10.0)	2 (0.08)	1 (48.5)	15
T.erecta	2 (0.04)	1 (31.0)	3 (4.3)	3 (500)	2 (17.7)	3 (2.4)	2 (0.08)	3 (96.5)	19

A_{max} and A_{360} were obtained from ACa curve

g_m and Γ were obtained from ACi curve

Number indicates a "rank" in descending order

Caemmerer and Farquhar, 1981). Results show that both ACa and ACi curves were similar to each other (Fig. 6.3 and 6.4). Since Ci is found in substomatal cavity which is near to carboxylation site, photosynthesis in all shrubs studied possibly were co-regulated by stomatal and mesophyll factors. Maximum assimilation rate, A_{max}, and ambient carbon dioxide, A_{360}, can be obtained from ACa curve. Both A_{max} ($\mu mol\ m^{-2}\ s^{-1}$) and A_{360} of *J.betonica* at 1000 $\mu E\ m^{-2}\ s^{-1}$ was observed to be the highest. In addition, the results showed that at ambient carbon dioxide, assimilation rate of *L.camara* was only 59.9% of A_{max}, followed by *J.betonica* and *T.erecta*, 43.1% and 13.6%, respectively.

Meanwhile, mesophyll conductance, g_m and CO_2 compensation point, Γ, can be obtained from ACi curve (Appendix 5). The g_m value of *J.betonica* was the highest among the shrubs and its assimilation rate is expected to be more efficient compared to other species. Whereas, CO_2 compensation point, Γ, is a point where photosynthesis rate is equal to respiration rate. The value of *L.camara* was observed to be the best and least carbon concentration is needed for the balance. It was also suggested that all the shrubs studied are C3 plants due to high Γ. C4 plants has much lower value of Γ which is close to 0 due to very low photorespiration rate (Fitter and Hay, 1981).

Studies have shown that A_{max} increases with intensity of light. This is because high amount of light would increase the rate of regeneration of RuBP substrate due to the increase rate of NADPH and ATP production in the light reaction (von Caemmerer and Farquhar, 1981). Results show that photosynthesis rate of *L.camara* was enhanced when PAR was 2000 $\mu E\ m^{-2}\ s^{-1}$ in both responses (ACa & ACi) (Fig. 6.3 and 6.4). *J.betonica* showed differences at PAR 500 $\mu E\ m^{-2}\ s^{-1}$ but not at PAR of 2000 and 1000 $\mu E\ m^{-2}\ s^{-1}$. However, *T.erecta* did not show any difference at any level of PAR. The results imply that photosynthesis rate in both *L.camara* and *J.betonica* were increased with light intensity while in *T.erecta* was not. Perhaps the photosynthesis rate of *T.erecta* may be affected by other factors such as plant- and soil-water relations.

Fig. 6.3 : Carbon response curve (ACa) of the species studied (a) *L. camara*, (b) *J. betonica* and (c) *T. erecta*, at PAR ■ 2000, ▲ 1000, ◆ 500 μE m^{-2} s^{-1}.

