Propagation of Native Forest Tree Species for Forest Restoration in Northern Thailand

Suphawan Vongkamjan*, Stephen Elliott, Vilaiwan Anusarnsunthorn and J. F. Maxwell
66 3 943346 x1114
g4265351@cm.edu
The Forest Restoration Research Unit
Department of Biology, Faculty of Science
Chiang Mai University, Thailand 50200

Abstract

Loss of forest in Thailand due to logging and shifting cultivation causes depletion of soil, water, and biological resources. To solve this problem, The Forest Restoration Research Unit (FORRU) carries out research to learn how to accelerate natural forest regeneration on degraded forestland. However there are many tree species, which FORRU has not been able to grow. The research reported here describes attempts to propagate 18 indigenous tree species, of potential value to forest restoration, but which FORRU has been unable to grow successfully in the nursery. Higher rates of seed germination were achieved under nursery conditions than under "natural" conditions in forest gaps. Seed germination was higher in partial shade than in deep shade, except for *Reevesia pubescens*, *Morus macroura* and *Betula alnoides*. Various seed pretreatments (heat, scarification, acid etc.) promoted seed germination for all species except, *Shorea obtusa* and *Debregeasia longifolia*. Various chemical treatments were tested to improve rooting success of cuttings. IBA 3000 ppm worked best for *Ficus superba*, Seradix # 2 for *Saurauia roxburghii* and no chemical treatment (control) for *Trema orientalis*.

Key words: seed germination; cutting propagation; seed pre-treatments

Introduction

Doi Suthep-Pui National Park is one of the most popular national parks in Thailand. Although an estimated 40-50% of the park is deforested, it retains an exceptionally rich vascular flora (CMU's Herbarium Database has records for 2,244 species from the national park). As a result, the park was recently listed by the IUCN as a "center of plant diversity" (Elliott and Maxwell 1995). Most of the deforestation in recent years has been due to agricultural expansion, especially by hill-tribe villagers resident inside the park. However, many of these agricultural areas has been abandoned and there are, therefore, large areas that could now be returned to forest for wildlife conservation.

The Forest Restoration Research Unit (FORRU), a co-operative project between CMU and Doi Suthep-Pui National Park, was established to develop appropriate methods to propagate and plant a wide range of native tree species and assess which ones might be useful for forest restoration. The unit carried out germination tests under different shade levels to determine which species are able to grow well in the hot, dry, sunny conditions found in deforested gaps (FORRU, 1998). However, many native tree species have long periods of seed dormancy or low germination rates and there is a lack of knowledge about the ecological functioning and

phenology of native forest tree species, and about how to propagate them from seeds or cuttings (Kuarak *et al.*, 2000; Blakesley *et al.*, 2000). The most effective conditions for growth, to ensure strong, healthy seedlings for planting in deforested areas are also unknown. Thus, the research reported here focused on improving propagation techniques for mass production of vigorous, healthy seedlings of a wide range of native forest tree species. The objectives of the present study were:

- to determine the variability in performance of native forest tree species seedlings propagated from seeds and cuttings;
- to determine whether species traits (such as) seed size, dispersal time or germination type can be used to predict germination and early seedling performance;
- to determine what factors affect the performance of native forest tree species propagated from cuttings and
- to develop the most appropriate propagation techniques for native forest tree species planted to restore forest to degraded areas.

Materials and Methods

Seed Germination

A review of the information stored in the databases of the CMU Herbarium and FORRU was carried out to identify native forest tree species, which could not previously be germinated. Seed germination experiments in the nursery were carried out to determine whether pre-treatments of the seeds stimulated germination. Scarification involved removing or breaking the seed coat by cutting with a sharp knife to facilitate imbibition of water. For heat treatments, seeds were dropped into hot water, which was then allowed to cool overnight. Acid treatments were also applied to break down impervious seed coats. Seeds were immersed in sulfuric acid for various lengths of time from 30 seconds to 10 minutes, depending on the size of the seed. The effects of shade were also tested by placing seed germination tray on bench tops in 40% sunlight (equivalent to shade levels beneath weeds in deforested sites) and under the benches (2% of full sunlight, equivalent to shade levels beneath an evergreen forest canopy). Seed germination experiments in the nursery were replicated under natural conditions in forest gaps to assess how much nursery conditions enhance germination and to determine levels of seed predation. These germination trials were carried out on 30 species, selected to represent 3 different seed size classes (small, medium and large).

