ORIGINAL ARTICLE

Assessment of the effect of water deficit on sap flow of longkong trees by using heat-pulse method

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Abstract

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The effect of water deficit on sap flow of longkong trees was studied by using heat-pulse method. An experiment was carried out in a glasshouse over 30-day period. There were 3 treatments: 1) daily watering or control, 2) 5-day interval watering or moderate water deficit (MWD) and 3) 10-day interval watering or high water deficit (HWD) with 4 replications. Twelve longkong trees (3-year old) were used. Each tree was grown in a 30L polybag filled with soil mixture. It was found that leaf water potential, stomatal conductance and Fv/Fm (at 10 day interval) in the MWD and HWD continuously decreased through the experimental period, and they were significantly different from those of the control at the end of the experimental period. Sap flow in the MWD and HWD treatments were consistently low around day 16 and day 13 after starting the experiment. Concomitantly, stomatal conductance of HWD rapidly decreased from day 10, and it was significantly different from those in MWD and control treatments. This implies that water deficit caused stomatal closure leading to the reduction of transpiration. Hence, it appears that water deficit causes the decrease of sap flow in longkong tree, and this incidence depends on the severity of water deficit.

Key words : heat-pulse method, longkong, sap flow, water deficit, leaf water potential, stomatal conductance

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บทคัดย่อ

สายัณห์ สดุดี และ นารี ว่องวงศ์อารี
การประเมินผลของสภาวะขาดน้ำที่มีต่อการไหลของน้ำในต้นลองกองโดยใช้วิธีพัลส์ความร้อน
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ได้ศึกษาผลของสภาวะขาดน้ำที่มีต่อการไหลของน้ำในต้นลองกอง โดยใช้วิธีพัลส์ความร้อน การทดลองทำในสภาพเรือนกระจกเป็นเวลา 30 วัน มี 3 วิธีการ คือ 1) ให้น้ำทุกวันหรือควบคุม 2) ให้น้ำทุกช่วง 5 วันหรือ สภาวะขาดน้ำปานกลาง (MWD) และ 3) ให้น้ำทุกช่วง 10 วัน หรือสภาวะขาดน้ำรุนแรง (HWD) ทำ 4 ซ้ำ ใช้ต้นลองกองอายุ 3 ปี จำนวน 12 ต้น โดยแต่ละต้นปลูกในถุงพลาสติกขนาด 30 ลิตร ที่ใส่ดินผสม จากการวัดผลของค่าศักย์ของน้ำในใบ ค่าการชักนำปากใบและค่า Fv/Fm ทุกช่วง 10 วัน พบว่าค่าดังกล่าวในวิธีทดลอง MWD และ HWD มีค่าลดลงอย่างต่อเนื่อง และเมื่อสิ้นสุดการทดลองพบว่า มีค่าแตกต่างอย่างมีนัยสำคัญจากการทดลองที่ควบคุม การไหลของน้ำในวิธีทดลอง MWD และ HWD มีค่าลดลงในวันที่ 16 และ วันที่ 13 ตามลำดับ ค่าการไหลของน้ำลดลงเหล่านี้ต่อเนื่องไปจนสิ้นสุดการทดลอง ในทำนองเดียวกับค่าการชักนำปากใบของวิธีทดลอง HWD มีค่าลดลงอย่างรวดเร็วคือ วันที่ 10 ของการทดลองมีค่าแตกต่างอย่างมีนัยสำคัญจากค่าที่วัดได้ในวิธีทดลอง MWD และควบคุม ผลดังกล่าวแสดงว่า สภาวะขาดน้ำมีผลทำให้ปากใบพืชปิดแล้วส่งผลให้การคายน้ำของพืชลดลง ดังนั้นสภาวะขาดน้ำจึงมีผลทำให้การไหลของน้ำในต้นลองกองลดลงและปรากฏการณ์นี้ขึ้นกับความรุนแรงของสภาวะขาดน้ำด้วย

