Flowering and Fruit Set of Rubber (*Hevea brasiliensis*) during Summer Rainfall in Songkhla Province, Southern Thailand

V. Wongvarodom[1,*], W. Duang-iat[1] and S. Sdoodee[1]

[1] Department of Plant Science, Faculty of Natural Resources,Prince of Songkhla University, Songkhla 90112 Thailand
[*] Corresponding author: vichai.w@psu.ac.th
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ABSTRACT

The incidence of summer rainfall and lower seed production by rubber trees in Songkhla province, southern Thailand are tending to arise more frequently and the impact of summer rainfall on the flowering and fruit set of rubber trees was therefore investigated. The incidence of summer rainfall during the months of January-April between 1969 and 2012 was plotted and the flowering phenology of early–introduced variety rubber trees aged more than 40 years old in the Hatyai Campus, Prince of Songkhla University, Songkhla province, Thailand was recorded. The results showed that anomalous summer rainfall had become a feature of the local climate with the most obvious increase, tending to occur in March. The 40 years average rainfall, the 8 years average and the total rainfall during March in the years 2011 and 2012 were 58.0 mm, 125.6 mm, 287.7 mm and 176.8 mm respectively. The 8 years average rainfall in March had increased by 116.55%, over the 40 years average rainfall with the 2011 and 2012 March rainfall increased by 396.03% and 204.83% respectively. The incidence of rainfall in March in 2011 and 2012 was 17 and 11 days, respectively. Summer rain conditions during the flowering period of rubber induced an outbreak of *Oidium* secondary leaf fall disease which destroy leaves, inflorescences and the fruit of rubber. Approximately 50% of the flowering shoots developed to the fruit-setting stage. The average number of fruits per flowering shoot was 2.18, and they all dropped within three weeks, mostly during the first (58.11%) and second (39.19%) week after fruit-setting. The results obtained are beneficial to the development of techniques to improve rubber seed production in commercial rubber plantations.

Keywords: Rubber (*Hevea brasiliensis*), summer rainfall, recalcitrant seed, fruit set, *Oidium* secondary leaf fall disease

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INTRODUCTION

Rubber (*Hevea brasiliensis*) is a commercial tree grown economically in Thailand, mainly in the southern part of the country. Most planting materials for rubber cultivation come from budded seedlings or budded rubber stumps either in polyethylene bags or as bare-root stumps obtained by grafting a scion of a high-yield clone on a seedling rootstock. The production of budded stumps requires a large quantity of seeds for rootstock production. Rubber Research Institute of Thailand (2012) reported that the area re-planted in 2010 was about 213,927 rai or 34,228 hectares which required more than 17 million budded

seedlings for re-planting. Therefore, a high quantity of rubber seed is needed for rootstock production each year. However, rubber seed produced from rubber trees in southern Thailand is low quality. This might be due to the influence of summer rain which affects flowering and fruit set during summer (February to April) after the wintering period (January and February) (Webster and Baulkwill, 1989; Yeang, 2007). IPCC (2001a and 2007) reported that global warming in the humid tropics and other parts of the world has caused climate change which has influenced the phenological cycle and agricultural productivity. An increase in global temperature will change the amount and pattern of in many parts of the world (Wikipedia, 2012). For example, the Australian Climate Change Science Program (2012) reported that north-west Australia has become wetter during summer and this situation has also arisen in Songkhla province in southern Thailand (Ruangsri *et al*., 2015). The main rubber flowering season occurs in summer during the period February to April, following wintering in January and February (Webster and Baulkwill, 1989; Yeang, 2007). If rain occurs during flowering this results in post-bloom fruit-drop in many fruit crops (Goes *et al*., 2008). The success rate of fruit set and seed maturation is important for both rubber propagation and breeding. Here, the authors report the effect of summer rainfall on rubber tree flowering and fruit set.

MATERIALS AND METHODS

Rainfall Data and Flowering Stages

The rainfall data during January-April between 1969 and 2012 were obtained from the Kho-Hong Meteorological Station located 1 km from the experimental plot, and were plotted against the flowering phenology between wintering to early fruit development including the incidence of red leaf and leaf fall, inflorescence emergence, inflorescence development, flower bloom, fruit set and fruit drop of early-introduced varieties of rubber trees aged more than 40 years old in Prince of Songkhla University, Hatyai Campus, Songkhla province.