Seeds were germinated in trays with 108 modules, containing forest soil. For each treatment, there were 3 replicates and a control group sown in a forest gap near the nursery, with 100 seeds in each replicate. In the forest gap, a caged replicate was used to control for the effects of seed predation. Seeds were protected from ant predation by being sprayed with an insecticide. Twenty seeds were saved for measurements of mass and seed size/species. Germination percentage was recorded every week and ANOVA with a complete randomized design was used to test the significance of the effect of each treatment on germination.

Propagation from cuttings

Experiments were carried out in the nursery to determine whether rooting of leafy stem cuttings could be stimulated or inhibited by various hormone treatments. Parent trees were

selected of native forest species, concentration on trees which attracted seed-dispersing wildlife (potential "framework" species fore forest restoration) or which are rare and in need of conservation. Leafy stem cuttings were sectioned in to heel shaped cuttings, below nodes (with the number of the nodes and leaves dependent on species) of desirable length (6-10 inch). The cuttings were trimmed as required and apical parts were removed. The cuttings were soaked in a fungicide solution for 10 minutes and then dipped in rooting powder or soaked in hormone solution for 10 minutes.

Forty stem cuttings were propagated in the nursery with each treatment, totally 280 cuttings/species subjected to 7 treatments, with four replications of each treatment i.e. control; IBA 3000 ppm; IBA 8000 ppm; Seradix #2; Seradix #3; IBA:NAA 1:1 (2500:2500 ppm) and IBA:NAA 2:1 (5000:2500 ppm).

A low–cost technology adapted from Kantari (1993) was used to propagate the cuttings. Cuttings were kept in transparent plastic bags filled with sand and ash rice husk in the ratio of 1:1. The small plastic bags were then placed in larger plastic bags. One liter of water was added, after which the bags were immediately sealed. The bags were placed in baskets stored under shade netting.

About three months from the day of planting, the plastic bags were opened and the number of living cuts counted. The percentages of cuttings producing new roots and shoots were also measured. ANOVA, applied to a complete randomized design, was used to test for significant difference among the treatments applied.

Results and Discussion

Germination

Results from 18 species of native forest tree species are presented in Table 1. In general, seed germination was more successful in the nursery than in natural forest gaps. The seeds responded to supplementary watering in the nursery, whilst germination success was limited by harsher, drier conditions and by seed predators in the forest gaps. In general, seed germination was better in partial shade than in deep shade except for *Reevesia pubescens*, *Morus macroura* and *Betula alnoides*.

Soaking in water significantly promoted germination of the following species compared with the control *Glochidion acuminatum* (60.19%), *Macropanax concinnus* (75%) (ANOVA, p= 0.01). Soaking in water increased percent germination of *Terminalia bellirica* (100%) but did not significantly with scarification (95.36%) and scarification followed by soaking overnight (97.22%) in partial shade and control (99.08%), soaking (96.31%) and scarification (95.67%) in deep shade (ANOVA, p= 0.05). Soaking in water increased percent germination of *Ficus capillipes* (89.81%) but did not significantly with soaking in acid 30 seconds (86.11%), acid 3 minute (85.19%) and acid 1 minute (84.25%) (ANOVA, p= 0.05). Scarification promoted germination of *Sindora siamensis* (74.08%) in partial shade but did not significantly with scarification followed by soaking overnight (66.67%) in deep shade (ANOVA, p= 0.05). Scarification followed by soaking overnight significantly promoted germination of *Elaeocarpus lanceifolius* (83.33%) in partial shade (ANOVA, p= 0.01).For *Afzelia xylocarpa* (96.31%) scarification followed by soaking overnight (96.31%) in partial shade did not significantly with scarification followed by soaking overnight (95.36%) in deep shade (ANOVA, p= 0.05). Soaking in hot water significantly promoted germination of Irvingia *malayana* (96.31%) (ANOVA, p=

