REPRODUCTIVE BIOLOGY AND PROPAGATION OF *LIMNOPHILA GEOFFRAYI* BONATI AND *L. AROMATICA* (LAM.) MERR.

RUNGTIP MALAIPHIS

A Thesis Submitted in Partial Fulfillment of the Requirement for the
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ชีววิทยาการสืบพันธุ์และการขยายพันธุ์ของกะออมและผักแขยง

นางสาวรุ่งทิพย์ มาลัยพิศ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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คำสำคัญ: ระบบสืบพันธุ์ การผสมเกสร การงอกของเมล็ด การสร้างยอดใหม่ *Limnophila*

Limnophila geoffrayi เป็นพืชสมุนไพรพื้นเมืองของประเทศไทย ในธรรมชาติพบว่ามีจำนวนลดลง ขณะที่ *L. aromatica* เป็นชนิดนำเข้าที่ปลูกกันอย่างแพร่หลาย พืชทั้งสองชนิดมีกลิ่นหอม นิยมใช้เป็นส่วนประกอบในอาหารอีสานและมีคุณสมบัติต้านอนุมูลอิสระ การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อศึกษาลักษณะทางสัณฐานวิทยาและชีพลักษณ์ของดอก ระบบสืบพันธุ์ และการถ่ายเรณูของพืชทั้งสองชนิด สำหรับ *L. geoffrayi* เป็นชนิดที่สามารถผลิตเมล็ดได้เองในธรรมชาติ จึงทำการศึกษาการงอกของเมล็ด และการเพาะเลี้ยงเนื้อเยื่อเพื่อเพิ่มจำนวนยอด เพื่อเป็นข้อมูลสำหรับการอนุรักษ์และการใช้ประโยชน์ที่ยั่งยืน ผลการศึกษาพบว่าลักษณะสัณฐานวิทยาของดอกทั้งสองชนิด มีลักษณะเหมือนกัน คือ ดอกเป็นหลอดสมมาตรด้านข้าง โดย *L. aromatica* มีกลีบดอกสีม่วง ส่วน *L. geoffrayi* มีความผันแปรของสีกลีบดอก *L. aromatica* อาจไม่มีความสามารถในการผสมตัวเองได้ เนื่องจากไม่พบการติดฝัก ในขณะที่ *L. geoffrayi* มีความสามารถในการผสมตัวเองได้ ด้วยการติดฝัก 100% จากผลการทดลองการติดฝักในธรรมชาติและการครอบถุง ในการสังเกตแมลงที่มาเยี่ยมเยือนดอกส่วนใหญ่ พบว่า เป็นผึ้งโดดเดี่ยว และแม้ว่า *L. geoffrayi* จะมีความสามารถในการผสมตัวเองได้ แต่การผสมเกสรข้ามต้นก็เป็นไปได้เนื่องจากพฤติกรรมของผึ้งที่มาเยี่ยมเยือน การทดสอบการงอกของเมล็ดแสดงให้เห็นว่าการเก็บเมล็ดไว้เป็นเวลา 12 เดือนช่วยให้การงอกดีขึ้นอย่างมีประสิทธิภาพมากกว่าการแช่เมล็ดในน้ำและ การแช่เมล็ดใน GA_3 ความเข้มข้น 250 ppm 500 ppm และ 1,000 ppm การเพาะเลี้ยงเนื้อเยื่อ โดยใช้ข้อ แสดงให้เห็นว่าการงอกของยอดเกิดขึ้นได้ 100% ในอาหาร Murashige and Skoog (MS) ที่เติม BAP 0.5 มก./ล. ให้ผลลัพธ์ที่ดีที่สุดไม่ว่าจะเป็น ความยาวยอด จำนวนยอด และการพัฒนาของใบ ซึ่งความเข้มข้นของ BAP ที่สูงขึ้นทำให้คุณภาพของยอดที่เกิดขึ้นใหม่ลดลง ข้อมูลจากการศึกษาครั้งนี้ให้ข้อมูลที่จำเป็นสำหรับการอนุรักษ์ การขยายพันธุ์ และการจัดการทรัพยากรทางพันธุกรรมของ *L. geoffrayi*

สาขาวิชาชีววิทยา ลายมือชื่อนักศึกษา รุ่งทิพย์ มาลัยพิศ

ปีการศึกษา 2567 ลายมือชื่ออาจารย์ที่ปรึกษา

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Keyword: Breeding system, Pollination, Seed germination, Shoot regeneration, *Limnophila.*

Limnophila geoffrayi, a native herb of Thailand, is declining in the wild, while *L. aromatica* is an introduced species, widely cultivated. Both species are aromatic plants used in Isaan local food and known for their antioxidant properties. This study investigated floral morphology and phenology, breeding systems, and pollination of both species. For *L. geoffrayi,* which produces natural seed, seed germination and in vitro shoot regeneration were studied to support the conservation and sustainable use. The result showed floral observations revealed tubular, bilaterally symmetrical flowers in both species, with *L. aromatica* displaying violet corolla and *L. geoffrayi* showing color variation. *Limnophila aromatica* may be self-incompatible with no fruit set, while *L. geoffrayi* was self-compatible with 100% fruit set under natural pollination and bag experiment. Pollination was primarily done by solitary bees, and despite *L. geoffrayi*'s autogamy, cross-pollination is possible due to visitor behavior. Seed germination tests showed that 12-month storage improved germination vigor more effectively than soaking seeds in water and soaking seeds in GA3 at concentrations of 250 ppm, 500 ppm, and 1,000 ppm. In vitro propagation using nodal segments showed 100% shoot regeneration, in Murashige and Skoog (MS) with 0.5 mg/l BAP, yielding the best results in shoot length, number, and leaf development. Higher BAP concentrations reduced shoot quality. These findings provide essential insights for the conservation, propagation, and genetic resource management of *L. geoffrayi*.

School of Biology
Academic Year 2024

Student's Signature _____
Advisor's Signature _____

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LIST OF ABBREVIATION

°C	Degree Celsius
am	Ante Meridiem
BAP	6-benzylaminopurine
ca.	approximately
GA_3	Gibberellic acid
KIN	Kinetin
mg/l	Milligram per liter
MS	Murashige and Skoog
pm	Post Meridiem
ppm	Parts per million

CHAPTER I

INTRODUCTION

1.1 Background of the study

Limnophila aromatica (Lam.) Merr. (Phak Kha Yaeng) and *L. geoffrayi* Bonati (Ka Om) are famous edible herbaceous plants used by Thai people who live in the northern and northeastern parts. Both species are used as spices in fish soup and eat as raw vegetables with chili paste. *Limnophila aromatica* is hardly seen as a natural population but is usually propagated as a cultivated crop. While *L. geoffrayi* thrives as natural population but has never been successful in agricultural production. Both species belong to the same genus of Plantaginaceae the comparative morphology of *L. aromatica* and *L. geoffrayi* is shown in Table 1.1. Sometimes there is a mixing between the local names.

Limnophila aromatica is an exotic plant introduced to cultivate as plot plant and vegetable crop in Thailand. It is distributed from India to Australia and to Japan, except Myanmar, Thailand, and Cambodia (POWO, 2025). Its scent is similar to *L. geoffrayi*. So, the local people use both species as same propose. It is also used as a medicinal purpose (Table 1.2). Thai people cultivate *L. aromatica* as a crop substitute to rice especially in Ubon Ratchathani including Ayutthaya, Nakhon Pathom, and Yasothon provinces. It is an export vegetable to Europe with value up to 2 million baht per year (The Office of Agriculture Regulation, 2009).

Limnophila geoffrayi prefers to grow in wet and open areas, distributed in the Indochina region. In Thailand, it has been found in northern, northeast, and eastern regions (Smitinand, T. and Larsen, K., 1990). It is a native herbaceous plant that occurs naturally and especially in rice fields and open and wet glass land. It can be propagated via seeds in nature, but it has not been planted as an agricultural crop. Villagers must wait to harvest them only in the late rainy season and dry for use all year. It has a pungent aroma and is also a medicinal plant (Table 1.2). This plant species can be potentially developed being a new agricultural crop. However, in the current situation, farmers usually use herbicide in rice field led to reducing *L. geoffrayi* populations. Moreover, the higher temperature caused by the global warming phenomenon affects the flowering of plants (Geissler, C., Davidson, A., and Niesenbaum, R. A., 2023). Rainfall changing due to El Niño may cause drought in the middle of the rainy season and may affect to herbaceous survival. At present, *L. geoffrayi* has currently vanished from several localities.

Table 1.1 The comparative morphology of *Limnophila aromatica* and *L. geoffrayi*. (Smittinand, T. and Larsen, K. (1990), eFloras (2008), and based on my observations)

Characters	*Limnophila aromatica*	*Limnophila geoffrayi*
Plant height	30-70 cm	10-35 cm
Leaves arrangement	mainly 3 in whorls	Mainly opposite
Leaf shape	ovate-lanceolate to lanceolate-elliptic	oblong-lanceolate, oblong, or ovate-elliptic
Leaf apices	acute	acute to obtuse
Leaf bases	semiamplexicaul	attenuate
Leaf margins	serrate	crenate-serrate
Leaf size	1-5 x 0.3-1.5 cm	1–3 x 0.3–1 cm
Inflorescence type	terminal branches, usually solitary	axillary or terminal racemes with 2-10 flowers
Flower size	1-1.3 cm long	0.1-1.3 cm long
Flower surfaces	Outside: pubescens Inside: white villous	Outside: glabrous Inside: villous posteriorly
Flower shape	campanulate-funel and slightly bilabiate	campanulate-funel and slightly bilabiate
Flower color	violet	white, dark violet, or purplish pink
Capsule	ovoid, ca. 6 mm long	ellipsoidal, 3 x 1.5 mm long

Table 1.2 The comparative benefits of *Limnophila aromatica* and *L. geoffrayi*.

	Benefit
Limnophila geoffrayi	1. antipyretic, expectorant, and galactogogue qualities as medicinal properties, used as a traditional medicinal herb, used as an antidote for toxin detoxification (Thongdon, A. J., and Inprakhon, P., 2009). 2. antimycobacterial and antioxidant properties (Suksamrarn, A., Poomsing, P., Aroonrerk, Punjanon, T., Suksamrarn, S., and Kongkun, S., 2003).
Limnophila aromatica	1. For exhibiting diuretic, muscle relaxant, and antispasmodic properties with little toxicity, kidney stones, excruciating cramps, wounds, ulcers, and wound care (Do, Q. D., Angkawijaya, A. E., Tran-Nguyen, P. L., Huynh, L. H., Soetaredjo, F. E., Ismadji, S., and Ju, Y.-H., 2014). 2. antibacterial activities (Rattanasena, P., 2012).

Plant reproductive biology focuses on investigating the mechanisms and processes involved in both sexual and asexual reproduction in plants. The field of study may include the examination of pollination methods, gene flow, genetic, variation and the spread of propagules both without and within populations (Simpson, M. G., 2019). The reproductive system covers the various events and characteristics associated with the activities that take place from pollination to embryo development (Cardoso, J. C. F., Viana, M. L., Matias, R., Furtado, M. T., Caetano, A. P. D. S., Consolaro, H., and Brito, V. L. G. D., 2018).

Reproductive biology is an important information for conservation and agricultural practice. Understanding of biological information of *L. geoffrayi* including blossoming, fruiting, breeding systems and pollination are the main factors that enables plant to endure in the nature. Moreover, promoting the threatened plant species as an agricultural crop is an optional conservation practice. So, I am interested to study

and reveal more information about floral phenology, breeding system, pollination, and propagation via seed and tissue culture of *L. geoffrayi* which is a native plant in Thailand to understand its biological information. Additionally, it is interesting to compare the reproductive biology of *L. geoffrayi*, a native plant and *L. aromatica*, which is exotic and cultivated plant in Thailand to understand their life for applying to their conservation and agricultural management.

1.2 Research objectives / Purposes of the study

3.1 To compare the floral morphology, floral phenology, pollination, and breeding system of *Limnophila aromatica* and *L. geoffrayi*.

3.2 To study seed germination and seed dormancy after seed pre-treatment of *L. aromatica* and *L. geoffrayi*.

3.3 To study the effect of 6-benzylaminopurine (BAP) on the shoot generation of *L. geoffrayi*.

1.3 Scope and limitations

I am interested in promoting *L. geoffrayi* as ornamental plot plant and an agricultural crop, which has never been done before. The basic information on reproductive and reproduction is the key information to fulfill my interest. Thus, this study is focused on the reproductive biology and reproduction of *L. geoffrayi* population in Thailand. In addition, *L. aromatica* is selected for comparative study because it is similar species based on morphology and traditional use. This study then shall be compared the reproductive biology of both species for (1) floral morphology, (2) floral phenology, (3) pollination, and (4) breeding system to understand more about their life. Additionally, I examine (5) seed germination to find out the suitable seed germination practice and to answer if it can be kept via seed banking or not and (6) the effect of BAP to shoot regeneration of *L. geoffrayi* nodes *in vitro* to find out the better practice of cloning propagation. I exclude the effect of BAP on its shoot generation of *L. aromatica* because it has been done by Dogan, M. (2019). Moreover,

L. aromatica is easily propagated by cutting but *L. geoffrayi* has never succeeded in asexual reproduction before. The scope of this study is shown in Figure 1.1.

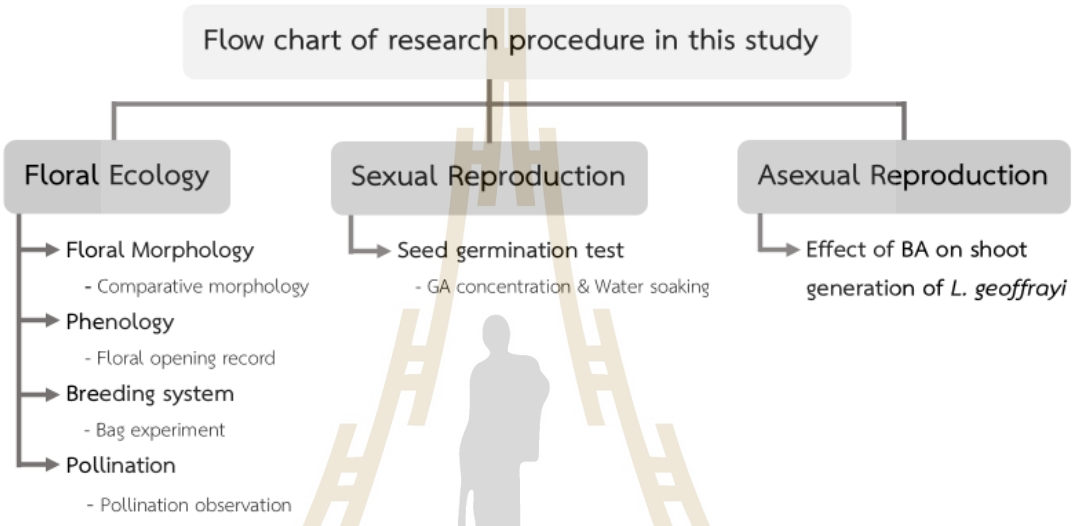

Figure 1.1 Flow chart of research procedure in this study.

CHAPTER II

LITERATURE REVIEW

2.1 Species classification

Limnophila aromatica (Lam.) Merr. and *L. geoffrayi* Bonati belong to the genus *Limnophila* R.Br. Previously they belonged to family Scrophulariaceae. Currently they have been transferred to Plantaginaceae based on molecular phylogenetic evident (Stevens, P. F., 2024). This genus has been classified based on taxonomic ranges according to POWO (2025) as follow:

Kingdom: Plantae
Phylum: Streptophyta
Class: Equisetopsida
Subclass: Magnoliidae
Order: Lamiales
Family Plantaginaceae
Genus *Limnophila* R.Br.
Species *Limnophila aromatica* (Lam.) Merr.
Limnophila geoffrayi Bonati

Smitinand, T. and Larsen, K. (1990) reported 19 species of *Limnophila* found in Thailand. *Limnophila aromatica* is called Phak Ka Yaeng, including Ka om, Kha yaeng, Phak Pha, Phak Luem Phua, Ma-Om and Yan Nang Yai as other vernacular names (Forest and Plant Conservation Research Office, 2024). It has never found in nature in Thailand although it is distributed from India to Australia and Japan (POWO, 2025). Currently it has become an economic plant which is cultivated as a substitute in rice fields. The morphology of Ka Yaeng is shown in Figure 2.1. *Limnophila aromatica* is an annual or perennial herb. Its stems are erect, 30-70 cm high, simple to much branched, glabrous or glandular, base decumbent and rooting from nodes. Leaves are mainly 3 in whorls and sessile. Leaf shape is ovate-lanceolate to lanceolate-elliptic, 1-5 cm long

and 0.3-1.5 cm broad and margin serrate and with pinnately venation. Flowers arise from the leaf axils or on terminal branches, usually solitary. It has a pedicel 0.5-2 cm long and glabrous or glandular. Calyx is green, 4-6 mm long, divided into 5 narrowly lobes and glabrous or glandular pubescent. Corolla is violet, 1-1.3 cm long, sub-bilaterally symmetry, with sparsely and finely glandular hairs and inside white villous. Style apex is dilated. Stigma is short and 2-lamellate. Capsule is ovoid, ca. 6 mm long (eFloras, 2008).

Limnophila geoffrayi has vernacular name as Ka Om, including Phak kha yaeng and Ang-om as other vernacular names (Forest and Plant Conservation Research Office, 2024). It is distributed in Cambodia, Laos, Thailand, and Vietnam. The first specimens for scientific naming were collected in Cambodia. In Thailand, it is found in the north, in Phitsanulok Province, and the northeastern region in Nong Khai, Maha Sarakham, Khon Kaen, and Nakhon Ratchasima provinces.

Limnophila geoffrayi is an aquatic annual herb, that is fragrant and prefers to grow in open, moist places. Stems are slender and erect, 10–35 cm high. Branches are simple or laxly branched near the base with densely hirsute. Leaves are mainly opposite, sessile, semi-amplexicaul, oblong-lanceolate, oblong, or ovate-elliptic, 1–3 x 0.3–1 cm width, acute to obtuse at apex, attenuate to base, crenate-serrate, scabrid or glabrous above, glabrous and punctate beneath and pinnately nerved. Flowers born in axillary or terminal racemes with 2–10 flowers. Peduncles are slender, 1.5–6 cm long and sparsely hirsute to glabrous. Pedicels are 1–4 mm long and sparsely hirsute to glabrous. Bracts are small and narrowly lanceolate, ca. 0.5 mm long. Bracteoles are filiform, acuminate, and 1–2 mm long. Calyx is about 3.5 mm long, sparsely short-hirsute, or glabrescent and striate at maturity. Calyx lobes are lanceolate, 2.5 mm long. Corolla is white, violet, or pink, 10–13 mm long, glabrous outside and villous posteriorly inside. The upper lip of corolla is broadly orbicular, emarginate and the lower lip is 3-lobed, orbicular. Capsule is ellipsoidal, 3 x 1.5 mm long (Smitinand, T. and Larsen, K., 1990). The morphology of Ka Om is shown in Figure 2.2.

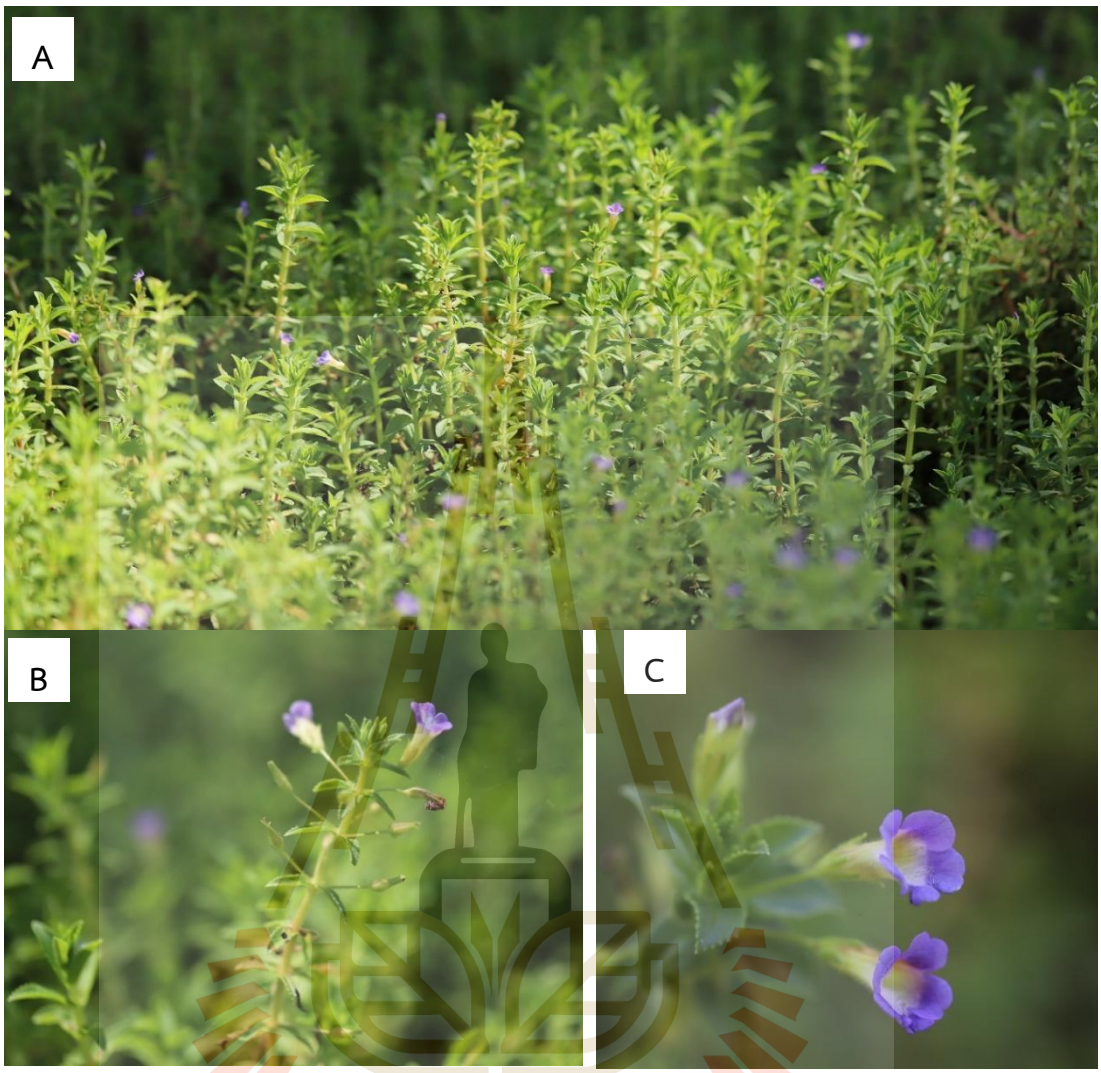

Figure 2.1 *Limnophila aromatica* A. Habit, B. Floral branches, C. Flowers.

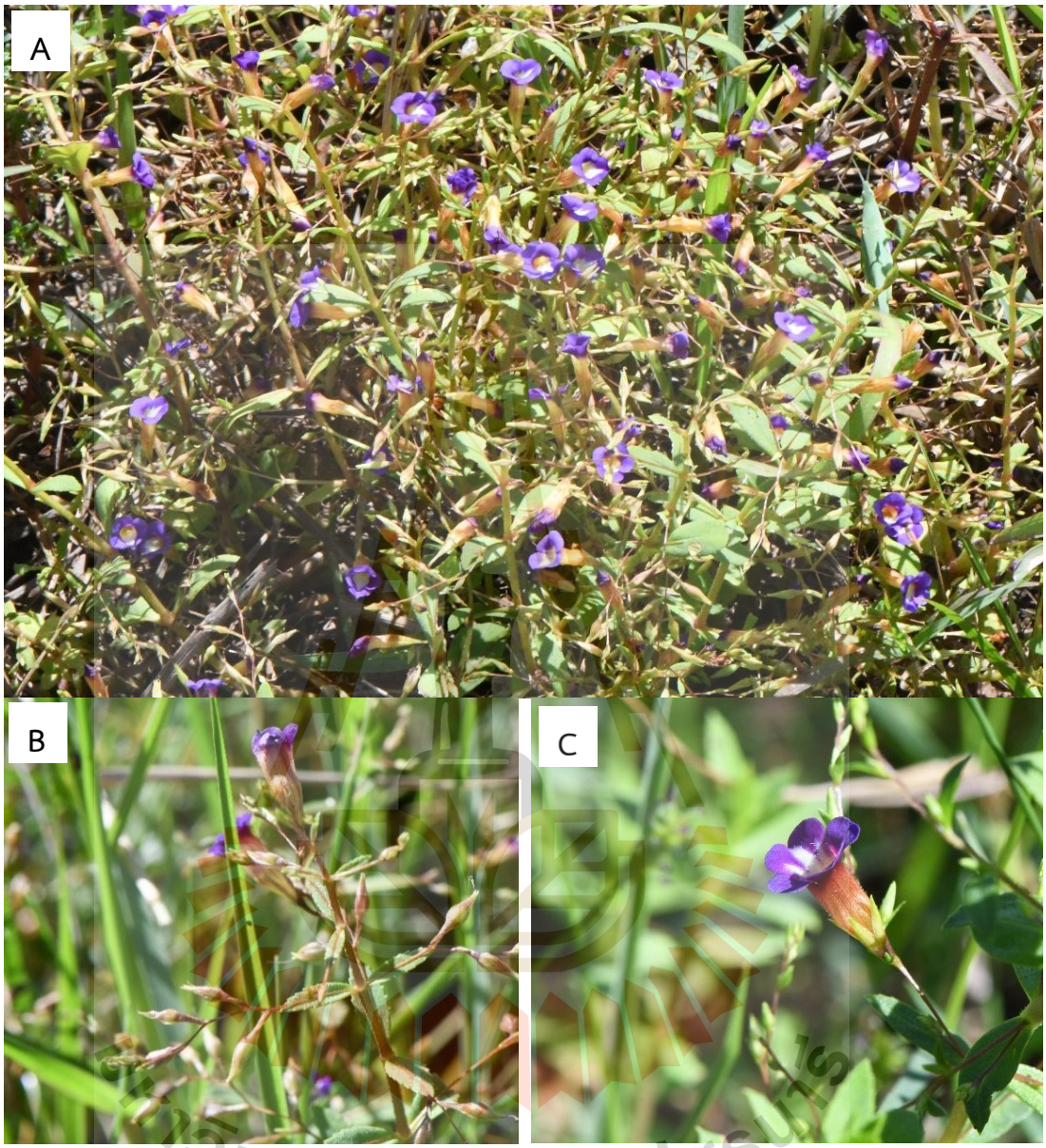

Figure 2.2 *Limnophila geoffrayi* A. Habit, B. Floral branches, C. Flowers.

