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Growth of *Sesbania rostrata* on Different Components of Tin Tailings

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ABSTRAK

Dua kajian di ladang telah dijalankan untuk menilai tumbesaran Sesbania rostrata *di kawasan tanah bekas lombong berpasir, lom berpasir dan slim yang dirawat dengan baja tak organik, dan di kawasan berpasir yang ditambah dengan campuran organik. Baja tak organik diberi pada kadar 30 kg N, 90 kg P_2O_5 dan 120 kg K_2O ha^{-1}. Campuran organik yang diguna terdiri daripada 50% sisa kering kilang kelapa sawit (SKKKS) dan tahi ayam pada jumlah kadar bersamaan 10 t ha^{-1}. Pokok dituai selepas 24, 42 dan 63 hari penanaman. Keputusan menunjukkan tumbesaran* S. rostrata *yang terbaik ialah di atas tanah slim dan terbantut di atas tanah berpasir. Pemberian baja tak organik meningkatkan tumbesaran pokok pada tanah slim dan lom berpasir tetapi tidak pada tanah berpasir. Bahagian atas, akar dan bintil pokok pada tanah berpasir yang ditambah dengan campuran organik didapati 29, 27, dan 2.5 kali lebih baik daripada yang diberi baja tak organik. Tumbesaran pokok di tanah berpasir ini bersamaan dengan 56% bahagian atas dan 200% bahagian akar pokok ditanam di tanah slim dibekalkan dengan baja tak organik.*

ABSTRACT

Two field experiments were conducted to evaluate the growth of Sesbania rostrata *on sandy, sandy loam and slime components of a tin tailing area treated with inorganic fertilizer, and on the sandy component amended with an organic mixture. Inorganic fertilizer was applied at a rate of 30 kg N, 90 kg P_2O_5 and 120 kg K_2O ha^{-1}. The organic mixture used consisted of 50% palm oil mill cake (POMC) and 50% chicken dung at a total equivalent rate of 10 t ha^{-1}. Plants were harvested after 24, 42 and 63 days of growth. The results showed that* S. rostrata *grew best on the slime and poorest on the sandy tailings. Inorganic fertilization increased plant growth on the slime and sandy loam but not on the sandy tailings. Plant tops, roots and nodules in sandy soil amended with organic mixture were 29, 27 and 2.5 times better than those with the inorganic fertilizer. Plant growth on sandy tailing was equivalent to 56% of plant tops and 200% of roots from plants grown on slime supplied with inorganic fertilizers.*

INTRODUCTION

Tin mining activities over the last 100 years in Malaysia have left large areas of tin tailings unsuitable for agriculture. A large proportion of the area is composed of sandy soil with low water holding capacity, high hydraulic conductivity, low nutrient status and poor structural stability (Lim *et al.* 1981). A typical exmining land is usually composed of sand and a mixture of silt and clay deposits usually referred as slime (Shamshuddin *et al.* 1986). Due to lack of profile and structural developments and the presence of weatherable minerals, the tailings can be considered as Entisols. These tailings are generally not suitable for crop production because of their poor physical and chemical properties.

Several methods have been used to improve their nutrient status and structure. Organic matter amendment such as organic manuring has been practised by most farmers so as to increase their fertility status and suitability for vegetable and fruit production (Tan and Khoo, 1981). Ploughing-in of suitable crops or green manuring is another possible method of improving the soil. Legumes are perhaps the best type of plant to be utilised for this purpose since it has the ability to fix atmospheric nitrogen when grown in soils with low nitrogen content.

Sesbania rostrata has been reported by Dreyfus and Dommergues (1981) as the most efficient N_2 fixing plant due to its ability to form profuse nodules both on the stems and roots when nodulated by *Azorhizobium caulinodans* (Dreyfus *et al.* 1988). The acetylene reduction activity (ARA) per plant was claimed to be about 600 μmole C_2H_4 h^{-1} compared to the ARA of soybean which ranged from 14 to 120 μmole C_2H_4 h^{-1}.

Previous studies have shown that *S. rostrata* can grow well on low-lying land or under water-logged conditions. Rinaudo *et al.* (1982) and Dreyfus *et al.* (1985) showed that this plant could increase the rice yield when grown in flooded paddy land and later cut and incorporated into the soil. However, the ability of the plant to grow and survive in the drier upland soils particularly on ex-mining land has not been previously evaluated. To test such a possibility, the following experiments were conducted to evaluate the growth of *S. rostrata* on sandy, sandy loam and slime tailings and to observe the growth of *S. rostrata* on the sandy fraction amended with organic matter.