ภาควิชาพืชศาสตร์ คณะทรัพยากรธรรมชาติ มหาวิทยาลัยสงขลานครินทร์ อำเภอหาดใหญ่ จังหวัดสงขลา 90112

Southern Thailand is currently the major producing area of longkong (*Aglaia dookkoo* Giff). However, fluctuation of rainfall during 1996-1999 affected on phenological development (Sdoodee, 2000). Under drought condition, inefficient irrigation is a limiting factor leading to poor growth and low fruit yield. Therefore, the response of longkong trees to water deficit needed to be investigated. Sdoodee and Singhabumrung (1996) reported that longkong trees are sensitive to water deficit, leaf water potential and stomatal conductance decrease during the progress of water deficit. This indicates that transpiration of the water-stressed tree is limited. Alarcon *et al*. (2000) suggested that tree transpiration can be estimated with direct measurement of sap flow within the plant stem. Recently, heat-balance (Lu, 1997; Lu *et al*., 1995) and heat-pulse (Alarcon *et al*., 2000; Cohen *et al*., 2001) techniques have been widely adopted as convenient and reliable methods to estimate the sap flow of plants. Sdoodee *et al*. (2000) also reported that the heat-pulse method is suitable for sap flow measurement in the longkong tree. Hence, the purpose of this work was to estimate sap flow of the longkong tree subjected to water deficit condition by using the heat-pulse method.

Materials and Method

An experiment was conducted in a glasshouse at the Faculty of Natural Resources, Prince of Songkla University, Songkhla. The investigation was conducted over a 30-day period between June 24 (DOY or day of the year 176) and July 24 (DOY 206) 2000. Twelve longkong trees aged 3-year old, about 1.50 m high and 0.75 m wide at the base of the canopy, and 1.5 cm stem diameter were grown in 30L polybag containing soil mixture at the ratio 1 clay loam: 3 sand: 1 compost. One tree was grown in each polybag, then the 12 polybags were arranged in the glasshouse in a completely randomized design manner. There were 3 treatments, daily watering or control, 5-day interval watering or moderate water deficit (MWD), and 10-day interval watering or high water deficit (HWD). Each treatment was replicated 4 times. One day before the experiment, all trees were watered at 80% of field capacity. During the experimental period, rewatering in each treatment was also maintained at 80% of field capacity. Air temperature inside the glasshouse during the experimental period was around 33 °C during the daytime and fell to about 23 °C at night.

Measurement of soil moisture

Changes of soil moisture during the experimental period were monitored by using Theta Probes type ML2, Delta-T Devices Ltd, UK. The Theta Probes were inserted at 20 cm depth from soil surface, then the data were continuously recorded by a datalogger.

Measurement of sap flow in the trunk

Sap flow was monitored routinely in the trunk of two trees in each treatment. Heat-pulse sapflow sensors (Greenspan Technology, Australia) used in sap flow measurement were miniprobes or SF200, as shown in Figure 1. They were installed into holes drilled into the trunk at the height of 0.3 m above the soil surface. Data were recorded by a datalogger, then sap flow was calculated using SAPCAL software (Anonymous, 1992).

Figure 1. Implanting the SF200 probe in the stem of longkong tree

Estimation of transpiration

The diurnal course of transpiration was measured in each plant. Each polybag was placed on top of an electrical balance (AND JG-30K). The soil surface of each polybag was covered with plastic to eliminate soil evaporation. Gravimetric transpiration measurements were synchronized with sap flow measurements, then the relationship between gravimetric transpiration and sap flow of all treatments during 2-15 July 2000 was analyzed.

Measurement of the physiological responses of longkong trees

Leaf stomatal conductance, leaf water potential, and chlorophyll fluorescence were measured during mid-day at 10-day intervals through the experimental period. All measurements were done in young fully expanding leaves of each plant. Leaf stomatal conductance was measured on the abaxial surface of sun-exposed leaves using a porometer AP4 (Delta-T Device Ltd., UK). Then, leaf water potential was measured on the leaves using a pressure chamber (Sdoodee and Singhabumrung, 1996).

