Rehabilitation of degraded and abandoned forestland, underutilized sandy soils and landfill sites

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Introduction

The widespread concern about tropical forests is caused mainly on two issues, deforestation and forest degradation, both resulting in potentially disastrous environmental, economic, social and cultural negative consequences. With the impending shortage of raw timber supply and the increasing area of degraded natural forest, forest rehabilitation is the key answer to overcome this problem. A group of researchers from Universiti Putra Malaysia have been working for the past several years to identify suitable indigenous timber species and appropriate techniques to rehabilitate the degraded forest land. The studies have been conducted on abandoned shifting cultivation area in Bintulu, Sarawak, logged-over forest in Pasoh Forest Reserve, N. Sembilan, landfill sites in Sabak, Kelantan and ex-mining land in Semenyih, Selangor.

Materials and Methods

In Bintulu, a total of 342, 393 seedlings of indigenous timber tree species were planted using two techniques, under direct sunlight and partial shade. The results reported in this abstract involve only 16 indigenous tree species namely *Calophyllum sclerophyllum, Cotylelobium melanoxylon, C. burckii, Dryobalanops beccarii, Syzygium sp., Hopea beccariana, H. cf. bracteata, Parashorea smythesii, Shorea dasyphylla, S. gibbosa, S. leprosula, S. maxwelliana, S. mecistopteryx, S. ovata, S. scaberrima* and *Whiteodendron moultonianum* for open planting.

Ten indigenous species namely Azadirachta excelsa, Cinnamomum iners, Dryobalanops aromatica, Hopea pubescens, Intsia palembanica, Neobalanocarpus hemii, Shorea acuminata, S. bracteolata, S. leprosula and S. parvifolia were planted at Pasoh Forest Reserve by using two planting techniques, open planting and under shade. A total of 1350 seedlings were planted.

Acacia mangium trees were planted on a landfill site in the state of Kelantan that has ceased operation. A total of 25 trees were planted in completely randomized block design. Heavy metal in soil and water were analyzed while analysis on N, P and K in leaves samples was done.

On the ex-mining land in Semenyih, Selangor, *Acacia mangium, A. auriculiformis* and *Ceiba pentandra* were planted in ex-mining land, Semenyih, Selangor to test the feasibility of inoculating the timber species or crops with VAM fungi for enhancing establishment, growth and sustainability of these species at moderate levels of fertilizer input.

Results and Discussion

The results reported from the study in Bintulu involved only 16 indigenous tree species namely Calophyllum sclerophyllum, Cotylelobium melanoxylon, C. burckii, Dryobalanops beccarii, Syzygium sp., Hopea beccariana, H. cf. bracteata, Parashorea smythesii, Shorea dasyphylla, S. gibbosa, S. leprosula, S. maxwelliana, S. mecistopteryx, S. ovata, S. scaberrima and Whiteodendron moultonianum for open planting. The results after 10 years planting showed that the best survival rate was exhibited by Shorea dasyphylla, followed by S. scaberrima, Whiteodendron moultonianum, Dryobalanops beccarii, Hopea beccariana, Cotylelobium burckii, Parashorea smythesii, Calophyllum sclerophyllum, Hopea cf. bracteata, Shorea gibbosa, S. mecistopteryx, S. maxwelliana and Cotylelobium melanoxylon. In terms of basal diameter, Shorea dasyphylla recorded the highest mean annual increment, followed by Dryobalanops beccarii and Whiteodendron moultonianum. In terms of total height, the highest mean annual increment was attained by Shorea dasyphylla, followed by Parashorea smythesii and Hopea cf. bracteata.

After 7 years of monitoring growth performance in degraded forestland in Pasoh, Negeri Sembilan, the best survival rate in the open planting area was attained by *Cinnamomum iners*, (74%) while *Dryobalanops aromatica* and *Shorea acuminata* showed the lowest survival rate with 8.14% and 6.67 % respectively. Under shade *Hopea pubescens* attained the highest survival rate, (56%). The lowest survival rate was attained by *Shorea acuminata*, 6% and *S. parvifolia*, 0%. In terms of basal diameter, there was no significant difference between the planting techniques. In the open area, *Shorea bracteolata* exhibited the highest mean annual increment by 12.09 mm per annum. The lowest mean annual increment was performed by *Cinnamomum iners* at 6.35 mm per annum. Under the shade planting technique, *Neobalanocarpus hemii* exhibited the highest mean annual increment of 4.47mm per annum. *Dryobalanops aromatica* showed the lowest mean annual increment at 0.92m per annum. In terms of total height, the highest mean annual increment was attained by *Shorea leprosula*, (1.83m per annum). Under the open area technique, *Cinnamomum iners* exhibited the lowest mean annual increment with 0.65m per annum. Meanwhile, *Shorea*

acuminata exhibit the highest mean annual increment under shade planting technique, (0.72m per annum). The lowest mean annual increment was performed by *Cinnamomum iners* (0.04m per annum).

Five heavy metals in the landfill site, particularly Fe, Cr, Zn, Cu and Cd analyzed in this study showed elevated concentration level compared to the control surface soil. The results indicate that cromium (Cr) and cadmium (Cd) uptakes by *A. mangium* in landfill site were higher than the control plants. The level of accumulation in *A. mangium* leaves was highest for ferum (Fe) that ranged between 139.5 to 537.6 µg/g, followed by cromium (Cr), 45.54 to 357.3 µg/g; zink (Zn), 29.36 to 57.23µg/g; copper (Cu), 6.88 to 15.61 µg/g and cadmium (Cd), 1.63 to 3.48 µg/g. However, ferum (Fe) accumulation in the foliage of *A. mangium* is not significantly difference between landfill and control plants. Effects of heavy metals on the nutrient uptake of macronutrients (N, P, K) and growth of *A. mangium* were not significant. However, the uptakes of nitrogen (N) and phosphorus (P) in a landfill by *A. mangium* were higher than the control, but on the contrary, potassium (K) was found higher in the control plants. There was a very high heavy metal concentration in water samples collected. Copper (Cu) concentrations in water samples were generally higher than the other heavy metals ranging between 0.03 to 6.14 mg/L whereas cadmium (Cd) and cromium (Cr) were generally very low. In terms of growth, *A. mangium* in landfill tend to produce more branches, leaves and increase in diameter.

