Effect of water stress on mango flowering in low latitude tropics of Northern Australia

Article *in* Acta Horticulturae · February 2000

DOI: 10.17660/ActaHortic.2000.509.31

Ping Lu
Energy Resources of Australia

EFFECT OF WATER STRESS ON MANGO FLOWERING IN LOW LATITUDE TROPICS OF NORTHERN AUSTRALIA

Lu, P. and Chacko[†], E.K.
CSIRO Plant Industry
Darwin Laboratory
PMB 44, Winnellie, NT 0822, Australia
e-mail: Ping.lu@pi.csiro.au

[†] Deceased 21 August 1997

Additional index words: soil water deficit, temperature, *Mangifera indica* L.

Abstract

In the sub-tropics, night temperatures of 15ºC or lower induce mango floral morphogenesis whereas temperatures of about 20ºC or higher promote vegetative growth. In the tropics where temperatures may remain too high for induction of flowering by cool nights, a dry period preceding flowering is generally believed to be necessary for reliable mango flowering. However, the effect of the soil water deficit on flowering response is still a matter of controversy. Our studies, for the first time, examined the effect of soil water stress on flowering in mango trees grown under quasi-natural conditions (in open-air and in 200-litre drums) in the low latitude tropics. Controlled soil water deficit lasting 5 weeks was demonstrated to promote earlier and more intense flowering in mango trees of both 'Kensington' and 'Irwin' cultivars. Final fruit yield was also higher in water-stressed trees. Environment *x* genotype effects on mango flowering were also discussed.

1. Introduction

It is well documented that in sub-tropics, temperature of 15ºC or lower induces mango floral morphogenesis whereas temperature of about 20ºC or higher promote vegetative growth (Davenport and Nunez-Elisea, 1997). In the tropics where temperatures may remain too high for induction of flowering by cool nights, a dry period preceding flowering is generally believed to be necessary for reliable mango flowering (Chacko, 1986). However, effect of the plant water stress on flowering response is still a matter of controversy. Under glass house conditions drought failed to promote flowering in containerized mango trees (e.g. Nunez-Elisea and Davenport, 1994). In contrast, more intense flowering in mango trees following extended drought period was observed in tropics (Ian Bally and Tony Whiley, personal communication). The containers used in Davenport and Nunez-Elisea's experiment were 12 L which could be too small and the soil dried out too quickly, making it impossible to maintain an adequate soil water stress over an extended period as occurred in field. Whereas for the experiment of Bally and Whiley carried out in north Queensland (high latitude tropics), periods of low temperature could have interfered with the flowering result.

This study, for the first time, examined the effect of soil water stress on flowering in mango trees grown under quasi-natural conditions (in open-air and in 200-litre drums) in the low-latitude Australian tropics.

2. Materials and Methods

Experiment was conducted at the CSIRO orchard in Darwin, Australia (12^{o}25'S, 130^{o}52'E) in 1996. Experimental tress were 4.5-year-old, mango trees of cvs. 'Irwin', 'Kensington' and 'Nam Dok Mai' grafted onto 'Kensington' rootstocks. They had been grown outdoors in 200-liter drums (57 x 84 cm, DxH) for 2.5 years prior to this study.

All experimental trees were well watered daily till 9 May 1996, from then they were exposed to two treatments: soil water stressed (six trees each of cvs. 'Kensington' and 'Irwin', referred to as KD and ID, respectively) and well-watered control (4 trees of 'Kensington' and 5 trees of 'Irwin', referred to as KC and IC, respectively). As a comparison, four well-watered 'Nam Dok Mai' (referred as to NC) were also studied. To mimic the natural occurrence of the soil water deficit, trees under the water-stress treatment were progressively stressed and subsequently exposed to a pre-set soil water deficit for about two months by supplying a reduced amount of water every night to the drums. For the control trees, soil moisture in the drums was maintained at field capacity by daily irrigation (10-12 liters per tree). To control the level of soil water deficit, volumetric soil water content was continuously monitored in six drums of the water-stress treatment (3 each of the 'Kensington' and 'Irwin') using EnviroSCAN Soil Moisture Probes (Sentek Pty. Ltd., Australia) at 5 depths (10, 30, 40, 50 and 70 cm). No soil moisture was measured for the control trees.