MATERIALS AND METHODS

Experiment 1

The objective of the first study was to evaluate the growth of *S. rostrata* on three different components of tin tailings, a consequence of gravel pump mining, located in the Universiti Pertanian Malaysia Farm, Serdang.

The three different components selected were sandy, sandy loam and slime tailings. The physical and chemical properties of the sites are shown in Table 1. Soil treatments applied were (i) unfertilized control and (ii) basal fertilization at the rates of 30 kg N, 90 kg P_2O_5 and 120 kg K_2O ha^{-1} as urea, triple superphosphate and muriate of potash, respectively. The experiment was a 3 × 2 factorial, laid out in a completely randomized design with four replicates.

The *S. rostrata* seeds were scarified with concentrated sulphuric acid for 30 minutes and rapidly washed with distilled water in six washings. They were then soaked overnight in two-day old *Azorhizobium* strain UPMR38 culture and then sown in 2 × 1.8 m plots at 30 cm distance between rows and 10 cm distance between plants.

TABLE 1

Physico-chemical properties of tin tailings

Physico-chemical property	Sand	Sandy loam	Slime
Depth (cm)	0–15	0–15	0–15
Sand (%)	95.3	87.90	36.2
Silt (%)	0.7	7.8	26.4
Clay (%)	4.0	4.3	37.4
Organic C (%)	0.20	0.36	2.36
Total N (%)	0.02	0.02	0.06
P (μg g^{-1})	5.0	2.4	8.7
K (cmol(+) kg^{-1})	0.01	0.01	0.05
Ca (cmol(+) kg^{-1})	0.31	0.17	12.65
Mg (cmol(+) kg^{-1})	0.02	0.02	0.17
pH (H_2O)	5.7	4.8	4.7
pH (KCl)	4.7	3.9	4.4

The plants were watered daily except on rainy days. Stem inoculation was carried out on day 10, 14, 21 and 28. A forty-eight hour culture of *Azorhizobium* strain UPMR37 was hand sprayed luxuriously on the stem and shoot of each plant. The *Azorhizobium* strains UPMR37 and UPMR38 were isolated from stem and root nodules of uninoculated *S. rostrata* plants grown on a paddy field at Beranang, Selangor. Both azorhizobial strains were cultured on Glutamate medium modified from nutrient solution of Dreyfus *et al.* (1985) (Table 2). Mulching with dried lalang (*Imperata cylindrica*) at the rate of 3 t ha^{-1} was applied to reduce the high soil temperature and loss of moisture through evaporation from the soil surface (Lim *et al.* 1981).

TABLE 2

Glutamate medium for *Azorhizobium* strain UPMR37 and *Rhizobium* strain UPMR38

Source	Concentration (g L^{-1})
Glutamic acid	10.0
K_2HPO_4	1.67
KH_2PO_4	0.87
$MgSO_4.7H_2O$	0.20
NaCl	0.10
EDTA-Fe^{+3}.Na salt	0.004
$(NH_4)_2SO_4$	1.0
Yeast extract	5.0
pH 6.8	

The plants were harvested after 24, 42 and 63 days of growth. Both tops and roots were oven-dried at 60°C for three days and their dry weights determined. Root nodule fresh weight was also determined at harvest.

Experiment 2

The second experiment was conducted to observe the growth of *S. rostrata* on sandy tin tailings amended with organic matter.

Soil treatments applied were (i) untreated control, (ii) inorganic fertilizer (NPK) application, (iii) organic matter application and (iv) both NPK and organic matter application. The rates of inorganic fertilizers used were similar to those in Experiment 1. A mixture consisting of 50% palm oil mill cake (POMC) and 50% chicken dung at a total equivalent rate of 10 t ha^{-1} was used as the organic matter amendment. The nutrient contents for both forms of organic matter are shown in Table 3. The organic matter was thoroughly mixed with the top 20 cm of the tailing manually and left for two weeks before planting.

The experiment was laid out in a completely randomized block design. Seed preparation, planting, stem inoculation, plant maintenance and harvesting were carried out as in Experiment 1.

TABLE 3

Nutrient contents of palm oil mill cake (POMC) and chicken dung

Nutrient	POMC	Chicken dung
N (%)	2.00	4.30
P (%)	0.35	8.70
K (%)	3.32	2.94

RESULTS

Growth of S. rostrata on Tin Tailings.