Fig.6.3: Carbon response curve (ACa) of the species studied

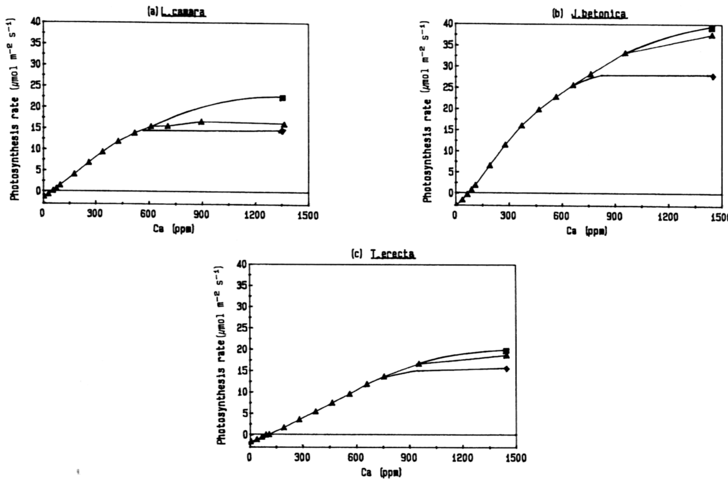


Fig. 6.4 : Carbon response curve (ACi) of the species studied (a) *L. camara*, (b) *J. betonica* and (c) *T. erecta*, at PAR ■ 2000, ▲ 1000, ◆ 500 μE m^{-2} s^{-1}.

It can be concluded that *J.betonica* was leading for most of the parameters studied, followed by *L.camara* and *T.erecta* (Table 6.2), as inferred in the cumulative rank. This shows that *J.betonica* and *L.camara* have promising characteristic features in aspects of photosynthetic components and would possibly be good slope plant.

6.3.2 Performance of the Plant Community

(a) Leaf Area Index (LAI)

The LAI is a measurement of leaf area per unit land area. The results show that there was significant difference among the treatments (LSD = 0.91 at $p < 0.001$). The mix-culture plot had the highest LAI which is possibly due to high diversity of plant species (Table 6.3). The developing leaf is dependent on import of carbon from other parts of the plant. This mix-culture plot was considered to have high photosynthetic activity. And these activities are dependent not only on the intensity of light but also on the distribution of this energy within the canopy. Since the mix-culture plot had dense vegetation cover, there is a greater competition for light, thus accelerating the growth compared to other plots. Conversely, monoculture plot had the lowest LAI for similar reason (Table 6.3).

(b) Diversity

Field examination of the plants showed that in all plots, other than the species planted, new species have established. The barren slope in December 1996 is totally covered by numerous species of shrubs, ferns and grasses in December 1997 in all plots except RV and R, with 6.5% and 26.7% of the slope areas still barren, respectively (Appendix 7).

In particular, within one year, the mix-culture (RVLJT) plot had increased its number of species by 144.4 % and the plot that was planted with only legumes (R) increased by only 25.0% (Table 6.4). This shows that the mix-culture system (e.g. RVLJT) has a

Table 6.3 : Performance of Leaf Area Index (LAI) of the plant community in December 1997.

PLOT	TYPE OF PLOTS	SPECIES	AVERAGE
PL 2-1	RVL	L + V + *L.camara*	3.57± 0.63
PL 2-2	RVJ	L + V + *J.betonica*	3.52± 0.34
PL 2-3	RVT	L + V + *T.erecta*	2.91± 0.83
PL 2-4	RVLJT	L + V + *L.camara* + *J.betonica* + *T.erecta*	4.69± 0.60
PL 3-1	RV	L + V	2.01± 0.26
PL 3-2	R	L	1.91± 0.20

Table 6.4 : The percentage of increment in diversity at the experimental plots from December 1996 to December 1997 (summarisation of Appendix 6 and 7).

PLOT	NO. SPECIES		% INCREASE
	(1996)	(1997)	
RVL	6	12	100
RVJ	7	13	85.7
RVT	7	13	85.7
RVLJT	9	22	144.4
RV	5	7	40
R	4	5	25

positive effect on diversity, in sense of maximising it. Meanwhile, plots RVL, RVJ and RVT had increased the diversity by 100.0%, 85.7% and 85.7%, respectively. These plots also show promising biodiversity enhancement.

Apparently, legumes faded in RVLJT, RV and R plots. In the former plot, various species had replaced legumes which ultimately decreased by 94.8% in vegetation cover. In the case of plots RV and R, legumes faded away more significantly and decreased by 183.1 and 670%, respectively. These results show that the two plots were not successful in terms of sustainability and stability. Natural succession was not favoured in both plots and lack of diversity meaning lack of anchorage to the soil.