Phenological observation was conducted on all terminal shoots of each experimental tree. At the time of the initiation of the water-stress treatment, no swollen buds were observed on all experimental trees. Flushes of all 'Irwin' trees were ½ or fully mature but on 'Kensington' trees only 95% of flushes were ½ or fully mature. No new flushes were observed on 'Irwin' trees, but 5% of the shoots on 'Kensington' trees were flushing. For 'Nam Dok Mai' trees, all shoots were fully mature and no new flushes were observed.

3. Results and Discussion

3.1. Weather and soil moisture conditions

The weather conditions at the experimental site from late wet season (March 1996) to end of September 1996 (fruits were of marble size) were presented in figure 1. Last rainfall occurred at the mid-April. Daily minimum air temperatures were always above 15^{o}C prior the peak flowering (early July). Minimum temperatures on rare occasion dropped below 18^{o}C. During May and June, the maximum temperatures were constantly above 32^{o}C and the daily mean temperatures were above 24^{o}C.

Prior to the initiation of the treatments, all trees were fully watered to field capacity, volumetric soil water content (%) was high (> 20% in the soil at depths below 30 cm and

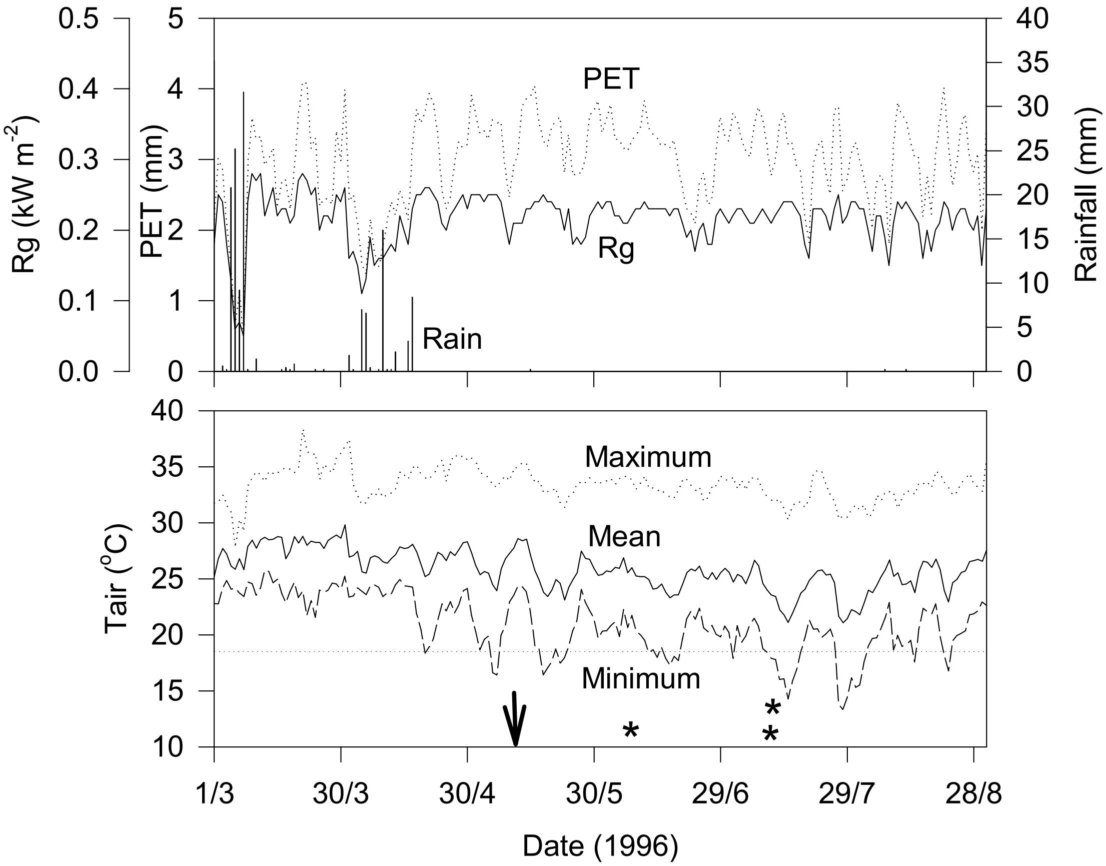