2.2 Floral ecology

2.2.1 Flower part and shape

Flower is a major diagnostic feature of angiosperm, modified reproductive shoot (Simpson, M. G., 2019). Typically, a flower is comprised sepals, petals, stamens and pistil, arranged from external to internal. All part attached to the receptacle, part of the stem. It composes of sterile parts, sepals and petals and reproductive part, stamens and pistil. It composes of an ovary at its basal part and a long neck called the style with stigma at the top. Inside the ovary, there is one or more ovule, which become to seed after fertilization (Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., and Reece, B. O., 2011)

The flower shape in angiosperm exhibits so diverse, depended on species. The feature of flowers is related to attracting the visitors, especially non environment vector of pollination. Every floral organ is generally thought to play a more or less specific role in pollination. Functional flower features are present according to specific plants (Willmer, P., 2011 quoted in Faegri, K., and Van Der Pijl, L. (1979). Willmer distinguished types of the flower in relation to actual visitors into 11 types as follow:

1. Open disk
2. Tubular flowers with radial symmetry
3. Tubular flowers with bilateral symmetry
4. Bell-shaped flowers
5. Spherical flowers
6. Keel flowers
7. Iris-type flowers
8. Orchid flower
9. Brush blossoms
10. Composite flowers
11. Trap flowers

The flower shape of *Limnophila* is a small tubular flower with bilateral sub-symmetry. The lower one consists of 3 lobes and the upper one consists of 2 lobes. The upper most corolla lobes are not expanded apically as a hood, part of stamens

protection, like Lamiaceae or some of Scrophulariaceae and Plantaginaceae. However, their tubular flower with bilateral sub-symmetry could be classed in this type.

2.2.2 Arrangement of stigma and stamen

Plants have evolved to guarantee successful reproduction through selfing, which is typically linked to a deficit of pollinators. In Botany, Herkogamy refers to the position of the anthers in a flower that is on a different plane from the position of the stigma of the same flower. As a result, self-pollination does not occur on the same flower. Herkogamy is divided into two forms: the anther is lower than the pistil (approach herkogamy), and the anthers are higher than the top of the pistil (reverse herkogamy) (Cardoso, J. C. F., Viana, M. L., Matias, R., Furtado, M. T., Caetano, A. P. D. S., Consolaro, H., and Brito, V. L. G. D., 2018). The arrangement of the stigma and stamen is related to self-pollination or cross-pollination, depending on species. In *Limnophila*, it has 4 stamens arranged in 2 pairs. The longer one is above the stigma and the shorter one is under the stigma, considered as non-herkogamy, due to the position of stamens and stigma promote self-pollination.

2.2.3 Anther dehiscence

The term "anther dehiscence" describes as the opening of the anther that allows pollen grains to break out (Beauzamy, L., Nakayama, N., and Boudaoud, A., 2014). Anther dehiscence has 4 types, longitudinal, poricidal, transverse, and valvular. The most prevalent and historical form of dehiscence is longitudinal dehiscing along the long axis of the thecae and along a suture. Other varieties are uncommon and unique to certain groups, such as having a pore at one end of the thecae, poricidal organisms dehisce via transverse, dehiscing at an angle to the Ericaceae; theca's long axis and valvular, dehiscing through a pore-like in the Lauraceae, tissue flap-covered (Simpson, M. G., 2019).

2.3 Floral phenology

Plant phenology is the time of different phases in the plant life cycle, such as leaf budding, blooming period, fruiting period, etc. (Stucky, B. J., Guralnick R., Deck, J.,

Denny, E. G., Bolmgren, K., and Walls, R., 2018). Floral phenology is the study of a flower's life cycle, starting from the date of opening, anthesis, to ending with wilting (Gentry, A. H., 1974). The phenology of the flowers will change depending on the species and other factors such as the habitat, length of the flowering season, seed predatory behavior, etc. (Willmer, P., 2011). It is possible to study phenology at several scales, including phylogenetic characteristics, populations, communities, single flowers, individual plants and dioecious plants (Dafni, A., 1992). An example of a phenology study of plant species which having floral characteristics similar to *Limnophila* is *Penstemon penlandii* W.A.Weber, Plantaginaceae. It is an endangered endemic plant in the state of Colorado United States. The flowers are tubular about 1.5 cm long and 0.5 cm wide. It has 2 short stamens and 2 long stamens. Flower phenology study showed that the anthers of the longer stamens break during 9:00-9:30 hrs. while the anthers of the shorter stamens break during 10:30-13:00 hrs. Bloom on the 3rd or 4th day before the flowers drop. The phenology of this type of flower affects pollination by insects, especially when pollinators visit the flowers (Tepedino, V. J., Sipes, S. D., and Griswold, T. L., 1999).

Opening and closure of the flower are an important trait of a reproductive syndrome because it allows pollen removal by vectors. Different traits such as diurnal and nocturnal and single or repeated opening depend on species. Cell expansion happens when osmotic solution levels increase causing the opening. Temperature, light intensity and humidity results in opening and depends on species (Van Doorn, W. G. V., and Van Meeteren, U. V., 2003).

2.4 Pollination system

Pollination is the process by which pollen grains fall on the surface of the stigma. This results in the germination of pollen tubes. There is the growth of the pollen tube to meet with the egg and fertilization occurs. There are three types of pollination.

1. Self-pollination means pollination in the same flower and is a transfer of pollen that can be found in flowers of two sexes in the same plant (bisexual flower).

2. Geitonogamous-pollination means pollen transfer from one flower to another in the same plant which relies on vectors to facilitate pollination (Richards, A. J., 1997). They can be found in both bisexual flowers and unisexual flowers.

3. Cross-pollination means the transfer of pollen from one flower to the top of the pistil of another flower. It is found in dioecious species. The general flowering plants have also this form of pollination. It can be found in monoecious plants, especially when anthers and stigma do not function at the same time or there are other barriers between anther and stigma. This type of pollination promotes high genetic diversity (Cardoso, J. C. F., Viana, M. L., Matias, R., Furtado, M. T., Caetano, A. P. D. S., Consolaro, H., and Brito, V. L. G. D., 2018). Most flowering plants that require vectors facilitate pollinators. Those vectors are usually insects. Hence, flowers are the structures of flowering plants that play an important role in helping each plant to reproduce successfully. The flowers can attract insects to help pollinate them. Mainly because flowers provide food for insects such as nectar or pollen, etc. In addition, insects help to pollinate may because that flowers can provide refuge for insects to escape from bad weather or predators. It is a spawning ground for females and in some cases, that can be a source of warmth for insects in cold climates (Willmer, P., 2011). There are various vector pollination patterns which are 1) pollination by flies, 2) pollination by butterflies and moths, 3) pollination by birds, 4) pollination by bats, 5) pollination by nonflying vertebrates and other oddities, and 6) pollination by bees, defined by Willmer.

2.5 Breeding system

The breeding system or reproductive system is a form of seed acquisition process through the fertilization of male gametes and female gametes by pollinators. There are various forms of pollination (Dafni, A., 1992), including:

1. Autogamy means the fertilization of male gametes and female gametes from pollinators in the same flower (self-pollination) that occurs in nature without the help of vectors. However, in the case where vectors such as insects are needed to help pollinate, it is called facilitated autogamy (Lloyd, D. G., and Webb, C. J., 1992).

2. Geitonomy means the fertilization of male gametes and female gametes, from the transmission of pollen from one flower to another in the same tree. This breeding system type resulting plants having more genetically diverse than autogamy plants due to the possibility of mutations in the proliferative tissues of the non-reproductive organs (vegetative organ) and organs that perform reproductive functions (Barrett S. C. H., and Harder L. D., 2017). However, it is less successful than autogamy because it requires vectors to facilitate pollination (Eckert, C. G., 2000).

3. Xenogamy means the fertilization of male gametes and female gametes from cross-pollinating by using vectors such as wind, water, and animals such as birds, bats, ants, or insects (Richards, A. J., 1997), which will give plants high genetic diversity. This breeding system results in increasing the survival rate in nature even more because they can adapt to a variety of environments (Simpson, M. G., 2006).

4. Cleisogamy means the fertilization of male gametes and female gametes from pollinators in the same flower (self-pollination) that occurs in immature flowers (Lord, E. M., 1981). It is an adaptive form of reproduction for the lowest cost but highest yield of plants with low insect pollination or in conditions that are restricted to growth (Culley T. M., and Klooster, M. R., 2007).

2.6 Seed germination

An ovule undergoes fertilization to become a reproductive unit called a seed. A seed's endosperm, embryo, and seed coat (testa) are its three primary structural components (Smith, P., 2018). Seed germination is the physiological process achieving of the embryo emerging from the seed coat. The imbibition, water absorption by seed, starts to activate the metabolism led to expansion of the embryo and produce the radicle throughout the seed (Bewley, J. D., Bradford, K., Hilhorst, H., and Nonogaki, H., 2013). Deterioration of seed quality may mean a loss of seed quality, strength, and viability of seeds due to inappropriate environmental factors such as temperature, humidity, or a too-high ratio of oxygen to carbon dioxide. Deterioration in seed quality can occur both before, during, and after harvest (Khan, F. A., Bhat, S. A., Narayan, S., Maqbool, R., Murtuza, I., and Khan, F. U., 2017).

Preparing seeds before planting by soaking seeds in water for a period of time appropriate for that type of seed can help stimulate seed germination. This is because water is an important contributor to various processes within the seed, such as protein synthesis or various substances that help the germination process. Soaking the seeds in water will help make the seeds with thick, hard shells softer. This makes water and air permeate into the seeds more easily than usual (Khammapana, L., Mulalin, S., and Tangteerawatana, S., 2019). Furthermore, researchers discovered that soaking seeds in water can enhance the germination of seeds exposed to unsuitable environmental conditions like salinity and drought. Different plants combined with different environmental conditions will result in different germination efficiencies (Farahani, H. A., and Maroufi, K., 2011), such as in the report of Casenave, E. C. and Toselli, M. E. (2007), who studied the method of preparing seeds before planting by soaking cotton seeds in water. Under conditions where rainfall and temperature fluctuate unevenly, the amount of rainfall and the temperature are important factors that hinder the germination of cotton seeds. Studies have shown that soaking cotton seeds in water can accelerate cotton seed germination. A study by Tiwari, R. K. S., Chandra, K. K., and Dubey, S. (2018) studied techniques for breaking seed dormancy and the germination efficiency of six important medicinal plants. It was found that soaking seeds in water for 24 hours increases seed germination of those six species is effective in three species, *Asparagus racemosus*, *A. moschatus*, and *Psoralea corylifolia*.

Gibberellins are hormones that stimulate plant growth and development. It plays an important role in stimulating seed germination, stimulates the development of the embryo from the division of tissue cells until it develops into various components such as roots, stems, and leaves. It also acts to stimulate the production of hydrolytic enzymes such as **α**-amylase in the aleurone layer in various grains to help stimulate germination (Gupta, R. and Chakrabarty, S. K., 2013). From these properties, studies on the use of gibberellins have been reported to stimulate the germination of various plant species. For example, Hilooglu, M., Sozen, E., Yucel, E., and Kandemir, A. (2018) studied seed germination of *Verbascum calycosum*, an endemic plant of Erzincan, Turkey, in the family Scrophulariaceae. The seeds are very small, approximately 1-1.3 mm. The seed shells are brown-black. It is very hard and seems like water and air

cannot penetrate the seeds. The results showed that the germination rate mostly increased in the method of soaking seeds in gibberellic acid (GA_3) 100 μM (39%) and 200 μM (54.5%). This is the most effective method for breaking dormancy in this type of seed.

2.7 Seed dormancy

There are many definitions but it most often refers to the failure of a seed that cannot germinate. Although environmental conditions such as water, temperature, light, and air are conductive to seed germination (Baskin, C. C. and Baskin, J. M., 2014). Seed dormancy can be divided into 3 main mechanisms as follows: 1) physical dormancy is a seed with a shell, usually in a thick, hard, impermeable form, 2) physiological dormancy is a seed that cannot germinate until some chemical change occurs, and 3) morphological dormancy is the seed that scatters when the fruit with seeds have fallen off to help with propagation but are not yet fully developed. As a result, when the seeds fall into areas with suitable conditions, they will not be able to germinate immediately. It requires further development until it can eventually germinate (Smith, P., 2018). Each species has a different method for overcoming seed dormancy. There is some research conducted a study to break the dormancy of seeds from plants in the same family as *Limnophila*. Kirmizi, S., Güleryüz, G., Arslan, H., Sakar, F. S., and Kocabıyık, G. A. (2010) used moist chilling, gibberellic acid, and scarification to break the dormancy of *Pedicularis olympica* seeds, a plant that grows in wet places but has very small seeds. The results showed that the highest germination rate and mean germination times were significantly lower in the seeds treated with 250 ppm GA_3. In addition, Jang, G. H., Chung, J. M., Rhie, Y. H., and Lee, S. Y. (2022) studied on breaking seed dormancy of *Veronicastrum sibiricum*, the result showed about 90% of the seeds germinated after the GA_3 treatment successfully broke physiological dormancy.

There is information suggesting that storing seeds at room temperature for a certain period can break seed dormancy such as the study of the effect of newly obtained and one-year-old seeds of four heathland species on seed germination by Valbuena, L., and Vera, M. L. (2002). The results of the experiment indicated that seeds

collected one year ago germinated better than freshly collected seeds. In addition, the method of using time to help break seed dormancy is also simple and beneficial to villagers because it is easy to follow.

2.8 Effect of BAP on shoot generation of *L. aromatica*

Plant tissue culture is an *in vitro* technique whereby plant tissue fragments, or explants, are grown in an artificial medium under aseptic conditions. Promote cell proliferation and plant regeneration, entails cultivating explants—such as shoot tips, root tips, calluses, seeds, embryos, pollen grains, ovules, or even a single cell—isolated from the original plant on a sterile nutrient medium (Hasnain, A., Naqvi, S. A. H., Ayesha, S. I., Khalid, F., Ellahi, M., Iqbal, ... Abdelhamid, M. M. A., 2022). At present, there are studies on the induction of shoot regeneration *in vitro* of *L. aromatica.* In addition, Karatas, M. and Aasim, M. (2015) conducted an *in vitro* study on the induction of shoots in *L. aromatica*, using both shoot and leaf fragments. They incorporated these fragments into the Murashige and Skoog (MS) medium, varying the benzyl adenine (BAP) concentration from 0.25-2 mg/l for 8 weeks. The results showed that BAP helped to induce better shoot formation. Shoots per explant ranged from 19.61 to 44.22, and high concentrations of BAP decreased the number of shoots per explant. Dogan, M. (2019) did a study on *L. aromatica* shoot induction in a lab setting using a shoot tip in MS medium with varying amounts of BAP, GA, and KIN. They also looked at the effects of white, red, and blue LED lights over 8 weeks. The results showed the maximum number of shoots/explants and the longest shoot lengths of LED lights in a 1:2:1 ratio in MS medium supplemented with 0.10 and 0.20 mg/l BAP. Tissue culture of *L. geoffrayi* has not yet been studied.

CHAPTER III

MATERIALS AND METHODS

3.1 Study sites and plant materials

A comparative study of reproductive biology, including floral morphology, floral phenology, breeding system, and pollination, was conducted in two areas. *Limnophila aromatica* was studied from a cultivated plot in the Suranaree University of Technology Botanical Garden, Mueang District, Nakhon Ratchasima Province, Thailand (Figure 3.1-A). While *L. geoffrayi* was studied from natural populations in rice fields at Chum Phuang District, Nakhon Ratchasima Province, Thailand (Figure 3.1-B). Seeds of *L. geoffrayi* was collected from the study area, then stored for 0 month and 12 months for the comparative seed germination test. To study the effect of BAP on shoot generation of *L. geoffrayi in vitro*, I used the 8-week-old explants on MS medium, obtained from Plant Genetic Conservation Project Under the Royal Initiation of Her Royal Highness Princess Maha Chakri Sirindhorn, Suranaree University of Technology.

Figure 3.1 Habitat of the study sites A. cultivated plots of *Limnophila aromatica* B. *L. geoffrayi* in rice field.

3.2 Floral morphology

3.2.1 Floral morphology and Anther dehiscence

For the study of floral morphology and dehiscence stages of anthers of *L. aromatica* and *L. geoffrayi*, I collected the flowers at different stages which are the early buds (corolla lobes have not yet opened and slightly emerged from the calyx), late buds (corolla lobes has not opened yet but almost full development), and open flower (corolla tube has opened), as in Figure 3.2. Those flowers were gently dissected to reveal the position of their sex organs. In addition, five flowers of each different stages were collected and preserved in formalin-alcohol-acetic acid (FAA) solution for taking pictures of anther breaking under a stereo-microscope, Nikon SMZ645.

3.2.2 Floral phenology

The period of floral opening is interesting because it is related to the insects visiting the flower. The open floral stage of *L. aromatica* and *L. geoffrayi* is shown in Figure 3.2-A3, B3, in which the blooming flower is considered from the corolla lobes starting to spread out from each one and corolla tube. The period of floral opening was observed from a total of 40 late bud stage (from at least 15 plants) for each species. Each flower was numbered to record how many days of flowers opening. Mean blooming periods of flowers of both species was calculated.

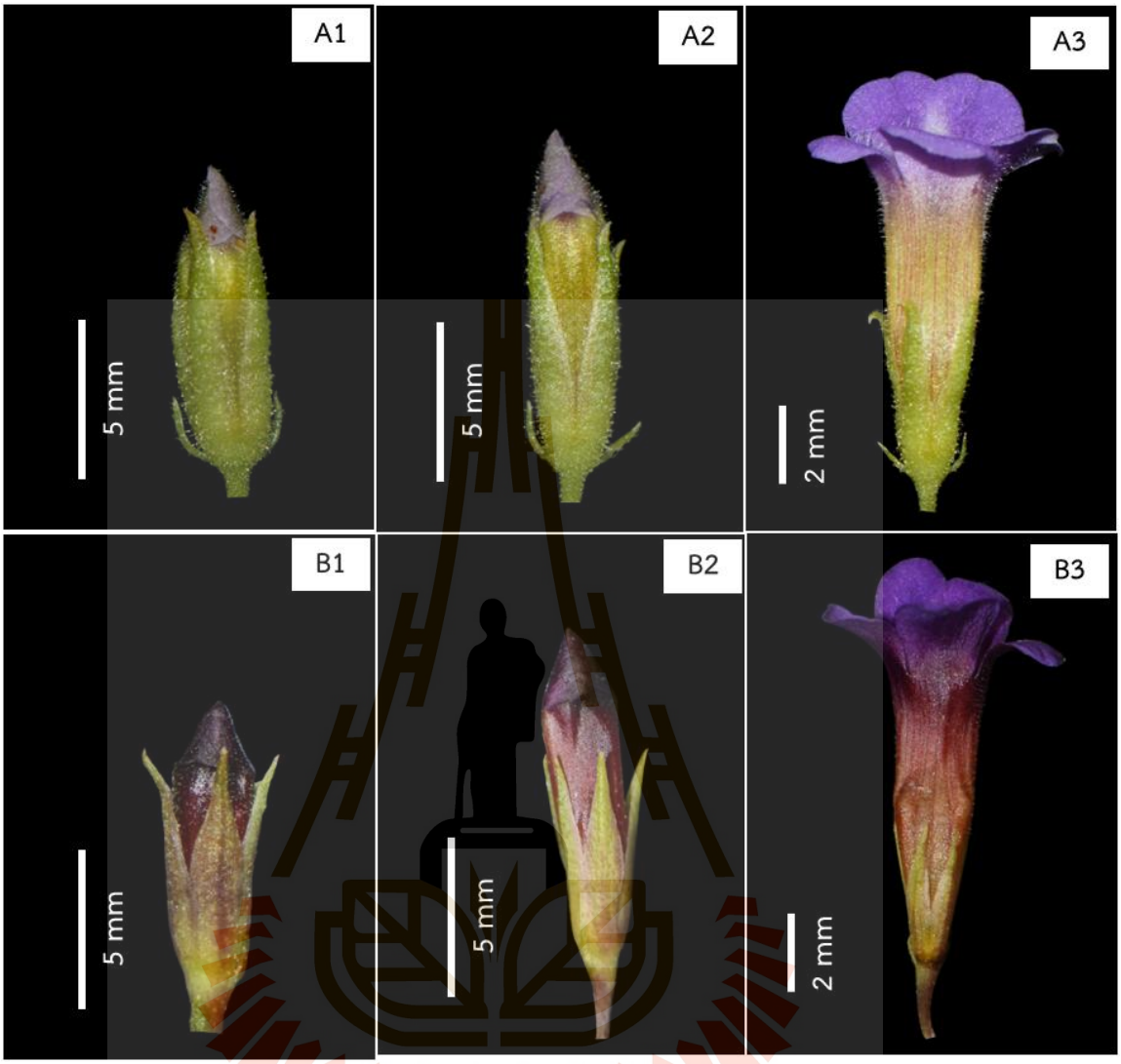

Figure 3.2 Characteristics of *Limnophila aromatica* (A) and *L. geoffrayi* (B) at each stage of development. A1, B1. Early bud, A2, B2. Late bud, A3, B3. Open floral stage.

3.3 Breeding system

Due to the rather small size and tubular flower shape, it is impossible to do hand cross-pollination to prove the breeding system types. Thus, I studied the breeding system of *L. aromatica* and *L. geoffrayi* by conducting 3 experiments (Figure 3.3), including:

1. Autogamy: 30 floral buds were randomly covered by nylon net to check self-compatibility or the ability to pollinate without pollinating insects.

2. Emasculation: 30 late buds were emasculated by cutting off stigma and stamens to check the appearance of parthenogenesis (The ovary develops into a seed without fertilization with the male gametes) of both species.

3. Natural pollination: 30 open flowers were tracked to check for fruit set in nature.

The data were calculated as the percentage of fruiting and investigated how fruit set is affected by pollination treatment, species, and their interactions using generalized linear models (GLMs) in SPSS version 25. Type III models of Wald Chi-square statistics employing identity link functions and normal error distributions were followed subsequently. For this research, a single fruit was artificially added to the data that did not contain fruit. Using the Dunn-Sidak test, (P-values < 0.05) from multiple comparisons between treatments were adjusted (Pakum, W., Kongbangkerd, A., Srimuang, K.-O., Gale, S. W., and Watthana, S., 2023).

Figure 3.3 Different treatments in breeding system study of *Limnophila aromatica* (A) and *L. geoffrayi* (B). A1, B1. The bag experiment A2, B2. Emasculation, A3, B3. Natural pollination

3.4 Pollination

Pollination was observed in *Limnophila aromatica* and *L. geoffrayi* by randomly selecting three clumps that have the most fully bloomed flowers (approximately 30-40 flowers/clump), shown in Figure 3.4. I observed and recorded temperature, humidity, duration of insects entering each flower, species, and behavior of insects from 6:00 am to 6:00 pm during three days for at least a period of 36 hours. The insects were randomly caught using transparent plastic bags and stunned with organic compounds, ethyl acetate. I catched the insects, not more than 5 individuals of each species (This work has Certificate of approval Institutional Animal Care and Use Committee, Animal License Number U1-11459-2566). The insect samples were then put in a 95% alcohol solution, and some samples were stored in an insect box. Insect voucher specimens were identified by Assistant Professor Dr. Natapot Warrit and Dr. Prapun Triyasut, bee taxonomists from Chulalongkorn University and Ubon Ratchathani Rajabhat University.

Figure 3.4 Pollination observation of A. *Limnophila aromatica* and B. *L. geoffrayi*.

3.5 Seed germination test

To study the seed germination after storage for 12 months, seeds of *L. geoffrayi* were collected and stored for 0 month and 12 months and kept at room temperature. In selecting seeds, physical methods are used by selecting seeds that are complete, well-developed, not flattened, placed in an Eppendorf tube, and centrifuged at 12,000 g for 30 seconds. Floating seeds were removed and sunken seeds were used in the germination test. The Completely Randomized Design (CRD) in four replicates, using 25 seeds per replicate, for a total of 100 seeds for each treatment were performed.

In this study, five treatments: (1) control, without soaking (2) soaking in water for 24 hours, (3) soaking in 250 ppm gibberellic acid (GA_3) for 24 hours, (4) soaking in 500 ppm gibberellic acid (GA_3) for 24 hours, and (5) soaking in 1,000 ppm gibberellic acid (GA_3) for 24 hours (Table 3.1) were conducted. A plastic plate containing three layers of germination test paper was used to test seed germination. After sowing seeds on each plate, it was provided moisture with distilled water. All experiments were maintained at a temperature of 25 ± 2 °C in the laboratory of the School of Biology, Institute of Science, Suranaree University, Nakhon Ratchasima Province, Thailand.

For data collection, I counted the number of explants that germinated every day until 120 days. The germination success was judged by the visibility of green. Then, data were calculated using the formula as follow.

1. The percentage of seed germination (Shen, S. K., Wu, F.Q., Yang, G. S., Wang, Y. H., and Sun, W. B., 2015)

GP = (Number of seeds germinated / Total number of seeds planted) x 100

2. Germination index (Akkajit, P., and Nuamkongman, W., 2016)

GI = ∑ [(Normal number of seedlings germinated each day) / (Number of days after planting counted)]

3. Mean germination time (Labouriau, L. G., 1983)

MGT = (G1T1 + G2T2 +...+GnTn) / (G1 + G2...+Gn)

Where G: germination count on any counting period; T: time.

The results of a study on stimulating the germination of seeds with different seed preparation methods were employed one-way analysis of variance (ANOVA). Comparing the means between each experimental method with Duncan's Multiple Range Test (DMRT) at a statistical confidence level of 95 percent ($P<0.05$). SPSS version 25 was used for statistical analysis. And the effect of different storage periods, treatment series, and their interaction was analyzed using two-way analysis of variance (ANOVA).

Table 3.1 Various methods used to prepare *Limnophila geoffrayi* seeds.

Treatment	Method for preparing seeds
T_1	non-soaking (Control)
T_2	Soaking in water for 24 hours
T_3	Soaking in 250 ppm gibberellic acid (GA_3) for 24 hours
T_4	Soaking in 500 ppm gibberellic acid (GA_3) for 24 hours
T_5	Soaking in 1,000 ppm gibberellic acid (GA_3) for 24 hours

3.6 Effect of BAP on shoot generation of *L. geoffrayi*

Nodes of 8 weeks-old on MS medium of *L. geoffrayi* about 1 cm long were cut and used as the explants. They were transferred to MS medium containing 0, 0.5, 1, and 2 mg/l 6-benzylaminopurine (BAP) with 3% sucrose and 0.65% agar. The pH of the medium was adjusted to 5.7±0.1 (adapted from Dogan, M., 2019). I used 3 nodes per a 4 oz bottle. A total of 15 nodes on each MS medium containing 0, 0.5, 1, and 2 mg/l BAP were used for this experimental study.

