EFFECTS OF PRESOWING SEED TREATMENTS AND MYCORRHIZAE ON GERMINATION AND SEEDLING GROWTH OF NATIVE TREE SPECIES FOR FOREST RESTORATION

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

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Thesis Title	Effects of Presowing Seed Treatments and Mycorrhizae on Germination and Seedling Growth of Native Tree Species for Forest Restoration
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ABSTRACT

Forests in Thailand have declined over the past 30 years due to agricultural expansion and illegal forest encroachment and logging. Deforestation causes depletion of soil fertility, soil erosion and flooding in the rainy season, and streams drying up in the dry season. Forest restoration by planting native tree species can help protect biodiversity, but many native tree species have long periods of seed dormancy or low germination rates and knowledge about how to propagate them from seeds is often lacking. For successful forest restoration vigorous seedlings are needed. Suitable seed

germination methods must be developed by testing various presowing seed treatments to optimize germination are needed. To produce high quality seedlings for forest restoration, seedling roots may be inoculated with mycorrhizae to accelerate seedling growth in the nursery before planting out in deforestated sites. This research was conducted at the Forest Restoration Research Unit (FORRU) at about 1,000 meter elevation. Seeds were collected from 6 native tree pecies: *Careya arborea* Roxb. (Lecythidaceae), *Ficus auriculata* Lour. (Moraceae), *Holigarna kurzii* King (Anacardiaceae), *Michelia baillonii* Pierre (Magnoliaceae), *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae), and *Quercus vestita* Rehd. & Wils. (Fagaceae). Five presowing treatments were applied to the seeds with three replications 1. control, 2. soaking in water for 24 hours, 3. heating in water at 60-70^0 C for 20 minutes, 4. scarification by hand by cutting the seed coats to make small holes about 1-2 mm wide for each species and 5. scarification with H_2SO_4 for about 3-10 minutes. After the seeds germinated, developed 2 pairs of leaves, and were vigorous, the seedlings were transferred into plastic bags (23 x 6 cm), filled with a mixture of forest soil, coconut husk, and peanut valves (2:1:1). Seedlings were divided into three groups, one received 3 ml of TRITON per bag, one 6 ml of TRITON per bag and the control group received no TRITON. TRITON a commercially produced mixture of the fungal spores of *Glomus etunicatum, G. intradices* and *G. fasciculatum* adsorbed onto clay particles. Morphological characteristics of seedlings such as height, stem diameter, and mortality were measured to monitor performance, finally shoots and roots were separated and the shoot:root dry weight values were calculated.

For *Careya arborea,* the best treatment was water soaking for 24 hours which raisied the germination percent from 55.1% to 79.6%. Almost all seeds were killed when treated with H_2SO_4. For *Ficus auriculata* heating in water at 60-70^0 C germination (42.1%) was the best treatment. For *Holigarna kurzii* and *Michelia baillonii* water soaking for 24 hours increased germination from 22.7% and 2.8% to 54.2% and 9.3%, respectively, but seed germination percentage of *Michelia baillonii* remained unacceptably low. For *Xantolis burmanica* the control had the highest percentage seed germination but was it still unacceptably low at about 12.9%.

Seedlings of three species (*Careya arborea, Ficus auriculata,* and *Holigarna kurzii*) were unaffected by TRITON. However for *Xantolis burmanica*, the 6 ml TRITON treatment was higher than with 3 ml of TRITON and the control treatment. Observations at the Laboratory of Applied Microbiology Research Unit, Chiang Mai University found fungi of *Glomus* sp. in the roots of *Xantolis burmanica* seedlings from this experiment, but no infection for *Careya arborea, Ficus auriculata* and *Holigarna kurzii* seedling. *Xantolis burmanica* species is recommended for TRITON treatment to increase the growth rate of seedlings and improve their vigour in the nursery.

ชื่อเรื่องวิทยานิพนธ์ ผลของการเตรียมเมล็ดและไมคอไรซาที่มีต่อการงอกและการเติบโตของกล้าไม้พันธุ์ท้องถิ่นเพื่อการฟื้นฟูป่า

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บทคัดย่อ

ป่าไม้ของประเทศไทยได้ลดลงมาได้ 30 ปีกว่ามาแล้ว โดยเป็นผลมาจากการขยายเนื้อที่การเกษตร การบุกรุกพื้นที่ป่าไม้ และ การโค่นไม้อย่างผิดกฎหมาย การทำลายป่าไม้เป็นสาเหตุให้เกิดการสูญเสียความอุดมสมบูรณ์ของดิน การพังทลายของชั้นดิน และทำให้เกิดน้ำท่วมในฤดูฝน ลำธารเหือดแห้งในฤดูแล้ง การฟื้นฟูป่าโดยการปลูกไม้พรรณพื้นเมืองสามารถช่วยอนุรักษ์ความหลากหลายทางชีวภาพได้ แต่เนื่องจากความรู้เกี่ยวกับวิธีการขยายพรรณไม้ท้องถิ่นยังไม่เพียงพอ ทำให้หลายชนิดใช้เวลาในการเพาะนาน หรือมีอัตราการงอกต่ำ เพื่อให้ประสบผลสำเร็จในการฟื้นฟูป่าจำเป็นต้องใช้กล้าไม้ที่มีคุณภาพดี และแข็งแรง วิธีการหนึ่งที่ควรได้รับการพัฒนาคือการกระตุ้นการงอกของเมล็ด โดยการทดสอบวิธีการเตรียมเมล็ดก่อนการเพาะให้เหมาะสมกับชนิดของพรรณไม้ และการใส่เชื้อไมคอไรซาที่รากของกล้าไม้อาจจะเพิ่มประสิทธิภาพ ทำให้กล้าไม้เจริญเติบโตได้ดีก่อนนำไปปลูกในพื้นที่เสื่อมโทรม งานวิจัยนี้ได้ทำการศึกษาที่เรือนเพาะชำของหน่วยวิจัยการฟื้นฟูป่า อุทยานแห่งชาติดอยสุเทพ-ปุย จังหวัดเชียงใหม่ โดยการเก็บเมล็ด

พันธุ์ 6 ชนิดคือ: กระโดน *Careya arborea* Roxb. (Lecythidaceae), เดื่อใบใหญ่ *Ficus auriculata* Lour. (Moraceae), น้ำเกลี้ยง *Holigarna kurzii* King (Anacardiaceae), จำปีป่า *Michelia baillonii* Pierre (Magnoliaceae), ละมุดป่า *Xantolis burmanica* (Coll & Hemsl.) P.Royen (Sapotaceae) และ ก่อตาหมู *Quercus vestita* Rehd. & Wils (Fagaceae) โดยทำการทดสอบวิธีการกระตุ้นเมล็ด เพื่อเร่งการงอก 5 วิธี แต่ละวิธีมี 3 ซ้ำดังนี้ 1.การควบคุม(Control) 2.แช่น้ำแล้วทิ้งไว้ 24 ชั่วโมง 3.แช่น้ำร้อนในระดับ 60-70^0 C ประมาณ 20 นาที 4.ทำลายเปลือกเมล็ดด้วยการตัด และ 5.ทำลายเปลือกเมล็ดด้วยกรดกำมะถันเข้มข้น หลังจากเมล็ดได้มีการงอก เจริญเติบโตจนมี 2 ใบเลี้ยง และมีคุณภาพแข็งแรงดี นำกล้าไม้ย้ายไปปลูกในถุงพาสติกขนาด 23 x 6 cm ที่บรรจุด้วยดินป่าไม้ กากมะพร้าว และกากถั่วลิสง(2:1:1). กล้าไม้ได้ถูกแบ่งเป็น 3 กลุ่ม คือ กลุ่มที่ 1 ใส่เชื้อ 3 ml TRITON ต่อถุง กลุ่มที่ 2 ใส่เชื้อ 6 ml TRITON ต่อถุง และ กลุ่มที่ 3 ไม่ใส่เชื้อเลย (TRITON เป็นผลิตภัณฑ์การค้าที่ประกอบด้วยเชื้อรา *Glomus etunicatum*, *G. intradices* และ *G. fasciculatum* โดยใส่ดินเหนียวภูเขาไฟเป็นตัวดูดซับ) ทำการตรวจวัด จดบันทึกลักษณะทางสันฐานวิทยาของต้นกล้า และอัตราส่วนน้ำหนักแห้งระหว่างลำต้นต่อราก

จากการศึกษาพบว่าพรรณไม้แต่ละชนิดมีวิธีการเพาะเมล็ดที่เหมาะสมแตกต่างกันดังนี้ กระโดนใช้วิธีการแช่น้ำแล้วทิ้งไว้ 24 ชั่วโมงจะเพิ่มการงอกของเมล็ดได้ร้อยละ 79.6 แต่ว่าเมล็ดทั้งหมดจะตายด้วยวิธีการการทดสอบแบบทำลายเปลือกเมล็ดด้วยกรดกำมะถันเข้มข้น เดื่อใบใหญ่ใช้วิธีการแช่น้ำร้อนในระดับ 60-70^0 C การงอกของเมล็ดจะได้ร้อยละ 42.1 น้ำเกลี้ยง และ จำปีป่าที่ใช้วิธีการแช่น้ำเย็นทิ้งไว้ 24 ชั่วโมง การงอกของเมล็ดจะได้ร้อยละ 54.2 และ 9.3 ตามลำดับ แต่ว่าการงอกของจำปีป่ายังมีอัตราที่ต่ำ ละมุดป่าที่ใช้วิธีการควบคุม(Control) การงอกของเมล็ดจะได้ร้อยละ 12.9 อัตราการงอกของเมล็ดชนิดนี้ก็ยังต่ำเหมือนกัน.

กล้าไม้ 3 ชนิด(กระโดน, เดื่อใบใหญ่ และ น้ำเกลี้ยง) การใส่เชื้อ TRITON ไม่มีผลต่อการเจริญเติบโต ถึงอย่างไรก็ตามมูลค่าผลประโยชน์ที่ได้รับของละมุดป่าจากการใส่เชื้อ 6 ml TRITON จะสูงกว่า 3 ml TRITON และ วิธีการควบคุม(Control) การที่ใส่เชื้อ TRITON ของชนิดพันธุ์นี้มีผลต่อการเพิ่มการเจริญเติบโตของกล้าไม้ พร้อมนี้ยังตรวจพบเชื้อรา *Glomus* sp. อยู่ที่รากซึ่งทำให้กล้าไม้ในเรือนเพาะชำมีความแข็งแรงยิ่งขึ้น

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ABBREVIATIONS

Cm:	centimeter
M:	meter
Ml:	milliliter
Mm:	millimeter
T1:	Treatment 1 (control)
T2:	Treatment 2 (soaking in water for 24 hours)
T3:	Treatment 3 (heating in water at 60-70^0 C)
T4:	Treatment 4 (scarification by hand)
T5:	Treatment 5 (scarification with H_2SO_4)

INTRODUCTION

Forests support fundamental ecological resources for life, such as water, clean air, and soil. They also provide many products such as fuel-wood, medicinal plants, food, chemical substances, fibers, recreational opportunities, educational values, genetic resources, *etc.* The indirect benefits of forests include watershed protection and prevention of soil erosion and flood damage. Forests are essential for many human needs and survival of many other living organisms.

Forests are an important habitat for wildlife. Fragmentation, by construction of infrastructure in forest areas, causes habitat destruction. Consequently, shortages of habitat and food for wild animals increase competition among species. When this happens many species are unable to maintain their populations and become locally extirpated. Deforestation in Thailand has isolated populations of large mammals such as elephants, tigers, bears, and wild cattle. Populations of smaller animals such as gibbons and hornbills have become perilously small and isolated (FORRU, 2000). This also causes loss of ecological balance. The overall effect is a loss of biodiversity (Maxwell, 1999).

The forests of northern Thailand are the most important natural resources to protect headwater resources that feed the Cho Phraya River, irrigate rice fields of the central plains, and supply water to Bangkok, the nation's capital. They are habitat for numerous wildlife species, including 150 mammal species (Lekagul & McNeely,

1988), 383 birds (Round, 1988) and at least 3,450 vascular plants, of which 1,116 are trees (CMU Herbarium Database, 1999).

However, the forested area in Thailand has declined dramatically over the past 30 years due to agricultural expansion and illegal forest encroachment and logging. In 1961, forest covered about 55% of the total land area of Thailand (Pratong 1996). Forest cover was about 40% in 1973, about 26% in 1993 (Sangwanit 1995), and about 25% in 1998 (Royal Forestry Department 1998). Maxwell (2001) estimates that it is c. 15%. In 1988, massive landslides, mudflows, and debris avalanches containing large volumes of downed trees and log with flooding in southern Thailand that destroyed villages and killed many people. (RAO, 1988).

The consequences of deforestation are particularly serious in watershed areas, such as soil erosion and flooding in the rainy season and streams drying up in the dry season (FORRU, 2000).

To solve this problem, the Thai Government has made a policy of reforestation, decided by the Council of Ministers on 3 November 1985, to fix the target for forest area at not less than 40% of the country or 1.298 million km^2 (Jitlam, 2001). At first, the Royal Forest Department planted pines, teak, and eucalyptus trees, but the value of such plantations for biodiversity and conservation is low. For many projects seedling quality was poor and such trees have low value for wildlife conservation and watershed protection (World Bank, 1993).

The Forest Restoration Research Unit (FORRU) aims to develop effective methods to complement and accelerate natural forest regeneration on deforested sites within conservation areas, to increase biodiversity and protect watersheds. (FORRU, 2000).

Forest restoration depends on raising high quality seedlings either from seeds or vegetative propagules. Raising seedlings from seeds poses some problems as it is governed by a number of factors. Knowledge about these factors is very limited. At a time when many tree species and their habitats are being threatened, it is urgent to learn more about them and use the information gained to propagate, utilize, and conserve native tree species (Helmut & Lohmann, 1991). Different tree species produce seeds at different times of the year and seedlings grow at different rates, yet they must all reach a plantable size (40-60 cm tall) at the planting time (May-June in northern Thailand). Approximately 1,200 tree species, indigenous to northern Thailand, have not been yet propagated in nurseries (FORRU, 2000). Lack of information about how to grow them has limited their use in forest restoration programmes (Kuarak *et al.* 2000).

Many native tree species have long periods of seed dormancy or low germination rates and knowledge about how to propagate them from seeds is often lacking.

Therefore, this project aimed to develop suitable seed germination methods by testing various presowing seed treatments to optimize germination of six different indigenous tree species of potential use in forest restoration planting programmes.

It is also well known that infection of tree roots with vesicular-arbuscular mycorrhizal (VAM) fungi, expands the root system within the surrounding soil, enhances nutrient uptake, reduces the need to fertilize and irrigate, and improves seedling health and resistance to diseases. VAM inoculation can improve plant growth (Mosse and Hayman 1980) by accelerating mycorrhiza formation or by introducing strains that are more effective than indigenous fungi. The commercial product TRITON is a high quality bio-stimulant product, developed on the basis of scientific research over many years. It is non-toxic, and completely safe to users and plants consumers. TRITON contains expanded clay with infective units (spores/hyphae) of arbuscular mycorrhizal fungi spores of *Glomus etunicatum, G. intradices* and *G. fasciculatum*. These fungi not only provide improved growth for different crops, but also increase resistance to root pathogens, and reduces the severity of foliar diseases (Umwelt, 2003).

A artificially inoculating forest tree seedlings with mycorrhizae have not been tested for the vast majority of Thailand's native species. My research also tested the effects of mycorrhizae inoculation on establishing optimal production schedules for the species studied. It aimed to develop more efficient seedling production techniques to improve plant quality and health, and to grow seedlings to a suitable size (40-50 cm tall) within one year.

Hypotheses

1. Various presowing seed treatments should accelerate and increase germination.
2. Application of mycorrhizae to the roots of potted seedlings should accelerate growth to attain suitable size for planting within one year after seed collection.

Objective

The objective of this research was to develop appropriate methods to achieve high rates of seed germination and seedling growth by applying different pre-sowing seed treatments and a mycorrhizal treatment to seedlings.

Educational Advantage

This research will generate new information for the improvement of native tree seedling production for forest restoration.

LITERATURE REVIEW

Southeast Asia, in common with all other tropical regions, is continuing to lose its forests and their associated biodiversity. In Thailand, for example, forest cover has been reduced from about 53% in the early 1960's (Bhumibamon, 1986) to about 19% in the year 2000 (FAO, 2000). Maxwell (2001) estimates that it is c. 15%. Forest cover change in Thailand during 1990-1995 was approximately -2.6% per year (FAO, 1997). Deforestation results from logging and agricultural expansion (Hirsch, 1990). The increase in the rate of deforestation in recent years is indicative of continued logging, shifting cultivation and development of infrastructure. Consequently today, large areas of Thailand, including considerable parts of the extensive system of national parks and wildlife sanctuaries, comprise secondary forests subjected to differing degrees of disturbance. In northern Thailand, populations of large vertebrates have been severely depleted and many species of large birds have become extirpated from the region. As a consequence of deforestation throughout the country, biodiversity is now severely threatened (Elliott *et al.*, 2000).

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 (Elliott *et al.*, 1995).

Germination, Establishment, and Speed of Growth

A seed germinates when moisture, the amount and sort of light, temperature, and other factors are suitable. A sequence of steps is involved. The seed coat absorbs water, swells, and becomes more permeable to water, oxygen, and carbon dioxide. Metabolism, which in the resting seed is extremely low, is stimulated. Food reserves are mobilised by hydrolysis, after intake of water. These nutrients are transported to the regions of growth activity of the young plant. In seeds, where the food is usually stored in the endosperm, this is taken up by the growing plant, especially the roots and epicotyl. In seedlings, with food-storing cotyledons, export of food from the cotyledons takes place. The absorbed water also induces swelling of the seed, which results in opening of the seed. The radicle, hypocotyl & epicotyl are then pushed out of the envelopments (De Vogel, 1980).

During establishment and initial growth, the seedling is very vulnerable. Adverse conditions easily affect the young plant. This sometimes results in the entire loss of a crop of seedlings. A seedling has no means of active protection against adverse conditions. When such conditions occur, the seedling is first hampered in its development and sometimes dies (De Vogel, 1980).

Speed of growth of the seedling, in the earliest stages of germination, is mainly determined by the food contents of the seed and its genetic properties. Further development depends on the food reserves present in the seedling and/or assimilates produced by the cotyledons and the developing leaves. In addition, growth is often

largely influenced by external factors, especially when the seedling has to rely partly or entirely on the food it produces through assimilation. The effect of light on seedling growth may be considerable, especially for plants with cotyledonary leaves, but it may also have a large effect on seedlings with a long persistent food reservoir (De Vogel, 1980).

Fenner (1985) states that "dormancy is a delaying mechanism which prevents germination under conditions which might prove to be unsuitable for establishment", while Bewley and Black (1994) defines seed dormancy as "the inability of the embryo to germinate because of some inherent inadequacy".

Vongkamjan (2002) studied 18 indigenous tree species of northern Thailand, of potential value to forest restoration. Higher rates of seed germination were achieved under nursery conditions than under natural conditions in forest gaps. Seed germination was higher in the sun than in shade, except for *Reevesia pubescens* Mast. Var. siamensis (Craib) Anth. (Sterculiaceae) and *Betula alnoides* B.H. (Betulaceae). Various seed pre-treatments (heat, scarification, acid *etc.*) promoted seed germination for all species except, *Shorea obtusa* Wall. *ex* Bl. (Dipterocarpaceae) and *Debregeasia longifolia* (Burm.f.) Wedd. (Urticaceae). This research showed 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.

However Vongkamjan (2002) provided no data on relative growth rate to produce seedlings of suitable size (50 cm) for planting in deforestated areas and no seed germination data for the species: Investigated *Careya arborea* Roxb. (Lecythidaceae), *Ficus auriculata* Lour. (Moraceae), *Holigarna kurzii* King (Anacardiaceae), *Michelia baillonii* Pierre (Magnoliaceae), *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae), and *Quercus vestita* Rehd. & Wils. (Fagaceae). Therefore this study was designed to fill these gaps in knowledge.

Singpetch (2001) also studied the propagation and growth of some potential framework tree species for forest restoration which had previously proved difficult to propagate in the nursery this included *Albizia chinensis* (Obs.) Merr. (Leguminosae, Mimosoidae), *Aporusa villosa* (Lindl.) Baill. (Euphorbiaceae), *Bauhinia variegata* L. (Leguminosae, Caesalpinoideae), *Ficus abelii* Miq. (Moraceae), *Ficus glaberrima* Bl. Var. *glaberrima* (Moraceae), *Ficus hirta* Vahl var. *roxburghii* (Miq.) King (Moraceae), *Macaranga denticulata* (Bl.) M.-A. (Euphorbiaceae), *Rhus chinensis* Mill. (Anacardiaceae), and *Terminalia alata* Hey. *ex* Roth (Combretaceae). Six different pre-sowing treatments were applied to the seeds to increase and accelerate germination (4 levels of temperature and scarification by hand and concentrated H_2SO_4. Two fertilizer treatments of "Osmocote" and NPK: 15:15:15 were applied to 2 randomized complete blocks. Scarification by hand was the best treatment for *Albizia chinensis* and *Bauhinia variegata* seeds, increasing the germination percent to 78% and 62%. Sulfuric acid was best for *Rhus chinensis* (68%). Soaking in water 27^0 C was best for *Aporusa villosa* and *Ficus abelii* (49% and 34%), but hot water 80-100^0 C killed all seeds. The optimal fertiliser for *Albizia chinensis* and *Terminalia*

alata was conventional, quick-release, soluble fertilizer, while the best fertiliser for *Bauhinia variegata*, *Aporusa villosa*, and *Rhus chinensis* was "Osmocote".

However Singpetch (2001) did not study the effects of mycrorrhizae to increase growth rate and dry mass of shoots:roots ratio among treatments. These data are very important to improve production of native tree seedlings for forest restoration.

Mycorrhizae are a type of minute endophytic, biotrophic, mutuelly symbiotic fungi, prevalent in many cultivated and natural ecosystems. There are numerous reports in the literature on the incidence of fungi on the roots of plants (Sutton, 1973; Powell, 1977; Hayman and Mosse, 1976; Rhodes and Gerdemann, 1978). There are three major groups of mycorrhizae viz. ectomycorrhizae, ectendomycorrhizae, and endomycorrhizae. Ectomycorrhizae and endomycorrhizae are generally associations of higher fungi (Basidomycetes and Ascomycetes), typically involving the roots of woody perennials (Marks and Kozlowski, 1973). The fungi form intercellular ramifications of mycelia within the host cortex (the hartig net), and dense hyphal encapsulations on fine roots (the sheath or fungal mantle). Ectomycorrhizae are the most important in forest ecosystems.

Endomycorrhizae are characterized by fungal penetration of the host cells. There are two major groups (Harley, 1969; Smith, 1980) of septate and aseptate hyphae. Septate hyphae occur in the groups *Orchidaceae* and the *Ericaceae*. The associated endophytes are higher fungi. Aseptate hyphae characterize the "phycomycetous" or vesicular-arbuscular (VA) mycorrhizae (Mosse, 1973;

Gerdemann, 1975). The fungi belonging to the family Endogonaceae class Zygomycetes order Endogonales (Trappe and Schenck, 1982). Four genera engage in known VA mycorrhizal interactions: *Acaulospora* Gerd. Trappe, *Gigaspora* Gerd. Trappe, *Glomus* Tul. Tul., and *Sclerocystis* Berk and Broome (Gerdemann and Trappe. 1974). Schenck and Smith (1982) divided VAM into two groups: Azygosporic genera, including *Gigaspora, Acaulospora*, and *Entrophospora* and Chlamydosporic genera, including *Glomus, Sclerocystis*, and *Complexipes*. Little knowledge of the life cycles of these organisms is known (Nopamornbodi and Vasuvat, 1989).

Vesticular arbuscular (VA) mycorrhiza infect the root with particular soil fungi to form symbiotic associations. It is often assumed that VA mycorrhizal fungi could increase the efficiency of phosphate fertilizers in agriculture. Many reports have indicated the incidence of VA fungi on the roots of fruit and plantation trees (McGraw & Schenck, 1980). There are two mechanisms through which the fungi benefit plant growth; 1) more efficient adsorption of phosphates from unavailable or slow release sources which is common to the tropics; 2) extending the absorbing surface area of root systems. Both mechanisms can reduce the requirement of phosphates and trace fertilizers and help resist many root diseases. (Omsub *et al.*, 1995).

Omsub *et al* (1995) studied the effect of endomycorrhizal inoculation of *Prunus mume* Authi (Rosaceae) planted at Angkhang in northern Thailand. An assessment of the VA mycorrhizae (VAM) was conducted on this fruit tree species, collected from highland areas in northern Thailand. Many surveys have been made for fruit tree

VAM fungi distribution. The characteristics and the quantities of indigenous VAM have been described. VAM genera found in this collection included *Glomus* spp., *Acaulopapora* spp., and *Gigaspora* spp., among which *Glomus* was dominant in the area. According to different sporulation abilities and root infection efficiency, 12 species were selected from 235 isolates. An inoculation test was conducted among the 12 species, to find out the most suitable VAM for Japanese aprocot (*Prumus mume).* Japanese apricot seedlings inoculated with 5 fungi species showed better growth than non-inoculated seedlings. Seedlings inoculated with any of the 12 species showed better survival in drought conditions than those without inoculation and no fertilizer application. The data also showed that VAM could increase growth rate in both situations. VAM species can foster nutrient absorption for host plants even when no fertilizer is applied. Without VAM inoculation, Japanese apricot growth was slow, especially with the non-fertilized treatments. The results showed the potential to use vesticular arbuscular mycorrhyzal fungi to increase the uptake efficiency of phosphates and other nutrients.

However Omsub *et al.* (1995) provided no data on the indigenous native tree species, presenting only results from fruit trees and exotic species (from Japan).

Uthaiwan *et al.* (1995) studied the effects of ectomycorrhizal fungi on growth of *Pinus kesiya* Royle ex Gordon seedlings grown in Angkhang soil northern Thailand. *Pinus kesiya* Royle *ex* Gordon (Penaceae) seedlings grown in autoclaved Angkhang soil were non-inoculated and inoculated with 6 species of ectomycorrhizal fungi. and placed in the Faculty of Forestry Nursery in Bangkok. The ectomycorrhizal fungi

were chopped fresh fruit bodies of *Astraeus hygrometricus* (Pers.) Morgan, *Laccaria laccata* (Fr.) Berk & Br., *Pisolithus tinctorius* Pers., *Russula virescens* Fries, and *Scleroderma citrinum* Pers., and a pure culture of *Cenococcum geophilum* (Sow.) Fred. & Winge. A completely randomized design was used to compare growth of the $8^1/_2$ month old seedlings. Inoculated seedlings formed distinctive ectomycorrhizae and most of them had better growth than the non-inoculated control seedlings. Seedlings inoculated with *P. tinctorius* had the highest growth. Their growth was significantly higher than that of the control and some of the other treatments. Seedlings inoculated with *Cenococcum geophilum, Laccaria laccata, Russula virescens* and *Scleroderma citrinum* had intermediate growth. Most of their growth parameters were significantly higher than those of the control. Although seedlings inoculated with *Astraeus hygrometricus* showed higher mean growth than the controls, the result was not significant. It is therefore recommended to inoculate *P. tinctorius* to the root system of *Pinus kesiya* seedlings produced in forest nurseries. Uthaiwan *et al,* (1995) provided data only on one native tree species, insufficient for forest restoration in conservation areas and studied only Angkang soil innoculated with 6 ectomycorrhizal fungi. Her study was conducted in the lowlands and in the central region Thailand.

MATERIALS and EQUIPMENT

Species studies

Seeds of six native tree species were collected from Doi Suthep-Pui National Park and from Chiang Mai University Campus:

- *Careya arborea* Roxb. (Lecythidaceae) (Figure 3)
- *Ficus auriculata* Lour. (Moraceae) (Figure 4)
- *Holigarna kurzii* King (Anacardiaceae) (Figure 5)
- *Michelia baillonii* Pierre (Magnoliaceae) (Figure 6)
- *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae) (Figure 7)
- *Quercus vestita* Rehd. & Wils. (Fagaceae) (Figure 8)

Criteria used to select species for this project

1. Potential framework tree species were selected because framework tree species grow fast and develop dense, spreading canopies that shade out herbaceous weeds. Such framework tree species must also provide resources for wildlife, such as edible fruits or seeds, nectar, as well as roosting or nesting sites. Planting them attracts seed-dispersing animals that might have fed on fruits and seeds in remaining nearby areas of forest. (FORRU, 2000)

2. The six tree species selected are nature to northern Thailand and are important for reforestation. They have fruit which attracts wildlife and which helps disperse these seeds into barren or deforestated sites, thus accelerating the return of biodiversity.

3. These species have not yet been tested with the mycorrhizae product "TRITON".

4. They were in fruit during the time (April-June) of this experiment and seeds could be collected.

5. According to the FORRU germination data, these species had low germination rates and some species have been not tested (Table 1).

