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PLANT GROWTH RETARDANTS EFFECT ON GROWTH AND FLOWERING OF POTTED *Hibiscus rosa-sinensis* L.

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ABSTRACT

A study was conducted to investigate the effects of plant growth retardants; paclobutrazol, uniconazole and flurprimidol on the growth and flowering response of Hibiscus rosa-sinensis. This species is introduced into the Malaysian landscape due to its large and distinctive colour of blooms. However, under local climate conditions, its flowering habits are unpredictable and the leaves always look unhealthy and yellowish. A more practical technique, using plant growth retardants (PGRs) was explored to induce flower and hence increase the aesthetic value of the species. Plant growth retardants such as paclobutrazol (0.25 gL^{-1}), uniconazole (2 mgL^{-1}) and flurprimidol (0.02 mgL^{-1}) were used in this study. Paclobutrazol significantly reduced the plant height and leaf area, increased the chlorophyll content and number of flower buds but delayed the blooming. Uniconazole was found to be more effective in promoting flowers and increased the root length as compared to the controls. This approach of using PGRs could be an alternative method in improving the flowering of H. rosa-sinensis in the urban landscape.

Keywords: *Hibiscus rosa-sinensis* L., chlorophyll content, flower induction, landscape, plant growth retardants

INTRODUCTION

Hibiscus rosa-sinensis L. of the family Malvaceae is native to East Africa (van Valkenburg & Bunyapraphatsara 2001). Locally known as Bunga Raya, this species has been officially honoured as the National Flower of Malaysia on 28 July 1960. It has significant red flowers and is widely planted as hedge plant or topiary. According to Chin (1986), the magnificent large blooms usually last for a day or two. However, the flowering habit of this species is very erratic and inconsistent. Some individuals of the species do not flower simultaneously within the same planting group. In other cases, this species flowers occasionally throughout the year. Therefore, a more practical technique of using plant growth retardants (PGRs) need to be explored to induce flowering and hence enhance the aesthetic qualities.

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Previous studies showed that PGRs, such as paclobutrazol, uniconazole and flurprimidol were widely used in inducing flower of ornamental species. Paclobutrazol has effectively increased the number of flowers of *Bougainvillea glabra* (Karaguzel & Ortacesme 2002), *Eucalyptus nitens* (William et al. 2003), *Lupinus varius* (Karaguzel et al. 2004), *Calendula officinalis* (Mahgoub et al. 2006), *Dendrobium* orchids (Te-chato et al. 2009) and *Consolida orientalis* (Mansuroglu et al. 2009). Similar results were also noticed of flurprimidol-treated *Melastoma decemfidum* (Abdullah et al. 1998) and uniconazole-treated *Dianthus caryophyllus* (Pobudkiewicz & Nowak 1994).

These PGRs inhibit the formation of growth-active gibberellin (GA) in plants. GA is known to stimulate cell division and elongation, and the growth of stem, leaf, flower stalk, and fruit. It can also inhibit the development of lateral buds (Salisbury & Ross 1992). Plants treated with the PGRs usually showed reduction in growth (Fletcher et al. 2000, Rademacher 2000). Reduced plant height and leaf area of *Syzygium campanulatum* and *Lilium* sp. were reported following treatment with paclobutrazol (Ahmad Nazarudin et al. 2007, Francescangeli et al. 2007). Uniconazole gave similar effects as paclobutrazol when applied to *Syzygium campanulatum* (Ahmad Nazarudin et al. 2010).

However, the specific study on the effectiveness of these PGRs on *H. rosa-sinensis* under local condition has not been established. Therefore, this study was initiated to determine the effects of paclobutrazol, uniconazole and flurprimidol on vegetative growth and flowering response of *H. rosa-sinensis.*

MATERIALS AND METHODS

The study site

The study site was established at a nursery in Forest Research Institute Malaysia (FRIM), Kepong, (3° 10' 0" N/101° 42' 0" E), Selangor, Malaysia. During the experimental period, the mean daily temperature ranged from 21.1 to 34.2 °C and the annual precipitation was 1914.8 mm, with 76% relative humidity.

Plant materials

Plants were purchased from a local nursery and transplanted into plastic pot (25 cm diameter x 20 cm height) filled with a mixture of top soil, organic matter and sand at a ratio of 3:2:1. The plants were then trimmed to approximately 60 cm in height and allowed to flush for a few weeks. From observation, *H. rosa-sinensis* requires a period of 20 days to flush and recover from the trimming effects. Randomised Complete Block Design (RCBD) with ten replicates was used as experimental design. A total of 40 plants were used in the experiment.

