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รายงานฉบับสมบูรณ์

การพัฒนารูปแบบของการเก็บรักษาเมล็ด เพื่อให้มีประสิทธิภาพสูงสุดในการผลิตพรรณไม้โครงสร้างที่ใช้ในการฟื้นฟูป่า

โดย

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ธันวาคม 2549

รหัสโครงการ R_348002

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สนับสนุนโดยโครงการพัฒนาองค์ความรู้
และศึกษานโยบายการจัดการทรัพยากรชีวภาพ
ในประเทศไทย (โครงการ BRT)

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ABSTRACT

Lack of seeds is often a serious limitation for tree planting programs to enhance biodiversity recovery, especially where natural forest is scarce. One challenge is to supply local people with high quality seeds of suitable tree species that help to accelerate natural forest regeneration (framework species). This Biodiversity Research and Training Program (BRT) project developed techniques and practical guidelines to store, distribute and germinate seeds of framework tree species that have never been stored before, whilst maintaining genetic diversity. Species studied were *Castanopsis acuminatissima* (Bl.) A. DC., *Erythrina stricta* Roxb., *Gmelina arborea* Roxb., *Hovenia dulcis* Thunb., *Melia toosendan* Sieb. & Zucc., *Michelia baillonii* (Pierre) Hu, *Prunus cerasoides* D. Don, *Quercus semiserrata* Roxb., *Rhus rhetsoides* Craib and *Spondias axillaris* Roxb. These are accepted as framework species of particular value for forest restoration and biodiversity recovery. A phenology study was determined optimum time of seed collection. Experiments on seed germination and seed storage were carried out on seeds collected at different times and temperature of seed storage.

Seeds collected from different fruiting periods had different germination percentages. Seeds of some framework tree species can be stored for more than 6 months whilst maintaining high germination percentage. This knowledge will be invaluable for planning seed collection strategies, seedling production and direct seeding for those species for future restoration planting, thus helping to ensure the conservation of forest tree genetic resources and accelerate biodiversity recovery in planted sites. Recommendations for optimal seed collection times, storage treatments, seedling production schedule and direct seeding for each species are reported.

การขาดแคลนเมล็ดถือว่าเป็นปัญหาสำคัญที่เป็นข้อจำกัดในโครงการปลูกป่าเพื่อนำความหลากหลายกลับคืนมาสู่ธรรมชาติ โดยเฉพาะอย่างยิ่งบริเวณที่ไม่มีป่าธรรมชาติหลงเหลืออยู่ การเป็นแหล่งสนับสนุนเมล็ดที่มีคุณภาพสูงและเป็นชนิดที่เหมาะสมสำหรับการปลูกป่าแก่ชาวบ้านเป็นวิธีการหนึ่งที่ช่วยฟื้นฟูสภาพป่า โครงการวิจัยนี้ได้ทุนจากโครงการพัฒนาองค์ความรู้และศึกษานโยบายการจัดการทรัพยากรชีวภาพในประเทศไทย เพื่อที่จะพัฒนาเทคนิคและวิธีการในการเก็บรักษาเมล็ด การเพาะเมล็ด การกระจายเมล็ดไปยังหน่วยงานที่รับผิดชอบเกี่ยวกับการปลูกป่า โดยยังคงไว้ซึ่งความหลากหลายทางพันธุกรรม ซึ่งเรายังไม่มีข้อมูลด้านนี้มาก่อน ชนิดที่จะศึกษาประกอบด้วย ก่อเดือย ทองเหลือง ซ้อ หมอนหิน เลี่ยน จำปีป่า นางพญาเสือโคร่ง ก่อตาหมูหลวง กอกกัน และมะกอกห้ารู ซึ่งทั้งหมดนี้ได้รับการยอมรับว่าเป็นพรรณไม้โครงสร้างที่มีศักยภาพในการฟื้นฟูป่าในบริเวณภูเขาสูงในเขตภาคเหนือ การศึกษาในครั้งนี้ประกอบไปด้วยการศึกษาชีพลักษณ์วิทยาเพื่อให้ทราบช่วงระยะเวลาที่เหมาะสมในการเก็บเมล็ด การทดลองการงอก การทดลองเก็บรักษาเมล็ดที่เก็บมาในแต่ละช่วงระยะเวลาของการเก็บเมล็ด และอุณหภูมิในการเก็บรักษาเมล็ดที่แตกต่างกัน นอกจากนั้นงานวิจัยในครั้งนี้ยังจะทดสอบการงอกของเมล็ดในแปลงทดลองเพื่อศึกษาถึงความเป็นไปได้ในการใช้เมล็ดชนิดนี้ปลูกป่าโดยตรงจากเมล็ดเพื่อลดค่าใช้จ่ายในการเตรียมต้นกล้าในเรือนเพาะชำ

จากผลการศึกษา พบว่าเมล็ดที่เก็บมาในแต่ละช่วงระยะเวลาของการเก็บเมล็ดมีเปอร์เซ็นต์การงอกแตกต่างกัน เมล็ดของไม้ต้นที่ศึกษาบางชนิดสามารถที่จะเก็บรักษาเมล็ดไว้ได้อย่างน้อย 6 เดือน และยังมีอัตราการงอกที่สูง ซึ่งความรู้ที่ได้จากการศึกษาใครั้งนี้สามารถที่จะนำไปวางแผนในการเก็บเมล็ดเพื่อในการการผลิตกล้าไม้ การใช้เมล็ดในการปลูกป่าโดยตรงจากเมล็ด (direct seeding) เพื่อใช้ในโครงการฟื้นฟูป่า เพื่อการอนุรักษ์ความหลากหลายทางพันธุกรรมและนำความหลากหลายทางชีวภาพกลับคืนมาสู่ป่า ในรายงานการศึกษานี้ได้สรุปถึงระยะเวลาการเก็บเมล็ดที่ดีที่สุด วิธีการเก็บรักษาเมล็ด สำหรับต้นไม้แต่ละชนิดด้วย

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INTRODUCTION

Lack of seeds is often a serious limitation for tree planting programs to enhance biodiversity recovery, especially where natural forest is scarce. One challenge is to supply local people with high quality seeds of suitable tree species that help to accelerate natural forest regeneration (framework species). This Biodiversity Research and Training Program (BRT) project developed techniques and practical guidelines to store, distribute and germinate seeds of framework tree species that have never been stored before, whilst maintaining genetic diversity.

Species studied were *Castanopsis acuminatissima* (Bl.) A. DC., *Erythrina stricta* Roxb., *Gmelina arborea* Roxb., *Hovenia dulcis* Thunb., *Melia toosendan* Sieb. & Zucc., *Michelia baillonii* (Pierre) Hu, *Prunus cerasoides* D. Don, *Quercus semiserrata* Roxb., *Rhus rhetsoides* Craib and *Spondias axillaris* Roxb. Previous research by CMU's Forest Restoration Research Unit showed that these species function well as framework tree species and are particularly effective at accelerating biodiversity recovery when planted out in deforested sites. A study of the seasonality of flowering and fruiting of 5 individuals of each of these species was carried out in their natural habitat to determine the optimum time of seed collection. Experiments on seed germination and seed storage were carried out on seeds collected at different times and for seeds stored for different lengths of time at different temperatures.

The germinability of stored seeds was also tested in deforested sites to determine if they might be suitable for direct seeding. This would remove the expense of establishing and running tree nurseries for forest restoration projects, making them much more economical. This project is significant, because it provides information about germination and storage characteristics of framework tree species that will have direct practical application to improve the efficiency of tree planting to enhance biodiversity recovery. This knowledge will be invaluable for planning seed collection strategies, seedling production schedules and direct seeding protocols for those species for future restoration plantings, thus helping to ensure the conservation of forest tree genetic resources and accelerate biodiversity recovery in planted sites.

PROJECT OBJECTIVES

1. To determine optimum seed collection techniques and times.
2. To determine the optimum techniques of seed storage.
3. To develop seedling production schedules to improve the efficiency of nursery work practises and produce vigorous, healthy trees, large enough for planting by the beginning of the rainy season.
4. To detemine the germinability of seeds in the field after storage and the feasibility of direct seeding.

Methods

SPECIES STUDIED

Research carried out by FORRU has confirmed several framework species which promote forest regeneration when planted in deforested site, based on their growth rate in the rehabilitation plots, dense spreading crowns, potential attractiveness to seed-dispersing wildlife and ease of propagation (Elliott *et al.,* 2003). Eleven species were selected for this study including *Castanopsis acuminatissima* (Bl.) A. DC. (Fagaceae), *Erythrina stricta* Roxb. (Leguminosae, Papilionoideae), *Gmelina arborea* Roxb. (Verbenaceae), *Hovenia dulcis* Thunb. (Rhamnaceae), *Melia toosendan* Sieb. & Zucc. (Meliaceae), *Michelia baillonii* (Pierre) Hu (Magnoliaceae), *Prunus cerasoides* D. Don (Rosaceae), *Quercus semiserrata* Roxb. (Fagaceae), *Rhus rhetsoides* Craib (Anacardiaceae), *Spondias axillaris* Roxb. (Anacardiaceae).

LOCATING SEED TREES

Field trips were carried out to locate suitable parent trees in Doi Suthep-Pui National Park (at least 5 per species). A minimum of 5 seed trees of each species, which were at least 100 m apart, were located and tagged. Characteristics of the seed trees most likely to influence seed characteristics and quality were recorded: i) girth at breast height (gbh) as an indicator of age and ii) habitat factors (elevation etc.).