Table: 1. Seed germination data from FORRU

Species	Problem in Nursery	Seed collection date	% germination (sun)	% germination (shade)
Careya arborea Roxb. (Lecythidaceae)	not yet tested with mycorrhizae	25/May/91	96	89
Ficus auriculata Lour. (Moraceae)	no germination	5/Feb./98	0	0
Holigarna kurzii King (Anacardiaceae)	not yet studied	no data	no data	no data
Michelia baillonii Pierre (Magnoliaceae)	low germination	29/July/98	29	0
Xantolis burmanica (Coll. & Hemsl.) P. Royen (Sapotaceae)	low germination	19/Feb./96	26	26
Quercus vestita Rehd. & Wils. (Fagaceae).	damping off	20/Feb./97	56	78

Source: FORRU 1991-1999.

Equipment

Modular trays (Figure 1)

Vernier caliper (mm)

Ruler (cm)

Thermometer (^{0}C)

Beakers 500 ml, 1000 ml

Graduated cylinder (ml)

Hot boil water equipment (stove)

Clamp

Camera

Data collection sheet

Drying oven

Cutter

Materials

Forest soil from Doi Suthep-Pui National Park	4 m^3
Coconut husk	180 Kg
Peanut valves	120 Kg

Plastic bags (23 x 6 cm)

"Osmocote", (NPK, 14-14-14)

Concentrated sulfuric acid (H_2SO_4)

70% ethyl alcohol

Micorrhizae 'TRITON' (Figure 7)

METHODS

Site Description

This study was conducted at the Forest Restoration Research Unit Nursery (FORRU). FORRU was established in November 1994 to address some of the technical problems of re-establishing natural forest ecosystems on degraded sites within conservation areas (Elliott *et al.*, 1995). It is a joint initiative between Chiang Mai University (CMU) and Doi Suthep – Pui National Park (under the Thai Royal Forest Department (RFD)) which adjoins the CMU. The unit is situated near the headquarters of Doi Suthep-Pui National Park (180 50' N, 980 50' E) at about 1,050 meter elevation amidst primary evergreen seasonal, hardwood forest on granite bedrock (Maxwell, 2001). The annual rainfall during 2001 and 2002 was 1.792 and 2.026 mm respectively, at the Chang Kian Research Station and the average temperature was 20.1^0 C and 20.2^0 C.

Seed collection

About 1200 seeds of each species were collected. Seeds of *Careya arborea* Roxb. (Lecythidaceae) and *Holigarna kurzii* King (Anacardiaceae) were collected from the ground at Chiang Mai University, 350 m elevation. Seeds of *Michelia baillonii* Pierre (Magnoliaceae) were collected from the ground and from the tree branches using a cutter near FORRU nursery, at of 1075 m. The seeds of *Ficus auriculata* Lour. (Moraceae), *Xantolis burmanica* (Coll. & Hemsl.) P. Royen

(Sapotaceae) were collected from the ground at Doi Pui near a Hmong village, at 1080-1400 m and *Quercus vestita* Rehd. & Wils (Fagaceae) was collected from Doi Mawn Lameg, 1475 m (Table 2). After collection, seeds were selected by flotation method to reject rotten seeds. Intact seeds sank while damaged ones floated. Only intact seeds were used for the germination experiment.

Table: 2. List of species studied

Species Studied	Parent tree(s)	Elevation (m)	GBH (cm)	Height (m)	Site of collection	Date of collection	Tree type	Forest type	Elevation range (m)	Seed size (mm)
Careya arborea	1	350	164	22	from the ground	29/June/02	deciduous	dof/bb/df	350-850	12-14 x 8-9
Ficus auriculata	1	1080	92	13	from the ground	24/June/02	evergreen	streams in dof, eg/pine	525-1400	1,5 x 1
Holigarna kurzii	1	350	204	15	from the ground	18/June/02	deciduous	dof, bb/df	350-550	9-11 x 8-9
Michelia baillonii	2	1075	256 205	25 25	cut branch and from the ground	24/June/02	deciduous	mxf, egf	650-1100	3 x 2,5
Xantolis burmanica	1	1400	83	14	from the ground	25/April/02	evergreen	dof, bb/df, mxf, egf, eg/pine	350-1525	20 x 12
Quercus vestita	1	1475	163	15	from the ground	23/Aug./02	evergreen	egf, eg/pine	1200-1600	15-20 x 10-20

* From Maxwell (2001)

dof	deciduous dipterocarp-oak forest
bb/df	degraded teak & bamboo + deciduous forest
egf	primary evergreen forest
eg/pine	evergreen forest with pine
mxf	mixed evergreen + deciduous, seasonal forest

Experimental Design

The experimental design for germination trials was a completely randomized design with five pre-sowing treatments and three replications. The pre-treatments applied to the seeds were 1. control (no treatment), 2. soaking in water for 24 hours, 3. heating in water at 60-70^0 C for 20 minutes, 4. scarification by hand by cutting the seed coats to make small holes about 1-2 mm wide for each species and 5. scarification with concentrated H_2SO_4 for about 3-10 minutes.

For testing TRITON treatments applied to young seedlings, the experimental design was also a completely randomized block design with three treatments and three replications. The three treatments were control, 3 ml TRITON per seedling, and 6 ml TRITON per seedling. "Osmocote" fertilizer was applied (14-14-14) to all bagged seedlings after three weeks (about 10 granules) and at three-month intervals thereafter. "TRITON" is not a fertilizer, but helps to improve nutrient uptake, drought tolerance, and diseases resistance. TRITON a commercially produced mixture of the fungal spores of *Glomus etunicatum, G. intradices* and *G. fasciculatum* adsorbed onto clay particles.

Pre-sowing seed treatments

Control: 216 seeds of each seed species were selected after a flotation test, without any further treatment, and divided into 3 blocks of each 72 seeds. The seeds were sown in modular trays.

Soaking in water for 24 hours: 216 seeds of each species were put in a beaker with water and allowed to stand in a shade room at 27^0 C for 24 hours.

Heating in water at 60-70^0 C for 20 minutes: seeds of each species were placed in a beaker [500 ml and 1000 ml] depending on the seed size. Hot water was poured into the beaker. The level of hot water covered all seeds by at least 2-3 cm. The seeds were soaked for about 20 minutes, after which the seeds were sown in the modular trays.

Scarification by hand: small holes were cut in the testa, about 1-2 mm wide opposite the hilum., using a cutter. Seeds of *Ficus auriculata* were too small to hard scarify.

Scarification with H_2SO_4: seeds of each species were placed in a beaker (500 ml and 1000 ml, depending on the seed size) and concentrated H_2SO_4 was poured into the beaker. The level of concentrated H_2SO_4 covered all the seeds by at least 1-2 mm. Large seeds, such as *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae) were soaked for about 10 minutes, but smaller seeds, such as *Ficus auriculata* Lour. (Moraceae) were soaked for 3 minutes. Medium-sized seeds, such as *Holigarna kurzii* King (Anacardiaceae) were soaked for 5 minutes. The different of exposure time was depend on the testa , seed coat and sized of embryo. After acid treatment, seeds were washed with water to remove all traces of acid.

Sowing the seeds

After the seeds were treated, 72 seeds of each species were sown into modular trays for each treatment in each block with 5 treatments per block, replicated 3 times. The modular trays were filled with coconut husk, peanut valves, and forest soil (Figure 15). Different seeds were sown at different depths, according to their sizes. Small-sized seeds such as *Ficus auriculata* Lour. (Moraceae) were sown at about 0.5-1 cm deep. Medium-sized seeds such as *Holigarna kurzii* King (Anacardiaceae) were sown at about 1-2 cm deep and large-sized seeds such as *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae) were sown at about 2-3 cm deep. The modular germination trays were placed on benches in the germination room at about 1.3 m above the ground, and protected from seed predators (Figure 14). The modular trays were watered every day, but during the rainy season, humidity was high and watering frequency was reduced.

"TRITON" Mycorrhizae treatment

Once seedlings had developed 2 pairs of leaves and were vigorous, they were transferred to plastic bags (23 x 6 cm), filled with a mixture of forest soil, coconut husk and peanut valves (2:1:1). Seedlings were divided into three groups, one received 3 ml TRITON per bag, one 6 ml TRITON per bag and the control group received no TRITON. TRITON was applied, after making a hole about 1-1.5 cm wide and 3-4 cm deep medially in each plastic bag. Seedlings were then moved from the

modular germination trays. A little soil was removed from roots, so that TRITON could come into direct contact with the roots. Half the TRITON doses were placed in the hole-bottom and half were placed around the roots, after that the soil was added. TRITON is a commercially produced mixture of the fungal spores of *Glomus etunicatum, G. intradices* and *G. fasciculatum* adsorbed onto clay particles. The number of seedlings in each treatment per block depended on the availability of seedlings from the germination experiments. Five species were divided into in 3 replicated blocks.

Data collection

The number of seeds germinating and seedling mortality were monitored for 3 months and the germination percent and seedling mortality were calculated by these formulae:

$$\text{Percent germination} = \frac{\text{total number of seeds germinated} \times 100}{\text{number of seed sowed}}$$

$$\text{Percent mortality} = \frac{\text{number of dead seedlings} \times 100}{\text{total number of seeds germinated}}$$

Median length of dormancy (MLD)

MLD = the number of days between sowing and 50% of total germination.

Every 30 days, height, root collar diameter, mortality, and health of the seedlings were recorded for about 5 months. Relative growth rates (RGR) were calculated using the following formula:

$$RGR = \frac{[\ln(H_t) - \ln(H_o)] \times 365 \text{ days}}{T_t - T_0}$$

H_t = height or diameter at time t (at the end of measurement)

H_0 = height or diameter at time 0 (at the beginning of measurement)

$T_1 - T_0$ = number of days between the beginning (T_0) and the last (T_t) time of measurement.

At the end of the experiment, the dry mass of seedling samples was measured. Shoots and roots were separated and the shoot:root ratios were calculated.

Seedlings biomass was measured. Seedlings were collected from the bags. Soil was washed off the roots. Each sample was put in to a plastic bag and labeled. The seedlings were dried in an oven for 48 hours at 80^0 C. Shoots and roots were separated and the shoot:root ratios were calculated.

Data Analysis

After 5 months of growth, the statistical analysis applied to the data, was an analysis of variance (ANOVA) for randomized complete block designs (RCBD), carried out using the Statistical Package for the Social Sciences (SPSS). In this experiment, the main comparison was among the five treatments.

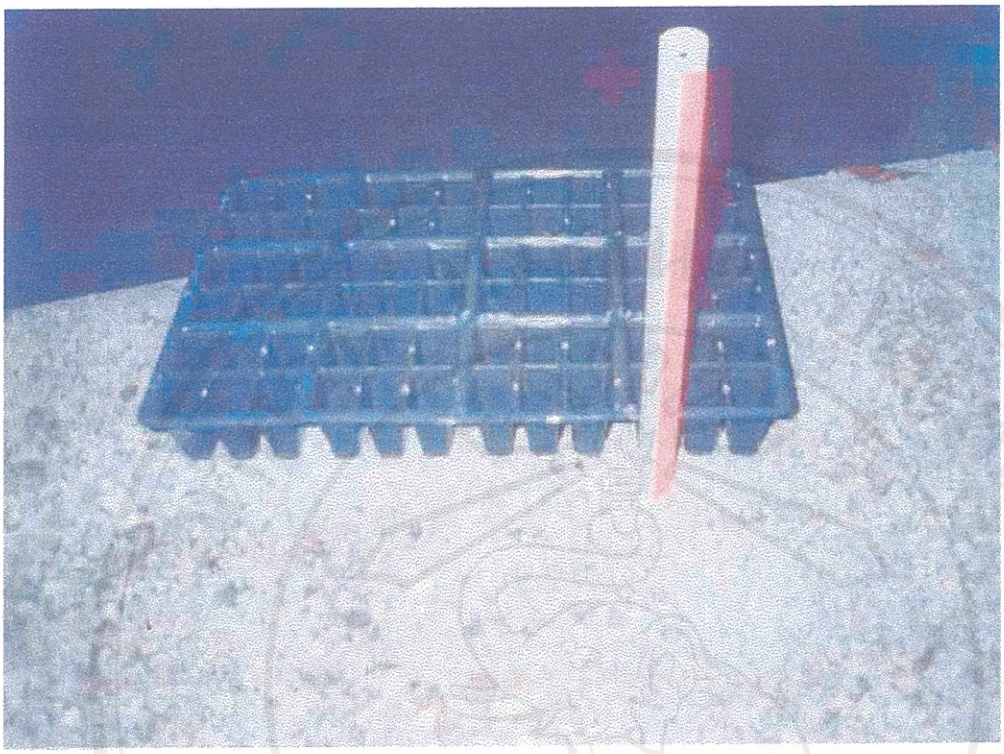

Figure 1. Modular trays

Figure 2. "TRITON" brand mycorrhizae product

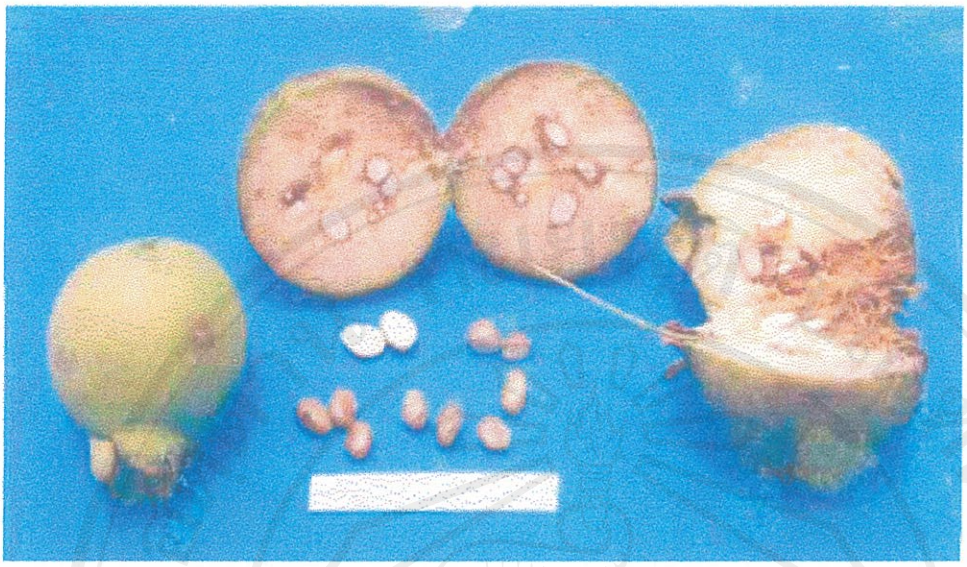

Figure 3. Fruit and seeds of *Careya arborea* Roxb. (Lecythidaceae)

Figure 4. Figs (synconia) of *Ficus auriculata* Lour. (Moraceae)

Figure 5. Fruits of *Holigarna kurzii* King (Anacardiaceae)

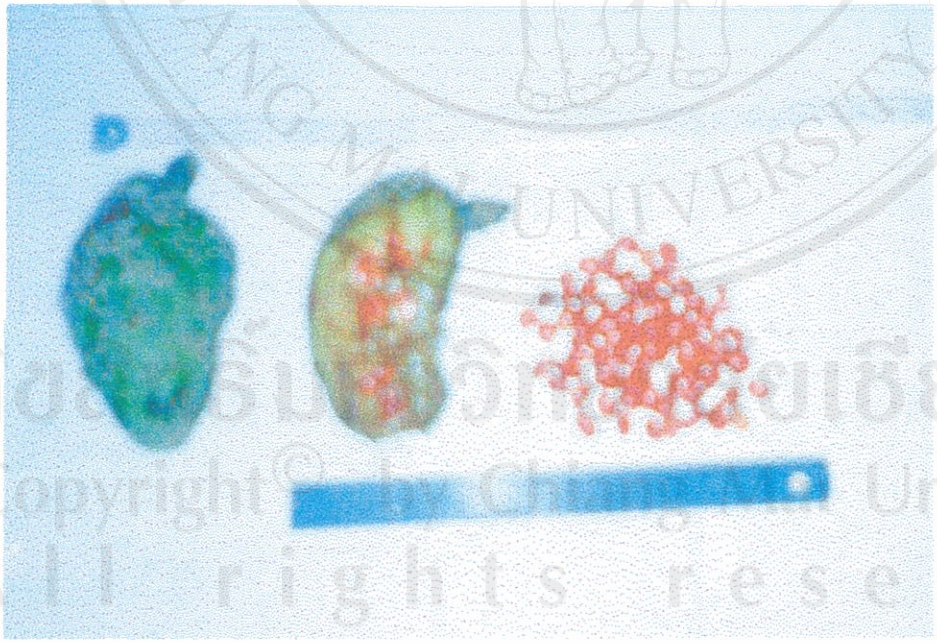

Figure 6. Synconia & seeds of *Michelia baillonii* Pierre (Magnoliaceae)

Figure 7. Fruit & seeds of *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae)

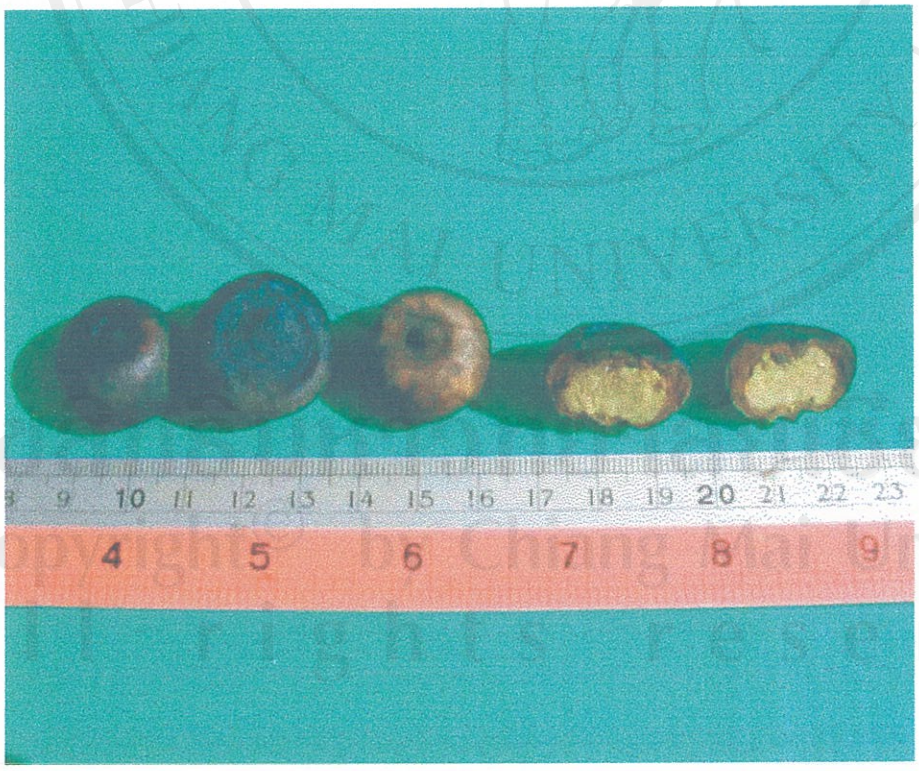

Figure 8. Nuts of *Quercus vestita* Rehd. & Wils.(Fagaceae)

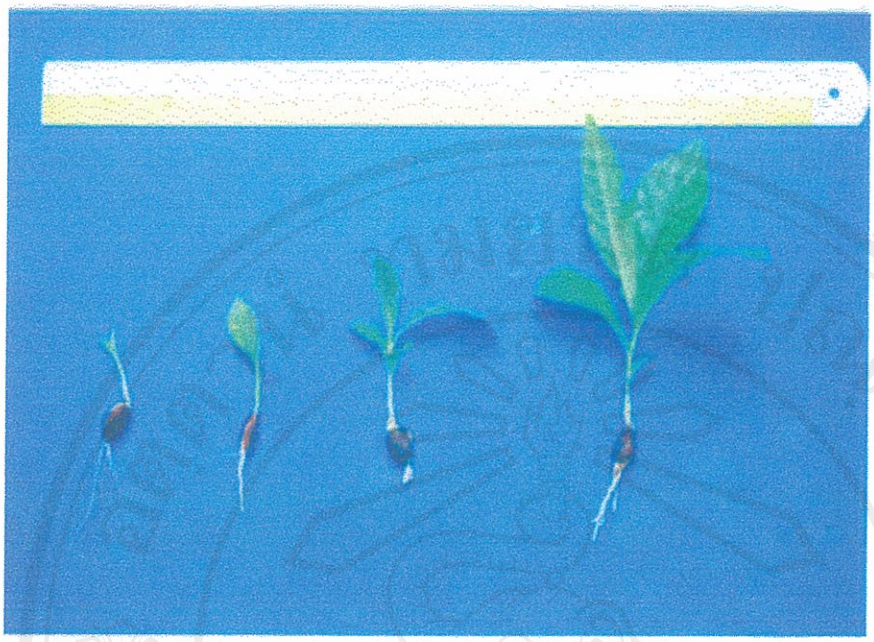

Figure 9. Seedlings of *Careya arborea* Roxb. (Lecythidaceae). 7, 14, 21, and 35 days after germination.

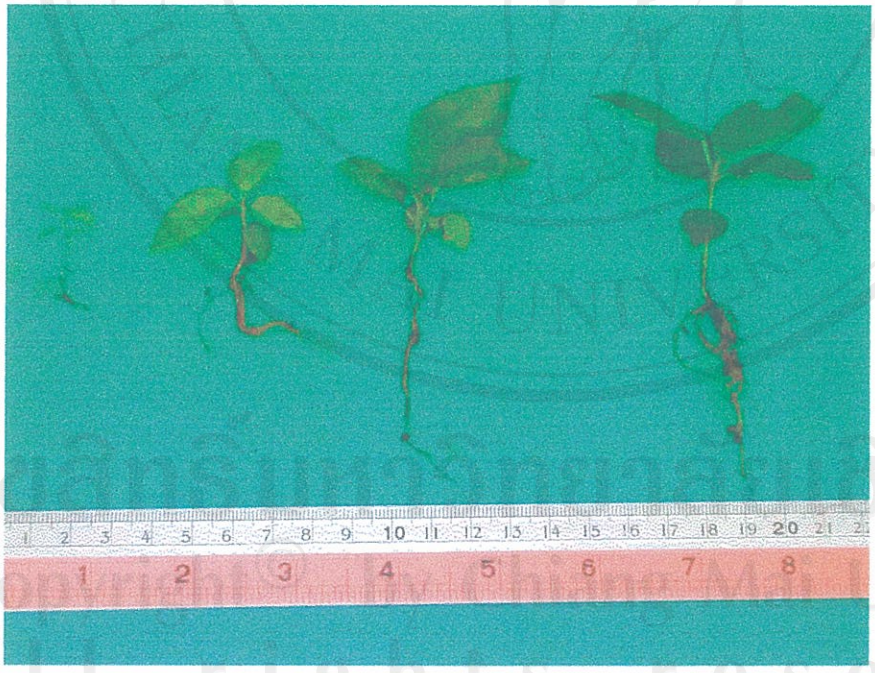

Figure 10. Seedlings of *Ficus auriculata* Lour. (Moraceae). 15, 45, 75, and 100 days after germination.

Figure 11. Seedlings of *Holigarna kurzii* King (Anacardiaceae). 7, 15, 35, and 60 days after germination.

Figure 12. Seedlings of *Michelia baillonii* Pierre (Magnoliaceae). 7, 21, 84, and 112 days after germination.

Figure 13. Seedlings of *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae). 7, 15, 30, and 60 days after germination.

Figure 14. The germination room at the FORRU nursery

Figure 15. Experiment design was in randomized blocks in the FORRU nursery (September 2002).

RESULTS

Effects of treatments on germination

There were significant differences in percent germination among the seed pre-treatments and median length of dormancy (MLD).

Careya arborea Roxb. (Lecythidaceae) seeds germinated between the 1st and 9th week after sowing (Figure 16). Most rapid germination was achieved by soaking seeds in water for 24 hours, resulting in a median length of dormancy (MLD) of 17 days. In contrast, the MLD of seeds treated with hot water and the control were 30 and 31 days. Seeds treated with H_2SO_4 failed to germinate (Table 3). ANOVA showed significant differences in germination percentage ($p<0.01$) among the treatments. The highest germination percentage (79%) was achieved by soaking in water for 24 hours. Hot water resulted in germination of 58% (not significantly higher compared with control at 57%) and treatment with scarification by hand resulted in 55% germination (Appendix II, Table 27).

Ficus auriculata Lour. (Moraceae) seeds germinated between the 3rd and 7th week after sowing. Most rapid germination occurred with the 24 hours water soaking with a MLD of 21 days after sowing (Figure 17). MLD for the control was 25 days (Table 3). The result from ANOVA showed significant differences ($p<0.01$) among the treatments. The highest percentage of germination (42%) was achieved with hot water. For the other 3 treatments (scarification with H_2SO_4 was 26%, control 24%,

and water soaking for 24 hours 19%), the germination percentage was very similar (Appendix II, Table 28).

Holigarna kurzii King (Anacardiaceae) seeds germinated between the 3rd and 10th week after sowing (Figure 18). The most rapid germination was achieved with hand scarification. The median length of dormancy was 29 days. The MLD was 36 days for the hot water treatment, 37 days for water soaking, 32 days for H_2SO_4 treatment, and 35 days for the control (Table 3). ANOVA showed significant differences in the percent of germination ($p<0.05$) among the treatments. The highest germination was achieved by soaking seeds in water for 24 hours (54%), but this value was not significantly higher than the control (47%), scarification with H_2SO_4 (39%), scarification by hand (31%), and hot water (22.7%). (Appendix II, Table 29).

Michelia baillonii Pierre (Magnoliaceae) seeds germinated between the 18th and 30th week after sowing (Figure 19). The first seeds to germinate were those scarified by hand. The median length of dormancy of scarified seeds was 145 days, followed by soaking seeds in water (147 days) and the control (176 days). Hot water and H_2SO_4 killed the seeds. (Table 3). In general, this species had an unacceptably low percent of germination. ANOVA showed significant differences ($p<0.01$) among the treatments in germination percent. Soaking in water and the control had 9.3 % and 8.3 % germination (not significantly different). Scarification by hand resulted in the lowest germination (2.8 %); which is not significantly different from the hot water and H_2SO_4 treatments (no germination) (Appendix II, Table 30).

Xantolis burmanica (Coll. & Hemsl.) P. Royen (Sapotaceae) seeds germinated between the 4th and 12th week after showing (Figure 20). The most rapid germination was achieved with H_2SO_4 with MLD of 27 days. Hot water, control, soaked seeds, and scarified by hand resulted in MLD's of 43, 39, 34, and 32 days (Table 3). ANOVA showed significant differences in percent germination ($p<0.01$) among the treatments. The control had the highest percent of seed germination with only 13%. In contrast, water soaking for 24 hours resulted in 3% germination, scarification by hand 6%, and heating in water at 60-70^0 C for 20 minutes 5 % with no significant differences among these 3 treatments. Scarification with H_2SO_4 resulted in only 2% germination (Appendix II, Table 31).

Quercus vestita Rehd. & Wils. (Fagaceae) all seeds in all treatments failed to germinate.

Table: 3. Median length of dormancy (MLD), mean values of 3 replicates (72 seeds per replicate)

Treat-ment	***Holigarna kurzii***		***Careya arborea***		***Xantolis burmanica***		***Ficus auriculata***		***Michelia baillonii***	
	MLD (days)		MLD (days)		MLD (days)		MLD (days)		MLD (days)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Control	35 AB	± 1.5	31 A	± 1.5	39 A	± 7.9	25 A	± 0.0	176 A	± 4.0
Water Soaking	37 A	± 0.6	17 C	± 2.0	34 AB	± 1.5	21 B	± 1.5	147 B	± 11.6
Sca. by hand	29 C	± 0.6	23 BC	± 8.1	32 AB	± 9.7	no treatment		145 B	± 0.0
Hot water	36 A	± 1.2	30 AB	± 4.0	43 A	± 4.0	24 A	± 0.6	no germination	
H_2SO_4	32 B	± 1.5	no germination		27 B	± 0.0	23 AB	± 1.2	no germination	

- Seed of *Ficus auriculata* were too small to scarify.
- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 4. Germination percentage of *Careya arborea,Ficus auriculata, Holigarna kurzii, Michelia baillonii and Xantolis burmanica* with mean values of 3 replicates (72 seeds per replicate)

Species	control		soaking		sca. by hand		hot water		H_2SO_4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Careya arborea	57.9 B	2.9	79.6 A	7.6	55.1 B	14.6	58.3 B	9.7	0.0 C	0.0
Ficus auriculata	23.6 B	7.2	19.4 B	2.8	no treatment		42.1 A	6.3	26.4 B	3.7
Holigarna kurzii	47.7 AB	19.3	54.2 A	2.4	31.0 BC	6.3	22.7 C	2.9	38.9 ABC	3.7
Michelia baillonii	8.3 A	1.4	9.3 A	3.5	2.8 B	3.7	0.0 B	0.0	0.0 B	0.0
Xantolis burmanica	12.9 A	3.5	2.8 BC	2.4	6.5 B	2.9	5.1 BC	1.6	1.8 C	1.6

- Seed of *Ficus auriculata* were too small to scarify.
- Results within species not sharing the same letter were significantly different ($P<0.05$).

