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Flowering, fruit set and fruitlet drop of durian (*Durio zibethinus* Murr.) under different soil moisture regimes

[Pembungaan, pembentukan dan pengguguran putik durian (*Durio zibethinus* Murr.) di bawah pelbagai regim air tanah]

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Key words: soil moisture contents, flowering, fruit set, fruitlet drop, durian

Abstrak

Kesan beberapa aras air tanah terhadap pembungaan, pembentukan dan pengguguran putik durian (*Durio zibethinus* Murr.) klon D24 telah dikaji di ladang. Perlakuan pengairan yang terdiri daripada T1 (1 pemancar/pokok), T2 (2 pemancar/pokok), T3 (3 pemancar/pokok) dan T4 (4 pemancar/pokok) dimulakan 2 minggu sebelum jangkaan pembungaan dan diteruskan selama 60 hari yang berikutnya. Kajian melibatkan pokok matang yang berumur 8 tahun. Potensi air tanah (ψs) digunakan untuk mengukur status air pada setiap perlakuan. T1 didapati mengalami tegasan air yang teruk dengan ψs sentiasa di bawah –0.50 MPa. T4 mengandungi lebihan air dengan ψs berada di sekitar –0.1 MPa. Kandungan air tanah bagi perlakuan T2 dan T3 dianggap sederhana dan berkisar antara –0.2 MPa dan –0.4 MPa pada kebanyakan hari. Dalam perlakuan T1 dan T4, pokoknya mengeluarkan paling sedikit jambak dan bunga. Keadaan ini menunjukkan ketiadaan air secara berterusan atau air yang berlebihan mengakibatkan pokok tidak dapat mengeluarkan bunga yang banyak. Didapati bahawa perlakuan T2 dan T3 yang sederhana status airnya menghasilkan jambak, bunga dan bilangan bunga sejambak yang terbanyak. Pembentukan putik durian D24 tinggi iaitu 76–88% dan tidak dipengaruhi oleh status air tanah. Kekurangan air tanah mengakibatkan pengguguran putik yang banyak mencapai 100% pada minggu kelima selepas pembentukan putik. Sementara perlakuan yang sentiasa dengan bekalan air yang sederhana (T2 dan T3) atau berlebihan (T4) hanya mengalami pengguguran putik sebanyak 97–99% dalam tempoh yang sama. Kesimpulannya pengurusan air yang baik sebelum dan semasa kemarau sangat penting bagi meningkatkan hasil durian. Kajian selanjutnya dalam aspek ini sangat diperlukan.

Abstract

The effects of different soil moisture levels on flowering, fruit set and fruitlet drop of durian (*Durio zibethinus* Murr.) of D24 clone were studied under field conditions. Treatments comprising T1 (1 emitter/tree), T2 (2 emitters/tree), T3 (3 emitters/tree) and T4 (4 emitters/tree) were imposed on 8-year-old matured trees, 2 weeks prior to expected flowering and continued thereafter for 60 days. Soil moisture potential (ψs) was used to indicate the water status in the various treatments. T1 was most severely stressed with ψs consistently maintained below –0.5 MPa. T4 had abundant water with ψs fluctuating around –0.1 MPa. Soil

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moisture status in T2 and T3 treatments were considered moderate with ψs ranging from –0.2 MPa to –0.4 MPa on most of the days. T1 and T4 produced the least number of inflorescence and flowers indicating that continuous water stress or excess supply of water failed to initiate more flowers. It was the T2 and T3 treatments, with moderate water supply, that produced the highest number of inflorescence, flowers and flowers per inflorescence. Fruit set was relatively high (76–88%) and was not influenced by soil moisture status. Plants under restricted soil moisture (T1) had a very high percentage of fruitlet drop, reaching 100% at 5 weeks after fruit set. However, those given moderate (T2 and T3) and abundant water supply (T4) showed a 97–99% fruitlet drop although these percentages were not statistically significant. In summary, water management prior to and during drought is important in ensuring higher yield of durian. More detailed studies on these aspects are critically needed.