PHENOLOGY STUDY

To determine early, medium and late fruiting times, 5 individual seed trees of each species studied were scanned with binoculars and scored for flowers and fruits using the crown density method (Koelmeyer, 1959; Newton, 1988) on or about 15th day of each month throughout the project. This method uses a linear scale of 0-4, with 4 representing the maximum intensity of flower + fruits (usually distributed across the whole crown). Values of 3, 2 and 1 represent three-quarters, half, and one-quarter of the maximum intensity, respectively, divisions that are easily distinguished in the field. A value of 0.5 was used to indicate the presence of small amounts of flowers or fruits below one-quarter of the maximum density. The sum of the flowers and fruits scores can never be greater than 4, but can be less because not all trees attain maximum intensity when flowering or fruiting. Graphical phenological profiles were generated by computer using the Excel spreadsheet package.

SEED COLLECTION AND GERMINATION EXPERIMENTS

Seeds of 10 species i.e. *Prunus cerasoides, Gmelina arborea, Erythrina stricta, Quercus semiserrata, Spondias axillaris, Michelia baillonii, Rhus rhetsoides, Castanopsis acuminatissima, Melia toosendan* and *Hovenia dulcis* were collected. Germination trials immediately after collection (to generate baseline data against which storage treatments will be compared) were initiated. Additional, batches were placed in storage for subsequent seed germination and direct seeding tests.

Seventy-five (three replicates of 25) seeds or pyrenes of each species were randomly selected and sown into modular plastic trays, on to the surface of a media of 2 parts forest soil to one

part coconut husk and one part peanut husk at FORRU's research nursery at Doi Suthep-Pui National Park Headquarters (at about 1,050 m elevation). Seed trays were placed randomly on the top of concrete benches, partially shaded under a transparent plastic roof. Watering was carried out daily. Germination was monitored twice per week throughout the germination period and defined as emergence of any part of the radicle or shoot. The dates on which individual seeds germinated were recorded.

STORAGE EXPERIMENTS

Fresh seed (pyrene) storage

The length of storage period required to optimize nursery production schedules varies according to seed collection time. The idea is to bring seeds (pyrenes) out of storage just in time to grow saplings to a plantable size by mid-June, without wasting nursery resources and without having the trees outgrow their containers. For fresh seeds/pyrenes, which cannot be dried, experiments are testing a storage temperature of 5 °C compared with storage at room temperature were tested. Seventy-five seeds of each treatment/seed collection time combination have been packed into hermetically sealed aluminium lined sachets, and are being stored at 5 °C and room temperature. Fresh seed storage of 4 species is currently in progress. For each species 6 months storage will be needed. After seed storage, seeds will be tested for viability.

Dried seed (pyrene) storage

Seeds from each collection time were dried above silica gel for 48 hours. Seventy-five seeds/pyrenes of each treatment were packed into hermetically sealed aluminium lined sachets, and then stored at 5 °C and at room temperature. For each species 6 months storage were needed. After storage, seeds were tested for viability, as described above.

GERMINATION TEST IN FIELD (DIRECT SEEDING)

The viability of seeds sown in the field (direct seeding), after storage will be tested. After the storage period, 75 seeds of each treatment will be randomly divided into 3 replications (25 seed for 1 replication). Ten seeds of each treatment will be sown directly into small experiment plots, 1 x 1 m square. Germination will be observed weekly throughout the germination period and will be defined as emergence of any part of the radicle or shoot. Seeds of *P. cerasoides* and *Q. semiserrata* were tested (direct seeding) on 18 June 2005 at Mae Sa Mai village. Seeds of *C. acuminatissima*, *H. dulcis*, *M. toosendan*, *R. rhetsoides* and *S. axillaris* were tested on 22 May 06 at Doi Suthep Pui National Park. Germination was monitored for at least 3 months.

RESULTS

GERMINATION EXPERIMENTS

Seeds of 10 study species were tested for germination percentage of seed collected from different fruiting periods (early, middle and late). However, seeds of *Q. semiserrata* and *E. stricta* and *C. acuminatissima* were collected only once, because their fruiting periods were

very short and seed dispersal was by wind, making it very difficult to collect seeds (*E. stricta*) and most seed were destroyed by insects and there were too few seeds remaining for the later fruiting period (*Q. semiserrata* and *C. acuminatissima*).

Table 1. Germination percentage and median length of dormancy (MLD) before storage of 10 species studied when seeds were collected in early, middle and late in the fruiting period.

Species	Germination percentage before storage				Median Length of Dormancy (days)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
P. cerasoides	**61**	54	43	53	22	24	20	22
G. arborea	42	39	**67**	49	25	25	15	22
E. stricta	-	**77**	-	76	-	9	-	9
Q. semiserrata	-	**40**	-	40	-	33	-	33
S. axillaris	77	**81**	52	75	70	55	43	56
M. baillonii	65	**67**	7	46	82	68	53	68
R. rhetsoides	1	**13**	7	7	38	77	98	71
C. acuminatissima	-	**72**	-	36	-	36	-	36
M. toosendan	**49**	33	32	37	109	63	60	77
H. dulcis	**66**	63	59	63	117	111	101	110

Germination percentage of species studied was ranged from 7 (*R. rhetsoides*) to 76 (*E. stricta*). Seeds with different seed collection periods had a different germination percentage. The best time to collect seeds of *P. cerasoides*, *Melia toosendan* and *Hovenia dulcis* was early in the fruiting period (18 March 2005, 16 November 2005 and 16 November 2005 respectively (appendix 1)). The germination percentage of *P. cerasoides* differed significantly amongst fruiting periods ($P<0.05$; ANOVA). Germination percentage was 61 when seeds were collected on 18 March 06 and dropped to 54% and 43% when seeds were collected on 1 April and 8 April 2006 respectively. Seeds of *Melia toosendan* had the highest germination percentage (49) when seeds were collected on 16 November 2005 and dropped to 33 and 32 when were collected in 2 and 26 December 2005 respectively ($P<0.05$; ANOVA). Seeds of *Hovenia dulcis* when collected early in the fruiting period also had the highest germination percentage (66) and germination percentage was dropped to 63 and 59 when collected in the middle and late of fruiting period, but differences among fruiting periods were not significantly ($P<0.05$; ANOVA).

For *S. axillaris* and *M. baillonii* and *R. rhetsoides*, the best time to collect seeds for seedling production was in the middle of the fruiting period (81 for *S. axillaris*, 67 for *M baillonii* and 13 for *R. rhetsoides*). Germination percentages showed significant differences among fruiting periods ($P<0.05$; ANOVA for *S. axillaris* and *R. rhetsoides*; $P<0.01$; ANOVA for *M. baillonii*) However, the germination percentage of seeds collected early in the fruiting period was still high, when compared with the middle fruiting period (except for *R. rhetsoides*). We can conclude that the best time to collect seed of those species was early and in the middle of the fruiting period. Seeds should be collected not later than July for both species, because germination percentage dropped to 52 for *S. axillaris* and only 7 for *M. baillonii* after that. Germination percentages of *R. rhetsoides* seed over the entire fruiting period were very low.

This is probably because they were in dormancy stage. This result will be compared with germination percentage of seeds after 6 months storage.

The best time to collect seeds of *G. arborea* was different from the other species studied and shown significantly differences among fruiting periods ($P<0.05$; ANOVA). Seeds collected late (11 April 05) had the highest percent germination (67%). Germination percentage of seeds collected early or in the middle of the fruiting period was only 42 and 39 respectively.

The median length of dormancy (MLD) of 10 species studied is shown in table 1. The species can divided into 3 groups of MLD (shortest {< 45 days}, short {45 - < 90 days} and longest MLD {> 90 days}). Tree species with the shortest MLD were *P. cerasoides*, *G. arborea*, *E. stricta*, *Q. semiserrata* and *C. acuminatissima*. Tree species with short MLDs were *S. axillaris*, *M. baillonii*, *R. rhetsoides*, and *M. toosendan* and tree species with the longest MLDs was *H. dulcis*. It was quite clear that fruits and seeds of tree species with the shortest MLDs ripened and dispersed late in the dry season or early wet season, except for *C. acuminatissima*. Seeds with short MLD tended to be dispersed in wet season and seeds with longest MLD were dispersed early in the dry season. The timing on seed collection (early, middle and late) also affected seed dormancy. Mean MLDs of seeds collected early in the fruiting period was longest (66 days), followed by the middle fruiting period (60 days) and was shortest for seeds collected late in the fruiting period.

GERMINATION TESTS IN THE FIELD (DIRECT SEEDING)

After 2 months storage, seeds of *P. cerasoides* and *Q. semiserrata* and after 6 months, seeds of *C. acuminatissima*, *H. dulcis*, *M. toosendan*, *Rhus rhetsoides* and *S. axillaris* were tested for germination in the field (for use in reforestation by direct seeding). Seeds of *P. cerasoides* and *H. dulcis* could be used for direct seeding, because seeds still had high germinability. However, seed of *Q. semiserrata*, *C. acuminatissima*, *M.* toosendan, *R. rhetsoides* and *S. axillaris* could not be stored successfully.

Germination percentage of *P. cerasoides* in the field, from different seed collection times, against storage treatment are shown below. Seed collected early in the fruiting period and with dry/room storage had the highest germination percentage (67); second was early fruiting period and dry/5°C storage (62). For each storage treatment, dry/room (55) had the highest germination percentage; second was dry/5°C (51) and third was fresh/5°C (49). Fresh/room storage treatment was not a good seed storage treatment, because germination percentage dropped to only 11 after 2 months storage. When germination percentage after 2 months storage is compared with germination after seed collection, dry/5°C storage treatment resulted in higher germination after seed collection and it dropped to 51 and 49 for dry/5°C and fresh/5°C storage treatment respectively.

Germination percentage of *H. dulcis* was fairly good for Dry/5C treatment (27), however germination percentage dropped from 38% (before storage) to only 13 for seed germination tested immediately after collection (63%). For each storage treatment, the best storage treatment was dry/5°C with a mean of 27%, second was dry/room (14%). Fresh/room and fresh/5°C storage treatments were not effective, because germination percentage dropped to only 10 and 1 respectively. For each seed collection time, seeds collected early in the fruiting period still had the highest germination percentage with a mean of 17%. It was confirmed that

the best time to collected *H. dulcis* seed for seedling production was early in the fruiting period.