PGRs treatment

PGRs, i.e. paclobutrazol (0.25 gL^{-1}), uniconazole (2 mgL^{-1}) and flurprimidol (0.02 mgL^{-1}) were then applied as soil drenching. Each rate of PGRs was topped up to 1 L with plain water before they were applied as soil drench (each plant received 1 L solution). At the same time, control plants were applied with 1 L of plain water. The PGRs were applied once at the commence of the study. Preliminary studies found that the rates of each PGRs used in this study were appropriate to control the growth without abnormal leaves formation of *H. rosa-sinensis* (data not shown).

Plant maintenance

Monthly, fertilizer (NPK 15:15:15) was applied at a rate of 5 g per plant to ensure satisfactory plant growth. The plants were generally watered twice daily, i.e. in the morning and late afternoon, depending on the weather. Weeds in the pots were removed manually.

Data collection

Plant height, leaf area and relative chlorophyll content were measured weekly. Plant height (cm) was measured from the soil surface to the highest shoot tip by using a metal ruler. A portable Leaf Area Meter (CI-202, USA) was used to measure the first ten uppermost fully developed leaves from each plant for leaf area measurement (cm^2). For chlorophyll content, the first ten uppermost fully expanded leaves per plant were measured by using a non-destructive portable meter, SPAD 502, Minolta, Japan.

For flowering response, observations on days to flower, number of flower buds, and number of blooms were carried out on daily basis. Days to flower were recorded as the length of time between treatment application and visible appearance of the first flower bud. After 90 days, the roots of each plant were cut from the basal stem and cleaned by using tap water. The total root length was measured (cm) by using a metal ruler.

Data analysis

All data were subjected to Analysis of Variance (ANOVA) and the treatment means were compared using Turkey's Honestly Significant Difference (HSD) Tests. The Pearson correlation was also performed to measure the degree of association between parameters.

RESULTS AND DISCUSSION

Plant morphological response

At 75 days after the application of PGRs, control plants recorded 83.44 cm in height, while paclobutrazol-treated plants recorded 70.44 cm, showing a height control by 15.6% (Table 1; Figure 1). Paclobutrazol also reduced the leaf area giving measurement of only 3.44 cm^2, while the leaf area of control plants measured 8.52 cm^2, showing a reduction by 59.6% (Table 1; Figure 2). The leaves of paclobutrazol-treated plants had significantly higher chlorophyll content (51.82) while the control plants measured 35.94 in this parameter indicating an increase of about 30.6% (Table 1; Figure 3). Increased chlorophyll content made the leaves appeared greener and shinier. This was due to enhanced chlorophyll content (Sankhla et al. 1996, Tekalign & Hammes 2004). According to Kim et al. (1999), paclobutrazol resulted in deeper green colouration of the leaves in *Dicentra spectablilis*. There was no significant difference found in plant height, leaf area and chlorophyll content of this species after treatment with uniconazole and flurprimidol.

Table 1: Effects of PGRs on the vegetative growth of *H. rosa-sinensis* at 75 days after treatment.

Treatment	Plant height (cm)	Leaf area (cm^2)	Chlorophyll content
C (control)	83.44a	8.52a	35.94b
Uniconazole, 2 mgL^{-1}	82.22ab	6.85a	38.11b
Flurprimidol, 0.02 mgL^{-1}	79.56ab	8.11a	38.77b
Paclobutrazol, 0.25 gL^{-1}	70.44b	3.44b	51.82a

Means followed by the same letter(s) within column do not differ ($p<0.05$) by Tukey's Honestly Significant Difference (HSD) Tests

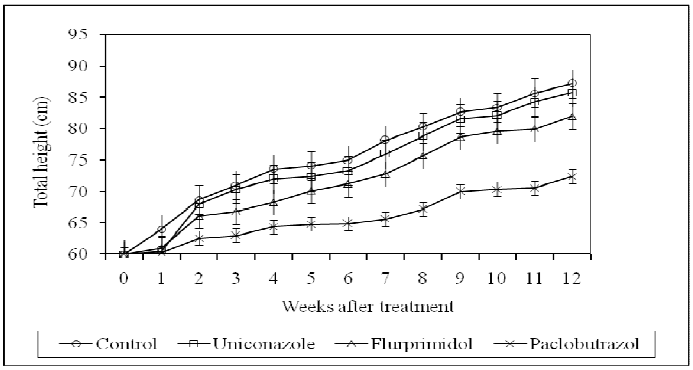

Figure 1. Height increment of *H. rosa-sinensis* after treatment with different growth retardants. Each point represents the means of ten replications. Vertical bars represent standard error.