0.01). Soaking in sulfuric acid for 3 minutes significantly promoted germination of the following species *Reevesia pubescens* (94.44%), *Trema orientalis* (98.15%) and for 10 minutes of *Cassia fistula* (98.14%) (ANOVA, p= 0.01). Soaking in acid for 3 minutes increased percent germination of *Lagerstroemia speciosa* (88.89%) but did not significantly with soaking (77.78%) and also cage in gap (74.08%) (ANOVA, p= 0.05). Soaking in acid for 3 minutes increased percent germination of *Betula alnoides* (42.58%) in deep shade. Soaking in acid for 3 minutes increased percent germination of *Eurya acumminata* var. *wallichiana* (75%) but did not significantly with all treatments in partial shade and in gaps. For *Morus macroura* both soaking in water or sulfuric acid for 1 minute (99.07%) had the same effect on germination percentage in partial shade and deep shade. *Ficus superba* var. *superba* soaking in water or sulfuric acid for 3 minutes (93.52%) had the same effect on germination percentage. For *Shorea obtusa* (83.33%) and *Debregeasia longifolia* (94.44%), however, all pre-treatments did not significantly increase germination. In the forest gaps, seed predation reduced germination by 62.97% in *Elaeocarpus lanceifolius*, 100% in *Irvingia malayana*, 100% in *Shorea obtusa* and 90.75% in *Reevesia pubescens*.

Propagation from cuttings

Ficus superba var. *superba* cuttings achieved a higher average percent survival with IBA 3000 ppm (72%) than with IBA:NAA = 2:1 (5000:2500 ppm) (62%) significantly at p=0.01. IBA 3000 ppm also resulted in highest average shooting percentage (42%) but did not with IBA:NAA = 2:1 (5000:2500 ppm) (ANOVA, p=0.05)(Table 2) IBA 3000 ppm had the highest rooting percentage (72%) significantly at p=0.05. Seradix #3 resulted in the highest average number of roots (22.54). *Saurauia roxburghii* had the highest average survival percentage with seradix #3 (75%) compared with IBA 3000 ppm (50%) significantly at p=0.01. Seradix #3 resulted in both the highest percentage of cuttings producing shoots and roots (75% and 65% respectively) significantly at p=0.01. Control resulted in the highest average number of roots (15.94). *Trema orientalis* achieved the highest average percent survival with control, seradix #2, and seradix #3 (75%) compared with IBA 8000 ppm (57.5%), but control resulted in a higher average shooting percentage (70%) than seradix #2 (65%) and seradix #3 (55%) significantly at p=0.01. Control resulted in a higher average rooting percentage (47.5%) than seradix #2 (37.5%) significantly at p=0.01 and it also resulted in the highest average number of roots (3.11).

Table 1. Average percent germination of eighteen native tree species

Condition	Treatment	*Afzelia xylocarpa*	*Elaeocarpus lancifolius*	*Irvingia malayana*	*Terminalia bellirica*	*Sindora siamensis*
sun	control	31.41	83.33	90.75	27.78	9.25
in nursery	soaking	39.81	86.11	100.00	31.47	9.25
	scarification	75.00	41.67	91.67	74.08	83.33
	scar.+soak	83.33	45.36	95.36	61.11	96.31
	heat	15.75	96.31	97.22	50.92	50.92
	acid 1	53.69	14.81	89.81	18.53	8.33
	acid 2	57.42	8.33	79.64	8.33	10.19
	acid 3	27.78	8.33	70.36	21.31	2.78
shade	control	36.11	78.69	99.08	19.44	7.42
in nursery	soaking	0.92	86.11	96.31	27.78	7.42
	scarification	16.67	34.25	95.67	64.81	82.42
	scar.+soak	13.89	28.69	92.58	66.67	95.36
	heat	0.00	84.25	93.53	51.86	39.81
	acid 1	0.92	10.19	89.81	13.89	7.42
	acid 2	0.00	11.11	86.11	8.33	12.97
	acid 3	0.92	24.08	53.69	20.36	6.47
gaps	caged	62.03	17.58	80.56	21.31	18.53
	uncaged	37.03	0.00	23.14	28.69	15.75

Condition	Treatment	*Shorea obtusa*	*Reevesia pubescens*	*Macropanax concinnus*	*Cassia fistula*	*Glochidion acuminatum*
sun	control	83.33	73.14	66.67	0.00	19.44
in nursery	soaking	78.69	60.19	75.00	0.00	43.53
	scarification	75.00	27.78	47.22	75.00	23.14
	scar.+soak	70.36	23.14	50.00	94.44	41.67
	heat	0.00	1.86	2.78	4.64	0.92
	acid 1	0.92	90.75	61.11	22.22	40.75
	acid 2	0.00	81.47	36.11	67.58	37.97
	acid 3	0.00	46.31	1.86	98.14	20.36
shade	control	64.81	73.14	34.25	0.00	36.11
in nursery	soaking	81.47	75.00	45.36	0.00	40.75
	scarification	68.53	26.86	44.44	45.36	5.56
	scar.+soak	67.58	66.67	29.64	87.03	13.89
	heat	0.00	5.56	0.00	5.56	0.00
	acid 1	0.92	94.44	32.42	45.36	34.25
	acid 2	0.00	64.81	18.53	60.19	17.58
	acid 3	0.00	84.25	0.00	82.42	12.97
gaps	cage	43.53	3.69	30.55	11.11	12.03
	uncage	23.14	9.25	35.19	6.47	16.67