Chlorophyll fluorescence was measured using a plant efficiency analyzer or PEA (Hansatech Instrument Ltd., UK). The leaf was attached by a leaf clip, and it was left in the dark for 30 minutes. Then, the clip and sensor unit were held together for the measurement.

Results and Discussion

The changes of water content at 20 cm soil depth in each treatment are illustrated in Figure 2. Rewatering of the stressed plants in MWD and HWD treatments ensured that similar amounts of water were supplied as the stress period progressed. In Figure 3, it is prominent that sap flow in the MWD and HWD treatment decreased, and their diurnal courses of sap flow were consistently low around day 16 and day 13 after starting the experiment, respectively. This indicates that plant water uptake in both water stressed treatments was limited. Concomitantly, the longkong trees subjected to the MWD and HWD treatments ex-

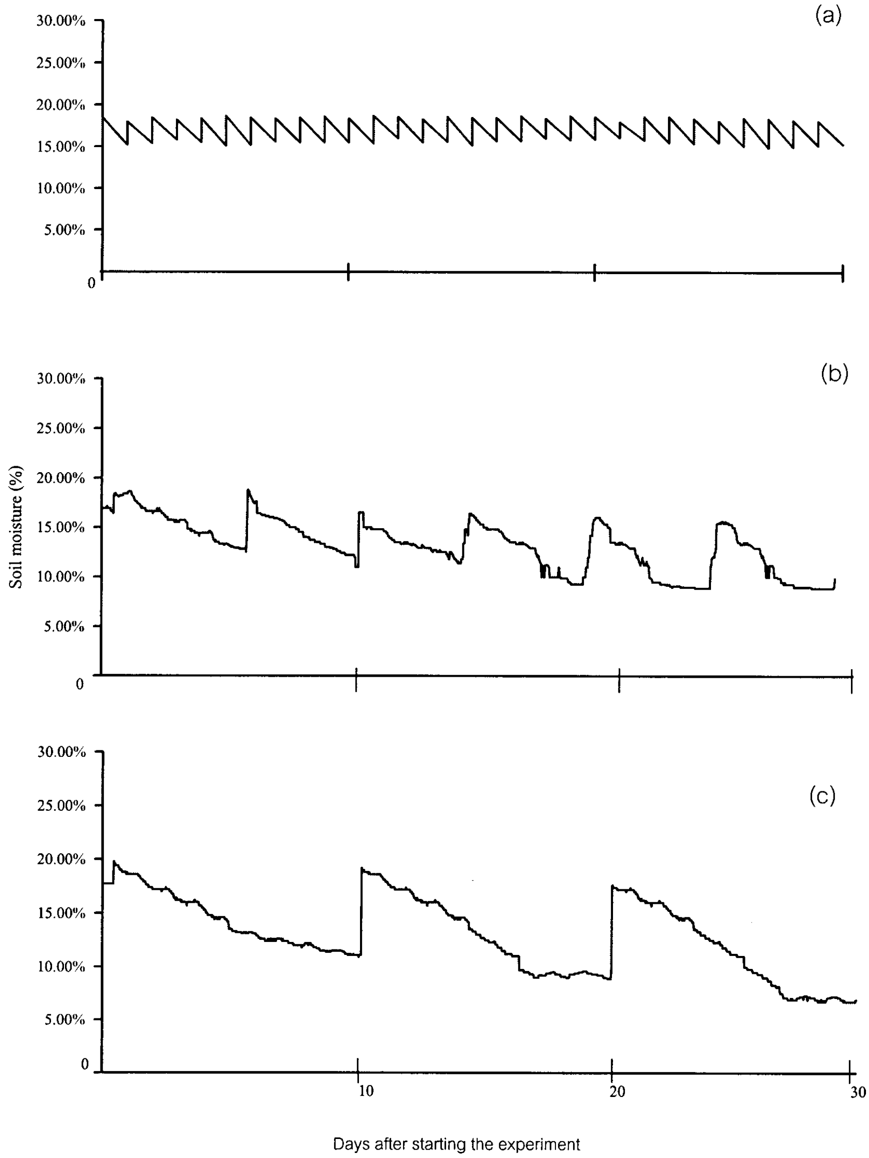

Figure 2. Changes in soil moisture during the experimental period in the control (a), MWD (b) and HWD (c) treatments.

