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Study of Trees Flowering Period and Its Usage in the Landscape

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Abstract. Trees in the landscape has strong character in color which is performed by flower, however flower appear only in certain period. This study aims to determine the flowering period of trees, climate factors that affect period of flowering, and its usage in planting plan. This study was conducted for 12 months from September 2013 to August 2014 using 10 species of flowering trees. Based on the observation, all species showed peak flowering in certain month while 8 species namely Caliandra surinamensis, Callistemon citrinus, Cassia siamea, Cerbera mangas, Jacaranda acutifolia, Lagerstroemia speciosa, Plumeria rubra, and Spathodea campanulata showed flower along the year, and 2 species namely Samanea saman and Tabebuia caraiba showed no flower in certain month. Based on analysis of percentage of flowering showed a significant correlation with climate factors. Rain days significantly affected flowering of J. acutifolia and S. saman, maximum temperature affected flowering of P. rubra, minimum temperature affected flowering of Samanea saman, length of irradiation affected flowering of Cassia siamea, P. rubra and T. caraiba and relative humidity affected flowering of P. rubra and T. caraiba. Aesthetic value of site can be increased by using more species with different in period of flowering to show flower blooming along the year.

1. Introduction

Flowering tree is commonly found in private garden, in the public park or in the side of the street. This type of tree is using in the landscape for many purposes. To create an attractive view and to create a comfort environment for outdoor activities are important to consider to use a flowering trees. Flowering trees as solitery plant is commonly used as vocal point in the garden, but in other case mass planting also used to perform an exclusive attraction in certain season.

Flowering trees varied in their physical characteristics such as tree dimension, architecture of canopy, leaf texture, branch pattern, and flower. Depend on species, flower of trees varied in color, shape and flowering season which it is important to consider when preparing a planting design. For selecting the tree species that suitable to a garden or park, characteristic of tree must be considered such as flowering period. However information about flowering period of tropical plant is still limited.

Flowering is a complex process of shifting vegetative growth to generative phase which influenced by internal factor of plant age, growth hormone, and plant genetic. This process also influenced by
environmental factor that influences generative phase indirectly by affecting physiological processes especially carbohydrate and hormone relations. Several environmental factor that influence reproductive growth including rainfall, light intensity, photoperiodism, water supply, temperature and soil fertility [1,2]. Blooming is a fenological phenomena which behavior of flowering can be observed related to plant environment [3]. Number of flower every month that covered the tree canopy thorough the year can be used as indicator to know the flowering period.

The objective of this research is to study flowering period of trees thorough year and climate factor that affect its flowering period, and to propose a model of planting design that perform attractive shape and color of flower a long the year. Flowering period is importantly discovered as reference to landscape architect when choosing the plant in preparing planting design of landscape that perform the beauty of tree flower, especially to select the tree species that blooming in each important event in planned site.

2. Research Method
Research was conducted for 12 months, from March 2013 to February 2014, located in Bogor Agricultural University Campus and location close to campus in Dramaga district of Bogor, West Java. This location was selected, due to varied flowering trees species used in this district (Figure 1). In this research, 10 species of flowering trees were selected to observe with 3 sample of trees/replications respectively (Table 1) Condition of tree as samples were mature tree, stand solitary, growth in maintained space and similar in plant height.

Flower of trees were observed by taking picture of tree from two angles, and from the distance that picture of tree canopy could be fully recorded. Using software of adobe photoshop, grid lines were plotted on the pictures (Figure 2), then red color was dotted in the grid contain flower pictures. Number of grid that contain flower and total number of grid overall the tree canopy were manually calculated. Percentage of flowering coverage was calculated using formula below.

\[
\text{Flower coverage} = \frac{\sum \text{grid of flower}}{\sum \text{grid of canopy}} \times 100\%
\]

*Figure 1 Research Location
(Source: (left) geospasial.bnpb.go.id (right) maps.google.com)*
Table 1  Species and family of observed trees

| No | Species                          | Family       | Location                                      |
|----|----------------------------------|--------------|-----------------------------------------------|
| 1  | *Calliandra surinamensis* Benth. | Fabaceae     | University Housing                            |
| 2  | *Callistemon citrinus* (Curtis) Skeels | Myrtaceae | Rector Office, AEP, Old Gymnasium             |
| 3  | *Cassia siamea* (Lam.) Irwin & Berney | Fabaceae     | Jl. Cikarawang                               |
| 4  | *Cerbera mangas* L.              | Apocynaceae  | AEP (Academic Event Plaza)                    |
| 5  | *Jacaranda acutifolia* Humb. & Bonpl. | Bignoniaceae | University Housing, Fac of Veterinary, Fac of Human Ecology |
| 6  | *Lagerstromia speciosa* (L.) Pers | Lythraceae   | GWW Hall, Lecturer Housing                    |
| 7  | *Plumeria rubra* L.              | Apocynaceae  | Node of Fac of Matematic and Life Sciences    |
| 8  | *Samanea saman* (Jacq.) Merr.    | Mimosaceae   | AEP, GWW Hall, Fac of Agriculture             |
| 9  | *Spathodea campanulata* Beauv.   | Bignoniaceae | GWW Hall, SC, Jl. Raya Dramaga                |
| 10 | *Tabebuia caraiba* (Mart.) Bureau | Bignoniaceae | Jl. Raya Dramaga                              |