Introduction

Many orchardmen in Malaysia tend to underestimate the effects of drought on growth and production of their fruit trees. They believe that under normal weather conditions most fruit trees can survive the intensity and durability of drought. However, Nieuwolt (1982) had warned that although the total annual rainfall in Malaysia is more than 2 500 mm, its uneven distribution may cause serious drought problems that could affect the growth and productivity of agricultural crops.

Insufficient water has been a major factor limiting growth and production of fruit trees (Hanan 1972). Jones et al. (1985) stated that water stress affected a wide range of physiological processes such as stomatal behaviour, photosynthesis, transpiration, translocation and partitioning of assimilates. Changes in all these processes are of particular importance due to their direct relationships with crop growth and productivity.

Among the Malaysian fruit trees, durian (*Durio zibethinus* Murr.) is one of the crops most sensitive to drought. Thus, it is difficult to establish. Lack of water has been the main limiting factor in determining the success of transplanted durian plants. Masri (1992) and Mohd. Razi et al. (1994) reported that vegetative growth of durian was greatly reduced by water deficits due to a reduction in leaf growth and photosynthetic capabilities. However, these reports on the effects of water stress were mainly confined to their vegetative growth stages.

Effects of water deficit on the reproductive growth are even more important on account of their direct relationship with plant yield. Flower initiation, fruit set, premature fruit drop, fruit growth and fruit quality are important aspects of yield potential that are considerably affected by water availability. These have been proven in the studies on papaya by Masri et al. (1990) and starfruit by Masri (1995). Observation suggests that considerable water deficit is needed to initiate flowering in durian. However, information on the roles of water in affecting other reproductive parameters is still lacking. Hence, this study was undertaken to quantify the effects of water deficits during the reproductive growth stages of durian, especially on flower initiation, fruit set and fruit drop. This knowledge may lead to a better understanding of the physiological contribution in ensuring higher yield as well as providing information for the proper irrigation management of this important fruit crop.

Materials and methods

Cultural practices

Durian plants of D24 clone at the MARDI Research Station, Bukit Tangga, Kedah were used in this experiment. They were planted in 1989 at 7.5 m x 7.5 m. The soil type at the experimental site is sandy clay loam. Fertilisation, irrigation and other agronomic practices prior to inception of treatments were applied as recommended by Zainal Abidin et al. (1991).

Treatments and experimental design

Treatments pertaining to the different levels of moisture were obtained by placing different number of emitters per tree. The trial was carried out during the drought months so as to coincide with the occurrence of flowering and fruiting as well as to minimise errors which might arise from the disturbances of rainfall. At the commencement of the experiment, the durian trees were 8 years old and had reached maturity. Treatments were imposed prior to the expected time of flowering and fruiting.

The treatments were designated as T1 (1 emitter/tree), T2 (2 emitters/tree), T3 (3 emitters/tree) and T4 (4 emitters/tree). Emitters were of spray-jet type with a flow rate of about 50 L/h at 100 psi pressure. The plants were irrigated every morning for half an hour but the water pressure was not measured. The locations of these emitters in relation to tree trunk are shown in *Figure 1*. Treatments were arranged in a randomised complete block design with three replications. Each replication consisted of a single tree. Data were analysed using the Analysis of Variance (ANOVA) and the differences between treatment means were compared by the Least Significant Difference (LSD) method.

Measurements of parameters

During the 60-day period, several parameters were measured. Soil water content at 30 cm depth from the soil surface was used to indicate the soil water status of each treatment. It was taken at intervals of 3–4 days using an aluminium core of 2.5 cm in diameter. At every sampling, soil samples were taken at four different locations from each tree *(Figure 1)*. These samples were mixed together and fresh weights of the composite samples were determined. Samples were then oven-dried at 90 °C for 48 h. The difference between fresh and oven-dried weights was used to determine the percentage of moisture content of the soil. Soil water potential was estimated by converting soil water content to water potential using the soil moisture characteristic curve specifically developed for the particular soil type.

