Flowering and fruiting phenology of Kemenyan toba (*Styrax sumatrana* J.J.Sm.) in AekNauli forest, North Sumatra

C R Kholibrina[1], Aswandi[1] and A Susilowati[2]

[1]Forestry and Environment Research Development Institute of Aek Nauli
Jl Raya Parapat Km 10.5 Sibaganding Parapat, Simalungun North Sumatra, 21174
[2]Faculty of Forestry, Universitas Sumatera Utara, Jl. Tridarma Ujung No. 1,
Kampus USU, Medan North Sumatra
E-mail: rizlanicut@gmail.com

Abstract. The observation on flowering, fruiting phenology and germination of Kemenyan toba (*Styrax sumatrana*) has not been widely reported. It isrequired to support the breeding activities for this tree improvement, the most Non-Timber Forest Product commodity in Lake Toba Catchment Area, North Sumatra. The objectives of the research were to identify the development of flowering, fruiting andto calculate the number of fruits that germinate for *S. sumatrana* in certain cycle period. The flowering and fruiting observation were conducted on ten sample trees in Aek Nauli forest from July 2012 to February 2013. The seeds viability was observed from January to November 2014 in the greenhouse. The study showed that the flowering development occurred for 30 to 152 days, began from the growing of generative buds, the flower's shoots and bursts were developed, and young fruits were matured. All of processes proceeded for 30 to 152 days. The average percentage of flowering is 53.5%, and 72.8% for flowering to fruiting, and 47.3% for young to mature fruit. The percentage of mature fruit to germinate was 89.3%.

1. Introduction

The kemenyan trees are closely related to the development of civilization in Tapanuli, North Sumatra. In the mountainous region around Lake Toba, these trees cultivation have been going on since the 17th century or longer [1, 2]. The main NTFPs commodities in the region contribute substantially to the household economy of farmers, reaching 70% to 75% [3]. Kemenyan resin contains benzoin compounds that used for industrial raw materials, cigarette adders, medicines, cosmetics, insect and mosquitoes repellents (natural insecticides), pharmaceuticals, and food and beverage preservatives [1, 2, 3]. There are two species of Kemenyan that cultivated by most of communities in Tapanuli, i.e. Kemenyan durame (*Styrax benzoin*) and Kemenyan toba (*S. sumatrana*). However, the latter species is preferred because it has a better and more expensive resin quality [2, 4].

Indisputable, the incense productivity from the kemenyan forests have been decreased [5]. Some factors are identified as the cause of this decline, such as forest and land conversion, illegal logging, and limited cultivation techniques, especially application the higher quality seeds. The seeds production, especially from superior mother trees which higher quality and quantity resin is still limited. The incense tapping were conducted when flowering, thus interfering the fruiting process. This condition triggers a decline in seeds production.

Fulfillment of higher quality seeds would be obtained by managing the superior mother tree as a source of seeds. The management efforts start from flowering to fruit ripening and harvesting.

Generally, seed production is influenced by various factors, i.e. flower initiation, flower fallen, periodicity, dichogamy (protandry and protoginous), pollen viability and stigma conditions, and environmental conditions (climate, pests or diseases attack) [6].These information haven't been much explored in flowering of Kemenyan toba before. But, this is needed as a basis in an effort to improve the flowering process.

The objectives of the research were to identify the development of flowering, fruiting and to calculate the number of fruits that germinate for *S. sumatrana* in certain cycle period. Observation the flower development cycle until the fruits maturation can also be used as a tool in predicting the right time for seed harvesting. Measurement of germination ability can also to describe flowering efficiency. These are important information in establishing the proper pollination time in seed orchard management.

2. Methods

2.1.Study sites

The flowering and fruiting observation were conducted on ten sample trees in Aek Nauli forest from July 2012 to February 2013. Furthermore, the seeds viability was investigated during January until November 2014 in greenhouse managed by Forestry Environment Research Development Institute of Aek Nauli. The trees grow at +/- 1200 m above sea level with the monthly average temperature of 23-24 ^{o}C and daily humidity 84 mm Hg. Rainfall in this region ranges from 2199 - 2452 mm/year so the area is included in type A according to Smith and Ferguson.

2.2. Data collection

The observations were conducted in two stages: flowering phase and seed germination from observed flower. Flowering observation was conducted on ten sampling trees. The investigation were conducted on the morphology of flowers and development stages ranging from initiation, differentiation, generative shoot generation, flower buds and flowers bloom [7]. The flowering structure changes were observed and recorded (date and period) both shapes and colors. This investigation was applied in four times a week (intermittent day) during three months. The seed germination was applied on the collected seeds. The seeds were collected from previously observed flowers. The germination abilities were calculated as the percentage of seed germinating.

3. Results and discussion

3.1. Flower of kemenyan toba

Kemenyan Toba flowers have a compound structure. Itare arranged in a bunch or panicle (inflorescence) with 5 to 12 flowers in a bunch (figure 1). The panicle of flower is at the tip of the branch with an upright position. The development of flowers from buds form to matured fruits is not the same period in one bunch [7]. There are a tendency that flowers in the top position is bloom first and then continued by the flowers at the bottom. The flower character and its structure are closely related to the type of pollination either by animals or wind [5].