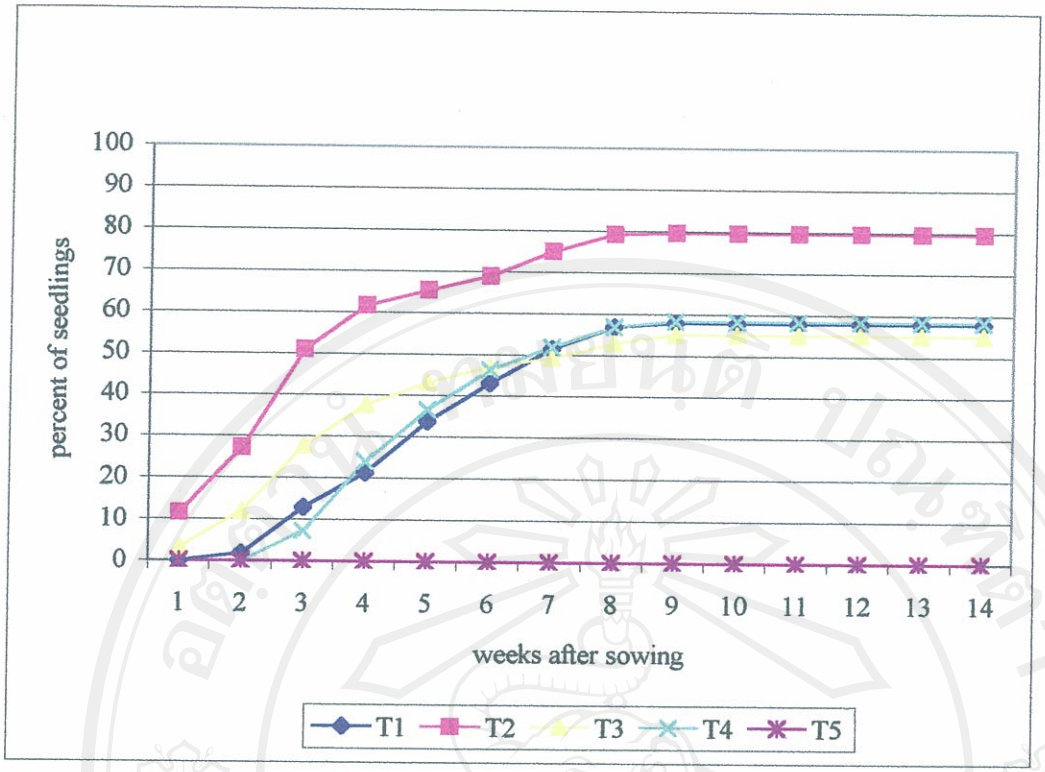

Figure 16. Germination of *Careya arborea*

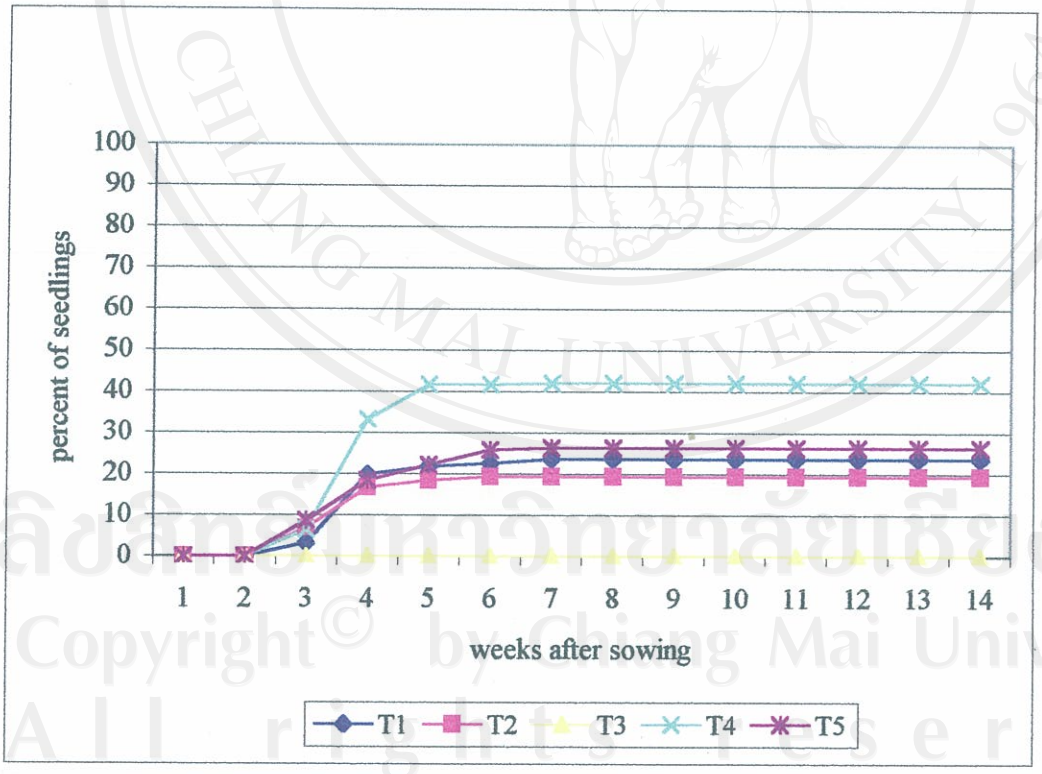

Figure 17. Germination of *Ficus auriculata*

T1 = control, T2 = water soaking, T3 = scarification by hand, T4 = heated in water 60-70^0 C and T5 = scarification by H_2SO_4.

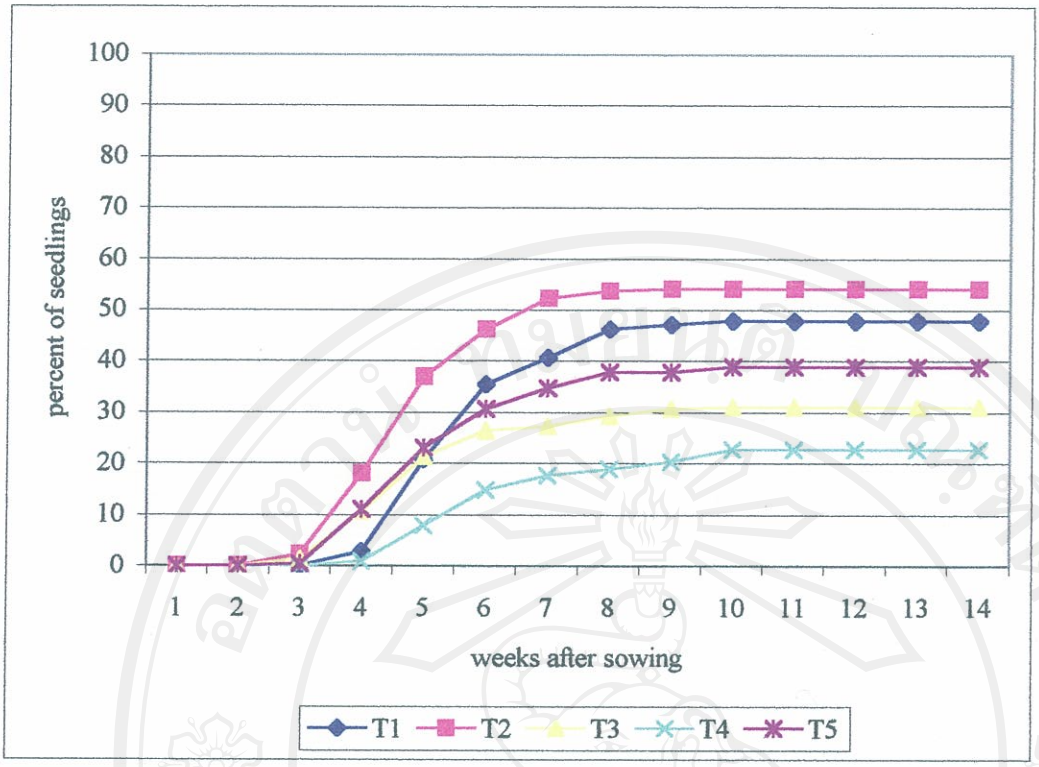

Figure 18. Germination of *Holigarna kurzii*

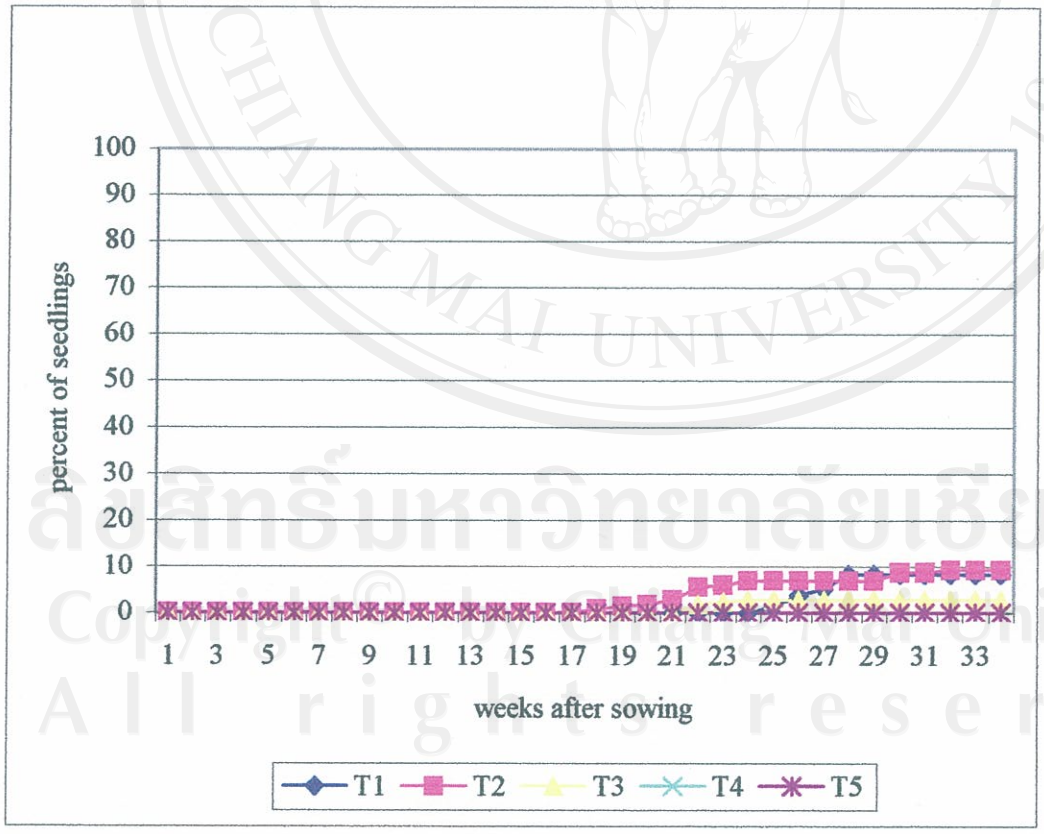

Figure 19. Germination of *Michelia baillonii*

T1 = control, T2 = water soaking, T3 = scarification by hand, T4 = heated in water 60-70^0 C and T5 = scarification by H_2SO_4.

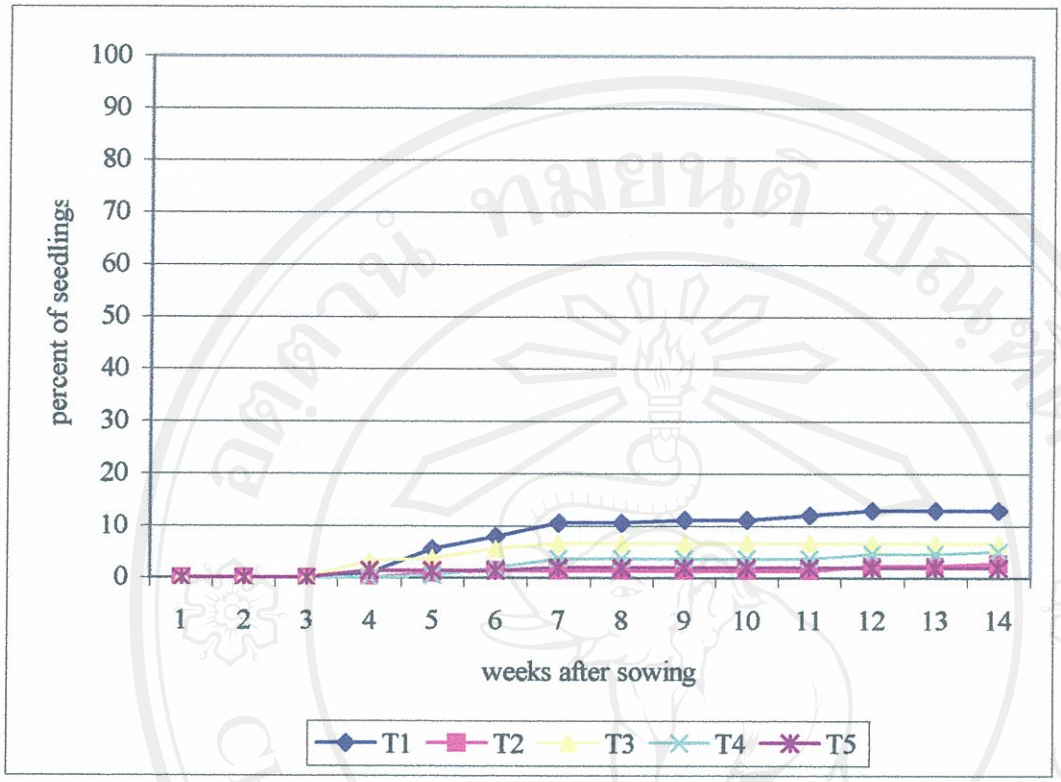

Figure 20. Germination of *Xantolis burmanica*

T1 = control, T2 = water soaking, T3 = scarification by hand, T4 = heated in water 60-70^0 C and T5 = scarification by H_2SO_4.

Mortality of seedlings in modular germination trays

The percent of mortality was compared among treatments by ANOVA during the seed germination period for over 3 months. The percent of mortality for *Careya arborea* varied from 0.8 to 4.2 % (Appendix II, Table 31) whereas for *Ficus auriculata* the mortality percent was the highest and similar for all treatments at 68.7 - 83.5% (Appendix II, Table 33). Mortality percent for *Holigarna Kurzii* King was not high, varying from 2.6 to 6.1 % (Appendix II, Table 34). For *Michelia baillonii* mortality only occurred with the control at 15.9 % (Appendix II, Table 35). *Xantolis burmanica* had a high percent mortality with all treatments varying from 32.5 to 58.3 % (Appendix II, Table 36).

The main cause of seedling mortality in the modular germination trays was damping off.

Table: 5. Percent mortality of seedlings to 3 months old in modular seed germination trays of *Careya arborea, Ficus auriculata, Holigarna kurzii, Michelia baillonii, and Xantolis burmanica* (n=3 replicates)

Species	control		soaking		sca. by hand		hot water		H_2SO_4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Careya arborea	4.2 A	7.2	2.8 A	2.5	0.8 A	1.4	0.0 A	0.0	0.0 A	0.0
Ficus auriculata	80.8 A	10.9	68.7 A	34.8	no treatment		73.1 A	6.4	83.5 A	11.2
Holigarna kurzii	2.6 B	2.6	0.0 B	0.0	6.1 A	2.7	0.0 B	0.0	0.0 B	0.0
Michelia baillonii	15.9 A	16.7	0.0 B	0.0	0.0 B	0.0	0.0 B	0.0	0.0 B	0.0
Xantolis burmanica	32.5 A	17.9	58.3 A	52.0	48.8 A	42.3	40.0 A	52.9	33.3 A	57.7

- Seed of *Ficus auriculata* were too small to scarify.
- Results within species not sharing the same letter were significantly different ($P<0.05$).

Relative Growth Rate (RGR) with TRITON after potting in the plastic bag

RGR's were calculated for height and root collar diameter of seedlings, which survived for seven months for *Careya arborea* and *Holigarna kurzii* and for four months with *Ficus auriculata* and *Xantolis burmanica.* Both height and root collar diameter of *Careya arborea* RGR patterns were similar among the control, 3 ml and 6 ml TRITON treatments (Figures 21 - 28). RGR's were high in the first 2 months of growth (September and October). For *Holigarna kurzii* the pattern of RGR was the same as *Careya arborea* (Figures 29- 38). For *Ficus auriculata* (Figures 39 - 40)

height and root collar diameter were high from December to March and also for *Xantolis burmanica* (Figures 41 - 42), while the RGR pattern was the same as for *Ficus auriculata.*

The effects of TRITON treatments

The effects of TRITON treatments were determined by ANOVA seven months after transfer in to plastic bags. For *Careya arborea*, ANOVA on RGR of height showed no significant differences among the control, 3 ml, and 6 ml TRITON treatments, with seedling grown from control, water soaking, scarification by hand, and heat 60-70^0 C (F=0.389, 0.793, 0.847, 0.698, df = 2, p< 0.01) and no significant differences between blocks (F=0.476, 0.725, 0.195, 0.132, df = 2, p< 0.01) (Appendix II, Tables 37-40). Moreover, RGRs of height did not differ significantly among seedlings grown from different seed treatments. For example, the RGRs of height from seeds treated with hot water were 1.26 cm (control), 1.12 cm (3 ml TRITON) and 1.06 cm (6 ml TRITON) (Table 9). Average heights at the end of the experiment were 3.9 cm (control), 3.8 cm (3 ml TRITON) and 3.9 cm (6 ml TRITON) (Table 6). ANOVA on average heights showed no significant differences among treatments (F = 0.246, 0.384, 0.833, 0.147, df = 2, p< 0.01), but significant differences between blocks in seedlings grown from seeds control, water soaking for 24 hours and heated in water at 60-70^0 C (F = 0.007, 0.020, 0.631, 0.106, df = 2, p< 0.01) (Appendix II, Tables 92-95). For RGRs of diameter, ANOVA showed also no significant differences among treatments (F = 0.942, 0.899, 0.579, 0.461, df = 2, p< 0.01) and no significant differences between blocks (F = 0.437, 0.028, 0.860, 0.027, df = 2, p<

0.01) (Appendix II, Tables 41-44). For shoot dry weight, ANOVA showed that there were no significant differences among treatments (F = 0.354, 0.464, 0.449, 0.974, df = 2, p< 0.01) and no significant differences between blocks (F = 0.349, 0.169, 0.398, 0.815, df = 2, p< 0.01) (Appendix II, Tables 45-48). Average shoot weight at 7 months in the heating in water at 60-70^0 C treatment was 0.118 g (control), 0.118 g (3 ml TRITON), 0.122 g (6 ml TRITON) (Table 15). For root dry weight, ANOVA showed no significant differences among treatments (F = 0.198, 0.570, 0.910, 0.378, df = 2, p< 0.01), but significant differences between blocks in seedlings grown from seeds heated in water at 60-70^0 C (F = 0.398, 0.516, 0.620, 0.063, df = 2, p< 0.01) (Appendix II, Table 49-52). Average root mass at 7 months from in heating in water at 60-70^0 C treatment was 0.600 g (control), 0.811 g (3 ml TRITON), 0.664 g (6 ml TRITON). Total average (shoot+root) mass in control treatment was 0.793 g (control), 0.781 g (3ml TRITON), 0.555 g (6 ml TRITON), and soaking in water was 0.828 g (control), 0.868 g (3 ml TRITON), 0.739 g (6 ml TRITON) (Table 15).

For *Holigarna kurzii*, ANOVA on RGR of height showed no significant differences among the control, 3 ml and 6 ml TRITON treatments with seedling grown from control, water soaking, scarification by hand, heat 60-70^0 C, and scarification with H_2SO_4 (F= 0.963, 0.537, 0.443, 0.237, 0.606, df = 2, P< 0.01), but significant differences among blocks in seedlings grown from the scarification by hand (F= 0.406, 0.516, 0.049, 0.354, 0.655, df = 2, p< 0.01) (Appendix II, Tables 53-57). RGRs of height at 7 months was 0.38 cm (control), 0.41 cm (3 ml TRITON) and 0.25 cm (6 ml TRITON) with seedlings grown from treatments with water soaking, seedlings grown from scarification by hand was 0.29 cm (control), 0.25 cm (3 ml

TRITON), and 0.27 cm (6 ml TRITON) (Table 9). The average height at the end of the experiment with seedlings grown from treatments with water soaking were 7.3 cm (control), 7.2 cm (3 ml TRITON) and 7.0 cm (6 ml TRITON) (Table 7). ANOVA on average heights showed no significant differences among treatments (F = 0.563, 0.757, 0.106, 0.435, 0.367 df = 2, $p < 0.01$), but significant differences between blocks in seedlings grown from the hot water treatment (F = 0.496, 0.138, 0.899, 0.062, 0.768 df = 2, $p < 0.01$) (Appendix II, Tables 96-100). For RGRs of diameter, ANOVA also showed no significant differences among treatments (F= 0.693, 0.214, 0.284, 0.897, df = 2, $p < 0.01$), but significant differences between blocks in seedlings grown from the control (F=0.009, 0.953, 0.249, 0.434, 0.430 df = 2, $p < 0.01$) (Appendix II, Table 58-62). For shoot dry weight, ANOVA showed no significant differences among treatments (F = 0.153, 0.843, 0.161, 0.72, 0.949 df = 2, $p < 0.01$), but significant differences between blocks in seedlings grown from the water soaking treatment (F = 0.522, 0.004, 0.347, 0.344, 0.585 df = 2, $p < 0.01$) (Appendix II, Tables 63-67). Average shoot weight at 7 months in the water soaked treatment was 0.054 g (control), 0.054 g (3ml TRITON), 0.067 g (6ml TRITON) (Table 16). For root dry weight, ANOVA showed no significant differences among treatments (F = 0.179, 0.855, 0.331, 0.858, 0.741, df = 2, $p < 0.01$), but significant differences between blocks in seedlings grown from the water soaking treatment (F = 0.919, 0.001, 0.690, 0.147, 0.655, df = 2, $p < 0.01$) (Appendix II, Tables 68-72). Average root mass at 7 months with the water soaking treatment was 0.148 g (control), 0.206 g (3 ml TRITON), 0.243 g (6 ml TRITON). Total average (shoot+root) mass in scarification by hand treatment was 0.317 g (control), 0.403 g (3 ml TRITON), 0.253 g (6 ml

TRITON) and heated in water was 0.304 g (control), 0.218 g (3 ml TRITON), 0.176 g (6ml TRITON) (Table 16).

Ficus auriculata did not produce enough seedlings for testing seed treatments separately. Therefore seedlings were combined across seed treatments and divided into three groups and treated with TRITON. ANOVA showed no significant differences in RGRs of height among the control, 3 ml and 6 ml TRITON treatments ($F= 0.923$, $df = 2$, $p< 0.01$), and no significant differences between blocks ($F=0.198$, $df = 2$, $p< 0.01$) (Appendix II, Table 73). RGRs of height at 4 months were 2.61 cm (control), 2.55 cm (3 ml TRITON) and 2.63 cm (6 ml TRITON) (Table 10). The average heights at the end of the experiment were 4.5 cm (control), 4.8 cm (3 ml TRITON) and 3.7 cm (6 ml TRITON) (Table 8). ANOVA on average heights showed significant differences among treatments ($F= 0.111$, $df = 2$, $p< 0.01$) and also significant differences between blocks ($F=0.001$, $df = 2$, $p< 0.01$) (Appendix II, Table 101). For RGRs of diameter, ANOVA showed also no significant differences among treatments ($F= 0.591$, $df = 2$, $p< 0.01$), but significant differences between blocks ($F=0.103$, $df = 2$, $p< 0.01$) (Appendix II, Table 74). For shoot dry weight, ANOVA showed no significant differences among treatments ($F = 0.849$, $df = 2$, $p< 0.01$), but significant differences between blocks ($F = 0.051$, $df = 2$, $p< 0.01$) (Appendix II, Table 75). Average shoot masses at 4 months were 0.274 g (control), 0.246 g (3 ml TRITON) and 0.230 g (6 ml TRITON) (Table 17). For root dry weight, ANOVA showed no significant differences among treatments ($F = 0.901$, $df = 2$, $p< 0.01$), but significant differences between blocks ($F = 0.107$, $df = 2$, $p< 0.01$) (Appendix II, Table 76). Average root masses at 4 months were 0.122 g (control), 0.113 g (3 ml

TRITON) and 0.103 g (6 ml TRITON). Total average (shoot+root) masses were 0.395 g (control), 0.360 g (3 ml TRITON), 0.333 g (6 ml TRITON) (Table 17).

Due to low germination, seedlings of *Xantolis burmanica* from all seed treatments were combined and treated with TRITON. ANOVA showed no significant differences in RGRs of height among the control, 3 ml, and 6 ml TRITON treatments ($F= 0.454$, $df = 2$, $p< 0.01$), and no significant differences between blocks ($F=0.282$, $df = 2$, $p< 0.01$) (Appendix II, Table 77). RGRs of height at 4 months were 0.32 cm (control), 0.31 cm (3 ml TRITON) and 0.50 cm (6 ml TRITON) (Table 10). The average heights of the end of the experiment were 10.4 cm (control), 10.4 cm (3 ml TRITON) and 10 cm (6 ml TRITON) (Table 8). ANOVA on average heights showed no significant differences among treatments ($F= 0.104$, $df = 2$, $p< 0.01$), but significant differences between blocks ($F=0.006$, $df = 2$, $p< 0.01$) (Appendix II, Table 102). For RGRs of diameter, ANOVA showed also no significant differences among treatments ($F= 0.881$, $df = 2$, $p< 0.01$) and no significant differences between blocks ($F=0.469$, $df = 2$, $p< 0.01$) (Appendix II, Table 78). For shoot dry weight, ANOVA showed no significant differences among treatments ($F = 0.965$, $df = 2$, $p< 0.01$), but significant differences between blocks ($F = 0.038$, $df = 2$, $p< 0.01$) (Appendix II, Table 79). The average shoot weight at 4 months was 0.512 g (control), 0.523 g (3ml TRITON) and 0.518 g (6ml TRITON) (Table 18). For root dry weight, ANOVA showed no significant differences among treatments ($F = 0.483$, $df = 2$, $p< 0.01$) and no significant differences between blocks ($F = 0.993$, $df = 2$, $p< 0.01$) (Appendix II, Table 80). The average root mass at 4 months was 0.309 g (control), 0.281g (3 ml

TRITON) and 0.288 g (6 ml TRITON). Total average (shoot+root) mass was 0.824 g (control), 0.846 g (3 ml TRITON), 0.877 g (6 ml TRITON) (Table 18).

Mortality of seedlings during the TRITON treatments

Mortality percentage was compared among treatments by ANOVA after transfer of the seedlings into plastic bag for 7 months. The percent of mortality of seedlings of *Careya arborea* varied from 12.5 to 33.4%. This was high (33.4%) in seedlings grown from seedlings of the control (in 6 ml TRITON treatment). The percent mortality among all treatments was mostly similar (Table 11). ANOVA showed no significant differences among the control, 3 ml, and 6 ml TRITON treatments (F= 0.320, 0.560, 0.786, 0.533 df = 2, $p< 0.01$), but significant differences between blocks in seedlings grown from seeds heated in water (F= 0.292, 0.401, 0.148, 0.014 df = 2, $p< 0.01$) (Appendix II, Table 81-84). For *Holigarna kurzii*, mortality varied from 33.3 to 79.4 % (Table 12). Mortality was high (79.4%) in seedlings grown from seedlings of scarification with H_2SO_4 (in 3ml TRITON treatment). This species had mostly high mortality. Causal factors included high humidity and the effects of fungi. ANOVA showed no significant differences among control, 3 ml and 6 ml TRITON treatments (F= 0.894, 0.882, 0.207, 0.482, 0.387 df = 2, $p< 0.01$), but significant differences between blocks in seedlings grown from control and heated in water (F= 0.000, 0.306, 0.316, 0.087, 0.924 df = 2, $p< 0.01$) (Appendix II, Table 85-89). For *Ficus auriculata*, mortality varied from 5.5 to 24.4 % (Table 13). Mortality was high with the treatment of 3 ml TRITON (24.4%). ANOVA showed no significant differences among control, 3 ml and 6 ml TRITON treatments (F= 0.302 df = 2, p<

0.01), and no significant differences between blocks (F= 0.291 df = 2, p< 0.01) (Appendix II, Table 90). For *Xantolis burmanica* mortality varied from 0 to 6.7 % (Table 14). This species was grew well. The mortality of the control and with 3 ml TRITON treatments was zero. ANOVA showed no significant differences among control, 3 ml and 6 ml TRITON treatments (F= 0.422 df = 2, p< 0.01), and no significant differences between blocks (F= 0.422 df = 2, p< 0.01) (Appendix II, Table 91).

