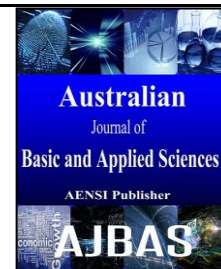




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Growth, Development and Flowering Behaviour of *Bougainvillea glabra* Under Natural Conditions

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ABSTRACT

An experiment was conducted to study the physiological and flowering behavior of *Bougainvillea glabra* cultivars. Plant morpho-physiological and flowering characteristics of *Bougainvillea* were observed during one year of study. It was observed that leaf and shoot growth rate were higher in earlier stage compared to later stage. Leaf, shoot and bract growth were also higher until 11 days from the initial days of observation. Flowering was greatly reduced or completely inhibited during the vegetative growth of the plant. It took 12 days to initiate the flowering bud from the vegetative stage. From this experiment, it was also recorded that the complete life cycle of *Bougainvillea* bract including flower around 28 days. Leaf pigments content; chlorophyll a (2.2 mg/gFW), chlorophyll b (1.8 mg/gFW) and Carotenoid (1.03 mg/g FW) were recorded at flowering stage. At the bud developmental stage, chlorophyll fluorescence, stomatal conductance and total sugar content of *Bougainvillea* leaves were 0.78, 25 mS/mol and 0.28 mg/G. Leaf nutrients N, P and K content at the vegetative stages were recorded around 2.18, 0.29 and 0.95 mg/L. This study will help further research about the vegetative growth and flowering behavior of *Bougainvillea* plant.

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INTRODUCTION

The genus *Bougainvillea* plant has a wide variety of traits that make it a potential as a new ornamental plant for floriculture, horticulture, pharmaceutical, agriculture and environmental industries on account of large flexibility in different agro climatic regions of the world (Suexia ., 2009; Simon ., 2006; Saifuddin ., 2009). Considering its vast scope, introduction and alteration of flower color and size are highly desired ornamental plant all over the world. Recently this species is vastly recommended for plantation in heavy industrial area and traffic island to absorb the pollutants and greenhouse gases from the environment (Kulshreshtha ., 2009; Saifuddin ., 2010).

Flower induction is the event that initiates the transition of a vegetative apex to a floral apex in response to an environmental development cue. In photoperiodically sensitive plants, the flowering signal is translocated from the perceiving organs (leaves) to the apex. Darnel ., (2003) reported that flowering in many species can be induced by the application of a variety of environmental techniques

and growth promoting chemicals. During inductive conditions for flowering, biochemical and physiological changes are recognized in the plants and one of the possible changes that might occur is in hormone content (Ito ., 2001). Changes in endogenous plant growth regulators during flower induction are still unclear; although it has been pointed out that the regulators could be closely related to reproductive growth. Although changes in endogenous cytokinins have an important role in flower induction in some plants, it has not been thoroughly investigated in *Bougainvillea*.

It is grown in tropical and subtropical zones and is enhanced with different varieties shades. Considering its vast scope, introduction and alteration of bract color and size are highly desired and sought after traits. The longevity of *Bougainvillea* bract is usually 5-6 weeks after that all bracts are abscised (Gordon, 2002). Commercial value of *Bougainvillea* bracts as well as flower can be improved by prolonging the bract longevity and increasing its quality. The vase life and commercial value of many ornamental potted plants are seriously affected by early senescence and dropping. Vase life

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is an important factor in consumer preference and considerable research has been carried out on senescence and dropping (Hosain, 2007). Currently there is very little information available on the growth, development and inflorescence development as well as bract enlargement in Bougainvillea plant. The aim of this research is to investigate the vegetative and reproductive growth of Bougainvillea under natural conditions. We also carried out the blooming behavior of Bougainvillea plant.

