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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 7 (9): 1624-1630, 2004
ISSN 1028-8880

Nong Rawiang Dry Dipterocarp Forest, Its Ecology, Diversity, Survival, Taxonomic Identification and Reproduction

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Abstract: An investigation on ecology, diversity, survival, taxonomic identification and reproduction of Nong Rawiang dry dipterocarp forest in Northeast Thailand was carried out on Warin soil series (Oxic Paleustults) during the 2000 to 2002. Eight quadratic plots, each with a dimension of 40x40 m, were chosen for this investigation. Each plot was divided into three equal subplots for soil sampling replications. The results showed that mean values of annual rainfall, relative humidity, temperature and radiant energy from the sun were 89.51 mm, 81.50%, 27.53°C and 341.19 Cal. cm^{-2}/day, respectively. Rainfall was occurred in all months of the year except December. Soil analysis data revealed that the Nong Rawiang dry dipterocarp forest soil is a poor soil type in Northeast Thailand. There are 10 dominant tree species with numbers of trees per quadratic plot ranged from 83 to 210 for Q6 and Q2, respectively. Shannon-Wiener index of diversity ranged from 1.25 to 2.12% for Q4 and Q5, respectively. The Nong Rawiang dry dipterocarp forest has 22 different tree families with 35 species. Only 5 dominant tree species gave fruits and seeds. Seed germination % of the tree species carried out under laboratory ranged from 16 to 93 for *Ellipanthus tomentosus* and *Sindora siamensis* and *V. maritime*, respectively. Reproductive success under natural germination, *Xylia xylocarpa* species was the lowest (0.01%) and *Ellipanthus tomentosus* species was the highest (40.89%).

Key words: Dominant tree species, dry dipterocarp forest, seed germination, soil properties

INTRODUCTION

Nong Rawiang dry dipterocarp forest consists of three separated portions, whilst other forested areas have been classified as dry mixed deciduous forests. It is located in Nakhon Ratchasima Province, Northeast Thailand. The Nong Rawiang forest as a whole is one of many important natural forests of the region with an area of approximately 400 ha. At present, Thailand has only approximately 26% forested area, which decreased from 53% in 1961. It is a huge decrease of the forested areas of the Thai communities due to mostly deforestation[1,2]. Nevertheless, within the past few decades, the Ministry of Agriculture and Cooperatives and the Thai people have been struggling hard to establish and increase more areas for reforestation in all regions of the country. Thus numbers of reforestation programmes have been developed and implemented with some considerable achievements. At present, the Thai people have realised how evergreen and deciduous forests can contribute to their daily life in their communities in terms of environmental conditions and household economic stabilities. At present, Thailand has a considerable number of forested areas known as National Parks such as Nam Now National Park, Kao Yai National Park, Phoo Kradurng National Park, Huay Ka Kang National Park and others. All of the national parks have been managed under special managements under the Thai Government and the local villagers in their respective areas in order to protect and conserve natural resources of the country. Nevertheless, deforestation problem remains relatively high due to an increase in population and illegal occupations of local villagers and also lumber industries. It is well established that natural forests provide many advantages in terms of environmental conditions, e.g., natural forests on high hills and mountainous areas provide a number of small streams where it becomes a large river later, homes for many beautiful creatures on earth, cleaned environmental air and others. Forested areas in most regions of Thailand particularly those located on high lands and mountainous areas tremendously aid in the establishment of numerous streams and then forming a number of rivers such as the Ping, Wang, Yom and Nan and later collectively formed

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the Chao Phraya River, an important river of the country[3]. This investigation focuses on the following aspects[1]: To obtain some important soil property data and meteorological information of Nong Rawiang dry dipterocarp forest[2]. An identification of the composition of trees taxonomically within the Nong Rawiang dry dipterocarp forest[3]. Some ecological functions in relation to reproductive phenomena of lumber trees and germination of seeds of dominant trees for sustainable forestation. It was revealed that published data on these aspects are inadequately available. Therefore, it is of important value to gather information concerning Nong Rawiang dry dipterocarp forest in order to conserve and protect this natural forest for sustainable forestation for future uses of the coming Thai generations.