Table: 6. Average height of *Careya arborea* Roxb. (Lecythidaceae), at 7 months

Time of experiment	treatments: control						treatments: water soaking for 24 hours						treatments: scarification by hand						treatments: heating in water at 60-70^{0}C					
	Control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)		Control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)		Control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)		Control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Beginning time	2.6 a	0.8	2.9 a	0.9	2.7 a	0.7	2.9 a	0.9	2.2 a	0.4	2.9 a	0.8	2.4 a	0.7	2.9 a	1.1	2.7 a	0.9	2.6 a	0.7	2.5 a	0.5	2.7 a	0.5
Last time	4.0 a	0.9	4.3 a	1.2	3.7 a	0.8	4.2 a	0.1	3.5 a	0.7	4.2 a	1.1	4.3 a	0.9	4.9 a	0.9	4.4 a	1.0	3.9 a	1.1	3.8 a	0.6	3.9 a	0.7

Table: 7. Average height of *Holigarna kurzii* King (Anacardiaceae), at 7 months

Time of experiment	treatments: control						treatments: water soaking for 24 hours						treatments: scarification by hand						treatments: heating in water at 60-70^{0}C						treatments: H_2SO_4					
	control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)		control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)		control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)		control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)		control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Beginning time	6.4 a	1.1	6.0 a	1.1	6.2 a	1.2	6.2 a	1.1	5.9 a	1.3	6.3 a	0.7	5.5 b	0.7	6.8 a	1.1	6.7 a	0.9	6.6 a	0.8	5.5 a	1.3	6.1 a	0.6	5.9 a	1.2	6.1 a	1.2	6.7 a	1.1
Last time	7.2 a	0.9	6.8 a	1.2	6.8 a	1.2	7.3 a	0.9	7.2 a	1.3	7.0 a	0.7	6.5 a	0.7	7.6 a	1.1	7.0 a	0.8	7.5 a	1.0	6.8 a	1.6	6.6 a	0.7	6.7 a	0.9	6.8 a	1.3	7.6 a	0.9

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 8. Average height of *Ficus auriculata* and *Xantolis burmanica*, at 4 months

Time of experiment	*Ficus auriculata*						*Xantolis burmanica*					
	Compilation of all treatments						Compilation of all treatments					
	Control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)		Control (cm)		TRITON 3 ml (cm)		TRITON 6 ml (cm)	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Beginning time	2.0 a	0.8	2.1 a	0.9	1.6 a	0.6	9.6 a	2.3	9.2 ab	2.1	7.6 b	3.0
Last time	4.5 ab	1.3	4.8 a	1.3	3.7 b	1.3	10.5 a	2.1	10.4 a	1.8	10.0 a	2.8

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 9. RGR of height of *Careya arborea* and *Holigarna kurzii* at 7 months after transfer to plastic bags / year

Treatment		*Careya arborea*		*Holigarna kurzii*	
		Mean (cm)	SD	Mean (cm)	SD
Control	Control	0.89 ns	0.09	0.22 ns	0.04
	TRITON 3 ml	0.83 ns	0.23	0.22 ns	0.04
	TRITON 6 ml	0.69ns	0.12	0.20 ns	0.15
Water Soaking for 24 hours	Control	0.74 ns	0.16	0.38 ns	0.19
	TRITON 3 ml	0.83 ns	0.16	0.41 ns	0.18
	TRITON 6 ml	0.76 ns	0.18	0.25 ns	0.13
Scarification by hand	Control	0.75 ns	0.29	0.29 ns	0.03
	TRITON 3 ml	0.86 ns	0.22	0.25 ns	0.06
	TRITON 6 ml	0.73 ns	0.30	0.27 ns	0.03
Heating in water at 60-70^0 C	Control	1.26 ns	0.24	0.24 ns	0.06
	TRITON 3 ml	1.12 ns	0.10	0.42 ns	0.21
	TRITON 6 ml	1.06 ns	0.44	0.21 ns	0.12
Scarification with H_2SO_4	Control	0.0 ns	0.0	0.29 ns	0.16
	TRITON 3 ml	0.0 ns	0.0	0.18 ns	0.13
	TRITON 6 ml	0.0 ns	0.0	0.21 ns	0.10

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 10. RGR of height of *Ficus auriculata* and *Xantolis burmanica* at 4 months after transfer to plastic bags / year

Treatment		*Ficus auriculata*		*Xantolis burmanica*	
		Mean (cm)	SD	Mean (cm)	SD
Compilation all treatments	Control	2.61 ns	0.14	0.32 ns	0.06
	TRITON 3 ml	2.55 ns	0.39	0.39 ns	0.11
	TRITON 6 ml	2.63 ns	0.21	0.50 ns	0.26

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 11. Mortality percent of seedlings with TRITON treatment 7 months after transfer to plastic bags

Treatment	*Careya arborea*					
	Control		3 ml TRITON		6 ml TRITON	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Control	20.4 ns	8.1	28.7 ns	8.7	33.4 ns	11.9
Water Soaking for 24 hours	32.3 ns	8.7	30.7 ns	9.8	22.3 ns	15.4
Scarification by hand	15.6 ns	15.0	20.3 ns	4.5	24.4 ns	21.4
Heating in water at 60-70^0 C	12.5 ns	12.5	20.8 ns	14.4	25.0 ns	12.5

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 12. Mortality percent of seedlings with TRITON treatment 7 months after transfer to plastic bags

Treatment	*Holigarna kurzii*					
	Control		3 ml TRITON		6 ml TRITON	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Control	48.3 ns	27.5	57.2 ns	23.9	48.3 ns	27.5
Water Soaking for 24 hours	65.0 ns	25.4	56.7 ns	17.0	60.0 ns	17.3
Scarification by hand	47.2 ns	20.9	47.2 ns	20.9	72.2 ns	4.8
Heating in water at 60-70^0 C	33.3 ns	38.2	44.4 ns	9.6	61.1 ns	24.1
Scarification with H_2SO_4	65.1 ns	7.3	79.4 ns	10.9	77.23 ns	17.5

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 13. Mortality percent of seedlings with TRITON treatment 4 months after transfer to plastic bags

Treatment	*Ficus auriculata*					
	Control		3 ml TRITON		6 ml TRITON	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Compilation all treatments	5.5 ns	9.6	24.4 ns	21.4	6.7 ns	11.5

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 14. Mortality percent of seedlings with TRITON treatment 4 months after transfer to plastic bags

Treatment	*Xantolis burmanica*					
	Control		3 ml TRITON		6 ml TRITON	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Compilation all treatments	0.0 ns	0.0	0.0 ns	0.0	6.7 ns	11.5

- Results within species not sharing the same letter were significantly different ($P<0.05$).

RGR for height (cm)

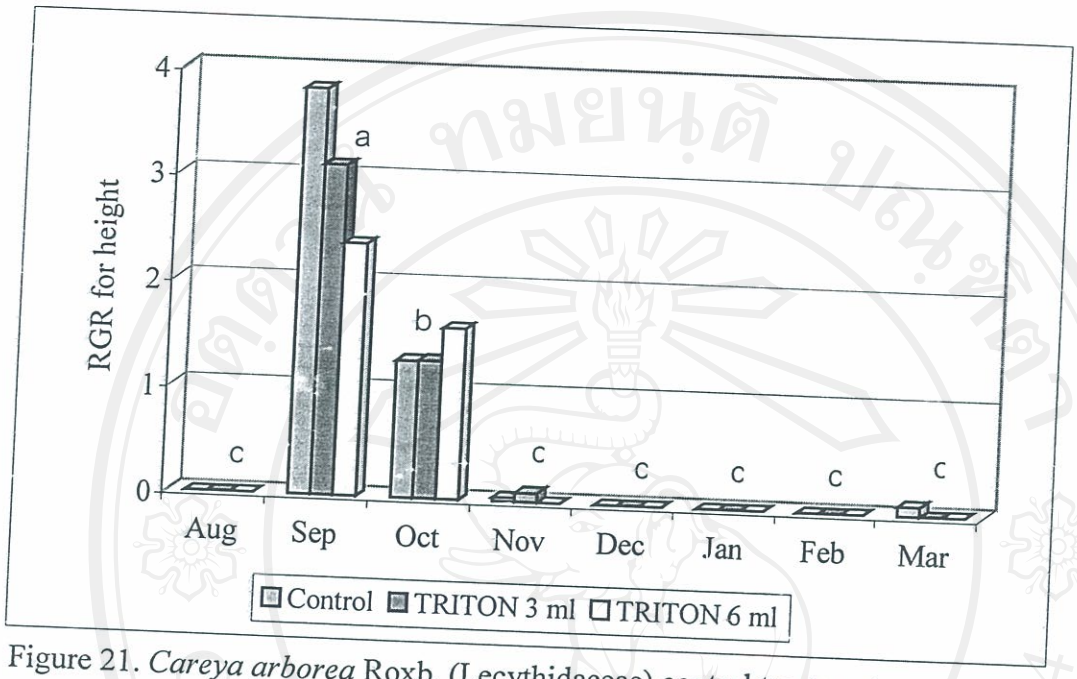

Figure 21. *Careya arborea* Roxb. (Lecythidaceae) control treatment

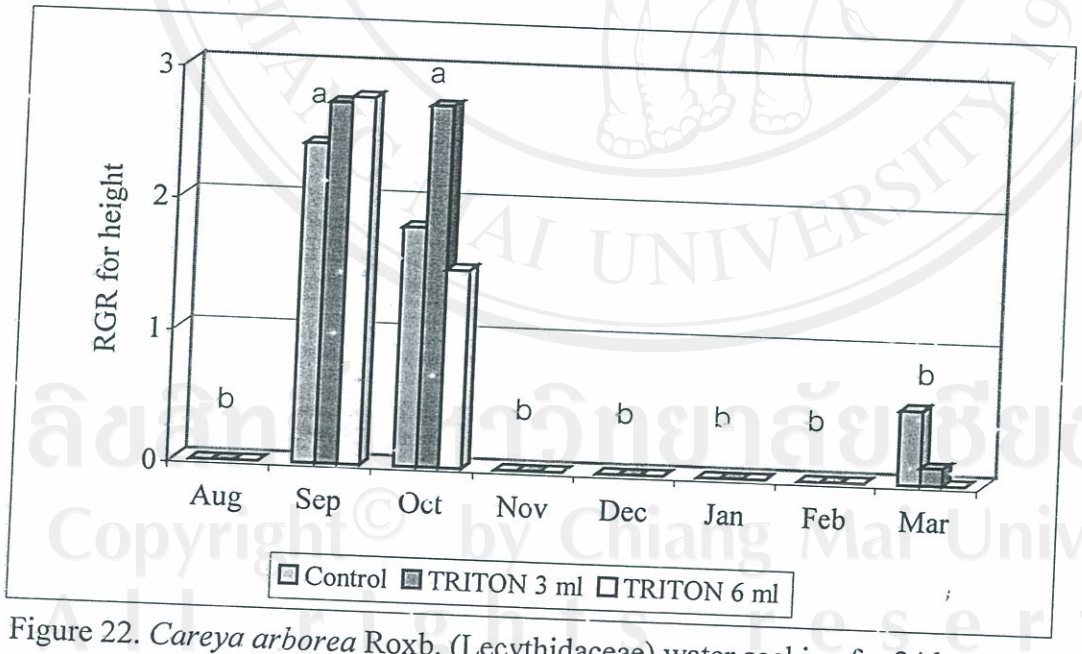

Figure 22. *Careya arborea* Roxb. (Lecythidaceae) water soaking for 24 hours

- Results of RGR graphs for height among months not sharing the same letter were significantly different ($P<0.05$).

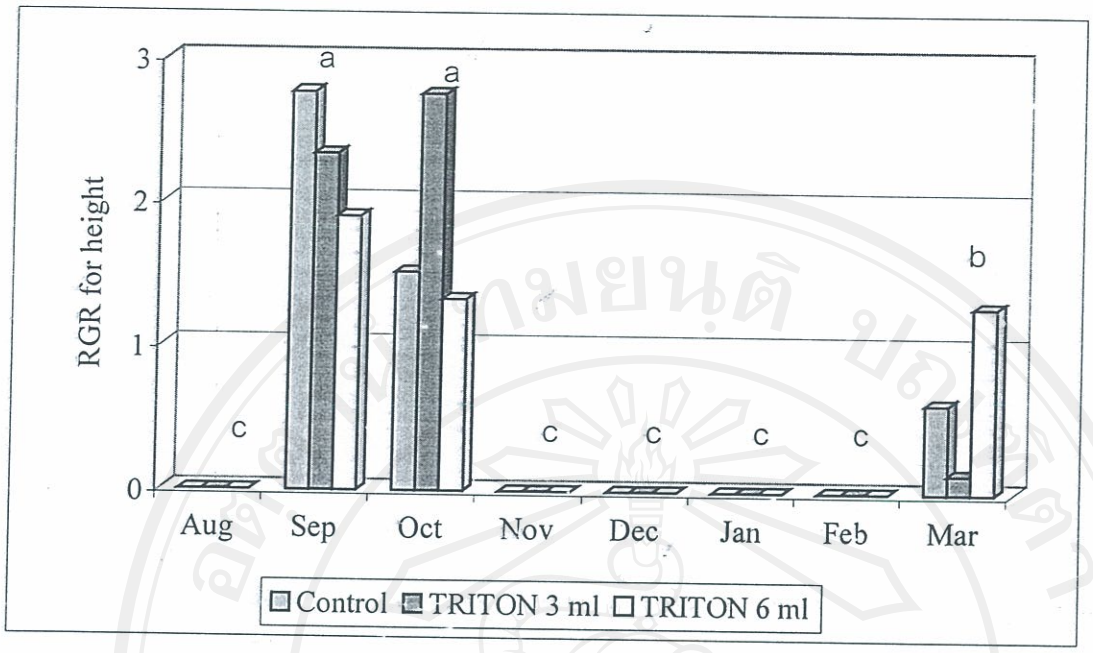

Figure 23. *Careya arborea* Roxb. (Lecythidaceae) scarification by hand

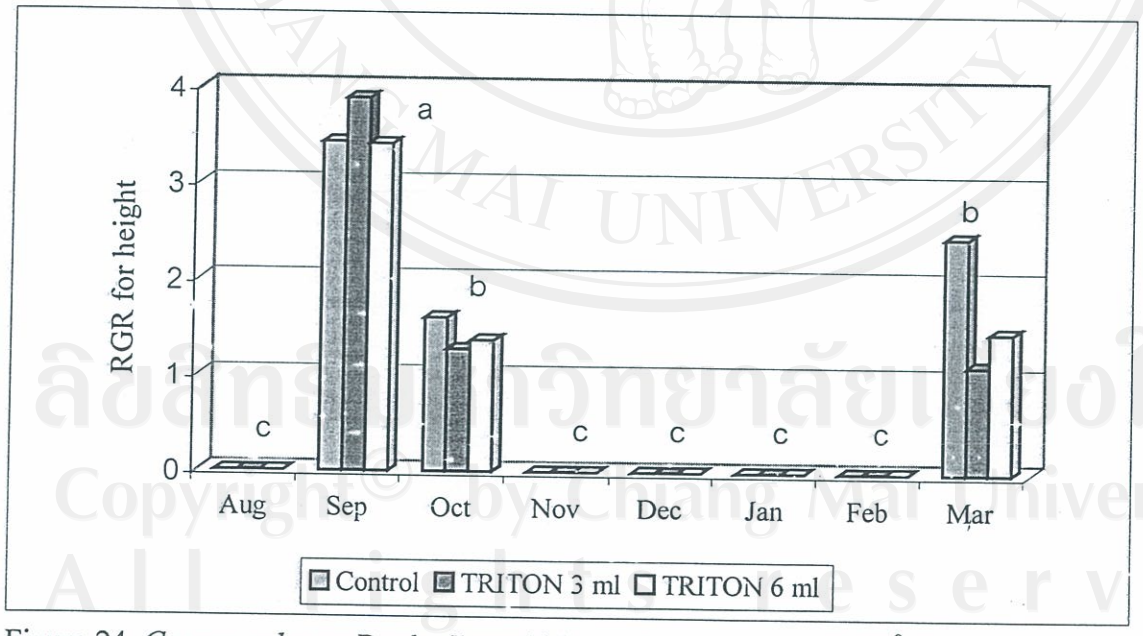

Figure 24. *Careya arborea* Roxb. (Lecythidaceae) treatment at 60-70^0 C

RGR for diameter (mm)

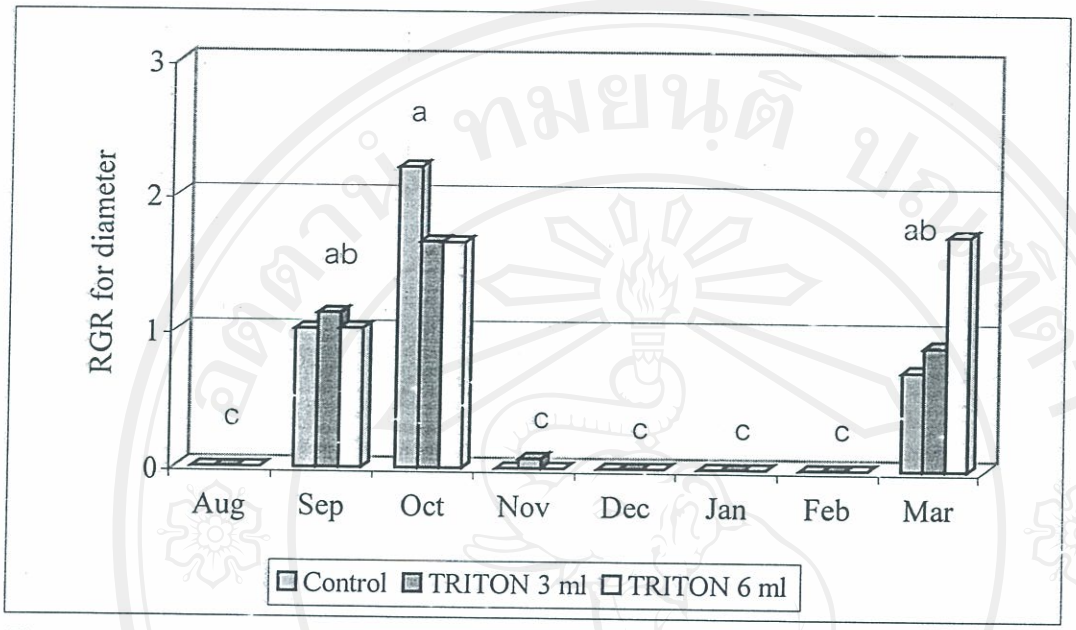

Figure 25. *Careya arborea* Roxb. (Lecythidaceae) control treatment

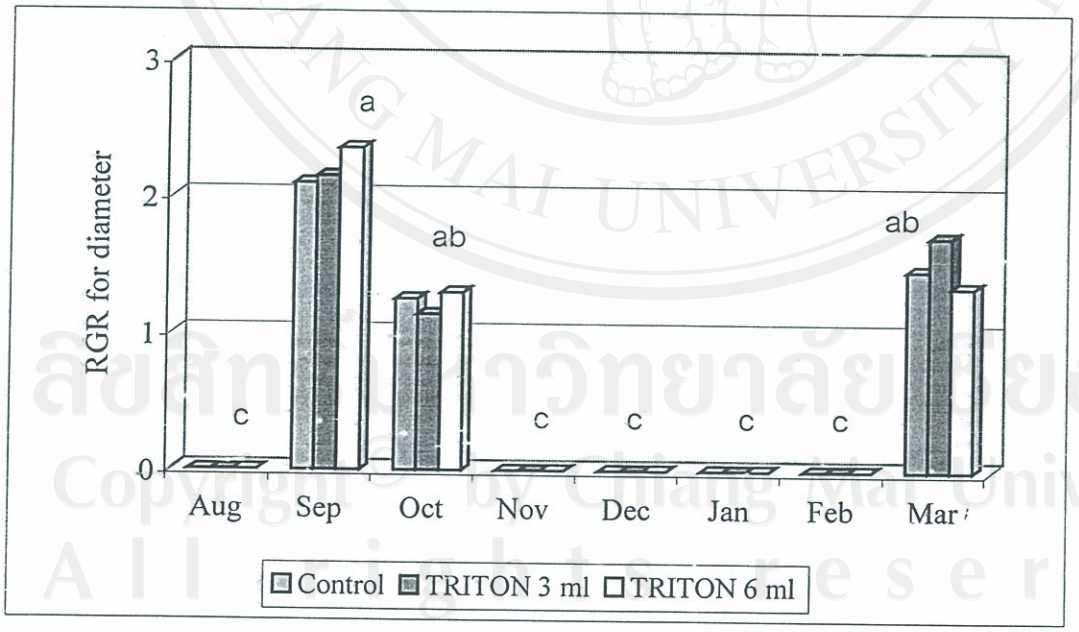

Figure 26. *Careya arborea* Roxb. (Lecythidaceae) water soaking for 24 hours

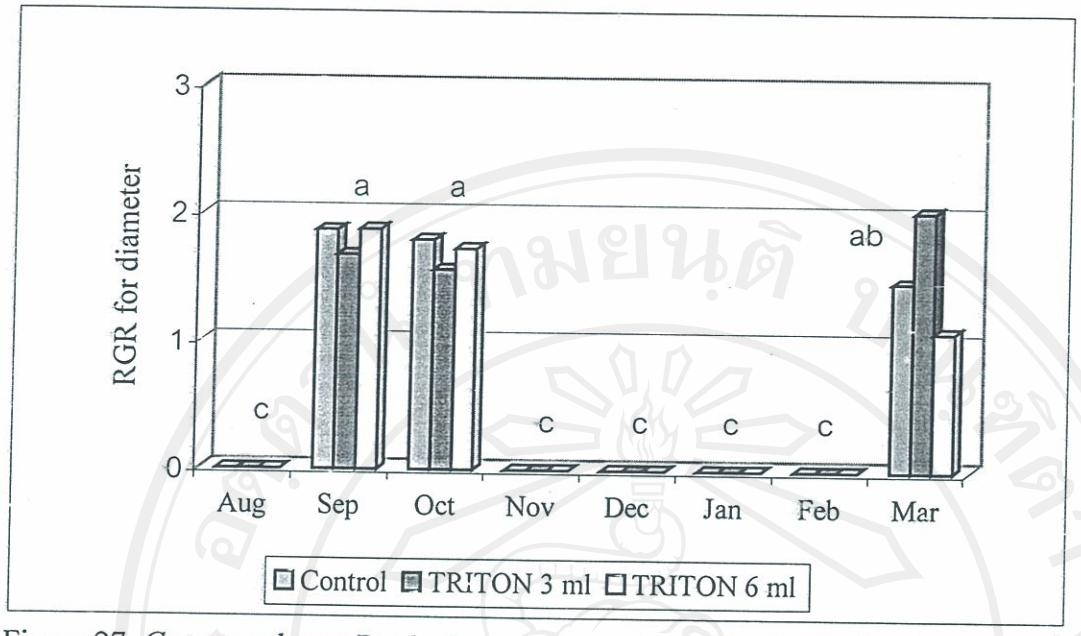

Figure 27. *Careya arborea* Roxb. (Lecythidaceae) scarification by hand

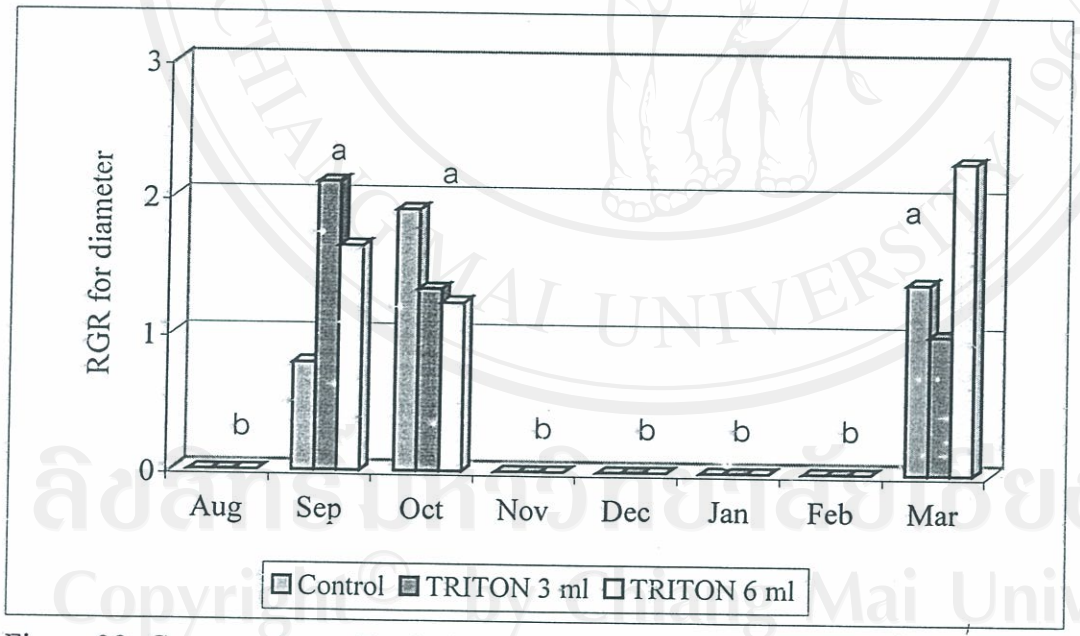

Figure 28. *Careya arborea* Roxb. (Lecythidaceae) treatment at 60-70^{0}C

RGR for height (cm)