MATERIALS AND METHODS

Experimental site and plant material:

The experiments were carried out at the Plant Physiology Garden, Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur 50603, Malaysia. One year old Bougainvillea cuttings, 0.5 m of height and canopy length 1.0 m were selected for the study. Twelve (12) field grown Bougainvillea plants were used in the experiment. Six selected branches per plant of the same length, same diameter and approximately same number of leaves were selected for vegetative and reproductive growth observations. The number of nodes to first inflorescence, number of buds/15cm branch, blooming rate, bract length and stem elongation were measured at three day intervals, whereas, Individual bract weight and weight of flower including bract were measured at (18 days) final days of observation.

Chlorophyll fluorescence yield measurements:

Chlorophyll fluorescence yield was measured by Plant Efficiency Analyzer (Hansatech Instrument Ltd., England). A single leaf was attached to the leaf clip and kept in dark place for 30-45 minutes to maintain dark adaptation. The fluorescence signal was measured for 3 seconds and fluorescence yield observed where, F_0 = Lower fluorescence, F_m = maximum fluorescence, F_v = relative variable fluorescence ($F_m - F_0$). Temperature = 27°C, Time range = 10 μ s- 3 sec.

Mineral content, Photosynthetic pigment levels, and Stomatal conductance measurements:

The nutrient content of Bougainvillea leaves (N and P) was analyzed using a multielement analyzer (MEA). Grounded leaf samples were mixed with water, and 1 mL of the sample extract was injected into the MEA for the calculation. The potassium (K^+) content of the leaves was determined using a

Cardy potassium meter. The chlorophyll and carotene contents of the Bougainvillea leaves were determined using the methods described by Hendry and Price (1993). Stomatal conductance was measured using a portable Porometer (Leaf Porometer, Model SC-1, USA). A leaf chamber was attached to one leaf and kept the leaf at an ambient temperature for 10–15min to maintain sunlight adaptation. Stomatal conductance was measured in three replicates from different spots on a single leaf. The total soluble sugar level of the leaves was determined using the phenol-sulphuric method (Dubois, 1956).

The shoot growth rates, flower bud number, blooming rate, bract length, and shoot elongation were measured at three-day intervals. Individual bract and flower weights, as well as bract length and wide, were measured after 15 days of observation. All of the growth rates were measured using a vernier scale, and the growth per day (in cm) was calculated. Close observations were made to determine the number of nodes before the first inflorescence for each treatment. Individual bract and bract cluster weight, including the flowers were measured using a Mettler PJ3000 balance, and bract lengths were measured on a Mitutoyo Vernier Scale. From the beginning of the experiments, 15 buds per treatment were selected for full blooming and longevity measurements. The observations were made when all of the bracts were open and abscission had occurred.

Statistical analysis:

A completely randomized design (CRD) with five replications was used for the experiments. The data were pooled and analyzed using MSTATC statistical software. The one-way ANOVA was applied to evaluate significant differences in the parameter studied for the different treatments. The least significant difference (LSD) and honestly significant difference (HSD) were calculated following a significant F-test (at $P = 0.05$).

RESULTS AND DISCUSSION

Chlorophyll fluorescence has become one of the most powerful and widely used techniques available to plant physiologist and ecophysiological. Chlorophyll fluorescence gives information about the state of photosystem II in the chloroplasts thylakoid membranes.

Table 1: Chlorophyll fluorescence and chlorophyll content of leaves of Bougainvillea plants.

Chlorophyll fluorescence	F_0	F_v	F_m	Chlo <i>a</i> (mg/gFW)	Chlo <i>b</i> (mg/gFW)
0.78±0.040	200	600	800	2.2	1.8

All the data are mean of five replications

Table 1 showed maximum fluorescence (F_m) obtained was 800 while variable fluorescence (F_v)

obtained was 600. From the results shown in Table 1, it can be seen that optimum quantum yield (F_v/F_m)

was 0.78 ± 0.040 . Leaf chlorophyll content indicated the health status of a plant. The chlorophyll a content

was 2.2 mg/gFW while the chlorophyll b content was 1.8 mg/gFW.

Table 2: Stomatal conductance, carotenoids, mineral ion content and total sugar of *Bougainvillea* leaves.