hibited rapid decreases of leaf water potentials with time after the imposition of water deficit (Figure 4a). The leaf water potentials in the HWD treatment were lowest from day 5 to the end of the experimental period, followed by those in the MWD treatment. On day 30, the leaf water potentials of MWD and HWD treatments dropped around -3.8 and -4.4 MPa, respectively, which were significantly different from the control treatment that remained high around -1.5 MPa. It was remarkable that the water-deficited plants also exhibited high response in stomatal closure during the midday (Figure 4b). In the MWD and HWD treatments, significant decreases of stomatal conductance were found on day 10 until the end of the experimental period. This indicates that stomatal closure is an adaptive mechanism of longkong to water deficit as reported by Sdoodee and Sing-

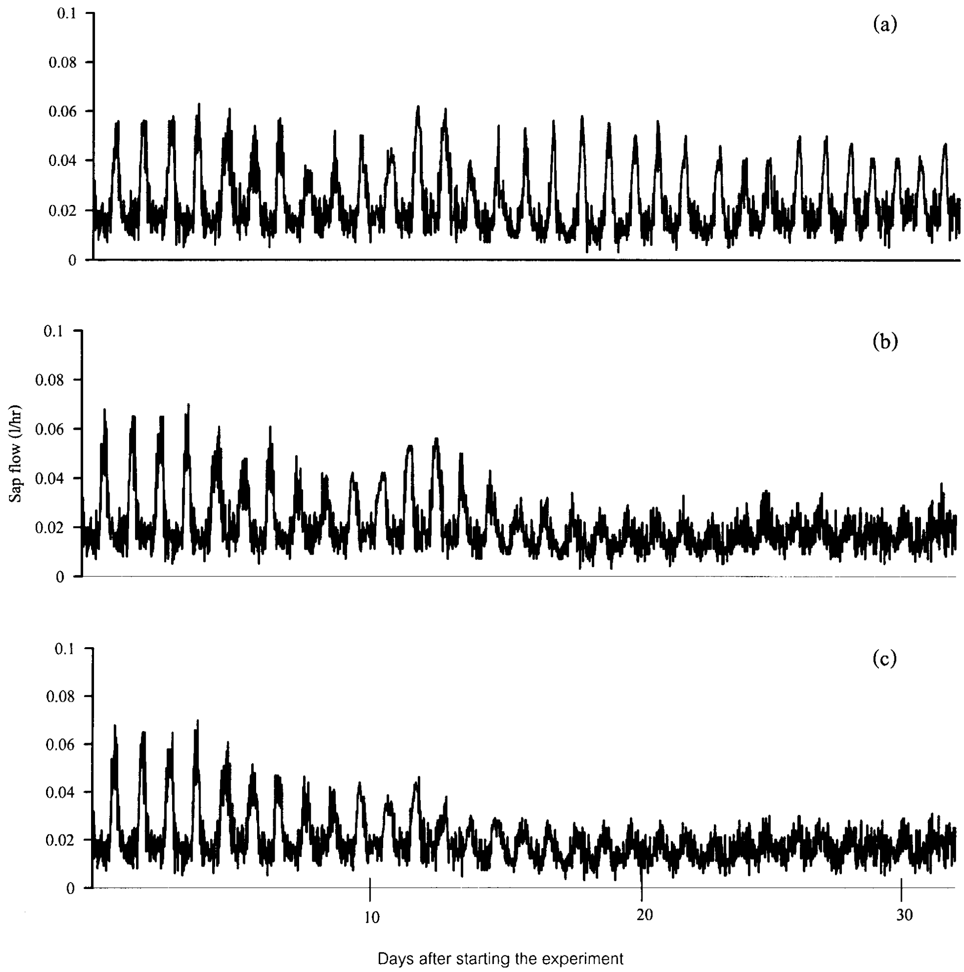

Figure 3. Changes of sap flow during the experimental period in the control (a), MWD (b) and HWD (c) treatments.

habumrung (1996). This led to the decreases of sap flow in MWD and HWD on day 16 and 13, respectively. This implies that transpiration of the plants in MWD and HWD was limited by the decreased stomatal conductance (Lu *et al.*, 1995).

The ratio of variable fluorescence to maximal fluorescence (Fv/Fm) in the MWD and HWD treatments declined to the end of the experimental period, and they were significantly different from that of the control treatment (Figure 4c). The results indicate that chlorophyll fluorescence provided a rapid and sensitive examination of the effect of water stress on photosynthetic apparatus (Thomas and Mickelbart, 1998). Björkman and Powles (1984) suggested that a severe inhibition of photosynthesis by water stress may proceed any appreciable change in fluorescence.

Figure 5 shows that there is a significant correlationship between gravimetric water loss of the container-grown trees and daily sap flow. The slope of sap flow and gravimetric water loss was 1.02. This illustrates that measurement of sap flow in longkong by using heat-pulse method is reliable even in water deficit condition. Similarly, the measurement of sap flow in droughted apricot trees was done using heat-pulse method by Alarcon *et al.* (2000), who reported that sap flow was correlated with actual transpiration. Nadezh-