MATERIALS AND METHODS

This investigation was carried out during January 2000 to December 2002 at the Nong Rawiang dry dipterocarp forest, Nakhon Ratchasima Province, Northeast Thailand. The forested area was divided into eight quadratic plots (Q1 to Q8) and each has an area of 40x40 m. Each quadratic plot was divided into three equal subplots for soil sampling replications. The study method in choosing plots was of Greig-Smith[4]. Each species of trees with diameter of 3 cm or larger being measured at 1.3 m in height above ground level was marked with aluminous sheets for analysis of quantitative characteristics. Flower specimens of trees of each species being used for taxonomic identification were collected and kept in a solution as described by Butratana[5]. Tree species identification in laboratory was carried out with the use of a key of the relative documents of Smitinand and Larsen[6-10], Gardner *et al.*[11] and Smitinand[12]. Both flowers and leaves of tree species were used for taxonomic identification. Six soil samples for laboratory analysis were taken at random to the depth of approximately 15 cm from the three subplots of each quadratic plot. The soil samples were taken annually within the three years of sampling periods from the 2000-2002. They were used for the determination of soil pH, electrical conductivity (EC), cation exchange capacity (CEC), organic matter (OM), soil nitrogen (N), phosphorous (P), exchangeable potassium (K), calcium (Ca), sodium (Na), magnesium (Mg) and sulphur (S) with the methods as described in Trelo-ges *et al.*[13]. Seeds of the dominant tree species were collected for seed vigor germination test. The seed vigor test was carried out in laboratory. They were replicated four times for each dominant tree species. Each replication has a number of seeds of 50. An observation on natural germination numbers of seedlings was carried out for the seeds fallen down to the ground area of the four chosen parental dominant tree species was recorded within the studied period. Numbers of seedlings of each dominant tree species were recorded and three months later the numbers of the survived seedlings were recorded again for reproductive success %. The collected data were statistically analysed where appropriate using an MSTAT-C Computer Programme[14].

RESULTS

Meteorological data: Monthly rainfall, relative humidity, temperature and radiant energy from the sun were recorded during the three-year period, i.e., from 2000 to 2002. The results showed that amount of rainfall was highest in August with a mean value of 284.13 mm. Rainfall was taken place in all months except December (Table 1). Rainy season in Thailand normally begins in April and ended in October [3]. Monthly mean values of relative humidity percentages ranged from 78.16 in January to 88.24 in September while mean values of temperature ranged from 25.01°C in January to 30.52°C in April. Radiant energy from the sun ranged from 313.19 Cal.cm^{-2}/day in August to 400.20 Cal.cm^{-2}/day in April. The average values of rainfall, relative humidity, temperature and radiant energy were 89.51 mm, 81.50%, 27.53 °C and 341.19 Cal.cm^{-2}/day, respectively.

Soil analysis data: Mean values of soil pH, electrical conductivity (EC), cation exchange capacity (CEC), organic matter %, nitrogen %, phosphorous (P), potassium (K), calcium (Ca), sodium (Na), magnesium (Mg) and sulphur (S) of the eight quadratic sites of the Nong Rawiang dipterocarp forest were 5.74, 0.02, 3.79, 0.34, 0.02, 1.69, 22.97, 120.08, 44.37, 30.43 and 14.05, respectively (Table 2).