Inflorescence Development and Fruit Setting Phase

The inflorescence development and fruiting of rubber trees aged more than 40 years old were monitored between February and April 2012. The observation was made on four flowering shoots of a rubber tree in Prince of Songkhla University, Hatyai Campus, Details of individual inflorescence development stages were studied daily from the first appearance of flower buds on the terminal of the flowering shoot to the beginning of fruit development and eleven different flowering stages were recognized.

Fruit Set and Fruit Drop in 2011 and 2012

The study was carried out in the flowering seasons in 2011 and 2012. In 2011, the experiment was conducted with four early-introduced variety rubber trees aged more than 40 years old in Prince of Songkhla University, Hatyai Campus and twenty flowering shoots were observed to investigate the fruit set capacity. In 2012 the experiment was conducted with five early-introduced variety rubber trees (aged more than 40 years old). Randomized samples of 69 flowering shoots were tagged and observed daily from the first appearance of flower buds on the terminal of the flowering shoot to fruit drop, and the following data were collected: percentage of shoots setting and not setting fruit (fruit set and non-fruit set), the number of fruit set/flowering shoots, percentage of fruit drop within three weeks.

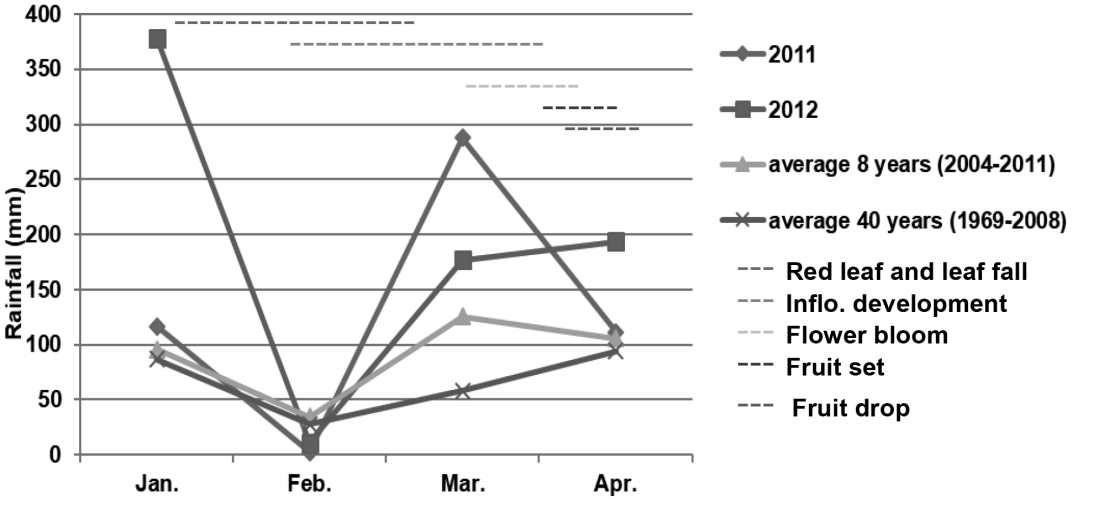

Figure 1 Precipitation during rubber tree flowering period (January to April) in Songkhla province, southern Thailand

RESULTS AND DISCUSSION

Occurrence of Summer Rainfall in Songkhla Province, Southern Thailand and Rubber Flowering Phenology

At the end of the rainy season and the beginning of the summer in Songkhla province, rainfall during January and February decreases and it then tends to become wetter in March and April (Figure 1). Based on data for the 40 years period, 1969–2008 summer rainfall during January-April of the years 2011 and 2012 and the annual average rainfall over the eight years, 2004–2011 in Hat Yai, Songkhla province showed an anomaly with summer rainfall tending to increase most obviously in March. The amounts of rainfall in March based on the 40 years average, the 8 years average, the year 2011 and the year 2012 were 58.0 mm, 125.6 mm, 287.7 mm and 176.8 mm respectively. In other words, the 8 years average rainfall in March had increased by 116.55%, while that for the years 2011 and 2012 had increased by 396.03% and 204.83%, respectively, compared to the 40 years average rainfall. Moreover, the incidence of rainfall in March in 2011 and 2012 was 17 and 11 days, respectively. This precipitation phenology is therefore consistent with the report of IPCC (2001b) that warming associated with increasing greenhouse gas concentrations will cause an increase in the variability of Asian summer monsoon precipitation.