For the other species studied, storage treatments for direct seeding were not successful, since germination percentage in the field was zero for *Q. semiserrata*, *C acuminatissima*, 0 for *M. toosendan*, 3 for *R. rhetsoides*, and 1 for *S. axillaris*,

Table 2. Germination percentages and median length of dormancy (MLDs) in the field (direct seeding) of 7 species studied when seeds were collected in early, middle and late fruiting period.

Species	Treatment	Fruiting period			Mean
		Early	Middle	Late	
P. cerasoides	Fresh/Room (N=75)	3	27	4	11
	Fresh/ 5 °C (N=75)	58	48	42	49
	Dry/Room (N=75)	67	51	47	55
	Dry/ 5 °C (N=75)	62	45	45	51
Q. semiserrata	Fresh/Room (N=75)	-	0	-	0
	Fresh/ 5 °C (N=75)	-	0	-	0
	Dry/Room (N=75)	-	0	-	0
	Dry/ 5 °C (N=75)	-	0	-	0
C. acuminatissima	Fresh/Room (N=75)	-	0	-	0
	Fresh/ 5 °C (N=75)	-	0	-	0
	Dry/Room (N=75)	-	0	-	0
	Dry/ 5 °C (N=75)	-	0	-	0
H. dulcis	Fresh/Room (N=75)	1	1	0	1
	Fresh/ 5 °C (N=75)	3	6	19	10
	Dry/Room (N=75)	12	23	7	14
	Dry/ 5 °C (N=75)	40	15	25	27
M. toosendan	Fresh/Room (N=75)	0	0	2	1
	Fresh/ 5 °C (N=75)	0	0	0	0
	Dry/Room (N=75)	0	0	0	0
	Dry/ 5 °C (N=75)	0	0	0	0
R. rhetsoides	Fresh/Room (N=75)	0	4	1	2
	Fresh/ 5 °C (N=75)	0	4	2	3
	Dry/Room (N=75)	2	2	1	2
	Dry/ 5 °C (N=75)	5	7	1	4
S. axillaris	Fresh/Room (N=75)	6	0	0	2
	Fresh/ 5 °C (N=75)	0	0	0	0
	Dry/Room (N=75)	0	2	2	1
	Dry/ 5 °C (N=75)	0	0	0	0

STORAGE EXPERIMENTS

Seeds of 10 species: *P. cerasoides, G. arborea, Q. semiserrata, S. axillaris, E. stricta, M. baillonii, C. acuminatissima, R. rhetsoides* and *M. toosendan* were tested after 6 months storage. The germination percentage of each treatment was shown in the table below.

Table 3. Germination percentage and median length of dormancy (MLD) after 6 months storage of *P. cerasoides* when seeds were collected in early, middle and late fruiting period.

	Germination percentage				Median Length of Dormancy (day)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	0	0	0	**0**	-	-	-	-
Fresh/ 5 °C *	35	42	51	**42**	26	23	19	**23**
Dry/Room*	64	47	52	**54**	20	22	19	**20**
Dry/ 5 °C *	74	36	61	**57**	24	19	17	**20**
Mean	**43**	**31**	**41**	**38**	**23**	**21**	**18**	**21**

Seeds of *P. cerasoides* could be stored for at least 6 months. The germination percentage dropped from 53 to 38. However, germination percentage after storage was still acceptable for seedling production. The best storage treatment was dry/5°C (57), 2nd was dry/room (54), and 3rd was fresh/room (42). Fresh/room storage treatment resulted in no germination. For different seed collection times, the early fruiting period still had a high germination percentage after 6 months storage. This result confirmed that the best time to collect seeds of *P. cerasoides* for seedling production for forest restoration is early in the fruiting period.

The MLD of this species, after 6 months storage was a 21 days less than before storage (22 days). For different storage treatments, fresh/5°C resulted in the longest MLD, 2nd was dry/room and 3rd was dry/5°C.

Table 4. Germination percentage and median length of dormancy (MLD) after 6 months storage of *G. arborea* when seeds were collected in early, middle and late fruiting period.

	Germination percentage				Median Length of Dormancy (day)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	0	17	41	**19**	-	18	18	**18**
Fresh/ 5 °C *	3	1	13	**6**	14	13	14	**14**
Dry/Room*	38	59	67	**55**	12	12	14	**13**
Dry/ 5 °C *	7	4	14	**8**	14	17	17	**16**
Mean	**12**	**20**	**34**	**22**	**13**	**15**	**16**	**15**

After 6 months storage with each treatment, the best treatment to store seeds of *G. arborea* was dry/room, which resulted in germination percentage higher than germination before

storage (55). The other treatments were not suitable for this species. This species could not be stored in cool conditions (5 °C). For different seed collection times, lately fruiting period still had a high germination percentage after 6 months storage. This result confirmed that the best time to collect seeds of *G. arborea* for seedling production for forest restoration is the lately fruiting period.

After 6 months storage, MLD was lower than before storage. The best storage treatment for this species was dry/room, which also had a shortest MLD (13 days). Longest MLD resulted from the fresh/room treatment (18 days).

Table 5. Germination percentage and median length of dormancy (MLD) after 6 months storage of *Q. semiserrata* when seeds were collected in early, middle and late fruiting period.

	Germination percentage					Median Length of Dormancy (day)			
	Fruiting period			Mean		Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)			Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	-	0	-	**0**		-	0	-	**0**
Fresh/ 5 °C *	-	0	-	**0**		-	0	-	**0**
Dry/Room*	-	0	-	**0**		-	0	-	**0**
Dry/ 5 °C *	-	0	-	**0**		-	0	-	**0**
Mean	-	**0**	-	**0**		-	**0**	-	**0**

The germination percentage after 2 months storage (direct seeding) was zero. Seeds of this species can not be stored.

Table 6. Germination percentage and median length of dormancy (MLD) after 6 months storage of *E. stricta* when seeds were collected in early, middle and late fruiting period.

	Germination percentage					Median Length of Dormancy (day)			
	Fruiting period			Mean		Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)			Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	-	7	-	**7**		-	11	-	**11**
Fresh/ 5 °C *	-	61	-	**61**		-	9	-	**9**
Dry/Room*	-	38	-	**38**		-	11	-	**11**
Dry/ 5 °C *	-	47	-	**47**		-	9	-	**9**
Mean	-	**38**		**38**			**10**		**10**

Seeds of *E. stricta* could be store for at least 6 months. However, germination percentage dropped by 50%. Germination percentage before storage was 77 dropping to only 34 after 6 months storage. The best storage treatment was fresh/5°C which resulted in germination percentage of 61. The germination percentages for the Dry/5°C and dry/room treatments were also high (47 and 38 respectively). Those treatments would also be accepted for storage protocols for this species. MLDs of seeds after 6 months storage was longer than before storage. Storage treatments with the shortest MLDs were fresh/5°C and dry/5°C, which also had the high germination percentages (61 and 47% respectively).

Table 7. Germination percentage and median length of dormancy (MLD) after 6 months storage of *S. axillaris* when seeds were collected in early, middle and late fruiting period.

	Germination percentage				Median Length of Dormancy (day)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	73	72	58	**68**	60	39	40	**46**
Fresh/ 5 °C *	11	62	2	**25**	74	55	59	**63**
Dry/Room*	70	79	48	**66**	67	42	41	**50**
Dry/ 5 °C *	78	39	19	**45**	75	49	40	**55**
Mean	**58**	**63**	**32**	**51**	**69**	**46**	**45**	**53**

After 6 months storage, seeds of *S. axillaris* could be germinated. The germination percentage did not drop much overall for and some treatments. The germination percentage dropped from 72 to 51 The best treatment was fresh/room treatment (68), 2nd was dry/room (66), and 3rd was dry/5°C (45). For different seed collection times, middle fruiting period still had a high germination percentage after 6 months storage (63%). This result confirmed that the best time to collect seeds of *S. axillaris* for seedling production for forest restoration is the middle of the fruiting period. MLDs of seeds after 6 months storage dropped from 56 days to 53.42 days. Fresh/room storage treatment resulted in the shortest MLD, and the highest germination percentage, 2nd was dry/room, 3rd was dry/5°C treatment. Fresh/5°C storage treatment had the longest MLD and also the lowest germination percentage. MLD was negatively correlated with germination percentage of this species.

Table 8. Germination percentage and median length of dormancy (MLD) after 6 months storage of *M. baillonii* when seeds were collected in early, middle and late fruiting period.

	Germination percentage				Median Length of Dormancy (day)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	0	0	0	**0**	-	-	-	-
Fresh/ 5 °C *	0	0	13	**4**	-	-	63	**63**
Dry/Room*	0	1	0	**0**	-	100	-	**100**
Dry/ 5 °C *	3	17	2	7	84	68	70	**74**
Mean	**1**	**4**	**4**	**3**	**84**	**84**	**67**	**79**

The mean germination percentage of *M. baillonii* seeds after collection (before storage) was 46.66%, which was acceptable for seedling production. However, after 6 months storage, the mean germination percentage dropped to less than 10% for all treatments. Dry/5°C storage treatment seemed to be best treatment for this species.

Table 9. Germination percentage and median length of dormancy (MLD) after 6 months storage of *C. acuminatissima* when seeds were collected in early, middle and late fruiting period.