After 8 weeks, data was recorded the average number of shoots per explant, the shoot length, and the average number of leaves per shoot. Data were analysed using the one-way ANOVA and Duncan tests were applied for post hoc tests ($P<0.05$), by SPSS progra

CHAPTER IV

RESULTS and DISCUSSIONS

4.1 Floral morphology and anther dehiscence of *L. aromatica* and *L. geoffrayi*

The floral color of *L. aromatica* is violet. While *L. geoffrayi* has dark violet, purplish pink, or white (Figure 4.1). The color variation of *L. geoffrayi* is firstly reported here, indicating that there are phenotypic forms in a population. It may be assumed that self-pollination promotes the recessive genes (Li, Q., Ruan, C.-J., and Silva, J. A. T. D., 2017), or mutations could naturally occur leading to color variations, for example, pink and white forms among these populations.

The floral shape of *L. aromatica* and *L. geoffrayi* is tubular floral with bilateral symmetry type Willmer, P., 2011), but it is small size (1-1.3 cm long) and slightly bilateral symmetry. The corolla consists of five unequal lobes, two upper lobes and three lower lobes, as indicated in Flora of Thailand (Smitinand, T. and Larsen, K., 1990). From my observation, in the early bud stage, the upper lobes cover the lower lobes (Figure 4.2-A1 and 4.2-B1). However, the upper lobes are positioned on the lower side of natural position when it is fully open. The outer surface of the corolla of both species is hairy, but more distinct in *L. aromatica* (Figure 4.2-A2 and 4.2-B2). The inner surface of the corolla of both species is distinctly and densely hairy from the base of the upper lobes. Trichomes found on one side of the corolla tube (Figure 4.2-A3 and 4.2-B3) and provided were insects with a footing, encouraging them to enter the flower correctly. Indeed, it plays an important role for pollinators. (Kampny, C. M., 1995).

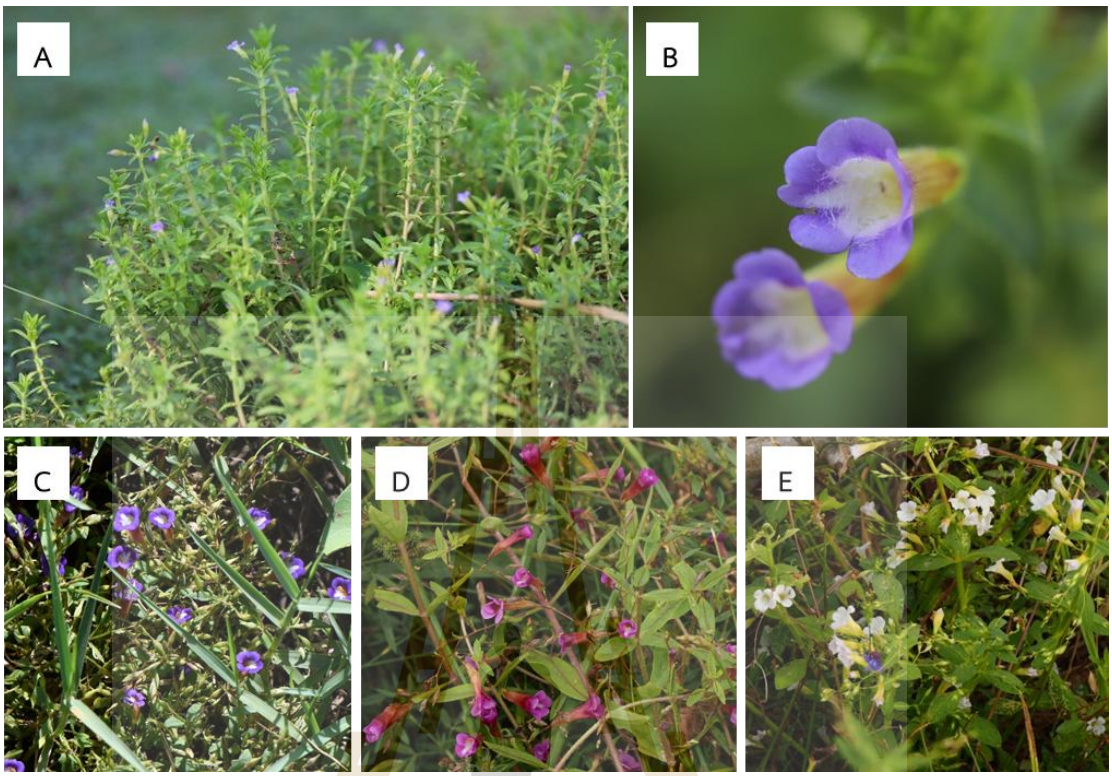

Figure 4.1 The floral colors of *Limnophila aromatica*: A-B. violet corolla. *L. geoffrayi:* C. dark violet, D. purplish pink, and E. white corolla.

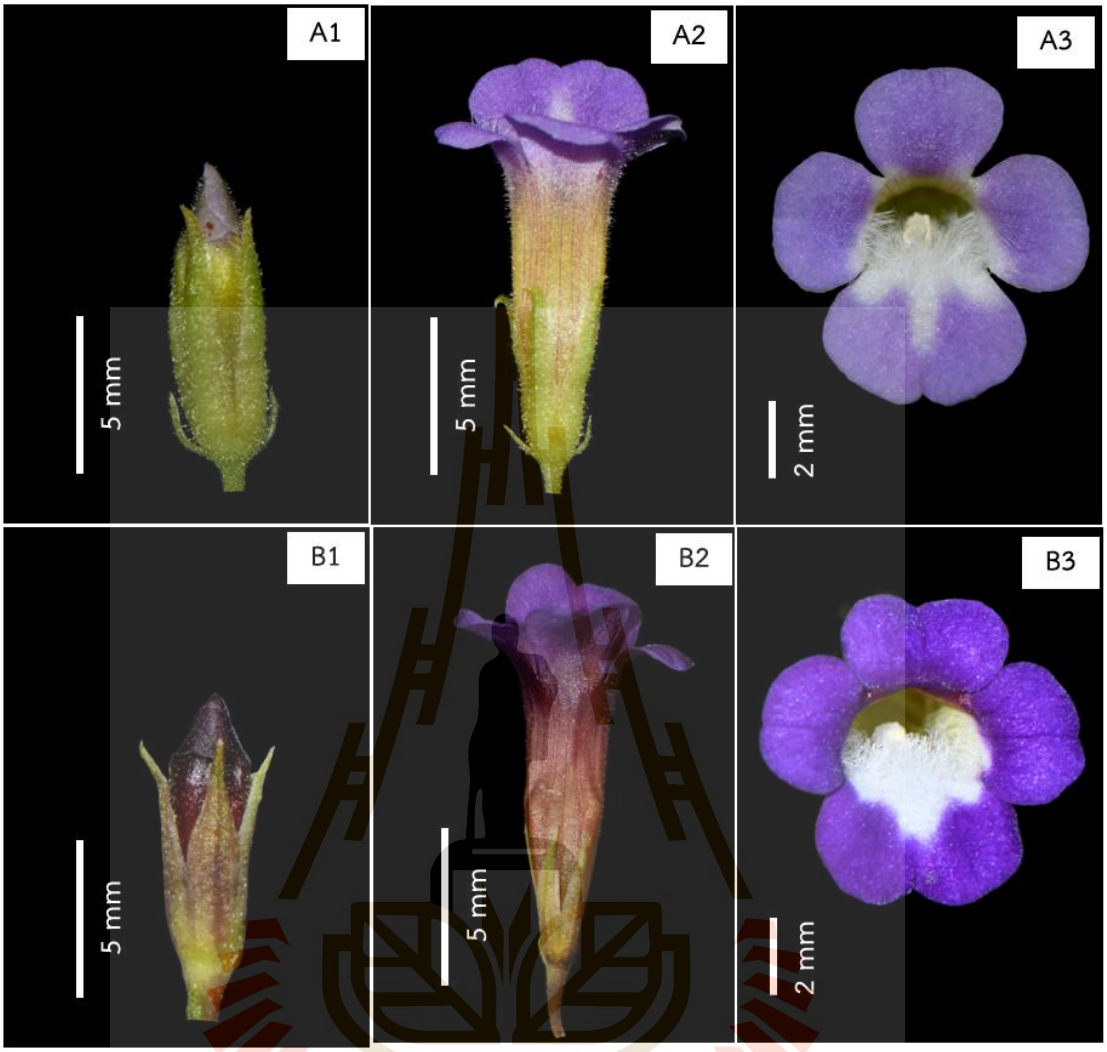

Figure 4.2 Floral morphological comparison of *Limnophila aromatica*: A1. early bud stage, A2. open floral stage, and A3. top view of floral. *L. geoffrayi*: B1. early bud stage, B2. open floral stage, and B3. top view of flower.

Both species have four stamens arranged in two pairs, two short ones located on the surface of the corolla tube at the upper lobe side, and other 2 long ones located on the surface of the corolla tube on the lower lobe side. Characteristically, the four anthers are inserted in the corolla tube and positioned in vertical arrangement inside the corolla tube, rather near to the upper lobe side (Figure 4.3-A1, B1, C1 and 4.4-A1, B1, C1). This may facilitate the insect's claw and step above the four anthers. The position of anthers and stigma in both species can promote self-pollination because the longer stamen pairs are positioned above the stigma. This pattern has been reported in some Scrophulariaceae and some taxa of Plantaginaceae (Kampny, C. M., 1995). Moreover, the shorter pair of the anther is located under the stigma lobe and deeper forward to the base of the corolla tube. Thus, it may induce the insect to go deeply into collecting the pollen, especially pollen collected insects.

The position of stamens and stigma in different floral stages of both species was investigated, as shown in Figure 4.3 and Figure 4.4. I divide flowers into three different stages, which are the early buds (corolla lobes have not yet opened and emerged slightly from the calyx), late buds (corolla lobes have not opened yet but are almost fully developed), and open flowers (corolla tube opens). In the early bud stage, the position of the shorter pair of stamens is lower than the stigma, and the longer pair of stamens is the same length as the stigma. On the other hand, the late bud stage and open flower have an elongated development of stamens, the longer pair of the anther extends and locates above the stigma, while the shorter pair is still below the stigma. Indeed, the position of the stamen and stigma promotes self-pollination in each flower. This characteristic is commonly found in *Limnophila*.

The anther attachment types of both species are dorsifixed. It is ca. 0.13 mm wide and ca. 0.27 mm long. The anther dehiscent in different floral stages of both species was investigated, as shown in Figure 4.3-A2, B2, C2 and Figure 4.4-A2, B2, C2. In the early bud and the late bud stages, the anther wall surface is smooth and not split. While in the open floral stage, the anther wall surface is rough and breaks. The anther dehiscence type is longitudinal, which is the most common type and a primitive characteristic of the anther dehiscence in the angiosperms. Normally, the anther will separate along a suture that runs parallel to the long axis of the thecae (Simpson, M.

G., 2019). I assumed that the heat from sunlight provides drier air around the anther and makes them break since the anthers were broken in the open floral stage. This study did not examine stigma receptivity, whether the stigma is ready for pollination before the anther disperse. However, in the late bud stage, the stigma surface of both species presented the stigma surface and was not ready for facilitating the pollen germination (Zulkarnain, Z., Eliyanti, E., and Swari, E. I., 2019). The active surface of the stigma can be recognized by having a sticky exudate on its surface (Wu Hai et al., 2008). Both species of *Limnophila*, the surface of the stigma is covered by a sticky exudate showing ready for pollination (Figure 4.3-C1, 4.4-C1) and facilitating the germination of the pollen.

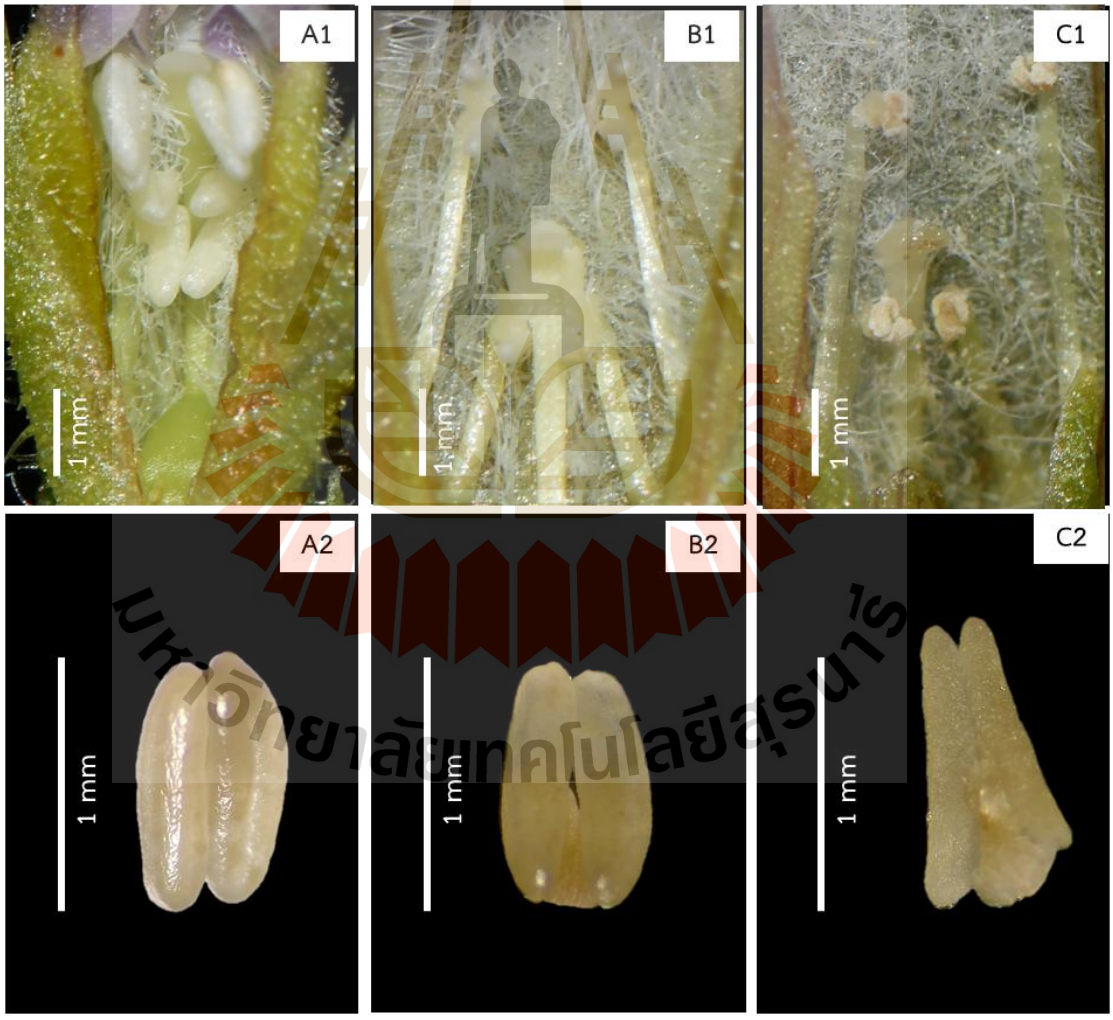

Figure 4.3 Position of sex organs and anther dehiscence at different floral stages of *Limnophila aromatica*. A1-A2: Early bud, B1-B2: Late bud, and C1-C2: Open floral stage.

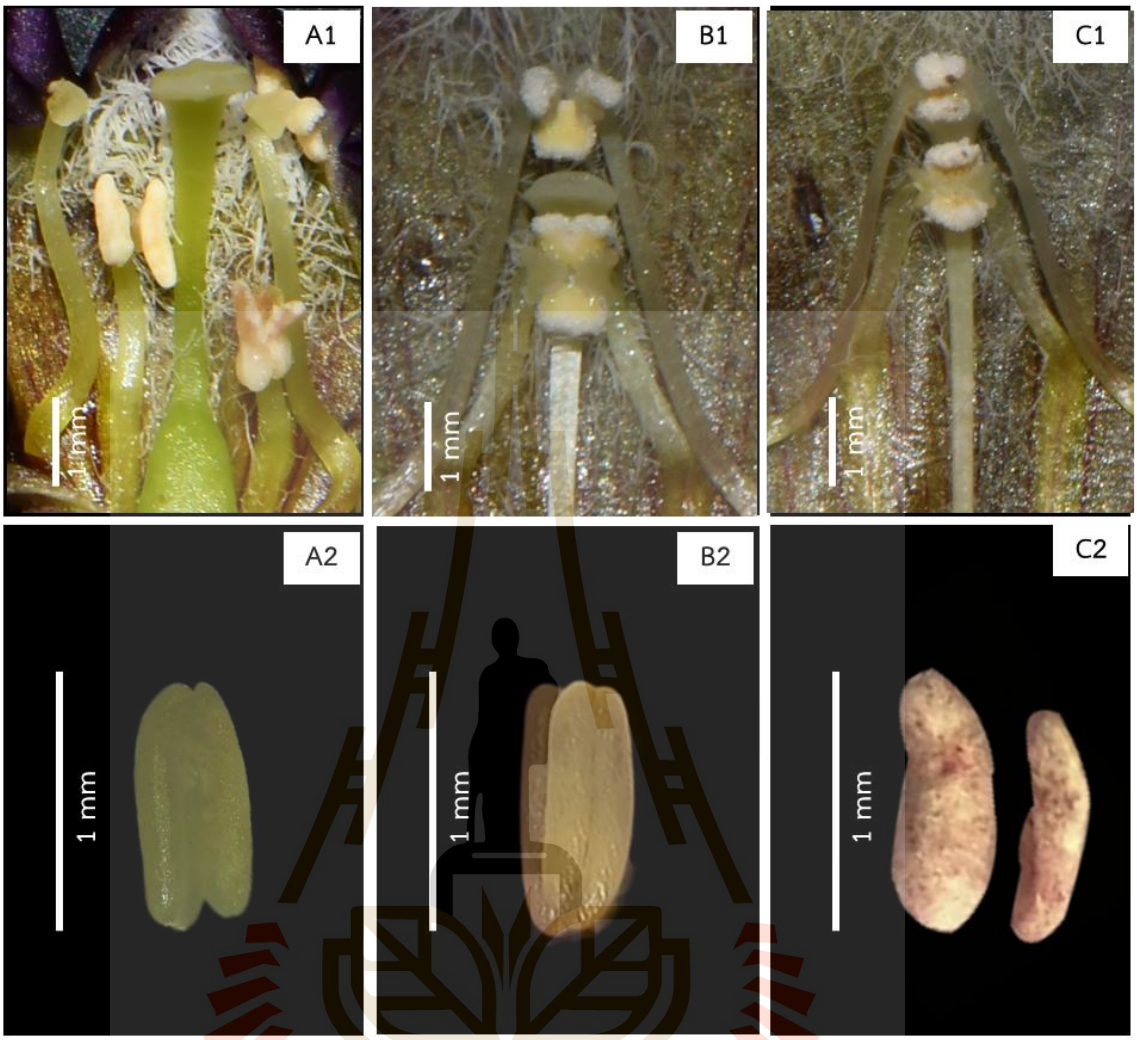

Figure 4.4 Position of sex organs and anther dehiscence at different floral stages of *Limnophila geoffrayi*. A1-A2: Early bud, B1-B2: Late bud, and C1-C2: Open floral.

4.2 Floral phenology of *L. aromatica* and *L. geoffrayi*

The individual floral opening period of *L. aromatica* and *L. geoffrayi* florals by tracking late-stage buds, it was found that *L. aromatica* florals opened only one day at daytime (6.31±0.66 hours; N = 48). The flowers started to open around 10:00-11:00 am, and fully opened 100% at 01:00-02:00 pm, then closed around 5:00-6:00 pm nearly sunset and fallen off the next day (Figures 4.5 and 4.6-A). On the other hand, some flowers of *L. geoffrayi* (about 1/3 of total flowers) opened 2 days (4.88 ± 1.07 hours on day one and 1.53 ± 2.35 hours on day two; N = 43). The first day, flowers started to open at 10:00-11:00 am, fully opened 100% around 01:00-02:00 pm, and close at 05:00-06:00 pm, and opened again at 10:00-11:00 am on the second day, fully opened only 32% of all flowers at 01:00-02:00 pm then closed around 05:00-06:00 pm and fallen off the next day (Figures 4.5 and 4.6-B). However, the open flowers in the studied population presented about one month.

This is the first report on the floral opening pattern of *Limnophila*. The floral opening patterns depended on species. The longer individual floral blooming pattern, more than one day of *L. geoffrayi* than *L. aromatica* may increase the chance of insects entering the flower. This pattern is similar to *Gossypium turneri*, which blooms for 2 days (Yescas-Romo, K. F., Hayano-Kanashiro, C., and Molina-Freaner, F., 2024).

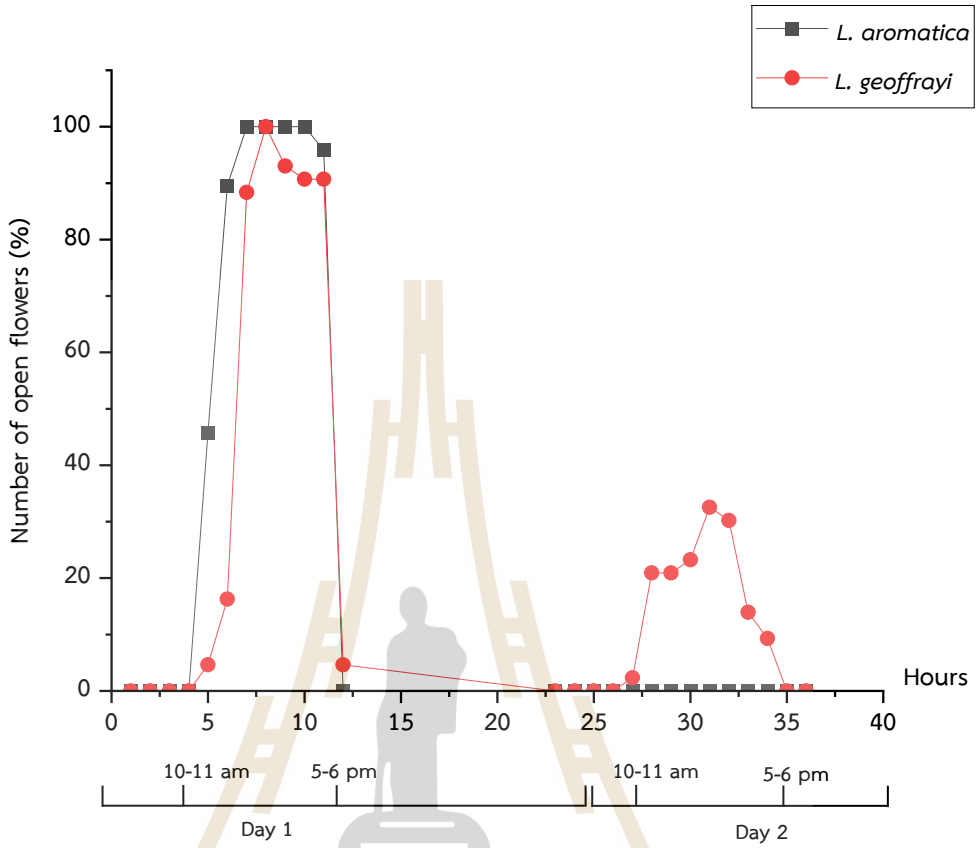

Figure 4.5 Percentage of open flowers of *Limnophila aromatica* and *L. geoffrayi* in the floral opening period.

Figure 4.6 Flower opening patterns of both species during the floral opening period. A: *Limnophila aromatica*, and B: *L. geoffrayi*.

4.3 Breeding systems

The result of breeding systems by bagged experiment to avoid pollinators of both species of *Limnophila* is shown in Table 4.1. Comparisons among species and breeding system types to fruit set were significantly different by GLM ($p<0.001$). *L. aromatica* showed no fruit set in any of the treatments (Figure 4.7), suggesting that the species may has completed self-incompatibility. The individual plant derived by cutting and came from the same genetic clone revealed no fruit setting, confirming the self-incompatibility. I assumed that the genetic diversity of this species is low. This species has not been found in a natural population in Thailand. However, it is quite interesting to breed different clones to increase the genetic diversity of this crop plant and check whether it could produce seed or not. In contrast, *L. geoffrayi*, has a 100% fruit set on autogamy and natural pollination (Figure 4.8), indicating self-compatibility. Neither of the species had parthenogenesis occurred because emasculation treatment did not set fruit (Table 4.1). For genetic diversity based on breeding system patterns, showing self-pollination species has rather low genetic diversity compared with cross-pollination species (Zhang, D., Li, Y.-Y., Zhao, X., Zhang, C., Liu, D.-K., Lan, S., Yin, W., and Liu Z.-J., 2024). From a conservation point of view, seed banking from different populations is a crucial need for keeping their genetic diversity.

Table 4.1 *Limnophila aromatica and L. geoffrayi* 's fruit set and treatments for pollination (Fruit set percentages with different letters are significantly different using Dunn-Sidak test at $P<0.05$).

Species	Pollination treatments	Number of florals	Number of fruits	Fruit set (%)
L. aromatica	Autogamy	30	0	0^{b}
	Emasculation	30	0	0^{b}
	Natural pollination	30	0	0^{b}
L. geoffrayi	Autogamy	30	30	100^{a}
	Emasculation	30	0	0^{b}
	Natural pollination	30	30	100^{a}

Figure 4.7 *Limnophila aromatica* 's fruit set and treatments for pollination. A1-A3: Autogamy, B1-B3: Emasculation, and C1-C3: Natural pollination. (Scale bar = 5 mm.)

Figure 4.8 *Limnophila geoffrayi* 's fruit set and treatments for pollination. A1-A3: Autogamy, B1-B3: Emasculation, and C1-C3: Natural pollination. (Scale bar = 5 mm.)