In general, results from Experiment 1 showed slow growth of *S. rostrata* during the initial 3 weeks of planting; an increase in plant tops occurred after 42 days (*Fig. 1A,B*). In the unfertilized control plots, plants grown on the slime component produced significantly (P = 0.05) higher top dry weight after 42 and 63 days of growth; the average weights after 63 days for the slime, sandy loam and sandy components were 3500, 200 and 200 mg $plant^{-1}$, respectively (*Fig. 1A*). A similar trend was observed in plots applied with inorganic fertilizers but the plants produced higher weights (*Fig. 1B*). Fertilization improved plant growth on slime and sandy loam but not on the sandy components. After 9 weeks of growth, plant top dry weight in the sandy loam and slime components were 8 and 3 times greater than their respective unfertilized plots.

Root growth followed a similar pattern as top growth (*Fig. IC, D*). A significantly (P = 0.05) higher root dry weight (1304 mg $plant^{-1}$) was obtained from the fertilized slime area.

All plants grown on the three soil components produced root nodules (*Fig. 1E, F*). The root nodule weight varied significantly (P = 0.05) according to the tailing components; the highest nodule fresh weight observed after 9 weeks was from the fertilized sandy tailing (*Fig. 1F*). Stem nodulation, however, was not observed even at the last harvest (9 weeks). Plants that were left to grow on the same area outside the experimental plots to observe the occurrence of stem nodules by native rhizobia were found to produce very few stem nodules even after 10 weeks of growth. Inoculation was unsuccessful probably due to either the method of inoculation or the loss of the *Azorhizobium* culture during storage. The pressure developed in the hand pump used for spraying the inoculum could have killed the *Azorhizobium* cells. In a subsequent experiment using a different *Azorhizobium* culture, stem inoculation with a simple hand sprayer with no pumping mechanism was found to successfully produce stem nodules on *S. rostrata* (Unpublished).

Effect of Organic Matter Amendment on Growth of S. rostrata *on Sandy Tin Tailings.*

In experiment 2, organic matter amendment of the sandy tailing markedly improved plant growth (*Fig. 2*). The application of an equivalent rate of 10 t ha^{-1} organic mixture to the sandy tailing significantly (P = 0.05) increased dry weights of plant tops and roots, and weight of root nodules. Amendment with organic matter produced the highest top dry weight (6,000 mg $plant^{-1}$) after 63 days of growth (*Fig. 2A*). The addition of organic matter together with the NPK fertilizer, however, managed to produce only 40% of maximum top dry weight. Plants from the