	Germination percentage				Median Length of Dormancy (day)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	-	0	-	0	-	-	-	-
Fresh/ 5 °C *	-	0	-	0	-	-	-	-
Dry/Room*	-	0	-	0	-	-	-	-
Dry/ 5 °C *	-	0	-	0	-	-	-	-
Mean	-	**0**	-	**0**	-	-	-	-

After 6 months storage, germination percentage of *C. acuminatissima* was zero. Seeds of this species can not be stored. This species belongs to family Fagaceae, Storage treatments in this studied were not suitable for both Fagaceae species (*C. acuminatissima* and *Q. semiserrata*).

Table 10. Germination percentage and median length of dormancy (MLD) after 6 months storage of *R. rhetsoides* when seeds were collected in early, middle and late fruiting period.

	Germination percentage				Median Length of Dormancy (day)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	0	7	5	**4**	-	37	67	**52**
Fresh/ 5 °C *	1	11	5	**6**	25	45	46	**39**
Dry/Room*	5	13	7	**8**	27	22	32	**27**
Dry/ 5 °C *	5	17	7	**10**	26	45	38	**36**
Mean	**3**	**12**	**6**	**7**	**26**	**37**	**46**	**39**

After 6 months storage, germination percentage of *R. rhetsoides* was less than 10% for all storage treatments with a mean of 7, which was not acceptable for seedlings production. However germination percentage before storage also was low. After 6 months storage in various treatments, some treatments resulted in higher germination percentage than before storage, *e. g.* Dry/Room (8%) and Dry/5°C (10%) treatment. MLDs of seeds after storage was lower than before storage by half. The relationship between germination percentage and MLD was negative.

Table 11. Germination percentage and median length of dormancy (MLD) after 6 months storage of *M. toosendan* when seeds were collected in early, middle and late fruiting period.

	Germination percentage				Median Length of Dormancy (day)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	3	1	15	**6**	47	79	25	**50**
Fresh/ 5 °C *	0	0	0	**0**	-	-	-	-
Dry/Room*	14	15	11	**13**	21	17	26	**21**
Dry/ 5 °C *	16	9	0	**8**	34	27	-	**31**
Mean	**8**	**6**	**7**	**7**	**34**	**41**	**25**	**34**

After 6 months storage, seeds of *M. toosendan* could be germinated, but not enough for seedling production. The germination percentage dropped substantially for all treatments. This species can not likely be stored fresh. The best treatment was dry/room treatment (14), 2nd was dry/5°C (8), 3rd was fresh/room (6) and zero for fresh/5°C. For different seed collection times, early fruiting period still resulted in higher germination percentage after 6 months storage (8%). This result confirmed that the best time to collect seeds of *M. toosendan* for seedling production for forest restoration is the middle in the fruiting period.

Table 12. Germination percentage and median length of dormancy (MLD) after 6 months storage of *H. dulcis* when seeds were collected in early, middle and late fruiting period.

	Germination percentage				Median Length of Dormancy (day)			
	Fruiting period			Mean	Fruiting period			Mean
	Early (N=75)	Middle (N=75)	Late (N=75)		Early (N=75)	Middle (N=75)	Late (N=75)	
Fresh/Room*	8	17	14	**13**	76	114	117	**102**
Fresh/ 5 °C *	43	39	37	**40**	59	43	47	**50**
Dry/Room*	45	46	40	**43**	52	42	40	**45**
Dry/ 5 °C *	89	71	64	**75**	31	40	26	**32**
Mean	**46**	**43**	**39**	**43**	**55**	**60**	**58**	**57**

Seeds of *H. dulcis* can be stored for at least 6 months. Germination percentage dropped from 63 to 43, acceptable for using in seedling production. The dry treatment seems to be a good storage treatment than fresh storage treatment for this species. The best treatment was dry/5°C (75) which was higher than before storage, 2nd was dry/room (43), 3rd was fresh/5°C (40) and 4th was fresh/room (13). For different seed collection times, the early fruiting period still resulted in the highest germination percentage after 6 months storage (46). This result confirmed that the best time to collect seeds of *H. dulcis* for seedling production for forest restoration is early fruiting period. The relationship between germination percentage and MLD was negative.

DISCUSSION AND CONCLUSION

The result of this study demonstrated that seeds collected in different part of the fruiting period had different germination percentage. Seeds of some framework tree species can be stored for more than 6 months whilst maintaining high germination percentages. This knowledge is useful for planning seed collection strategies and seedling production and direct seeding for those species for future restoration plantings, thus helping to ensure the conservation of forest tree genetic resources and biodiversity recovery in planted sites. The recommendations for the best seed collection time, the best storage treatment, seedling production and direct seeding for each species were given below.

P. cerasoides

Because seeds of *P. cerasoides* are dispersed in March to April, there is insufficient time to grow saplings to a plantable size by the early wet season. Plants reach a suitable height for planting in the early part of the subsequent dry season (September – October), some 6 months ahead of the scheduled planting date. Therefore, seeds should be collected early in the fruiting period (middle of March). Germination percentage should be up to 60%. Seeds should be stored dry at 5°C for 6 months and then sown in germination trays. Seedlings are ready for planting the following in next rainy season. In this study, seedlings growth was monitored until the end of May. They average 45.29±11.91 cm with a root collar diameter (RCD) 2.62±0.71 mm. For direct seeding, seeds should be stored for 2 months (April to May). Direct seeding of this species should be successful since germination percentage was high (Table 2).

G. arborea

Seeds of *G arborea* are dispersed in March-April. Seeds germinate quickly, and the plants reach a suitable height for planting in the early part of the subsequent dry season, some 6 months ahead of the scheduled planting date. Therefore, it would be highly desirable to store seed for up to 6 months prior to sowing. Seeds should be collected late in the fruiting period (mid-April), for highest germination percentage (67%). Seeds should be stored with dry/room storage treatment for 6 months and then sown in germination trays. The germination percentage was 67%. By the end of May, seedling height and root collar diameter were 42.88±9.92 cm and 3.01±0.93 mm respectively which is suitable for planting out.

E. stricta

The problem of seedling production for *E. stricta* is the same as with *G. arborea*. Seeds are dispersed in April and May, which gives insufficient time to grow saplings to a plantable size by the early wet season planting (mid-June). However, seeds germinate quickly, and the plants reach a suitable height for planting in the early part of the subsequent dry season, some 8 months ahead of the optimal planting date. Storing plantable saplings in the nursery for 8 months is costly in terms of labour and space. Therefore, it would be highly desirable to store seed for up to 6 months prior to sowing. The results from this study showed that seeds of *E. stricta* can be stored up to 6 months. Germination percentage was 61.33 (Fresh/5°C). Seedlings also grew to a suitable size by the end of May (59.87±17.25 cm for height and 6.31±1.65 mm for root collar diameter.

Q. semiserrata

The fruiting period of *Q. semiserrata* is usually from December to July, but this species exhibits masting, so that seeds must be stored from year to year to maintain a steady supply of

seedlings. Direct seeding is also recommend for this species, but would necessitate seed storage for 6 months. To assure seed supply for seedling production, seed distribution and direct seeding between masting years, a seed stock should be established. However, the results demonstrated that seeds of this species could not be easily stored. Germination percentage was zero for direct seeding (2 months storage) and for the 2nd germination test (6 months storage).

S. axillaris

S. axillaris is recommended by FORRU for using for direct seeding in northern Thailand at elevations higher than 1000 m above sea level. However, for direct seeding and seed distribution, seeds must be stored for at least 6 months. To assure seed supply for direct seeding program, a seed stock should be established. Seeds collected in the middle of fruiting period had the highest germination percentage (81). Seeds could be storage for more than 6 months. The best treatment was fresh/room. However, direct seeding was not successful since germination percentage dropped to only 2% for the fresh/room storage treatment after 6 months.

M. baillonii

Seeds of *M. baillonii* are dispersed in May–August saplings of this species take at least 1 year to grow to a plantable size. This means that plants reach a suitable height for planting in September or October of the year after seed collection, some 8 months ahead of the scheduled planting date. Storing plantable saplings in the nursery for 8 months is costly in terms of labour and space. Therefore, it would be highly desirable to store seed for up to 6 months prior to sowing. For seedling production, seeds should be collected in the middle of fruiting period (middle July). Unfortunately seeds of this species could not be stored by our storage treatments. Germination percentage dropped to only 3% (Table 8) after 6 months. Seedling growth was also too slow far the plants to reach a suitable size for planting by the end of May (15.90±3.30 cm for height and 2.77±0.54 cm for root collar diameter).

R. rhetsoides

R. rhetsoides is a medium-sized, deciduous tree which is particularly suitable for forest restoration plantings in Northern Thailand. The fruiting period is September to November. Seedlings are ready for planting by the second season after germination, so there are no problems for seedling production. However, for direct seeding and seed distribution, seeds would have to maintain their variability over 6 months. Germination percentage was low for all fruiting periods. Seeds collected in the middle of the fruiting period resulted in the highest germination percentage; although it was not acceptable for seedlings production. After 6 months storage, germination remained also low for both 2nd germination tested and for direct seeding. Seeds of this species might need a special treatment to enhance seed germination *i. e.* scarification, soaking in water before sowing.

C. acuminatissima

C. acuminatissima has been studied for seed germination, genetic diversity (Pakkad, 2002) and was recommended for planting for forest restoration in Northern Thailand. However, seed storage has not been studied. Seedlings are ready for planting in the second season after germination. However, for direct seeding in June and seed distribution, seeds would have to maintain their variability over 6 months of storage, which had not been tested. Germination percentage of this species before storage was high (72), this species could not be stored. Germination percentage was zero for both the direct seeding and 2nd germination test.

M. toosendan

M. toosendan has been identified as an excellent framework species for forest restoration planting in northern Thailand. The fruiting period is October to November, which usually gives sufficient time to grow saplings to a plantable size by the early wet season planting (mid-June). However, for direct seeding and seed distribution, seed must be stored for at least 6 months for seeding in June. Seeds should be collected early in the fruiting period (middle November). However, storage treatments in this study were not suitable for *M. toosendan*. Germination percentage after 6 months storage was only 7%, which was not acceptable using in seedling production. Germination percentage for direct seeding was also low.