Figure 2  Plant canopy (left), plotted grid in canopy picture (right). Red grid was flower grid, while green grid was no flower grid

Pictures of canopy were taken twice in each month, in the first and third week. The percentage of flowering coverage was the average of that flower coverage of twice observations. Using software SPSS Statistics 17.0, regression analysis were used to evaluate the influence of climate factor of temperature, irradiation length, rainfall, number of rain days, relative humidity to flower coverage. To utilize research result of tree flowering period, it was selected site of Convention Hall of Graha Widya Wisuda (GWW) of Bogor Agricultural University (IPB) to propose planting design model which perform flower blooming when a regular event of graduation ceremony celebrated in GWW convention hall.

3. Results and Discussion

Result of 12 months observation indicated 8 species of trees produced a flower thorough year. It were including (1) *Spathodea campanulata*, (2) *Plumeria rubra*, (3) *Calliandra surinamensis*, (4) *Callistemon citrinus*, (5) *Jacaranda acutifolia*, (6) *Lagerstroemia speciosa*, (7) *Cassia siamea*, and (8) *Cerbera mangas*. The rest of 2 species of trees did not produce flower thorough year. *Tabebuia caraiba* did not produce flower in 5 months, namely in June, July, December, January and February. Rain tree (*Samanea saman*) did not produce flower in 3 month, namely in April, October, and November.
Based on flower coverage value, even on flower peak season, distribution of flower did not covered overall the canopy area, however the flower only covered part of the canopy. The value of flower coverage when peak season was different among trees. The highest coverage value was found on *Jacaranda acutifolia* (30.6%), than followed by *Caliandra surinamensis* (30.2%) *Calistemon cytrimus* (26.1%), *Cerbera mangas* (21.6%), *Lagerstromia speciosa* (21.3%), *Plumeria rubra* (19.1%), *Spathodea campanulata* (15.4%), *Tabebuia caraiba* (7.6%), *Samanea saman* (5.9%), and *Cassia siamea* (4.9%).

The appearance of tree become more attractive when it performed a lot of flowers in their canopy. Results of study show value of flower coverage fluctuated thorough the year. If the peaks of graph is assumed as peaks of flowering (Figure 3), the trees can be divided in to 5 flowering period pattern, namely (1) four peaks flowering tree with 1-3 months interval including *Caliandra surinamensis*, *Calistemon cytrimus*, (2) three peak flowering tree with 1-5 months interval including *Spathodea campanulata*,(3) two peaks flowering tree with 5 month flowering interval including *Cassia siamea*, *Cerbera mangas*, *Jacaranda acutifolia*, *Lagerstroemia speciosa*, *Plumeria rubra* and (4) one peak flowering tree with 11 months flowering interval including *Samanea saman* and *Tabebuia caraiba*.

Elements of Climate in research area is presented in Table 2. Based on regression analysis (Figure 4), climate factor affected significantly the value of flower coverage of 5 trees (*Cassia siamea*, *Jacaranda acutifolia*, *Plumeria rubra*, *Samanea saman*, and *Tabebuia caraiba*). However no significant effect of climate found on 5 tree species (*Caliandra surinamensis*, *Calistemon cytrimus*, *Cerbera mangas*, *Lagerstroemia speciosa*, and *Spathodea campanulata*). The last 5 species were probably influenced by plant internal factor such as plant genetic and hormone activities. It was found that induction stage flowering was characterized by sharp decrease of gibberellic acid (GA3, GA5, GA7) and increase of total sugar content of leaf [4] and external factor such as soil fertility [1].

Irradiation length which reflect intensity of solar irradiation was significantly affected flowering of *Cassia siamea*, *Plumeria rubra*, and *Tabebuia caraiba*, but respond among plants was different. Flower coverage of *Cassia siamea* was significantly decreased by the increasing irradiation length, in the contrary the value of flower coverage of *Plumeria rubra* and *Tabebuia caraiba* increased. When higher value of irradiation length occurred on August, September, October, it was found the lowest value of flower coverage of *Cassia siamea*, but the highest value found in *Plumeria rubra* and *Tabebuia caraiba*. Time of flowering depend on the sum of heat accumulated by plant, but the sum of heat required for flowering varied greatly among the plants [1]. In this case of *Plumeria rubra* and *Tabebuia caraiba* have probably received adequate heat that stimulated their flowering.

