The Rufford Small Grants Foundation

Final Report

Congratulations on the completion of your project that was supported by The Rufford Small Grants Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Laura Graham
Project title	Mycorrhizae as necessary tools for restoring tropical peatlands, Indonesia
RSG reference	88.09.08
Reporting period	Grant awarded February 2009, Report to be submitted February 2010
Amount of grant	£5972
Your email address	l.l.b.graham.02@cantab.net
Date of this report	24th February 2010

1. Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Monthly growth measurements carried out on the transplanted *D. polyphylla and S. balangeran* seedlings			Y	
One *S. Balangeran* and *D. polyphylla* seedling harvested from each growth plot and sent for analysis at IPB, Oct 08 (dry season)			Y	
Level of mycorrhizal colonisation established for *D. polyphylla and S. Balangeran* during the dry season			Y	
One *D. polyphylla* seedling harvested from each growth plot and sent for analysis at IPB, Mar 09 (wet season)			Y	
Level of mycorrhizal colonisation established for *D. polyphylla* during the wet season			Y	
Work disseminated to wider scientific community			Y	Presented paper on the research in Tropical Peatland conference, Kuching 2008
Work disseminated to wider scientific community		Y		The findings are being worked into a paper for submission to the Journal of Forest Ecology and Management

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

The project ran smoothly, and there were no unforeseen difficulties

3. Briefly describe the three most important outcomes of your project.

1) **Physical findings:**
The level of mycorrhizal colonization: One seedling of *S. balangeran* and *D. polyphylla* was harvested from each plot along each transect at both the peak wet season and peak dry season during each of their respective growth years. Their roots were stained to show percentage of mycorrhizal colonization. Overall, *D. polyphylla* supported a much higher mycorrhizal colonization than *S. balangeran*, frequently reaching over 80% root colonization. However, *D. polyphylla* did not

show much seasonal effect. *S. balangeran* showed a far more marked seasonal effect with both mycorrhizal treatments significantly reducing from the wet season to the dry season.

In the wet season, *S. balangeran* seedlings inoculated with *S. columnare* were consistently higher in percentage of mycorrhizal colonization. However, this effect was reduced in the dry season with only two of the forest zones having significantly higher percentage colonization. In all cases for *S. balangeran* there was no significant difference across the forest zones with respect to percentage colonization.

For *D. polyphylla*, in both the wet season and the dry season, all mycorrhizal treatments, including the control were able to attain high mycorrhizal colonization in the pristine forest zone, indicating the under normal environmental conditions, natural mycorrhizal levels are high. However, the *D. polyphylla* seedlings sampled from the four disturbed forest zones, both in the wet and dry season, all had markedly reduced colonization levels for the control seedlings, which were also significantly lower than the inoculated seedlings in most cases. This indicates that not only mycorrhizal species appropriate to *D. polyphylla* seedlings are less available in disturbed forest zones, but that these lower levels are lower than optimal, and with the inoculants provided they support a higher percentage of colonization.

Survival and growth: The growth rates of the seedlings were monitored monthly for a year through recording basal diameter, height and leaf number, survival was also recorded. Interestingly, despite the contrary in other studies, the mycorrhizal treatment - whether the seedlings had received a mycorrhizal inoculants or not, or the actual measured percentage of mycorrhizal colonisation level did not correspond strongly to the growth or survival rates.

Overall the survival rates of both species were comparable to other transplant studies, reaching 60-75% survival after one year, but these did not differ in relation to mycorrhizal treatment.

Regarding the growth rates, level of degradation proved a far greater factor in determining growth rate than mycorrhizal treatment. Basal diameter growth rate increased for both tree species as the level of forest degradation increased, probably due to the increased light. For *D. polyphylla* seedlings, those inoculated with mycorrhizae did support higher basal diameter growth rates, but the effect of forest zone was stronger. Height revealed no correlation to either forest zone or mycorrhizal treatment. Leaf number also did not correspond to mycorrhizal treatment, however, the degraded zones saw rapid reduction in leaf number, probably linked to the high light intensity. When linking these growth factors to actual recorded mycorrhizal colonisation percentage (from the harvested seedlings) loose correlations were observed in that higher colonisation percentage led to higher basal diameter, height, and leaf number, irrespective of treatment. The exception to this was basal diameter did not correlate to percentage colonisation for *S. balangeran.*

Biomass and nutrient content correlated to mycorrhizal colonisation: Perhaps the most interesting results were in the correlation of the biomass of the shoots and roots of the harvested samples, and the nitrogen and phosphorus content of their shoots, to the actual mycorrhizal colonisation percentage. For *D. polyphylla* it showed that high colonisation percentage also resulted in high shoot biomass, weakly to root biomass, and strongly to nitrogen and phosphorus content. Furthermore more, the actual species of mycorrhizae that were colonising the seedlings seemed to play an important role. However, for *S. balangeran* only shoot biomass correlation with mycorrhizal colonisation, root biomass and nitrogen and phosphorus did not.