Figure 1. The type of panicles and flowers of *Styrax sumatrana*

According to flower types, shapes and colors, the pollination were identified occurs with insect vectors, naturally. Bees and butterflies were observed flying around the flowers at 08.00-11.15 WIB [7] or 01.00-04.15 GMT. The flowers have white or cream color, irregular or tubular shapes, consisting of several parts, there are places of landing and flowers frequented by bees and moths [8].

The genital expression is hermaphrodite, where ♂ and ♀ consisted in a same flower, with anther and stigma close together, allowing for self-pollination. There were identified nine anthers that surrounded, with sticky pollen. There were indicated from the observed anther have been opening during investigation. Another tree species with sticky pollen is Teak (*Tectona grandis*) with medium tricolpatc form [9]. An anther and stigma position adjacent to each other is shown in Figure 2. The nature and shape of pollen will affects the controlled pollination patterns.

The anther and stigma positions are close together, but the compatibility is unknown. This condition raises the possibility of self pollination (autogamy) and cross (allogamy). The proportion of self and cross-pollination in a population are influenced by self-sterility, flowering behavior and the presence of pollinating vectors [10, 11].Generally, flowers have a natural mechanism to reduce their self-pollination both temporal and spatially. In this case, temporarily, the ripening of male and female flowers occurs at different times, whereas male flowers are spatially separated from female.

Petal is white and it is a part of flower to attract insects to pollinate. White pistil surrounded by orange stamens, light green sepals attached to bottom of the ovary. Diameter of flowers reaches 18 mm at the bud form, when blooming it reach 91 mm [7]. The panicle length is 65.4 to 75.0 mm, and the length of the stylus is 15 mm. The stamen length is 11 mm and it has 9 anthers. The stylus is longer than stamen. This is a defense mechanism to minimize the self-pollination. The anther is slightly hairy with a bright orange color when ripe and the stigma (pistil) is slightly slimy with a bright greenish white color when receptive condition.

3.2. Flowering periods

The flowering development starts from the emergence of generative shoots that come out from the leaves armpits in the form of small bends, then developed into a flower bud (designated panicles). Shoots of panicles will develop into a clearer flower arrangement with petal still closed. Flowers on the buds develop to a complete flower structure with petal still in bud form. Further, individual flowers bloom with light green sepal color and white pistil parts (receptive flower conditions). If pollination occurs, the flowers will abort the petals and ovule starts to swell [7].

The designated flowers or generative shoots begin to appear at the end of June to July, then flower will appear and elongate at the end of August. In August to September the flower buds on the panicle

grow and emerge a white petal. Generally, the flower blooms from August to September. In late September to early October, the flowers are fallen, and fertilization process has begun.

The flowering development occurs for 30 to 152 days, begin from the growing of generative buds, the flower's shoots and bursts isdeveloped, and young fruits ismatured. The developmental period of flowering of *S. sumatrana* is shown in Table 1. It is illustrates that the flowering cycle of this species incidence relatively longer than *S. benzoin*. The latter takes between 35 and 62 days [12].

Table 1. Flowering period of *Styrax sumatrana* in Aek Nauli forest, North Sumatra

No	Sequence of reproductive organs	Period	Times	Remarks
1.	Flowering initiation	1day	June	
2.	Generative shoots	4-5 days	End June – July	
3.	Shoots of the panicles	7-8 days	1st week August	
4.	Designated panicles open, individual flowers buds	4-5 days	2nd – 3th weeksAugust	
5.	Panicles developed, flower buds enlarged	10-14 days	LateAugust	The flower on the lower part of the stalk is open but not yet blooming
6.	Individual flowers bloom	4-5 days	Late August – early September	Most flowers bloom on panicles
7.	Receptive flower	1-2 days	Early – mid September	Characterized by the slimy stigma and opening anthers
8.	Petal fallen	4-5 days	Late September– early October	

Source: [7]

The flowers appear after the budding period. The number of *Styrax* flowers in one panicle varies in one tree as well as compared to other trees and the wind direction. Variations in the number of flowers often reported in tree plantations such as variations of flower production among clones, canopy and season in the seed orchard of *Pinus sylvetris*[13].

Environmental factors such as the adequacy of sunlight and soil nutrients affect the flowering. The sunlight reception is related to photosynthesis rate as a energy source for flowering process. The observations were showed that branching in the East has a higher proportion of flowers than in the West direction [7]. This is related to the intensity of sunlight received. Conversely, the less intensity of sunlight affects the flowering inhibition in reverse direction. While the availability of soil nutrients associated with energy supply and building materials for formation and development of flowers. The effects of competition among individual trees also determine the flowering [13].