Table 1. (continued)

Condition	Treatment	*Lagerstroemia speciosa*	*Debregeasia longifolia*	*Trema orientalis*	*Morus macroura*
sun	control	26.86	94.44	5.56	97.22
in nursery	soaking	77.78	88.89	2.78	99.08
	scarification	11.11	-	-	-
	scar.+soak	11.11	-	-	-
	heat	1.86	88.89	2.78	63.89
	acid 1	88.89	75.92	15.75	95.36
	acid 2	74.08	89.81	12.97	99.08
	acid 3	48.14	88.89	98.14	74.08
shade	control	10.19	92.58	0.92	65.75
in nursery	soaking	14.81	91.67	0.00	99.08
	scarification	2.78	-	-	-
	scar.+soak	0.00	-	-	-
	heat	4.64	85.19	0.00	53.69
	acid 1	18.53	65.75	0.00	98.14
	acid 2	19.44	83.33	0.00	99.08
	acid 3	10.19	85.19	0.00	88.89
gaps	cage	74.08	47.22	4.64	60.19
	uncage	49.08	84.25	2.78	50.92

Condition	Treatment	*Ficus superba*	*Ficus capillipes*	*Betula alnoides*	*Eurya acumminata*
sun	control	87.03	79.64	19.44	67.58
in nursery	soaking	93.53	89.81	12.97	70.36
	scarification	-	-	-	-
	scar.+soak	-	-	-	-
	heat	65.75	10.19	6.47	62.03
	acid 1	92.58	86.11	19.44	64.81
	acid 2	89.81	84.25	18.53	66.67
	acid 3	93.53	85.19	8.33	75.00
shade	control	77.78	45.36	27.78	0.00
in nursery	soaking	90.75	37.03	23.14	0.00
	scarification	-	-	-	-
	scar.+soak	-	-	-	-
	heat	34.25	12.03	7.42	0.00
	acid 1	83.33	54.64	42.58	0.00
	acid 2	81.47	46.31	14.81	0.00
	acid 3	87.03	58.33	5.56	0.00
gaps	cage	38.89	48.14	21.31	49.08
	uncage	37.97	75.92	21.31	49.08

Table 2. Average percent of cutting surviving, rooting and producing new shoots of leafy stem cuttings of tree species subjected to various auxin treatments.

Species	Treatment	% survival	% rooting	% with shoots	no. of roots
Ficus	control	60.0	58.0	18.0	10.69
superba	seradix #2	50.0	50.0	18.0	16.61
	seradix #3	56.0	56.0	18.0	22.54
	IBA 3000 ppm	72.0	72.0	42.0	10.7
	IBA 8000 ppm	34.0	34.0	22.0	8.17
	IBA:NAA=1:1	42.0	38.0	28.0	11.27
	IBA:NAA=2:1	62.0	62.0	42.0	12.37
Saurauia	control	37.5	37.0	37.5	15.94
roxburghii	seradix #2	42.5	25.0	42.5	7.78
	seradix #3	75.0	65.0	75.0	11.25
	IBA 3000 ppm	50.0	32.5	47.5	5.56
	IBA 8000 ppm	37.5	15.0	37.5	5.27
	IBA:NAA=1:1	10.0	5.0	10.0	2.19
	IBA:NAA=2:1	37.5	20.0	37.5	3.86
Trema	control	72.5	47.5	70.0	3.11
orientalis	seradix #2	72.5	37.5	65.0	1.57
	seradix #3	72.5	32.5	55.0	1.53
	IBA 3000 ppm	47.5	32.5	42.5	2.77
	IBA 8000 ppm	57.5	22.5	50.0	0.91
	IBA:NAA=1:1	35	10.0	30.0	1.25
	IBA:NAA=2:1	27.5	7.5	17.5	2.13

Conclusion

Framework tree species are those, which accelerate natural forest regeneration. They are selected on the basis of high rates of survival and growth in degraded areas and dense spreading crowns, capable of shading out herbaceous weeds and "capturing" the site (Lamb et al. 1997). FORRU has identified many tree species, which match these criteria (FORRU 1998, 2000), but several have proved difficult to propagate in the nursery. The research presented here shows that factors limiting the production of potential framework tree species in the nursery can be overcome easily through the application of relatively simple, low cost technologies.