Prior to the imposition of moisture treatments, four primary and four secondary branches were randomly selected from the sample trees and tagged. These branches were marked at 1-m length from the base using white paint. Number of inflorescence, flowers and fruitlets per meter length of these branches were later manually counted. Date of anthesis was recorded as when more than 50% of the flowers bloom. Initial fruit set is defined as the number of fruitlets retained on the branches at 2 weeks after anthesis (Zainal Abidin et al. 1991)

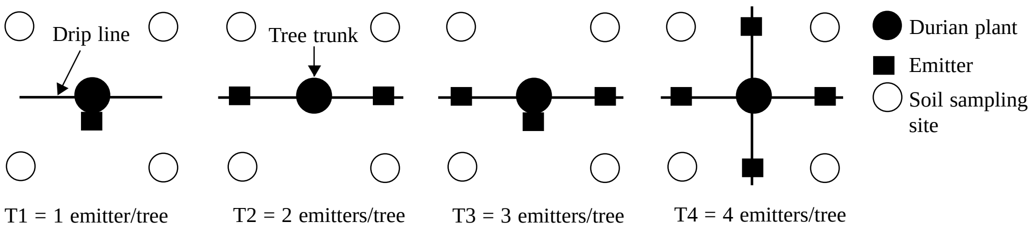

Figure 1. A schematic diagram showing the positions and number of emitters per tree as well as the location of soil sampling sites relative to durian tree trunk for the four treatments

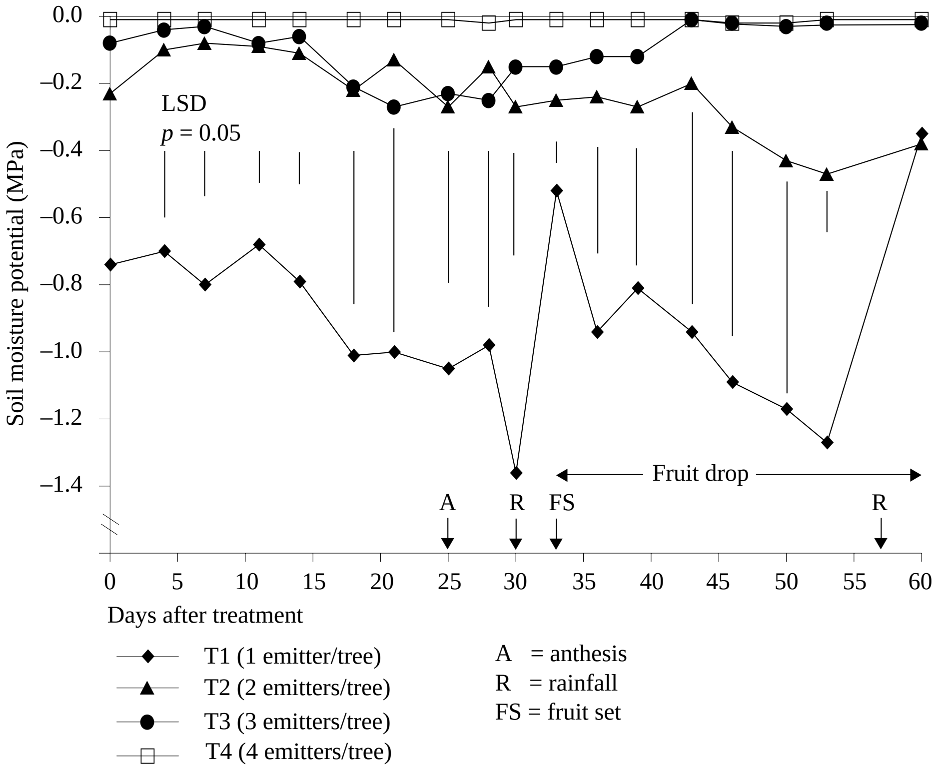

Figure 2. Changes in the soil moisture potential of various treatments during the 60-day experimental period

compared with the initial number of flowers. Similarly, percentage of fruitlet drop was calculated as the number of fruitlets drop after the date of fruit set compared with the initial number at fruit set.