H. dulcis

H. dulcis an excellent framework tree species for restoring forest in Northern Thailand. Although FORRU has studied germination of this species, seed storage has not been studied. It is valuable to do seed storage and germination of this species, since it is a rare species. This species does not pose a problem for seedling production, since it is dispersed in November to December, which gives sufficient time to grow saplings to a plantable size by the early wet season planting (mid-June). However, for seed distribution and direct seeding, seeds must be stored at least 6 months for sowing in June. Seeds should be collected early in the fruiting period, for highest germination percentage (66). Seeds of *H. dulcis* can be storage for more than 6 months with high germination percentage. The best storage treatment was dry/5°C. Seeds also were usable for direct seeding, because germination percentage was high with the dry/5°C treatment, especially for seeds collection in early fruiting period (40).

Table 13. Summary of recommendations

Species	Optimum seed collection date		Optimum storage treatment	Optimum sowing date	Suitable for direct seeding
P. cerasoides	Early	18-Mar-05	Dry/ 5 °C	23-Sep-05	Yes
G. arborea	Late	11-Apr-05	Dry/Room	18-Oct-05	
E. stricta	Middle	19-Apr-05	Fresh/ 5 °C	6-Nov-05	
Q. semiserrata	Middle	3-May-05	-	-	No
S. axillaris	Middle	19-July-05	Fresh/Room	25-Jan-06	No
M. baillonii	Middle	19-July-05	Dry/ 5 °C	25-Jan-06	
R. rhetsoides	Middle	13-Oct-05	Dry/ 5 °C	19-Apr-06	No
C. acuminatissima	Middle	27-Oct-05	-	-	No
M. toosendan	Early	16-Nov-05	Dry/Room	17-May-06	No
H. dulcis	Early	16-Nov-05	Dry/ 5 °C	21-May-06	Yes

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Appendix 1. Summary of each species, dates on which they were collected, germination tests and storage test.

Species	Activities	Fruiting period		
		Early	Middle	Late
P. cerasoides	Seed collection	18-Mar-05	1-Apr-05	8-Apr-05
	1st Germination test	24-Mar-05	8-Apr-05	12-Apr-05
	Storage initiated	24-Mar-05	4-Apr-05	12-Apr-05
G. arborea	Seed collection	28-Mar-05	4-Apr-05	11-Apr-05
	1st Germination test	1-Apr-05	8-Apr-05	12-Apr-05
	Storage initiated	30-Mar-05	11-Apr-05	18-Apr-05
E. stricta[1]	Seed collection	-	19-Apr-05	-
	1st Germination	-	22-Apr-05	-
	Storage initiated	-	22-Apr-05	-
Q. semiserrata[2]	Seed collection	-	3-May-05	-
	1st Germination test	-	4-May-05	-
	Storage initiated	-	6-May-05	-
S. axillaris	Seed collection	4-July-05	19-July-05	16-Aug-05
	1st Germination test	11-July-05	25-July-05	19-Aug-05
	Storage initiated	7-July-05	25-July-05	19-Aug-05
M. baillonii	Seed collection	4-July-05	19-July-05	1-Aug-05
	1st Germination test	11-July-05	25-July-05	9-Aug-05
	Storage initiated	7-July-05	25-July-05	10-Aug-05
R. rhetsoides	Seed collection	26-Sep-05	13-Oct-05	1-Nov-05
	1st Germination	3-Oct-05	18-Oct-05	8-Nov-05
	Storage initiated	30-Sep-05	19-Oct-05	4-Nov-05
C. acuminatissima	Seed collection	-	27-Oct-05	-
	1st Germination test	-	27-Oct-05	-
	Storage initiated	-	31-Oct-05	-
M. toosendan	Seed collection	16- Nov-05	2-Dec-05	26-Dec-05
	1st Germination	16- Nov-05	13-Dec-05	4-Jan-06
	Storage initiated	18-Nov-05	8-Dec-05	3-Jan-06
H. dulcis	Seed collection	16- Nov-05	7-Dec-05	4-Jan-06
	1st Germination test	16- Nov-05	13-Dec-05	6-Jan-06
	Storage initiated	21-Nov-05	11-Dec-05	6-Jan-06
A. xylocarpa	Seed collection	-	31-Mar-06	-
	1st Germination test	-	3-Apr-06	-
	Storage initiated	-	7-Apr-06	-

[1] *Seeds were collected only in the middle of fruiting period, because the fruiting period was very short and seed dispersal was by wind, making it very difficult for seed collection.*

[2] *Seeds were collected only in the middle of the fruiting period, because most seeds were destroyed by insects and there were too few seeds remaining for the later fruiting period.*

Appendix 2. Summary of each species, dates on which they were taken out of storage for the direct seeding test.

Species	Activities	Early	Middle	Late
P. cerasoides	2nd Germination test	23-Sep-05	4-Oct-05	12-Oct-05
	Direct seeding	18-Jun-05	18-Jun-05	18-Jun-05
G. arborea	2nd Germination test	30-Sep-05	11-Oct-05	18-Oct-05
	Direct seeding	No	No	No
E. stricta	2nd Germination test	No	22-Oct-05	No
	Direct seeding	No	No	No
Q. semiserrata	2nd Germination test		6-Nov-05	
	Direct seeding	No	18-Jun-05	No
S. axillaris	2nd Germination test	7-Jan-06	25-Jan-06	19-Feb-06
	Direct seeding	22-May-06	22-May-06	22-May-06
M. baillonii	2nd Germination test	7-Jan-06	25-Jan-06	10-Feb-06
	Direct seeding	No	No	No
R. rhetsoides	2nd Germination test	30-Mar-06	19-Apr-06	4-May-06
	Direct seeding	22-May-06	22-May-06	22-May-06
C. acuminatissima	2nd Germination test	-	30-Apr-06	-
	Direct seeding	-	22-May-06	-
M. toosendan	2nd Germination test	17-May-06	8-Jun-06	3-Jul-06
	Direct seeding	22-May-06	22-May-06	22-May-06
H. dulcis	2nd Germination test	22-May-06	11-Jun-06	6-Jul-06
A. xylocarpa	2nd Germination test	-	7-Aug-06	-
	Direct seeding	-	No	-

Appendix 3. Moisture content percentage of seed before storage and after storage

P. cerasoides

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early	13.32	2.97	10.21	11.15	5.55	4.35
	Middle	5.80	0.66	4.88	5.17	3.35	0.59
	Late	4.39	0.72	5.97	6.56	1.03	0.17

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early	2.29	1.61	1.52	1.22	0.78	0.58
	Middle	4.20	0.88	0.56	0.60	0.63	0.62
	Late	1.56	1.06	0.81	1.83	0.87	0.54

G. arborea

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early	20.42	5.96	11.08	11.07	4.82	3.71
	Middle	8.02	3.69	8.09	8.91	3.48	2.88
	Late	8.51	2.01	8.63	8.59	3.25	2.18

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early	3.08	1.46	1.71	0.62	0.72	0.82
	Middle	2.46	0.90	1.00	0.45	3.50	0.79
	Late	3.40	0.60	0.59	0.64	0.51	0.87

E. stricta

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early						
	Middle	8.60	4.23	9.15	9.13	5.69	4.62
	Late						

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early						
	Middle	0.96	0.76	1.10	2.11	0.64	1.02
	Late						

Q. semiserrata

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early						
	Middle	41.44	36.35	33.22	26.65	33.68	30.26
	Late						

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early						
	Middle	5.72	5.90	10.39	6.79	6.89	7.39
	Late						

S. axillaris

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early	15.00	8.47	17.15	15.98	11.48	11.14
	Middle	13.32	8.77	16.11	15.35	8.23	6.89
	Late	24.66	7.11	22.76	23.53	8.70	8.68

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early	1.28	1.64	1.06	0.73	3.80	0.60
	Middle	0.41	4.42	0.60	2.01	0.25	0.28
	Late	2.09	0.95	1.78	1.68	0.16	0.36

M. baillonii

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early	11.91	6.28	7.41	9.92	4.02	2.89
	Middle	10.46	5.13	9.38	11.02	8.24	6.24
	Late	8.85	7.52	7.61	9.65	5.62	2.08

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early	2.14	2.11	1.86	0.89	2.07	1.64
	Middle	1.35	1.23	1.74	1.50	1.24	2.35
	Late	4.32	2.87	1.08	1.31	1.23	1.21

R. rhetsoides

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early	25.71	6.40	25.29	30.03	8.38	9.07
	Middle	7.31	1.82	8.42	11.32	8.09	6.57
	Late	12.07	7.87	10.88	13.53	16.16	7.71

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early	3.26	1.97	2.84	2.65	1.67	3.56
	Middle	1.71	2.47	2.56	2.16	1.57	2.18
	Late	3.68	2.15	2.34	2.65	20.15	2.70

C. acuminatissima

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early						
	Middle	30.38	25.07	35.49	28.35	31.99	32.28
	Late						

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early						
	Middle	0.73	1.14	3.08	2.86	2.17	21.20
	Late						

H. dulcis

	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early	7.89	4.11	7.36	11.44	5.85	5.80
	Middle	9.57	6.35	9.50	9.48	6.80	4.51
	Late	7.46	6.14	8.53	7.62	7.33	7.35