Rubber trees start winter leaf-shedding, between mid-January and mid-February, and the leaves turn red and are shed, coinciding with the minimum rainfall. Inflorescences appear about 10 days after wintering; inflorescence emergence and development occurs between February and March, coinciding with an increase in rainfall and an increase in day length. The flowers bloom, fruit sets and fruit drops in March, as the rainfall increases.

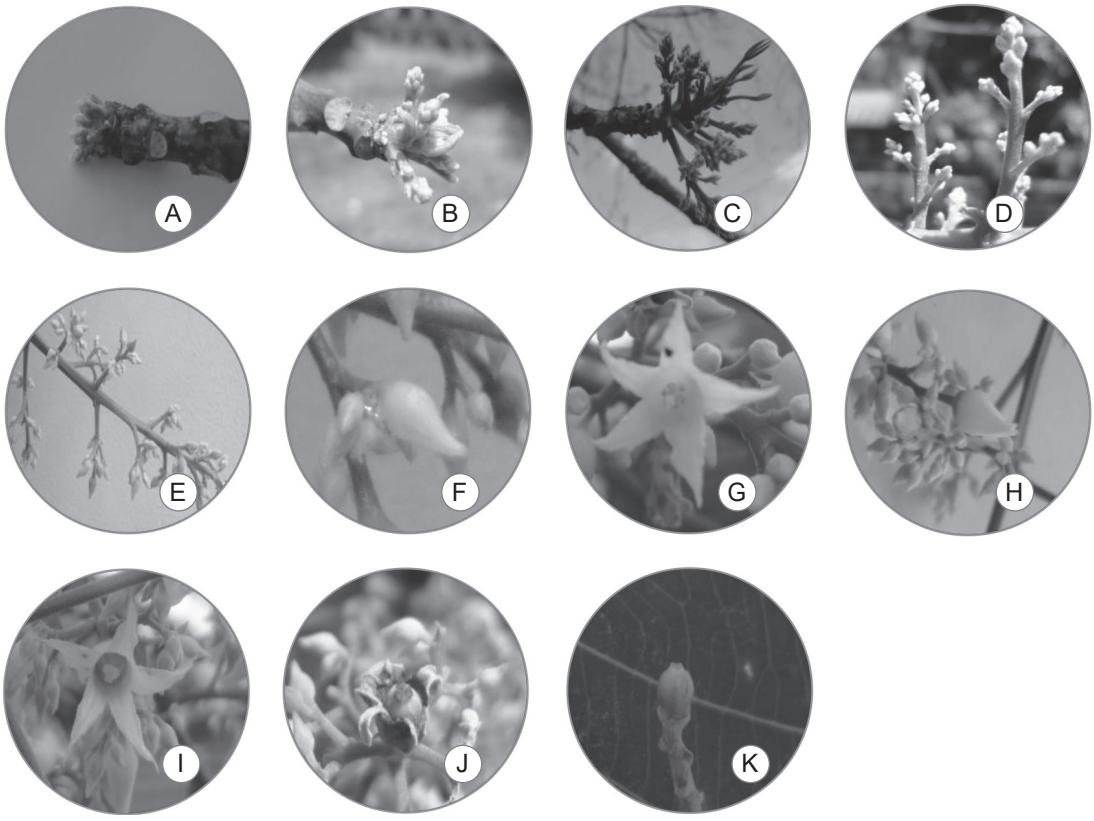

Figure 2 Rubber inflorescence development stages: A (bud burst), B (inflorescence and leaf emergence; 3 DABB), C (inflorescence and leaf development; 7 DABB), D (developing inflorescence; 7 DABB), E (mature inflorescence; 16 DABB), F (mature male flower; 20 DABB), G (male flower bloom; 23 DABB), H (mature female flower; 23 DABB), I (female flower full bloom; 25 DABB), J (fruit set; 28 DABB) and K (fruit development; 34 DABB)

Inflorescence Development and Fruit Set Under Summer Rainfall Conditions

The rubber inflorescence development stages were shown in Figure 2. Stage A (day 0) was the day on which the flower buds started appearing at the terminal of the shoot. Stage B (day 3): was the day the inflorescence and leaf emerged from the bud. Development then continued passing from stages C to D on day 7 and continued to stage E on day 16 when the inflorescence reached full maturity. Stage F was reached on day 20, which was the day on which male flowers matured and they then bloomed on day 22 (stage G). Stage H on day 23 was the day on which the female flowers matured and they then bloomed on day 25 (stage I), Stages J and K were the stages in which the fruit set (day 28) and was fully developed (day 34), respectively. Overall, the total duration of the development stages from bud burst (A) to fruit development (K) was 34 days (Figure 2).