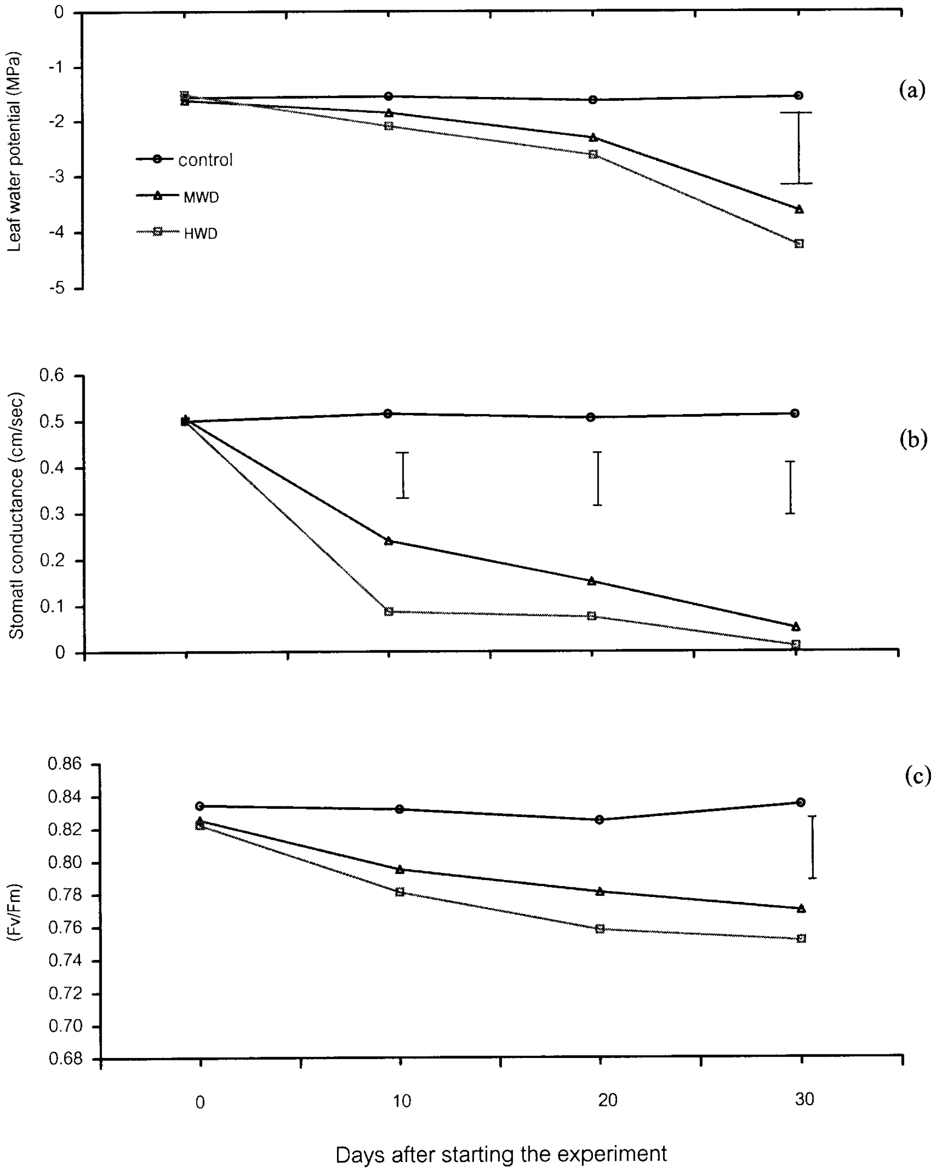

Figure 4. Changes of leaf water potential (a), stomatal conductance (b) and Fv/Fm (c) in the control (-⊖-), MWD (-▲-) and HWD (-⊟-) treatments. (Vertical bars indicate LSD.05)

dina (1999) also suggested that sap flow index is a sensitive indicator and it is closely related to the other parameters of plant water status. This aspect should be studied further in other tropical fruits. Then, it can be used to assess the seasonal development of plant drought stress and can be used to estimate plant water status.

Conclusion