4.4 Pollination

A total of 84 individual insects were observed to visit the flowers of *L. aromatica,* whereas 60 individual insects visited the flowers of *L. geoffrayi*. The main visitors of both species were solitary bees belonging to the Hymenoptera in various orders; furthermore, other orders, such as Coleoptera and Thysanoptera, were rarely seen and did not exhibit pollen-collecting behavior, only visiting flowers (Table 4.2). The visitors of both species were similar at 0.5 based on Sorensen's similarity index, which were *Braunsapis puangensis*, *Lasioglossum* (*Ctenonomia*) *albescens*, (*Ctenonomia*) *vagans* gr., and *Thrips* sp. This study revealed that the number of flower visits on *L. aromatica* in the cultivated plot was higher than that of *L. geoffrayi* in the natural habitat. This may be due to the greater diversity of flowering plants in the natural habitat where *L.*

geoffrayi was located (Figure 4.9). The main visitors of both *Limnophila* species were pollen-collecting bees. I observed that they collected the pollens from other flowering plant species, such as *Ipomoea aquatica*, *Lobelia thorelii*, *Murdannia* sp., and *Xyris* sp. in the natural habitat of *L. geoffrayi* (Figure 4.9). Indeed, *Limnophila* flower served as insect food. There are few reports on the pollination of *Limnophila.* Kato, M., Kosaka, Y., Kawakita, A., Okuyama, Y., Kobayashi, C., Phimminith, T., and Thongphan, D. (2008) recorded that the flower visitors of *L. geoffrayi* were small bees*, Lasioglossum* sp., and Laha, S., Chatterjee, S., Das, A., Smith, B., and Basu, P. (2020) recorded that the flower visitors of *L. repens* were bees belonging to various families in Apidae, Halictidae, and Magachilidae.

The visiting time of the main visitors of both species, which are solitary bees, was from 9:00 a.m. to 04:00 p.m. The average temperature was 31 °C, and the average humidity was 64 percent. Most solitary bees enter the flowers at 11:00 a.m.-12:00 p.m. (Figure 4.10), which coincides with the time when the flowers are in full bloom (Figure 4.6). There is another study of the foraging behavior of solitary bees, with the peak time of 10:00-11:00 a.m. and a decline in the afternoon (Lim, Z., Lord, J., and Johnson, S., 2025; Gonzalez, V. H., Mantilla, B., and Palacios, E., 2006). The solitary bees that visited the flowers of both *Limnophila* have landed on the upper lobe of the corolla and clawed into the corolla tube, stepping on the anthers and stigma. The lower pair of stamens make the insect claw deeper into the corolla tube (Figure 4.11 and Figure 4.12). Generally, the time visiting of each insect to each flower was 3-12 seconds, (10.76 ± 11.36). It is impossible to observe the pollination process inside the small corolla tube of both species. However, all the pollen-collecting solitary bees that visited the flower usually have several pollen grains collected in the scopa (an anatomical structure of a bee specifically adapted for the storage and delivery of pollen). Some pollen might be attached to solitary bee legs before it claws to the corolla. The collecting pollen behavior of the solitary bees as described may increase the chance of cross-pollination of the *L. geoffrayi*, since the insect had carried pollen from the previous plants. However, *L. geoffrayi* exhibited a breeding system from self-pollination without vectors (see above). I assumed that the autogamy in *L. geoffrayi* resulted from pollinators scarcity.

Table 4.2 Insect visits of *Limnophila aromatica* (Botanical Garden) compared with *L. geoffrayi* (Rice fields).

Orders	Families	Species	*L. aromatica*	*L. geoffrayi*
Coleoptera	Coccinellidae	*Micraspis* sp.		x
	Chrysomelidae	*Monolepta* sp.		x
Hymenoptera	Andrenidae	Unknown		x
	Apidae	*Ceratina* (*Neoceratina*) *dentipes*		x
		Ceratina (*Pithitis*) *smaragdula*		x
		Braunsapis hewitti	x	
		Braunsapis malliki	x	
		*Braunsapis puangensis**	x	x
	Halictidae	*Ceylalictus* sp.		
		Lasioglossum (*Ctenonomia*) *albescens* *	x	x
		Lasioglossum (*Ctenonomia*) *vagans* gr.*	x	x
	Magachilidae	*Heriades* (*Michenerella*) sp.		x
Thysanoptera	Thripidae	*Thrips* sp.*	x	x

* Means the species found in both *Limnophila* florals.

Figure 4.9 Some of flowering plants in the study plots of *Limnophila geoffrayi* and insects that forage in the flowers: A. *Ipomoea aquatica*, B. *Lobelia thorelii*, C. *Murdannia* sp., and D. *Xyris* sp.

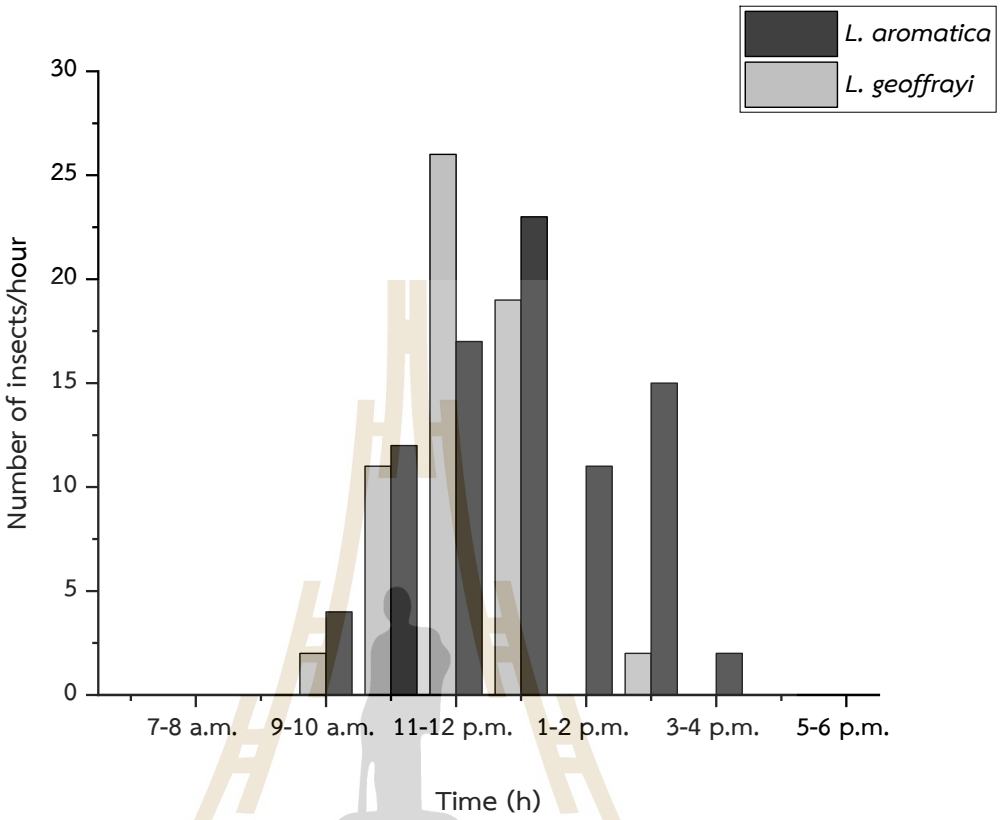

Figure 4.10 Number of insects visiting the flowers of *Limnophila aromatica* and *L. geoffrayi* from 06:00 a.m. to 06:00 p.m., for 3 days (36 h) of the flowering season.

Figure 4.11 A diversity of insects that have foraging behaviors in the flowers of *Limnophila aromatica*. A-D: solitary bees insert the head into the flower, collect pollen. (Scale bar = 5 mm.)

Figure 4.12 A diversity of insects that have foraging behaviors in the flowers of *Limnophila geoffrayi*. A-D: solitary bees insert the head into the flower, collect pollen. (Scale bar = 5 mm)

4.5 Seed germination test

Limnophila geoffrayi capsule is ellipsoidal, 1.5 mm width, and 3 mm long (Figure 4.13-A). The seed characters are minute, with black in color and exhibit a variety of shapes, such as oblong, rectangular, and reniform (Figure 4.13-B). According to Ghimire, B., Choi, G. E., Lee, H., Heo, K., and Jeong, M. J. (2017), the seeds of *L. indica* and other species in the same family ranged from ovoid to broad ovoid to sub-spherical. The number of seeds per fruit is approximately 230 seeds. Seed is 0.35 ± 0.04 mm long and 0.23 ± 0.03 mm width (n = 30).

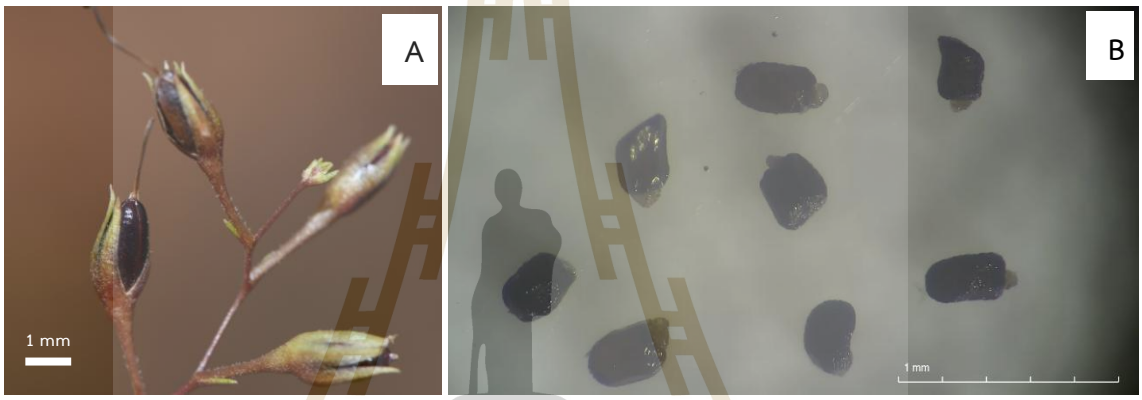

Figure 4.13 Capsule and seed of *Limnophila geoffrayi*. A. capsule, B. variety of seed shape.

The comparison of the seed germination test of *L. geoffrayi* after storage for 0 month and 12 months with various pre-treatments by counting the number of seedlings that germinated daily as determined by the visibility of green (Figure 4.14) then calculated the percentage of seed germination (GP; %), germination index (GI), and mean germination times (MGT; days) are shown in Table 4.3.

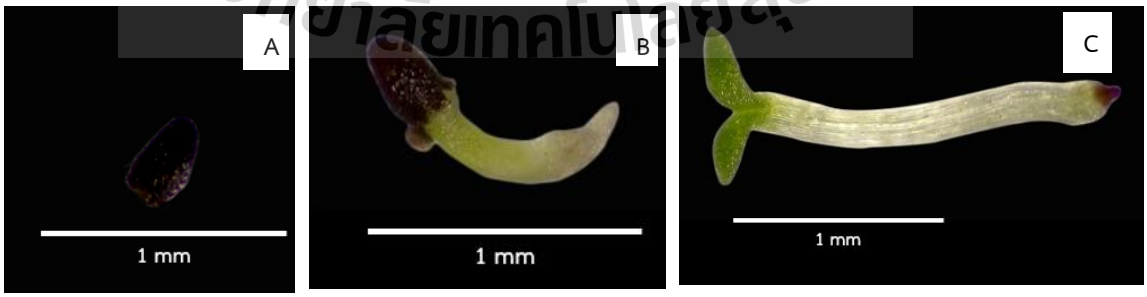

Figure 4.14 The success of seed germination in *Limnophila geoffrayi* assessed by the visibility of green. A. Germination fails, B. Germination success, and C. Seedling.

Table 4.3 One-way ANOVA of the percentage of seed germination (GP; %), germination index (GI), and mean germination times (MGT; days) of *Limnophila geoffrayi* seeds for different treatment series.

Treatment series		GP (%)	GI	MGT (days)
0 month	non-soaking (Control)	35.00±8.55	0.18±0.04	68.30±4.68
	Soaking Water	21.75±4.03	0.12±0.03	66.94±5.68
	250 ppm GA_3	21.50±6.76	0.08±0.03	65.57±6.53
	500 ppm GA_3	19.25±3.50	0.07±0.01	57.39±10.94
	1,000 ppm GA_3	23.50±8.11	0.17±0.06	42.17±16.14
	Sig.	ns	ns	ns
12 months	non-soaking (Control)	42.75±8.84	0.42±0.14	56.29±7.11
	Soaking Water	26.75±5.95	0.31±0.10	54.99±9.16
	250 ppm GA_3	29.75±12.20	0.27±0.09	52.72±13.14
	500 ppm GA_3	15.75±4.23	0.16±0.08	63.79±12.11
	1,000 ppm GA_3	31.75±9.72	0.22±0.09	70.85±6.51
	Sig.	ns	ns	ns

Values are means followed by the standard error (n = 4); ns means not statistically significant (at the α = 0.05 level using DMRT).

The germination percentage (GP) and germination index (GI) of seeds from different storage periods in the five preliminary experimental methods were not significantly different. However, the highest percentages of seed germination and germination index are the seeds stored for 12 months with control (42.75%), the seeds stored for 0 month with control (35%), and the seeds stored for 12 months with 1,000 ppm GA_3 (31.75%). The remaining experiments had germination percentages lower than 30%, which is consistent with other *Limnophila* and other plants in the other family, as Les, D. H. (2018) cited in Panda, M., Satapathy, M. K., and Samal, R. N. (2020), who studied *L. indica* seeds with low germination rates, and the germination study of *Verbascum calycosum* seeds found that the highest germination percentage was only 39-54.5%.

The mean germination times of seeds from different storage periods in the five preliminary experimental methods were also not significantly different. Additionally,

the treatment series with the least amount of time to germinate was the seeds stored for 0 month with 1,000 ppm GA_3 (42.17 days), the seeds stored for 12 months with 250 ppm GA_3 (52.72 days), and the seeds stored for 12 months that were soaked with water (54.99 days). The remaining experiments had mean germination times of over 55 days to 70 days (approximately 2 months), which means that *L. geoffrayi* has seed dormancy. Indeed, seeds of *L. geoffrayi* are orthodox due to non-viability loss during storage (Fatima, H., Ishaque, S., Hashim, M., Hano, C., Abbasi, B. H., and Anjum, S., 2023). Similar to other species, such as the study by Hilooglu, M., Sozen, E., Yucel, E., and Kandemir, A. (2018) on *V. calycosum* seeds, which had low germination rates., The study of *Pedicularis olympica* seed, the highest germination rate of this plant occurs after 21 days, possibly demonstrating an interaction of physical and physiological dormancy (Kirmizi, S., Güleryüz, G., Arslan, H., Sakar, F. S., and Kocabıyık, G. A., 2010), and *Scrophularia marilandica* displays physiological dormancy (Nurse, R. E., and Cavers, P. B., 2008).

Gibberellic acid has a crucial role in regulating and enhancing germination in cereal grains and many crop species (Gupta, R. and Chakrabarty, S. K., 2013). However, it did not enhance the germination of *L. geoffrayi* seeds, while enhancing the germination in other plants, such as *V. calycosum* seeds (Hilooglu, M., Sozen, E., Yucel, E., and Kandemir, A., 2018), *P. olympica* seeds (Kirmizi et al., 2010), and *Scrophularia marilandica* seeds (Nurse, R. E., and Cavers, P. B., 2008). I assumed it could be as a result of the unique traits of the *Limnophila* seed coat, which was impenetrable and deteriorated (Ghimire, B., Choi, G. E., Lee, H., Heo, K., and Jeong, M. J., 2017), similar to *P. olympica,* which lacked thick seed coverings, but their endosperm might function as a mechanical limitation to seed germination (Kirmizi, S., Güleryüz, G., Arslan, H., Sakar, F. S., and Kocabıyık, G. A., 2010).

The different treated seeds under seed storage for 0 month, the first seed germination occurred on day 12 in seeds soaked in 500 ppm GA_3, day 17 in seeds soaked in 1,000 ppm GA_3, day 24 in seeds soaked in 250 ppm GA_3, day 27 in control, and day 36^{th} in seed soaked in water (Figure 4.15). It was shown that the application of GA_3 stimulated faster germination compared to the control. However, after approximately 60 days of the seed germination test, the control showed faster

cumulative germination than the other treatments. It was shown that although GA_3 did not increase the germination percentage as high as the control, it helped to stimulate germination faster.

In addition, stimulating germination by soaking seeds in water did not stimulate the germination of *L. geoffrayi* seeds as well. Normally, seeds soaked in water induces the seeds to germinate faster because water helps increase the activity of enzymes to produce energy and stimulates an increase in the levels of metabolites involved in the germination process (Rodríguez et al., 2015). As studied in other plants by Artola, A., Carrillo-Castañeda, G. and García de los Santos, G. (2003), it was found that water soaking of *Lotus corniculatus* L. seeds could increase the germination rate when the seeds were soaked in water for 19 and 23 hours.

The result of data analysis with two-way analysis of variance (ANOVA) are shown in Table 4.4. Storage period, seed preparation methods (treatment), and their interaction, do not affect the percentage of seed germination (GP) and mean germination times (MGT) values, but storage period has a significant effect on GI values at the α = 0.05 level. From the results, it means that storage of *L. geoffrayi* is seeds without doing any further pre-treatment is better way to accelerate germination. I suggest that studying various methods to find the best way to promote germination is required, such as scarification, like the experiment on other plants in the same family, *Veronicastrum sibiricum*. The seeds of this plant treated with different incubation times of cold stratification can enhance the germination (Jang, G. H., Chung, J. M., Rhie, Y. H., and Lee, S. Y., 2022).

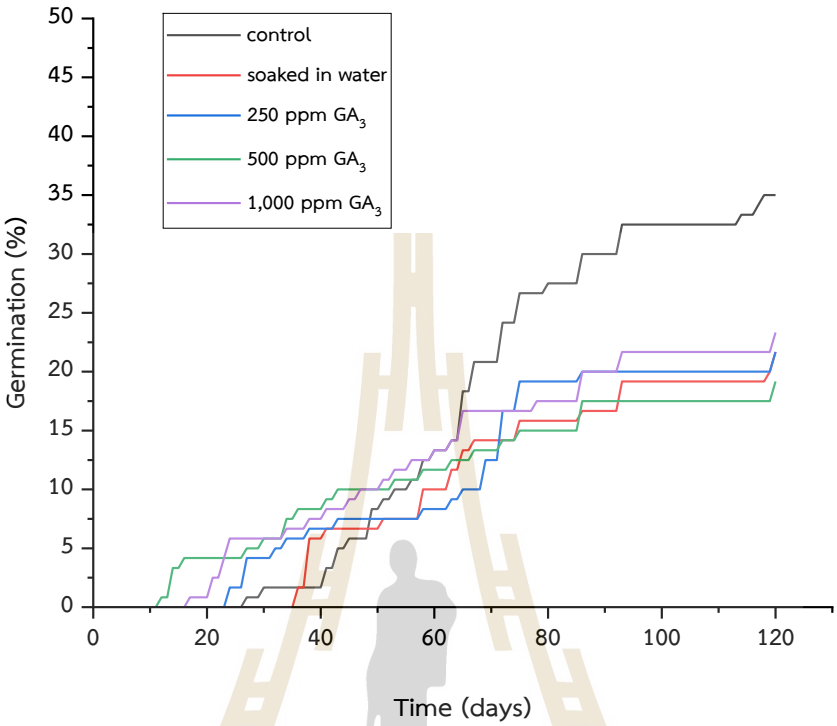

Figure 4.15 Cumulative germination percentage diagrams for *Limnophila geoffrayi* seeds in different treatments under storage seed conditions for 0 month.

Table 4.4 Two-way ANOVA of the percentage of seed germination (GP; %), germination index (GI), and mean germination times (MGT; days) in different storage period, treatment series, and their interaction of *Limnophila geoffrayi* seeds.

Independent variables	Dependent variables	Significant
Treatment series		0.113^{ns}
Different storage period	GP	0.297^{ns}
Treatment series*Different storage period		0.928^{ns}
Treatment series		0.219^{ns}
Different storage period	GI	0.004^{*}
Treatment series*Different storage period		0.695^{ns}
Treatment series		0.982^{ns}
Different storage period	MGT	0.956^{ns}
Treatment series*Different storage period		0.179^{ns}

The ns means not statistically significant, and * means significant at the α = 0.05 level.

In *L. geoffrayi*, different treated seeds were stored for 12 months. The first seed germination occurred on day 9 in seeds soaked in water, in 250 ppm GA_3, and in 500 ppm GA_3, on day 10 in control, and on day 12 in seeds soaked in 1,000 ppm GA_3 (Figure 4.15). It was shown that seeds subjected to 12 months of storage exhibited faster germination than those without a storage period (Figure 4.14). Notably, after approximately 60 days of the seed germination test, the control group showed faster cumulative germination than the other treatments. In this study, it was shown that the storage period increased germination percentage faster than GA_3 application, which was consistent with studies in other families, such as Kumar, V., Sharma, S., Sharma, R. K., Kumar, V., and Sharma, S. S. (2024) examined germination test of Scrophulariaceae, *Verbascum thapsus, and* found that germination was significantly affected by storage time, with seeds stored for one year (81%) having a higher germination percentage than 0 year (55%). Similarly, Lu, J. J., Tan, D. Y., Baskin, C. C., and Baskin, J. M. (2017) found that the germination of Brassicaceae, *Isatis violascens,* was significantly affected

by storage time, with seeds stored for 6 months having a higher germination percentage than seed with non-stored seeds.

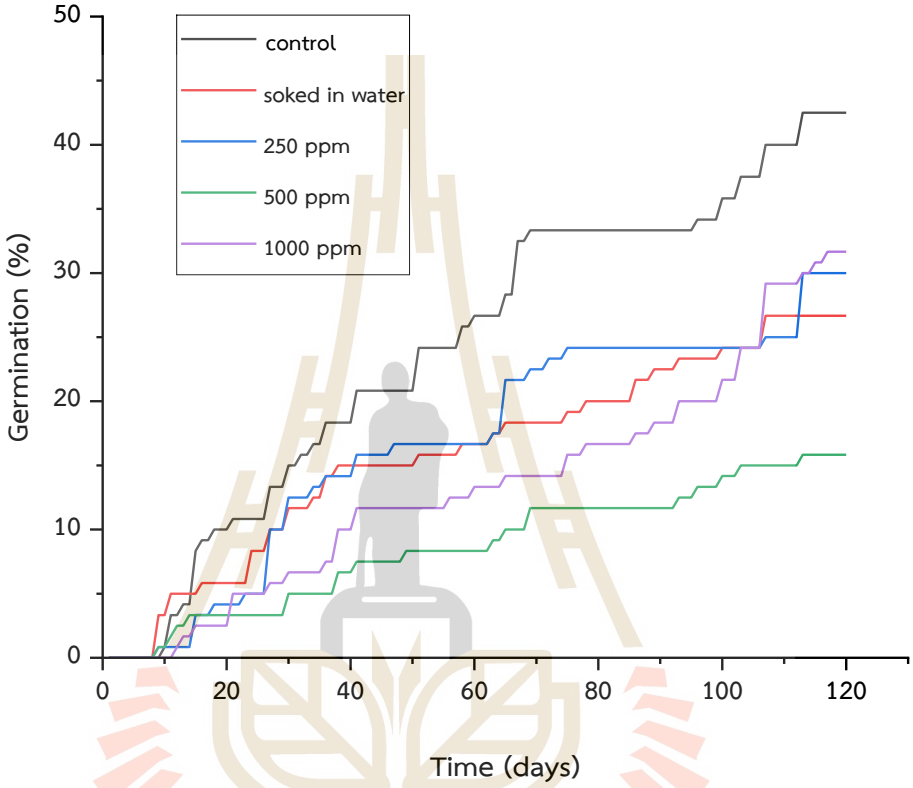

Figure 4.16 Cumulative germination percentage diagrams for *Limnophila geoffrayi* seeds in different treatments under storage conditions for 12 months.

4.6 Effect of BAP on shoot generation of *L. geoffrayi*

The nodal segments of *L. geoffrayi* that were cultured in Murashige and Skoog (MS) medium containing different concentrations of BAP showed 100% regenerated shoots after 8 weeks of culture (Figure 4.17). The first shoot was observed within two weeks in all media. Then after 4 weeks, the number of shoots in control was 1.83±0.38 shoots, the shoot length was 0.53±0.19 cm, with 5.83±0.99 leaves per node. After 6 weeks, all morphological values were increased; the number of shoots in the control was 1.87±0.35 shoots, the shoot length was 0.78±0.22 cm, with 7.10±1.40 leaves per node. The results in other media with different BAP had also increased (Figures 4.18, 4.19, and 4.20).

The addition of BAP into the culture medium significantly increased shoot regeneration in comparison to the control (Table 4.5). However, different BAP concentrations did not result in significant differences in the shoot number. The highest number of shoots was observed at 1 mg/l BAP (52.07±8.22), 0.5 mg/l BAP (46.80±9.94), and 2 mg/l BAP (46.67±9.27), respectively. The study on tissue culture of *Limnophila* is very few. However, Dogan, M. (2019) reported his study on the effective of BAP, to *L. aromatica* shoot generation. BAP concentrations ranging from 0.05, 0.1, and 0.2 mg/l stimulated 21.33, 29.22, and 22.91 shoots per explant, respectively. Indeed, cytokinin (BAP) effectively promotes shoot generation of the genus *Limnophila.*

The longest shoot was found in the media supplemented with 0.5 mg/l BAP (3.38±0.48 cm) and 1 mg/l BAP (3.13±0.29 cm), both of which were significantly longer than the medium added with 2 mg/l BAP (1.81±0.27 cm) and the control (0.95±0.05 cm). It is indicated that BAP not only stimulates to generate the shoot numbers but also shoot length. In *L. aromatica* shoot length were 1.64 cm (0.05 mg/l BAP), 1.92 cm (0.1 mg/l BAP), and 2.11 cm (0.2 mg/l BAP), showing that BAP promoted the shoot length as well (Dogan, M., 2019). Similarly, the number of leaves per shoot showed significant variation among treatments, with the highest values recorded in 1 mg/l BAP (17.53±1.19) and 0.5 mg/l BAP (16.93±2.31), followed by 2 mg/l BAP (11.53±1.18) and the control (8.00±0.26), respectively.

The results indicate that media with 0.5 mg/l BAP is the best concentration that should be used to increase the shoot growth of *L. geoffrayi,* and when BAP

concentration was increased, the shoot growth was decreased, consistent with Karatas, M. and Aasim, M. (2015) reported on the study of shoot regeneration of *L. aromatica*. There were reduced shoots per explant when the BAP concentration was raised.