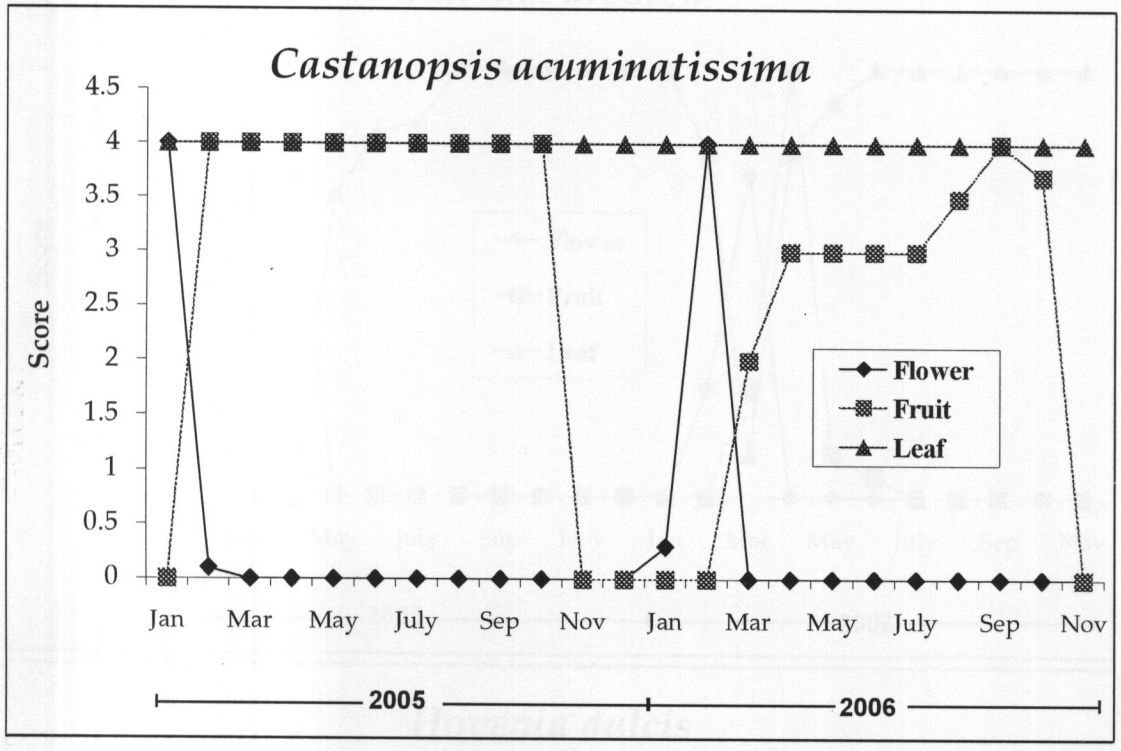
	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early	2.70	2.82	3.11	3.07	2.77	2.55
	Middle	2.74	2.33	3.77	2.72	5.18	4.82
	Late	3.03	3.18	3.91	4.29	4.77	3.61

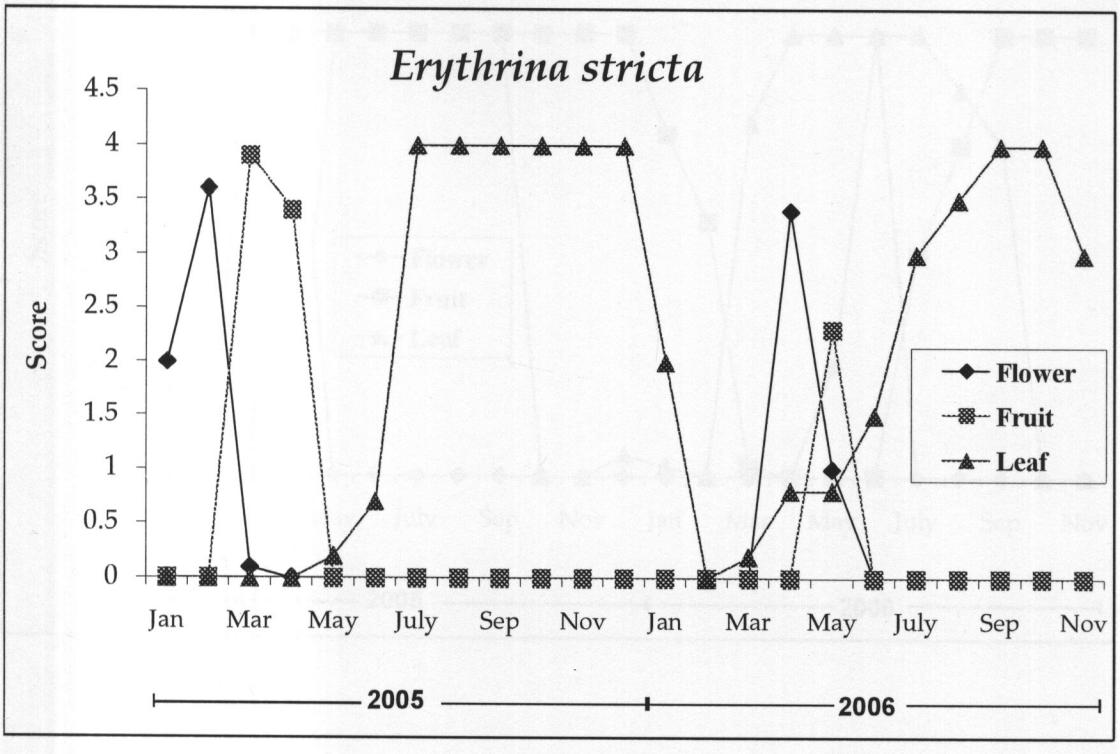
M. toosendan

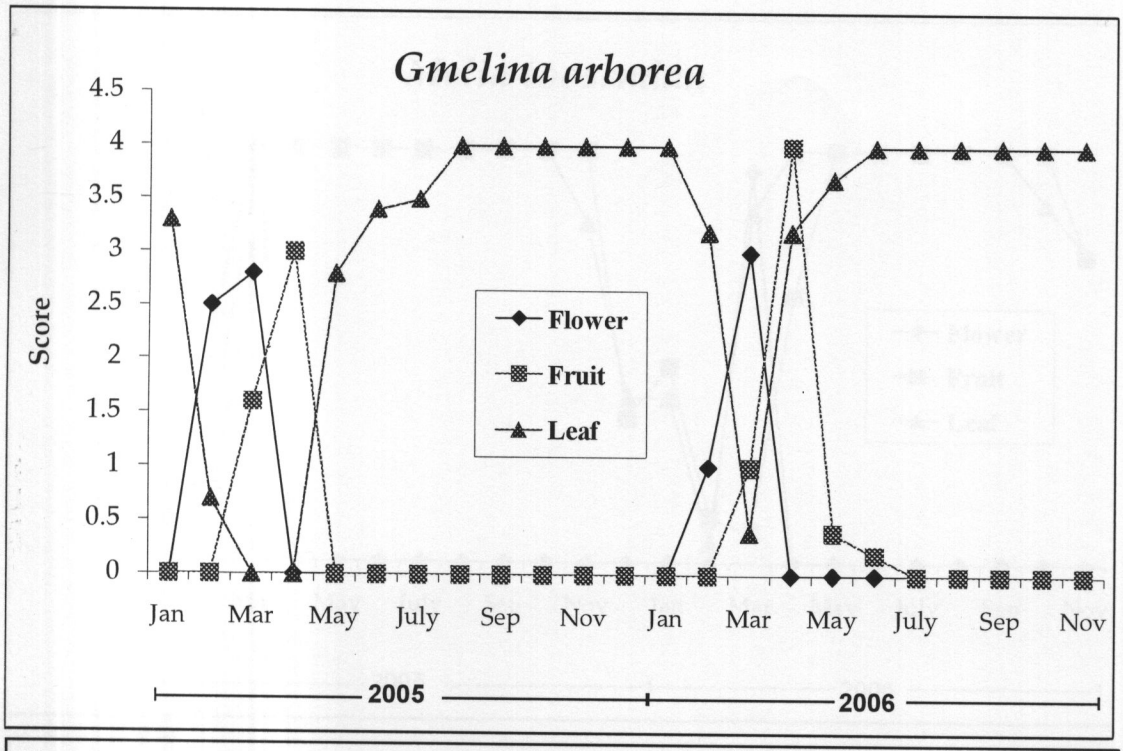
	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
Mean	Early	19.43	7.69	19.56	19.90	5.25	3.94
	Middle	19.22	5.87	21.36	17.77	6.52	4.72
	Late	9.51	3.36	5.29	12.55	5.45	17.10