Water deficit caused a decrease of sap flow in longkong stem with the magnitude depending on the amount of water deficit. Therefore, change of sap flow can be used as an indicator of physiological response of longkong trees to water deficit.

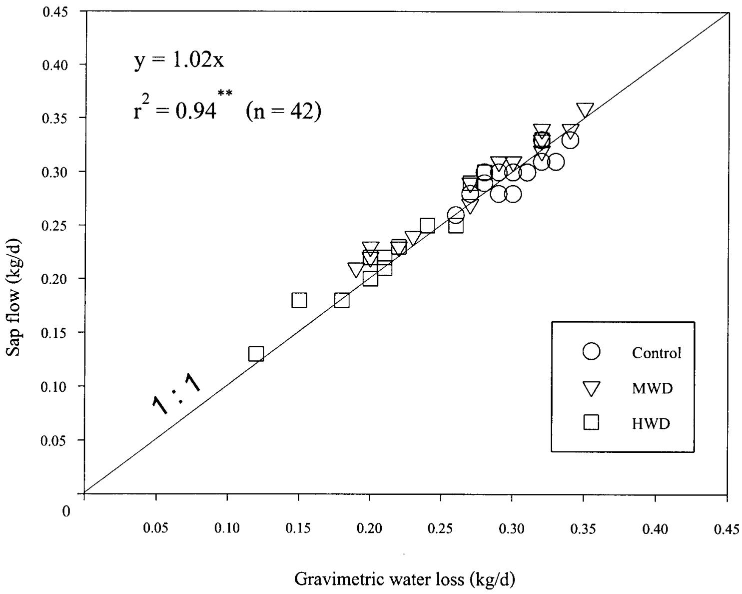

Figure 5. Comparison of daily sap flow and gravimetric water loss of the container-grown trees in three treatments (control, MWD and HWD) during 2-15 July 2000. The slope of sap flow and gravimetric loss was 1.02 as the regression line passes through the origin.

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