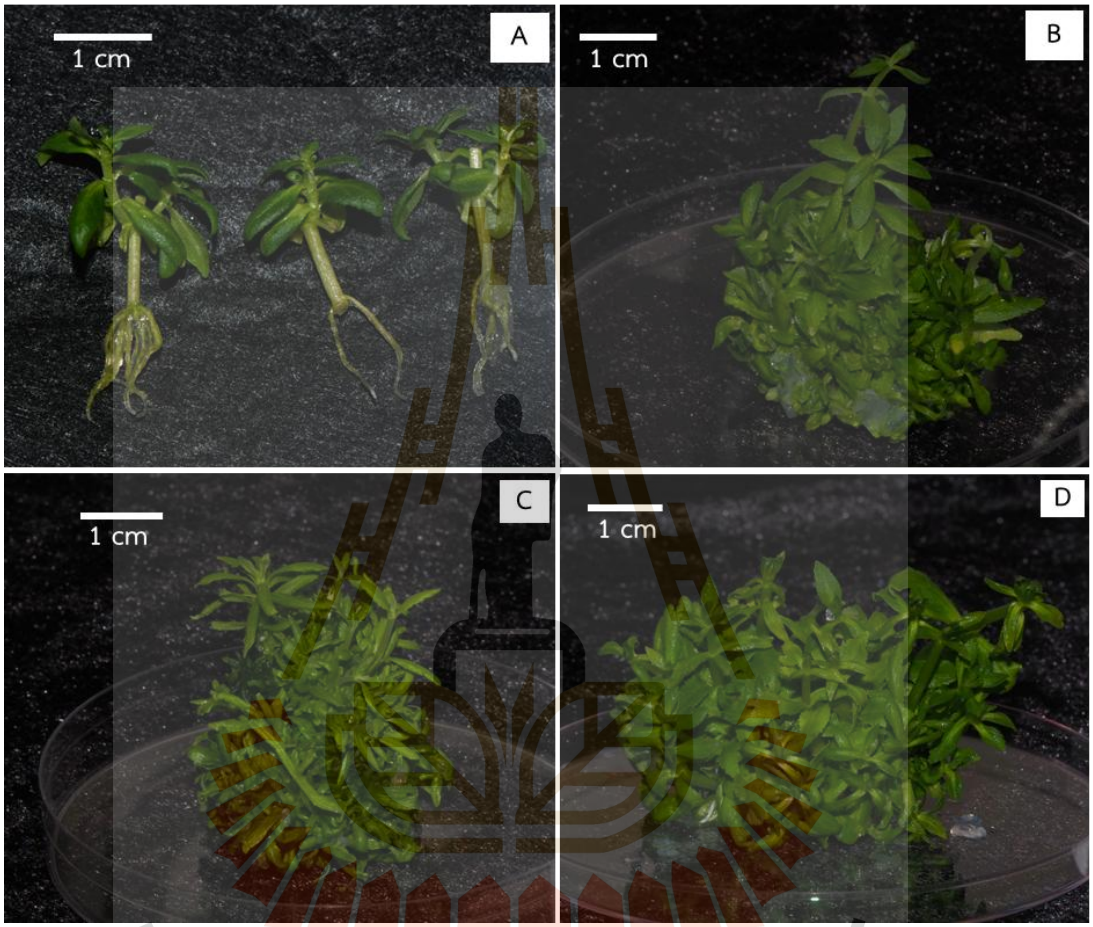

Figure 4.17 Shoot regeneration of *Limnophila geoffrayi* on different concentrations of BAP medium at 8 weeks after culture. A: 0 mg/l BAP, B: 0.5 mg/l BAP, C: 1 mg/l BAP, D: 2 mg/l BAP.

Table 4.5 Effect of different concentrations of BAP on shoots per explant, shoot length, leaves per shoot, roots per explant, and root length of *Limnophila geoffrayi* for 8 weeks (n=15). Values are means followed by the standard error (n = 15); ns means not statistically significant (at the α = 0.05 level using DMRT).

BAP (mg/l)	Shoots/explant	Shoot length (cm)	Leaves/shoot
0	1.87±0.06^{b}	0.95±0.05^{c}	8.00±0.26^{c}
0.5	46.80±9.94^{a}	3.38±0.48^{a}	16.93±2.31^{a}
1	52.07±8.22^{a}	3.13±0.29^{a}	17.53±1.19^{a}
2	46.67±9.27^{a}	1.81±0.27^{b}	11.53±1.18^{b}

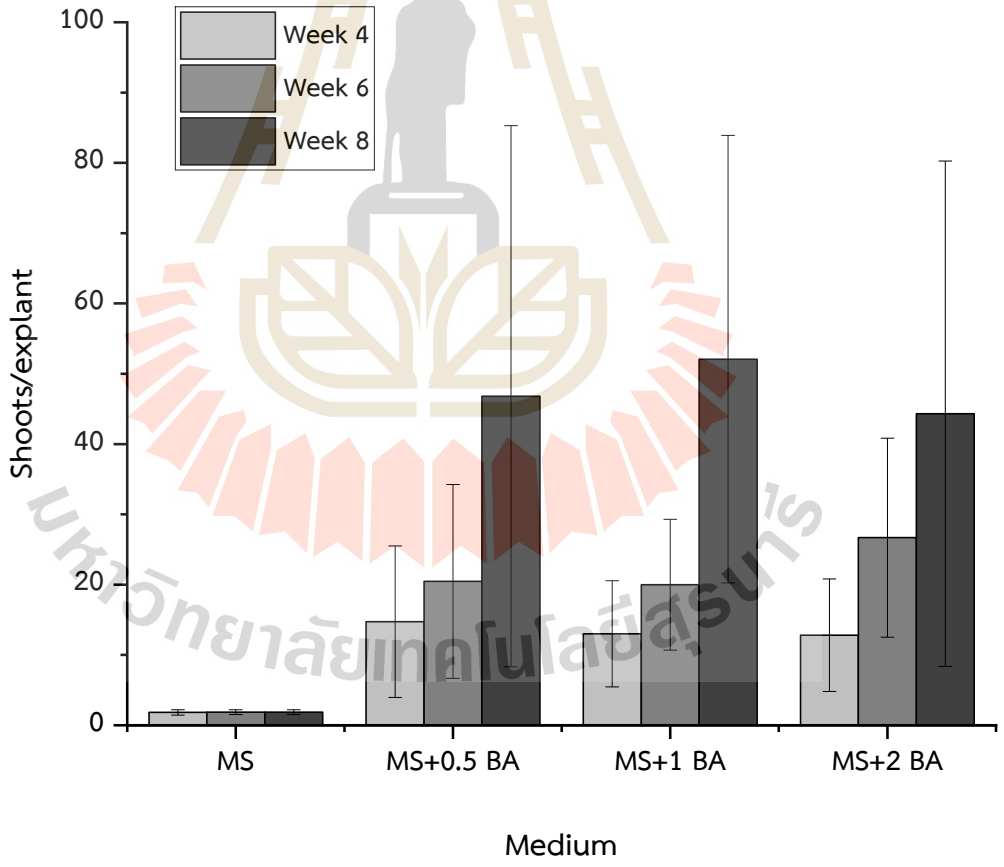

Figure 4.18 The effect of different concentrations of BAP on the number of shoots per explant of *Limnophila geoffrayi* at 4, 6, and 8 weeks.

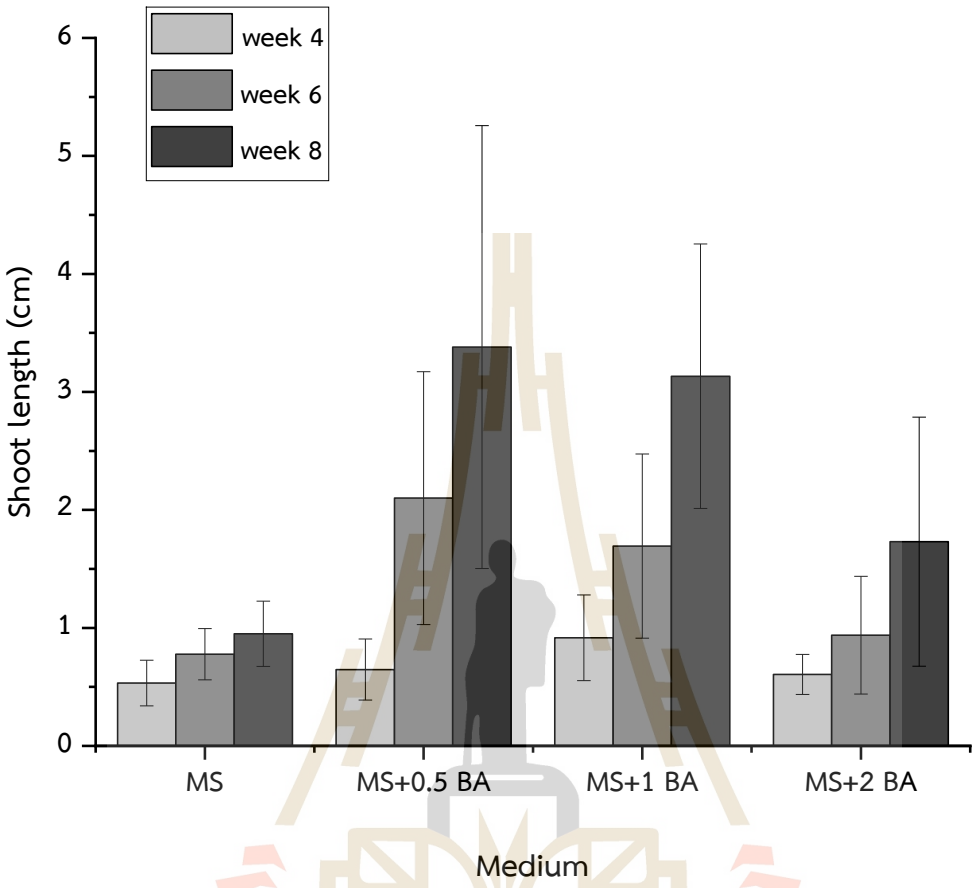

Figure 4.19 The effect of different concentrations of BAP on the shoot length of *Limnophila geoffrayi* at 4, 6, and 8 weeks.

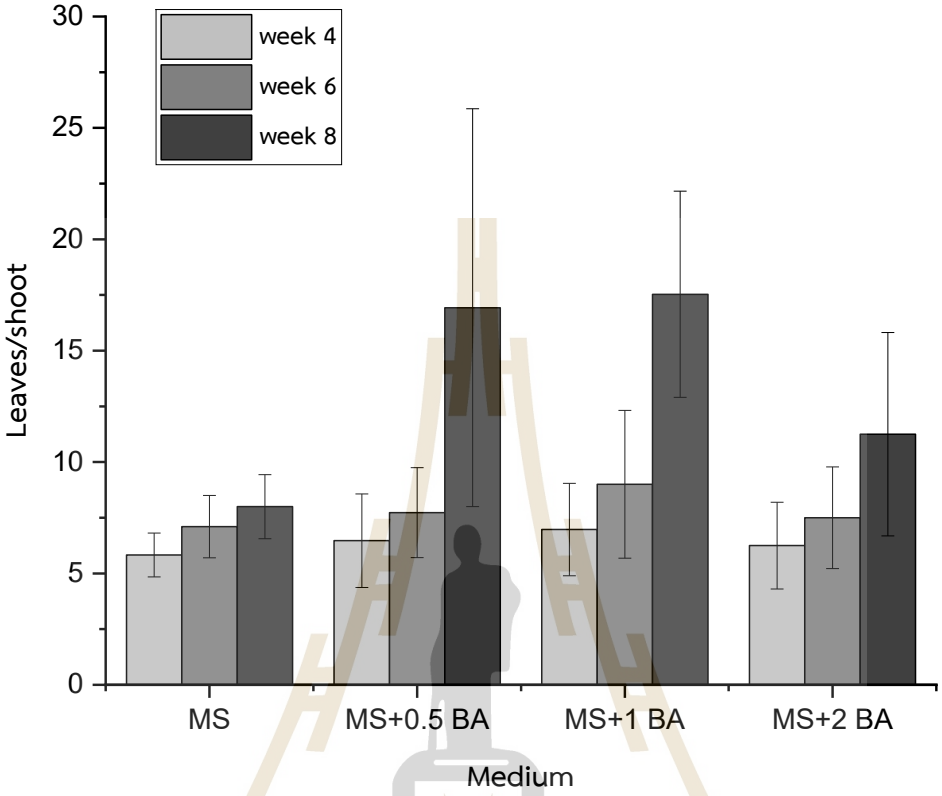

Figure 4.20 The effect of different concentrations of BAP on leaves per explant of *Limnophila geoffrayi* at 4, 6, and 8 weeks.

CHAPTER V
CONCLUSION

5.1 Floral morphology

Limnophila aromatica blooms with violet flowers, whereas *L. geoffrayi* exhibits color variation of dark violet, purplish pink, or white. These phenotypic forms could be resulted from self-pollination, which exhibited the recessive gene. Both species possess small tubular, bilaterally symmetrical flowers with hairy corollas, and the stamens and stigma arrangement promoting self-pollination. The dorsifixed anthers dehiscent longitudinally at the open floral stage, which is likely to be heat-induced. The stigma becomes receptive only when the flower is at the open stage. With respect to flower opening, *L. aromatica* blooms for a single day, while some *L. geoffrayi* flowers extend bloom duration for two days, which might be beneficial for visitors. This is the first report of floral opening patterns in *Limnophila*.

5.2 Breeding system

Breeding trials revealed *L. aromatica* may be self-incompatible, with no fruit set under any pollination treatment, even among clones, which indicates low genetic variability and the necessity for cross-clone reproduction from different genetics. On the other hand, *L. geoffrayi* is self-compatible, showing 100% fruit set through autogamy and natural pollination. Both species failed to achieve fruit set from emasculated flowers, confirming the absence of parthenogenesis. *L. geoffrayi* likely suffers from low genetic variability due to self-pollination, thus highlighting the need for population-based seed banking for conservation.

5.3 Pollination

From this study, the number of visitors to the flowers of *L. aromatica* was higher than *L. geoffrayi,* but lower diversity of visitor species than *L. geoffrayi*, possibly due to lower plant diversity in the cultivated plot of *L. aromatica*. Mainly, visitors were pollen-collecting solitary bees (Hymenoptera). Flower visitors of both species have Sorensen's similarity index is 0.5, with observations on *L. geoffrayi* due to its natural habitat. Bees visited flowers between 9:00 am and 4:00 pm, peaking around 11:00 am, coinciding with full bloom. They entered the flower via the upper corolla lobe, stepping on stamens and stigma, likely aiding pollination. Although *L. geoffrayi* is self-compatible and capable of autogamy, bee behavior suggests potential for cross-pollination because they took the pollens from different plant individuals. Autogamy may have evolved due to low pollinator availability.

5.4 Seed germination test

Limnophila geoffrayi produces small black seeds (ca. 0.35 mm long) with about 230 seeds per capsule. Germination tests over 0 and 12 months with five pre-treatments showed no significant differences in germination percentage (GP) or mean germination time (MGT), though seed storage significantly affected the germination index (GI). The highest germination (42.75%) was from seeds stored for 12 months without treatment. Non-storage seeds, GA_3 helped seeds germinate faster but did not improve overall, as no statistically significant germination rates. While seeds store for 12 months, GA_3 did not help seeds germinate faster compared with the control. Water soaking was ineffective. Results suggest *L. geoffrayi* seeds have dormancy and orthodox characteristics. Longer storage improved germination more than soaking seeds in various GA_3 and water, indicating storage alone was a better method to enhance germination. Further studies, like scarification, may help improve germination.

5.5 Effect of BAP on shoot generation of *Limnophila geoffrayi*

Nodal segments of *L. geoffrayi* showed 100% shoot regeneration in all media after 8 weeks. BAP-supplemented media significantly increased shoot growth compared to the control. The optimal concentration was 0.5 mg/l BAP, producing the longest shoots (3.38±0.48 cm), highest shoot number (46.80±9.94), and most leaves per shoot (16.93±2.31). Higher BAP concentrations reduced shoot quality. Root formation began within 8 weeks, but root data in BAP media were not recorded due to shoot clustering. The findings align with previous studies on *L. aromatica*, confirming that moderate BAP levels enhance shoot regeneration effectively.

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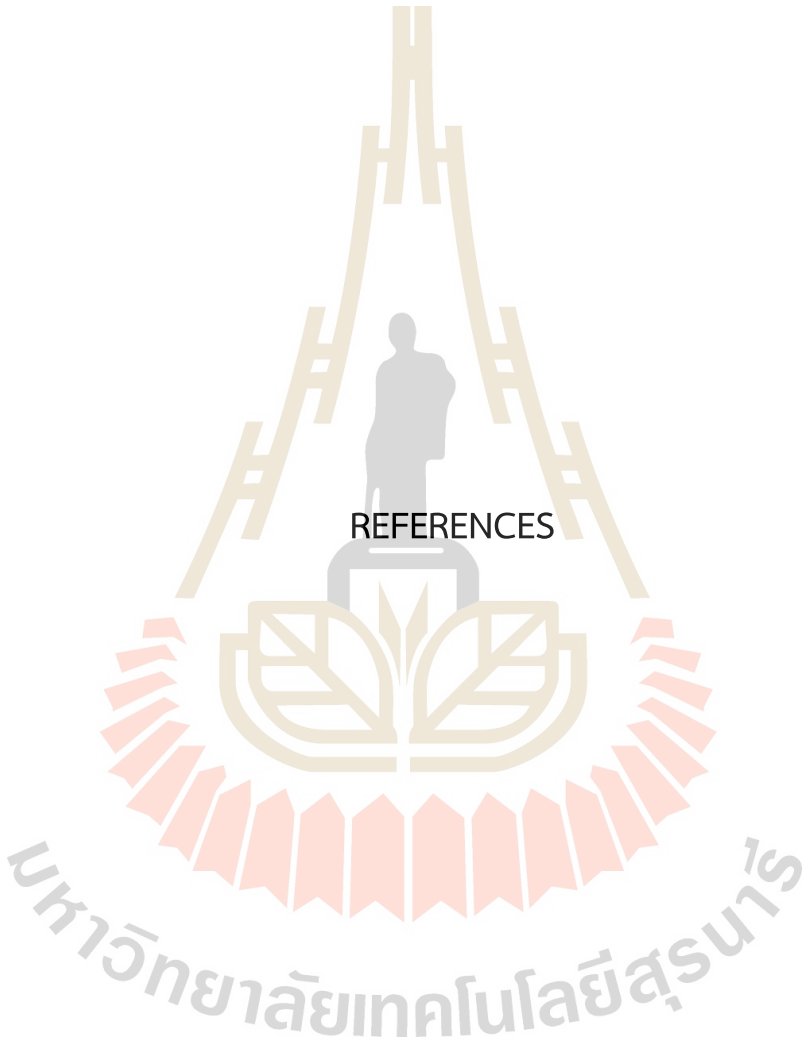

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APPENDICES

APPENDIX A

DATA RECORD OF SEED GERMINATION OF *LIMNOPHILA GEOFFRAYI*

Table A.1 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 0 month for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	0	0	0	0.00	0.00
27/3/2567	10	0	0	0	0	0	0.00	0.00
28/3/2567	11	0	0	0	0	0	0.00	0.00
29/3/2567	12	0	0	0	0	0	0.00	0.00
30/3/2567	13	0	0	0	0	0	0.00	0.00
31/3/2567	14	0	0	0	0	0	0.00	0.00
1/4/2567	15	0	0	0	0	0	0.00	0.00
2/4/2567	16	0	0	0	0	0	0.00	0.00
3/4/2567	17	0	0	0	0	0	0.00	0.00
4/4/2567	18	0	0	0	0	0	0.00	0.00
5/4/2567	19	0	0	0	0	0	0.00	0.00
6/4/2567	20	0	0	0	0	0	0.00	0.00
7/4/2567	21	0	0	0	0	0	0.00	0.00
8/4/2567	22	0	0	0	0	0	0.00	0.00
9/4/2567	23	0	0	0	0	0	0.00	0.00

Table A.1 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
10/4/2567	24	0	0	0	0	0	0.00	0.00
11/4/2567	25	0	0	0	0	0	0.00	0.00
12/4/2567	26	0	0	0	0	0	0.00	0.00
13/4/2567	27	0	0	1	0	1	0.83	0.83
14/4/2567	28	0	0	0	0	1	0.00	0.83
15/4/2567	29	0	0	0	0	1	0.00	0.83
16/4/2567	30	1	0	0	0	2	0.83	1.67
17/4/2567	31	0	0	0	0	2	0.00	1.67
18/4/2567	32	0	0	0	0	2	0.00	1.67
19/4/2567	33	0	0	0	0	2	0.00	1.67
20/4/2567	34	0	0	0	0	2	0.00	1.67
21/4/2567	35	0	0	0	0	2	0.00	1.67
22/4/2567	36	0	0	0	0	2	0.00	1.67
23/4/2567	37	0	0	0	0	2	0.00	1.67
24/4/2567	38	0	0	0	0	2	0.00	1.67
25/4/2567	39	0	0	0	0	2	0.00	1.67
26/4/2567	40	0	0	0	0	2	0.00	1.67
27/4/2567	41	0	1	1	0	4	1.67	3.33
28/4/2567	42	0	0	0	0	4	0.00	3.33
29/4/2567	43	0	1	1	0	6	1.67	5.00
30/4/2567	44	0	0	0	0	6	0.00	5.00
1/5/2567	45	0	0	0	1	7	0.83	5.83
2/5/2567	46	0	0	0	0	7	0.00	5.83
3/5/2567	47	0	0	0	0	7	0.00	5.83
4/5/2567	48	0	0	0	0	7	0.00	5.83
5/5/2567	49	0	0	3	0	10	2.50	8.33
6/5/2567	50	0	0	0	0	10	0.00	8.33
7/5/2567	51	0	0	0	1	11	0.83	9.17
8/5/2567	52	0	0	0	0	11	0.00	9.17
9/5/2567	53	0	1	0	0	12	0.83	10.00

Table A.1 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
10/5/2567	54	0	0	0	0	12	0.00	10.00
11/5/2567	55	0	0	0	0	12	0.00	10.00
12/5/2567	56	0	0	0	1	13	0.83	10.83
13/5/2567	57	0	0	0	0	13	0.00	10.83
14/5/2567	58	0	0	2	0	15	1.67	12.50
15/5/2567	59	0	0	0	0	15	0.00	12.50
16/5/2567	60	0	1	0	0	16	0.83	13.33
17/5/2567	61	0	0	0	0	16	0.00	13.33
18/5/2567	62	0	0	0	0	16	0.00	13.33
19/5/2567	63	1	0	0	0	17	0.83	14.17
20/5/2567	64	0	0	0	0	17	0.00	14.17
21/5/2567	65	0	0	2	3	22	4.17	18.33
22/5/2567	66	0	0	0	0	22	0.00	18.33
23/5/2567	67	0	2	1	0	25	2.50	20.83
24/5/2567	68	0	0	0	0	25	0.00	20.83
25/5/2567	69	0	0	0	0	25	0.00	20.83
26/5/2567	70	0	0	0	0	25	0.00	20.83
27/5/2567	71	0	0	0	0	25	0.00	20.83
28/5/2567	72	0	2	1	1	29	3.33	24.17
29/5/2567	73	0	0	0	0	29	0.00	24.17
30/5/2567	74	0	0	0	0	29	0.00	24.17
31/5/2567	75	0	1	1	1	32	2.50	26.67
1/6/2567	76	0	0	0	0	32	0.00	26.67
2/6/2567	77	0	0	0	0	32	0.00	26.67
3/6/2567	78	0	0	0	0	32	0.00	26.67
4/6/2567	79	0	0	0	0	32	0.00	26.67
5/6/2567	80	0	0	0	1	33	0.83	27.50
6/6/2567	81	0	0	0	0	33	0.00	27.50
7/6/2567	82	0	0	0	0	33	0.00	27.50
8/6/2567	83	0	0	0	0	33	0.00	27.50

Table A.1 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
9/6/2567	84	0	0	0	0	33	0.00	27.50
10/6/2567	85	0	0	0	0	33	0.00	27.50
11/6/2567	86	0	0	2	1	36	2.50	30.00
12/6/2567	87	0	0	0	0	36	0.00	30.00
13/6/2567	88	0	0	0	0	36	0.00	30.00
14/6/2567	89	0	0	0	0	36	0.00	30.00
15/6/2567	90	0	0	0	0	36	0.00	30.00
16/6/2567	91	0	0	0	0	36	0.00	30.00
17/6/2567	92	0	0	0	0	36	0.00	30.00
18/6/2567	93	1	0	0	2	39	2.50	32.50
19/6/2567	94	0	0	0	0	39	0.00	32.50
20/6/2567	95	0	0	0	0	39	0.00	32.50
21/6/2567	96	0	0	0	0	39	0.00	32.50
22/6/2567	97	0	0	0	0	39	0.00	32.50
23/6/2567	98	0	0	0	0	39	0.00	32.50
24/6/2567	99	0	0	0	0	39	0.00	32.50
25/6/2567	100	0	0	0	0	39	0.00	32.50
26/6/2567	101	0	0	0	0	39	0.00	32.50
27/6/2567	102	0	0	0	0	39	0.00	32.50
28/6/2567	103	0	0	0	0	39	0.00	32.50
29/6/2567	104	0	0	0	0	39	0.00	32.50
30/6/2567	105	0	0	0	0	39	0.00	32.50
1/7/2567	106	0	0	0	0	39	0.00	32.50
2/7/2567	107	0	0	0	0	39	0.00	32.50
3/7/2567	108	0	0	0	0	39	0.00	32.50
4/7/2567	109	0	0	0	0	39	0.00	32.50
5/7/2567	110	0	0	0	0	39	0.00	32.50
6/7/2567	111	0	0	0	0	39	0.00	32.50
7/7/2567	112	0	0	0	0	39	0.00	32.50
8/7/2567	113	0	0	0	0	39	0.00	32.50

Table A.1 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
9/7/2567	114	0	0	0	1	40	0.83	33.33
10/7/2567	115	0	0	0	0	40	0.00	33.33
11/7/2567	116	0	0	0	0	40	0.00	33.33
12/7/2567	117	1	0	0	0	41	0.83	34.17
13/7/2567	118	0	0	0	1	42	0.83	35.00
14/7/2567	119	0	0	0	0	42	0.00	35.00
15/7/2567	120	0	0	0	0	42	0.00	35.00

Table A.2 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 0 month for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	0	0	0	0.00	0.00
27/3/2567	10	0	0	0	0	0	0.00	0.00
28/3/2567	11	0	0	0	0	0	0.00	0.00
29/3/2567	12	0	0	0	0	0	0.00	0.00
30/3/2567	13	0	0	0	0	0	0.00	0.00
31/3/2567	14	0	0	0	0	0	0.00	0.00
1/4/2567	15	0	0	0	0	0	0.00	0.00
2/4/2567	16	0	0	0	0	0	0.00	0.00
3/4/2567	17	0	0	0	0	0	0.00	0.00
4/4/2567	18	0	0	0	0	0	0.00	0.00
5/4/2567	19	0	0	0	0	0	0.00	0.00
6/4/2567	20	0	0	0	0	0	0.00	0.00
7/4/2567	21	0	0	0	0	0	0.00	0.00
8/4/2567	22	0	0	0	0	0	0.00	0.00
9/4/2567	23	0	0	0	0	0	0.00	0.00
10/4/2567	24	0	0	0	0	0	0.00	0.00
11/4/2567	25	0	0	0	0	0	0.00	0.00
12/4/2567	26	0	0	0	0	0	0.00	0.00
13/4/2567	27	0	0	0	0	0	0.00	0.00
14/4/2567	28	0	0	0	0	0	0.00	0.00
15/4/2567	29	0	0	0	0	0	0.00	0.00
16/4/2567	30	0	0	0	0	0	0.00	0.00