Stomatal conductance	Carotenoids mg g ⁻¹ FW	N mg/g	P mg/g	K mg/g	Total sugar mg/L
25 (m ² S/mol)	1.03	2.18	0.29	0.95	0.28

All the data are mean of five replications

When stomatal conductance was 25 (m²S/mol), carotenoids content was 1.03 mg g⁻¹ FW. Meanwhile the mineral nutrient content of *Bougainvillea* leaves showed that Nitrogen is the highest which is 2.18 compared to other nutrients; Phosphorus which is 0.29 and Potassium which is 0.29 (Table 2). Total

sugar content was 0.28. In addition, it was referred that leaves from the younger branch or middle age had a higher rate of photosynthesis and high stomatal conductance than the leaves of older branches (Nabi *et al*, 2000; Poni and Intrieri, 1996).

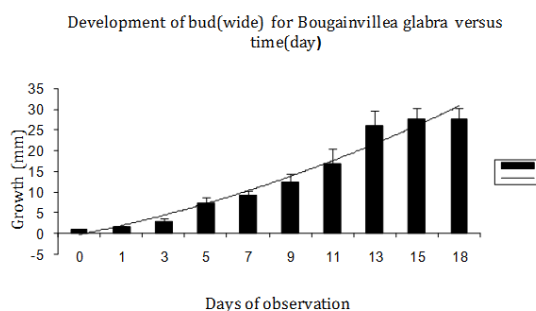


Fig. 1: Bud development (wide) behaviour for *Bougainvillea glabra* versus time.

Figure 1 shows the time course growth of *Bougainvillea* bud under natural conditions. It has been recorded that initially (0 to 13 days) bud growth is very high. At 13 days of observation growth bud growth relatively slow then the earlier stage. These effects may be due to the rapid translocation of

photosynthates during the early stage of bud development, hereafter, decreased with time being. Similarly growth in bud wide, bud length growth was also faster in early two weeks of observations and it seems to be slow after two weeks (Figure 2).

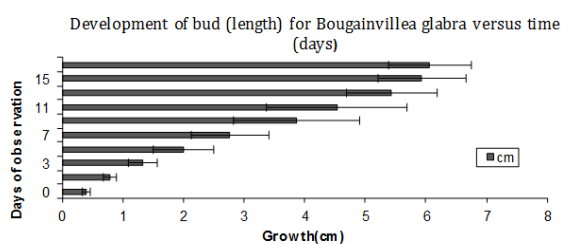


Fig. 2: Bud development (Length) behaviour for *Bougainvillea glabra* versus time.

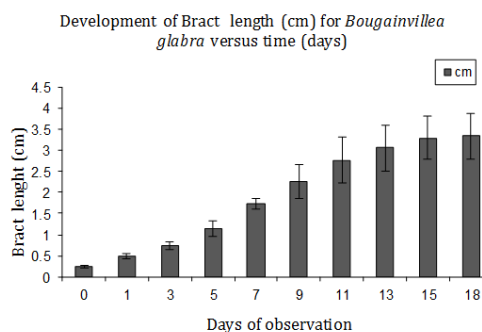


Fig. 3: Development of Bract length (cm) for *Bougainvillea glabra* versus time (days).

Bougainvillea bract growth (wide) was higher in the early growth stage (0 to 11 days) than in the later stage (two weeks after initiations) which has a gradual increase until the fully blooming. This growth trend for bract length was also observed during the entire reproductive period and resulted in

larger flower bract. The bract length growth rate was nearly 30% higher in early stage compared to later stage of development. From figure 4, bract wide for *Bougainvillea glabra* increase tremendously from 0 to 9 days and increase steadily from 9 to 18 days.

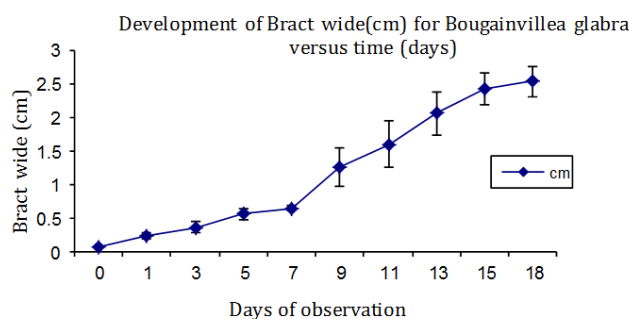


Fig. 4: Bract growth (wide) for *Bougainvillea glabra* versus time (days).