Number of rain days affected significantly flower coverage of *Jacaranda acutifolia*, *Samanea saman*. Generally when number of rain day increased, flower coverage of *Jacaranda acutifolia* increased, however flower coverage of *Samanea saman* decreased. In March when the rain days reach the highest value, it was found the highest value of *Jacaranda acutifolia* flower coverage. Similar result was found in *Santalum Album* Linn while prolonged rainfall affected to longer its flowering period [5]. In the contrary, in August when rain day in the lowest level, flower coverage of *Samanea saman* reach the highest level. The similar result was found in *Averhoa carambola* which water stress stimulate flowering rate [6]. On the other hand water stress in drought season triggered flowering of *Samanea saman*, but moist condition in rainy season triggered flowering of *Jacaranda acutifolia*. 
Figure 3 Flower Coverage of 10 observed Trees
Figure 4  Relation between flower coverage and climate elements
Table 2  Monthly Climate elements in Research Area 2013/2014

| Month       | Rainfall (mm) | Rain days (days) | Temperature (°C) | Irradiation length | Relative Humidity |
|-------------|---------------|------------------|-----------------|--------------------|-------------------|
|             |               |                  | Average | Max | Min | (%) | (%) |
| March 2013  | 289.8         | 26               | 26.2    | 32.4 | 23  | 62.8 | 84  |
| April 2013  | 216           | 25               | 26.4    | 32.4 | 23.5| 60.9 | 85  |
| Mei 2013    | 399.3         | 22               | 26.2    | 32.2 | 23.2| 63.1 | 85  |
| June 2013   | 62.3          | 18               | 26.3    | 32.5 | 22.9| 63   | 82  |
| July 2013   | 360.2         | 24               | 25.4    | 30.8 | 22.4| 48.8 | 85  |
| August 2013 | 258.3         | 12               | 25.7    | 32.6 | 21.9| 86   | 85  |
| September 2013 | 503.2   | 19               | 25.1    | 32.6 | 22.3| 86   | 78  |
| October 2013| 393.6         | 17               | 26.1    | 32.6 | 22.4| 86.9 | 80.4|
| November 2013| 186.9       | 21               | 25.3    | 32.1 | 22.3| 62.1 | 78.1|
| December 2013| 407.7      | 25               | 25.5    | 30.8 | 22.6| 44.1 | 84.4|
| January 2014 | 702          | 27               | 24.6    | 28.4 | 22.2| 26.7 | 89.6|
| February 2014| 337.4       | 22               | 25      | 29   | 23  | 29.2 | 89  |

Source : Agency of Meteorological, Climatological and Geophysical in Dramaga

Respond to temperature was different among the trees. Temperature significantly affected flowering coverage Plumeria rubra and Samanea saman, while more higher maximum temperature affected more higher flower coverage of Plumeria rubra. In case of Samanea saman, flowering coverage decreased when minimum temperature increased. Flower coverage of Plumeria rubra reach highest value on September, and October when the highest maximum temperature occurred. It was probably when maximum temperature increased, heat accumulated by Plumeria rubra reach more quantities to stimulate their flower, in the contrary when minimum temperature increased, heat accumulated by Samanea saman decreased which affected inadequate heat to stimulate their flower coverage.

Relative humidity was significantly affected flower coverage of Plumeria rubra and Tabebuia caraiba. Both species showed a similar respond to relative humidity while flowering coverage decreased significantly when relative humidity increased. Value of flower coverage of Plumeria rubra reach lower level in January and February when relative humidity in the highest period. In that same period Tabebuia caraiba did not produce flower on December, January and February.

It can be proved that flower coverage of five species of Cassia siamea, Jacaranda acutifolia, Plumeria rubra, Samanea saman, Tabebuia caraiba were influenced significantly by climate element. Flower coverage of Cassia siamea increased significantly when irradiation length decreased. Flower coverage of Jacaranda acutifolia increased significantly when number of rain days increased. Flower coverage of Plumeria rubra significantly increased when maximum temperature and irradiation length increased, and when relative humidity decreased. In the case of Samanea saman, their flower coverage increased when number of rain days and minimum temperature decreased. Tabebuia caraiba flower coverage increased significantly when irradiation length increased, and when relative humidity decreased.

Flower coverage of five species of trees (Caliandra surinamensis, Calistemon citrinus, Cerbera mangas, Lagerstroemia speciosa, and Spathodea campanulata) did not affected significantly by any climate elements. This species produce flower thorough the year with multiple flower peak month.