Table 1: Mean values of annual rainfall, relative humidity, temperature and radiant energy from the sun at the Nong Rawiang, Muang District, Nakhon Ratchasima, Northeast Thailand from 2000-2002

Months	Rainfall (mm)	Relative humidity (%)	Temperature (°C)	Radiant energy (Cal. cm^{-2}/day)
January	3.37	80.42	25.01	338.47
February	30.00	78.16	26.35	361.96
March	36.47	78.99	28.79	356.12
April	103.54	78.80	30.52	400.20
May	153.73	82.13	29.23	349.24
June	116.60	80.82	28.94	340.87
July	69.33	81.30	28.84	328.67
August	284.13	84.24	28.30	313.19
September	180.37	88.24	27.63	328.85
October	87.03	84.40	27.04	308.16
November	9.53	80.97	24.52	351.18
December	0.00	79.48	25.14	317.35
Mean	89.51	81.50	27.53	341.19

Table 2: Mean values of soil properties of eight quadratic sites of the Nong Rawiang dry dipterocarp forest, Northeast Thailand recorded in 2000-2002

Site	pH (1:1 H_2O)	EC (1:5) (mS cm^{-1})	CEC (NH_4OCA) (me/100 g)	OM (%)	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Na (ppm)	Mg (ppm)	S (ppm)
Q1	5.47	0.02	3.65	0.37	0.02	1.83	42.00	64.00	42.60	28.43	17.91
Q2	5.07	0.02	4.22	0.30	0.02	<1	8.67	42.67	42.73	22.43	11.18
Q3	6.33	0.02	3.46	0.32	0.02	4.93	32.93	191.33	45.93	51.20	14.99
Q4	5.47	0.02	3.84	0.48	0.02	2.63	15.40	72.00	40.47	21.87	14.39
Q5	6.30	0.02	4.74	0.33	0.02	0.50	25.13	149.33	43.40	27.23	17.06
Q6	5.73	0.02	2.64	0.23	0.01	2.50	22.80	163.33	47.47	32.80	14.33
Q7	5.67	0.01	3.17	0.30	0.01	<1	14.73	132.67	49.00	17.00	11.61
Q8	5.87	0.02	4.60	0.42	0.02	1.10	22.07	145.33	43.33	42.47	10.94
Mean	5.74	0.02	3.79	0.34	0.02	1.69	22.97	120.08	44.37	30.43	14.05
p=0.05	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Q = Quadratic site, ns = non-significant

Table 3: Dominant tree species, relative frequency, relative density, relative dominance, important value index (IVI) and relative important value index (RIVI) of the Nong Rawiang dry dipterocarp forest in Northeast Thailand

Dominant tree species	Relative frequency (%)	Relative density (%)	Relative dominance (%)	Important value index (%)	Relative important value index (%)
Shorea siamenensis	5.59	49.32	50.17	105.08	35.03
Xylia xylocarpa	5.59	7.32	10.60	23.51	7.84
Ellipanthus tomentosus	5.59	7.64	6.08	19.31	6.44
Sindora siamensis	4.89	5.89	6.91	17.69	5.90

Table 4: Number of trees $quadrat^{-1}$, number of trees ha^{-1}, number of tree species ha^{-1}, basal area (m^2 ha^{-1}) of trees with DBH higher than 3 cm and Shannon-Wiener index of eight quadratic plots

Quadratic No.	Number of trees $quadrat^{-1}$	Number of Trees ha^{-1}	Number of species $quadrat^{-1}$	Basal area (m^2 ha^{-1})	H (S)*
Q 1	165	1,031	17	10.88	1.963
Q 2	210	1,313	22	11.19	2.108
Q 3	123	769	16	8.88	1.641
Q 4	181	1,131	15	12.94	1.252
Q 5	153	956	20	11.50	2.115
Q 6	83	519	13	11.56	1.908
Q 7	163	1,019	15	11.69	1.528
Q 8	179	1,119	21	14.94	1.581
Mean	157	982	17	11.70	2.087

*Shannon-Wiener index of diversity

Dominant tree species: The results showed that there are only four dominant tree species found at the Nong Rawiang dry dipterocarp forest in Northeast Thailand. They include *Shorea siamenensis*, *Xylia xylocarpa*, *Ellipanthus tomentosus* and *Sindora siamensis* (both varieties *siamensis* and *maritima*), with relative important value indices ranged from 5.90 to 35.03 for *Sindora siamensis* and *Shorea siamensis*, respectively (Table 3). These dominant types of tree species have been ranked according to their availability in the quadratic plots used.

