

Water management to induce early flowering and fruiting in *Lansium domesticum*

[Pengurusan air untuk mengaruh pembungaan dan pembuahan awal duku terengganu (*Lansium domesticum*)]

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Keywords: *duku terengganu* (*Lansium domesticum* Corr.), regulation of flowering, water stress, fruiting and yield

Abstract

A technique to induce early flowering and fruiting in *duku terengganu* (*Lansium domesticum* Corr.), using water management as a tool was developed. Three treatments were imposed, i.e. T1, T2 and T3. In T1 and T2, soil moisture content was monitored at the onset of the dry season until depleted to 7–10% and 10–15% (volumetric) respectively. This was followed by irrigation until soil moisture content of 25% was attained. In T3 (control), irrigation was not done until the trees bore fruits. Irrigation applied after soil moisture content was depleted to either T1 or T2 promoted earlier flowering and fruiting compared to the control plot T3. Anthesis date for T1 and T2 was significantly earlier by 27–28 days than T3. Commercial harvest was significantly earlier by 39–40 days for the regulated plot. Yield per tree was, however, not significantly different ($p > 0.05$) between treatments. However, with an ex-farm price of RM2.50/kg of fruits for the early season crop (T1 and T2) and RM 0.80/kg for the mid-season crop (T3), income generation was higher for T1 compared to T2 and T3. This technique can increase farm income and can be adopted effectively in areas with a distinct dry period by farmers with irrigation facilities.

Introduction

The phenomenon of price fluctuation especially for seasonal fruits is becoming a major problem lately, especially during glut years. The ex-farm price of *duku terengganu* (*Lansium domesticum*) ranged from RM2.80/kg during the early season to RM0.80/kg during the mid-season. Retail price ranged from as high as RM6.00/kg during the early season and declining to RM1.50/kg in mid-season. Hence, the production strategy

should be targeted for early season harvest to obtain the advantage of a higher price.

Water stress is a major environmental factor implicated in floral initiation in plants (Grierson et al. 1982.) Water stress during summer induced flower formation in certain lemon cultivars (Monselise and Halevy 1964). Nakata and Suehisa (1969) showed that soil moisture potentials of -1.50 MPa inhibited leaf flushing and promoted flowering in 'Tai So' litchi in Hawaii.

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Studies by Nir et al. (1972) had shown that flower differentiation occurred during the stress period and generative buds formed did not undergo flower development until water was applied.

Kamariah (2001) indicated that flower inflorescences (spikes) of *L. domesticum* which were originally short, brownish and scaly became swollen, and started to elongate 10–15 days after irrigation following water stress of 4–6 weeks. Similarly, the onset of flowering usually occurred during the drought months for durian (Masri 1999). However, insufficient water supply for a continuous period failed to stimulate trees to produce more flowers (Masri 1999), while moderate irrigation after 4 weeks of drought could substantially increase fruit yield of durian and mangosteen (Masri 2003). These results indicated that sufficient moisture was important for the development of flowers in many tropical fruit species.

This information can be used to regulate flowering and fruiting using irrigation as a tool, especially in areas with long and distinct dry season. Once the level of water stress needed to induce flowering is achieved, the next strategy is to relieve the stress and provide enough moisture to enhance flower development. Under non-irrigated conditions, flower development will presumably be delayed until enough moisture is accumulated from rain, thus causing a delay in the flowering. Hence, the longer the dry period, the greater is the impact of supplemental irrigation on flowering. This study was undertaken to quantify the effectiveness of irrigation as a tool to induce early flowering and fruiting of *L. domesticum*.

Materials and methods

Experimental plants

The plants used for the experiment were planted in 1968 at MARDI Research Station, Jerangau, Terengganu. The planting distance was 12 m x 12 m x 12 m (triangular) and the soil type was sandy clay loam.

Fertilization and agronomic practices were as recommended by MARDI (Norlia and Kamariah 1999). The canopy diameter of the trees ranged from 7–9 m with the plant height at about 10 m.