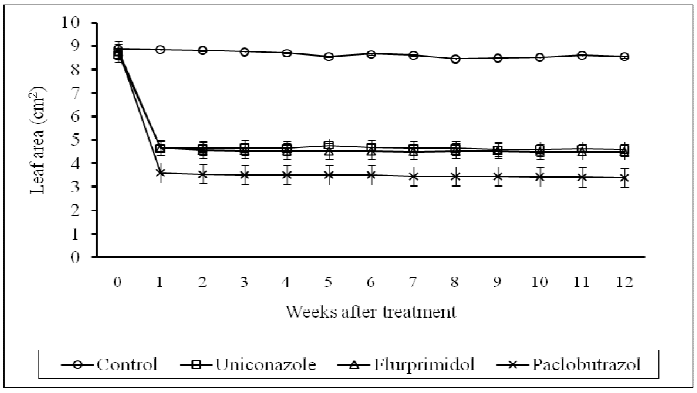

Figure 2. Leaf area of *H. rosa-sinensis* after treatment with different growth retardants. Each point represents the means of 100 replications. Vertical bars represent standard error.

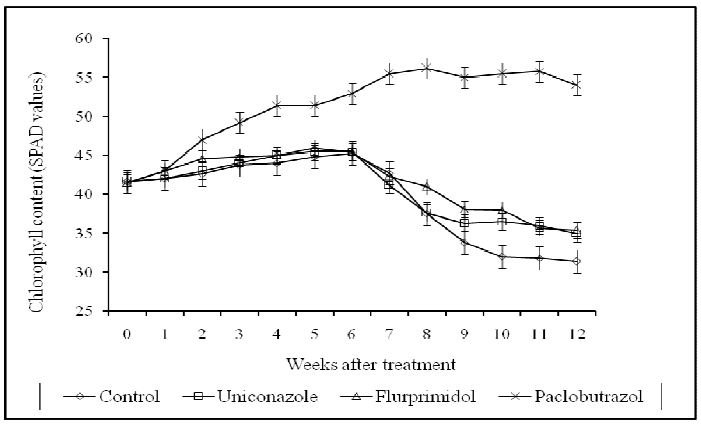

Figure 3. Chlorophyll content of *H. rosa-sinensis* after treatment with different growth retardants. Each point represents the means of 100 replications. Vertical bars represent standard error.

There is a significant negative relationship between leaf area and chlorophyll content (Figure 4), implying that the chlorophyll content would be increased if the leaf area decreased. The leaves of both treated and untreated plants possibly contain the same number of cells, but because the cells in leaves of treated plants are smaller, the chlorophyll is more concentrated in the reduced cell volume (Khalil 1995, Chaney 2008). In addition, however, there is evidence that the amount of chlorophyll is actually increased following treatment with PGRs (Sankhla et al. 1996, Tekalign & Hammes 2004).

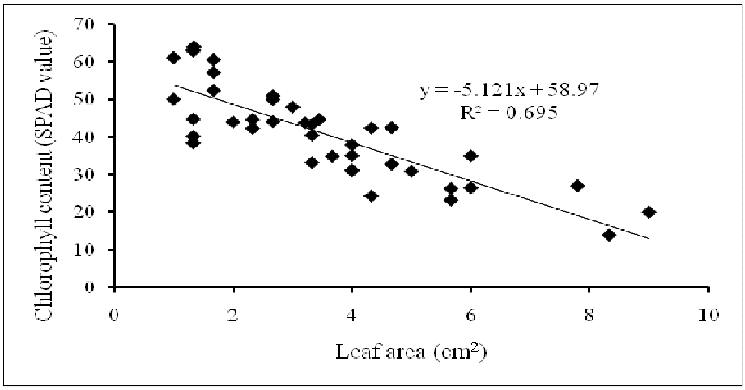

Figure 4: Relationship between chlorophyll content and leaf area of *H. rosa-sinensis* following the treatments.