Number of trees, tree species in each quadratic plot (Q) and its Shannon-Wiener index: Of the eight-quadratic plots used, numbers of trees per quadratic plot ranged from 83 to 210 for Q6 and Q2, respectively. Whilst numbers of trees per hectare ranged from 519 to 1,313 with numbers of species ranged from 13 to 22 for Q6 and Q2, respectively. Basal area of trees ha^{-1} ranged from 8.88-14.94 m^2 ha^{-1} for Q3 and Q8, respectively. Shannon-Wiener index of diversity ranged from 1.252 to 2.115 for Q4 and Q5, respectively (Table 4).

Taxonomic identification: An identification of trees taxonomically was carried out. They were classified into their respective family names and scientific names. The Nong Rawiang dry dipterocarp forest has 22 different family names with 37 species (scientific names) of trees. For this study, families were alphabetically arranged commencing from Anacardiaceae to Strychnaceae family. Some of the families have different tree species even though they belong to the same family, e.g. Caesalpinioideae family has 5 different scientific names, i.e. *Bauhinia racemosa* Lam., *Erythrophleum succirubrum* Gagnep., *Senna garrettiana* (Craib) Irwin and Barneby, *Sindora siamensis* Teijsm. and Miq. var. *siamensis*, *Sindora siamensis* Teijsm. and Miq. var. *maritima* (Pierre) K. and S.S. Larsen. However, some families have only a single species such as Apocynaceae and Connaraceae families and some other families (Table 5).

Fruit and seed characteristics, seed quality and reproductive success: The four dominant tree species were able to produce some considerable amount of fruits. The four species include *Shorea siamensis* (A), *Xylia xylocarpa* (B), *Ellipanthus tomentosus* (C), *Sindora siamensis v. siamensis* (D) and *Sindora siamensis v. maritima* (E), with their numbers of seeds per fruit of

Table 5: Family names and scientific names of tree species found within the Nong Rawiang dry dipterocarp forest, Nakhon Ratchasima Province, Northeast Thailand

Family name	Scientific name
Anacardiaceae	*Buchanania lanzan* Spreng.
	Lannea coromandelica (Houtt.) Merr.
Apocynaceae	*Wrightia arborea* (Dennst.) Mabb.
Burseraceae	*Canarium subulatum* Guillaumin
Caesalpinioideae	*Bauhinia racemosa* Lam.
	Erythrophleum succirubrum Gagnep.
	Senna garrettiana (Craib) Irwin and Barneby
	Sindora siamensis Teijsm. and Miq. Var. *siamensis*
	Sindora siamensis Teijsm. and Miq. Var. *maritima* (Pierre) K. and S.S. Larsen
Connaraceae	*Ellipanthus tomentosus* Kurz Var. *tomentosus*
Dipterocarpaceae	*Dipterocarpus intricatus* Dyer
	Shorea obtusa Wall. ex Blume
	Shorea roxburghii G.Don
	Shorea siamensis Miq.
Ebenaceae	*Diospyros ehretioides* Wall. ex G.Don
Euphorbiaceae	*Aporosa villosa* (Wall. ex Lindl.) Baill.
	Bridelia retusa (L.) A.Juss.
	Phyllanthus emblica L.
Guttiferae	*Cratoxylum cochinchinense* (Lour.) Blume
	Cratoxylum formosum (Jack) Dyer subsp. *pruniflorum* (Kurz) Gogel.
Irvingiaceae	*Irvingia malayana* Oliv. ex A.W.Benn.
Labiatae	*Vitex pinnata* L.
Lecythidaceae	*Careya sphaerica* Roxb.
Lythraceae	*Lagerstroemia floribunda* Jack
Melastomataceae	*Memecylon edule* Roxb.
Meliaceae	*Chukrasia tabularis* A.Juss.
Mimosoideae	*Albizia lebbeck* (L.) Benth.
	Xylia xylocarpa (Roxb.) Taub. Var. *kerrii* (Craib and Hutch.) I.C.Nielsen
Moraceae	*Artocarpus lacucha* Roxb.
Ochnaceae	*Ochna integerrima* (Lour.) Merr.
Papilionoideae	*Pterocarpus macrocarpus* Kurz
Rubiaceae	*Gardenia sootepensis* Hutch.
	Haldina cordifolia (Roxb.) Ridsdale
	Morinda coreia Ham.
	Morinda elliptica Ridl.
	Rothmannia wittii (Craib) Bremek.
Sapindaceae	*Schleichera oleosa* (Lour.) Oken
Strychnaceae	*Strychnos nux-vomica* L.