Treatments and experimental design

The experiment was conducted during the dry months of January, February and March 2004. Soil moisture content was monitored using the TDR soil moisture probe (IMKO, Germany) until soil moisture was depleted to either 7–10% on a volumetric basis (T1) or 10–15% (T2). Once the desired soil moisture depletion was achieved, the plants of T1 and T2 were irrigated 3 h daily for 6 consecutive days using two sprinkler heads per plant with a flow rate of 600 litres/h at 25 psi until the soil moisture level reached at least 25%. After the 6th day, maintenance irrigation was carried out on alternate days until maturity, but irrigation time was reduced to 1–1½ h per day. The control plots (T3) were not irrigated until the trees bore fruits under natural conditions. Irrigation schedule for T3 was started at early fruit development stage until maturity. Irrigation during this period reduced fruit-splitting in *L. domesticum* (Kamariah et al. 2006)

A completely randomized design (CRD) was used with 7, 8 and 6 observations for T1, T2 and T3 respectively. A more appropriate design for field experiments, the randomized complete block design (RCBD) was not used in this situation due to the difficulty in finding experimental trees with the desired moisture content at the same time within a specified block. Data were analysed using the SAS package with analysis of variance (ANOVA) and the differences between treatment means separated using Duncan Multiple Range Test.

Measurement of parameters

Soil moisture content was calculated as an average of two points taken from each tree within 2 m radius of the sprinkler head. A total of five branches of similar

size were tagged and inflorescences were counted manually over a meter length of the branches. Data were expressed as the number of inflorescences per meter of branch. Yield was taken on a tree basis. Income was calculated based on total yield per tree and the actual price of the fruits set by the local bidders.

Results and discussion

Soil moisture content

The soil moisture content of all treatment plots declined from 26–30% (volumetric) with the advancement of the drought period (Figure 1). The desired depletion in moisture content (T1: 7–10%; T2: 10–15%; T3: control) was attained where average moisture content was approximately 8.8% and 13.3% for T1 and T2 respectively, while that of the control plot was 10.8%. This moisture regime was accomplished after 6 weeks of drought. This was quite close to data obtained by Kamariah (2001), whereby after 6 weeks of induced drought, the soil moisture content dropped to 13% (volumetric) and this was sufficient to induce a reasonably good flowering and cropping of *L. domesticum*.

The 6-week dry period was interrupted by some rain. However rainfall intensity of

less than 5 mm in the middle of the drought season did not raise the moisture content of the soil. This was probably because this amount of rainfall was barely enough to replace the loss through evapo-transpiration which was about 8–10 mm/day.

Irrigation was carried out for 6 consecutive days for T1 and T2. This resulted in a sharp increase in soil moisture content in the T1 and T2 plots, from 8.8–26.0% and 13.3–28.0% respectively, while the control plot T3 increased slightly from 10.8–16.9% due to rain. After the 6th day, with maintenance irrigation for 1–1½ h/day, on alternate days, the soil moisture content for T1 and T2 plots were maintained above 25.0% while that of the control plots T3 fluctuated between 10–16% due to interruption by rain.

All T1 and T2 plants responded to the irrigation treatments in the middle of the dry season. The inflorescences which were spikes (Salma and Razali 1987) which originally appeared as small, brownish protuberances during the dry season, became swollen and turned whitish/light green about 2 weeks after the commencement of irrigation. Thereafter, the inflorescences started to elongate. On the other hand, the inflorescences of the control plot (T3)