Increased root length was also found in uniconazole-treated plants (81.33 cm) as compared to the controls (50.33 cm), showing an increase of 38.1% (Table 2; Figure 5). Previous studies found that PGRs promoting root growth and cytokinin production in the roots (Fletcher & Arnold 1986, Henrique et al. 2006, Khairun & Te-Chato 2009), thus stimulating chloroplast differentiation and chlorophyll biosynthesis (Fletcher et al. 1982). Watson and Himelick (2004) observed that fine root density on *Quercus palustris* was increased as compared to untreated plants. Increased root growth of the treated plants may be due to increased carbohydrate supply to the roots, probably due to reduced demand for above ground growth (Watson 1996). As the amount of the fibrous roots increased, the efficiency of the plant in absorbing water and nutrients into the plant cells was also enhanced.

Table 2. Effects of PGRs on total roots length of *H. rosa-sinensis*.

Treatment	Total root length (cm)
C (control)	50.33b
Uniconazole, 2 mgL^{-1}	81.33a
Flurprimidol, 0.02 mgL^{-1}	50.11b
Paclobutrazol, 0.25 gL^{-1}	41.33b

Means followed by the same letter(s) within column do not differ ($p<0.05$) by Tukey's Honestly Significant Difference (HSD) Tests

Figure 5: Root length of *H. rosa-sinensis,* 13 weeks after treatment with 0.25 gL^{-1} paclobutrazol (P), 2 mgL^{-1} uniconazole (U), 0.02 mgL^{-1} flurprimidol (F) and control (C).

Flowering response

Paclobutrazol induced more flower buds (50.89) as compared to control plants (30.78), showing an increase of 39.5% (Table 3). However, no significant difference in terms of flower buds was found between paclobutrazol, uniconazole and flurprimidol treatments. The first flower bud appeared at day 50 after the application of uniconazole, followed by flurprimidol (day 53), control (day 54) and paclobutrazol (day 76). This indicated that paclobutrazol at this rate delayed the flowering by about 26 days as compared to uniconazole (Table 3). Number of blooms was also significantly higher in uniconazole-treated plants as compared to other treatments (Table 3; Figure 6). Omran (2003) found that paclobutrazol significantly induced uniform flowering of *Averrhoa carambola*. Goulston and Shearing (1985) reported that paclobutrazol produced superior quality plants and quantity of flowers of certain species.

A significant positive relationship was found between the number of blooms and the total root length (Figure 7), indicating that the number of blooms increased as the total root length increased. It was also observed that more fine roots developed after PGRs treatment. Fine roots are responsible for most water and nutrient uptake (Pallardy 2008, Harris 1992), and hence promoting plant health. The efficiency of the roots in absorbing essential nutrients may induce the flowering of the species.

Table 3. Effects of PGRs on flowering response of *H. rosa-sinensis* at 75 days after treatment.

Treatment	No. of flower buds	No. of blooms	Days to flower
C (control)	30.78b	0.4b	54b
Uniconazole, 2 mgL^{-1}	43.67ab	1.9a	50b
Flurprimidol, 0.02 mgL^{-1}	37.44ab	1.0ab	53b
Paclobutrazol, 0.25 gL^{-1}	50.89a	0.2b	76a

Means followed by the same letter(s) within column do not differ ($p<0.05$) by Tukey's Honestly Significant Difference (HSD) Tests.

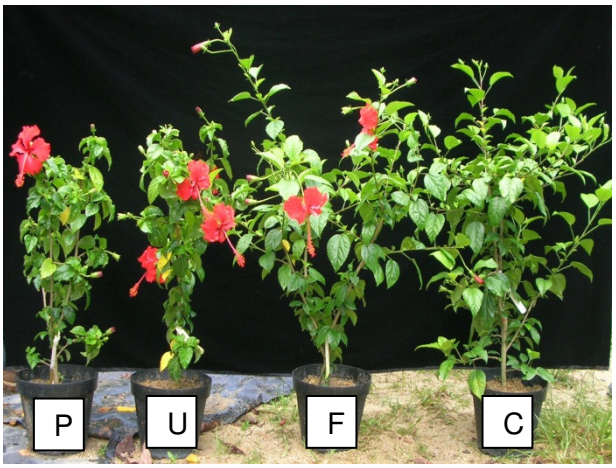

Figure 6: Height and number of flowers of *H. rosa-sinensis,* ten weeks after treatment with 0.25 gL^{-1} paclobutrazol (P), 2 mgL^{-1} uniconazole (U), 0.02 mgL^{-1} flurprimidol (F) and control (C).