Based on flowering period (Table 3), observed 10 species of trees are possible to use together in a site to perform flower blooming thorough years as mass planting or arranged the same species of tree in a row. To perform a model of flowering tree usage in any site, it is selected the site of Bogor Agricultural
University GWW Convention Hall that regularly used for graduation ceremony 7 times in year in January, March, May, July, September, October, and December. Outdoor space of hall mainly used as car and bike parking lot in the east and north side of hall and plaza in the west side of hall. In this case, concept of planting proposed for outdoor hall is to create an attractive landscape by using flowering trees that blooming in each graduation day and to provide a comfort out door space by proving enough tree shading. Planting plan is presented in Figure 5. In planting plan, existing plants are added with 10 tree species used in this research including Cerbera manghas, Jacaranda acutifolia, Spathodea campanulata, Cassia siamea, Plumeria rubra, Calistemon citrinus, Caliandra surinamensis, Lagerstroemia speciosa where arranged in Plaza in front of the hall and in hall entrance, then Lagerstroemia speciosa, Samanea saman, Spathodea campanulata, and Tabebuia caraiba are arranged in the parking lot behind the hall.

Table 3 Month of flowering period

| Month/Species of Tree          | J | F | M | A | M | J | A | S | O | N | D |
|-------------------------------|---|---|---|---|---|---|---|---|---|---|---|
| Calliandra surinamensis Benth.|   |   |   |   |   |   |   |   |   |   |   |
| Callistemon citrinus (Curtis) Skeels |   |   |   |   |   |   |   |   |   |   |   |
| Cassia siamea (Lam.) Irwin & Berneby |   |   |   |   |   |   |   |   |   |   |   |
| Cerbera manghas L.            |   |   |   |   |   |   |   |   |   |   |   |
| Jacaranda acutifolia Humb. & Bonpl. |   |   |   |   |   |   |   |   |   |   |   |
| Lagerstromia speciosa (L.) Pers |   |   |   |   |   |   |   |   |   |   |   |
| Plumeria rubra L.             |   |   |   |   |   |   |   |   |   |   |   |
| Samanea saman (Jacq.) Merr.   |   |   |   |   |   |   |   |   |   |   |   |
| Spathodea campanulata Beauv.  |   |   |   |   |   |   |   |   |   |   |   |
| Tabebuia caraiba (Mart.) Bureau |   |   |   |   |   |   |   |   |   |   |   |

Month of graduation ceremony

Note: □: flower month □: peak flower month □: no flower month

Legend

Am : Arundinaria pumila
Cs : Calliandra surinamensis
Cc : Callistemon citrinus
Cg : Cassia glauca
Cs : Cassia siamea
Cm : Cerbera manghas
Dr : Delonix rega
Eg : Erythrina cristagali
Ja : Jacaranda acutifolia
Ls : Lagerstroemia speciosa
Mk : Manilkara kauki
Me : Mimusops elengi
Pe : Peltolorum sp.
Pd : Pithecellobium dulce
Pr : Plumeria rubra
Se : Samanea saman
A : GWW Convention Hall
B : Academic Event Plaza
C : Parking Lot

Figure 5 Proposed planting plan of GWW convention hall
4. Conclusion and Suggestion
Based on research results, there were 8 species of trees including Spathodea campanulata, Plumeria rubra, Caliandra surinamensis, Calistemon citrinus, Jacaranda acutifolia, Lagersroemia speciosa, Cassia siamea, and Cerbera mangas blooming throughout the year, and there were 2 species blooming only in certain month. Samanea saman did not produce flower on April, and Tabebuia caraiba did not produce flower on January, February, June, July and December.

Respond to climate factors varied among trees. Flowering coverage of 5 trees were significantly affected, and the rest of 5 species including Caliandra surinamensis, Calistemon citrinus, Cerbera mangas, Lagerstroemia speciosa, and Spathodea campanulata were not affected by climate factor. In addition respond to climate elements were also different among trees. Flower coverage of Cassia siamea increased by the increasing of irradiation length. Flower coverage of Jacaranda acutifolia increased when number of rain day increased. Flower coverage of Plumeria rubra increased when maximum temperature increased, but decreased when relative humidity increased. Flowering coverage of Samanea saman decreased when minimum temperature increased. Flowering coverage of Tabebuia caraiba increased when irradiation length increased.

Blooming and flower peak season of trees show different pattern, but usage of combination of tree species in a site make possible to create blooming attraction throughout the year.

In this research half of observed trees were not significantly influenced by climate factor, therefore it is recommended to investigate the influence of external factor other than climate elements such as soil fertility, water availability to flowering period of trees.

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