Figure 1. Weather conditions (PET: Potential evapotranspiration, Rg: global radiation, Rainfall, and Tair: air temperature) from late wet season to middle of dry season in 1996. Arrow indicates the date when irrigation was withheld and stars indicate the time of first flowering and peak flowering.

>15% at depths above 30 cm, Figure 2A). It was assumed that soil water conditions for the control trees were maintained at this level over the whole study period. After the withholding of the irrigation on 9 May, volumetric soil water content decreased quickly to an average of 10% (about 20% of extractable soil water content) and was then maintained at that level for about 2 months (Figures 2BC) by receiving small quantity of water regularly. During the period of stress, soil moisture varied only in the layer of soil of the first 30 cm (Figure 2A) while in the deeper layers, moisture level was kept constantly low (about 10%, v/v). Upon the full rewatering at mid-July, soil moisture recovered almost fully to the pre-stress level.

3.2. Flowering and fruiting

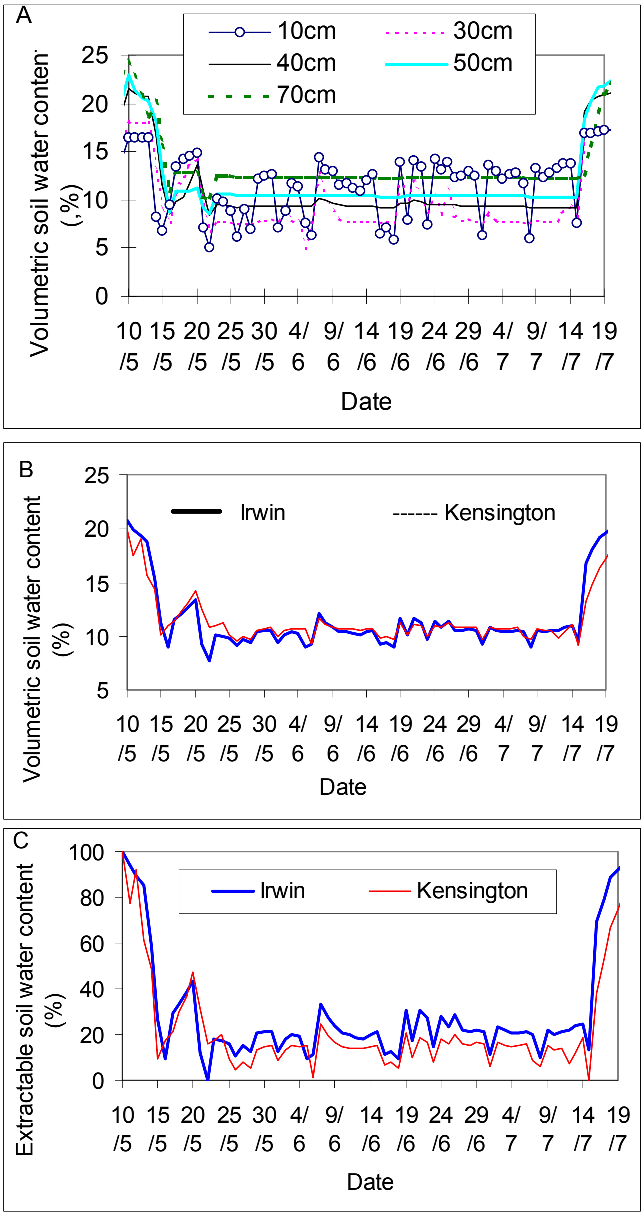

Figure 2. Soil moisture conditions of water-stressed trees. A) volumetric water contents at 10, 30, 40, 50 and 70 cm depths, B) average volumetric water content, and C) average extractable soil water content.