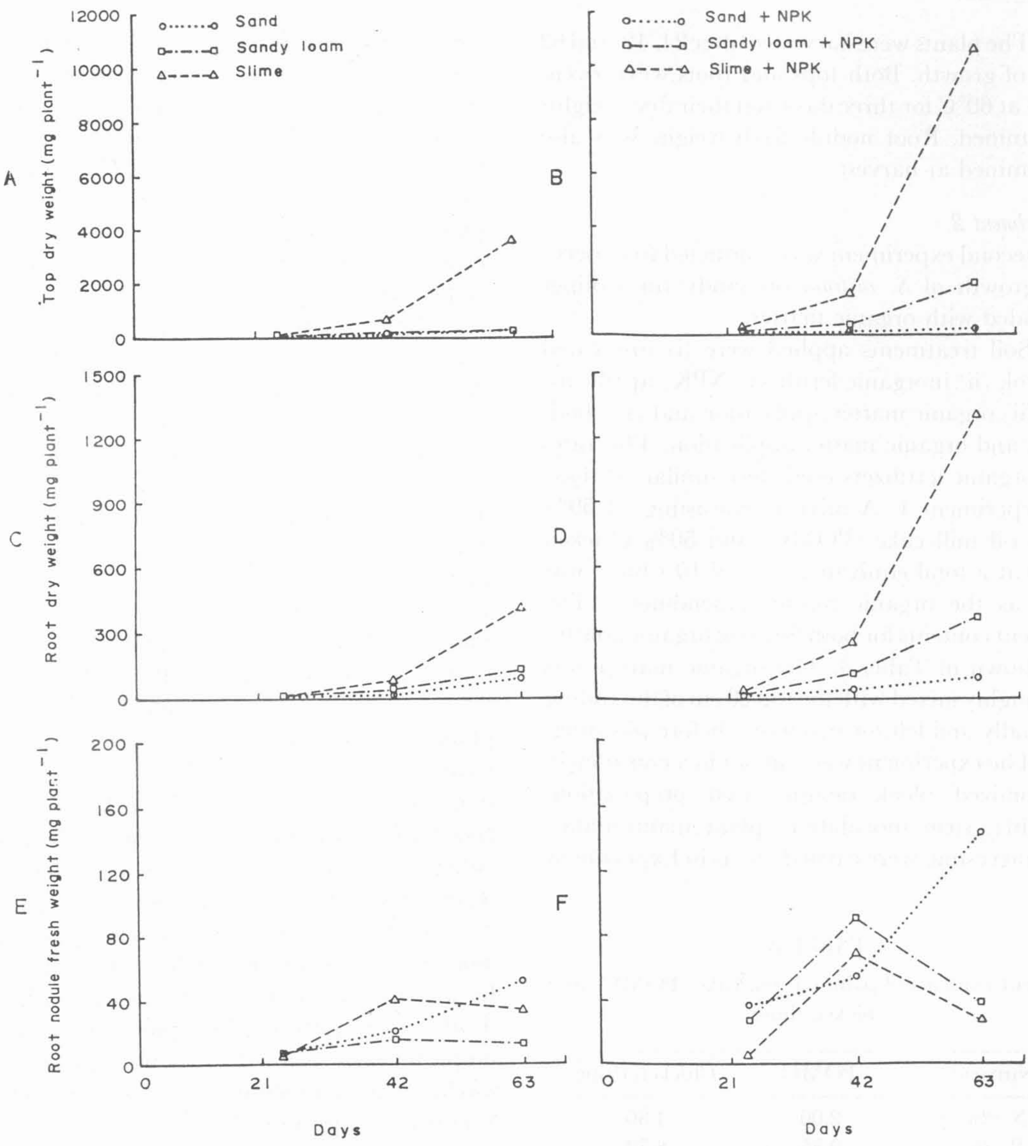

Fig. 1: Growth and nodulation of S. rostrata *on sand, sandy loam and slime components of tin tailings with and without mineral fertilizers.*

inorganic fertilizer treatment grew just as poorly as those from the control plot.

Root development showed a similar trend as the plant tops. The addition of organic matter significantly (P = 0.01) increased the root dry weight to a maximum of 2,500 mg plant^{-1} at 63 days (*Fig. 2B*).

The application of organic matter alone or in combination with NPK fertilizer seemed to promote root nodule development. After 9 weeks of growth, higher root nodule fresh weight (330-350 mg plant^{-1}) was observed in both treatments (*Fig. 2C*).

DISCUSSION

The above results showed that growth of *S. rostrata* was affected by the soil conditions of the tin tailings. The slime component which had higher silt and clay contents had more available nutrients and moisture for root and shoot growth compared to the sandy component (*Table 1*).

Fertilization with N, P and K increased plant growth on the sandy loam and slime but not on

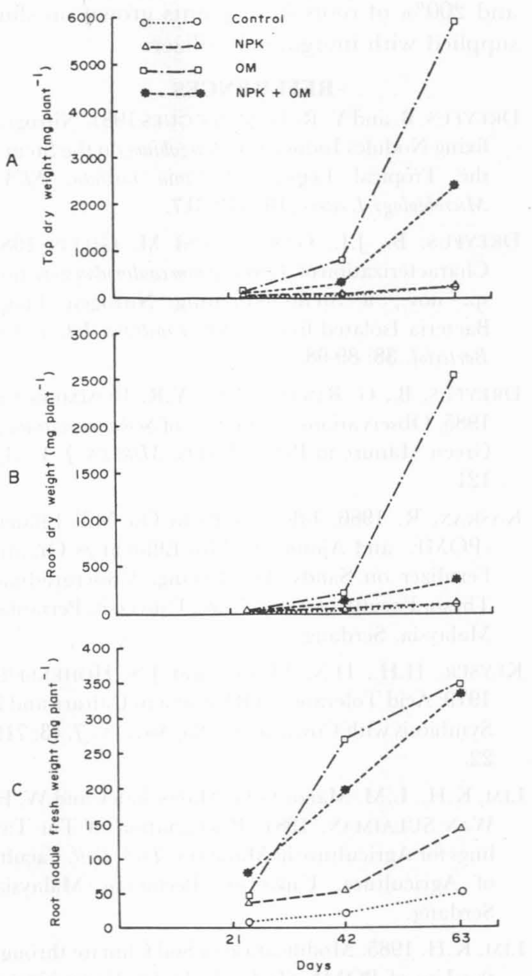

Fig. 2: Growth and nodulation of S. rostrata *on sandy tailings amended with organic and mineral fertilizers.*