The presence of excess water in the mycorrhizal plots in ex-mining land have reduced growth of stem diameter in *Ceiba pentandra* ranging between (15.4 to 30.5 cm per month), *A. mangium*, (18.8 to 55.3cm per month) and *A. auriculiformis*, (10.1 to 38.5 cm per month). Total nitrogen (N) in *Ceiba pentandra* was highest between (3.46 to 6.45%); followed by *A. mangium*, (3.25 to 6.30%) and *A. auriculiformis*, (2.82 to 5.69%). The level of total phosphorus (P) in *Ceiba pentandra* was high, ranging between (0.20 to 0.33%); followed by *A. auriculiformis*, (0.23 to 0.28%) and *A. mangium*, (0.21 to 0.28%). In terms of total potassium (K), *A. auriculiformis* showed the highest level that ranged between (1.07 to 3.83%); followed by *A. mangium*, (1.27 to 2.66%) and *Ceiba pentandra*, (1.27 to 2.56%). Of the three forest species tested, *Acacia mangium* and *A. auriculiformis* showed faster growth rate than *Ceiba pentandra*. Total carbon content of the soil under the inoculated *A. mangium* is higher than in the other species of (7% to 24%).

Conclusions

The study in ex-shifting cultivation, Bintulu, Sarawak indicates that, for the open area planting method, it would be best to select light demander species such as *Shorea dasyphylla, Whiteodendron moultonianum* and *Shorea scaberrima.*

The most promising species for rehabilitation of logged-over forest are *Azadirachta excelsa, Hopea pubescens* and *Neobalanocarpus hemii.*

Acacia mangium is very tolerant to heavy metals and suitable to rehabilitate the contaminated landfill area.

On the ex-mining land, the results indicate that, the introduced VAM species resulted in higher percent colonization in roots of three forest species tested, with the highest colonization of 90.6% in *Ceiba* roots. Effectivity of the VAM fungi is low probably due to the fact that presence of very high soil moisture prevents the extensive spread of the fungal mycelium in the soil beyond the root zones. This observation paralled the low spore count (50%) in the soil. Presence of the mycorrhiza fungi did not seem to favour proliferation of other species of soil fungi. This could be due to the production of antibiotics /physical barrier by VAM which hinders growth of these lower fungi. Presence of the mycorrhiza fungi however seems to have a synergistic effect on the total bacteria population. Overall, the highest mycorrhizosphere was from *A. mangium* and this timber species is most suited for rehabilitation of ex-tin mining land.

Benefits from the study

The results from the study had been used by Forestry Department and Agricultural Department as a guide for a sound basis for restoration of degraded areas.

Other benefits are:

Information on the restoration methods has been applied on degraded areas using sustainable agro-forestry method.

Operational remote sensing result has been used as a basis for identification and mapping restoration degraded areas.

Guidelines on the sustainable agro-forestry method had been introduced to be applied in degraded areas.

Overall, methods and guidelines developed in this study have been employed by relevant agencies (Forest Dept. and Agricultural Dept.) to restore the degraded areas for sustainable agro-forestry production.

Patent(s), if applicable :

Nil

Stage of Commercialization, if applicable:

Nil

Project Publications in Refereed Journals

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1. Faridah Hanum I., Nik Muhamad N.M., Mohd Kamil Y., Mokhtaruddin A.M., Tuan Mohd Norhisyam T.D., Kobayashi S. Tree species composition and above ground biomass of a 10 year old logged-over forest at Pasoh, Negeri Sembilan, Peninsular Malaysia. Paper presented at the Workshop on the Rehabilitation of Degraded Tropical Forest Ecosystems Nov. 2-4 1999. Bogor, Indonesia.

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8. Awang Noor A.G., Nik Muhamad N.M. Economic Analysis of Agroforestry Interplanting rattan with rubber. Paper presented at "Seminar on Agroforestry Development and Effective Environmental Management", June 12, 2000, Kota Kinabalu, Sabah.

Graduate Research

Name of Graduate	Research Topic	Field of Expertise	Degree Awarded	Graduation Year
Bimal K. Paudyal	Fertilization and thinning studies in *Acacia mangium* plantation.	Forest silviculture	PhD	1995
Hasnah Binti Jais	The potential of Utilizing Vesicular-Arbuscular Mycorrhiza (VAM) in the Rehabilitation of Sandy Tailing	Soil science	PhD	1996
Mohamad Azani Bin Alias	Rehabilitation of degraded forest land using native timber species	Forest rehabilitation	MSc. PhD	1996
Maswa	Effects of different rehabilitation methods on soil parameters on the establishment of forest tree seedlings in a degraded forest.	Soil science	MSc.	2000
Evelyn V. Bigcas	Growth performance of rehabilitation species and vegetational succession in a logged-over tropical lowland forest in Malaysia	Forest soil	PhD	2004
Nik Mohd Shibli Nik Jaafar	Heavy metal accumulation in *Acacia mangium* on landfill site.	Environmental science	MSc.	2003
Nayandeep Singh	Rehabilitation of closed landfill site in Kelantan, Malaysia.	Forest management	MSc	2004

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