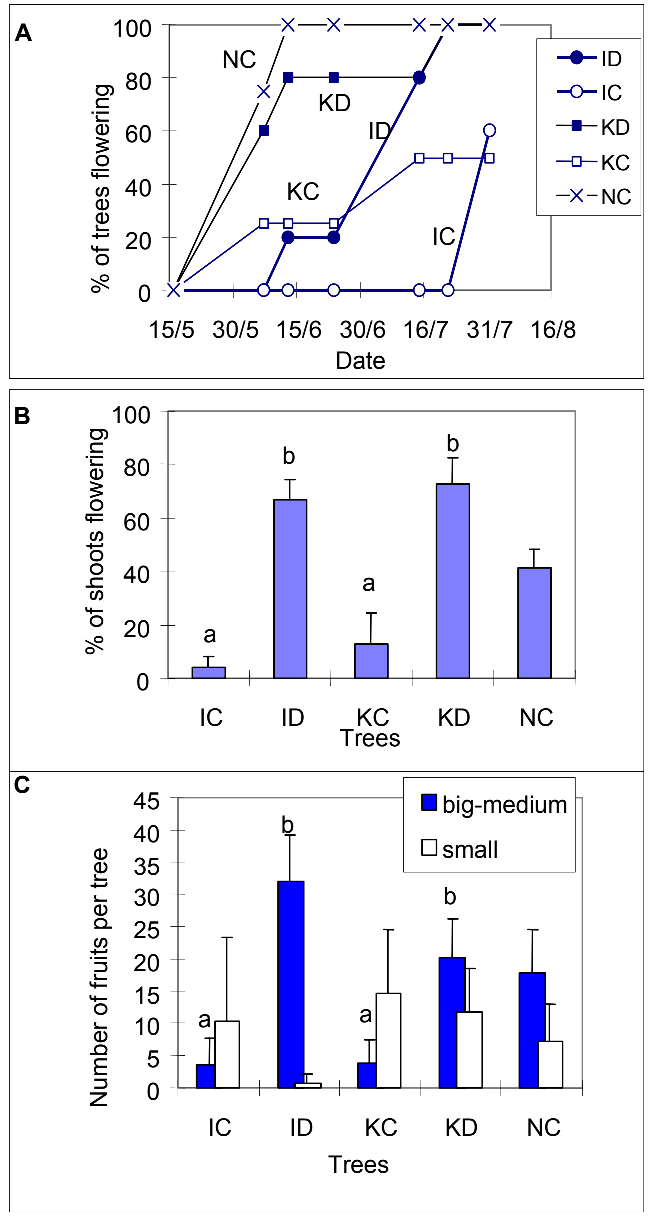

Figure 3. Effects of soil water stress on A) mango flowering time, B) flowering intensity, and C) number of fruits per tree. Different letters for the same cultivars indicate significant difference ($p<0.05$) between treatments