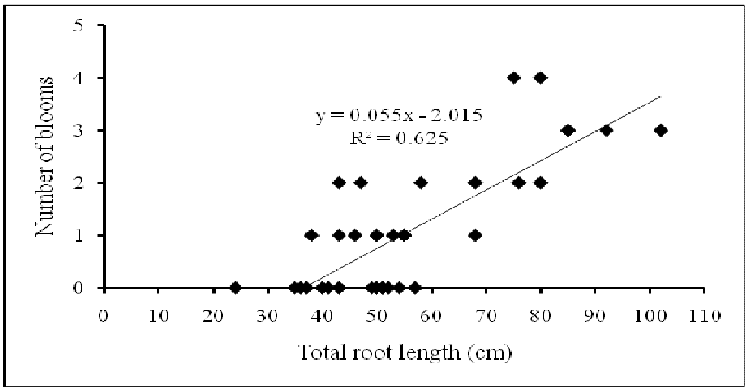

Figure 7: Relationship between the number of blooms and total root length of *H. rosa-sinensis* following the treatments.

CONCLUSIONS

In conclusion, paclobutrazol reduced the plant height and leaf area, but increased the chlorophyll content in the leaves of *H. rosa-sinensis*. This compound also increased the number of flower buds of this species at 75 days after application. Paclobutrazol at this rate, however, delayed the flowering as compared to uniconazole. Increased root length and number of blooms were also recorded with uniconazole treatment. Therefore, 2 mgL^{-1} uniconazole is recommended for flower induction of potted *H. rosa-sinensis.* This approach could serves as an alternative method in improving the unpredictable flowering habit of *H. rosa-sinensis* in the urban landscapes.

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REFERENCES

Abdullah, T., Malek, A.A., Ahmad, S.H. 1998. Chemical manipulation of growth and flowering in potted *Melastoma decemfidum* and *Tibouchina semidecandra. Acta Horticulturae* **454**: 297-301.

Ahmad Nazarudin, M.R., Mohd Fauzi, R., Tsan, F.Y. 2007. Effects of paclobutrazol on the growth and anatomy of stems and leaves of *Syzygium campanulatum*. *Journal of Tropical Forest Science* **19**(2): 86-91.

Ahmad Nazarudin, M.R., Tsan, F.Y., Mohd Fauzi, R. 2010. Growth inhibition of *Syzygium campanulatum* Korth. for container planting by the application of uniconazole. *Pertanika Journal of Tropical Agriculture Science* **33**(1): 1-6.

Chaney, W.R. 2008. *Growth Retardants: A Promising Tool for Managing Urban Trees.* Purdue Extension. Purdue University, https://www.extension.purdue.edu/extmedia/FNR/FNR-252-W.pdf. Accessed on 30 June 2012.

Chin, H.F. 1986. *The Hibiscus, Queen of Tropical Flowers.* Tropical Press Sdn. Bhd., Kuala Lumpur, 151.

Fletcher, R.A., Gilley, A., Sankhla, N., Davis, T.D. 2000. Triazoles as plant growth retardants and stress protectants. *Horticultural Reviews* **24**: 55-138.

Fletcher, R.A., Arnold, V. 1986. Stimulation of cytokinins and chlorophyll synthesis in cucumber cotyledons by Triadimefon. *Plant Physiology* **66**: 197-201.

Fletcher, R.A., Kallidumbil, V., Steele, P. 1982. An improved bioassay for cytokinins using cucumber cotyledons. *Plant Physiology* **69**: 675-677.

Francescangeli, N., Marinangeli, P., Curvetto, N. 2007. Paclobutrazol for height control of two *Lilium* L.A. hybrids grown in pots. *Spanish Journal of Agricultural Research* **5**(3): 425-430.

Goulston, G.H., Shearing, S.J. 1985. Review of the effects of paclobutrazol on ornamental pot plants. *Acta Horticulturae* **167**: 339-348.

Harris, R.W. 1992. Root-shoot ratios. *Journal of Arboriculture* **18**(1): 39-42.

Henrique, A., Campinhos, E.N., Ono, E.O., Pinho, Z. 2006. Effect of plant growth regulators in the rooting of *Pinus* cuttings. *Brazilian Archives of Biology and Technology* **49**(2): 189-196.