Complete life cycle of Bougainville bud including bract with flower are shown in Figure 5. From this study, it was observed that complete life cycle of *Bougainvillea* bracts including flower is about 28 days. For bud initiations and initiations to complete blooming it takes 1 and 12 days. From bud blooming to senescence the flowers longevity on plants was about 13 days. All the bracts containing the flower dropped within two days of senescence. Saifuddin (2009) reported that *Bougainvillea* bract longevity almost 24 days. They also reported that bract longevity can be extended four and 6 days more with phloemic stress and GA3 plus phloemic stress. But only GA3 application shortened the longevity of bract including flower. Initiation stage only represent 4% from the complete life cycle while initiation stage to complete blooming represent 43% which considered longer life cycle. Complete blooming stage to senescence is the longest stage which represent 46%, meanwhile from senescence to dropping stage only 7% from the overall life cycle.

Leaf growth (length) rate first two week is relatively higher than the latter stage as seen in Figure 6. After 7 days the growth of leaf has a steady increase. Figure 7 also shows a sharp increase until day 7 and a steady rise after day 7. Plant growth and development depends on water uptake, cell division, cell elongation and the permeability of plant cell membranes (Hangarter ., 1978). Moneruzzaman (2012) reported that application of plant growth regulators increased the leaf area of *Bougainvillea* plant. Primarily, leaf growth depends on leaf age and growth conditions. At immature stage the growth is higher than the mature stage because all growth stimulants are available during this stage. At the later stage leaf has very slow growth due to potential influence of flowering. Gonzalez (2009) suggest that some of the rosette leaves might show a further increase in size when the plants are mature. It also been reported that all the growth of the plant depends on environmental factors.

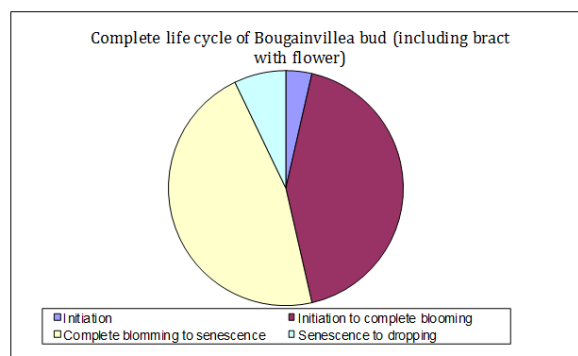


Fig. 5: Complete life cycle of *Bougainvillea glabra* bract including flower.

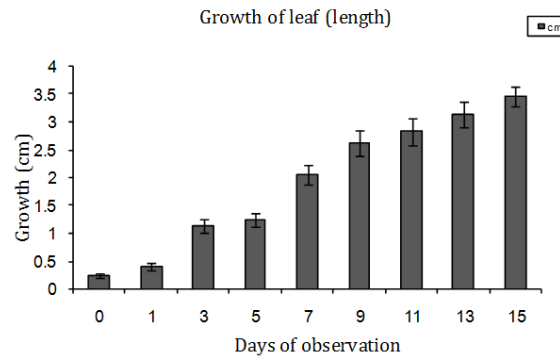


Fig. 6: leaf growth (length) of *Bougainvillea glabra* versus time.