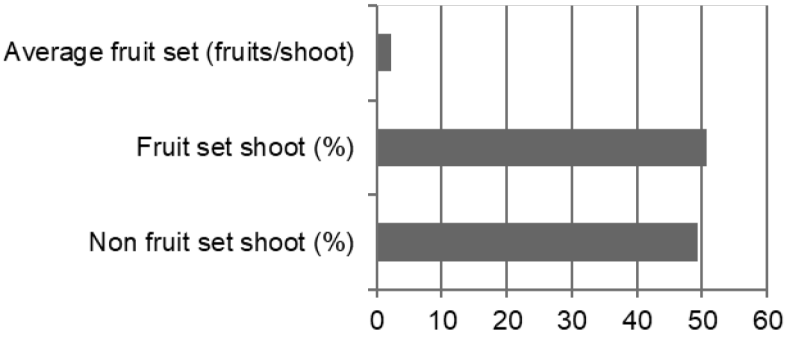

Figure 3 Severe impact of summer rainfall on rubber fruit-set in 2012 in Songkhla province

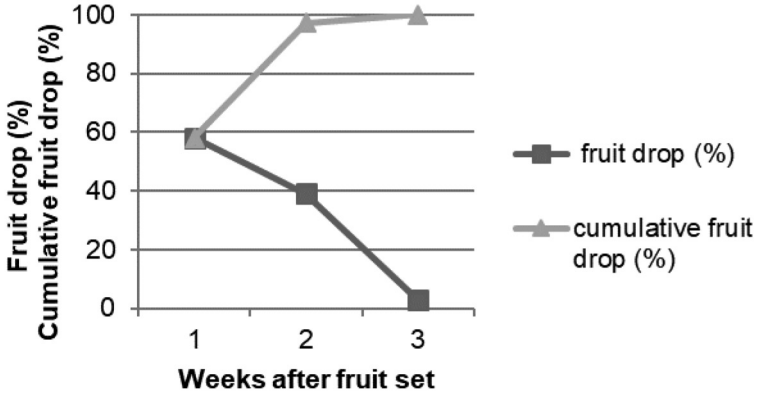

Figure 4 Percentage fruit-drop of rubber under summer rainfall conditions in 2012

The Effect of Summer Rainfall on Rubber Fruit-Set

The weather had a strong influence on fruit set. In this study, it was found that poor fruit-set might be related to heavy rainfall during the period when the inflorescences expand and bloom. During the flowering period in March 2011, there were 17 days of rainfall with a monthly rainfall of 287.7 mm and as a result no fruit set (data not shown). Poor fruit set was also observed in 2012 with fruit setting on 50.72% of the flowering shoots but no fruit setting on 49.28% (Figure 3). The average number of fruits per flowering shoot was 2.18. All of these fruits dropped within three weeks after fruit set, most of them in the first (58.11%) and second (39.19%) weeks (Figure 4). Severe fruit drop during the initial 3–4 weeks growth period after anthesis causes relatively low fruit productivity in many fruit crops (Roemer *et al*., 2011). Low fruit set in rubber trees during summer rain might have mainly resulted from an outbreak of *Oidium* secondary leaf fall disease on leaves and inflorescences (Figure 5). *Oidium heveae* is a fungal infection which destroys leaves and inflorescences and also newly fertilized fruits which finally drop (Figure 6), and this leads to low seed production. High amounts of rainfall occurring during the summer period can lead to outbreaks of leaf diseases, particularly powdery mildew disease (Ruangsri *et al*., 2015). Jat and

Goyal (2009) reported that severe powdery mildew infection on fruits of ber (*Ziziphus mauritiana* Lam.) is a major problem in India which causes significant loss of productivity and reduces the quality of fruit, particularly of mango. (Nasir *et al*., 2014). However, there are numerous causes of post-bloom fruit drop or premature fruit abscission, including lack of pollination and/or pollen germination, poor pollen tube growth, failure of fertilization, biotic stress (pest injury and disease damage) and endogenous hormonal status (Pozo, 2001; Roemer *et al*., 2011; Silva-Jr. *et al*., 2014; Garner and Lovatt, 2016). Therefore, more observations over more years in multiple sites will provide more valuable data for drawing a solid conclusion.