Similar to legumes, vetiver did not perform very well in all plots except RV. In fact, in plot RVJ, vetiver could not survive beyond three months. In plot RV, the increment of the ground cover was very low, about 16% only. This species performed poorly possibly due to high light requirement which they did not get. However, in this experimental design where vetiver was planted in the middle and at the edge of the plot, its tillers mingled with other species, occasionally causing necrosis. It is suggested that vetiver be planted only on the berms, not in the middle of a plot.

Melastoma malabatricum was consistently found in every plot. This species occupied 8.0 - 27.7% of ground cover in December 1997 compared to 1.0 - 9.0% in December 1996. Amongst unplanted shrubs observed in December 1997, melastoma is considered to be dominant in all plots. This result suggested that this species is arguably the best invading species on slopes.

(c) Biomass

The results showed that there was significant difference among the treatments (LSD = 201.8 at $p < 0.001$). The RVLJT had the highest biomass, which was four fold that of plot R, thus exhibiting the lowest (Fig. 6.5). The reason behind this good performance of plants in plot RVLJT is perhaps related to their accomplishment in photosynthesis (Fig. 6.2), LAI (Table 6.3), plants diversity (Table 6.4), and RLD (Appendix 8 and Fig. 6.7).

(d) Relationship between Diversity and Biomass

Results showed that both parameters had very high relationship between them (r = 0.98). The high biomass may be due to the high species-richness in the indicated plot and *vice versa* (Fig. 6.6). When plants start to increase in diversity, space, light and other resources have to be shared, creating different trophic levels, which further enhance the requirements for more diversity and individuals. Thus, the plants are in favourable condition to complement and supplement each other which ultimately increase further the diversity.

6.3.3 Stability of the Slopes

(a) RLD of Plant Community on the Slopes

The RLD of all plots decreased with soil depth (Fig. 6.7). As expected, results show that the mix-culture plot had the highest total RLD, conceivably due to dense vegetation cover. On the other hand, monoculture plot had the lowest RLD. The trend of the total RLD in descending order is as follows (* not significant between the two plots):

RLD :	RVLJT	> RVJ	> RVL >	RVT >	RV	> R
(km m^{-3})	**(35.8)**	**(17.3)**	**(15.4*)**	**(15.2*)**	**(14.9)**	**(12.6)**

The results are consistent with the RLD of the bushy and failed slope along the NSE