Table A.2 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
17/4/2567	31	0	0	0	0	0	0.00	0.00
18/4/2567	32	0	0	0	0	0	0.00	0.00
19/4/2567	33	0	0	0	0	0	0.00	0.00
20/4/2567	34	0	0	0	0	0	0.00	0.00
21/4/2567	35	0	0	0	0	0	0.00	0.00
22/4/2567	36	0	1	0	1	2	1.67	1.67
23/4/2567	37	0	0	0	0	2	0.00	1.67
24/4/2567	38	0	2	0	3	7	4.17	5.83
25/4/2567	39	0	0	0	0	7	0.00	5.83
26/4/2567	40	0	0	0	0	7	0.00	5.83
27/4/2567	41	0	0	1	0	8	0.83	6.67
28/4/2567	42	0	0	0	0	8	0.00	6.67
29/4/2567	43	0	0	0	0	8	0.00	6.67
30/4/2567	44	0	0	0	0	8	0.00	6.67
1/5/2567	45	0	0	0	0	8	0.00	6.67
2/5/2567	46	0	0	0	0	8	0.00	6.67
3/5/2567	47	0	0	0	0	8	0.00	6.67
4/5/2567	48	0	0	0	0	8	0.00	6.67
5/5/2567	49	0	0	0	0	8	0.00	6.67
6/5/2567	50	0	0	0	0	8	0.00	6.67
7/5/2567	51	1	0	0	0	9	0.83	7.50
8/5/2567	52	0	0	0	0	9	0.00	7.50
9/5/2567	53	0	0	0	0	9	0.00	7.50
10/5/2567	54	0	0	0	0	9	0.00	7.50
11/5/2567	55	0	0	0	0	9	0.00	7.50
12/5/2567	56	0	0	0	0	9	0.00	7.50
13/5/2567	57	0	0	0	0	9	0.00	7.50
14/5/2567	58	1	1	1	0	12	2.50	10.00
15/5/2567	59	0	0	0	0	12	0.00	10.00

Table A.2 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
16/5/2567	60	0	0	0	0	12	0.00	10.00
17/5/2567	61	0	0	0	0	12	0.00	10.00
18/5/2567	62	0	0	0	0	12	0.00	10.00
19/5/2567	63	0	0	1	1	14	1.67	11.67
20/5/2567	64	0	0	0	0	14	0.00	11.67
21/5/2567	65	0	1	0	1	16	1.67	13.33
22/5/2567	66	0	0	0	0	16	0.00	13.33
23/5/2567	67	0	0	0	1	17	0.83	14.17
24/5/2567	68	0	0	0	0	17	0.00	14.17
25/5/2567	69	0	0	0	0	17	0.00	14.17
26/5/2567	70	0	0	0	0	17	0.00	14.17
27/5/2567	71	0	0	0	0	17	0.00	14.17
28/5/2567	72	0	0	0	0	17	0.00	14.17
29/5/2567	73	0	0	0	0	17	0.00	14.17
30/5/2567	74	0	0	0	0	17	0.00	14.17
31/5/2567	75	0	0	1	1	19	1.67	15.83
1/6/2567	76	0	0	0	0	19	0.00	15.83
2/6/2567	77	0	0	0	0	19	0.00	15.83
3/6/2567	78	0	0	0	0	19	0.00	15.83
4/6/2567	79	0	0	0	0	19	0.00	15.83
5/6/2567	80	0	0	0	0	19	0.00	15.83
6/6/2567	81	0	0	0	0	19	0.00	15.83
7/6/2567	82	0	0	0	0	19	0.00	15.83
8/6/2567	83	0	0	0	0	19	0.00	15.83
9/6/2567	84	0	0	0	0	19	0.00	15.83
10/6/2567	85	0	0	0	0	19	0.00	15.83
11/6/2567	86	0	0	1	0	20	0.83	16.67
12/6/2567	87	0	0	0	0	20	0.00	16.67
13/6/2567	88	0	0	0	0	20	0.00	16.67

Table A.2 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
14/6/2567	89	0	0	0	0	20	0.00	16.67
15/6/2567	90	0	0	0	0	20	0.00	16.67
16/6/2567	91	0	0	0	0	20	0.00	16.67
17/6/2567	92	0	0	0	0	20	0.00	16.67
18/6/2567	93	1	2	0	0	23	2.50	19.17
19/6/2567	94	0	0	0	0	23	0.00	19.17
20/6/2567	95	0	0	0	0	23	0.00	19.17
21/6/2567	96	0	0	0	0	23	0.00	19.17
22/6/2567	97	0	0	0	0	23	0.00	19.17
23/6/2567	98	0	0	0	0	23	0.00	19.17
24/6/2567	99	0	0	0	0	23	0.00	19.17
25/6/2567	100	0	0	0	0	23	0.00	19.17
26/6/2567	101	0	0	0	0	23	0.00	19.17
27/6/2567	102	0	0	0	0	23	0.00	19.17
28/6/2567	103	0	0	0	0	23	0.00	19.17
29/6/2567	104	0	0	0	0	23	0.00	19.17
30/6/2567	105	0	0	0	0	23	0.00	19.17
1/7/2567	106	0	0	0	0	23	0.00	19.17
2/7/2567	107	0	0	0	0	23	0.00	19.17
3/7/2567	108	0	0	0	0	23	0.00	19.17
4/7/2567	109	0	0	0	0	23	0.00	19.17
5/7/2567	110	0	0	0	0	23	0.00	19.17
6/7/2567	111	0	0	0	0	23	0.00	19.17
7/7/2567	112	0	0	0	0	23	0.00	19.17
8/7/2567	113	0	0	0	0	23	0.00	19.17
9/7/2567	114	0	0	0	0	23	0.00	19.17
10/7/2567	115	0	0	0	0	23	0.00	19.17
11/7/2567	116	0	0	0	0	23	0.00	19.17
12/7/2567	117	0	0	0	0	23	0.00	19.17

Table A.2 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
13/7/2567	118	0	0	0	0	23	0.00	19.17
14/7/2567	119	0	0	1	0	24	0.83	20.00
15/7/2567	120	0	1	1	0	26	1.67	21.67

Table A.3 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	0	0	0	0.00	0.00
27/3/2567	10	0	0	0	0	0	0.00	0.00
28/3/2567	11	0	0	0	0	0	0.00	0.00
29/3/2567	12	0	0	0	0	0	0.00	0.00
30/3/2567	13	0	0	0	0	0	0.00	0.00
31/3/2567	14	0	0	0	0	0	0.00	0.00
1/4/2567	15	0	0	0	0	0	0.00	0.00
2/4/2567	16	0	0	0	0	0	0.00	0.00
3/4/2567	17	0	0	0	0	0	0.00	0.00
4/4/2567	18	0	0	0	0	0	0.00	0.00
5/4/2567	19	0	0	0	0	0	0.00	0.00
6/4/2567	20	0	0	0	0	0	0.00	0.00
7/4/2567	21	0	0	0	0	0	0.00	0.00
8/4/2567	22	0	0	0	0	0	0.00	0.00
9/4/2567	23	0	0	0	0	0	0.00	0.00
10/4/2567	24	0	0	2	0	2	1.67	1.67
11/4/2567	25	0	0	0	0	2	0.00	1.67
12/4/2567	26	0	0	0	0	2	0.00	1.67
13/4/2567	27	1	0	2	0	5	2.50	4.17
14/4/2567	28	0	0	0	0	5	0.00	4.17
15/4/2567	29	0	0	0	0	5	0.00	4.17
16/4/2567	30	0	0	0	0	5	0.00	4.17

Table A.3 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
17/4/2567	31	0	0	0	0	5	0.00	4.17
18/4/2567	32	1	0	0	0	6	0.83	5.00
19/4/2567	33	0	0	0	0	6	0.00	5.00
20/4/2567	34	0	0	1	0	7	0.83	5.83
21/4/2567	35	0	0	0	0	7	0.00	5.83
22/4/2567	36	0	0	0	0	7	0.00	5.83
23/4/2567	37	0	0	0	0	7	0.00	5.83
24/4/2567	38	0	0	1	0	8	0.83	6.67
25/4/2567	39	0	0	0	0	8	0.00	6.67
26/4/2567	40	0	0	0	0	8	0.00	6.67
27/4/2567	41	0	0	0	0	8	0.00	6.67
28/4/2567	42	0	0	0	0	8	0.00	6.67
29/4/2567	43	0	1	0	0	9	0.83	7.50
30/4/2567	44	0	0	0	0	9	0.00	7.50
1/5/2567	45	0	0	0	0	9	0.00	7.50
2/5/2567	46	0	0	0	0	9	0.00	7.50
3/5/2567	47	0	0	0	0	9	0.00	7.50
4/5/2567	48	0	0	0	0	9	0.00	7.50
5/5/2567	49	0	0	0	0	9	0.00	7.50
6/5/2567	50	0	0	0	0	9	0.00	7.50
7/5/2567	51	0	0	0	0	9	0.00	7.50
8/5/2567	52	0	0	0	0	9	0.00	7.50
9/5/2567	53	0	0	0	0	9	0.00	7.50
10/5/2567	54	0	0	0	0	9	0.00	7.50
11/5/2567	55	0	0	0	0	9	0.00	7.50
12/5/2567	56	0	0	0	0	9	0.00	7.50
13/5/2567	57	0	0	0	0	9	0.00	7.50
14/5/2567	58	0	0	1	0	10	0.83	8.33
15/5/2567	59	0	0	0	0	10	0.00	8.33

Table A.3 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
16/5/2567	60	0	0	0	0	10	0.00	8.33
17/5/2567	61	0	0	0	0	10	0.00	8.33
18/5/2567	62	0	0	0	0	10	0.00	8.33
19/5/2567	63	0	0	1	0	11	0.83	9.17
20/5/2567	64	0	0	0	0	11	0.00	9.17
21/5/2567	65	0	0	0	1	12	0.83	10.00
22/5/2567	66	0	0	0	0	12	0.00	10.00
23/5/2567	67	0	0	0	0	12	0.00	10.00
24/5/2567	68	0	0	0	0	12	0.00	10.00
25/5/2567	69	0	1	1	1	15	2.50	12.50
26/5/2567	70	0	0	0	0	15	0.00	12.50
27/5/2567	71	0	0	0	0	15	0.00	12.50
28/5/2567	72	1	0	3	1	20	4.17	16.67
29/5/2567	73	0	0	0	0	20	0.00	16.67
30/5/2567	74	0	0	0	0	20	0.00	16.67
31/5/2567	75	0	0	0	3	23	2.50	19.17
1/6/2567	76	0	0	0	0	23	0.00	19.17
2/6/2567	77	0	0	0	0	23	0.00	19.17
3/6/2567	78	0	0	0	0	23	0.00	19.17
4/6/2567	79	0	0	0	0	23	0.00	19.17
5/6/2567	80	0	0	0	0	23	0.00	19.17
6/6/2567	81	0	0	0	0	23	0.00	19.17
7/6/2567	82	0	0	0	0	23	0.00	19.17
8/6/2567	83	0	0	0	0	23	0.00	19.17
9/6/2567	84	0	0	0	0	23	0.00	19.17
10/6/2567	85	0	0	0	0	23	0.00	19.17
11/6/2567	86	0	0	0	1	24	0.83	20.00
12/6/2567	87	0	0	0	0	24	0.00	20.00
13/6/2567	88	0	0	0	0	24	0.00	20.00

Table A.3 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
14/6/2567	89	0	0	0	0	24	0.00	20.00
15/6/2567	90	0	0	0	0	24	0.00	20.00
16/6/2567	91	0	0	0	0	24	0.00	20.00
17/6/2567	92	0	0	0	0	24	0.00	20.00
18/6/2567	93	0	0	0	0	24	0.00	20.00
19/6/2567	94	0	0	0	0	24	0.00	20.00
20/6/2567	95	0	0	0	0	24	0.00	20.00
21/6/2567	96	0	0	0	0	24	0.00	20.00
22/6/2567	97	0	0	0	0	24	0.00	20.00
23/6/2567	98	0	0	0	0	24	0.00	20.00
24/6/2567	99	0	0	0	0	24	0.00	20.00
25/6/2567	100	0	0	0	0	24	0.00	20.00
26/6/2567	101	0	0	0	0	24	0.00	20.00
27/6/2567	102	0	0	0	0	24	0.00	20.00
28/6/2567	103	0	0	0	0	24	0.00	20.00
29/6/2567	104	0	0	0	0	24	0.00	20.00
30/6/2567	105	0	0	0	0	24	0.00	20.00
1/7/2567	106	0	0	0	0	24	0.00	20.00
2/7/2567	107	0	0	0	0	24	0.00	20.00
3/7/2567	108	0	0	0	0	24	0.00	20.00
4/7/2567	109	0	0	0	0	24	0.00	20.00
5/7/2567	110	0	0	0	0	24	0.00	20.00
6/7/2567	111	0	0	0	0	24	0.00	20.00
7/7/2567	112	0	0	0	0	24	0.00	20.00
8/7/2567	113	0	0	0	0	24	0.00	20.00
9/7/2567	114	0	0	0	0	24	0.00	20.00
10/7/2567	115	0	0	0	0	24	0.00	20.00
11/7/2567	116	0	0	0	0	24	0.00	20.00
12/7/2567	117	0	0	0	0	24	0.00	20.00

Table A.3 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
13/7/2567	118	0	0	0	0	24	0.00	20.00
14/7/2567	119	0	0	0	0	24	0.00	20.00
15/7/2567	120	1	1	0	0	26	1.67	21.67

Table A.4 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	0	0	0	0.00	0.00
27/3/2567	10	0	0	0	0	0	0.00	0.00
28/3/2567	11	0	0	0	0	0	0.00	0.00
29/3/2567	12	0	0	0	1	1	0.83	0.83
30/3/2567	13	0	0	0	0	1	0.00	0.83
31/3/2567	14	3	0	0	0	4	2.50	3.33
1/4/2567	15	0	0	0	0	4	0.00	3.33
2/4/2567	16	1	0	0	0	5	0.83	4.17
3/4/2567	17	0	0	0	0	5	0.00	4.17
4/4/2567	18	0	0	0	0	5	0.00	4.17
5/4/2567	19	0	0	0	0	5	0.00	4.17
6/4/2567	20	0	0	0	0	5	0.00	4.17
7/4/2567	21	0	0	0	0	5	0.00	4.17
8/4/2567	22	0	0	0	0	5	0.00	4.17
9/4/2567	23	0	0	0	0	5	0.00	4.17
10/4/2567	24	0	0	0	0	5	0.00	4.17
11/4/2567	25	0	0	0	0	5	0.00	4.17
12/4/2567	26	0	0	0	0	5	0.00	4.17
13/4/2567	27	0	1	0	0	6	0.83	5.00
14/4/2567	28	0	0	0	0	6	0.00	5.00
15/4/2567	29	0	0	0	0	6	0.00	5.00
16/4/2567	30	0	0	0	1	7	0.83	5.83

Table A.4 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
17/4/2567	31	0	0	0	0	7	0.00	5.83
18/4/2567	32	0	0	0	0	7	0.00	5.83
19/4/2567	33	0	0	0	0	7	0.00	5.83
20/4/2567	34	0	0	0	2	9	1.67	7.50
21/4/2567	35	0	0	0	0	9	0.00	7.50
22/4/2567	36	1	0	0	0	10	0.83	8.33
23/4/2567	37	0	0	0	0	10	0.00	8.33
24/4/2567	38	0	0	0	0	10	0.00	8.33
25/4/2567	39	0	0	0	0	10	0.00	8.33
26/4/2567	40	0	0	0	0	10	0.00	8.33
27/4/2567	41	1	0	0	0	11	0.83	9.17
28/4/2567	42	0	0	0	0	11	0.00	9.17
29/4/2567	43	0	1	0	0	12	0.83	10.00
30/4/2567	44	0	0	0	0	12	0.00	10.00
1/5/2567	45	0	0	0	0	12	0.00	10.00
2/5/2567	46	0	0	0	0	12	0.00	10.00
3/5/2567	47	0	0	0	0	12	0.00	10.00
4/5/2567	48	0	0	0	0	12	0.00	10.00
5/5/2567	49	0	0	0	0	12	0.00	10.00
6/5/2567	50	0	0	0	0	12	0.00	10.00
7/5/2567	51	0	0	0	0	12	0.00	10.00
8/5/2567	52	0	0	0	0	12	0.00	10.00
9/5/2567	53	0	0	0	1	13	0.83	10.83
10/5/2567	54	0	0	0	0	13	0.00	10.83
11/5/2567	55	0	0	0	0	13	0.00	10.83
12/5/2567	56	0	0	0	0	13	0.00	10.83
13/5/2567	57	0	0	0	0	13	0.00	10.83
14/5/2567	58	0	1	0	0	14	0.83	11.67
15/5/2567	59	0	0	0	0	14	0.00	11.67

Table A.4 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
16/5/2567	60	0	0	0	0	14	0.00	11.67
17/5/2567	61	0	0	0	0	14	0.00	11.67
18/5/2567	62	0	0	0	0	14	0.00	11.67
19/5/2567	63	0	1	0	0	15	0.83	12.50
20/5/2567	64	0	0	0	0	15	0.00	12.50
21/5/2567	65	0	0	0	0	15	0.00	12.50
22/5/2567	66	0	0	0	0	15	0.00	12.50
23/5/2567	67	0	1	0	0	16	0.83	13.33
24/5/2567	68	0	0	0	0	16	0.00	13.33
25/5/2567	69	0	0	0	0	16	0.00	13.33
26/5/2567	70	0	0	0	0	16	0.00	13.33
27/5/2567	71	0	0	0	0	16	0.00	13.33
28/5/2567	72	1	0	0	0	17	0.83	14.17
29/5/2567	73	0	0	0	0	17	0.00	14.17
30/5/2567	74	0	0	0	0	17	0.00	14.17
31/5/2567	75	0	0	0	1	18	0.83	15.00
1/6/2567	76	0	0	0	0	18	0.00	15.00
2/6/2567	77	0	0	0	0	18	0.00	15.00
3/6/2567	78	0	0	0	0	18	0.00	15.00
4/6/2567	79	0	0	0	0	18	0.00	15.00
5/6/2567	80	0	0	0	0	18	0.00	15.00
6/6/2567	81	0	0	0	0	18	0.00	15.00
7/6/2567	82	0	0	0	0	18	0.00	15.00
8/6/2567	83	0	0	0	0	18	0.00	15.00
9/6/2567	84	0	0	0	0	18	0.00	15.00
10/6/2567	85	0	0	0	0	18	0.00	15.00
11/6/2567	86	0	0	3	0	21	2.50	17.50
12/6/2567	87	0	0	0	0	21	0.00	17.50
13/6/2567	88	0	0	0	0	21	0.00	17.50

Table A.4 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
14/6/2567	89	0	0	0	0	21	0.00	17.50
15/6/2567	90	0	0	0	0	21	0.00	17.50
16/6/2567	91	0	0	0	0	21	0.00	17.50
17/6/2567	92	0	0	0	0	21	0.00	17.50
18/6/2567	93	0	0	0	0	21	0.00	17.50
19/6/2567	94	0	0	0	0	21	0.00	17.50
20/6/2567	95	0	0	0	0	21	0.00	17.50
21/6/2567	96	0	0	0	0	21	0.00	17.50
22/6/2567	97	0	0	0	0	21	0.00	17.50
23/6/2567	98	0	0	0	0	21	0.00	17.50
24/6/2567	99	0	0	0	0	21	0.00	17.50
25/6/2567	100	0	0	0	0	21	0.00	17.50
26/6/2567	101	0	0	0	0	21	0.00	17.50
27/6/2567	102	0	0	0	0	21	0.00	17.50
28/6/2567	103	0	0	0	0	21	0.00	17.50
29/6/2567	104	0	0	0	0	21	0.00	17.50
30/6/2567	105	0	0	0	0	21	0.00	17.50
1/7/2567	106	0	0	0	0	21	0.00	17.50
2/7/2567	107	0	0	0	0	21	0.00	17.50
3/7/2567	108	0	0	0	0	21	0.00	17.50
4/7/2567	109	0	0	0	0	21	0.00	17.50
5/7/2567	110	0	0	0	0	21	0.00	17.50
6/7/2567	111	0	0	0	0	21	0.00	17.50
7/7/2567	112	0	0	0	0	21	0.00	17.50
8/7/2567	113	0	0	0	0	21	0.00	17.50
9/7/2567	114	0	0	0	0	21	0.00	17.50
10/7/2567	115	0	0	0	0	21	0.00	17.50
11/7/2567	116	0	0	0	0	21	0.00	17.50
12/7/2567	117	0	0	0	0	21	0.00	17.50

Table A.4 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
13/7/2567	118	0	0	0	0	21	0.00	17.50
14/7/2567	119	0	0	0	0	21	0.00	17.50
15/7/2567	120	1	1	0	0	23	1.67	19.17

Table A.5 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	0	0	0	0.00	0.00
27/3/2567	10	0	0	0	0	0	0.00	0.00
28/3/2567	11	0	0	0	0	0	0.00	0.00
29/3/2567	12	0	0	0	0	0	0.00	0.00
30/3/2567	13	0	0	0	0	0	0.00	0.00
31/3/2567	14	0	0	0	0	0	0.00	0.00
1/4/2567	15	0	0	0	0	0	0.00	0.00
2/4/2567	16	0	0	0	0	0	0.00	0.00
3/4/2567	17	0	0	1	0	1	0.83	0.83
4/4/2567	18	0	0	0	0	1	0.00	0.83
5/4/2567	19	0	0	0	0	1	0.00	0.83
6/4/2567	20	0	0	0	0	1	0.00	0.83
7/4/2567	21	0	1	1	0	3	1.67	2.50
8/4/2567	22	0	0	0	0	3	0.00	2.50
9/4/2567	23	0	0	2	0	5	1.67	4.17
10/4/2567	24	0	2	0	0	7	1.67	5.83
11/4/2567	25	0	0	0	0	7	0.00	5.83
12/4/2567	26	0	0	0	0	7	0.00	5.83
13/4/2567	27	0	0	0	0	7	0.00	5.83
14/4/2567	28	0	0	0	0	7	0.00	5.83
15/4/2567	29	0	0	0	0	7	0.00	5.83
16/4/2567	30	0	0	0	0	7	0.00	5.83

Table A.5 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
17/4/2567	31	0	0	0	0	7	0.00	5.83
18/4/2567	32	0	0	0	0	7	0.00	5.83
19/4/2567	33	0	0	0	0	7	0.00	5.83
20/4/2567	34	0	0	1	0	8	0.83	6.67
21/4/2567	35	0	0	0	0	8	0.00	6.67
22/4/2567	36	0	0	0	0	8	0.00	6.67
23/4/2567	37	0	0	0	0	8	0.00	6.67
24/4/2567	38	1	0	0	0	9	0.83	7.50
25/4/2567	39	0	0	0	0	9	0.00	7.50
26/4/2567	40	0	0	0	0	9	0.00	7.50
27/4/2567	41	0	1	0	0	10	0.83	8.33
28/4/2567	42	0	0	0	0	10	0.00	8.33
29/4/2567	43	0	0	0	0	10	0.00	8.33
30/4/2567	44	0	0	0	0	10	0.00	8.33
1/5/2567	45	1	0	0	0	11	0.83	9.17
2/5/2567	46	0	0	0	0	11	0.00	9.17
3/5/2567	47	1	0	0	0	12	0.83	10.00
4/5/2567	48	0	0	0	0	12	0.00	10.00
5/5/2567	49	0	0	0	0	12	0.00	10.00
6/5/2567	50	0	0	0	0	12	0.00	10.00
7/5/2567	51	0	0	1	0	13	0.83	10.83
8/5/2567	52	0	0	0	0	13	0.00	10.83
9/5/2567	53	0	1	0	0	14	0.83	11.67
10/5/2567	54	0	0	0	0	14	0.00	11.67
11/5/2567	55	0	0	0	0	14	0.00	11.67
12/5/2567	56	0	0	1	0	15	0.83	12.50
13/5/2567	57	0	0	0	0	15	0.00	12.50
14/5/2567	58	0	0	0	0	15	0.00	12.50
15/5/2567	59	0	0	0	0	15	0.00	12.50

Table A.5 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
16/5/2567	60	0	1	0	0	16	0.83	13.33
17/5/2567	61	0	0	0	0	16	0.00	13.33
18/5/2567	62	0	0	0	0	16	0.00	13.33
19/5/2567	63	0	0	1	0	17	0.83	14.17
20/5/2567	64	0	0	0	0	17	0.00	14.17
21/5/2567	65	1	2	0	0	20	2.50	16.67
22/5/2567	66	0	0	0	0	20	0.00	16.67
23/5/2567	67	0	0	0	0	20	0.00	16.67
24/5/2567	68	0	0	0	0	20	0.00	16.67
25/5/2567	69	0	0	0	0	20	0.00	16.67
26/5/2567	70	0	0	0	0	20	0.00	16.67
27/5/2567	71	0	0	0	0	20	0.00	16.67
28/5/2567	72	0	0	0	0	20	0.00	16.67
29/5/2567	73	0	0	0	0	20	0.00	16.67
30/5/2567	74	0	0	0	0	20	0.00	16.67
31/5/2567	75	0	0	0	0	20	0.00	16.67
1/6/2567	76	0	0	0	0	20	0.00	16.67
2/6/2567	77	0	0	0	0	20	0.00	16.67
3/6/2567	78	0	1	0	0	21	0.83	17.50
4/6/2567	79	0	0	0	0	21	0.00	17.50
5/6/2567	80	0	0	0	0	21	0.00	17.50
6/6/2567	81	0	0	0	0	21	0.00	17.50
7/6/2567	82	0	0	0	0	21	0.00	17.50
8/6/2567	83	0	0	0	0	21	0.00	17.50
9/6/2567	84	0	0	0	0	21	0.00	17.50
10/6/2567	85	0	0	0	0	21	0.00	17.50
11/6/2567	86	2	1	0	0	24	2.50	20.00
12/6/2567	87	0	0	0	0	24	0.00	20.00
13/6/2567	88	0	0	0	0	24	0.00	20.00