Results

Soil moisture status

Soil water potential (ψs) was used as the indicator of water status in the various treatments *(Figure 2)*. The four soil moisture levels as required for this study were successfully maintained for almost 2 months, with slight disturbance due to rainfall on the 30th day after treatments were imposed. Plants in T1 were most severely stressed with ψs values consistently maintained below –0.5 MPa. These values were significantly lower than those of the other treatments throughout the dry period. However, the values of ψs in T2, T3 and T4 treatments were not significantly different. Nevertheless, the trend showed that T4 consistently had abundant water with ψs fluctuated around –0.1 MPa. Soil water status in T2 and T3 treatments was considered moderate with ψs values ranging from –0.2 MPa to –0.4 MPa on most days.

Flower initiation and fruit set

Generally, the secondary branches produced more flowers than the primary ones, regardless of soil moisture levels *(Table 1)*. The most severely stressed plants (T1) and those with excess water (T4) produced the least number of inflorescence and flowers. For primary branches, T3 plants produced the largest number of inflorescence, flowers and flowers per inflorescence followed by T2. However, for the secondary branches, T2 plants produced the maximum number of flowers, followed by T3.

Table 1. Effects of different soil moisture levels on flower initiation and fruit set of D24 durian

Treatment	No. of emitters/tree	No. of inflorescence	No. of flowers	Flowers/ inflorescence	Fruit set (%)
Primary branch					
T1	1	6.0bc	37.3b	5.7b	79.1a
T2	2	10.7ab	166.5a	14.8a	84.4a
T3	3	12.8a	199.8a	15.7a	84.5a
T4	4	2.2c	20.2b	8.9b	85.8a
Secondary branch					
T1	1	5.3b	41.8c	7.6b	82.8a
T2	2	12.5a	169.2a	13.8a	88.3a
T3	3	9.8ab	105.2b	10.7ab	75.7a
T4	4	4.5b	31.2c	6.7b	86.9a

Number of inflorescence and flowers are per 1-m length of selected primary and secondary branches
Mean values in each column with the same letter are not significantly different at $p < 0.05$ according to LSD test

Initial fruit set in D24 durian was relatively high and was not influenced by soil moisture status *(Table 1)*. In both branch types, fruit set ranged from 76% to 88% and was not significantly different among treatments. There was no specific trend of fruit set with respect to water levels. For the primary and secondary branches, T1 and T3 plants respectively had the lowest percentage of fruit set.

Fruitlet drop

There was no clear indication which branch type influenced the rate of fruit drop in D24 durian *(Table 2)*. However, restricted soil moisture significantly increased the percentage of fruit drop 2 weeks after fruit set. The most severely stressed treatment (T1) had 44% and 27% fruitlet drop from their primary and secondary branches respectively. These percentages were the highest among the other treatments. However, at 5 weeks after fruit set, fruitlet drops among treatments were not significantly different for both branch types. Nevertheless, plants under moderate (T2 and T3) and abundant (T4) water supply showed 1–3% reduction in fruitlet drop.

Discussion

In any water-related studies under field conditions, it is important to have a technique that can significantly maintain the different levels of moisture between the treatments for a considerable time period. Then, only measurements of plant parameters in response to the water levels could be meaningful. In this study, irrigating the trees with different number of emitters per tree during the drought months was able to maintain different soil moisture levels for almost 2 months. Similar technique was also used in studies with papaya (Masri et al. 1990) and starfruit (Masri 1995).

Mengel and Kirkby (1982) pointed out that for most crop species, the optimum ψs lies in the range of –0.20 MPa to –0.50 MPa. It was observed that T1 consistently had the ψs well below –0.50 MPa throughout the experimental period. The significantly lower values (more negative) of ψs indicating that plants under T1 treatment had experienced water stress. In contrast, plants under T4 treatment had abundant water with their ψs constantly around –0.1 MPa and as such were not stressed. With ψs fluctuating between –0.2 MPa and –0.5 MPa, plants in T2 and T3 could be considered as having moderate stress.