sandy tailings. The former two components with their higher clay contents could absorb and retain more of the added nutrients required for plant growth. The high percentage of sand (>95%) in the sandy component probably promoted a greater loss of fertilizers through leaching. Similarly, Lim *et al.* (1981) observed that significantly high amounts of nutrients were leached through the sandy tin tailings when applied with compound fertilizers only. Furthermore, the low water holding capacity of this sandy tailing could have contributed to the poor plant growth. Although root nodule weight was highest in the fertilized sandy component after 63 days, this was not reflected in the plant growth; it could merely be a compensatory effect to overcome a possible decrease in specific nitrogen fixing activity under adverse conditions (Keyser *et al.* 1979). Plant growth was not adversely affected by waterlogged conditions in the fine textured slime component which usually occurred during rainy weather. The saturated soil condition might have promoted plant growth since *S. rostrata* was originally found in the wet areas of Africa (Dreyfus *et al.* 1985). The results indicate that with moderate fertilization and appropriate water management, *S. rostrata* could be grown on some areas of tin tailings with the exception of the sandy component. This finding increases the potential for the plant to be grown as a green manure on tin tailing areas.

The application of organic matter improved growth of *S. rostrata* on the sandy tin tailings. The nutrients in POMC (2% N, 0.4% P. 3.3% K) and chicken dung (4.3% N, 8.7% P, 2.9% K) (Table 3) and the organic properties had improved the nutrient status of the tailing and allowed these nutrients to be released slowly thus reducing losses through leaching. Plant tops in sandy tailing with organic matter was 29 times better than those with NPK fertilizers (*Fig. 2A*) and was as high as 56% of the best treatment with inorganic fertilizers in the 3 tin tailing components ie. slime (*Fig. 1B*). Root dry weight in the sandy soil with organic matter was 27 times better than that with NPK fertilizers (*Fig. 2B*) and was 2 times higher than the best tin tailing components with inorganic fertilizers, ie. slime (*Fig. 1D*). Root development was improved and more nutrients were absorbed for better top growth. Similar results were obtained on sandy soils where the addition of organic mixture containing POMC increased growth of *S. rostrata* (Noriah, 1987) and palm oil mill effluent (POME) increased the dry matter production of maize (Xavier 1977). The application of chicken dung to sandy tailing was found to be beneficial for growth of mungbean and *Brassica chinensis* (Lim *et al.* 1981).

Improved plant growth with the addition of organic matter could also be indirectly due to the improved properties of the tailing. Other studies have indicated that addition of POMC or POME increased the waterholding capacity, stabilized the soil surface temperature (Lim 1985) and increased the microbial activities (Rokiah 1977) of sandy tin tailing.

A lower shoot/root ratio was observed for plants grown on sandy tailing amended with organic matter compared to plants in fertilized slime. This could probably be due to the relatively lower availability of water and nutrients in the sandy component which reduced the dry matter production of shoots compared to roots (Russell 1977). The slime component, which could retain more moisture and nutrients, promoted higher production of plant shoots compared to roots.

A reduction in plant growth observed in the combined organic matter and inorganic fertilizers treatments was rather unusual. Palaniappan *et al.* (1983) indicated that addition of inorganic fertilizers together with POME increased the decomposition and mineralization of POME, and consequently released more nutrients during the early period of plant growth. However, in this study, the addition of inorganic fertilizers had probably increased the microbial population leading to an increase in the mineralization of the organic matter. The nutrients released could have been rapidly leached through the sandy medium and rendered unavailable to the plants. Thus plants were smaller than those treated with organic matter alone in which the mineralization of organic matter progressed at a slower rate.

The addition of organic matter also resulted in an increase in nodule fresh weight, probably due to better nodule development and increased nodule numbers, indicative of greater growth and survival of the inoculated and indigenous *Azorhizobium*. The increase in nodule fresh weight in sandy tailing with organic matter was 2.5 times better than in treatment with NPK fertilizers (*Fig. 2C*). More effective nodulation of cowpea was also observed by Kasran (1986) in sandy soil amended with POMC.