Fig.6.5: Biomass of the plots studied at FSKTM

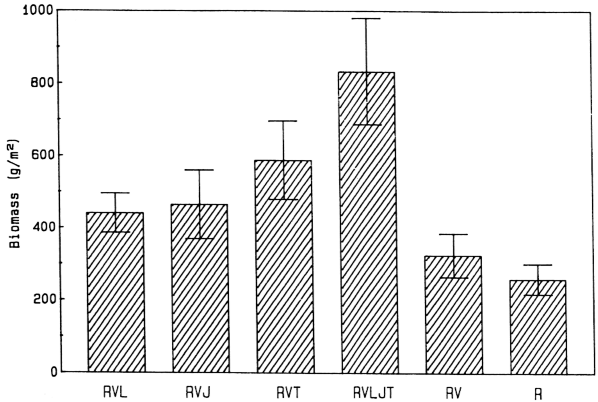


Fig.6.6: Relationship between biomass and diversity of the plot studied

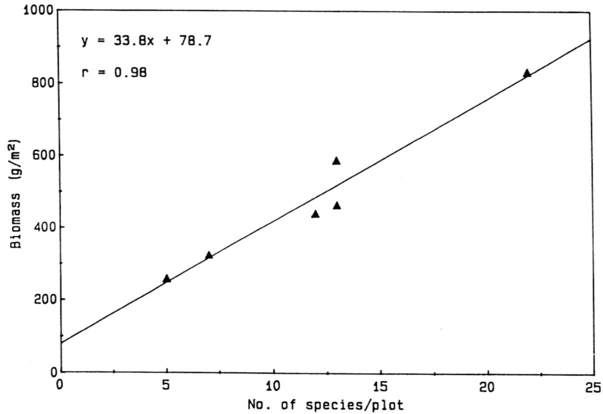
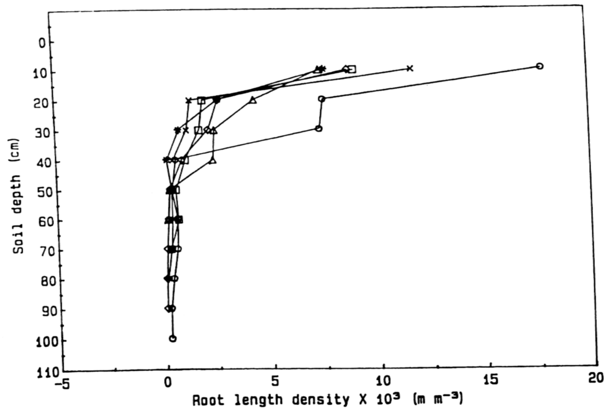


Fig. 6.7 : RLD at 5 type of slopes along the NSE. Each point represents the mean of 4 determinations (○ RVLJT, □ RVL, Δ RVJ, ◊ RVT, × RV and ✳ R).

Fig.6.7: Root length density of 6 plots studied at FSKTM slopes



discussed in earlier chapter (5.3a). Furthermore, only mix-culture plot showed root length exceeding 100 cm soil depth. The other three plots had similar total of RLD. The RVJ plot had the highest RLD among the plots. It had vigorous RLD at 20-40 cm soil depth compared to other plots. This is likely related to the results of the previous experiment where *J.betonica* was found to have the highest RLD among the species studied (see 2.3.2).

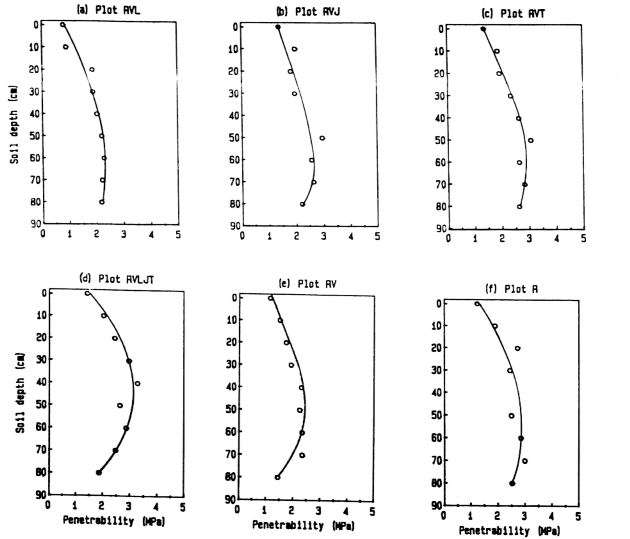
In the case of RV plot, it had moderately high RLD with the second highest at the first 10 cm soil depth (Appendix 8). Since this plot was grown with legumes and vetiver, the high RLD most probably be a contribution of vetiver. Numerous studies have proved that vetiver has extensive RLD (Grimshaw, 1995). Moreover, lack of competition in this plot allowed vetiver to grow well and received enough light. However, the RLD sharply decreased beyond 10 cm soil depth and only reached a depth of 40 cm. In all plots studied the highest RLD was seen at the first 10 cm contributing 43.1 – 79.2% of the total.

(b) Soil Penetrability

The resistance to penetration of the soil in all plots varied from about 0.81 to 3.96 MPa (Fig. 6.8). The plot which showed the highest penetrability, RVLJT, had the range of 2.62 – 3.96 MPa. These values fit the range of penetrability of type A to type C slope along NSE (5.3.3). This result implies that all plots studied at FSKTM was unlikely to fail and stable in terms of the soil penetrability.