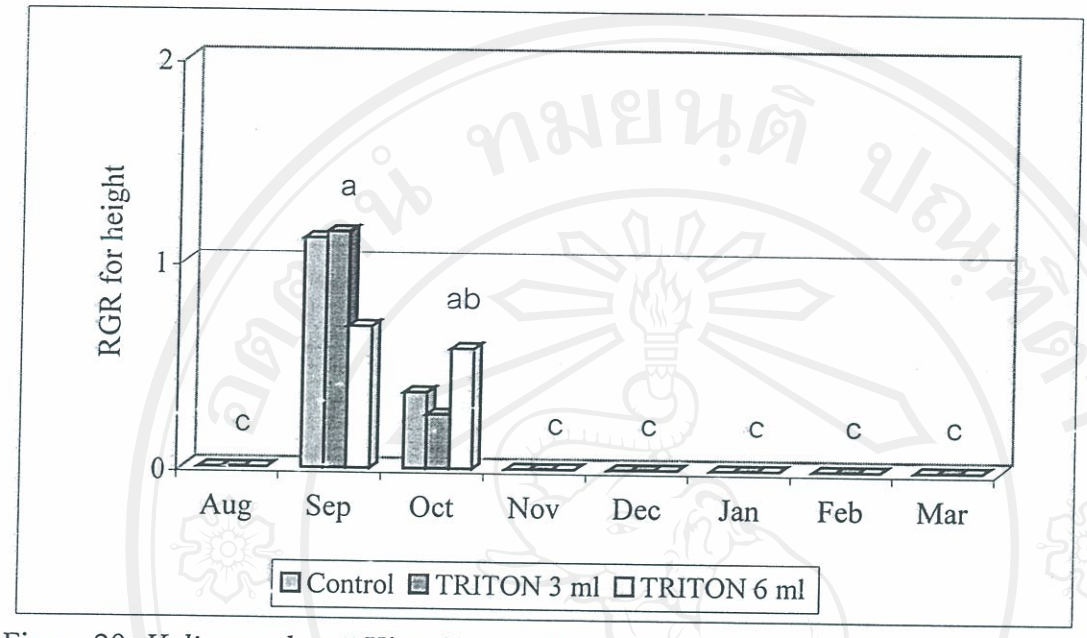

Figure 29. *Holigarna kurzii* King (Anacardiaceae) control treatment

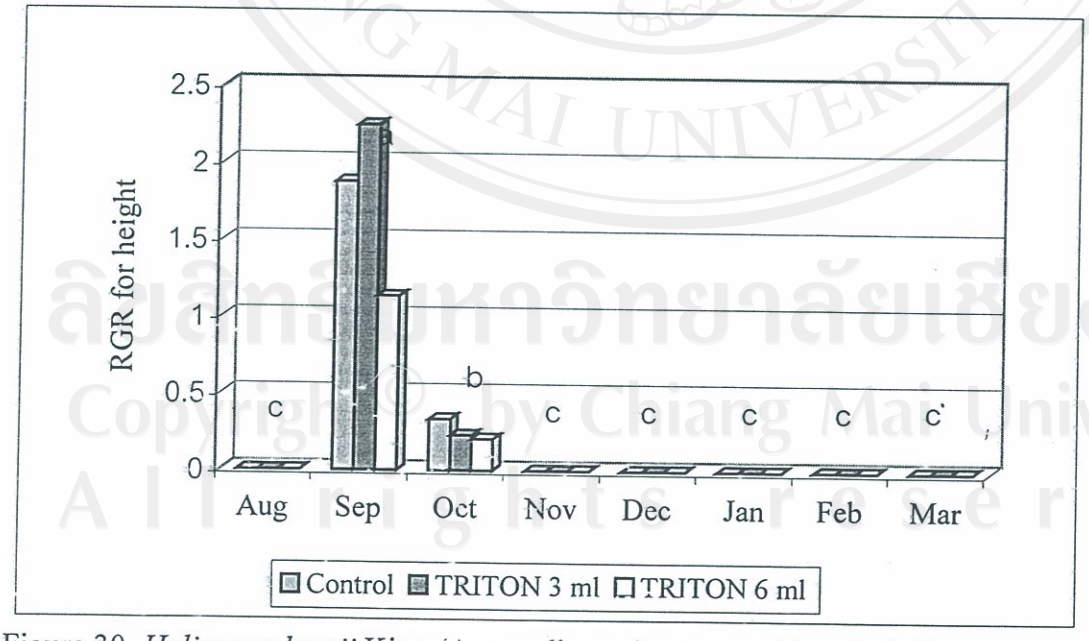

Figure 30. *Holigarna kurzii* King (Anacardiaceae) water soaking for 24 hours

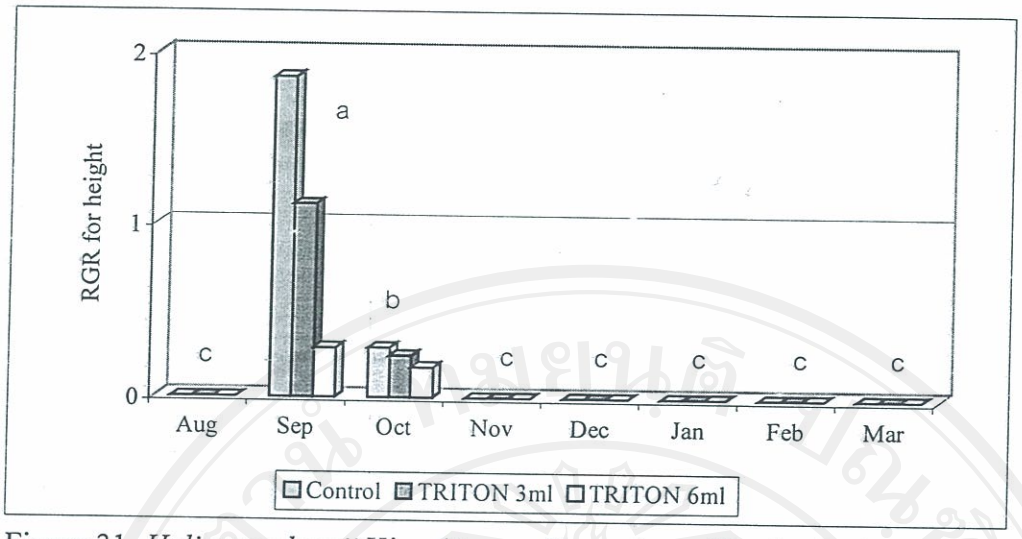

Figure 31. *Holigarna kurzii* King (Anacardiaceae) scarification by hand

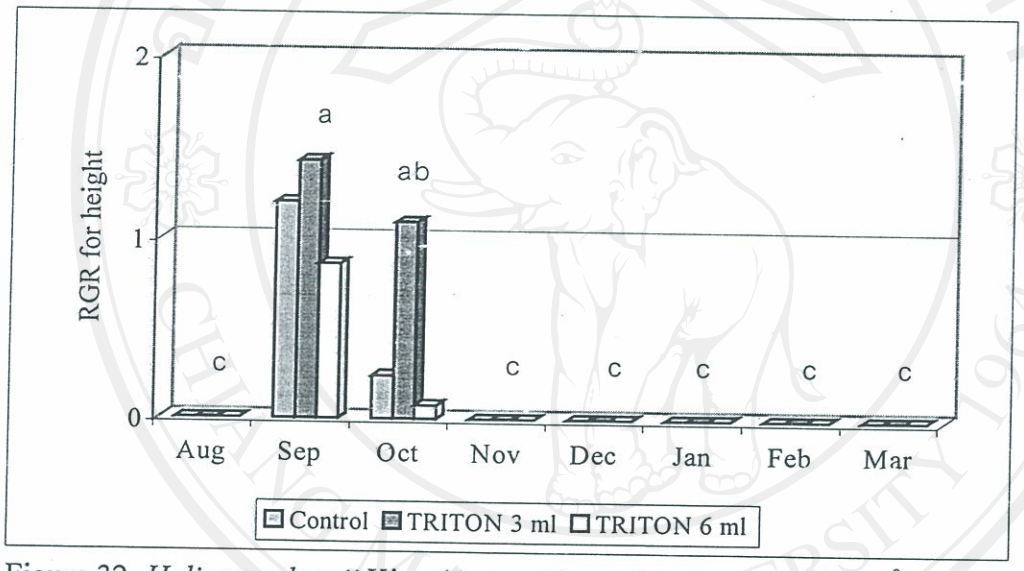

Figure 32. *Holigarna kurzii* King (Anacardiaceae) treatment at 60-70^{0}C

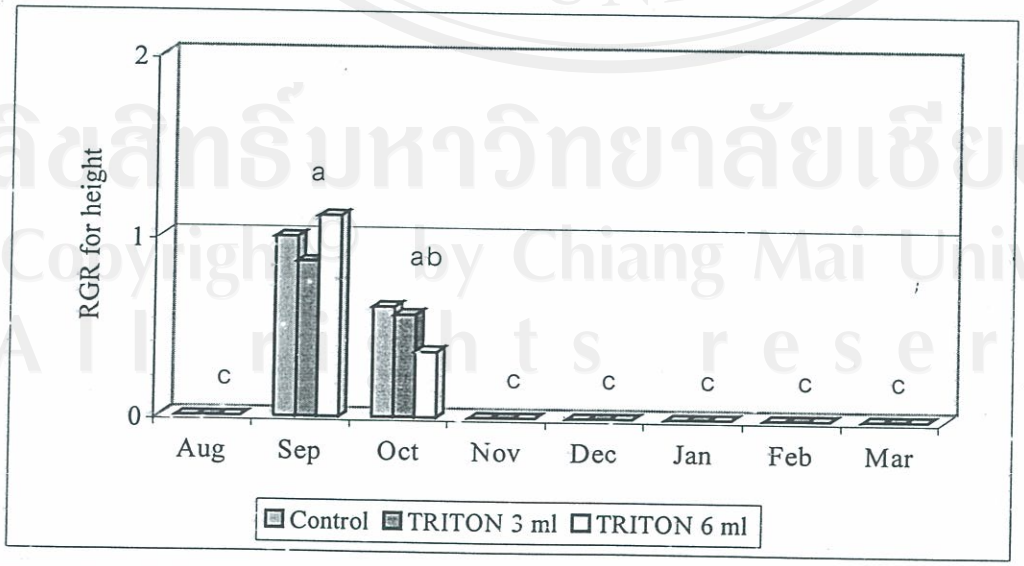

Figure 33. *Holigarna kurzii* King (Anacardiaceae) scarification by H_2SO_4

RGR for diameter (mm)

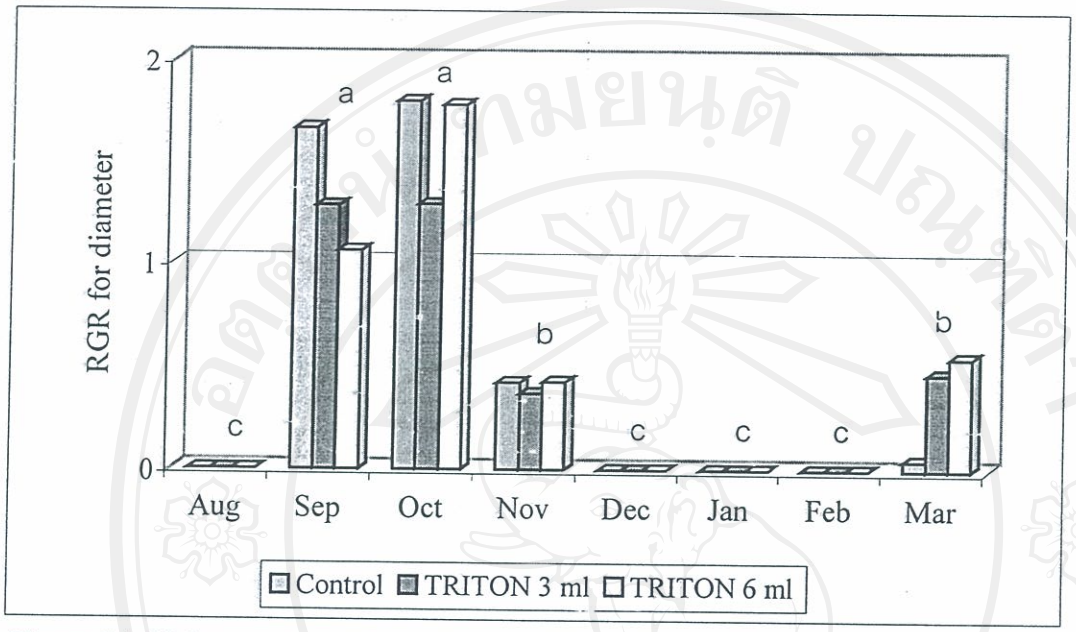

Figure 34. *Holigarna kurzii* King (Anacardiaceae) control treatment

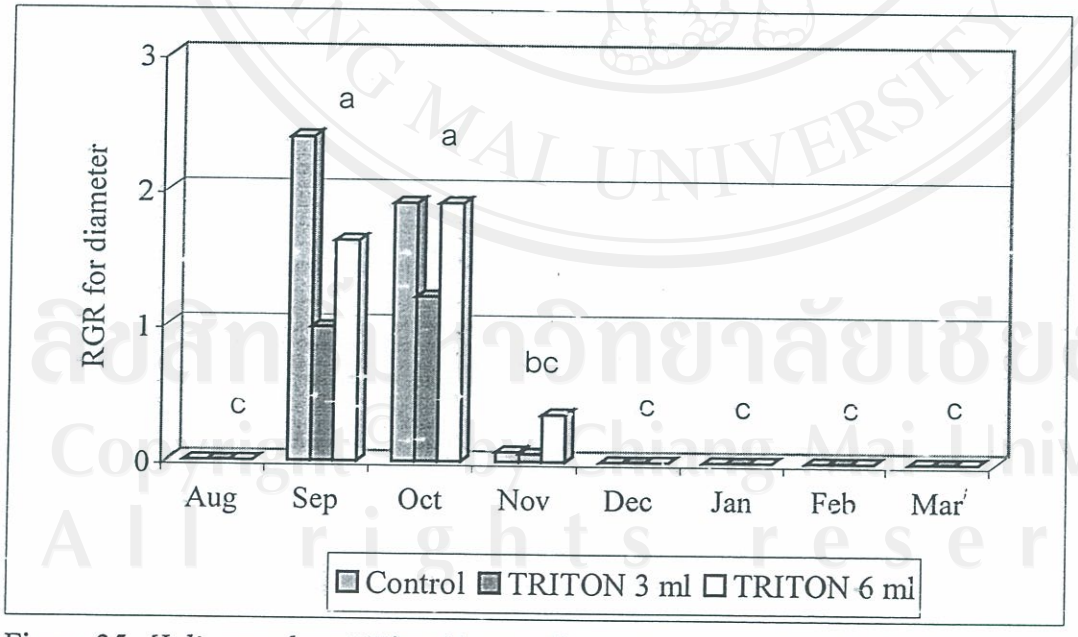

Figure 35. *Holigarna kurzii* King (Anacardiaceae) water soaking for 24 hours

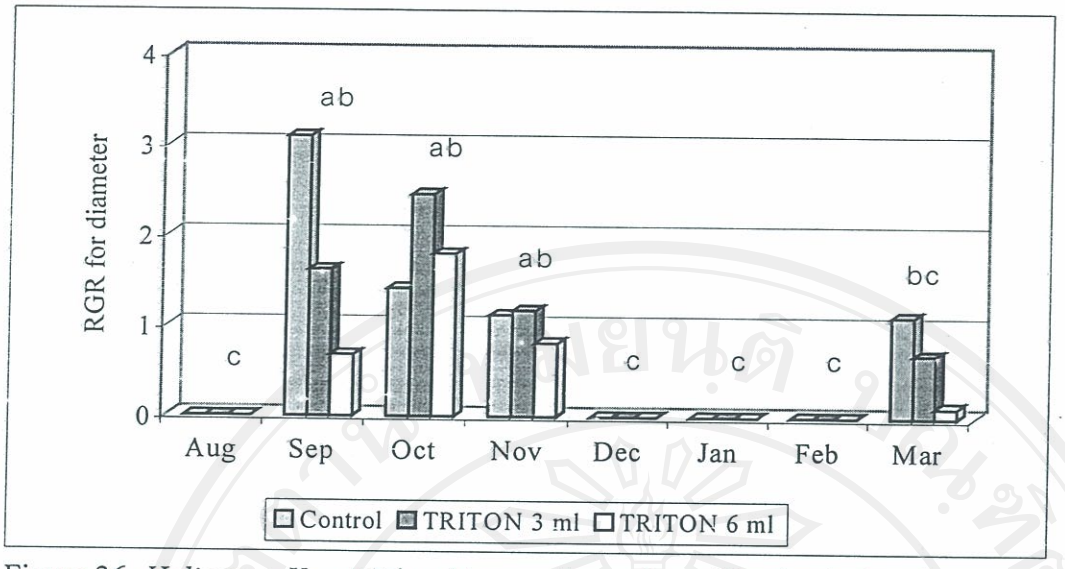

Figure 36. *Holigarna Kurzii* King (Anacardiaceae) scarification by hand

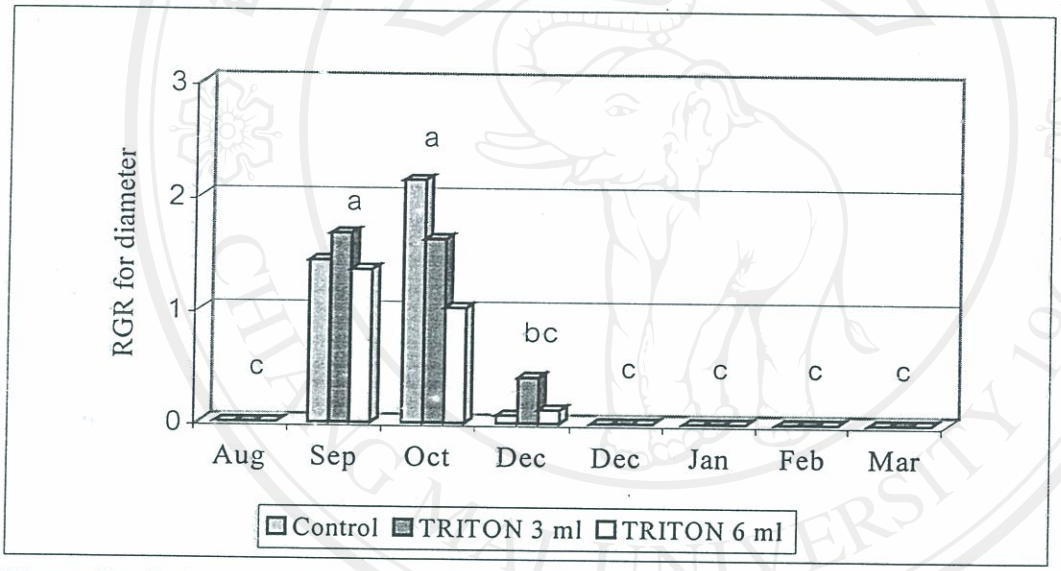

Figure 37. *Holigarna Kurzii* King (Anacardiaceae) treatment at 60-70^{0}C

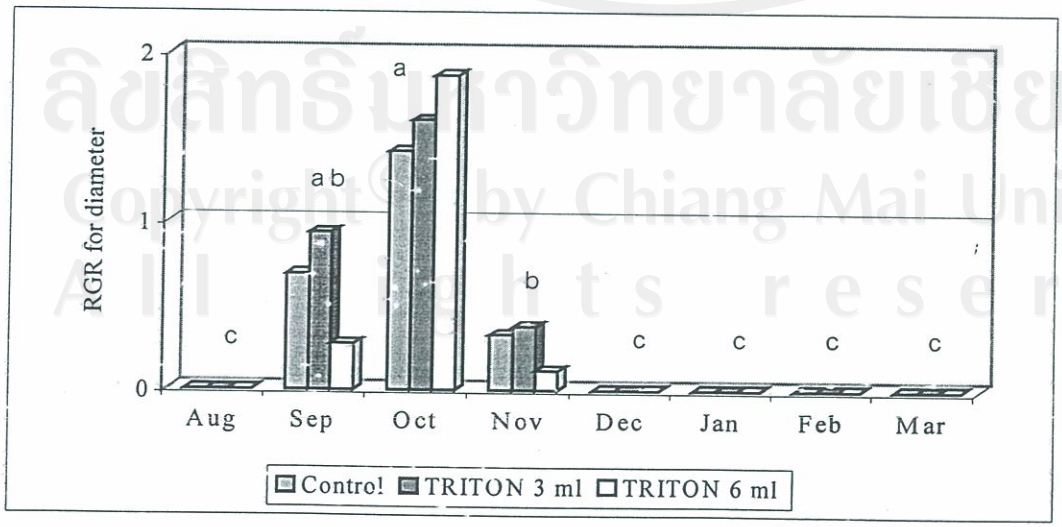

Figure 38. *Holigarna kurzii* King (Anacardiaceae) scarification by H_2SO_4

RGR for height (cm)

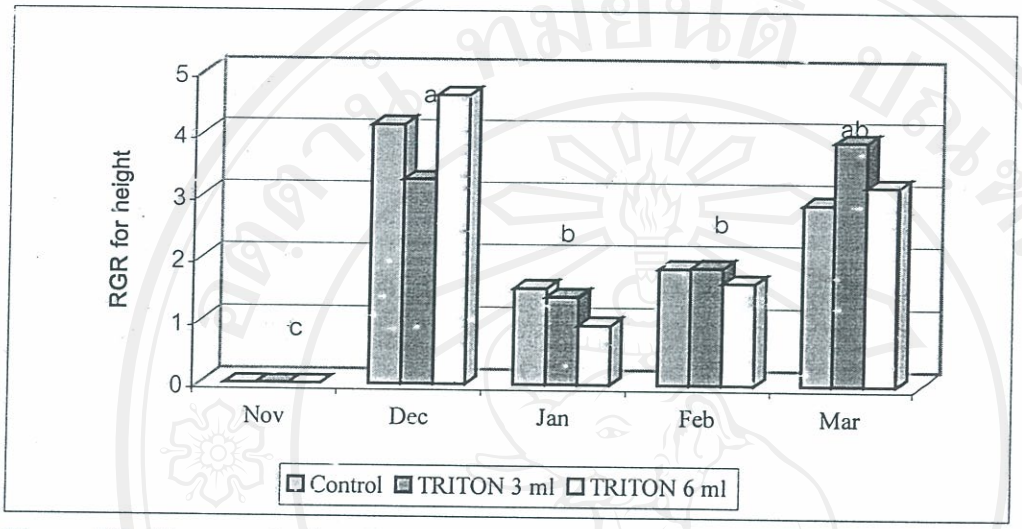

Figure 39. *Ficus auriculata* Lour.

RGR for diameter (mm)

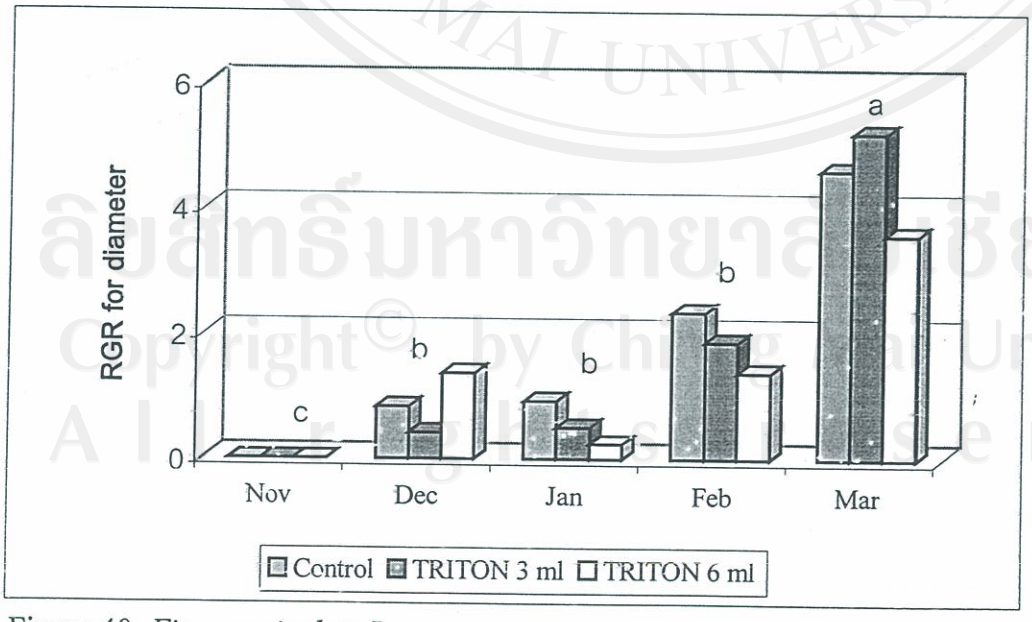

Figure 40. *Ficus auriculata* Lour.

RGR for height (cm)

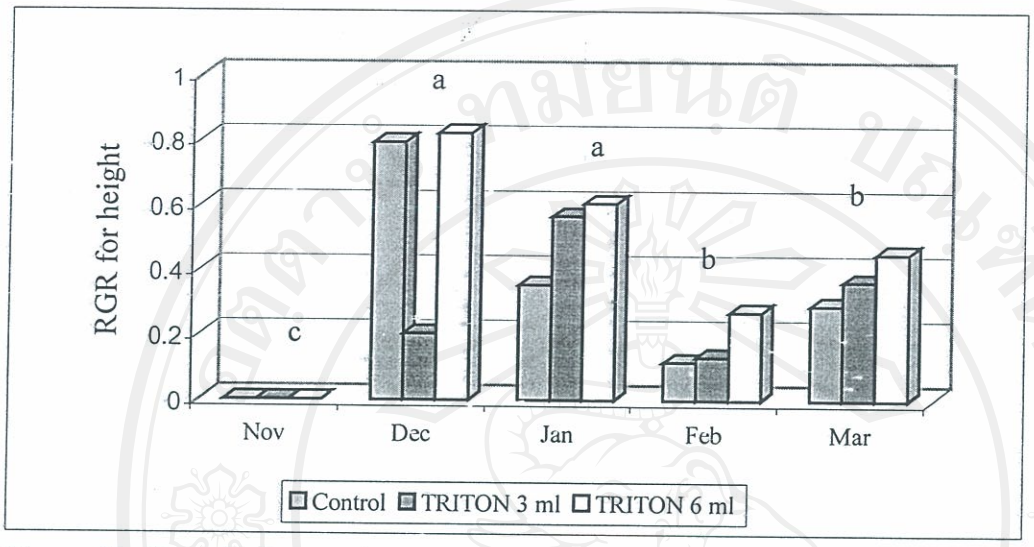

Figure 41. *Xantolis burmanica*

RGR for diameter (mm)

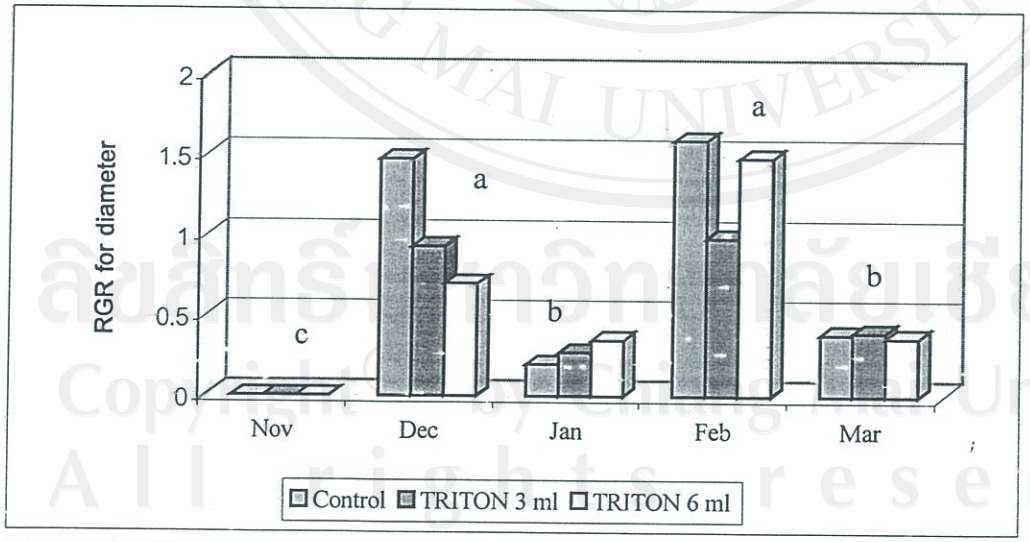

Figure 42. *Xantolis burmanica*

Table: 15. Average values of shoot and root dry weight of *Careya arborea* Roxb. (Lecythidaceae)

Treatment		*Careya arborea*			
		Shoot (g)	Root (g)	shoot:root ratio	Total shoot+root
Control	Control	0.124 ns	0.669 ns	0.499 ns	0.793 ns
	TRITON 3 ml	0.170 ns	0.611 ns	0.373 ns	0.781 ns
	TRITON 6 ml	0.085 ns	0.470 ns	0.206 ns	0.555 ns
Water Soaking for 24 hours	Control	0.110 ns	0.718 ns	0.169 ns	0.828 ns
	TRITON 3 ml	0.100 ns	0.768 ns	0.130 ns	0.868 ns
	TRITON 6 ml	0.085 ns	0.654 ns	0.123 ns	0.739 ns
Scarification by hand	Control	0.099 ns	0.662 ns	0.176 ns	0.762 ns
	TRITON 3 ml	0.104 ns	0.632 ns	0.152 ns	0.737 ns
	TRITON 6 ml	0.128 ns	0.670 ns	0.213 ns	0.798 ns
Heating in water at 60-70^0 C	Control	0.118 ns	0.600 ns	0.214 ns	0.718 ns
	TRITON 3 ml	0.118 ns	0.811 ns	0.141 ns	0.929 ns
	TRITON 6 ml	0.122 ns	0.664 ns	0.173 ns	0.786 ns

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 16. Average values of shoot and root dry weight of *Holigarna kurzii* King (Anacardiaceae)

Treatment		*Holigarna kurzii*			
		Shoot (g)	Root (g)	shoot:root ratio	Total shoot+root
Control	Control	0.055 ns	0.176 ns	2.602 ns	0.230 ns
	TRITON 3 ml	0.062 ns	0.264 ns	0.217 ns	0.326 ns
	TRITON 6 ml	0.069 ns	0.286 ns	0.213 ns	0.356 ns
Water Soaking for 24 hours	Control	0.054 ns	0.148 ns	0.254 ns	0.202 ns
	TRITON 3 ml	0.054 ns	0.206 ns	0.219 ns	0.260 ns
	TRITON 6 ml	0.067 ns	0.243 ns	0.271 ns	0.310 ns
Scarification by hand	Control	0.063 ns	0.255 ns	0.251 ns	0.317 ns
	TRITON 3 ml	0.075 ns	0.328 ns	0.126 ns	0.403 ns
	TRITON 6 ml	0.053 ns	0.200 ns	0.283 ns	0.253 ns
Heating in water at 60-70^0 C	Control	0.077 ns	0.227 ns	0.332 ns	0.304 ns
	TRITON 3 ml	0.058 ns	0.162 ns	0.318 ns	0.218 ns
	TRITON 6 ml	0.051 ns	0.128 ns	0.267 ns	0.179 ns
Scarification with H_2SO_4	Control	0.043 ns	0.108 ns	0.426 ns	0.152 ns
	TRITON 3 ml	0.039 ns	0.128 ns	0.269 ns	0.167 ns
	TRITON 6 ml	0.044 ns	0.125 ns	0.203 ns	0.169 ns

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 17. Average values of shoot and root dry weight of *Ficus auriculata* Lour. (Moraceae)

Treatment		*Ficus auriculata*			
		Shoot (g)	Root (g)	shoot:root ratio	Total shoot+root
Compilation of all treatments	Control	0.274 ns	0.122 ns	1.986 ns	0.395 ns
	TRITON 3 ml	0.246 ns	0.113 ns	1.920 ns	0.360 ns
	TRITON 6 ml	0.230 ns	0.103 ns	2.788 ns	0.333 ns

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Table: 18. Average values of shoot and root dry weight of *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae)

Treatment		*Xantolis burmanica*			
		Shoot (g)	Root (g)	shoot:root ratio	Total shoot+root
Compilation of all treatments	Control	0.514 ns	0.310 ns	1.658 ns	0.824 ns
	TRITON 3 ml	0.549 ns	0.297 ns	1.848 ns	0.846 ns
	TRITON 6 ml	0.546 ns	0.331 ns	1.649 ns	0.877 ns

- Results within species not sharing the same letter were significantly different ($P<0.05$).