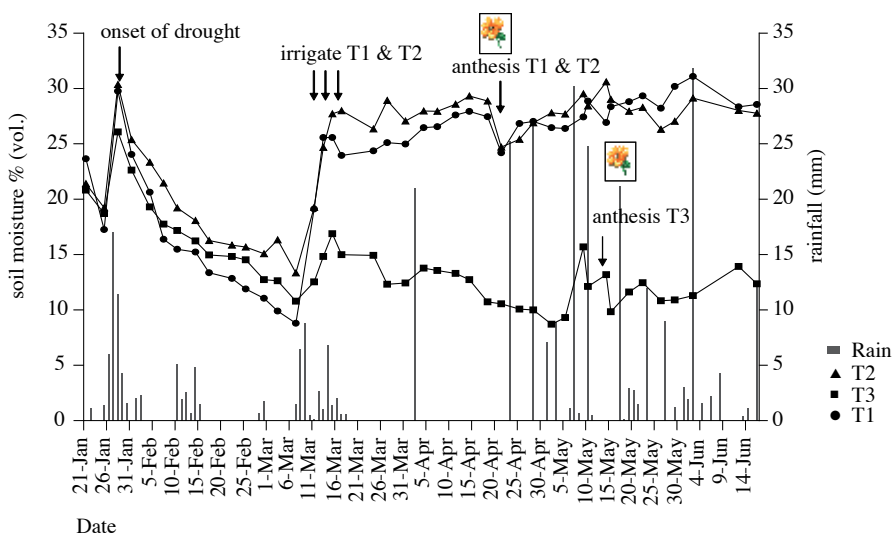


Figure 1. Soil moisture content and rainfall pattern of experimental plots

remained short and brownish in colour at this time, most probably because moisture was inadequate for the development of the flowers since no irrigation was given. This was in accordance with the findings of Salma and Razali (1987), who indicated that these protuberances were flower buds enclosed in brown hairy scales and which might stay on the tree for one or two years if conditions were unfavourable. However, if the weather was favourable, the scales would drop and the flower buds develop and become greenish in colour.

In Israel, flowering of lemon occurred 2–3 weeks after the first irrigation following a drought period of approximately 60 days (Nir et al. 1972). Masri (1999) reported that flowering in durian occurred after exposure to 4 weeks of drought. The induction of flowering by drought was probably due to the inhibition of root growth followed by changes in hormonal balance of the tree (Monselise and Halevy 1964). In lemon, drought result in flower differentiation and development of sepals only. The effect produced by resuming irrigation following water stress suggests that the resumed root growth increases production of gibberellic acid (GA3) which is needed to induce growth of the generative branch in general, and the pedicel of the flower in particular (Nir et al. 1972). Cases of GA spray in increasing size of *Protea* flowers and increasing the length of pedicels of

individual flowers of *Pelagonium* has been reported by Ben-Jaacov (2006).

Flowering and harvesting time

Table 1 indicates that in the control plot (T3), floral development was delayed by 28 days (138 Julian date). It was observed that under conditions of ample water supply, anthesis was faster (110 and 111 Julian dates for T1 and T2 respectively) indicating floral development was enhanced. Similarly, the harvesting date was earlier in the regulated plots (T1 and T2). The time to reach maturity in the regulated plots was between 110 and 112 days while that of the control plot (T3) was 123 days. This might be due to the watering schedule, whereby T3 plots were only irrigated during early fruit development until maturity, while T1 and T2 plots were irrigated during inflorescence development until maturity. This suggested that sufficient moisture during inflorescence development until early fruit development stage also contributed to the enhancement of maturity.

Flowering intensity, yield and quality

Flowering intensity as indicated by the number of inflorescences/m of branch was significantly different between treatments in the order of T1>T3 >T2 (22, 17 and 12 inflorescences/m respectively (Table 2). This ranking was inversely related to the ranking of the soil moisture level attained just before

Table 1. Flowering and fruiting of *Lansium domesticum* in response to water stress and irrigation

Treatment	Date of 50% anthesis	Harvest date	Days to maturity
	Julian date*	Julian date*	
T1	110b	222b	112b
T2	111b	221b	110b
T3 (control)	138a	261a	123a
Mean	118	233	115
CV (%)	2.67	2.03	3.95

Figures with the same letters in the same column are not significantly different at $p < 0.05$ according to DMRT

*Each Julian date represents one day from a total of 365 days in a year

commencing irrigation with T1, T3 and T2 having soil moisture content depleted to 8.8% < 10.8% < 13.3% respectively (Figure 1). However significant difference in flowering intensity was only obtained between T1 and T2 where the range of soil moisture content between the two treatments was large (8.8% versus 13.3% respectively). Similarly, Southwick and Davenport (1986) had discovered that more flowering shoots and flowers per plant of the 'Tahiti' lime were produced as the leaf xylem pressure potential increased.

However, no significant yield difference was obtained among treatments although the yield ranking was similar to that of the flowering intensity in the order of T1>T3>T2 probably due to the high coefficient of variation (Table 2). Yield is a highly variable parameter that responds to genetic and environmental traits (Bhat et al. 2003; Aggelopoulo et al. 2010). Farms are often not uniform and soil variability occurs in different parts of the field. Yield, TCSA

and per cent fruit-splits with coefficients of variation frequently exceeding 50% within block had been reported by Neilsen et al. (2009). In apples, the coefficient of variation for yield within a 0.8 ha plot varies between years ranging from 17–42% (Aggelopoulo et al. 2010)