Most of the plots showed the increasing penetrability at 50 – 60 cm soil depth. However, for the mix-culture (RVLJT) plot, the highest penetrability was obtained at about 30 cm soil depth. This may be due to the extensive RLD at that soil depth in the plot.

Fig.6.8: Penetrability of the soil at FSKTM slopes



(c) Shear Strength

The mix-culture (RVLJT) plot had the lowest shear strength at 4 inches (10 cm) of the soil depth among the plots (Table 6.5). This result is similar to type A slope along NSE (5.3.4) which was quite low just for the same reason explained earlier (5.3.4). However, at 12 inches (30 cm) soil depth, RVLJT plot had the highest shear strength which may be due to the high RLD at this depth. In that respect, the shear strength of the type A slope studied was expected to have the highest shear strength amongst the slopes studied along the NSE at 12 inches soil depth. The RVL, RVJ and RVT plots had moderate shear strength which may be due to the combination of low SWC but moderately higher RLD. Plot RV can be considered a stable slope as it had the highest shear strength amongst the slopes, arguably due to low SWC at 20 cm (Fig. 6.9). All plots showed very high shear strength at 30 cm (12 inches) soil depth. This may be due to the reinforcement by the root system with increasing depth. The shear strength at 30 cm is more relevant to a soil mechanic, for instance, because most slope failures occur at a depth between 20 to 50 cm.

(d) Soil Water Content (SWC)

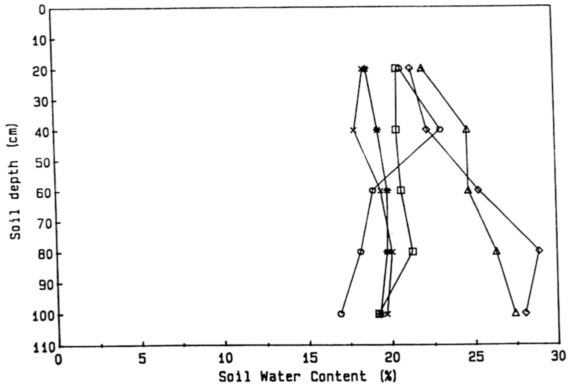
The results showed that the range of SWC of all the slopes studied was 18.0 – 29.0 % (Fig. 6.9). This range is similar to those of the slopes along the NSE, except type E slope (5.3.2). It indicates that all the slopes studied at the FSKTM were not likely to fail as it did not have the features of a failing slope i.e. SWC 45.5 – 48.3%. The RVLJT plot showed similar magnitude of SWC to that of the type A slope on the NSE, an indication of the effectiveness of the high RLD. It was observed that SWC of plots RVL, RVJ, RVT, RV and R fall in the same range as that of type B and C slopes along the NSE. It is interesting to note that the experimental slope at FSKTM is stable with the median SWC of 23.5%, about 75% of the field capacity.

Table 6.5: Shear strength value (kPa) of the plots studied at FSKTM slopes.

Plots	**Shear Strength (kPa)**	
	at 4 inches of soil depth	***at 12 inches of soil depth***
RVL	85.7 ± 9.5	171.3 ± 8.3
RVJ	93.3 ±13.9	150.6 ± 14.8
RVT	99.7 ± 10.9	162.8 ± 24.3
RVLJT	64.7 ± 10.0	184.5 ± 9.1
RV	117.0 ± 11.3	162.3 ± 5.3
R	100.5 ± 7.6	144.3 ± 10.7

Fig. 6.9 : SWC at 5 type of slopes along the NSE. Each point represents the mean of 4 determinations (○ RVLJT, □ RVL, Δ RVJ, ◊ RVT, × RV and ✳ R).