Table 6: Mean values of seed characteristics, seed quality and reproductive success of five dominant tree species of the Nong Rawiang dry dipterocarp forest, Northeast Thailand

	Tree species				
Characteristics	*Shorea siamensis* (A)	*Xylia xylocarpa* (B)	*Ellipanthus tomentosus* ©	*Sindora siamensis v. siamensis* (D)	*Sindora siamensis v. maritima* (E)
Lab. determinations					
Seed/fruit	1	3 -11	1-2	1-6	1-7
Seed number/kg	815	3,450	470	564	685
Fruit length (mm)	87.40	176.42	42.58	63.75	73.57
Fruit width (mm)	13.63	61.70	22.85	48.10	52.99
Seed length (mm)	17.35	14.82	25.05	17.02	17.22
Seed width (mm)	12.75	10.10	17.03	13.52	13.47
1,000-seed weight (g)	1,227	289	2,128	1,773	1,460
Seed moisture content (%)	48.18	12.10	67.12	12.44*	11.46*
Seed germination (%):					
Normal	85	87	16	85*	93*
Abnormal	6	4	24	5	2
Ungerminated	9	9	60	10*	5*
Germination indices	25	38	3.28	37.03**	62.02**
Natural germination					
Initial No. of seedlings	9	165	653	49	80
Survival numbers after 3 months	37	7	66	23	21
Reproductive success(%)	5.57	0.01	40.89	0.89	0.80

* P = 0.05, ** P = 0.01

1, 3-11, 1-2, 1-6 and 1-7 seeds, respectively (Table 6). Seed numbers/kg ranged from 470 to 3450 kg for items C and B, respectively. Fruit length ranged from 42.58 to 176.42 mm for items C and B, respectively. 1,000-seed weight or seed sizes ranged from 289 to 2,128 g for items B and C, respectively, whilst germination indices ranged from 25 to 62.02 for items A and E, respectively. The reproductive success % ranged from 0.01 to 40.89 for *Xylia xylocarpa* and *Ellipanthus tomentosus*, respectively.

With natural germination, the number of initial counted seedlings ranged from 9 to 653 for A and C, respectively, whilst the survival of seedlings after three months grown for reproductive success % ranged from 7 to 66 for A and B, respectively.

DISCUSSION

Ecological conditions of the Nong Rawiang dry dipterocarp forest indicate a typical rainforest environment in the tropics, i.e. there has been a relative amount of rainfall in all months of the three years studied except that of December when no rain was occurred. The results indicated that the plants of the Nong Rawiang dry dipterocarp forest received, more or less, a moderate amount of rainwater for growth and the survival of the plant species if not adequately available. Mean value of relative humidity exceeded 80% suggesting a high evapo-transpiration rate of water through leaves of the plant species within its community throughout the year apart from rainwater and the loss of water through the soil surface. This may have been partly attributable to high relative air temperature when the mean value of air temperature exceeded 27°C. High losses of water through plant leaves under high ambient air temperature have been reported[3]. The high ambient air temperature could be attributable to high incoming radiant energy from the sun when it reaches a range of 313.19 - 361.96 Cal. cm^{-2}/day. The results indicate a typical rainforest environment in the tropical area of Thailand.