Total cost per seedling per season (see Appendix III)

1. Container

Modular germination tray	0.035 baht/seedling/season
Plastic bags 23 x 6 cm	0.127 baht/seedling/season

2. Media

For modular germination tray

Media	0.0434 baht/seedling/season

For growing seedlings (plastic bag 23 x 6 cm)

Media	0.1671 baht/seedling/season

3. Chemical reagent (H_2SO_4)	0.7 baht/seedling/season
4. Fertilizer (Osmocote)	0.18 baht/seedling/season
5. Microrrhizae product TRITON	
0.3 ml	0.03 baht/seedling/season
0.6 ml	0.06 baht/seedling/season

1. Labor cost

Labor cost for seed collection	0.1 baht/seedling/season
Labor cost for filling the germination trays	0.0065 baht/seedling/season
Labor cost for filling the plastic bags	0.078 baht/seedling/season
Labor cost for fertilization (Osmocote)	0.0624 baht/seedling/season
Labor cost for cutting seeds	0.0104 baht/seedling/season
Labor cost for sowing seeds	0.00052 baht/seedling/season

Table 19. Total cost per seedling per season for germination

Treatment	Cost (baht)				
	Container	Media	Chemical Reagent	Labor	Total
Control	0.035	0.0434	none	0.10702	0.18542
Water Soaking for 24 hours	0.035	0.0434	none	0.10702	0.18542
Scarification by hand	0.035	0.0434	none	0.11742	0.19582
Heating in water at 60-70^0 C	0.035	0.0434	none	0.10702	0.18542
Scarification with H_2SO_4	0.035	0.0434	0.7	0.10702	0.88542

Table 20. Total cost per seedling per season for growing seedling

Treatment	Cost (baht)					
	Container	Media	TRITON	Labor	Fertilizer	Total
Control	0.127	0.1671		0.1404	0.18	0.6145
			0.03			0.6445
			0.06			0.6745
Water Soaking for 24 hours	0.127	0.1671		0.1404	0.18	0.6145
			0.03			0.6445
			0.06			0.6745
Scarification by hand	0.127	0.1671		0.1404	0.18	0.6145
			0.03			0.6445
			0.06			0.6745
Heating in water at 60-70^0 C	0.127	0.1671		0.1404	0.18	0.6145
			0.03			0.6445
			0.06			0.6745
Scarification with H_2SO_4	0.127	0.1671		0.1404	0.18	0.6145
			0.03			0.6445
			0.06			0.6745

Benefit Value

To determine with the optimal presowing seed treatments and seedlings grown by inoculated mycorrhizae TRITON was difficult. Some species had similar germination and growth. The benefit value was calculated to determine the optimal treatment for each species. The benefit value was calculated from seeds germination index (percent germination / time of germination) and seedling quality index (SQI)= standardized value (of height X basal diameter X shoot / root ratio), divided by the total cost per seedling per season (Table 19-20).

For *Careya arborea*, *Holigarna kurzii* and *Ficus auriculata*, the highest benefit value was the control treatment (0.821) (Table 21), (1.210) (Table 22) and (25.296) (Table 23), but for *Xantolis burmanica* the highest benefit value was achieved with the 6ml TRITON treatment (1.558) (Table 24).

Table 21. Benefit value (Germination Index (GI) X (Seedling Quality Index (SQI)/Cost) of *Careya arborea*

Treatment		Cost	GI	Height	Diameter	Shoot/ root	SQI	Benefit value
control	control	0.6145	0.969	0.998	1.046	0.499	0.504	0.821
	3 ml TRITON	0.6445	0.969	1.055	0.821	0.373	0.313	0.486
	6 ml TRITON	0.6745	0.969	0.831	0.851	0.206	0.141	0.209
Water soaking	control	0.6145	1.344	0.903	1.006	0.169	0.206	0.336
	3 ml TRITON	0.6445	1.344	0.999	0.976	0.130	0.170	0.264
	6 ml TRITON	0.6745	1.344	0.942	1.028	0.123	0.160	0.237
Sca. by hand	control	0.6145	1.101	1.071	0.958	0.176	0.198	0.323
	3 ml TRITON	0.6445	1.101	1.001	0.940	0.152	0.157	0.244
	6 ml TRITON	0.6745	1.101	0.944	0.857	0.213	0.189	0.281
heat at 60-70^0 C	control	0.6145	1.081	1.436	0.797	0.214	0.264	0.431
	3 ml TRITON	0.6445	1.081	1.238	1.033	0.141	0.194	0.302
	6 ml TRITON	0.6745	1.081	1.534	1.099	0.173	0.315	0.467

Table 22. Benefit value (Germination Index (GI) X (Seedling Quality Index (SQI)/Cost) of *Holigarna kurzii*

Treatment		Cost	GI	Height	Diameter	Shoot/ root	SQI	Benefit value
control	control	0.6145	1.014	0.272	1.036	2.602	0.743	1.210
	3 ml TRITON	0.6445	1.014	0.259	0.916	0.217	0.052	0.081
	6 ml TRITON	0.6745	1.014	0.319	0.682	0.213	0.047	0.069
Water soaking	control	0.6145	0.903	0.521	0.859	0.254	0.103	0.167
	3 ml TRITON	0.6445	0.903	0.585	0.576	0.219	0.067	0.103
	6 ml TRITON	0.6745	0.903	0.396	0.752	0.271	0.072	0.108
Sca. by hand	control	0.6145	0.535	0.329	1.823	0.251	0.080	0.131
	3 ml TRITON	0.6445	0.535	0.318	1.170	0.126	0.025	0.039
	6 ml TRITON	0.6745	0.535	0.297	1.061	0.283	0.047	0.071
heat at 60-70^0 C	control	0.6145	0.357	0.306	0.731	0.332	0.026	0.043
	3 ml TRITON	0.6445	0.357	0.663	0.684	0.318	0.051	0.079
	6 ml TRITON	0.6745	0.357	0.322	0.822	0.267	0.025	0.037
Sca. with H_2SO_4	control	0.6145	0.745	0.429	0.515	0.426	0.070	0.114
	3 ml TRITON	0.6445	0.745	0.315	0.777	0.269	0.049	0.076
	6 ml TRITON	0.6745	0.745	0.304	0.443	0.203	0.020	0.030

Table 23. Benefit value (Seedling Quality Index (SQI)/Cost) of *Ficus auriculata*

Treatment		Cost	Height	Diameter	Shoot/root	SQI	Benefit value
all treatments	control	0.6145	2.766	2.829	1.986	15.544	25.296
	3 ml TRITON	0.6445	2.863	2.067	1.920	11.362	17.630
	6 ml TRITON	0.6745	2.847	2.125	2.788	16.865	25.003

Table 24. Benefit value (Seedling Quality Index (SQI)/Cost) of *Xantolis burmanica*

Treatment		Cost	Height	Diameter	Shoot/root	SQI	Benefit value
all treatments	control	0.6145	0.369	0.850	1.658	0.520	0.846
	3 ml TRITON	0.6445	0.500	0.827	1.848	0.764	1.185
	6 ml TRITON	0.6745	0.754	0.845	1.649	1.051	1.558

Germination Type

The germination type of *Ficus auriculata* Lour. (Moraceae), *Michelia baillonii* Pierre (Magnoliaceae), and *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae) is epigeal, because their cotyledons were lifted above the soil surface. (Figures 48, 50, 51, and 52). The germination type of *Careya arborea* Roxb. (Lecythidaceae), *Holigarna kurzii* King (Anacardiaceae), and *Quercus vestita* Rehd. & Wils. (Fagaceae) is hypogeal, where the cotyledons were not lifted above the soil surface (Figure 47 and 49).

DISCUSSION

ANOVA showed that all species had significant differences in germination among the treatments, but there were no significant differences among blocks.

Optimal treatment

Seeds of *Careya arborea* presowing seeds treated with water soaking, scarification by hand, hot water and the control had good germination. For *Holigarna kurzii*, seeds treated with water soaking and control germinated well, *Ficus auriculata* seeds heated in water germinated well. The highest percent of germination of *Careya arborea*, *Holigarna kurzii* and *Michelia baillonii* seeds was achieved by water soaking (79.6 %, 54.2% and 9.3 %). These results agreed with Sigpetch (2001), who reported that soaking seeds in water increased germination of *Aporusa villosa* and *Ficus abelii* more than scarification by hand and concentrated H_2SO_4. The water soaking treatment was suitable for species without hard seed coats and agrees with FORRU data was started in 1994. H_2SO_4 killed all seeds of *Careya arborea* and *Michelia baillonii*. This result also agreed with Singpetch (2001), who reported that when *Bauhinia variegata* L. Leguminosae, Caesalpinoideae seeds were treated with concentrated sulfuric acid, the acid damaged the seeds. Seeds of *Michelia baillonii* also were killed when treated with hot water. This result agrees with those of Puaeleang and Liengsriri (1981), who found that *Dalbergia cochinchinensis* Pierre (Leguminosae, Papilionoideae) seeds were killed when treated with boiling water. The highest percent of germination for *Ficus auriculata* was achieved with the hot

water treatment (42.1%). Smith and Benjak (1995) reported that hot water might softens the testa, stimulates the embryo, remove chemical inhibitors by washing them away and allowes entry of water. This result agreed with those of Kopachon (1995), who reported that germination percentage of *Albizia odoratissima* (L.f.) Bth. (Leguminosae, Mimosoideae) increased after treatment with hot water 60-70^0 C for 20 minutes more than for dry heat treatments (hot sand 60-70^{0}C for 20 minutes).

The mortality percentage of *Ficus auriculata* was very high (68.7 to 83.5%). The main cause of mortality was damping off (Figure 46). *Michelia baillonii* and *Xanlolis burmanica* had low percent germination for all treatments. These results agreed with data from FORRU (1999). For *Michelia baillonii*, only seed germination was studied, because not enough seedlings germinated and they were too young (long of median length of dormancy (MLD) about 145 to 176 days) for seedling experiments. So further study needs to be done especially on its growth rate. Both my data and those of FORRU show that *Michelia baillonii* and *Xantolis burmanica* are very difficult to germinate for producing seedling stock. Other methods, such as cuttings or tissue culture should be investigated for producing planting stock.

All seeds of *Quercus vestita* Rehd. & Wils. (Fagaceae), failed to germinate. The fruiting time of this species was June-July (Maxwell *et al*., 2001), seeds were recalcitrant without long dormancy. This result also agreed with data from FORRU (1997) which had much trouble with damping off. Causal factors might come from the nuts were not ripe, long dormancy because seeds were collected on 23 August 2003. Also some nuts showed signs of nothing.

Effects of TRITON inoculum on seedlings

For *Careya arborea* Roxb. (Lecythidaceae), *Ficus auriculata* Lour. (Moraceae) and *Holigarna kurzii* King (Anacardiaceae), there were no significant differences in RGR for height, and root collar diameter, shoot and root biomass among treatments (control, TRITON 3 ml and TRITON 6 ml). The highest benefit values for these 3 species occured with the controls (0.821, 25.296 and 1.210). This means that TRITON had no effect. Yadi (2000) reported that beneficial effects of seedling inoculation with mycorrhizal fungi did not occur with some species (*Eucalyptus* sp., *Melaleuca leucadendron*, *Ochroma bicolor* and *Pometia pinnata*). My results contrast with those of Omsub *et al.* (1995) who reported that vesticular arbuscular mycorrhyzal fungi increased the growth rate of Japanese apricot (fruit tree). Uthaiwan *et al.* (1995) also reported that ectomycorrhizal fungi inoculated into seedlings of *Pinus kesiya* Royle *ex* Gordon grown in Angkhang soil, increased growth. Only *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae) seedlings had a higher benefit value with 6 ml of TRITON (1.558). Seedlings inoculated with TRITON had better growth than non-inoculated (control) ones. Observations at the Laboratory of Applied Microbiology Research Unit, Chiang Mai University found fungi of *Glomus* sp. in the roots of *Xantolis burmanica* seedlings from this experiment, but no infection for *Careya arborea*, *Ficus auriculata* and *Holigarna kurzii* seedling. Therefore the most likely explanation for failure of TRITON to effect growth rates was that the roots of the latter three species failed to accept infection by the mycorrhiza species which comprise TRITON.

Seedlings grew rapidly in September and October, but growth was typically slow during the cool season. De Vogel (1980) reported that growth of the seedlings, in the earliest stages of development, is mainly determined by the food contents of the seed and its genetic properties. Further development depends on the food reserves present in the seedling, and/or assimilates produced by the cotyledons and the leaves. September and October, plants had high photosynthetic capacity due to many leaves in the rainy season. Amounts of water, nutrients and light conditions might promote growth of seedlings at that time. In contrast, RGR was reduced during the cool season (December to March), because in this season (winter) many seedlings began to shed their leaves. In particular, *Careya arborea* and *Holigarna kurzii* should be studied over a longer period, because these species shed their leaves during winter season and were dormant during that time.

Mortality of seedlings was high in all treatments for *Careya arborea* and *Holigarna kurzii.* 6 ml TRITON treatment had highest than other treatments (control and 3 ml TRITON), but ANOVA showed no significant differences between treatments. Environmental factors such as location might are a probable because they are lowland deciduous species grown in a highland nursery. Their seedlings became infected by bacteria causing damping off (Figures 43-45) and also their growth rates were low. TRITON might be competed with native mycorrhizae and also when TRITON applied much of doses causes mechanical damage to roots and seedling was damping off. Caterpillars were also a pest (Figure 46) and ate the leaves and shoots, but seedlings produced new leaves after two weeks, this also effected the growth rate.

Damping off could be solved by using chemicals or by pricking out earlier and isolating seedlings. Caterpillars should be frequently removed by hand.

Most seedlings failed to grow to a plantable height within one year after germination (Table 26). The average height of seedlings planted by FORRU is usually 50-60 cm (FORRU 2000). *Careya arborea* and *Holigarna kurzii* should studied again in a lowland nursery. *Xantolis burmanica* and *Ficus auriculata* alternative techniques to produce planting stock, such as cuttings, should be investigated.

With *Ouercus vestita* had not yet tested with TRITON, because all seeds for each treatment were failed, it was to late collected seeds from the parent tree. The suitable time was June-July, but this experiment was collected in August the recalcitrant seed without long dormancy. Further treatment should be collected seeds from the beginning of July. For this species should be investigated optimal seeds pre-treatment again and test with mycorrhizae.

Figure 43. Natural leaf shed in *Careya arborea* Roxb. (Lecythidaceae)
(February 2003)

Figure 44. Damping off in natural leaf shed *Holigarna kurzii* King (Anacardiaceae)
(February 2003)

Figure 45. Damping off of *Ficus auriculata* Lour. (Moraceae)

Figure 46. Caterpillar, damaging *Ficus auriculata* Lour. (Moraceae)

CONCLUSIONS

Responses to seed germination treatments mostly depend on differences in the seed coat. For *Careya arborea,* the best treatment was water soaking for 24 hours and an alternative treatment was heating in water at 60-70^0 C. For *Ficus auriculata* the best treatment was heating in water at 60-70^0 C. For *Holigarna kurzii* water soaking for 24 hours was the best treatment. For *Michelia baillonii* water soaking for 24 hours was the best treatment, but seed germination was unacceptably low. *Xantolis burmanica* also had alternatives to propagation from low germination.

For *Michelia baillonii* and *Xantolis burmanica* propagation by cuttings or culture tissue should be investigated.

Seedlings of *Careya arborea*, *Ficus auriculata* and *Holigarna kurzii* were unaffected by TRITON, since the benefit value was lower than with the control treatment, but for *Xantolis burmanica* the benefit value with 6 ml of TRITON treatment was higher than 3 ml of TRITON and the control treatment. This species is recommended for growing with TRITON. Observations at the Laboratory of Applied Microbiology Research Unit, Chiang Mai University found fungi of *Glomus* sp. in the roots of *Xantolis burmanica* seedlings from this experiment, but no infection for *Careya arborea*, *Ficus auriculata* and *Holigarna kurzii* seedling.

For all species, good quality seedlings can be produced in the second and the third year after seed collection but FORRU wants only 1 year. The schedule is shown in (Table 26).

Table 25. Optimal pre-treatment and optimal inoculation with TRITON

Species	Fruit/seed type/ Dispersal	Germination Type	Seed dormancy	Optimal germination pre-treatment	Optimal inoculated TRITON
Careya arborea	fruit in figs, animals	hypogeal	recalcitrant	water soaking for 24 hours	none
Ficus auriculata	fruit in figs, animals	epigeal	recalcitrant	heat in water at 60-70^0 C	none
Holigarna kurzii	drupe figs, animals	hypogeal	recalcitrant	water soaking for 24 hours	none
Michelia baillonii	capsule animals	epigeal	recalcitrant	water soaking for 24 hours	none
Xantolis burmanica	berry animals	epigeal	recalcitrant	control	TRITON
Quercus vestita	berry animals	hypogeal	recalcitrant	failed	not yet tested

Table 26. A provisional production schedule for four species at FORRU

species	This year												Next year												Harden and Plant in May & June of 3 years
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Careya arborea					x	x	⊕	⊕	⊕	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	
Ficus auriculata						x	x	⊕	⊕	⊕	⊕	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✪ P
Holigarna kurzii					x	x	⊕	⊕	⊕	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✪ P
Xantolis burmanica				x	x	⊕	⊕	⊕	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧	✪ P

x = Collecting and sowing seeds

⊕ Pricking out and bagging seedling

✧ Growth in nursery

✪ Hardening of seedlings

P = Transplanting to deforestation sites

RECOMMENDATIONS

1. Experiments should be repeated with some species, especially *Ficus auriculata, Michelia baillonii, Xantolis burmanica* and *Quercus vestita*, to determine optimal seed pre-treatment.

2. Lowland species, viz. *Careya arborea* and *Holigarna kurzii*, should not studied in the highlands, because the environment is unnatural to them so there was much damping off and the growth rates were also not so good.

3. For *Careya arborea* and *Holigarna kurzii* their RGRs should be studied for greater than 7 months, because these species shed their leaves during winter season and are dormant during that time.

4. Mycorrhizae TRITON should be tested with other seedling species to test for improved vigorous or health for forest restoration.

5. *Quercus vestita* should be collected seeds from beginning of July, because it was the ripe time for the seeds and they also could not long dormancy.

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APPENDIX I: Seedling Descriptions

Voucher specimens are deposited in CMU Herbarium (Biology Department, CMU)

***Careya arborea* Roxb. (Lecythidaceae)**

This description is based on seedlings grown at the Forest Restoration Unit nursery. All seeds were collected on 29 June 2002 from one tree parent near the presidents Office, Chiang Mai University at about 350 m elevation in old deciduous secondary growth forest. Small seedlings in the liquid collection are 5 – 35 days old and 1.5 – 4 cm tall, while the dry seedlings are 4 months old and 4 – 5 cm tall. The stages of development are shown in Figure 47.

Planting date: 30 June 2002

Germination date: 5 July 2002

Germination: hypogeal

Cotyledons: plano-convex, light green, 12 - 14 x 8 - 9 mm

Radicle: primary root straight, 1mm diameter after 7 days, pale yellow,

becoming brown with age

Stem: hypocotyl glabrous, light green; epicotyl pale light green; cataphylls subulate, pale yellow, becoming green with age, 1-2 mm long

Eophylls: simple, alternate; blades: apex acuminate, base cuneate, margin shallowly crenate; venation pinnate; first three blades 72 x 24, 72 x 30 and 80 x 30 mm, with 4 –7 subopposite to alternate secondary veins on each side of the midrib, light green; flat above, raised below, finer nerves indistinct; glabrous; petiole light to mid-green; 1-2 mm long

Stipules: none

Voucher: Philachanh 1

FLORA OF THAILAND

CMU Herbarium, Faculty of Science, Chiang Mai University

Chiang Mai, Thailand

In Liquid Seedling Collection

FAMILY: LECYTHIDACEAE Lao common name: kadon

BOTANICAL NAME: *Careya arborea* Roxb.

Province: Chiang Mai District: Muang

Location: near the President's Office, Chiang Mai University

Elevation: 350 m Date: 29 June 2002

Habitat: In old very degraded deciduous secondary growth forest, granite bedrock

Note: deciduous tree 22 m tall; dbh 52 cm; bark grey-brown, cracked and flaking in thin strips; fruits bright green ripening brownish, globose or ovoid with persistent style and calyx teeth at top, pericarp thick with fleshy mesocarp, 5-7 cm x 3-5 cm; seeds many; leaf blades broadly obovate, tips rounded with a short point, base tapering, margin usually with fine, rounded teeth, maturing dull green and smooth, 13-30 x 6-14 cm; germination hypogeal

Collected by: B. Philachanh Number: 1 Duplicates: 0

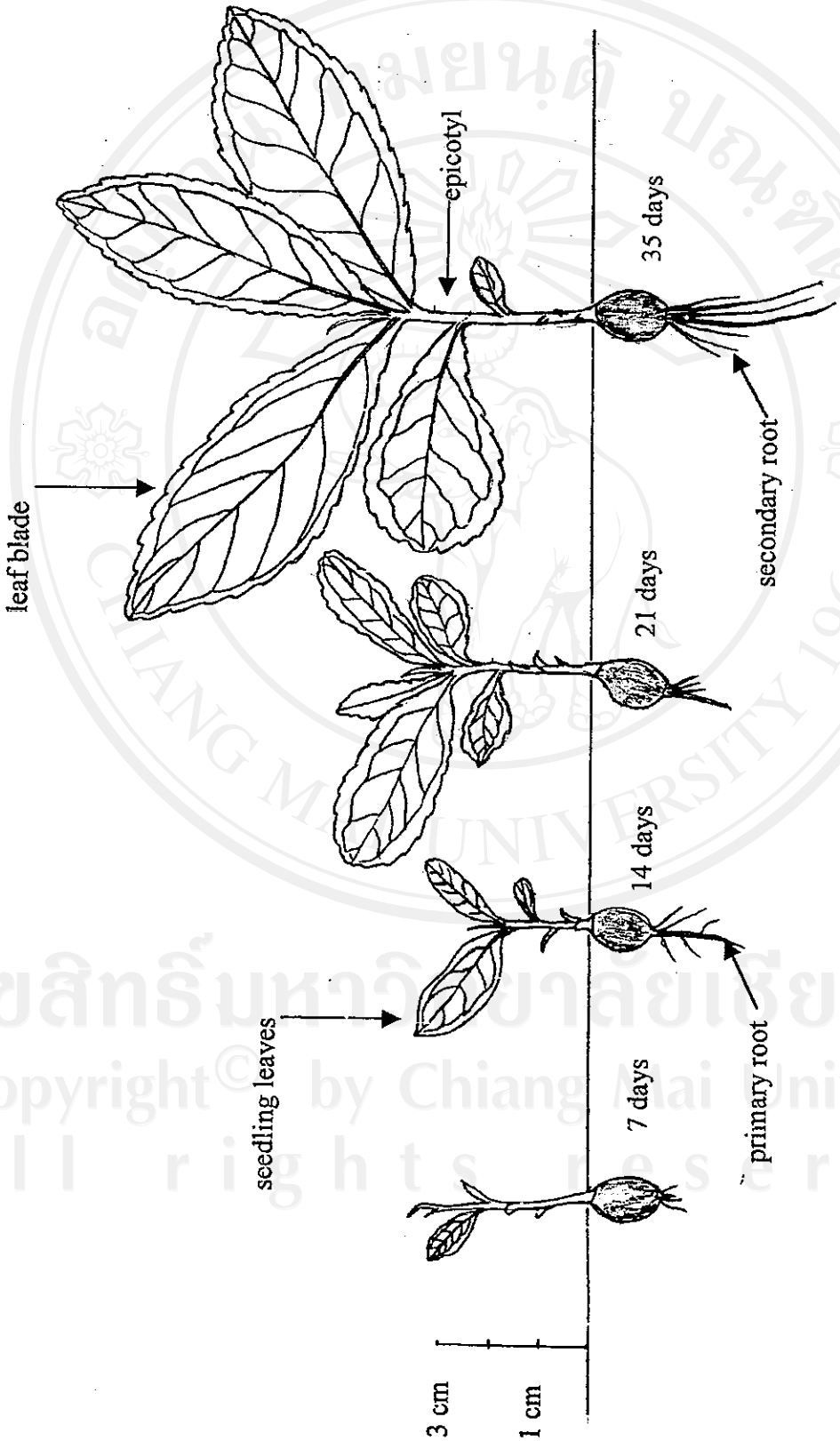

Figure 47. *Careya arborea* Roxb. (Lecythidaceae) seedling development

***Ficus auriculata* Lour. (Moraceae)**

This description is based on seedlings grown at the Forest Restoration Unit nursery. All seeds were collected on 24 June 2002 from one tree parent in Doi Sutep-Pui National Park below Doi Pui Hmong village at about 1080 m elevation in primary evergreen, seasonal, hardwood forest. Small seedlings in the liquid collection are 7 – 100 days old and 0.5 – 2.5 cm tall, while the dry seedlings are 4 months old and 2 – 4.5 cm tall. The stages of development are shown in Figure 48.

Planting date: 30 June 2002

Germination date: 15 July 2002

Germination: epigeal

Cotyledonary leaves: opposite; blades orbicular, apex and base rounded, inside light green, outside paler green margin entire; venation pinnate; petiole light green, 1 mm long

Radicle: primary root whitish when young and becoming light brown with age; fibrous

Stem: hypocotyl light green; epicotyl light green, with minute white hairs

Eophylls: spirally arranged, simple; blades ovate, first blade apex and base rounded, subsequent blades with an acute apex, margins shallowly undulate with tiny white hairs; green above, light green below; venation pinnate, secondary veins alternate, 4-5 on either side of the midrib; petiole with tiny white hairs, light green, 2-3 mm long; axillary buds 0.5-1mm long with white hairs

Stipules: triangular, firm, light green, 2 mm long

Voucher: Philachanh 2

FLORA OF THAILAND

CMU Herbarium, Faculty of Science, Chiang Mai University

Chiang Mai, Thailand

In Liquid Seedling Collection

FAMILY: MORACEAE Lao common name: dua by yai, dua wa

BOTANICAL NAME: *Ficus auriculata* Lour.