Fig.6.9: Soil Water Content of FSKTM Slopes



6.4 General Discussion

There is no relationship between the parameters studied (Fig. 6.10, 6.11, and 6.12). This is in coherent with the results obtained in the previous studies on slopes along the NSE (5.4). However, some relationships have been observed between shear strength and RLD (Fig. 6.13). Although the relationship was not obviously seen at first , it surfaced upon closer examination in the form of positive linear relationship similar to previous observation (5.4). In the present case, the linearity observed at the two depths is separated possibly due to different soil type.

From visual observations *J.betonica* and *L.camara* successfully grew as mono and mix-culture system with plants in all replicates flower until the end of the experiment. Moreover, both species seemed to show good performance in terms of physiological aspects studied especially in the mix-culture plot implying that they are suitable to be the pioneer plants on slopes. On the other hand, *T.erecta* did not show promising characteristics in respect of all physiological aspects. Its low photosynthesis rates and LAI might indicate that this species are not likely to be able to compete with the other species on the slopes. Although it needs low light intensity (500 $\mu E\ m^{-2}\ s^{-1}$), this species is suggested to be planted on slope after reaching a suitable height.

Bushy ecosystem (mix-culture treatment) was successfully implemented on a previously barren slope at FSKTM, University of Malaya. Based on ecophysiological parameters and visual examination, it clearly revealed the positive effect of vegetation cover on the stability of slopes in sense of biomass product, species diversity and slope stability.

Fig.6.10: Relationship between penetrability (MPa) and SWC (%)

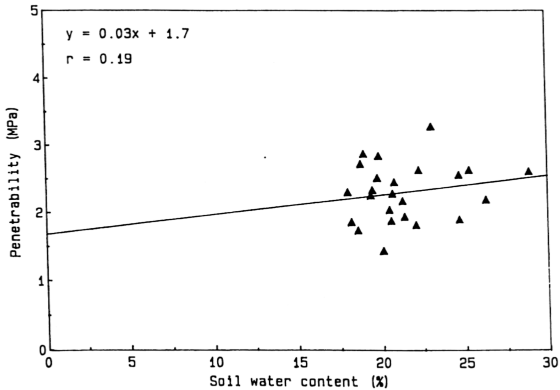


Fig.6.11: Relationship between penetrability (MPa) and RLD (km m^{-3})

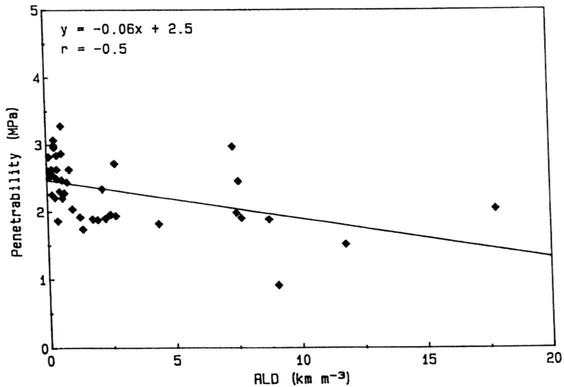


Fig.6.12: Relationship between soil water content (%) and shear strength (kPa)

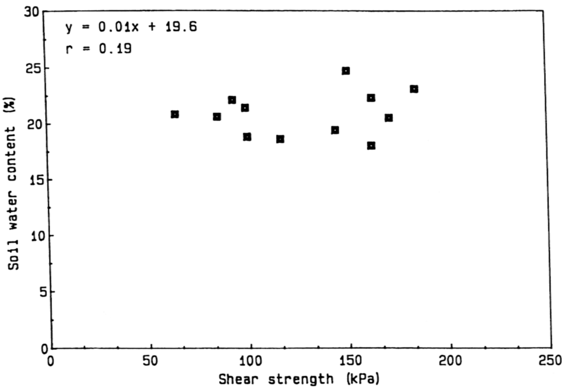


Fig.6.13: Relationship between shear strength (kPa) and RLD (km m^{-3})