Soil analysis data revealed that mean value of soil pH was slightly acidic but perhaps if the ratio between soil sample and water was 1:2.5 instead of 1:1 then the mean value of soil pH could have been slightly increased to a value of 6 or even slightly higher, hence soil pH of the Nong Rawiang dry diperocarp forest may be considered as a suitable level for growth of most plant species as stated by Miller and Donahue[15] and Suksri[3]. The results on soil property showed that mean values of most items such as organic matter, CEC, EC and others were relatively low particularly soil nitrogen (N), phosphorous (P) and potassium (K) suggesting inefficient amounts of nutrients for a rapid growth of most tree species. Obviously for a normal fertile soil, phosphorous should be at a range of 15-25 ppm, whilst potassium should be at a range of 80-120 ppm as stated by Mengel and Kirkby[16] and Suksri[3]. The low amounts of soil nutrients could have been attributable to perhaps the high leaching rate and run off of soil nutrients due to heavy rainfall and partly due to the cutting down of trees for lumber industries in the past decades taken away a large amount of calcium. The results also suggested the need to add some certain amounts of a complete chemical fertiliser (NPK) annually in order to achieve a rapid growth of the tree species. This may include the application of some certain amounts of micronutrients to the soil, since most soil series in the tropics contained inadequate amount of microelements[3]. However, soil analysis data of the soil samples taken to a depth lesser than half a metre may not be sufficient to explain soil fertility level, since most tree roots could be able to anchor downward to a considerable depth. It is evidently found that soil organic matter was extremely low with a mean value of 0.34%. The results indicated that the fallen down of leaves of trees during the past decades failed to increase soil organic matter. Leaves of the dry dipterocarp forest trees obviously fall down annually, hence the fallen leaves could have been burned out by fire in dry seasons and washed away in rainy seasons and partly due to termite population when they used dry leaves for their food and its residues could have been washed away by rainwater annually. Therefore, in order to protect and conserve the Nong Rawiang dry dipterocarp forest trees for sustainable forestry, an intensive management to retain a huge amount of the fallen dry leaves to cover the ground area must be practiced. The ground area being covered by a dense amount of dried leaves should prevent both a high speed of surface runoff and evaporation rate of water losses through the soil surface. However, it has been pointed out that this type of dry dipterocarp forest could be able to exist if not being interfered by man. The drought conditions could have aided these four dominant tree species and some other minority tree species to exist[17]. This could possibly be implied that wet conditions with a high soil fertility level could have affected the potentiality to survive of these four dominant tree species due to perhaps their poor competitive efficacy to survive when they could not compete with other tree species in the community. It has been stated by Kutintara[18] and Ketpraneet[19] that a periodically burning of fallen leaves of trees of this type of forest in dry season is needed in order to retain this type of dry dipterocarp forest otherwise this type of forest could not be existed and then it could be categorized into a mixed deciduous forest. Furthermore, if the forest trees continue to grow without a periodic burning of the fallen aging dry leaves for a number of years then it could be classified as a dry evergreen forest eventually.