Table 2. Effects of different soil moisture levels on fruitlet drop of D24 durian at 2 and 5 weeks after fruit set

Treatment	% fruitlet drop (primary branch)		% fruitlet drop (secondary branch)	
	2 weeks AFS	5 weeks AFS	2 weeks AFS	5 weeks AFS
T1	44.2a	100.0a	26.5a	100.0a
T2	12.5b	98.2a	11.3b	97.4a
T3	9.6b	98.5a	14.6b	97.1a
T4	13.7b	99.1a	14.3b	98.8a

Mean values in each column with the same letter are not significantly different at $p < 0.05$ according to LSD test
AFS = after fruit set

Soil moisture had tremendous effects on flower initiation of durian trees. It is popularly believed that durian trees need a certain level of drought to trigger flowering. Onset of flowering usually occurs during the drought months. However, insufficient water supply for a continuous long period failed to stimulate the trees to produce more flowers. This was observed in plants under T1 treatment. Johnson et al. (1992) also found severe stress decreased flowering in peach. In contrast, continuous oversupply of water as depicted by T4 treatment also produced less number of flowers. This is in agreement with Elfving's (1994) report that flowering in apple is usually reduced or absent in vigorous trees. In the present study, it was the moderate water level treatments (T2 and T3) that produced the highest number of flowers. Several other works also similarly suggest that moderate stress increases flowering (Johnson et al. 1992; Elfving 1994). It is relevant to mention that the actual drought had begun about 4 weeks prior to the inception of these treatments. This means that after exposure to 4 weeks of drought, durian trees need to be moderately irrigated to induce more flowers. They could not flower profusely if they were exposed to long drought or overirrigated conditions.

Initial fruit set, defined as the number of fruitlets retained on the branches 2 weeks after anthesis, is relatively high (76–88%). This high percentage is probably not a surprise since D24 durian is largely cross-pollinated which could lead to high fruit set (Valmayor et al. 1965; Shaari et al. 1985). It was also observed that irrigation water did not influence initial fruit set percentages. This is because water is not considered as an important determinant of initial fruit set. Failure of pollination and deficiency in embryo fertilisation are two important factors limiting fruit set of D24 durian (Shaari et al. 1985). However, it was also reported that rainfall during anthesis could reduce fruit set due to pollen damage (Shaji et al. 1992).

Although fruit set was high fruit drop was also extremely excessive in D24 durian. At 5 weeks after fruit set, 97–100% of the fruitlets dropped prematurely. This is not surprising if compared with apple. About 90–95% potential apple fruit are lost in a series of fruit drop events that occur during the first month after bloom (Elfving 1994). In durian, Zainal Abidin et al. (1991) even reported that fruitlets of durian could drop prematurely even when they have reached the size of a tennis ball. Although not statistically significant, results showed that water is very important in reducing fruitlet drop. Treatments with moderate (T2 and T3) and abundant (T4) water supply during early fruit development stage showed a considerable 1–3% reduction in fruit drop. Such improvement, although small, is considered significant in increasing tree yield. Elfving (1994) reported that only about 5–10% of the flowers on a tree need to form apples to have a full crop. Furthermore, moderate stress is good for fruit growth and development. Since shoot growth is more sensitive to water stress than fruit growth, moderate stress would be expected to reduce vegetative growth without affecting fruit growth (Chalmers et al. 1984). Chalmers et al. (1986) reported that under periods of moderate stress, fruit osmoregulate and grow faster once the stress is relieved, ending up in larger size. This moderate irrigation strategy, which has been termed regulated deficit irrigation, has been attempted in many parts of the world.

Conclusion

Soil moisture had tremendous effects on flower initiation and fruitlet drop but not fruit set of D24 durian. A continuous insufficient or oversupply of water during drought failed to initiate more flowers. The trees that received moderate irrigation water produced the highest number of flowers. Fruit set was unsurprisingly high in D24 durian but was not influenced by soil moisture status. Although fruit set was high, premature fruitlet drop was also excessive particularly under the restricted soil moisture conditions. It was shown that moderate irrigation after 4 weeks of drought could substantially increase fruit yield. However, more detail studies on this aspect are critically needed.

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