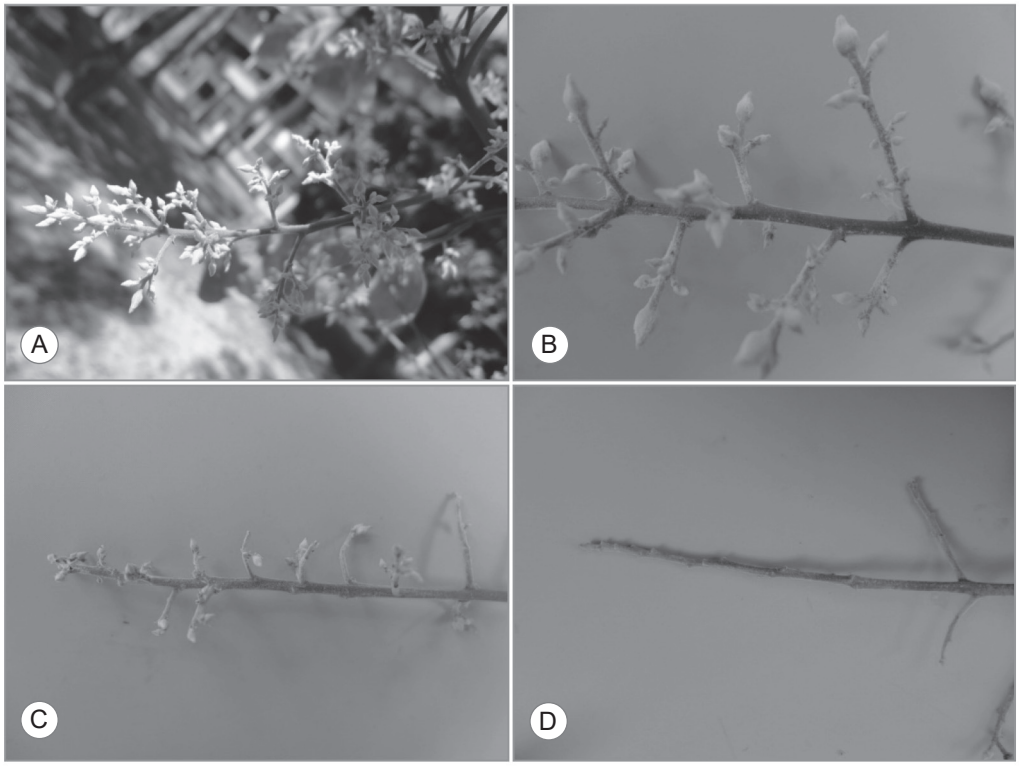

Figure 5 General aspect of the rubber inflorescence destroyed by *Oidium heveae* (whitish areas); The symptoms begin with a superficial white powdery growth on the inflorescence (A), 5 days later symptoms showing the presence of fungal mycelium with more obvious infestation (more white powder) on the surface of the inflorescence (B), inflorescence wilting and partly falling off the flower cluster 3 days later (C), shows severe flower cluster fall at 11 days after the commencement (D)

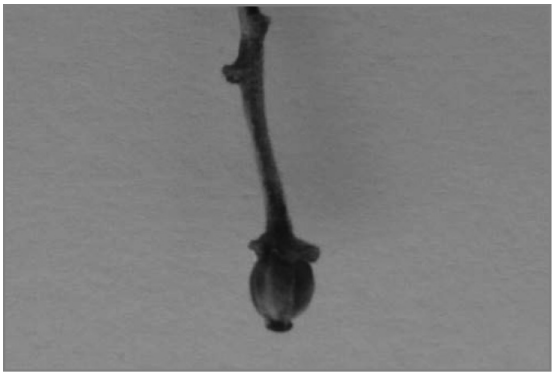

Figure 6 A young developing rubber fruit destroyed by *Oidium heveae.* The fruit wilts and its color changes to brownish and it finally drop