Consequently, a wider range of indigenous forest tree species can be used as framework tree species for the restoration of natural forest ecosystems. The chemicals used to induce rooting of cuttings are fairly readily available and the techniques described could all be used in community tree nurseries or in nurseries attached to national parks with minimal training of staff.

Nursery conditions enhance seed germination compared with "natural" germination rates in forest gaps. This suggests that it is better to raise seedlings in nurseries than to rely on natural seed dispersal or direct seeding. For most species, seed germination was higher in partial shade compared with deep shade, even for so-called "climax" forest tree species. This raises the possibility of including climax forest tree species in planting mixtures of framework tree species planted to restore degraded forestland, since their germination and early seedling development appears not to be inhibited by open sunny conditions.

In general, pre-treatments promoted seed germination. Most of the pre-treatments had a similar effect in that they weakened or perforated the seed coat. This allowed water to enter the seed and facilitated increased gaseous exchange, important factors known to trigger germination. Therefore, it can be concluded that dormancy in most of the species studied was due to the restrictive effects of the seed coat. In the forest gap, seed predation limited seed survival and hence germination percent. It particularly affected the larger or medium sized seeds, whilst smaller seeds were less affected. This result suggests that direct seeding of degraded forestland might have limited application in forest restoration programs due to the effects of seed predation. For species with limited seed germination success, propagation from cuttings appears to offer a viable, cost-effective alternative. For the three species presented here, IBA 3000 ppm produced the best results with *Ficus superba* and seradix #2 for *Saurauia roxburghii*, whilst *Trema orientalis* survived and rooted most efficiently without any hormone treatment.

Acknowledgments

This research was carried out in partial fulfillment of the requirements of a PhD at Chiang Mai University, under the supervision of Dr. Stephen Elliott and Dr. Vilaiwan Anusarnsunthorn. The work was supported by funds from the Rajbahat Institute, Nakornsawan. The first author thanks Dr. Ching-Te Chien and Dr. Robin Rose for the invitation to present this work at the "Tropical Forestry Symposium: the Art and Practice of Conservation Planting."

Literature Cited

Blakesley, D., V. Anusarnsunthorn, J. Kerby, P. Navakitbumrung, C. Kuarak, S. Zangkum, K. Hardwick and S. Elliott. 2000. Nursery technology and tree species selection for restoring forest biodiversity in northern Thailand. pp 207-222 IN Elliott, S., J., Kerby, D. Blakesley, K. Hardwick, K. Woods and V. Anusarnsunthorn (Eds.). Forest Restoration forWildlife Conservation. Chiang Mai University.

Elliott, S. and J. F. Maxwell, 1995. Doi Suthep. Pp 210-214 in Davis S. D., V. H. Heywood and A. C. Hamilton (Eds.) Centres of Plant Diversity A Guide and Strategy for their Conservation Volume 2 Asia, Australasia and the Pacific. Published by the World Wide Fund for Nature and IUCN – The World Conservation Union.

Forest Restoration Research Unit. 1998. Forests for the future: growing and planting native trees for restoring forest ecosystems. Biology Department, Science Faculty, Chiang Mai University, Thailand. 60 pp.

Forest Restoration Research Unit. 2000. Tree Seeds and Seedlings for Restoring Forests in Northern. Biology Department, Science Faculty, Chiang Mai University, Thailand. 151 pp.

Kuarak, C., S. Elliott, D. Blakesley, P. Navakitbumrung, S. Zangkum and V. Anusarnsunthorn. 2000. Propagating native trees to restore degraded forest ecosystems in northern Thailand. IN Elliott, S.,J., Kerby, D. Blakesley, K. Hardwick, K. Woods and V. Anusarnsunthorn (Eds.). ForestRestoration for Wildlife Conservation. Chiang Mai University

Lamb, D., J. Parrotta, R. Keenan and N. Tucker. 1997. Rejoining habitat fragments: restoring degraded forest lands. IN Laurance, W. F. and R. O. Bierregaard, Tropical Forest

Remnants: Ecology, Management and Conservation of Fragmented Communities, pp. 366-385. University of Chicago Press.

Kantarli M. 1993. Vegetative Propagation of Dipterocarps by Cuttings in ASEAN Region. Review Paper No. 1, ASEAN-Canada Forest Tree Seed Centre Project, Muak-Lek, Saraburi, Thailand.