Importance of herbivory: An unexpected discovery was that for both *S. balangeran* and *D. polyphylla* seedlings, physical damage, which also linked to mortality, was much higher inside the forest, and particularly for those seedlings that had been inoculated with mycorrhizae. This highlights to an interesting disadvantage of receiving of seedlings receiving inoculants. Given that the inoculated seedlings had greater biomass and nutrient content, and that the majority of physical damage was linked to insect herbivory which was higher in the forest, as animal presence reduces in the more degraded zones, this suggests that the inoculated seedlings are 'more appealing' and thus predated more heavily.

2) **Relevance of species:**
As was expected, the two tree species did not react in the same ways to the treatments. Overall, *D. polyphylla* showed a much greater response to receiving mycorrhizal inoculation; greater basal diameter, root and shoot biomass and nitrogen and phosphorus content. However, these advantages brought a disadvantage also, that where herbivory was high, the inoculated seedlings were consequently more 'appealing', resulting in a greater degree of damage. However, because animal presence reduced outside the forest, in the areas where transplantation for restoration would most likely occur, this disadvantage does not seem too severe.

3) **Application to restoration activities:**
Based on the above findings, this study would recommend that mycorrhizae can provide an important tool to restoration in increasing the growth, biomass and nutrient content of seedlings post-transplantation, and not just in the nursery. However, this study also showed that although mycorrhizal species may be known to colonise a particular species of tree, and further they have been shown to provide advantage to the seedlings whilst growing in the nursery, this advantage may not continue in the field, as was seen for *S. balangeran*. Therefore, trials should be carried out for each transplant species to determine the given value of a mycorrhizal inoculation both in the nursery and post-transplantation, and from this the benefit versus the cost can be determined. Based on this study's findings, it would be strongly recommended that *D. polyphylla* is inoculated with either of its known mycorrhizal species; *G. clarum* or *G. decipiens* , however, whilst it is known that *S. balangeran* receives advantages from being inoculated with *S. columnare* whilst growing in the nursery, this advantage does not continue to the field, thus if used, this fact should be considered.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

Three members of the local community were employed through this project and through this grant, gaining forestry and ecology experience and skills.

5. Are there any plans to continue this work?

At present this project is not continuing directly, however the researcher and the research assistants have now joined a large-scale restoration project in the same area and the knowledge gained and methods used are being applied and implemented.

6. How do you plan to share the results of your work with others?

The findings from this research will be written up as a paper (presently being written) and will be submitted to the Journal of Forest Ecology and Management for hopeful publication to make the

findings known to the wider scientific community. Furthermore, as described above, those undertaking this research are now members of a large-scale forest restoration project on the peatlands of Central Kalimantan and are able to convey this information directly to those involved in this field.

7. Timescale: Over what period was the RSG used? How does this compare to the anticipated or actual length of the project?

As anticipated, the growth measurements of the seedlings were recorded for 8 months, then the seedlings which were harvested needed to be processed at the Institute Pertanian Bogor for level of mycorrhizal colonisation, this took a further two month. Thus the project ran for the expected 10 months.

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Return flight to Indonesia	600	570	-30	
Internal flights to and from Palangka Raya	80	90	+10	
Year-long research permit and visa	150	170	+20	
Field equipment and clothes	150	165	+15	
Staff forest uniform	60	100	+40	
Staff insurance	35		-35	Provided by Indonesian employers
Transport to and from research site for the staff paid per month	200	300	+100	Petrol price rise occurred in Indonesia during the study time
Research assistants daily wage	720	720		
Food costs at research site per day	480	480		
Internal flights to and from Jakarta from P.Raya	160	180	+20	
Transport to and around Bogor	50		-50	Dr. Maman provided personal transportation
Accommodation in Bogor	72	75	+3	
Dry season (final) collection of *Shorea balangeran* (October) (myc and nutrients)	850	850		
Dry season (first) collection of *Dyera polyphylla* (October) (myc only)	900	900		
Wet season (final) collection of *Dyera polyphylla* (June) (myc and nutrients)	1275	1275		
TOTAL	5782	5875	93	Exchange rate £1 : 16,00Rp

9. Looking ahead, what do you feel are the important next steps?

Tropical peatland restoration is a fast emerging field, and as the fires, smoke and devastation caused by the peatland degradation get worse every year, there is more and more attention and interest to find fast and effective methods to recovering the peatland forests; the only way to protect the peat sustainably. This research has illustrated that applied scientific ecological knowledge can provide previously unused methods, and increase success rates and speed of recovery. This is just one example of numerous areas that could be explored to increase our knowledge and skills in tropical peatland restoration, and I hope that I, along with others working in this field, will continue to explore them, and find much needed solutions.

10. Did you use the RSGF logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?

No

11. Any other comments?

I would like to thank Rufford for supporting my research and providing this grant. The data it attained proved to be extremely relevant and will hopefully go on to provide methods for tropical peatland forest restoration. Furthermore, through this grant I was able to continue in a field that I enjoy immensely, and make crucial contacts that have now led me to begin a career in this area.