Figure 8 shows growth of shoot *Bougainvillea glabra* versus time. From day 0 to day 7, the shoot growth has a sharp increase while gradual increase after one week. With full expansion of the shoot and leaves, the first priority in the shoot is the deposition of carbohydrate behind the new buds. Shoot storage is always filled with carbohydrate from the tip downward. There should be a positive relationship both in shoot and root. Shoot and root obviously act together and distribute resources to make sure the plant success (Coder, 1997). From our experiment, it was observed that shoot elongation or stem growth

was almost same at early and later stage. This all vegetative growth depends on availability of plant growth regulators and nutrients substances. Muthuchelian . (2003), who reported that growth regulators treatments increased the root and shoot length, leaf density and area, and fresh and dry biomass accumulation of *Erythrina variegata* plants. These effects may be due to the rapid translocation of growth regulators throughout the plant, causing a cascade of metabolic events and resulting in significant increases in growth and dry matter (Ries and Wort, 1992).

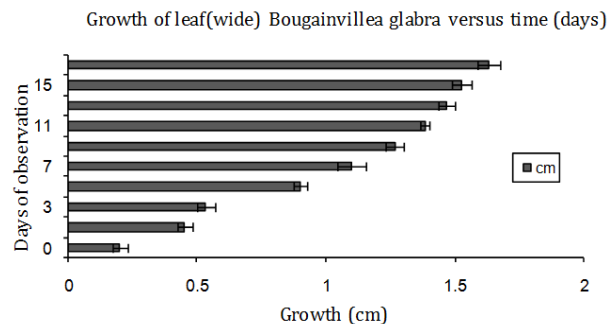


Fig. 7: Leaf growth (wide) *Bougainvillea glabra* versus time.

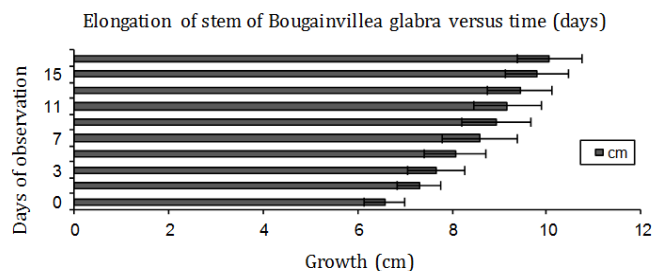


Fig. 8: Growth of shoot of *Bougainvillea glabra* versus time.

The results showed that all the vegetative growth; leaf growth, shoot length were higher in earlier stage. However, these growth relatively slow at later stage. For the growth of *Bougainvillea* bud under natural conditions (Figure 1), from 0 to 13 days, bud growth is relatively high and the bud

growth start to slow down after 13 days. An additional factor that can promote flower bud development is the endogenous cytokinin level in the shoot apex. Wim . (1990) reported that exogenous application of cytokinin in in vitro cultures of tobacco stimulated flower bud formation. From

Moneruzzaman (2010a), it is clear that cytokinin treatment with defoliation increased the production of floral buds. Similar findings were also reported by Even-Chen (1979). They reported that in Bougainvillea, cytokinin treatments promoted flower bud formation and decreased endogenous gibberellin content was necessary for flower bud formation. Moneruzzaman (2010b), also reported that sucrose treatment at lower temperature increased the vase life as well as bract quality of Bougainvillea.

Figure 3 showed the development of bract length for Bougainvillea while Figure 4 showed bract growth (width) for Bougainvillea under natural condition. Both growth of bract length and width was higher in the early growth stage (0 to 11 days) compared to later stage, 11 days onwards. In Saifuddin et al., 2010 research, results showed that in the final season, the highest bract length and weight was observed in the frequent pruning as compared with control plants. It was clear that frequent pruning had a positive effect on bract length and weight compared to non-pruning and other types of pruning. Furthermore, it has been revealed that pruning increased the supply of cytokinins from the roots, measured as increased concentration in the remaining above-ground tissue (Avner and Staden, 1983).

Conclusion:

The increase of hormone levels is probably responsible for stimulating cell division, new shoot formation and ultimately more flower per branch and frequent flower bud initiation. Reproductive organ bract including flower growth started to decrease after 13 days of initiation. It was also observed that leaf and shoot growth rate were higher in earlier stage compared to later stage due to gibberellic production in early vegetative growth. From this study, it can be concluded that complete life cycle of Bougainvillea bracts including flower is about 28 days.

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