Table A.5 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
14/6/2567	89	0	0	0	0	24	0.00	20.00
15/6/2567	90	0	0	0	0	24	0.00	20.00
16/6/2567	91	0	0	0	0	24	0.00	20.00
17/6/2567	92	0	0	0	0	24	0.00	20.00
18/6/2567	93	2	0	0	0	26	1.67	21.67
19/6/2567	94	0	0	0	0	26	0.00	21.67
20/6/2567	95	0	0	0	0	26	0.00	21.67
21/6/2567	96	0	0	0	0	26	0.00	21.67
22/6/2567	97	0	0	0	0	26	0.00	21.67
23/6/2567	98	0	0	0	0	26	0.00	21.67
24/6/2567	99	0	0	0	0	26	0.00	21.67
25/6/2567	100	0	0	0	0	26	0.00	21.67
26/6/2567	101	0	0	0	0	26	0.00	21.67
27/6/2567	102	0	0	0	0	26	0.00	21.67
28/6/2567	103	0	0	0	0	26	0.00	21.67
29/6/2567	104	0	0	0	0	26	0.00	21.67
30/6/2567	105	0	0	0	0	26	0.00	21.67
1/7/2567	106	0	0	0	0	26	0.00	21.67
2/7/2567	107	0	0	0	0	26	0.00	21.67
3/7/2567	108	0	0	0	0	26	0.00	21.67
4/7/2567	109	0	0	0	0	26	0.00	21.67
5/7/2567	110	0	0	0	0	26	0.00	21.67
6/7/2567	111	0	0	0	0	26	0.00	21.67
7/7/2567	112	0	0	0	0	26	0.00	21.67
8/7/2567	113	0	0	0	0	26	0.00	21.67
9/7/2567	114	0	0	0	0	26	0.00	21.67
10/7/2567	115	0	0	0	0	26	0.00	21.67
11/7/2567	116	0	0	0	0	26	0.00	21.67
12/7/2567	117	0	0	0	0	26	0.00	21.67

Table A.5 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 0 month for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
13/7/2567	118	0	0	0	0	26	0.00	21.67
14/7/2567	119	0	0	0	0	26	0.00	21.67
15/7/2567	120	1	1	0	0	28	1.67	23.33

Table A.6 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 12 months for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	0	0	0	0.00	0.00
27/3/2567	10	0	0	1	0	1	0.83	0.83
28/3/2567	11	0	0	3	0	4	2.50	3.33
29/3/2567	12	0	0	0	0	4	0.00	3.33
30/3/2567	13	0	0	1	0	5	0.83	4.17
31/3/2567	14	0	0	0	0	5	0.00	4.17
1/4/2567	15	1	0	3	1	10	4.17	8.33
2/4/2567	16	1	0	0	0	11	0.83	9.17
3/4/2567	17	0	0	0	0	11	0.00	9.17
4/4/2567	18	1	0	0	0	12	0.83	10.00
5/4/2567	19	0	0	0	0	12	0.00	10.00
6/4/2567	20	0	0	0	0	12	0.00	10.00
7/4/2567	21	1	0	0	0	13	0.83	10.83
8/4/2567	22	0	0	0	0	13	0.00	10.83
9/4/2567	23	0	0	0	0	13	0.00	10.83
10/4/2567	24	0	0	0	0	13	0.00	10.83
11/4/2567	25	0	0	0	0	13	0.00	10.83
12/4/2567	26	0	0	0	0	13	0.00	10.83
13/4/2567	27	1	2	0	0	16	2.50	13.33
14/4/2567	28	0	0	0	0	16	0.00	13.33
15/4/2567	29	0	0	0	0	16	0.00	13.33
16/4/2567	30	2	0	0	0	18	1.67	15.00

Table A.6 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
17/4/2567	31	0	0	0	0	18	0.00	15.00
18/4/2567	32	0	1	0	0	19	0.83	15.83
19/4/2567	33	0	0	0	0	19	0.00	15.83
20/4/2567	34	0	1	0	0	20	0.83	16.67
21/4/2567	35	0	0	0	0	20	0.00	16.67
22/4/2567	36	1	0	1	0	22	1.67	18.33
23/4/2567	37	0	0	0	0	22	0.00	18.33
24/4/2567	38	0	0	0	0	22	0.00	18.33
25/4/2567	39	0	0	0	0	22	0.00	18.33
26/4/2567	40	0	0	0	0	22	0.00	18.33
27/4/2567	41	2	1	0	0	25	2.50	20.83
28/4/2567	42	0	0	0	0	25	0.00	20.83
29/4/2567	43	0	0	0	0	25	0.00	20.83
30/4/2567	44	0	0	0	0	25	0.00	20.83
1/5/2567	45	0	0	0	0	25	0.00	20.83
2/5/2567	46	0	0	0	0	25	0.00	20.83
3/5/2567	47	0	0	0	0	25	0.00	20.83
4/5/2567	48	0	0	0	0	25	0.00	20.83
5/5/2567	49	0	0	0	0	25	0.00	20.83
6/5/2567	50	0	0	0	0	25	0.00	20.83
7/5/2567	51	2	2	0	0	29	3.33	24.17
8/5/2567	52	0	0	0	0	29	0.00	24.17
9/5/2567	53	0	0	0	0	29	0.00	24.17
10/5/2567	54	0	0	0	0	29	0.00	24.17
11/5/2567	55	0	0	0	0	29	0.00	24.17
12/5/2567	56	0	0	0	0	29	0.00	24.17
13/5/2567	57	0	0	0	0	29	0.00	24.17
14/5/2567	58	1	1	0	0	31	1.67	25.83
15/5/2567	59	0	0	0	0	31	0.00	25.83
16/5/2567	60	0	1	0	0	32	0.83	26.67

Table A.6 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
17/5/2567	61	0	0	0	0	32	0.00	26.67
18/5/2567	62	0	0	0	0	32	0.00	26.67
19/5/2567	63	0	0	0	0	32	0.00	26.67
20/5/2567	64	0	0	0	0	32	0.00	26.67
21/5/2567	65	0	0	1	1	34	1.67	28.33
22/5/2567	66	0	0	0	0	34	0.00	28.33
23/5/2567	67	3	1	1	0	39	4.17	32.50
24/5/2567	68	0	0	0	0	39	0.00	32.50
25/5/2567	69	0	0	0	1	40	0.83	33.33
26/5/2567	70	0	0	0	0	40	0.00	33.33
27/5/2567	71	0	0	0	0	40	0.00	33.33
28/5/2567	72	0	0	0	0	40	0.00	33.33
29/5/2567	73	0	0	0	0	40	0.00	33.33
30/5/2567	74	0	0	0	0	40	0.00	33.33
31/5/2567	75	0	0	0	0	40	0.00	33.33
1/6/2567	76	0	0	0	0	40	0.00	33.33
2/6/2567	77	0	0	0	0	40	0.00	33.33
3/6/2567	78	0	0	0	0	40	0.00	33.33
4/6/2567	79	0	0	0	0	40	0.00	33.33
5/6/2567	80	0	0	0	0	40	0.00	33.33
6/6/2567	81	0	0	0	0	40	0.00	33.33
7/6/2567	82	0	0	0	0	40	0.00	33.33
8/6/2567	83	0	0	0	0	40	0.00	33.33
9/6/2567	84	0	0	0	0	40	0.00	33.33
10/6/2567	85	0	0	0	0	40	0.00	33.33
11/6/2567	86	0	0	0	0	40	0.00	33.33
12/6/2567	87	0	0	0	0	40	0.00	33.33
13/6/2567	88	0	0	0	0	40	0.00	33.33
14/6/2567	89	0	0	0	0	40	0.00	33.33
15/6/2567	90	0	0	0	0	40	0.00	33.33

Table A.6 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in control under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
16/6/2567	91	0	0	0	0	40	0.00	33.33
17/6/2567	92	0	0	0	0	40	0.00	33.33
18/6/2567	93	0	0	0	0	40	0.00	33.33
19/6/2567	94	0	0	0	0	40	0.00	33.33
20/6/2567	95	0	0	0	0	40	0.00	33.33
21/6/2567	96	0	0	1	0	41	0.83	34.17
22/6/2567	97	0	0	0	0	41	0.00	34.17
23/6/2567	98	0	0	0	0	41	0.00	34.17
24/6/2567	99	0	0	0	0	41	0.00	34.17
25/6/2567	100	1	1	0	0	43	1.67	35.83
26/6/2567	101	0	0	0	0	43	0.00	35.83
27/6/2567	102	0	0	0	0	43	0.00	35.83
28/6/2567	103	0	1	1	0	45	1.67	37.50
29/6/2567	104	0	0	0	0	45	0.00	37.50
30/6/2567	105	0	0	0	0	45	0.00	37.50
1/7/2567	106	0	0	0	0	45	0.00	37.50
2/7/2567	107	0	2	0	1	48	2.50	40.00
3/7/2567	108	0	0	0	0	48	0.00	40.00
4/7/2567	109	0	0	0	0	48	0.00	40.00
5/7/2567	110	0	0	0	0	48	0.00	40.00
6/7/2567	111	0	0	0	0	48	0.00	40.00
7/7/2567	112	0	0	0	0	48	0.00	40.00
8/7/2567	113	0	0	2	1	51	2.50	42.50
9/7/2567	114	0	0	0	0	51	0.00	42.50
10/7/2567	115	0	0	0	0	51	0.00	42.50
11/7/2567	116	0	0	0	0	51	0.00	42.50
12/7/2567	117	0	0	0	0	51	0.00	42.50
13/7/2567	118	0	0	0	0	51	0.00	42.50
14/7/2567	119	0	0	0	0	51	0.00	42.50
15/7/2567	120	0	0	0	0	51	0.00	42.50

Table A.7 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 12 months for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	2	0	2	4	3.33	3.33
27/3/2567	10	0	0	0	0	4	0.00	3.33
28/3/2567	11	0	0	1	1	6	1.67	5.00
29/3/2567	12	0	0	0	0	6	0.00	5.00
30/3/2567	13	0	0	0	0	6	0.00	5.00
31/3/2567	14	0	0	0	0	6	0.00	5.00
1/4/2567	15	0	0	0	0	6	0.00	5.00
2/4/2567	16	0	0	0	1	7	0.83	5.83
3/4/2567	17	0	0	0	0	7	0.00	5.83
4/4/2567	18	0	0	0	0	7	0.00	5.83
5/4/2567	19	0	0	0	0	7	0.00	5.83
6/4/2567	20	0	0	0	0	7	0.00	5.83
7/4/2567	21	0	0	0	0	7	0.00	5.83
8/4/2567	22	0	0	0	0	7	0.00	5.83
9/4/2567	23	0	0	0	0	7	0.00	5.83
10/4/2567	24	0	0	3	0	10	2.50	8.33
11/4/2567	25	0	0	0	0	10	0.00	8.33
12/4/2567	26	0	0	0	0	10	0.00	8.33
13/4/2567	27	0	1	1	0	12	1.67	10.00
14/4/2567	28	0	0	0	0	12	0.00	10.00
15/4/2567	29	0	0	0	0	12	0.00	10.00
16/4/2567	30	0	0	0	2	14	1.67	11.67

Table A.7 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
17/4/2567	31	0	0	0	0	14	0.00	11.67
18/4/2567	32	0	0	0	0	14	0.00	11.67
19/4/2567	33	0	0	0	0	14	0.00	11.67
20/4/2567	34	0	0	0	1	15	0.83	12.50
21/4/2567	35	0	0	0	0	15	0.00	12.50
22/4/2567	36	0	1	0	1	17	1.67	14.17
23/4/2567	37	0	0	0	0	17	0.00	14.17
24/4/2567	38	0	1	0	0	18	0.83	15.00
25/4/2567	39	0	0	0	0	18	0.00	15.00
26/4/2567	40	0	0	0	0	18	0.00	15.00
27/4/2567	41	0	0	0	0	18	0.00	15.00
28/4/2567	42	0	0	0	0	18	0.00	15.00
29/4/2567	43	0	0	0	0	18	0.00	15.00
30/4/2567	44	0	0	0	0	18	0.00	15.00
1/5/2567	45	0	0	0	0	18	0.00	15.00
2/5/2567	46	0	0	0	0	18	0.00	15.00
3/5/2567	47	0	0	0	0	18	0.00	15.00
4/5/2567	48	0	0	0	0	18	0.00	15.00
5/5/2567	49	0	0	0	0	18	0.00	15.00
6/5/2567	50	0	0	0	0	18	0.00	15.00
7/5/2567	51	0	0	0	1	19	0.83	15.83
8/5/2567	52	0	0	0	0	19	0.00	15.83
9/5/2567	53	0	0	0	0	19	0.00	15.83
10/5/2567	54	0	0	0	0	19	0.00	15.83
11/5/2567	55	0	0	0	0	19	0.00	15.83
12/5/2567	56	0	0	0	0	19	0.00	15.83
13/5/2567	57	0	0	0	0	19	0.00	15.83
14/5/2567	58	0	0	0	1	20	0.83	16.67
15/5/2567	59	0	0	0	0	20	0.00	16.67

Table A.7 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
16/5/2567	60	0	0	0	0	20	0.00	16.67
17/5/2567	61	0	0	0	0	20	0.00	16.67
18/5/2567	62	0	0	0	0	20	0.00	16.67
19/5/2567	63	0	0	1	0	21	0.83	17.50
20/5/2567	64	0	0	0	0	21	0.00	17.50
21/5/2567	65	0	0	1	0	22	0.83	18.33
22/5/2567	66	0	0	0	0	22	0.00	18.33
23/5/2567	67	0	0	0	0	22	0.00	18.33
24/5/2567	68	0	0	0	0	22	0.00	18.33
25/5/2567	69	0	0	0	0	22	0.00	18.33
26/5/2567	70	0	0	0	0	22	0.00	18.33
27/5/2567	71	0	0	0	0	22	0.00	18.33
28/5/2567	72	0	0	0	0	22	0.00	18.33
29/5/2567	73	0	0	0	0	22	0.00	18.33
30/5/2567	74	0	0	0	0	22	0.00	18.33
31/5/2567	75	1	0	0	0	23	0.83	19.17
1/6/2567	76	0	0	0	0	23	0.00	19.17
2/6/2567	77	0	0	0	0	23	0.00	19.17
3/6/2567	78	1	0	0	0	24	0.83	20.00
4/6/2567	79	0	0	0	0	24	0.00	20.00
5/6/2567	80	0	0	0	0	24	0.00	20.00
6/6/2567	81	0	0	0	0	24	0.00	20.00
7/6/2567	82	0	0	0	0	24	0.00	20.00
8/6/2567	83	0	0	0	0	24	0.00	20.00
9/6/2567	84	0	0	0	0	24	0.00	20.00
10/6/2567	85	0	0	0	0	24	0.00	20.00
11/6/2567	86	1	0	1	0	26	1.67	21.67
12/6/2567	87	0	0	0	0	26	0.00	21.67
13/6/2567	88	0	0	0	0	26	0.00	21.67

Table A.7 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
14/6/2567	89	0	0	1	0	27	0.83	22.50
15/6/2567	90	0	0	0	0	27	0.00	22.50
16/6/2567	91	0	0	0	0	27	0.00	22.50
17/6/2567	92	0	0	0	0	27	0.00	22.50
18/6/2567	93	0	0	1	0	28	0.83	23.33
19/6/2567	94	0	0	0	0	28	0.00	23.33
20/6/2567	95	0	0	0	0	28	0.00	23.33
21/6/2567	96	0	0	0	0	28	0.00	23.33
22/6/2567	97	0	0	0	0	28	0.00	23.33
23/6/2567	98	0	0	0	0	28	0.00	23.33
24/6/2567	99	0	0	0	0	28	0.00	23.33
25/6/2567	100	0	1	0	0	29	0.83	24.17
26/6/2567	101	0	0	0	0	29	0.00	24.17
27/6/2567	102	0	0	0	0	29	0.00	24.17
28/6/2567	103	0	0	0	0	29	0.00	24.17
29/6/2567	104	0	0	0	0	29	0.00	24.17
30/6/2567	105	0	0	0	0	29	0.00	24.17
1/7/2567	106	0	0	0	0	29	0.00	24.17
2/7/2567	107	0	2	0	1	32	2.50	26.67
3/7/2567	108	0	0	0	0	32	0.00	26.67
4/7/2567	109	0	0	0	0	32	0.00	26.67
5/7/2567	110	0	0	0	0	32	0.00	26.67
6/7/2567	111	0	0	0	0	32	0.00	26.67
7/7/2567	112	0	0	0	0	32	0.00	26.67
8/7/2567	113	0	0	0	0	32	0.00	26.67
9/7/2567	114	0	0	0	0	32	0.00	26.67
10/7/2567	115	0	0	0	0	32	0.00	26.67
11/7/2567	116	0	0	0	0	32	0.00	26.67
12/7/2567	117	0	0	0	0	32	0.00	26.67

Table A.7 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking water for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
13/7/2567	118	0	0	0	0	32	0.00	26.67
14/7/2567	119	0	0	0	0	32	0.00	26.67
15/7/2567	120	0	0	0	0	32	0.00	26.67

Table A.8 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	0	1	1	0.83	0.83
27/3/2567	10	0	0	0	0	1	0.00	0.83
28/3/2567	11	0	0	0	0	1	0.00	0.83
29/3/2567	12	0	0	0	0	1	0.00	0.83
30/3/2567	13	0	0	0	0	1	0.00	0.83
31/3/2567	14	0	0	0	0	1	0.00	0.83
1/4/2567	15	0	0	1	2	4	2.50	3.33
2/4/2567	16	0	0	0	0	4	0.00	3.33
3/4/2567	17	0	0	0	0	4	0.00	3.33
4/4/2567	18	0	0	1	0	5	0.83	4.17
5/4/2567	19	0	0	0	0	5	0.00	4.17
6/4/2567	20	0	0	0	0	5	0.00	4.17
7/4/2567	21	0	0	0	0	5	0.00	4.17
8/4/2567	22	0	0	0	0	5	0.00	4.17
9/4/2567	23	1	0	0	0	6	0.83	5.00
10/4/2567	24	0	0	0	0	6	0.00	5.00
11/4/2567	25	0	0	0	0	6	0.00	5.00
12/4/2567	26	0	0	0	0	6	0.00	5.00
13/4/2567	27	1	1	1	3	12	5.00	10.00
14/4/2567	28	0	0	0	0	12	0.00	10.00
15/4/2567	29	0	0	0	0	12	0.00	10.00
16/4/2567	30	3	0	0	0	15	2.50	12.50

Table A.8 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
17/4/2567	31	0	0	0	0	15	0.00	12.50
18/4/2567	32	0	0	0	0	15	0.00	12.50
19/4/2567	33	0	0	0	0	15	0.00	12.50
20/4/2567	34	0	0	1	0	16	0.83	13.33
21/4/2567	35	0	0	0	0	16	0.00	13.33
22/4/2567	36	1	0	0	0	17	0.83	14.17
23/4/2567	37	0	0	0	0	17	0.00	14.17
24/4/2567	38	0	0	0	0	17	0.00	14.17
25/4/2567	39	0	0	0	0	17	0.00	14.17
26/4/2567	40	0	0	0	0	17	0.00	14.17
27/4/2567	41	1	0	0	1	19	1.67	15.83
28/4/2567	42	0	0	0	0	19	0.00	15.83
29/4/2567	43	0	0	0	0	19	0.00	15.83
30/4/2567	44	0	0	0	0	19	0.00	15.83
1/5/2567	45	0	0	0	0	19	0.00	15.83
2/5/2567	46	0	0	0	0	19	0.00	15.83
3/5/2567	47	1	0	0	0	20	0.83	16.67
4/5/2567	48	0	0	0	0	20	0.00	16.67
5/5/2567	49	0	0	0	0	20	0.00	16.67
6/5/2567	50	0	0	0	0	20	0.00	16.67
7/5/2567	51	0	0	0	0	20	0.00	16.67
8/5/2567	52	0	0	0	0	20	0.00	16.67
9/5/2567	53	0	0	0	0	20	0.00	16.67
10/5/2567	54	0	0	0	0	20	0.00	16.67
11/5/2567	55	0	0	0	0	20	0.00	16.67
12/5/2567	56	0	0	0	0	20	0.00	16.67
13/5/2567	57	0	0	0	0	20	0.00	16.67
14/5/2567	58	0	0	0	0	20	0.00	16.67
15/5/2567	59	0	0	0	0	20	0.00	16.67

Table A.8 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
16/5/2567	60	0	0	0	0	20	0.00	16.67
17/5/2567	61	0	0	0	0	20	0.00	16.67
18/5/2567	62	0	0	0	0	20	0.00	16.67
19/5/2567	63	1	0	0	0	21	0.83	17.50
20/5/2567	64	0	0	0	0	21	0.00	17.50
21/5/2567	65	4	0	0	1	26	4.17	21.67
22/5/2567	66	0	0	0	0	26	0.00	21.67
23/5/2567	67	0	0	0	0	26	0.00	21.67
24/5/2567	68	0	0	0	0	26	0.00	21.67
25/5/2567	69	1	0	0	0	27	0.83	22.50
26/5/2567	70	0	0	0	0	27	0.00	22.50
27/5/2567	71	0	0	0	0	27	0.00	22.50
28/5/2567	72	0	0	0	1	28	0.83	23.33
29/5/2567	73	0	0	0	0	28	0.00	23.33
30/5/2567	74	0	0	0	0	28	0.00	23.33
31/5/2567	75	1	0	0	0	29	0.83	24.17
1/6/2567	76	0	0	0	0	29	0.00	24.17
2/6/2567	77	0	0	0	0	29	0.00	24.17
3/6/2567	78	0	0	0	0	29	0.00	24.17
4/6/2567	79	0	0	0	0	29	0.00	24.17
5/6/2567	80	0	0	0	0	29	0.00	24.17
6/6/2567	81	0	0	0	0	29	0.00	24.17
7/6/2567	82	0	0	0	0	29	0.00	24.17
8/6/2567	83	0	0	0	0	29	0.00	24.17
9/6/2567	84	0	0	0	0	29	0.00	24.17
10/6/2567	85	0	0	0	0	29	0.00	24.17
11/6/2567	86	0	0	0	0	29	0.00	24.17
12/6/2567	87	0	0	0	0	29	0.00	24.17
13/6/2567	88	0	0	0	0	29	0.00	24.17

Table A.8 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
14/6/2567	89	0	0	0	0	29	0.00	24.17
15/6/2567	90	0	0	0	0	29	0.00	24.17
16/6/2567	91	0	0	0	0	29	0.00	24.17
17/6/2567	92	0	0	0	0	29	0.00	24.17
18/6/2567	93	0	0	0	0	29	0.00	24.17
19/6/2567	94	0	0	0	0	29	0.00	24.17
20/6/2567	95	0	0	0	0	29	0.00	24.17
21/6/2567	96	0	0	0	0	29	0.00	24.17
22/6/2567	97	0	0	0	0	29	0.00	24.17
23/6/2567	98	0	0	0	0	29	0.00	24.17
24/6/2567	99	0	0	0	0	29	0.00	24.17
25/6/2567	100	0	0	0	0	29	0.00	24.17
26/6/2567	101	0	0	0	0	29	0.00	24.17
27/6/2567	102	0	0	0	0	29	0.00	24.17
28/6/2567	103	0	0	0	0	29	0.00	24.17
29/6/2567	104	0	0	0	0	29	0.00	24.17
30/6/2567	105	0	0	0	0	29	0.00	24.17
1/7/2567	106	0	0	0	0	29	0.00	24.17
2/7/2567	107	1	0	0	0	30	0.83	25.00
3/7/2567	108	0	0	0	0	30	0.00	25.00
4/7/2567	109	0	0	0	0	30	0.00	25.00
5/7/2567	110	0	0	0	0	30	0.00	25.00
6/7/2567	111	0	0	0	0	30	0.00	25.00
7/7/2567	112	0	0	0	0	30	0.00	25.00
8/7/2567	113	3	2	0	1	36	5.00	30.00
9/7/2567	114	0	0	0	0	36	0.00	30.00
10/7/2567	115	0	0	0	0	36	0.00	30.00
11/7/2567	116	0	0	0	0	36	0.00	30.00
12/7/2567	117	0	0	0	0	36	0.00	30.00

Table A.8 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 250 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
13/7/2567	118	0	0	0	0	36	0.00	30.00
14/7/2567	119	0	0	0	0	36	0.00	30.00
15/7/2567	120	0	0	0	0	36	0.00	30.00

Table A.9 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	1	0	1	0.83	0.83
27/3/2567	10	0	0	0	0	1	0.00	0.83
28/3/2567	11	0	1	0	0	2	0.83	1.67
29/3/2567	12	0	0	1	0	3	0.83	2.50
30/3/2567	13	0	0	0	0	3	0.00	2.50
31/3/2567	14	0	0	1	0	4	0.83	3.33
1/4/2567	15	0	0	0	0	4	0.00	3.33
2/4/2567	16	0	0	0	0	4	0.00	3.33
3/4/2567	17	0	0	0	0	4	0.00	3.33
4/4/2567	18	0	0	0	0	4	0.00	3.33
5/4/2567	19	0	0	0	0	4	0.00	3.33
6/4/2567	20	0	0	0	0	4	0.00	3.33
7/4/2567	21	0	0	0	0	4	0.00	3.33
8/4/2567	22	0	0	0	0	4	0.00	3.33
9/4/2567	23	0	0	0	0	4	0.00	3.33
10/4/2567	24	0	0	0	0	4	0.00	3.33
11/4/2567	25	0	0	0	0	4	0.00	3.33
12/4/2567	26	0	0	0	0	4	0.00	3.33
13/4/2567	27	0	0	0	0	4	0.00	3.33
14/4/2567	28	0	0	0	0	4	0.00	3.33
15/4/2567	29	0	0	0	0	4	0.00	3.33

Table A.9 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
16/4/2567	30	0	2	0	0	6	1.67	5.00
17/4/2567	31	0	0	0	0	6	0.00	5.00
18/4/2567	32	0	0	0	0	6	0.00	5.00
19/4/2567	33	0	0	0	0	6	0.00	5.00
20/4/2567	34	0	0	0	0	6	0.00	5.00
21/4/2567	35	0	0	0	0	6	0.00	5.00
22/4/2567	36	0	0	0	0	6	0.00	5.00
23/4/2567	37	0	0	0	0	6	0.00	5.00
24/4/2567	38	0	0	2	0	8	1.67	6.67
25/4/2567	39	0	0	0	0	8	0.00	6.67
26/4/2567	40	0	0	0	0	8	0.00	6.67
27/4/2567	41	0	0	1	0	9	0.83	7.50
28/4/2567	42	0	0	0	0	9	0.00	7.50
29/4/2567	43	0	0	0	0	9	0.00	7.50
30/4/2567	44	0	0	0	0	9	0.00	7.50
1/5/2567	45	0	0	0	0	9	0.00	7.50
2/5/2567	46	0	0	0	0	9	0.00	7.50
3/5/2567	47	0	0	0	0	9	0.00	7.50
4/5/2567	48	0	0	0	0	9	0.00	7.50
5/5/2567	49	0	1	0	0	10	0.83	8.33
6/5/2567	50	0	0	0	0	10	0.00	8.33
7/5/2567	51	0	0	0	0	10	0.00	8.33
8/5/2567	52	0	0	0	0	10	0.00	8.33
9/5/2567	53	0	0	0	0	10	0.00	8.33
10/5/2567	54	0	0	0	0	10	0.00	8.33
11/5/2567	55	0	0	0	0	10	0.00	8.33
12/5/2567	56	0	0	0	0	10	0.00	8.33
13/5/2567	57	0	0	0	0	10	0.00	8.33
14/5/2567	58	0	0	0	0	10	0.00	8.33