With the four dominant tree species found in the Nong Rawiang dry dipterocarp forest, most of which are of hard wood trees for lumbers, thus dry conditions encourage dry dipterocarp forest to exist. This would suggest an excellent idea for a long-term utility of economic lumber trees for hard wood industries. However, at present their availability is relatively small. The work of Pipitwittaya[17] on a dry dipterocarp forest of the nearby zoning area of Nakorn Ratchasima Province confirms this finding. Therefore, the cutting down of trees should not be done at least within the coming few more decades, but villagers should be allowed to collect those annual natural mushroom species for their daily diets. The results also showed that number of tree species/quadratic site was relatively low suggesting an urgent need to add more seedlings of tree species to this dry dipterocarp forest or otherwise leaving this forest alone without any interference from man and other pesters for years to come. The Nong Rawiang dry dipterocarp forest also has a smaller number of trees/ha when compared with the Nongteng-Jakkarat dry dipterocarp forest of the nearby area of Nakhon Ratchasima Province[20]. The results indicated that only species with a high tolerance to this extremely poor soil conditions could be able to survive and it could have been possible that deforestation was severely done with the Nong Rawiang dry dipterocarp forest. Shannon-Wiener index of diversity value was relatively low with a mean value of 2.09, thus some tree species could possibly have had its influence on the survival of other tree species. Therefore, its diversity was relatively low. Similarly, basal area of tree was relatively low indicating a certain area without vegetation except grasses. The results suggested an urgent need to manage this dry dipterocarp forest with an intensive care. This dry dipterocarp forest has only 22 tree families with 37 species, which is lesser than the work reported by Khamyong[21] with another dry dipterocarp forest in the northern part of Thailand (Doi Inthanon) where the recorded species reached a value of 41. Therefore, there is a tendency to increase tree species as that of Doi Inthanon dry dipterocarp forest in the northern part of the country.

For fruit and seed characteristics and seed germination, the results showed that the four dominant tree species were able to produce some large amounts of fruits and seeds. These four species include *Shorea siamensis*, *Xylia xylocarpa*, *Ellipanthus tomentosus*, *Sindora siamensis v. siamensis* and *Sindora siamensis v. maritima*. The infertile fruits and seeds could possibly be due partly to the effect of poor soil fertility when other tree species could have been hardly developed fruits and seeds. The poor soil conditions could have been affected seed germination % when the seeds did not attain adequate amount of nutrients for the development of seeds. The four tree species produced different numbers of seeds/fruit, seed number/kg, 1000-seed weights and germination indices. The highest value of germination index was significantly found with *Sindora siamensis v. maritima* followed by *Sindora siamensis v. siamensis*, whilst other three species gave smaller and not statistically significant. The results indicated a fair adaptability to the environment of these two species since both possessed the highest value of germination index. Nevertheless, the results showed that the survival of seedlings of the four species was relatively low. This could have been attributable to the poor soil fertility level where the tree species were not able to attain adequate nutrients in order to produce a high quality of seeds. With respect to productive success, the results indicate that only *Ellipanthus tomentosus* has reproductive success % up to 40.89, whilst *Shorea siamensis* attained only 5.57 and even lesser than 1% for the other species. The results suggested that high percentage of reproductive success could have been developed from those inbred types rather than out-crossing type where only *Ellipanthus tomentosus* is considered to be an inbreed type of flower fertilization, whilst the rest are not. The work reported by Weins *et al.*[22] confirms this finding. From these results, it may be of important value to provide an utmost management method to conserve the Nong Rawiang dry dipterocarp forest and perhaps the same method should be applied to all of the natural forests of the country in order to encourage the rapid growth of the tree species. It seems more likely that more reforestation programmes have been implemented in Thailand but with only a small attention on soil fertility programme, thus a large amount of the planted seedlings were not able to survive across the seasons. In order to obtain a greater success on the survival of seedlings, an advanced fertiliser technology on drought tolerance is urgently needed.

ACKNOWLEDGMENTS

The authors wish to thank the TRF/BIOTEC Special Program for Biodiversity Research and Training grant BRT 543028 for financial assistance. Asst. Prof. Dr. Achara Thammathaworn, Dr. Nathawut Thanee, Dr. Bundit Ponoy, Dr. Chaweewan Hutacharern, Miss Chutinan Choosai, Mr. Luis Garcia and Mr. Boonchai Srisassawatkul for their kind assistance when this work was carried out.

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