3.3. Flowering effectiveness

The results of observing the panicles, flowers, young and ripe fruits, and seed germination are shown in Table 2.The flower has an average 7 panicles with a range of 5 to 10 panicles on the observed branch. There are average 54 flowers in each panicle (range 30 - 79 flowers). These flowers will develop into young fruits with a percentage of 72.8% (Table 2). The young fruit will grow and matured. The percentage of young fruits that developed to mature fruits reached 47.3%. Furthermore, the matured fruit is germinated. The percentage of mature fruit to germinate was 89.3%.

Table 2. Number of panicles, fruits, flowers and germination of *Styrax sumatrana* seeds

No	Number of panicles	Number of flowers	Number of young fruits	% flower developed to fruits	Number of mature fruits	% young fruits developed to mature fruits	Amount of germination	% of germination
1	7	58	40	68.9	28	70.0	25	89.3
2	5	43	31	72.1	20	64.5	15	75.0
3	6	30	23	76.7	19	82.6	18	94.7
4	5	38	30	78.9	14	46.7	13	92.9
5	5	41	22	53.7	9	40.9	8	88.9
6	8	64	54	84.4	8	14.8	8	100.0
7	8	57	40	70.2	12	30.0	11	91.7
8	9	70	43	61.4	13	30.2	11	84.6
9	10	79	58	73.4	29	50.0	25	86.2
10	7	55	49	89.1	21	42.9	19	90.5
Average	7	54	39	72.8		47.3		89.3

4. Conclusions

The genital expression of *S.sumatrana* flower is hermaphrodite, where the ♂ and ♀ consisted in a same flower, with the anther and stigma close together, allowing for self-pollination. The flowering development occurs for 30 to 152 days, begin from the growing of generative buds, the flower's shoots and bursts isdeveloped, and young fruits is matured. The average percentage of flowering was 53.5%, and 72.8% for flowering to fruiting, and 47.3% for young to mature fruit. The percentage of matured fruit to germinate was 89.3%. This preliminary study should be continued by examining the pollination vector by investigating the pollen attached to body part of vector agent. To identify the grain pollen, microscopic observation and grain pollen germination should be necessary.

References

[1] Heyne K 1987 Useful Plants of Indonesia Volume I Forestry Research Center Jakarta.
[2] Kholibrina C R 2012 Strategi Pemuliaan dan Peningkatan Teknik Budidaya Kemenyan Toba (*Styrax sumatrana* J.J.Sm. sinonim *S. paralleloneurum*) *Prosiding Ekspose Hasil-hasil Penelitian Kehutanan* Medan, 3 Juli 2012 Pusat Penelitian dan Pengembangan Konservasi dan Rehabilitasi Kementerian Kehutanan.
[3] Sianipar H and Simanjuntak B 2000 Isolation and Identification of Sinamat Acid from Kemenyan Sumatrana *Media Farmasi* **4(1)** 22-28
[4] Susilowati A, Hendalastuti H, Kholibrina C R, and Ramadhani R 2017 Weak delineation of *Styrax* species growing in North Sumatra, Indonesia by *matK* + *rbcL* gene Biodiversitas **18(3)** 2085-4722. DOI: 10.13057/biodiv/d180353.
[5] Central Bureau of Statistics of North Sumatra Province 2008 *North Sumatra in Figures 2008* Medan: BPS Provinsi Sumatera Utara
[6] Sedgley M and Griffin A R 1989 *Sexual Reproduction of Tree Crops* Academic Press.
[7] Kholibrina C R 2017 Pembungaan PohonKemenyan Toba (*Styrax sumatrana* J.J.Sm.) di Arboretum Aek Nauli,Sumatera Utara *Prosiding Seminar Hasil Penelitian Balai Penelitian Pengembangan Lingkungan Hidup dan Kehutanan Aek Nauli*. Pusat Litbang Hasil Hutan. Badan Litbang dan Inovasi.
[8] Palupi E R 2001 *Pollination, fertilization and seed development* The 3rd Training on Seed Biology. IFSP-BTP. Badan Litbang Kehutanan. Departemen Kehutanan dan Perkebunan, Bogor
[9] Owens J N, Sornsathapornkul P, Tangmitchareon S 1996 *Studying Flowering and Seed Ontogeny inTropical Forest Trees*. ASEAN-Canada Forest tree Seed Centre. Muak Lek, Saraburi. Thailand.
[10] Kittelson P M and Maron J L 2000 Outcrossing rate and inbreeding depression in the perennial

yellow bush lupine, *Lupinus arboreus* (Fabaceae) *American Journal of Botany* **87**652-660
[11] Satifah and Darjanto 1984 *Pengetahuan Dasar Biologi Bunga dan Teknik Penyerbukan Silang Buatan*. Gramedia, Jakarta.
[12] Syamsuwida D, Aminah A, Nurochman N, Sumarni EB dan Ginting J 2014 Flowering and Fruiting Development Cycle and Fruit Set of Kemenyan (*Styrax benzoin*) at Aek Nauli *Jurnal Penelitian Hutan Tanaman* **11(2)** 89-98
[13] Burczyk J and Lewandowski C 1998 Resin production of scots pine trees maybe associated with multilocus allozyme variation *Arboretum kdrnickie* **43** 79-83