CONCLUSION

Anomalous summer rainfall in Songkhla province in southern Thailand has been a recent feature of the local climate with rainfall tending to increase most obviously in March. The 40-year average rainfall in March, the 8-year average, and the rainfall in March of the years 2011 and 2012 were 58.0 mm, 125.6 mm, 287.7 mm and 176.8 mm, respectively, and the 8-year average March rainfall increased 116.55% over the 40-year average, with the 2011 and 2012 March rainfall increasing 396.03% and 204.83%, respectively. Poor fruit set might be related to heavy rainfall during the period when inflorescences expand and bloom. The destruction of the leaf, inflorescences and developing fruit of rubber trees was due to an outbreak of secondary leaf fall disease, caused by the fungus, *Oidium heveae,* which occurred due to summer rain during the rubber tree flowering period. It was found that under summer rain conditions, only around 50% of the flowering shoots set fruit. The average number of fruit per flowering shoot was 2.18 and they all dropped within three weeks, 58.11% in the first week and 39.19%, in the second week. The results obtained are useful in the development of techniques to improve rubber seed production in commercial rubber plantations.

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REFERENCES

Australian Climate Change Science Program. 2012. Climate Change in Australia. Available Source: http://www.climatechangeinaustralia. gov.au/pastchange.php, June 28, 2012.

Garner, L.C. and C.J. Lovatt. 2016. Physiological factors affecting flower and fruit abscission of 'Hass' avocado. Sci. Hortic. 199: 32–40.

Goes, A., R.B.O. Garrido, R.F. Reis, R.B. Baldassari and M.A. Soares. 2008. Evaluation of fungicide applications to sweet orange at different flowering stages for control of post bloom fruit drop caused by *Colletotrichum acutatum*. Crop Prot. 27: 71–76.

IPCC. 2001a. Climate Change 2001: Synthesis report. Available Source: https://www.ess.uci.edu/researchgrp/prather/files/2001IPCC_SyR-Watson.pdf, July 7, 2016.

IPCC. 2001b. Climate Change 2001: The scientific basis. Available Source: https://www.ipcc.ch/ipccreports/tar/wg1/pdf/WG1_TAR-FRONT.PDF, July 7, 2016.

IPCC. 2007. Climate Change 2007: Working group II: Impacts, adaptation and vulnerability. Available Source: https://www.ipcc.ch/ publications_and_data/ar4/wg2/en/ch1s1-3-5-1.html, July 7, 2016.

Jat, R.G. and S.K. Goyal. 2009. Epidemiological studies on powdery mildew of ber, *Ziziphus mauritiana* Lamarck, pp. 439–445. *In*: Proceedings of the 1st International Jujube Symposium, Baoding, China, 21–25 September 2008.

Nasir, M., S.M. Mughal, T. Mukhtar and M.Z. Awan. 2014. Powdery mildew of mango: A review of ecology, biology, epidemiology and management. Crop Prot. 64: 19–26.

Pozo, L.V. 2001. Endogenous hormonal status in citrus flowers and fruitlets: relationship with postbloom fruit drop. Sci. Hortic. 91: 251–260.

Roemer, M.G., M. Hegele and J.N. Wünsche. 2011. Possible physiological mechanisms of premature fruit drop in mango (*Mangifera indica* L.) in northern Vietnam, pp. 999–1006. *In:* Proceedings of the IXth International Symposium on Integrating canopy, Rootstock and Environmental Physiology in Orchard Systems Volume 2, USA, 4–8 August 2008.

Ruangsri, K., K. Makkaew and S. Sdoodee. 2015. The impact of rainfall fluctuation on tapping days and rubber productivity in Songkhla province. IJAT. 11(1): 181–191.

Rubber Research Institute of Thailand. 2012. Para rubber plantation statistics in Thailand. Available Source: http://124.109.2.78/statistic/ stat_index.htm, June 26, 2012.

Silva-Junior, G.J., M.B. Spósito, D.R. Marin and L. Amorim, 2014. Efficacy and timing of application of fungicides for control of citrus postbloom fruit drop. Crop Prot. 59: 51–56.

Webster, C.C. and W.J. Baulkwill. 1989. Rubber. New York: Longman Scientific & Technical, John Wiley & Son, Inc.

Wikipedia. 2012. Global warming. Available Source: http://en.wikipedia.org /wiki/Global_warming, June 28, 2012.

Yeang, H.Y. 2007. Synchronous flowering of the rubber tree (*Hevea brasiliensis*) induced by high solar radiation intensity. New Phytol. 175: 283–289.