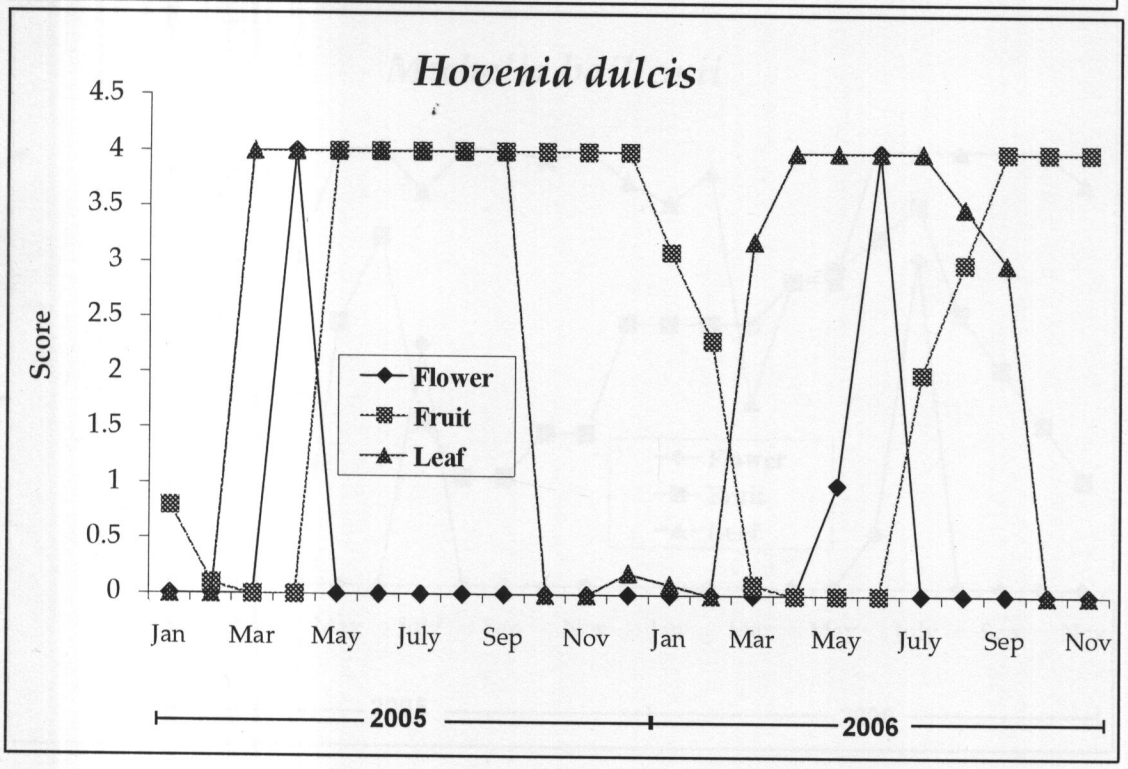
	Fruiting period	Before storage		After storage			
		Fresh	Dry	Fresh/Room	Fresh/5°C	Dry/Room	Dry/5°C
SD	Early	3.27	2.97	5.46	3.29	2.20	2.46
	Middle	1.93	1.97	4.91	2.44	2.05	2.68
	Late	1.52	0.92	2.70	2.06	2.76	4.32