Regulation for early production affected fruit quality to a certain extent. Length of 20 fruits was significantly longer in the control plot (T3) compared to the regulated plots (T2 and T1) by 13% and 6% respectively (Table 2) although irrigation was given over a shorter period of time i.e. during early fruit development until maturity. It appeared that besides water availability, other factors might have an effect on fruit length. Width of 20 fruits for the treatments was, however, not significantly different, probably due to the high coefficient of variation. In China, commercial production of off-season longan is associated with a number of problems such as poor fruit set, high incidence of fruit

Table 2. Effect of water stress and irrigation on flowering intensity and yield of *Lansium domesticum*

Treatment	Inflorescence (no./m)	Yield/tree (kg)	Length 20 fruits (cm)	Width 20 fruits (cm)
T1	22a	167a	57.6ab	54.4a
T2	12b	106a	53.1b	60.8a
T3 (control)	17ab	147a	61.3a	55.8a
Mean	17	138	56.9	57.2
CVX (%)	33.85	58.35	11.81	41.5

Figures with the same letters in the same column are not significantly different at $p < 0.05$ according to DMRT

Table 3. Effect of water stress and irrigation on yield and farm income

Treatment	Yield/plant (kg)	Yield/ha* (kg)	Gross income/ha @ RM0.80/kg**	Gross income/ha @ RM2.50/kg***
T1	167	9519	–	23,798
T2	106	6042	–	15,105
T3 (control)	147	8379	6,703	

Assumptions:

Planting distance 12 m x 12 m x 12 m = 77 plants/ha

*75% of population fruiting each year = 57 plants/ha/year

ex-farm price during mid-season; *ex-farm price during early season

cracking and stunted fruit due to adverse climatic conditions such as temperature and drought during fruit development (Huang et al. 2004).

Economic impact of early yield

Ex-farm price differences were large, ranging between RM2.50/kg and RM2.80/kg for the early season crops (T1 and T2), and between RM0.80/kg and RM1.50/kg for the mid-season crop (T3). This resulted in significantly large differences in income. Taking the lower price range (RM2.50/kg for T1 and T2; RM0.80/kg for T3) an income of RM418/tree, RM265/tree and RM147/tree was generated from T1, T2 and T3 plots, respectively, giving an advantage of RM271/tree in T1 plot compared to that of T3 (Table 3). This was indeed substantial when calculated on a hectare basis and justified the extra cost over a period of time needed for irrigation facilities and control of mammalian pests for the early season crop.

Conclusion

Water management is a good tool to induce early flowering and fruiting in *Lansium domesticum* (*duku Terengganu*). The management involves subjecting the trees to natural drought until soil moisture drops to 7–10% (volumetric). Re-watering immediately until soil moisture content increases to at least 25% will induce flowering one month earlier compared to the control plants. Although yield was not significantly different between treatments, the harvesting date was earlier in the regulated plants and hence could obtain a better price. This technique can be effectively used in areas with a distinct dry season of at least two months.

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Abstrak

Teknik untuk mengaruh pembungaan dan pempubuhan awal bagi tanaman duku terengganu (*Lansium domesticum* Corr.) telah dibangunkan dengan menggunakan kaedah pengurusan air yang terancang. Tiga rawatan telah diuji, iaitu T1, T2 dan T3. Bagi rawatan T1 dan T2, kelembapan tanah (volumetric) dipantau pada permulaan musim kemarau sehingga masing-masing turun ke aras 7–10% dan 10–15% diikuti dengan pengairan sehingga kelembapan tanah mencapai sekurang-kurangnya 25%. Dalam T3 (kawalan), pengairan tidak diberi sehingga pokok mengeluarkan buah. Apabila pengairan diberi setelah kelembapan tanah menurun ke tahap T1 atau T2, bunga dan buah keluar lebih awal berbanding dengan kawalan (T3). Bunga T1 dan T2 mekar 27–28 hari lebih awal daripada T3. Penguapan hasil bagi T1 dan T2 ialah 39–40 hari lebih awal berbanding dengan T3. Tiada perbezaan signifikan ($p > 0.05$) antara ketiga-tiga rawatan. Walau bagaimanapun dengan harga di ladang RM2.50/kg untuk buah yang dikutip pada awal musim (T1 dan T2) dan RM 0.80/kg untuk buah yang dikutip pada pertengahan musim (T3), pendapatan adalah lebih tinggi untuk T1 dibandingkan dengan T2 dan T3. Teknik ini boleh meningkatkan pendapatan ladang dan boleh diguna pakai dengan berkesan oleh petani yang mempunyai kemudahan pengairan di kawasan yang mempunyai musim kemarau yang ketara.