Province: Chiang Mai District: Muang

Location: Doi Sutep-Pui National Park, south side; below Doi Pui Hmong village

Elevation: 1080 m Date: 24 June 2002

Habitat: primary, evergreen, seasonal, hardwood forest; shaded, moist area; granite bedrock

Note: evergreen tree 13 m tall; dbh 29 cm; bark yellow-brown; inflorescences cauliflorus, figs with fleshy pulp bright red, ripening red-brown or dark purple 6-7 cm x 4-6 cm, achenres many; leaf blades broadly ovate or almost orbicular with slightly pointed or blunt tip and flat or cordate base; maturing smooth above, 13-38 x 10-35 cm; germination epigeal

Collected by: B. Philachanh Number: 2 Duplicates: 0

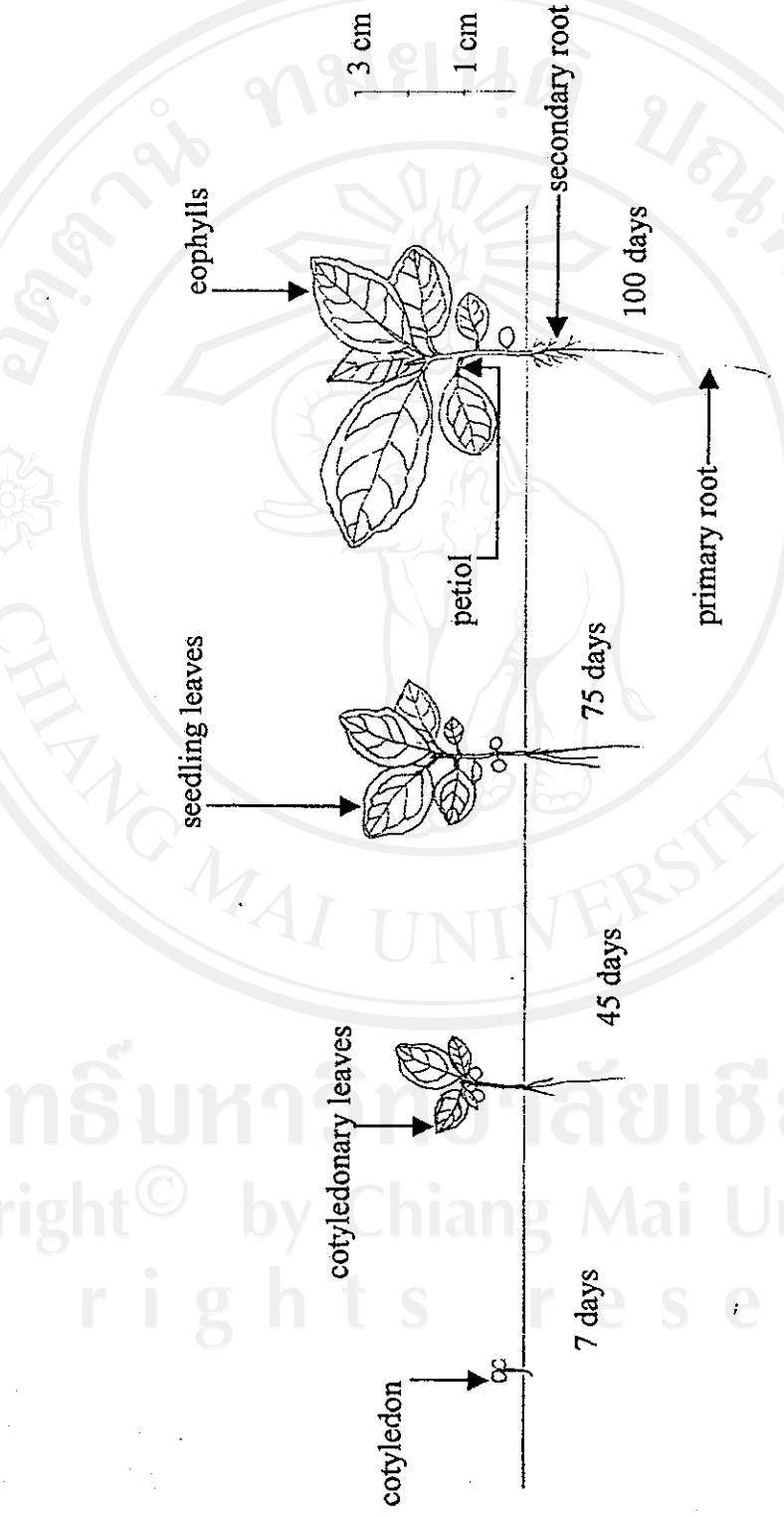

Figure 48. *Ficus auriculata* Lour. (Moraceae) seedling development

***Holigarna kurzii* King (Anacardiaceae)**

This description is based on seedlings grown at the Forest Restoration Unit nursery. All seeds were collected on 18 June 2002 from one tree parent at the Registrar's Office, Chiang Mai University at about 350 m elevation in old deciduous secondary growth. Small seedlings in the liquid collection are 7 – 60 days old and 1.5 – 10.5 cm tall, while the dry seedlings are 2 months old and 7 – 10 cm tall. The stages of development are shown in Figure 49.

Planting date: 30 June 2002

Germination date: 5 July 2002

Germination: hypogeal

Cotyledons: plano-convex, cream, 9 - 11 x 8 - 9 mm

Cotyledonary petiole: stout, 4 mm long, 2 mm thick, green after 21 days

Radicle: primary root straight, reddish-brown, 2 mm diameter after 60 days; secondary roots fibrous, 0.5 mm diameter

Epicotyl: straight, stout, glabrous, green; with 2-3 spaced, spirally arranged, scale-like cataphylls

Eophylls: alternate, simple; blades oblong, apex acute and mucronulate, base obtuse, margins entire; midnerve distinct, dorsally flat, raised ventrally; secondary veins pinnate, 5-6 on each side of the midrib; arching; finer veins reticulate; glossy green dorsally, glossy light green underneath; petioles glabrous, light green, 2-3 mm long

Stipules: none

Voucher: Philachanh 3

FLORA OF THAILAND

CMU Herbarium, Faculty of Science, Chiang Mai University

Chiang Mai, Thailand

In Liquid Seedling Collection

FAMILY: ANACARDIACEAE Lao common name: nam kiang kahn

BOTANICAL NAME: *Holigarna kurzii* King

Province: Chiang Mai District: Muang

Location: Registrar's Office, Chiang Mai University

Elevation: 350 m Date: 18 June 2002

Habitat: old remnant of open deciduous secondary growth, granite bedrock

Note: deciduous tree 12 m tall; dbh 65 cm; bark thickened, dark-brown; testa light brown 9-11 x 8-9 mm; leaf blades dark green above, pale green underneath; germination hypogeal

Same tree as Maxwell 00-195,00-443

Collected by: B. Philachanh Number: 3 Duplicates: 0

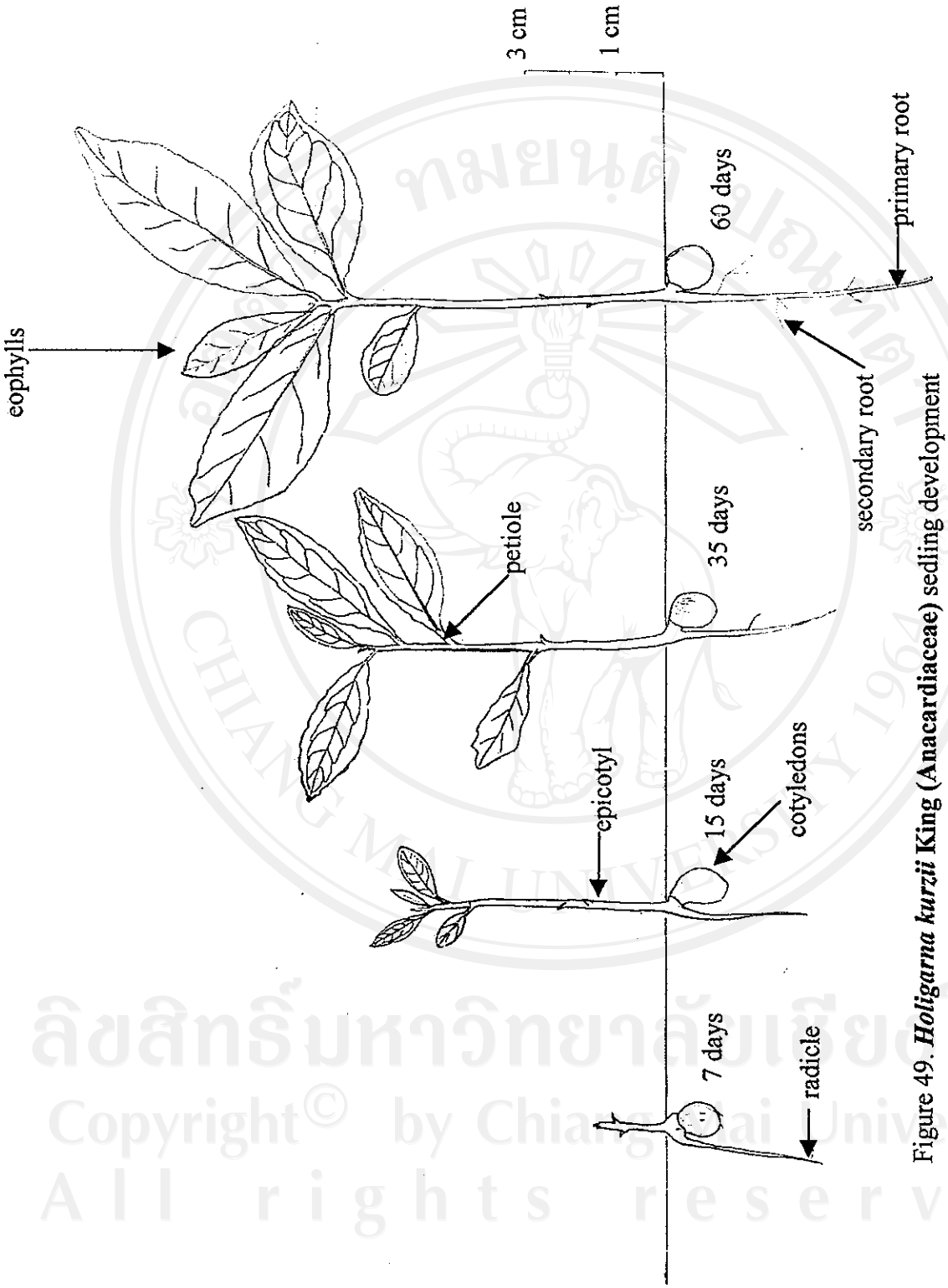

Figure 49. ***Holigarna kurzii*** **King (Anacardiaceae)** sedling development

***Michelia baillonii* Pierre (Magnoliaceae)**

This description is based on seedlings grown at the Forest Restoration Unit nursery. All seeds were collected on 24 June 2002 from two parent trees near the headquarters of Doi Suthep-Pui Natioal Park at about 1075 m elevation in primary, evergreen, seasonal, hardwood forest. Small seedlings in the liquid collection are 7– 112 days old and 1 – 4 cm tall, while the large, dry seedlings are 4 months old and 2 – 4 cm tall. The stages of development are shown in Figure 50.

Planting date: 30 June 2002

Germination date: 21 October 2002

Germination: epigeal

Cotyledons: opposite, thin, elliptic; apex acute, base obtuse, margin entire; venation pinnate, 3 – 4 with secondary nerves on each side of the midrib; finer venation indistinct, with fine white hairs, pale yellow and becoming green with age, 23 x 12 mm

Cotyledonary leaves: opposite; blades elliptic, apex rounded, base obtuse, margin entire; light green; venation pinnate, indistinct

Radicle: primary root straight, slender, white, 1-2 cm long, about 0.5 mm diameter. Secondary roots fibrous sinuous and densely branching, cream or whitish, becoming light brown and later brown with age

Stem: hypocotyl stout, finely white puberulous at the base, light green; epicotyl similar, also with fine white hairs

Eophylls: alternate, simple; blades ovate, apex acuminate, base acute; margin entire; with fine white hairs; vennation pinnate, with 5-7 alternate secondary veins on either side of the midrib; finer venation indistinct; petiole 2-3 mm long with abundant, fine, short, white hairs; light green; terminal bud finely puberulous

Stipules: none

Voucher: Philachanh 4

FLORA OF THAILAND

CMU Herbarium, Faculty of Science, Chiang Mai University

Chiang Mai, Thailand

In Liquid Seedling Collection

FAMILY: MAGNOLIACEAE Lao common name: champa ba

BOTANICAL NAME: *Michelia baillonii* Pierre

Province: Chiang Mai District: Muang

Location: near the headquaters of Doi Suthep-Pui National Park

Elevation: 1075 m Date: 24 June 2002

Habitat: primary, evergreen, seasonal, hardwood forest; granite bedrock

Note: deciduous tree 25 m tall; dbh 81 cm; bark longitudinally cracked, brown; fruitting syncarps oblong-ovoid, 7 x 4.5 cm; seeds bright red; leaf blades dark green above, pale green underneath; germination epigeal

Collected by: B. Philachanh Number: 4 Duplicates. 0

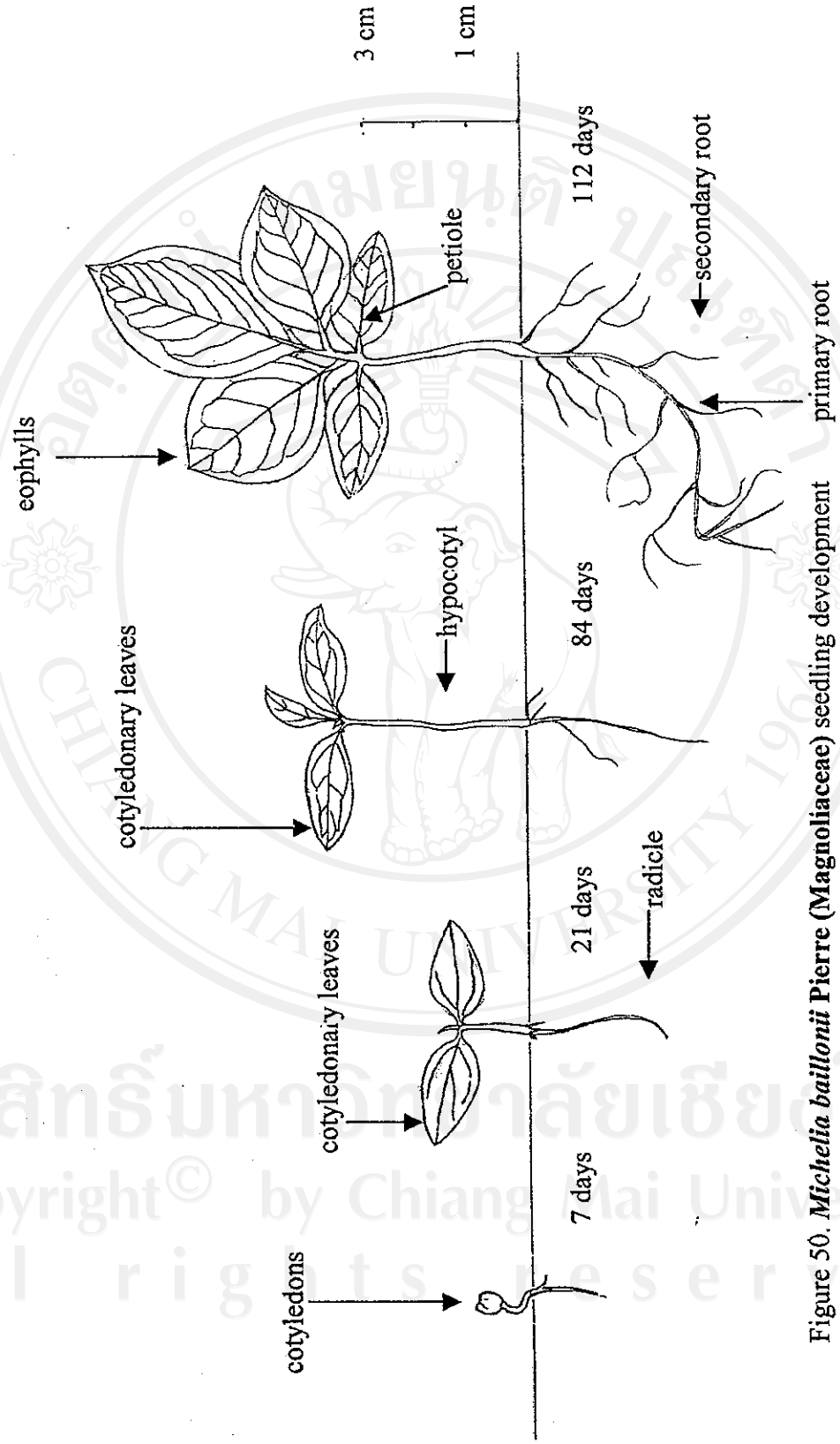

Figure 50. ***Michelia baillonii* Pierre (Magnoliaceae)** seedling development

***Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae)**

This description is based on seedlings grown at the Forest Restoration Unit nursery. All seeds were collected on 29 June 2002 from a tree parent in Doi Suthep-Pui National Park below Doi Pui Hmong village at about 1400 m elevation in primary, evergreen, seasonal, hardwood forest. Small seedlings in the liquid collection are 7 – 60 days old and 2 – 10.5 cm tall, while the dry seedlings are 5 months old and 8 – 12.5 cm tall. The stages of development are shown in Figures 51 and 52.

Planting date: 1 July 2002

Germination date: 22 July 2002

Germination: epigeal

Cotyledonary leaves: opposite, thin, elliptic; apex rounded, base cuneate, margin entire; venation pinnate, with 5-7 secondary nerves on each side of the midrib; finer venation indistinct, glabrous; green dorsally (outside), light green underneath (inside), 36 x 20 mm

Radicle: primary root straight, dark brown, 2 mm diameter after 60 days; fibrous roots 1 mm diameter

Eophylls: alternate, simple; blades lanceolate; apex acuminate, base acute, margins entire, midnerve distinct, dorsally flat, ventrally raised; secondary veins pinnate, 6-12 on each side of the midrib; arching; finer veins reticulate, glossy green above and glossy light green underneath; petioles light green, 4 - 5 mm long

Epicotyl: glabrous, straight, green and red-brown or pink with age; first internodes about 3 mm long, light green

Hypocotyl: red-brown, 7-8 cm long

Stipules: none

Voucher: Philachanh 5

FLORA OF THAILAND

CMU Herbarium, Faculty of Science, Chiang Mai University

Chiang Mai, Thailand

In Liquid Seedling Collection

FAMILY: SAPOTACEAE Lao common name: lah moot ba

BOTANICAL NAME: *Xantolis burmanica* (Coll. & Hemsl.) P. Royen

Province: Chiang Mai District: Muang

Location: Doi Suthep-Pui National Park, south side; below Doi Pui Hmong village

Elevation: 1400 m Date: 25 April 2002

Habitat: shaded place in primary, evergreen, seasonal, hardwood forest; granite bedrock

Note: evergreen tree 14 m tall; dbh 26 cm; bark longitudinally cracked, light brown; berries: exocarp green, mesocarp fleshy with white latex 35-45 mm x 25-30 mm; seeds 20 mm x 12 mm, testa dark brown; leaf blades dark green above, pale green underneath; germination epigeal

Collected by: B. Philachanh Number: 5 Duplicates: 0

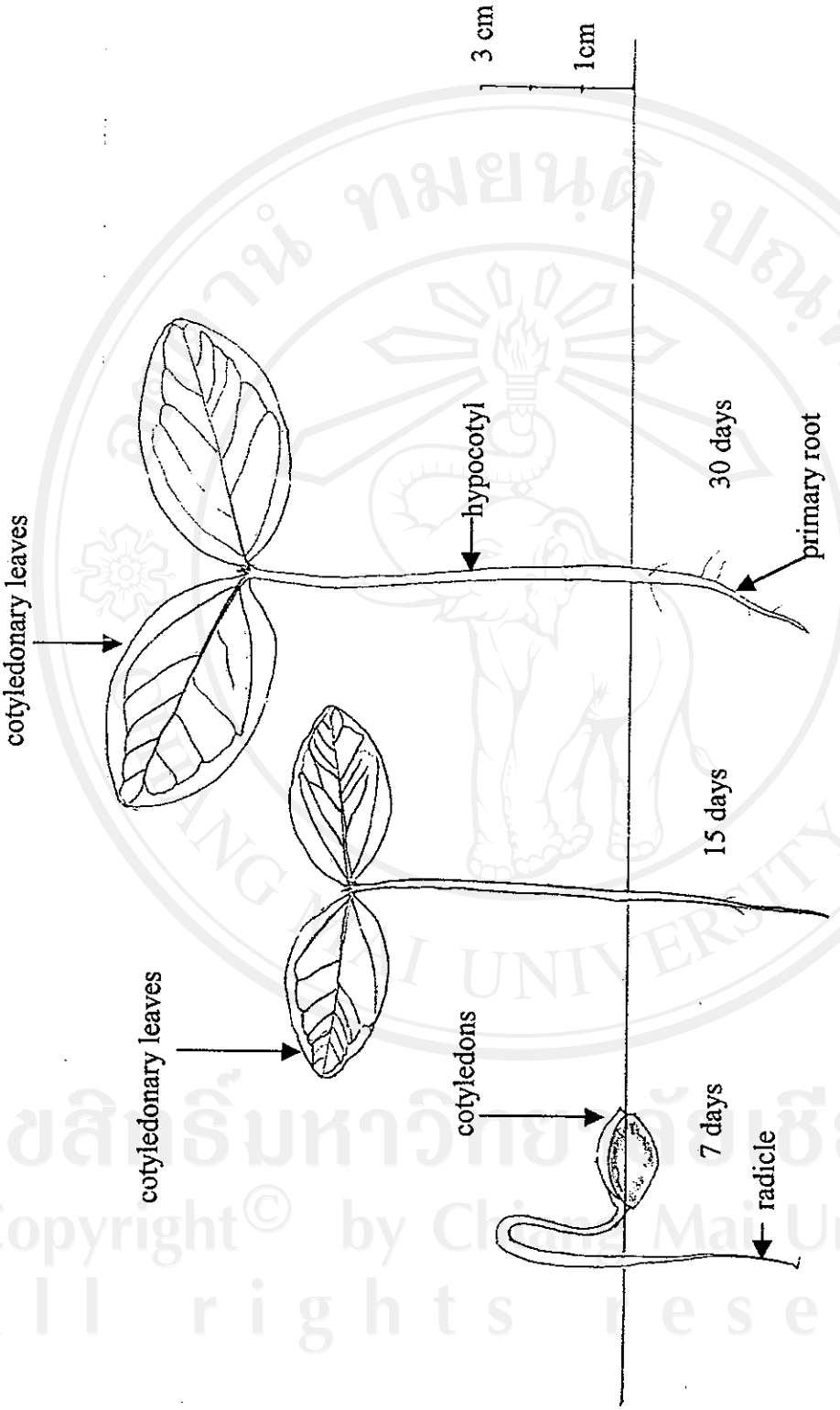

Figure 51. *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae) seedling development

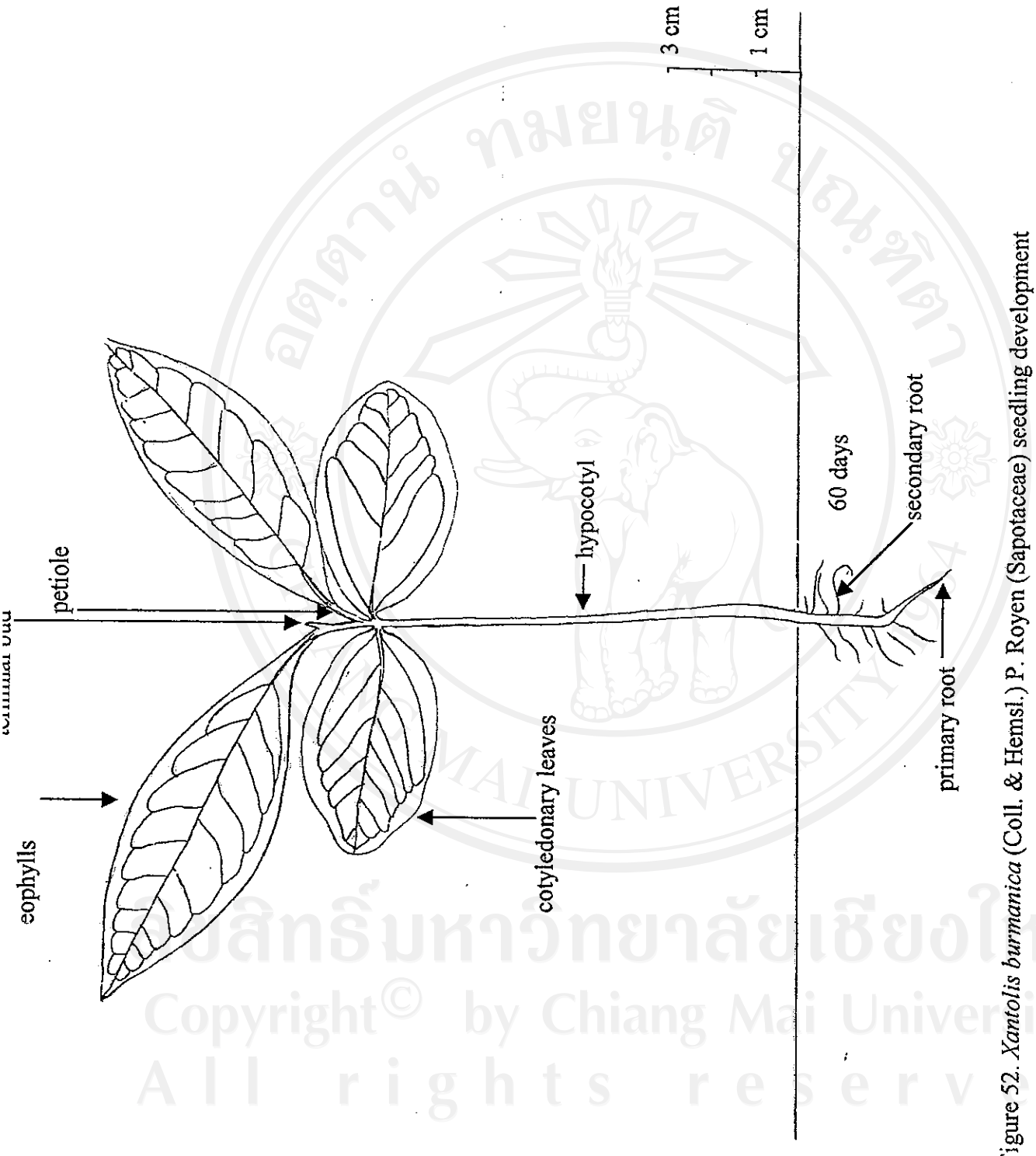

Figure 52. *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae) seedling development

APPENDIX II: Analysis of Variance

Table 27. *Careya arborea* Roxb. (Lecythidaceae): Number of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	61.11	56.94	55.55	173.6	57.867 B	2.894
Water Soaking for 24 hours	83.33	84.72	70.83	238.88	79.627 A	7.649
Scarification by hand	69.44	55.55	40.28	165.27	55.090 B	14.585
Heating in water at 60-70^0 C	48.61	58.33	68.05	174.99	58.330 B	9.72
Scarification with H_2SO_4	0	0	0	0	0.000 C	0
Block Total	262.49	255.54	234.71	752.74	50.183	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	10604.262	4	2651.065	31.911
Block	83.595	2	41.797	0.503
Residual	664.615	8	83.077	
Total	11352.472	14	810.891	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

APPENDIX II: Analysis of Variance

Table 27. *Careya arborea* Roxb. (Lecythidaceae): Number of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	61.11	56.94	55.55	173.6	57.867 B	2.894
Water Soaking for 24 hours	83.33	84.72	70.83	238.88	79.627 A	7.649
Scarification by hand	69.44	55.55	40.28	165.27	55.090 B	14.585
Heating in water at 60-70^0 C	48.61	58.33	68.05	174.99	58.330 B	9.72
Scarification with H_2SO_4	0	0	0	0	0.000 C	0
Block Total	262.49	255.54	234.71	752.74	50.183	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	10604.262	4	2651.065	31.911
Block	83.595	2	41.797	0.503
Residual	664.615	8	83.077	
Total	11352.472	14	810.891	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

Table 28. *Ficus auriculata* Lour. (Moraceae): Number of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	19.44	31.94	19.44	70.82	23.607 B	7.217
Water Soaking for 24 hours	16.67	19.44	22.22	58.33	19.443 B	2.775
Heating in water at 60-70^0 C	36.11	48.61	41.67	126.39	42.130 A	6.263
Scarification with H_2SO_4	30.55	25	23.61	79.16	26.387 B	3.671
Block Total	102.77	124.99	106.94	334.7	27.892	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	884.192	3	294.731	11.392
Block	69.743	2	34.872	1.348
Residual	155.234	6	25.872	
Total	1109.169	11	100.834	

			5%	1%
Critical Value of Distribution for Treatment			4.76	9.78
Critical Value of Distribution for Blocks			5.14	10.92

Table 29. *Holigarna kurzii* King (Anacardiaceae): Number of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	26.39	63.89	52.78	143.06	47.687 AB	19.262
Water Soaking for 24 hours	52.78	52.78	56.94	162.5	54.167 A	2.402
Scarification by hand	30.55	37.5	25	93.05	31.017 BC	6.263
Heating in water at 60-70^0 C	19.44	23.61	25	68.05	22.683 C	2.893
Scarification with H_2SO_4	40.28	41.67	34.72	116.67	38.890 ABC	3.678
Block Total	169.44	219.45	194.44	583.33	38.9	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	1906.21	4	476.552	6.093
Block	250.1	2	125.05	1.599
Residual	625.721	8	78.215	
Total	2782.031	14	198.716	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

Table 30. *Michelia baillonii* Pierre (Magnoliaceae): Number of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	6.94	8.33	9.72	24.99	8.33 A	1.39
Water Soaking for 24 hours	5.55	9.72	12.5	27.77	9.26 A	3.498
Scarification by hand	1.389	6.94	0	8.329	2.78 B	3.672
Heating in water at 60-70^0 C	0	0	0	0	0.00 B	0
Scarification with H_2SO_4	0	0	0	0	0.00 B	0
Block Total	13.879	24.99	22.22	61.089	0	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	239.55	4	59.889	11.427
Block	13.38	2	6.69	1.276
Residual	41.928	8	5.241	
Total	294.858	14	21.061	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

Table 31. *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae): Number of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	9.72	12.5	16.67	38.89	12.963 A	3.498
Water Soaking for 24 hours	5.55	1.39	1.39	8.33	2.777 BC	2.402
Scarification by hand	5.55	4.17	9.72	19.44	6.480 B	2.889
Heating in water at 60-70^0 C	6.94	4.17	4.17	15.28	5.093 BC	1.599
Scarification with H_2SO_4	2.78	0	2.78	5.56	1.853 C	1.605
Block Total	30.54	22.23	34.73	87.5	5.833	

Scource of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	230.959	4	57.74	9.873
Block	16.191	2	8.095	1.384
Residual	46.785	8	5.848	
Total	293.935	14	20.995	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