On 15 May, five days after the withholding of the irrigation, new flushes, of about 5 cm long in KD trees, became apparently permanently wilted. Four weeks after the start of the deficit irrigation, flowering was observed in all treatments except for IC trees (Figure 3A). At mid-June, 80% of KD trees flowered while only about 20% of KC and ID trees flowered. At that time, all well-watered 'Nam Dok Mai' (NC) trees flowered. Water-stressed 'Irwin' trees flowered more than one month earlier than well-watered ones. Re-watering of stressed trees on 15 July seemed to have "pushed" the burst of flower buds. On 22 July (one week after rewatering), all KD, ID and NC trees flowered. IC trees did not initiate inflorescence until 1 August. It is not clear whether the flowering of IC trees was related to spells of low night temperatures in late July (Figure 1). Observation made at the end of the flowering season showed that all water-stressed trees flowered. In contrast, two of the four KC trees and two of the five IC failed to flower in spite of spells of low temperatures. As commonly observed in Darwin area 'Irwin' trees flowered later than 'Kensington' trees. All well-watered 'Nam Dok Mai' trees flowered as early as KD trees and well before KC and 'Irwin' trees (Figure 3A).

Flowering intensity of each flowered tree (% of shoots flowering) was significantly higher on water-stressed trees than on non-stressed ones (Figure 3B). 67% of shoots flowered in ID trees while only 4% of shoots flowered in IC trees. Similarly 72% of shoots of KD trees flowered and only 13% of shoots flowered in KC trees. Well-watered 'Nam Doc Mai' (NC) trees had 41% of shoots flowered. Number of marketable fruits (big and medium size) per flowered tree of 'Irwin' and 'Kensington', was also significantly higher in water-stressed trees than well-watered ones (Figure 3C).

3.3. Cool temperatures or water stress ?

Peak flowering of stressed 'Kensington' trees occurred when the cumulative hours at less 18°C was only 20 (Figure 4), and well before occurrence of inductive temperature (<15°C). Four out of nine well-watered 'Kensington' and "Irwin" trees failed to flower in 1996, suggested that marginally cool night temperature occurred in low latitude tropical areas, such as Darwin, might not be a sufficiently strong flower promoter. In spite of the small number of trees studied, this experiment, conducted in the low altitude tropics, clearly demonstrated that water stress did promote early and intense flowering in

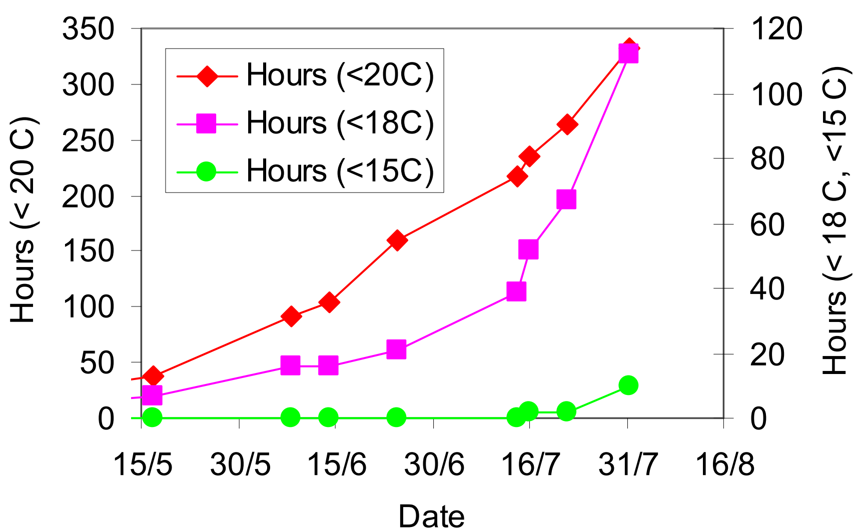

Figure 4. Cumulative hours with temperatures below 20, 18 and 15°C since 1 April (late wet season).

‘Kensington’ and ‘Irwin’ mango trees.

Although the mechanism of mango floral induction in warm environments still remains elusive (Davenport and Nunez-Elisea, 1997), most mango trees (e.g. Kensington and Irwin) flower only when their leaves are fully mature (Nam Dok Mai is an exception). It has been demonstrated that the floral stimulus originates from mature leaves in mango and young leaves inhibit the floral initiation of buds (Kulkarni, 1988). It is possible that water stress restricts the growth of new leaves and increases the proportion of mature and inductive leaves and consequently makes the trees more receptive to the marginally inductive temperatures in the warm tropics (Nunez-Elisea and Davenport, 1994).