Karaguzel, O., Baktir, I., Cakmakci, S., Ortacesme, V. 2004. Growth and flowering responses of *Lupinus varius* L. to paclobutrazol. *HortScience* **39**(7): 1659-1663.

Karaguzel, O., Ortacesme, V. 2002. Influence of paclobutrazol on the growth and flowering of *Bougainvillea glabra* 'Sanderiana'. *Ziraat Fakultesi Dergisi, Akdeniz Universitesi* **15**(1): 79-84.

Khairun, N., Te-chato, S. 2009. Optimizing of root induction in oil palm plantlets for acclimatization by some potent plant growth regulators (PGRs). *Journal of Agricultural Technology* **5**(2): 371-383.

Khalil, I.A. 1995. Chlorophyll and carotenoid contents in cereals as affected by growth retardants of the triazoles series. *Cereal Research Communications* **23**: 183-189.

Kim, S., De Hertogh, A.A., Nelson, P.V. 1999. Effects of plant growth retardants apply as sprays or media drenches on forcing of Dutch-grown bleeding heart as a flowering potted plant. *HortTechnology* **9**: 629-633.

Mahgoub, M.H., Abd El Aziz, N.G., Youssef, A.A. 2006. Influence of foliar spray with paclobutrazol or glutathione on growth, flowering and chemical composition of *Calendula officinalis* L. plant. *Journal of Applied Sciences Research* **2**(11): 879-883.

Mansuroglu, S., Karaguzel, O., Ortacesme, V., Sayan, M.S. 2009. Effect of paclobutrazol on flowering, leaf and flower colour of *Consolida orientalis. Pakistan Journal of Botany* **41**(5): 2323-2332.

Omran, H. 2003. Regulation of flowering for staggered production of carambola by using growth retardant paclobutrazol. *Transactions of the Malaysian Society of Plant Physiology* **12**: 255-261.

Pallardy, S.G. 2008. *Physiology of Woody Plants*. 3rd Edition. Academic Press, the United States of America. 454 pp.

Pobudkiewicz, A., Nowak, J. 1994. The influence of flurprimidol and uniconazole on growth of the CMM dwarf *Dianthus caryophyllus* L. cv. Snowmass. *Journal of Fruit and Ornamental Plant Research* **2**: 135-142.

Rademacher, E. 2000. Growth retardants: effects on gibberellin biosynthesis and other metabolic pathway. *Annual Review of Plant Physiology and Molecular Biology* **51**: 501-531.

Salisbury, F.B., Ross, C. 1992. *Plant Physiology*. 4th Edition. Freeman and Worth. New York, 682.

Sankhla, N., Kachhwaha, S., Mali, S., Dinesh, R., Choudhary, R., Misra, N., Srivastava, H.P. 1996. Effect of salt, paclobutrazol and thidiazuron on in vitro growth and oxidative stress in Ziziphus seedlings. *Proceedings of Plant Growth Regulation Society of America* **23**: 152-158.

Te-chato, S., Nujeen, P., Muangsorn, S. 2009. Paclobutrazol enhance budbreak and flowering of Friederick's dendrobium orchid *in vitro*. *Journal of Agricultural Technology* **5**(1): 157-165.

Tekalign, T., Hammes, P.S. 2004. Response of potato grown under non-inductive condition to paclobutrazol: shoot growth, chlorophyll content, net photosynthesis, assimilate partitioning, tuber yield, quality, and dormancy. *Plant Growth Regulation* **43**: 227-236.

van Valkenburg, J.L.C.H., Bunyapraphatsara, N. 2001. Plant Resources of South-East Asia **12**(2). *Medicinal and Poisonous Plants 2*. Backhuys Publishers, Leiden, the Netherlands, 782.

Watson, G.W., Himelick, E.B. 2004. Effects of soil pH, root density, and tree growth regulator treatments on pin oak chlorosis. *Journal of Arboriculture* **30**(3): 172-177.

Watson, G.W. 1996. Tree root system enhancement with paclobutrazol. *Journal of Arboriculture* **22**(5): 211-217.

Williams, D.R., Potts, B.M., Smethurst, P.J. 2003. Promotion of flowering in *Eucalyptus nitens* by paclobutrazol was enhanced by nitrogen fertilizer. *Canadian Journal of Forest Research* **13**: 74-81.