Table 32. *Careya arborea* Roxb. (Lecythidaceae): Percent mortality of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	0	0	12.5	12.5	4.167 A	7.217
Water Soaking for 24 hours	5	3.28	0	8.28	2.760 A	2.54
Scarification by hand	0	2.5	0	2.5	0.833 A	1.443
Heating in water at 60-70^0-C	0	0	0	0	0.000 A	0
Scarification with H_2SO_4	0	0	0	0	0.000 A	0
Block Total	5	5.78	12.5	23.28	1.552	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	40.889	4	10.222	0.714
Block	6.801	2	3.401	0.238
Residual	114.438	8	14.305	
Total	162.128	14	11.581	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

Table 33. *Ficus auriculata* Lour. (Moraceae): Percent mortality of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	71.43	78.26	92.86	242.55	80.850 A	10.947
Water Soaking for 24 hours	75	100	31.25	206.25	68.750 A	34.798
Heating in water at 60-70^0 C	76.92	65.71	76.67	219.3	73.100 A	6.401
Scarification with H_2SO_4	90.91	88.89	70.59	250.39	83.463 A	11.194
Block Total	314.26	332.86	271.37	918.49	76.541	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	417.079	3	139.026	0.334
Block	497.211	2	248.606	0.597
Residual	2496.922	6	416.154	
Total	3411.212	11	310.11	

			5%	1%
Critical Value of Distribution for Treatment			4.76	9.78
Critical Value of Distribution for Blocks			5.14	10.92

Table 34. *Holigarna kurzii* King (Anacardiaceae): Percent mortality of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	5.26	0	2.63	7.89	2.630 B	2.63
Water Soaking for 24 hours	0	0	0	0	0.0 B	0
Scarification by hand	9.09	3.7	5.55	18.34	6.113 A	2.739
Heating in water at 60-70^0 C	0	0	0	0	0.0 B	0
Scarification with H_2SO_4	0	0	0	0	0.0 B	0
Block Total	14.35	3.7	8.18	26.23	1.749	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	87.002	4	21.75	10
Block	11.437	2	125.05	57.494
Residual	17.399	8	2.175	
Total	115.838	14	8.274	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

Table 35. *Michelia baillonii* Pierre (Magnoliaceae): Percent mortality of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	0	33.33	14.29	47.62	15.873 A	16.721
Water Soaking for 24 hours	0	0	0	0	0	0
Scarification by hand	0	0	0	0	0	0
Heating in water at 60-70^0 C	0	0	0	0	0	0
Scarification with H_2SO_4	0	0	0	0	0	0
Block Total	0	33.33	14.29	47.62	0	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	604.711	4	151.178	2.703
Block	111.841	2	55.92	1
Residual	447.363	8	55.92	
Total	1163.915	14	83.137	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

Table 36. *Xantolis burmanica* (Coll. & Hemsl.) P. Royen (Sapotaceae): Percent mortality of seedlings germinated after 3 months

Treatment	Block			Treatment Total	Treatment mean	Standard Deviation
	1	2	3			
Control	14.28	33.33	50	97.61	32.537 A	17.873
Water Soaking for 24 hours	75	100	0	175	58.333 A	52.042
Scarification by hand	75	0	71.43	146.43	48.810 A	42.308
Heating in water at 60-70^0 C	20	100	0	120	40.000 A	52.915
Scarification with H_2SO_4	0	0	100	100	33.333 A	57.735
Block Total	184.28	233.33	221.43	639.04	42.603	

Source of Variation	Sum of Square	Dregree of Freedom	Mean Square	Variance Ratio
Treatment	1440.011	4	360.003	0.133
Block	261.842	2	130.921	0.048
Residual	21640.39	8	2705.049	
Total	23342.244		1667.303	

			5%	1%
Critical Value of Distribution for Treatment			3.84	7.01
Critical Value of Distribution for Blocks			4.46	8.65

Table 37. *Careya arborea*: height at 7 months (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.059	2	0.029	1.109	0.389
Treatment	0.059	2	0.029	1.109	0.389
Block	0.048	2	0.024	0.843	0.476
Explained	0.059	2	0.029	1.109	0.389
Residual	0.159	6	0.027		
Total	0.218	8	0.027		

Table 38. *Careya arborea*: height at 7 months (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.014	2	0.007	0.241	0.793
Treatment	0.014	2	0.007	0.241	0.793
Block	0.020	2	0.010	0.340	0.725
Explained	0.014	2	0.007	0.241	0.793
Residual	0.179	6	0.030		
Total	0.194	8	0.024		

Table 39. *Careya arborea*: height at 7 months (scarification by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.027	2	0.013	0.171	0.847
Treatment	0.027	2	0.013	0.171	0.847
Block	0.207	2	0.103	2.173	0.195
Explained	0.27	2	0.013	0.171	0.847
Residual	0.466	6	0.078		
Total	0.492	8	0.062		

Table 40. *Careya arborea* Roxb. (Lecythidaceae): height at 7 months (60-70^0 C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.067	2	0.033	0.381	0.698
Treatment	0.067	2	0.033	0.381	0.698
Block	0.290	2	0.145	2.889	0.132
Explained	0.067	2	0.033	0.381	0.698
Residual	0.525	6	0.087		
Total	0.591	8	0.074		

Table 41. *Careya arborea*: diameter at 7 months (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.005	2	0.002	0.60	0.942
Treatment	0.005	2	0.002	0.60	0.942
Block	0.055	2	0.028	0.954	0.437
Explained	0.005	2	0.002	0.60	0.942
Residual	0.224	6	0.037		
Total	0.229	8	0.029		

Table 42. *Careya arborea*: diameter at 7 months (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.006	2	0.003	0.109	0.899
Treatment	0.006	2	0.003	0.109	0.899
Block	0.116	2	0.058	6.890	0.028
Explained	0.006	2	0.003	0.109	0.899
Residual	0.161	6	0.027		
Total	0.167	8	0.021		

Table 43. *Careya arborea*: diameter at 7 months (scarification by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.018	2	0.009	0.599	0.579
Treatment	0.018	2	0.009	0.599	0.579
Block	0.005	2	0.003	0.155	0.860
Explained	0.018	2	0.009	0.599	0.579
Residual	0.091	6	0.015		
Total	0.109	8	0.014		

Table 44. *Careya arborea*: diameter at 7 months (60-70^0 C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.058	2	0.029	0.885	0.461
Treatment	0.058	2	0.029	0.885	0.461
Block	0.178	2	0.089	6.982	0.027
Explained	0.058	2	0.029	0.885	0.461
Residual	0.197	6	0.033		
Total	0.255	8	0.032		

Table 45. *Careya arborea*: shoot at 7 months (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.026	2	0.013	1.243	0.354
Treatment	0.026	2	0.013	1.243	0.354
Block	0.026	2	0.013	1.261	0.349
Explained	0.026	2	0.013	1.243	0.354
Residual	0.062	6	0.010		
Total	0.087	8	0.011		

Table 46. *Careya arborea*: shoot at 7 months (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.001	2	0.000	0.876	0.464
Treatment	0.001	2	0.000	0.876	0.464
Block	0.001	2	0.001	2.430	0.169
Explained	0.001	2	0.000	0.876	0.464
Residual	0.003	6	0.000		
Total	0.003	8	0.000		

Table 47. *Careya arborea*: shoot at 7 months (scarification by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.001	2	0.001	0.917	0.449
Treatment	0.001	2	0.001	0.917	0.449
Block	0.002	2	0.001	1.077	0.398
Explained	0.001	2	0.001	0.917	0.449
Residual	0.005	6	0.001		
Total	0.006	8	0.001		

Table 48. *Careya arborea*: shoot at 7 months (60-70^0 C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.000	2	0.000	0.027	0.974
Treatment	0.000	2	0.000	0.027	0.974
Block	0.000	2	0.000	0.212	0.815
Explained	0.000	2	0.000	0.027	0.974
Residual	0.005	6	0.001		
Total	0.005	8	0.001		

Table 49. *Careya arborea*: root at 7 months (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.063	2	0.031	2.147	0.198
Treatment	0.063	2	0.031	2.147	0.198
Block	0.040	2	0.020	1.077	0.398
Explained	0.063	2	0.031	2.147	0.198
Residual	0.087	6	0.015		
Total	0.150	8	0.019		

Table 50. *Careya arborea*: root at 7 months (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.016	2	0.008	0.619	0.570
Treatment	0.016	2	0.008	0.619	0.570
Block	0.018	2	0.009	0.741	0.516
Explained	0.016	2	0.008	0.619	0.570
Residual	0.077	6	0.013		
Total	0.092	8	0.012		

Table 51. *Careya arborea*: root at 7 months (scarification by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.005	2	0.002	0.095	0.910
Treatment	0.005	2	0.002	0.095	0.910
Block	0.023	2	0.011	0.517	0.620
Explained	0.005	2	0.002	0.095	0.910
Residual	0.150	6	0.025		
Total	0.155	8	0.019		

Table 52. *Careya arborea*: root at 7 months (60-70^0 C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.052	2	0.026	1.151	0.378
Treatment	0.052	2	0.026	1.151	0.378
Block	0.113	2	0.056	4.542	0.063
Explained	0.052	2	0.026	1.151	0.378
Residual	0.136	6	0.023		
Total	0.188	8	0.023		

Table 53. *Holigarna kurzii*: height at 7 months (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.001	2	0.000	0.037	0.963
Treatment	0.001	2	0.000	0.037	0.963
Block	0.014	2	0.007	1.051	0.406
Explained	0.001	2	0.000	0.037	0.963
Residual	0.053	6	0.009		
Total	0.054	8	0.007		

Table 54. *Holigarna kurzii*: height at 7 months (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.042	2	0.021	0.692	0.537
Treatment	0.042	2	0.021	0.692	0.537
Block	0.045	2	0.022	0.740	0.516
Explained	0.042	2	0.021	0.692	0.537
Residual	0.183	6	0.031		
Total	0.226	8	0.028		

Table 55. *Holigarna kurzii*: height at 7 months (scarification by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.003	2	0.002	0.935	0.443
Treatment	0.003	2	0.002	0.935	0.443
Block	0.009	2	0.004	5.219	0.049
Explained	0.003	2	0.002	0.935	0.443
Residual	0.011	6	0.002		
Total	0.14	8	0.002		

Table 56. *Holigarna kurzii*: height at 7 months (60-70^0 C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.079	2	0.039	1.844	0.237
Treatment	0.079	2	0.039	1.844	0.237
Block	0.061	2	0.030	1.240	0.354
Explained	0.079	2	0.039	1.844	0.237
Residual	0.128	6	0.021		
Total	0.207	8	0.026		

Table 57. *Holigarna kurzii*: height at 7 months (H_2SO_4)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.019	2	0.010	0.545	0.606
Treatment	0.019	2	0.010	0.545	0.606
Block	0.016	2	0.008	0.454	0.655
Explained	0.019	2	0.010	0.545	0.606
Residual	0.105	6	0.018		
Total	0.125	8	0.016		

Table 58. *Holigarna kurzii*: diameter at 7 months (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.044	2	0.022	0.391	0.693
Treatment	0.044	2	0.022	0.391	0.693
Block	0.300	2	0.150	11.169	0.009
Explained	0.044	2	0.022	0.391	0.693
Residual	0.337	6	0.056		
Total	0.381	8	0.048		

Table 59. *Holigarna kurzii*: diameter at 7 months (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.061	2	0.030	2.016	0.214
Treatment	0.061	2	0.030	2.016	0.214
Block	0.002	2	0.001	0.048	0.953
Explained	0.061	2	0.030	2.016	0.214
Residual	0.091	6	0.015		
Total	0.151	8	0.019		

Table 60. *Holigarna kurzii*: diameter at 7 months (scarification by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.618	2	0.309	1.563	0.284
Treatment	0.618	2	0.309	1.563	0.284
Block	0.668	2	0.334	1.766	0.249
Explained	0.618	2	0.309	1.563	0.284
Residual	1.185	6	0.198		
Total	1.803	8	0.225		

Table 61. *Holigarna kurzii*: diameter at 7 months (60-70^0 C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.012	2	0.006	0.110	0.897
Treatment	0.012	2	0.006	0.110	0.897
Block	0.083	2	0.042	0.962	0.434
Explained	0.012	2	0.006	0.110	0.897
Residual	0.331	6	0.055		
Total	0.344	8	0.043		

Table 62. *Holigarna kurzii*: diameter at 7 months (H_2SO_4)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.089	2	0.044	1.963	0.221
Treatment	0.089	2	0.044	1.963	0.221
Block	0.055	2	0.028	0.975	0.430
Explained	0.089	2	0.044	1.963	0.221
Residual	0.136	6	0.023		
Total	0.225	8	0.028		

Table 63. *Holigarna kurzii*: shoot at 7 months (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.001	2	0.000	2.605	0.153
Treatment	0.001	2	0.000	2.605	0.153
Block	0.000	2	0.000	0.726	0.522
Explained	0.001	2	0.000	2.605	0.153
Residual	0.001	6	0.000		
Total	0.002	8	0.000		

Table 64. *Holigarna kurzii*: shoot at 7 months (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.000	2	0.000	0.176	0.843
Treatment	0.000	2	0.000	0.176	0.843
Block	0.004	2	0.002	15.897	0.004
Explained	0.000	2	0.000	0.176	0.843
Residual	0.005	6	0.001		
Total	0.005	8	0.001		

Table 65. *Holigarna kurzii*: shoot at 7 months (scarification by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.000	2	0.000	2.518	0.161
Treatment	0.000	2	0.000	2.518	0.161
Block	0.000	2	0.000	1.268	0.347
Explained	0.000	2	0.000	2.518	0.161
Residual	0.000	6	0.000		
Total	0.000	8	0.000		

Table 66. *Holigarna kurzii*: shoot at 7 months (60-70^0 C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.000	2	0.000	0.613	0.572
Treatment	0.000	2	0.000	0.613	0.572
Block	0.001	2	0.000	1.281	0.344
Explained	0.000	2	0.000	0.613	0.572
Residual	0.002	6	0.000		
Total	0.002	8	0.000		

Table 67. *Holigarna kurzii*: shoot at 7 months (H_2SO_4)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.000	2	0.000	0.053	0.949
Treatment	0.000	2	0.000	0.053	0.949
Block	0.000	2	0.000	0.586	0.585
Explained	0.000	2	0.000	0.053	0.949
Residual	0.002	6	0.000		
Total	0.002	8	0.000		

Table 68. *Holigarna kurzii*: root at 7 months (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.046	2	0.023	2.321	0.179
Treatment	0.046	2	0.023	2.321	0.179
Block	0.003	2	0.001	0.086	0.919
Explained	0.046	2	0.023	2.321	0.179
Residual	0.059	6	0.010		
Total	0.105	8	0.013		

Table 69. *Holigarna kurzii*: root at 7 months (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.006	2	0.003	0.160	0.855
Treatment	0.006	2	0.003	0.160	0.855
Block	0.106	2	0.053	26.541	0.001
Explained	0.006	2	0.003	0.160	0.855
Residual	0.112	6	0.019		
Total	0.117	8	0.015		

Table 70. *Holigarna kurzii*: root at 7 months (scarification by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.031	2	0.016	1.339	0.331
Treatment	0.031	2	0.016	1.339	0.331
Block	0.012	2	0.006	0.395	0.690
Explained	0.031	2	0.016	1.339	0.331
Residual	0.071	6	0.012		
Total	0.102	8	0.013		

Table 71. *Holigarna kurzii*: root at 7 months (60-70^0 C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.003	2	0.001	0.157	0.858
Treatment	0.003	2	0.001	0.157	0.858
Block	0.024	2	0.012	2.687	0.147
Explained	0.003	2	0.001	0.157	0.858
Residual	0.049	6	0.008		
Total	0.052	8	0.006		

Table 72. *Holigarna kurzii*: root at 7 months (H_2SO_4)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.005	2	0.002	0.315	0.741
Treatment	0.005	2	0.002	0.315	0.741
Block	0.005	2	0.002	0.315	0.741
Explained	0.005	2	0.002	0.315	0.741
Residual	0.046	6	0.008		
Total	0.051	8	0.006		

Table 73. *Ficus auriculata*: height at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.012	2	0.006	0.081	0.923
Treatment	0.012	2	0.006	0.081	0.923
Block	0.187	2	0.093	2.143	0.198
Explained	0.012	2	0.006	0.081	0.923
Residual	0.436	6	0.073		
Total	0.448	8	0.056		

Table 74. *Ficus auriculata*: diameter at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.325	2	0.163	0.575	0.591
Treatment	0.325	2	0.163	0.575	0.591
Block	1.074	2	0.537	3.395	0.103
Explained	0.325	2	0.163	0.575	0.591
Residual	1.698	6	0.283		
Total	2.023	8	0.253		

Table 75. *Ficus auriculata*: shoot at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.004	2	0.002	0.168	0.849
Treatment	0.004	2	0.002	0.168	0.849
Block	0.052	2	0.026	5.078	0.051
Explained	0.004	2	0.002	0.168	0.849
Residual	0.079	6	0.013		
Total	0.083	8	0.010		

Table 76. *Ficus auriculata*: root at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.001	2	0.000	0.106	0.901
Treatment	0.001	2	0.000	0.106	0.901
Block	0.012	2	0.006	3.320	0.107
Explained	0.001	2	0.000	0.106	0.901
Residual	0.021	6	0.004		
Total	0.022	8	0.003		

Table 77. *Xantolis burmanica*: height at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.050	2	0.025	0.904	0.454
Treatment	0.050	2	0.025	0.904	0.454
Block	0.074	2	0.037	1.577	0.282
Explained	0.050	2	0.025	0.904	0.454
Residual	0.166	6	0.028		
Total	0.216	8	0.027		

Table 78. *Xantolis burmanica*: diameter at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.006	2	0.003	0.130	0.881
Treatment	0.006	2	0.003	0.130	0.881
Block	0.031	2	0.016	0.862	0.469
Explained	0.006	2	0.003	0.130	0.881
Residual	0.134	6	0.022		
Total	0.139	8	0.017		

Table 79. *Xantolis burmanica*: shoot at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.002	2	0.001	1.120	0.386
Treatment	0.002	2	0.001	1.120	0.386
Block	0.013	2	0.007	5.912	0.038
Explained	0.002	2	0.001	1.120	0.386
Residual	0.006	6	0.001		
Total	0.008	8	0.001		

Table 80. *Xantolis burmanica*: root at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	0.002	2	0.001	1.558	0.285
Treatment	0.002	2	0.001	1.558	0.285
Block	0.002	2	0.001	1.516	0.293
Explained	0.002	2	0.001	1.558	0.285
Residual	0.003	6	0.001		
Total	0.005	8	0.001		

Table 81. *Careya arborea*: Percent mortality of seedlings during 7 months after potting in the plastic bag (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	262.587	2	131.293	1.388	0.320
Treatment	262.587	2	131.293	1.388	0.320
Block	279.167	2	139.583	1.520	0.292
Explained	262.587	2	131.293	1.388	0.320
Residual	567.673	6	94.612		
Total	830.260	8	103.783		

Table 82. *Careya arborea*: Percent mortality of seedlings during 7 months after potting in the plastic bag (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	174.676	2	87.338	0.640	0.560
Treatment	174.676	2	87.338	0.640	0.560
Block	260.976	2	130.488	1.069	0.401
Explained	174.676	2	87.338	0.640	0.560
Residual	818.660	6	136.443		
Total	993.336	8	124.167		

Table 83. *Careya arborea*: Percent mortality of seedlings during 7 months after potting in the plastic bag (sca. by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	118.149	2	59.074	0.251	0.786
Treatment	118.149	2	59.074	0.251	0.786
Block	720.222	2	360.111	2.673	0.148
Explained	118.149	2	59.074	0.251	0.786
Residual	1410.520	6	235.087		
Total	1528.669	8	191.084		

Table 84. *Careya arborea*: Percent mortality of seedlings during 7 months after potting in the plastic bag (60-70^{0}C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	243.056	2	121.528	0.700	0.533
Treatment	243.056	2	121.528	0.700	0.533
Block	972.222	2	486.111	9.333	0.014
Explained	243.056	2	121.528	0.700	0.533
Residual	1041.667	6	173.611		
Total	1284.722	8	160.590		

Table 85. *Holigarna kurzii*: Percent mortality of seedlings during 7 months after potting in the plastic bag (control)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	158.420	2	79.210	0.114	0.894
Treatment	158.420	2	79.210	0.114	0.894
Block	4086.087	2	2043.043	48.530	0.001
Explained	158.420	2	79.210	0.114	0.894
Residual	4180.260	6	696.710		
Total	4338.680	8	542.335		

Table 86. *Holigarna kurzii*: Percent mortality of seedlings during 7 months after potting in the plastic bag (water soaking)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	105.556	2	52.778	0.128	0.882
Treatment	105.556	2	52.778	0.128	0.882
Block	838.889	2	419.444	1.452	0.306
Explained	105.556	2	52.778	0.128	0.882
Residual	2466.667	6	411.111		
Total	2572.222	8	321.528		

Table 87. *Holigarna kurzii*: Percent mortality of seedlings during 7 months after potting in the plastic bag (sca. by hand)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	1250.000	2	625.000	2.074	0.207
Treatment	1250.000	2	625.000	2.074	0.207
Block	974.447	2	487.223	1.403	0.316
Explained	1250.000	2	625.000	2.074	0.207
Residual	1807.780	6	301.297		
Total	3057.780	8	382.223		

Table 88. *Holigarna kurzii*: Percent mortality of seedlings during 7 months after potting in the plastic bag (60-70^{0}C)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	1171.976	2	585.988	0.825	0.482
Treatment	1171.976	2	585.988	0.825	0.482
Block	3027.902	2	1513.951	3.776	0.087
Explained	1171.976	2	585.988	0.825	0.482
Residual	4261.853	2	710.309		
Total	5433.829	8	679.229		

Table 89. *Holigarna kurzii*: Percent mortality of seedlings during 7 months after potting in the plastic bag (H_2SO_4)

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	357.069	2	178.534	1.116	0.387
Treatment	357.069	2	178.534	1.116	0.387
Block	34.282	2	17.141	0.080	0.924
Explained	357.069	2	178.534	1.116	0.387
Residual	960.060	6	160.010		
Total	1317.129	8	164.641		

Table 90. *Ficus auriculata*: Percent mortality of seedlings during 4 months after potting in the plastic bag

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	672.816	2	336.408	1.473	0.302
Treatment	672.816	2	336.408	1.473	0.302
Block	688.889	2	344.444	1.526	0.291
Explained	672.816	2	336.408	1.473	0.302
Residual	1370.520	6	228.420		
Total	2043.336	8	255.417		

Table 91. *Xantolis burmanica*: Percent mortality of seedlings during 4 months after potting in the plastic bag

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	88.889	2	44.444	1.000	0.422
Treatment	88.889	2	44.444	1.000	0.422
Block	88.889	2	44.444	1.000	0.422
Explained	88.889	2	44.444	1.000	0.422
Residual	266.667	6	44.444		
Total	355.556	8	44.444		

Table 92. Average height of *Careya arborea* (control), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	284.942	2	142.471	1.451	0.246
Treatment	284.942	2	142.471	1.451	0.246
Block	929.781	2	464.891	5.663	0.007
Explained	284.942	2	142.471	1.451	0.246
Residual	3928.500	40	98.212		
Total	4213.442	42	100.320		

Table 93. Average height of *Careya arborea* (water soaking), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	232.721	2	116.361	0.986	0.384
Treatment	232.721	2	116.361	0.986	0.384
Block	709.608	2	354.804	4.237	0.020
Explained	232.721	2	116.361	0.986	0.384
Residual	3778.022	32	118.063		
Total	4010.743	34	117.963		

Table 94. Average height of *Careya arborea* (scarification by hand), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	26.761	2	13.381	0.184	0.833
Treatment	26.761	2	13.381	0.184	0.833
Block	66.900	2	33.450	0.466	0.631
Explained	26.761	2	13.381	0.184	0.833
Residual	3127.152	43	72.724		
Total	3153.913	45	70.087		

Table 95. Average height of *Careya arborea* (heating in water), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	358.659	2	179.329	1.984	0.147
Treatment	358.659	2	179.329	1.984	0.147
Block	417.094	2	208.547	2.335	0.106
Explained	358.659	2	179.329	1.984	0.147
Residual	4971.686	55	90.394		
Total	5330.345	57	93.515		

Table 96. Average height of *Holigarna kurzii* (control), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	144.454	2	72.227	0.586	0.563
Treatment	144.454	2	72.227	0.586	0.563
Block	175.434	2	87.717	0.718	0.496
Explained	144.454	2	72.227	0.586	0.563
Residual	3820.017	31	123.226		
Total	3964.471	33	120.135		

Table 97. Average height of *Holigarna kurzii* (water soaking), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	62.041	2	31.021	0.281	0.757
Treatment	62.041	2	31.021	0.281	0.757
Block	414.608	2	207.304	2.131	0.138
Explained	62.041	2	31.021	0.281	0.757
Residual	2978.759	27	110.324		
Total	3040.800	29	104.855		

Table 98. Average height of *Holigarna kurzii* (scarification by hand), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	426.183	2	213.091	2.617	0.106
Treatment	426.183	2	213.091	2.617	0.106
Block	23.197	2	11.598	0.107	0.899
Explained	426.183	2	213.091	2.617	0.106
Residual	1221.429	15	81.429		
Total	1647.611	17	96.918		

Table 99. Average height of *Holigarna kurzii* (heating in water), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	272.849	2	136.425	0.880	0.435
Treatment	272.849	2	136.425	0.880	0.435
Block	806.194	2	403.097	3.375	0.062
Explained	272.849	2	136.425	0.880	0.435
Residual	2324.929	15	154.995		
Total	2597.778	17	152.810		

Table 100. Average height of *Holigarna kurzii* (H_2SO_4), at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	246.336	2	123.168	1.072	0.367
Treatment	246.336	2	123.168	1.072	0.367
Block	67.083	2	33.542	0.267	0.768
Explained	246.336	2	123.168	1.072	0.367
Residual	1723.275	15	114.885		
Total	1969.611	17	115.859		

Table 101. Average height of *Ficus auriculata*, at 4 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	795.243	2	397.621	2.331	0.111
Treatment	795.243	2	397.621	2.331	0.111
Block	3129.286	2	1564.643	8.012	0.001
Explained	795.243	2	397.621	2.331	0.111
Residual	6651.733	39	170.557		
Total	7446.976	41	181.634		

Table 102. Average height of *Xantolis burmanica*, at 7 months

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	2542.905	2	1271.452	2.397	0.104
Treatment	2542.905	2	1271.452	2.397	0.104
Block	4327.474	2	2163.737	5.847	0.006
Explained	2542.905	2	1271.452	2.397	0.104
Residual	20690.714	39	530.531		
Total	23233.619	41	566.674		

APPENDIX III: Cost-benefit Analysis

CONTAINER

Modular Tray

Cost		25	baht/tray
Transportation		5	baht/tray
72 cells : 1 tray			
1 cell	30/72	=	0.416 baht/seedling/12 season
1 cell	0.416/12	=	0.035 baht/seedling/season

Plastic bag 23 x 6 cm

Cost		30	baht/kilogram
One kilogram has		236	bags
Cost of 1 bag	30/236	=	0.127 baht/seedling/season

MEDIA

Forest Soil	1,685,500 cm^3	=	1,000 baht
	1 cm^3	=	0.0059 baht/cm^3
Coconut husk	98,400 cm^3	=	50 baht
	1 cm^3	=	0.000508 baht/cm^3

Peanut husk 46,300 cm^3 = 25 baht

1 cm^3 = 0.00054 baht/cm^3

Volume used

Modular Tray 3.5 x 3 x 7 = 73.5 cm^3

Plastic bag 23 x 6 cm 800 cm^3

Potting media cost/seedling/season

Modular Tray

Use forest soil 73.5 cm^3 x 0.00059 = 0.0434 baht/seedling/season

Plastic bag 23 x 6 cm

Use forest soil 400 cm^3 x 0.00059 = 0.236 baht

Use coconut husk 200 cm^3 x 0.000508 = 0.1016 baht

Use peanut husk 200 cm^3 x 0.0054 = 0.103 baht

= 0.1671 baht/seedling/season

CHEMICAL REAGENT

Conc. H_2SO_4 1000 ml = 700 baht

Volume used/seed = 1 ml/seed

= 0.7 baht/seedling/season

FERTILIZER

Osmocote	1,000g	=	150 baht
	0.3g	=	0.045 baht/seedling
Use 4 time for season 0.045 x 4		=	0.18 baht/seedling/season

TRITON

Microrrhizae product TRITON	1.000 ml	=	100 baht
	0.3 ml	=	0.03 baht/seedling/season
	0.6 ml	=	0.06 baht/seedling/season

LABOR COST

For seed collection

1,000	seeds	=	100 baht
1	seed	=	0.1 baht/seed

Labor wages	1 day (8 hrs.)	=	150 baht
	8 hrs.	=	28,800 second
	1 second	=	0.0052 baht/second

For filling containers

Modular Tray 1.25 second/seedling x 0.0052 baht/second