Results of the present experiment was further confirmed by an experiment on 7-year-old, field-grown ‘Kensington’ mango trees carried out near Darwin area by the Northern Territory Department of Primary Industry and Fishery (Y. Deczibalis and C. Wicks, unpublished). They found that flowering response was correlated with the intensity of the soil water deficit preceding flowering. Under warm weather and non-limiting soil water conditions trees maintained high vegetative growth, while water stress was found to check the growth (branch diameter) and to predispose the tree to weaken floral stimulus (Figure 5).

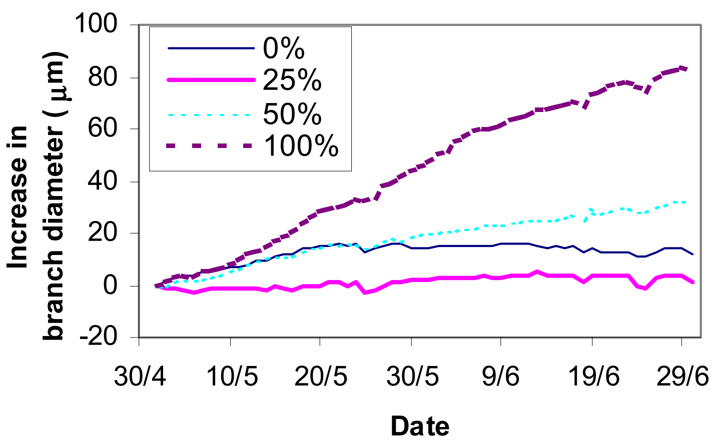

Figure 5. Pre-flowering soil water deficit checked growth of branches of ‘Kensington’ mango trees (7.5-Y-O). Trees under irrigation at 100% of evaporation replacement maintained high growth rate. Trees under 50%, 25% and 0% of evaporation replacement showed very low or no growth (P. Lu, Y. Diczbalis and C. Wicks, unpublished).

Three cultivars examined in present study exhibited different sensitivity to environmental signals. ‘Nam Dok Mai’, as frequently observed in Darwin areas to flower even during wet season (Lu, personal observation), seemed not to need strong floral stimulus such as low temperature or water stress despite that for ‘Nam Dok Mai’ grown in the central plains of Thailand, low night temperatures (below 16^{o}C) is believed to be critical for flower bud formation (Pongsomboon, 1991). ‘Irwin’, contrary to generally perceived as a cultivar without problem of flowering in Darwin area, seemed to need stronger signals (stress) than ‘Kensington’.

4. Acknowledgements

This research was supported by a grant from the Australian Center for International Agricultural Research (ACIAR Project 9012).

5. References

Chacko E.K. 1986. Physiology of vegetative and reproductive growth in mango (*Mangifera indica* L) trees. *Proceedings of the First Australian Mango Research Workshop*. Cairns, Qld., Australia, 26-30 November 1984, pp. 54-71, CSIRO, Melbourne, Australia.

Davenport T.L. and R. Nunez-Elisea, 1997. Reproductive physiology. In*: The mango: botany, production and uses* (Ed. R.E. Litz). CAB International, Oxon, pp69-146

Kulkarni V.J. 1988. Further studies on graft-induced off-season flowering in mango (Mangifera indica L.) J. Horticu. Sci., 63, 361-367.

Nunez-Elisea R. and Davenport T. L. 1994 Flowering of mango trees in containers as influenced by seasonal temperature and water stress. *Scientia Horticulturae*, 57-66.

Pongsomboon W. 1991. Effect of temperature and water stress on tree growth, flowering, fruit growth and retention of mango (Mangifera indica L.). Unpublished PhD thesis, kasetsart university, Bangkok, Thailand.