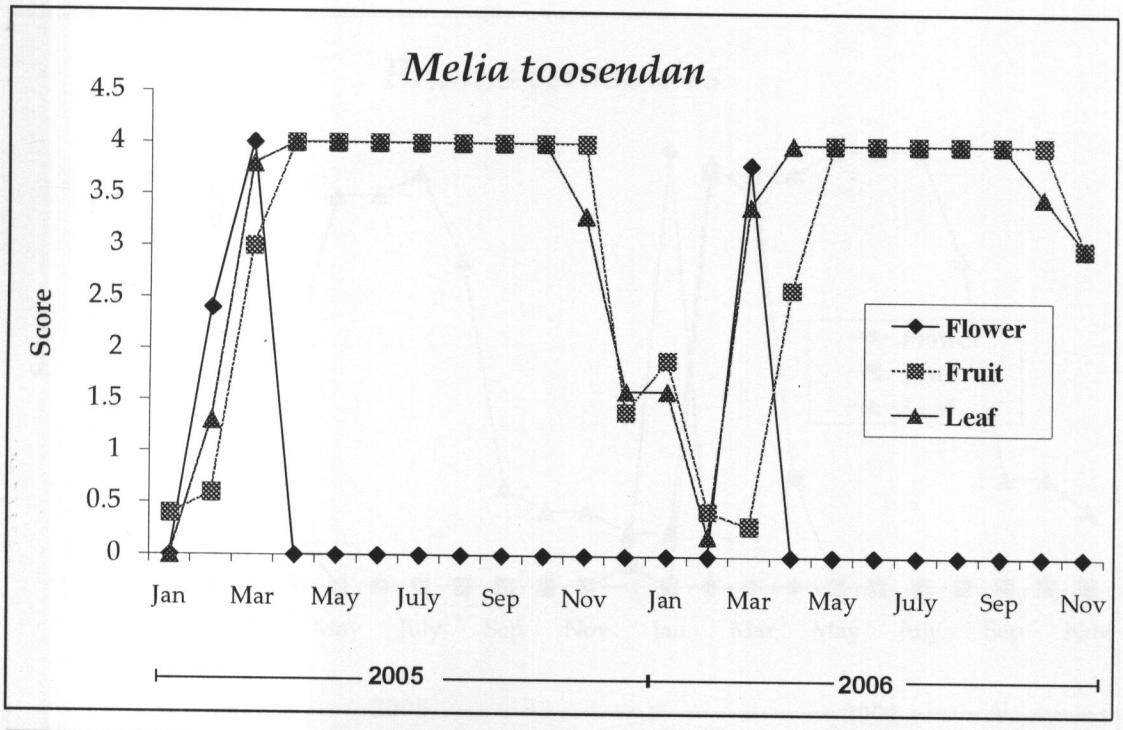
Appendix 4. Phenology

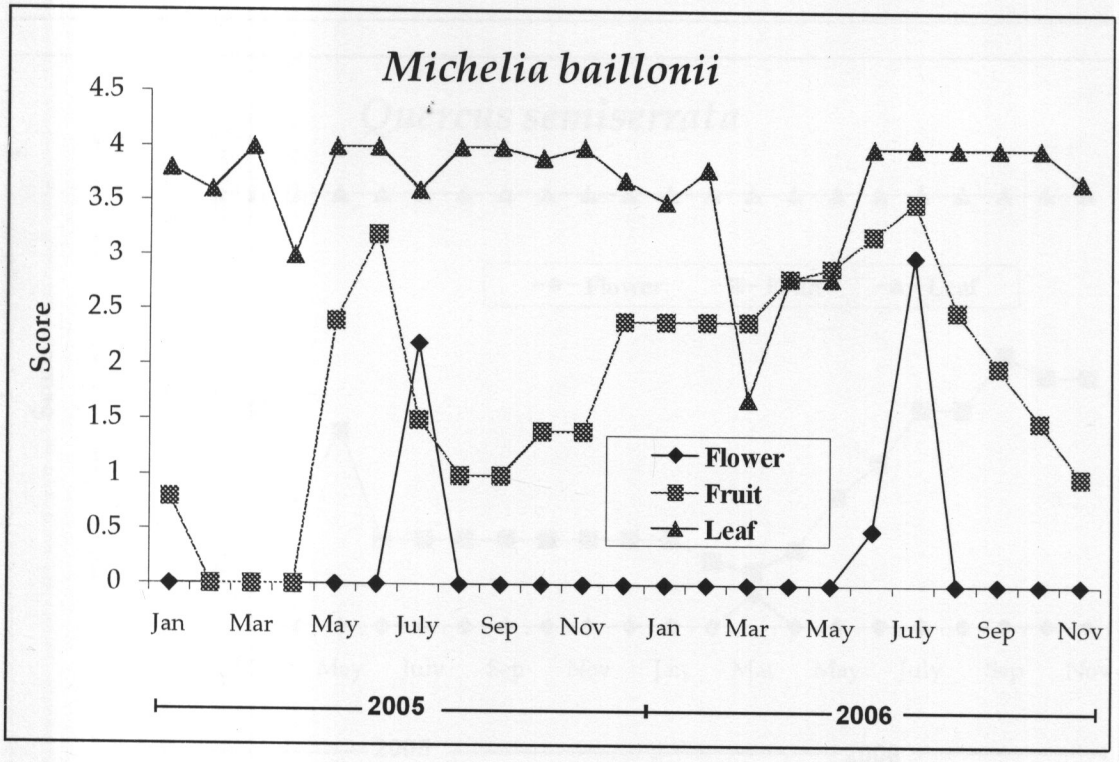


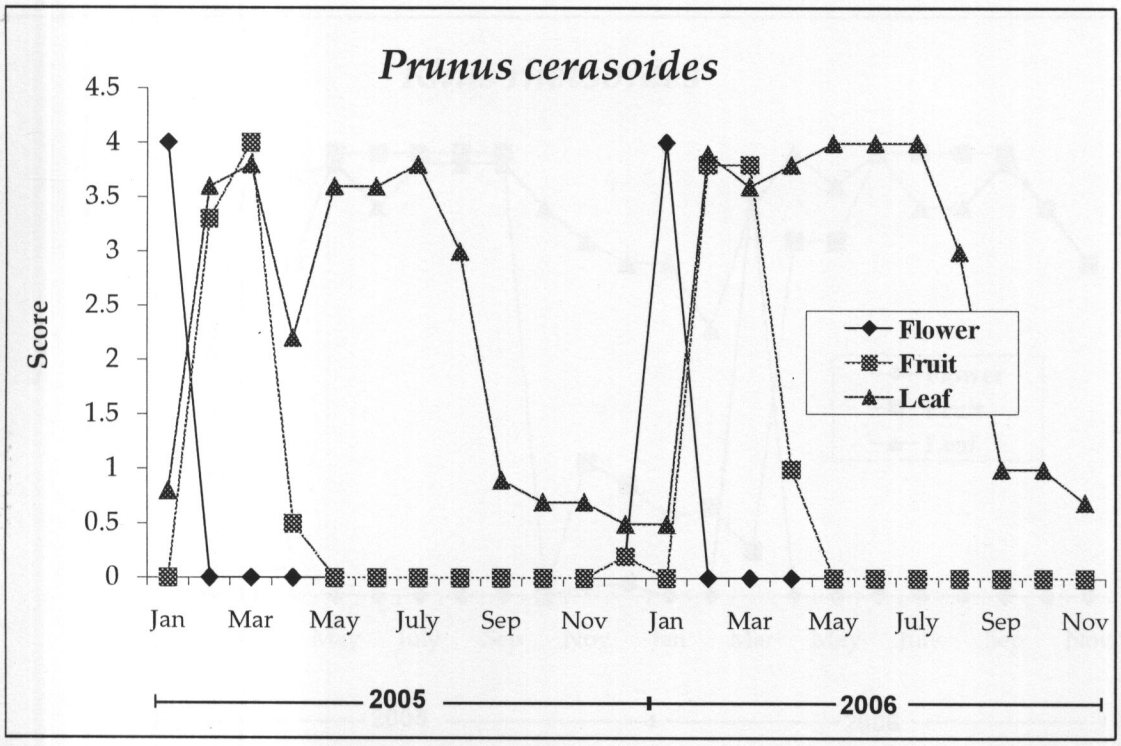


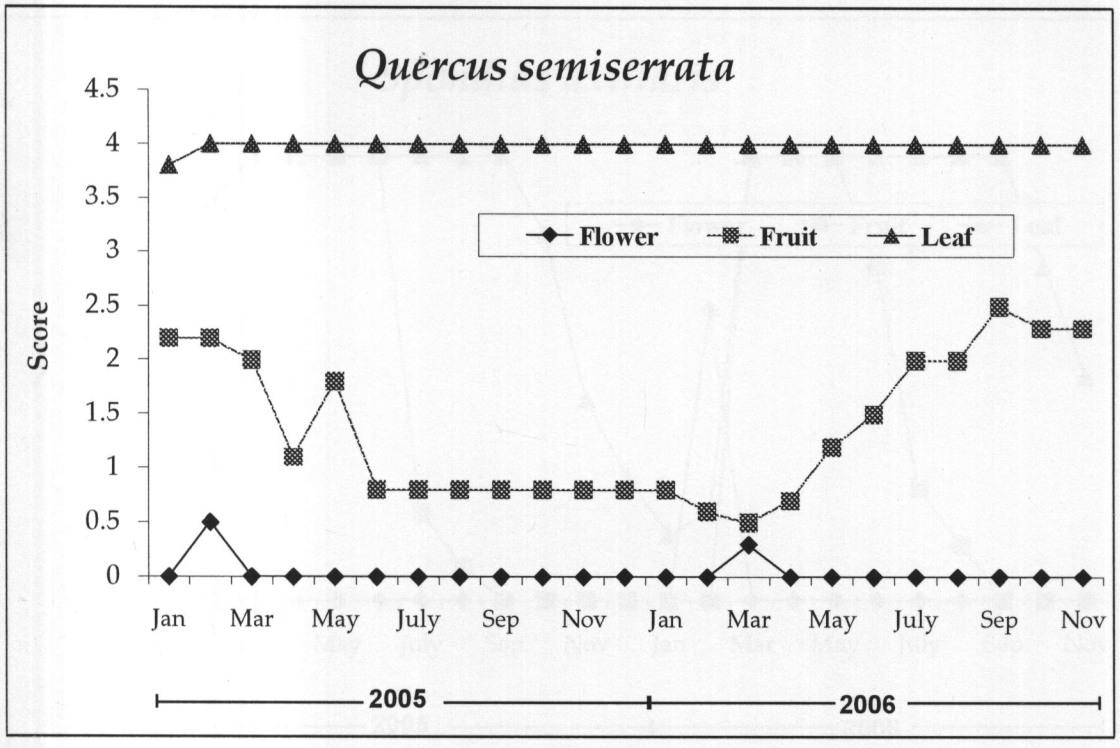

Gmelina arborea
Score
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flower
Fruit
Leaf
Jan
Mar
May
July
Sep
Nov
Jan
Mar
May
July
Sep
Nov
2005
2006

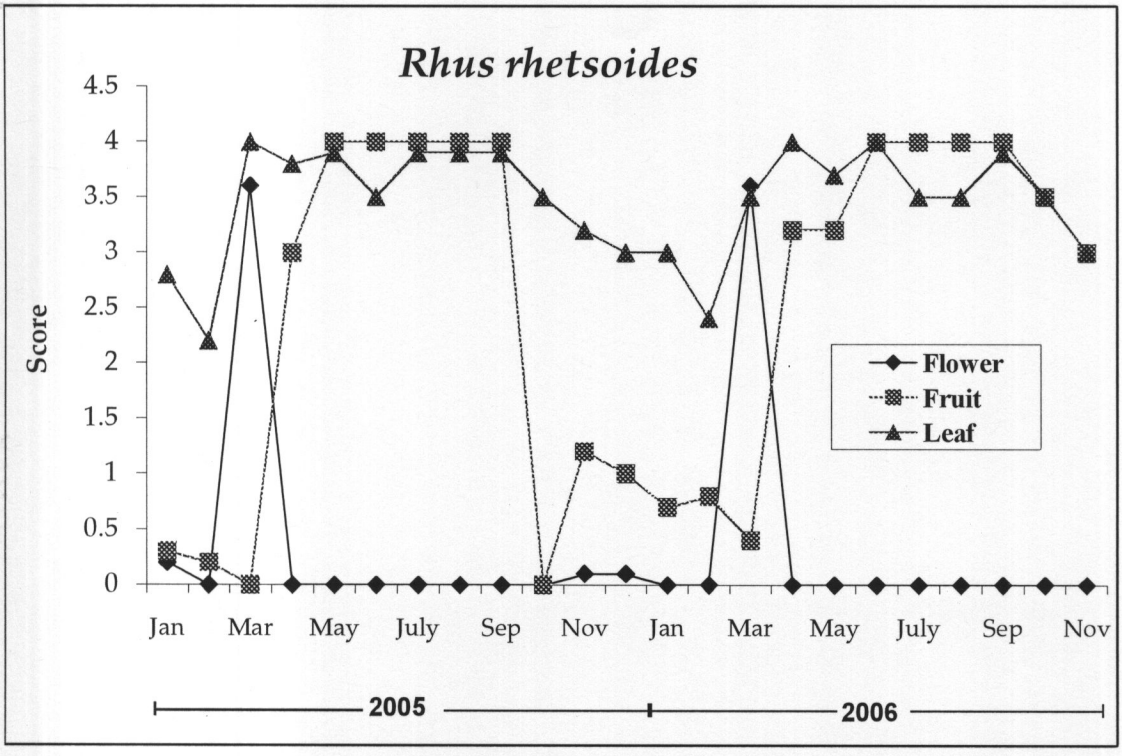

Hovenia dulcis
Score
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flower
Fruit
Leaf
Jan
Mar
May
July
Sep
Nov
Jan
Mar
May
July
Sep
Nov
2005
2006

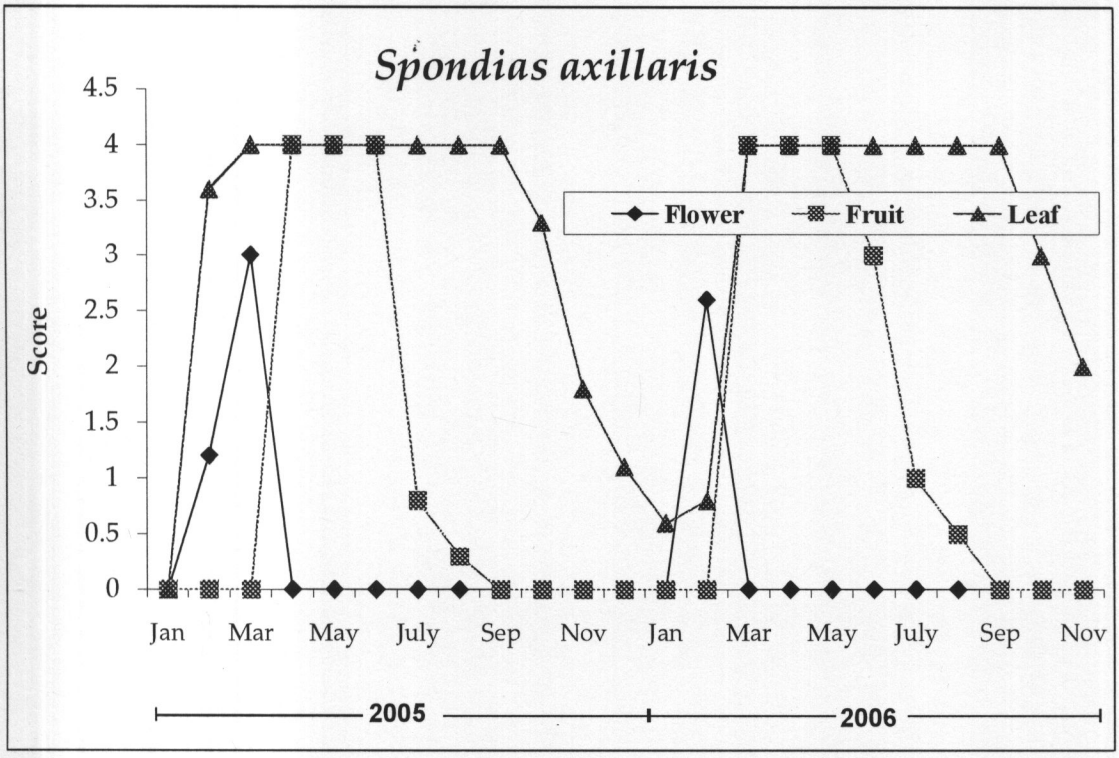

Melia toosendan
Score
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan
Mar
May
July
Sep
Nov
Jan
Mar
May
July
Sep
Nov
2005
2006
Flower
Fruit
Leaf


Michelia baillonii
Score
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan
Mar
May
July
Sep
Nov
Jan
Mar
May
July
Sep
Nov
2005
2006
Flower
Fruit
Leaf


Prunus cerasoides
Score
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flower
Fruit
Leaf
Jan
Mar
May
July
Sep
Nov
Jan
Mar
May
July
Sep
Nov
2005
2006


Quercus semiserrata
Score
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flower
Fruit
Leaf
Jan
Mar
May
July
Sep
Nov
Jan
Mar
May
July
Sep
Nov
2005
2006


Rhus rhetsoides
Score
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan
Mar
May
July
Sep
Nov
Jan
Mar
May
July
Sep
Nov
2005
2006
Flower
Fruit
Leaf


Spondias axillaris
Score
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan
Mar
May
July
Sep
Nov
Jan
Mar
May
July
Sep
Nov
2005
2006
Flower
Fruit
Leaf