Table A.9 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
15/5/2567	59	0	0	0	0	10	0.00	8.33
16/5/2567	60	0	0	0	0	10	0.00	8.33
17/5/2567	61	0	0	0	0	10	0.00	8.33
18/5/2567	62	0	0	0	0	10	0.00	8.33
19/5/2567	63	0	1	0	0	11	0.83	9.17
20/5/2567	64	0	0	0	0	11	0.00	9.17
21/5/2567	65	1	0	0	0	12	0.83	10.00
22/5/2567	66	0	0	0	0	12	0.00	10.00
23/5/2567	67	0	0	0	0	12	0.00	10.00
24/5/2567	68	0	0	0	0	12	0.00	10.00
25/5/2567	69	2	0	0	0	14	1.67	11.67
26/5/2567	70	0	0	0	0	14	0.00	11.67
27/5/2567	71	0	0	0	0	14	0.00	11.67
28/5/2567	72	0	0	0	0	14	0.00	11.67
29/5/2567	73	0	0	0	0	14	0.00	11.67
30/5/2567	74	0	0	0	0	14	0.00	11.67
31/5/2567	75	0	0	0	0	14	0.00	11.67
1/6/2567	76	0	0	0	0	14	0.00	11.67
2/6/2567	77	0	0	0	0	14	0.00	11.67
3/6/2567	78	0	0	0	0	14	0.00	11.67
4/6/2567	79	0	0	0	0	14	0.00	11.67
5/6/2567	80	0	0	0	0	14	0.00	11.67
6/6/2567	81	0	0	0	0	14	0.00	11.67
7/6/2567	82	0	0	0	0	14	0.00	11.67
8/6/2567	83	0	0	0	0	14	0.00	11.67
9/6/2567	84	0	0	0	0	14	0.00	11.67
10/6/2567	85	0	0	0	0	14	0.00	11.67
11/6/2567	86	0	0	0	0	14	0.00	11.67
12/6/2567	87	0	0	0	0	14	0.00	11.67

Table A.9 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
13/6/2567	88	0	0	0	0	14	0.00	11.67
14/6/2567	89	0	0	0	0	14	0.00	11.67
15/6/2567	90	0	0	0	0	14	0.00	11.67
16/6/2567	91	0	0	0	0	14	0.00	11.67
17/6/2567	92	0	0	0	0	14	0.00	11.67
18/6/2567	93	0	0	0	1	15	0.83	12.50
19/6/2567	94	0	0	0	0	15	0.00	12.50
20/6/2567	95	0	0	0	0	15	0.00	12.50
21/6/2567	96	0	0	0	1	16	0.83	13.33
22/6/2567	97	0	0	0	0	16	0.00	13.33
23/6/2567	98	0	0	0	0	16	0.00	13.33
24/6/2567	99	0	0	0	0	16	0.00	13.33
25/6/2567	100	0	1	0	0	17	0.83	14.17
26/6/2567	101	0	0	0	0	17	0.00	14.17
27/6/2567	102	0	0	0	0	17	0.00	14.17
28/6/2567	103	0	0	1	0	18	0.83	15.00
29/6/2567	104	0	0	0	0	18	0.00	15.00
30/6/2567	105	0	0	0	0	18	0.00	15.00
1/7/2567	106	0	0	0	0	18	0.00	15.00
2/7/2567	107	0	0	0	0	18	0.00	15.00
3/7/2567	108	0	0	0	0	18	0.00	15.00
4/7/2567	109	0	0	0	0	18	0.00	15.00
5/7/2567	110	0	0	0	0	18	0.00	15.00
6/7/2567	111	0	0	0	0	18	0.00	15.00
7/7/2567	112	0	0	0	0	18	0.00	15.00
8/7/2567	113	0	1	0	0	19	0.83	15.83
9/7/2567	114	0	0	0	0	19	0.00	15.83
10/7/2567	115	0	0	0	0	19	0.00	15.83
11/7/2567	116	0	0	0	0	19	0.00	15.83

Table A.9 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 500 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
12/7/2567	117	0	0	0	0	19	0.00	15.83
13/7/2567	118	0	0	0	0	19	0.00	15.83
14/7/2567	119	0	0	0	0	19	0.00	15.83
15/7/2567	120	0	0	0	0	19	0.00	15.83

Table A.10 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days.

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
18/3/2567	1	0	0	0	0	0	0.00	0.00
19/3/2567	2	0	0	0	0	0	0.00	0.00
20/3/2567	3	0	0	0	0	0	0.00	0.00
21/3/2567	4	0	0	0	0	0	0.00	0.00
22/3/2567	5	0	0	0	0	0	0.00	0.00
23/3/2567	6	0	0	0	0	0	0.00	0.00
24/3/2567	7	0	0	0	0	0	0.00	0.00
25/3/2567	8	0	0	0	0	0	0.00	0.00
26/3/2567	9	0	0	0	0	0	0.00	0.00
27/3/2567	10	0	0	0	0	0	0.00	0.00
28/3/2567	11	0	0	0	0	0	0.00	0.00
29/3/2567	12	0	0	1	0	1	0.83	0.83
30/3/2567	13	1	0	0	0	2	0.83	1.67
31/3/2567	14	0	0	0	0	2	0.00	1.67
1/4/2567	15	0	0	1	0	3	0.83	2.50
2/4/2567	16	0	0	0	0	3	0.00	2.50
3/4/2567	17	0	0	0	0	3	0.00	2.50
4/4/2567	18	0	0	0	0	3	0.00	2.50
5/4/2567	19	0	0	0	0	3	0.00	2.50
6/4/2567	20	0	0	0	0	3	0.00	2.50
7/4/2567	21	3	0	0	0	6	2.50	5.00
8/4/2567	22	0	0	0	0	6	0.00	5.00
9/4/2567	23	0	0	0	0	6	0.00	5.00
10/4/2567	24	0	0	0	0	6	0.00	5.00
11/4/2567	25	0	0	0	0	6	0.00	5.00
12/4/2567	26	0	0	0	0	6	0.00	5.00
13/4/2567	27	1	0	0	0	7	0.83	5.83
14/4/2567	28	0	0	0	0	7	0.00	5.83

Table A.10 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
15/4/2567	29	0	0	0	0	7	0.00	5.83
16/4/2567	30	1	0	0	0	8	0.83	6.67
17/4/2567	31	0	0	0	0	8	0.00	6.67
18/4/2567	32	0	0	0	0	8	0.00	6.67
19/4/2567	33	0	0	0	0	8	0.00	6.67
20/4/2567	34	0	0	0	0	8	0.00	6.67
21/4/2567	35	0	0	0	0	8	0.00	6.67
22/4/2567	36	0	0	1	0	9	0.83	7.50
23/4/2567	37	0	0	0	0	9	0.00	7.50
24/4/2567	38	0	0	2	1	12	2.50	10.00
25/4/2567	39	0	0	0	0	12	0.00	10.00
26/4/2567	40	0	0	0	0	12	0.00	10.00
27/4/2567	41	1	0	0	1	14	1.67	11.67
28/4/2567	42	0	0	0	0	14	0.00	11.67
29/4/2567	43	0	0	0	0	14	0.00	11.67
30/4/2567	44	0	0	0	0	14	0.00	11.67
1/5/2567	45	0	0	0	0	14	0.00	11.67
2/5/2567	46	0	0	0	0	14	0.00	11.67
3/5/2567	47	0	0	0	0	14	0.00	11.67
4/5/2567	48	0	0	0	0	14	0.00	11.67
5/5/2567	49	0	0	0	0	14	0.00	11.67
6/5/2567	50	0	0	0	0	14	0.00	11.67
7/5/2567	51	0	0	0	0	14	0.00	11.67
8/5/2567	52	0	0	0	0	14	0.00	11.67
9/5/2567	53	0	0	0	0	14	0.00	11.67
10/5/2567	54	0	0	0	0	14	0.00	11.67
11/5/2567	55	0	0	0	0	14	0.00	11.67
12/5/2567	56	0	1	0	0	15	0.83	12.50

Table A.10 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
13/5/2567	57	0	0	0	0	15	0.00	12.50
14/5/2567	58	0	0	0	0	15	0.00	12.50
15/5/2567	59	0	0	0	0	15	0.00	12.50
16/5/2567	60	1	0	0	0	16	0.83	13.33
17/5/2567	61	0	0	0	0	16	0.00	13.33
18/5/2567	62	0	0	0	0	16	0.00	13.33
19/5/2567	63	0	0	0	0	16	0.00	13.33
20/5/2567	64	0	0	0	0	16	0.00	13.33
21/5/2567	65	1	0	0	0	17	0.83	14.17
22/5/2567	66	0	0	0	0	17	0.00	14.17
23/5/2567	67	0	0	0	0	17	0.00	14.17
24/5/2567	68	0	0	0	0	17	0.00	14.17
25/5/2567	69	0	0	0	0	17	0.00	14.17
26/5/2567	70	0	0	0	0	17	0.00	14.17
27/5/2567	71	0	0	0	0	17	0.00	14.17
28/5/2567	72	0	0	0	0	17	0.00	14.17
29/5/2567	73	0	0	0	0	17	0.00	14.17
30/5/2567	74	0	0	0	0	17	0.00	14.17
31/5/2567	75	0	2	0	0	19	1.67	15.83
1/6/2567	76	0	0	0	0	19	0.00	15.83
2/6/2567	77	0	0	0	0	19	0.00	15.83
3/6/2567	78	1	0	0	0	20	0.83	16.67
4/6/2567	79	0	0	0	0	20	0.00	16.67
5/6/2567	80	0	0	0	0	20	0.00	16.67
6/6/2567	81	0	0	0	0	20	0.00	16.67
7/6/2567	82	0	0	0	0	20	0.00	16.67
8/6/2567	83	0	0	0	0	20	0.00	16.67
9/6/2567	84	0	0	0	0	20	0.00	16.67

Table A.10 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
10/6/2567	85	0	0	0	0	20	0.00	16.67
11/6/2567	86	0	0	1	0	21	0.83	17.50
12/6/2567	87	0	0	0	0	21	0.00	17.50
13/6/2567	88	0	0	0	0	21	0.00	17.50
14/6/2567	89	0	0	1	0	22	0.83	18.33
15/6/2567	90	0	0	0	0	22	0.00	18.33
16/6/2567	91	0	0	0	0	22	0.00	18.33
17/6/2567	92	0	0	0	0	22	0.00	18.33
18/6/2567	93	2	0	0	0	24	1.67	20.00
19/6/2567	94	0	0	0	0	24	0.00	20.00
20/6/2567	95	0	0	0	0	24	0.00	20.00
21/6/2567	96	0	0	0	0	24	0.00	20.00
22/6/2567	97	0	0	0	0	24	0.00	20.00
23/6/2567	98	0	0	0	0	24	0.00	20.00
24/6/2567	99	0	0	0	0	24	0.00	20.00
25/6/2567	100	0	2	0	0	26	1.67	21.67
26/6/2567	101	0	0	0	0	26	0.00	21.67
27/6/2567	102	0	0	0	0	26	0.00	21.67
28/6/2567	103	2	1	0	0	29	2.50	24.17
29/6/2567	104	0	0	0	0	29	0.00	24.17
30/6/2567	105	0	0	0	0	29	0.00	24.17
1/7/2567	106	0	0	0	0	29	0.00	24.17
2/7/2567	107	2	2	2	0	35	5.00	29.17
3/7/2567	108	0	0	0	0	35	0.00	29.17
4/7/2567	109	0	0	0	0	35	0.00	29.17
5/7/2567	110	0	0	0	0	35	0.00	29.17
6/7/2567	111	0	0	0	0	35	0.00	29.17
7/7/2567	112	0	0	0	0	35	0.00	29.17

Table A.10 Cumulative germination percentage (GP) of *Limnophila geoffrayi* seeds in soaking 1,000 ppm GA_3 for 24 hours under storage conditions for 12 months for 120 days. (Continued)

Date	Day	Number of seed germination/plate/day				Cumulative number of seed germinated/day	GP/day	Cumulative GP/day
		1	2	3	4			
8/7/2567	113	0	0	0	1	36	0.83	30.00
9/7/2567	114	0	0	0	0	36	0.00	30.00
10/7/2567	115	0	0	1	0	37	0.83	30.83
11/7/2567	116	0	0	0	0	37	0.00	30.83
12/7/2567	117	1	0	0	0	38	0.83	31.67
13/7/2567	118	0	0	0	0	38	0.00	31.67
14/7/2567	119	0	0	0	0	38	0.00	31.67
15/7/2567	120	0	0	0	0	38	0.00	31.67

APPENDIX B

DATA RECORD OF EFFECT OF BA ON SHOOT GENERETION OF *LIMNOPHILA GEOFFRAYI*

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded).

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
4	1	0	2	4	0.3	6	0.9
4	2	0	2	6	0.5	6	1.2
4	3	0	1	8	0.6	1	1
4	4	0	2	6	0.5	5	1.2
4	5	0	1	7	0.6	3	0.8
4	6	0	2	4	0.5	9	0.5
4	7	0	2	6	0.5	3	0.9
4	8	0	2	6	0.6	4	0.5
4	9	0	2	6	0.5	3	1
4	10	0	2	6	0.7	2	1
4	11	0	2	4	0.3	5	0.3
4	12	0	2	6	0.5	8	0.3
4	13	0	2	6	0.5	2	0.3
4	14	0	2	6	0.7	3	1
4	15	0	2	4	0.5	1	0.7
4	16	0	1	8	1	3	1.2
4	17	0	2	6	1	6	0.8
4	18	0	2	6	0.5	2	0.9
4	19	0	2	6	0.5	5	0.7

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
4	20	0	2	6	0.5	5	0.5
4	21	0	2	6	0.4	4	1
4	22	0	2	6	0.5	2	0.3
4	23	0	1	4	0.5	3	0.5
4	24	0	1	6	1	3	0.3
4	25	0	2	6	0.6	5	1
4	26	0	2	6	0.3	3	2
4	27	0	2	6	0.3	3	2
4	28	0	2	6	0.5	4	5
4	29	0	2	6	0.3	2	3
4	30	0	2	6	0.3	4	4
4	1	0.5	8	8	1	NA	NA
4	2	0.5	12	8	0.6	NA	NA
4	3	0.5	2	6	0.5	NA	NA
4	4	0.5	39	6	0.5	NA	NA
4	5	0.5	30	5	0.5	NA	NA
4	6	0.5	26	8	0.6	NA	NA
4	7	0.5	12	4	0.3	NA	NA
4	8	0.5	4	6	0.8	NA	NA
4	9	0.5	10	8	0.7	NA	NA
4	10	0.5	15	4	0.5	NA	NA
4	11	0.5	9	6	1	NA	NA
4	12	0.5	7	12	1.2	NA	NA
4	13	0.5	6	4	0.3	NA	NA
4	14	0.5	27	6	0.5	NA	NA
4	15	0.5	14	6	0.7	NA	NA
4	1	1	11	7	0.7	NA	NA

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
4	2	1	6	6	0.7	NA	NA
4	3	1	18	5	0.6	NA	NA
4	4	1	12	6	1	NA	NA
4	5	1	23	5	0.7	NA	NA
4	6	1	9	7	0.7	NA	NA
4	7	1	11	9	0.9	NA	NA
4	8	1	5	5	0.6	NA	NA
4	9	1	6	6	1.2	NA	NA
4	10	1	27	9	1	NA	NA
4	11	1	20	10	1.5	NA	NA
4	12	1	18	5	0.7	NA	NA
4	13	1	4	8	1.4	NA	NA
4	14	1	3	6	0.7	NA	NA
4	15	1	18	8	1.2	NA	NA
4	16	1	17	6	1.1	NA	NA
4	17	1	14	14	1.9	NA	NA
4	18	1	19	6	0.8	NA	NA
4	19	1	3	9	1.8	NA	NA
4	20	1	18	7	1	NA	NA
4	21	1	28	5	0.6	NA	NA
4	22	1	11	7	1	NA	NA
4	23	1	23	5	0.7	NA	NA
4	24	1	14	7	0.9	NA	NA
4	25	1	12	8	0.5	NA	NA
4	26	1	2	5	0.5	NA	NA
4	27	1	13	4	0.4	NA	NA
4	28	1	19	9	1	NA	NA

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
4	29	1	3	6	0.8	NA	NA
4	30	1	3	9	0.9	NA	NA
4	1	2	12	6	0.9	NA	NA
4	2	2	8	5	0.7	NA	NA
4	3	2	15	4	0.3	NA	NA
4	4	2	20	12	0.5	NA	NA
4	5	2	9	5	0.4	NA	NA
4	6	2	18	6	0.5	NA	NA
4	7	2	14	8	0.9	NA	NA
4	8	2	5	5	0.6	NA	NA
4	9	2	5	4	0.4	NA	NA
4	10	2	37	6	0.7	NA	NA
4	11	2	3	6	0.6	NA	NA
4	12	2	14	6	0.6	NA	NA
4	13	2	10	7	0.6	NA	NA
4	14	2	11	8	0.6	NA	NA
4	15	2	9	7	0.6	NA	NA
4	16	2	15	5	0.8	NA	NA
6	1	0	2	6	0.4	6	2
6	2	0	2	6	0.6	6	2.2
6	3	0	1	8	0.7	2	2
6	4	0	2	8	0.6	5	3
6	5	0	1	9	0.8	4	2.5
6	6	0	2	6	0.7	9	1
6	7	0	2	6	0.6	3	2.5
6	8	0	2	6	0.6	6	0.7
6	9	0	2	8	0.6	6	2

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
6	10	0	2	8	1	3	2
6	11	0	2	6	0.7	5	0.5
6	12	0	2	6	1	8	0.5
6	13	0	2	8	1	2	0.5
6	14	0	2	8	1	4	1
6	15	0	2	6	0.7	4	1
6	16	0	1	12	1.2	3	1.5
6	17	0	2	6	1	8	1.5
6	18	0	2	8	0.6	2	1.5
6	19	0	2	6	1	5	2
6	20	0	2	6	1	5	1.5
6	21	0	2	8	0.8	4	1.8
6	22	0	2	6	0.7	3	0.6
6	23	0	2	6	0.7	3	1
6	24	0	1	8	1.2	6	1
6	25	0	2	8	0.7	5	2
6	26	0	2	6	0.7	3	2.8
6	27	0	2	6	0.5	3	3
6	28	0	2	8	1.1	4	3
6	29	0	2	8	0.6	2	3
6	30	0	2	6	0.5	4	4
6	13	0	2	8	1	2	0.5
6	14	0	2	8	1	4	1
6	15	0	2	6	0.7	4	1
6	16	0	1	12	1.2	3	1.5
6	17	0	2	6	1	8	1.5
6	18	0	2	8	0.6	2	1.5

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
6	19	0	2	6	1	5	2
6	20	0	2	6	1	5	1.5
6	21	0	2	8	0.8	4	1.8
6	22	0	2	6	0.7	3	0.6
6	23	0	2	6	0.7	3	1
6	24	0	1	8	1.2	6	1
6	25	0	2	8	0.7	5	2
6	26	0	2	6	0.7	3	2.8
6	27	0	2	6	0.5	3	3
6	28	0	2	8	1.1	4	3
6	29	0	2	8	0.6	2	3
6	30	0	2	6	0.5	4	4
6	1	0.5	8	10	1.6	NA	NA
6	2	0.5	17	10	1.7	NA	NA
6	3	0.5	2	5	0.9	NA	NA
6	4	0.5	49	8	1.9	NA	NA
6	5	0.5	40	8	1.9	NA	NA
6	6	0.5	36	8	1.6	NA	NA
6	7	0.5	22	6	1.5	NA	NA
6	8	0.5	8	10	1.9	NA	NA
6	9	0.5	15	8	2	NA	NA
6	10	0.5	26	6	2.3	NA	NA
6	11	0.5	12	6	5	NA	NA
6	12	0.5	9	12	4.2	NA	NA
6	13	0.5	8	6	1.5	NA	NA
6	14	0.5	32	6	1.8	NA	NA
6	15	0.5	23	7	1.7	NA	NA

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
6	1	1	22	7	1	NA	NA
6	2	1	15	8	0.8	NA	NA
6	3	1	39	8	0.7	NA	NA
6	4	1	36	6	3.2	NA	NA
6	5	1	12	5	2.4	NA	NA
6	6	1	13	11	2.3	NA	NA
6	7	1	20	9	1.3	NA	NA
6	8	1	16	9	1.7	NA	NA
6	9	1	10	10	3	NA	NA
6	10	1	30	14	1.1	NA	NA
6	11	1	25	18	2	NA	NA
6	12	1	22	6	1	NA	NA
6	13	1	12	8	1.7	NA	NA
6	14	1	8	8	1.2	NA	NA
6	15	1	20	8	2	NA	NA
6	1	2	22	7	1.9	NA	NA
6	2	2	17	6	1.4	NA	NA
6	3	2	18	5	0.7	NA	NA
6	4	2	38	12	0.5	NA	NA
6	5	2	31	6	0.5	NA	NA
6	6	2	48	8	0.6	NA	NA
6	7	2	26	8	1.9	NA	NA
6	8	2	16	5	0.8	NA	NA
6	9	2	19	4	0.6	NA	NA
6	10	2	37	10	0.7	NA	NA
6	11	2	30	6	0.6	NA	NA
6	12	2	35	10	1.4	NA	NA

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
6	13	2	10	7	0.6	NA	NA
6	14	2	12	8	0.7	NA	NA
6	15	2	9	7	0.6	NA	NA
6	16	2	59	11	1.5	NA	NA
8	1	0	2	8	0.7	8	2.9
8	2	0	2	6	0.7	7	2.6
8	3	0	1	10	1	2	3.1
8	4	0	2	9	0.7	7	3.6
8	5	0	1	10	1	6	2.8
8	6	0	2	8	1	9	1.9
8	7	0	2	6	0.6	4	2.8
8	8	0	2	10	0.8	8	1.2
8	9	0	2	8	0.8	7	2.5
8	10	0	2	8	1	3	2.6
8	11	0	2	6	0.8	6	1.7
8	12	0	2	8	1	10	1.4
8	13	0	2	9	1.1	5	1.5
8	14	0	2	8	1.2	9	1.7
8	15	0	2	6	1	5	1.4
8	16	0	1	12	1.8	3	1.7
8	17	0	2	8	1.4	9	1.6
8	18	0	2	9	0.7	2	1.5
8	19	0	2	8	1	7	2.5
8	20	0	2	8	1	7	1.8
8	21	0	2	9	0.8	7	2
8	22	0	2	8	0.8	6	1.2
8	23	0	2	8	0.7	5	1.9

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
8	24	0	1	8	1.5	6	1.2
8	25	0	2	8	0.8	8	2.3
8	26	0	2	6	1	3	3
8	27	0	2	6	0.7	4	3
8	28	0	2	8	1.3	6	3.3
8	29	0	2	8	1	2	3.3
8	30	0	2	6	0.6	4	4
8	1	0.5	8	12	1.6	NA	NA
8	2	0.5	18	10	1.7	NA	NA
8	3	0.5	2	5	0.9	NA	NA
8	4	0.5	70	12	2.5	NA	NA
8	5	0.5	48	10	2.4	NA	NA
8	6	0.5	55	14	3.7	NA	NA
8	7	0.5	61	12	3.4	NA	NA
8	8	0.5	56	15	2.7	NA	NA
8	9	0.5	34	33	3.5	NA	NA
8	10	0.5	47	19	3.8	NA	NA
8	11	0.5	17	27	8.4	NA	NA
8	12	0.5	32	37	6.4	NA	NA
8	13	0.5	10	18	3.4	NA	NA
8	14	0.5	94	12	3.5	NA	NA
8	15	0.5	150	18	2.8	NA	NA
8	1	1	79	21	4.4	NA	NA
8	2	1	94	11	1.8	NA	NA
8	3	1	117	15	2.5	NA	NA
8	4	1	89	14	4.4	NA	NA
8	5	1	14	11	3	NA	NA

Table B.1 Effect of BA on shoot formation of *Limnophila geoffrayi* on each node in different media for 4, 6 and 8 weeks (in column medium 0 means MS medium, 0.5 means MS medium with BA 0.5 mg/l, 1 means MS medium with BA 1 mg/l, 2 means MS medium with BA 2 mg/l, and in column root length NA means data were not recorded). (Continued)

Week	Node	Medium	Shoots	Leave	Shoot length (cm)	Number of roots	Root length (cm)
8	6	1	18	22	3.5	NA	NA
8	7	1	44	13	2.4	NA	NA
8	8	1	34	19	2.9	NA	NA
8	9	1	23	27	5.3	NA	NA
8	10	1	65	21	2	NA	NA
8	11	1	44	17	4.3	NA	NA
8	12	1	71	18	2.4	NA	NA
8	13	1	33	16	2.2	NA	NA
8	14	1	19	15	1.8	NA	NA
8	15	1	37	23	4.1	NA	NA
8	1	2	28	16	2.9	NA	NA
8	2	2	23	8	1.5	NA	NA
8	3	2	30	6	1	NA	NA
8	4	2	50	16	0.8	NA	NA
8	5	2	55	6	0.8	NA	NA
8	6	2	82	8	0.9	NA	NA
8	7	2	110	17	3.7	NA	NA
8	8	2	24	13	1.9	NA	NA
8	9	2	26	8	2.5	NA	NA
8	10	2	82	20	1.5	NA	NA
8	11	2	24	14	3.3	NA	NA
8	12	2	22	15	3	NA	NA
8	13	2	10	7	0.6	NA	NA
8	14	2	12	8	0.7	NA	NA
8	15	2	9	7	0.6	NA	NA
8	16	2	122	11	2	NA	NA

CURRICULUM VITAE

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Awards	Quality Persons of The Year 2022 from Foundation of Science and Technology Concil of Thailand (FSTT)
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