CONCLUSION

Sesbania rostrata can be grown on the sandy loam and slime components of the tin tailings when provided with moderate amounts of inorganic fertilizers. Organic matter amendment improved the fertility status of the sandy tin tailings compared to inorganic fertilizer application. The application 10t ha^{-1} organic mixture consisting of equal weights of palm oil mill cake and chicken dung increased growth of plant tops, roots and nodules by 29, 27 and 2.5 times compared to plants with inorganic fertilization. Plant growth on sandy soil was equivalent to 56% of plant tops and 200% of roots from plants grown on slime supplied with inorganic fertilizer.

REFERENCES

DREYFUS, B. and Y. R. DOMMERGUES 1981. Nitrogen-fixing Nodules Induced by *Rhizobium* on the Stem of the Tropical Legume *Sesbania rostrata*. *FEMS Microbiology Letters*. **10**: 313-317.

DREYFUS, B., J.L. GARCIA, and M. GILLIS 1988. Characterization of *Azorhizobium caulinodan* gen. nov. sp. nov., a Stem-nodulating Nitrogen Fixing Bacteria Isolated from *Sesbania rostrata*. *Int. J. Syst. Bacteriol.* **38**: 89-98.

DREYFUS, B., G. RINAUDO and Y.R. DOMMERGUES 1985. Observations on the Use of *Sesbania rostrata* as Green Manure in Paddy Fields. *MIRCEN J.* **1**: 111-121.

KASRAN, R. 1986. Effect of Palm Oil Mill Effluent (POME) and Ajinomoto Mill Effluent as Organic Fertilizer on Sandy Tin Tailing. Undergraduate Thesis, Faculty of Agriculture, Universiti Pertanian Malaysia, Serdang.

KEYSER, H.H., D.N. Munns and J.S. HOHENBERG 1979: Acid Tolerance of Rhizobia in Culture and in Symbiosis with Cowpea. *Soil Sci. Soc. Am. J.* **43**: 719-22.

LIM, K.H., L.M. Maene G.G. Maesschalck and W. H. WAN SULAIMAN, 1981. Reclamation of Tin Tailings for Agriculture in Malaysia. *Tech. Bull.* Faculty of Agriculture. Universiti Pertanian Malaysia, Serdang.

LIM, K.H. 1985. Modification of Soil Climate through the Use of POME Sludge Cake for Vegetation of Sand Slopes. pp. 163-174. In *Proc National Conference on Soil-Climate Relationships on Crop Production in Malaysia*. ed. Mok, C.K., Lim, K.H. and Azmi M.A Malaysian Soil Science Society, Kuala Lumpur.

NORIAH, M.N. 1987. Effect of Organic Mixture and Rhizobia Inoculation on Growth of *Sesbania rostrata* on Sandy Tin Tailing. Undergraduate Thesis, Faculty of Agriculture, Universiti Pertanian Malaysia, Serdang.

PALANIAPPAN S., SYED SOFI SYED OMAR and V.M Palaniappan 1983. Land Application of Raw Palm Oil Mill Effluent (POME). Studies on Leaching and Decomposition and Nutrient Release of the Residues pp. 180-221. In *Proc. Sem. on Land Application of Palm Oil and Rubber Factory Effluents*, ed. K.H. Lim, B. Abu Talib and YC Poon Malaysian Soil Science Society, Universiti Pertanian Malaysia, Serdang.

RINAUDO, G., DREYFUS, B. and Y.R. DOMMERGUES. 1982. Influence of *Sesbania rostrata* Green-manure on the Nitrogen Content of Rice Crop and Soil. *Soil Biology and Biochemistry*. **15**: 111-113.

ROKIAH, Y. 1977. Effect of Amended Sandy Tin Tailing on Microbial Activities and Growth of Groundnut (*Arachis hypogaea*) and Ragi (*Eleusine coracana*). Undergraduate Thesis. Faculty of Agriculture, Universiti Pertanian Malaysia, Serdang.

RUSSELL, R.S. 1977. *Plant Root Systems: Their Function and Interaction with the Soil*. London: McGraw-Hill, (UK).

SHAMSHUDDIN, J., MOKHTAR NIK and S. PARAMANANTHAN. 1986. Morphology, Mineralogy and Chemistry of an Ex-mining Land in Ipoh, Perak. *Pertanika*. **9(1)**: 89-97.

TAN, W.H. and S.H. KHOO. 1981. The Utilization of Ex-mining Land in Peninsular Malaysia. *Malays. Geo*. **3**: 36-46.

XAVIER, A. 1977. Utilization of Organic Wastes for Crop Production on Tin Tailing Sand. Undergraduate Thesis, Faculty of Agriculture, Universiti Pertanian Malaysia, Serdang.

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