JOURNAL OF DEGRADED AND MINING LANDS MANAGEMENT
ISSN: 2339-076X, Volume 2, Number 1 (October 2014): 219-222
DOI:10.15243/jdmlm.2014.021.219

Research Article

Application of drip irrigation technology for producing fruit of Salak 'Gula Pasir' (*Salacca zalacca* var. Gula Pasir) off season on dry land

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Abstract: Naturally, Salak Gula Pasir (*Salacca zalacca* var. Gula Pasir) is flowering every three months or four times a year, but only one or two flowering seasons that the flowers can develop into fruit. The condition causes Salak Gula Pasir is available in the market in a short period (only 2-3 months) i.e. at the time of harvest (on-season) from December to February. This seasonal nature of Salak Gula Pasir occurs because Salak Gula Pasir is planted on dry land where irrigation depends only on rainfall, and drought occurs when water is shortage so that the plant internal water content is low that causes a high failure development rate of flower to become fruit (fruit-set failure). This study was aimed to overcome the fruit-set failure by providing drip irrigation. Two treatments (with drip irrigation and without drip irrigation/control) with sixteen replicates were tested at Salak Gula Pasir production centre (at Sibetan village, Bebandem District, of Karangasem Regency, Bali) at two harvest seasons, i.e. Gadu (July) and Sela II (October). The results showed that the plant provided with drip irrigation significantly yielded fruit-set percentage higher that that without drip irrigation, both in Gadu and Sela II seasons. The percentages of fruit-set in Gadu and Sela II seasons provided with drip irrigation were 75.30% and 93.13%, respectively, while those without drip irrigation were only 59.94% and 61.67%, respectively. The increase of fruit-set observed for drip irrigation treatment associated with the increase of leaf chlorophyll content, relative water content (RWC) of leaves, and leaf N, P, and K contents. The increase of fruit-set led to higher number of fruits and fruit weight per plant under drip irrigation than that without drip irrigation. Based on the results of this study, drip irrigation can be applied to produce Salak Gula Pasir planted out of season on dry land.

***Keywords**: drip irrigation, dry land, fruit-set, off-season, Salak Gula Pasir,*

Introduction

Salak Gula Pasir is one of superior tropical fruits native to Indonesia preferred by the community that has been released by the Minister of Agriculture of the Republic of Indonesia through Kepmentan No. 584 / Kpts / TP.240 / 7/1994. The superiorities of Salak Gula Pasir are as follows: sweet fruit flavour even at young age, no sour taste, no sandy taste, and the flesh fruit is thick and not attached to the seed. These salak fruit characteristics are considered ideal to meet the demands of salak commodity markets, both for domestic and export markets (Bank Indonesia, 2004).

Until today, the availability of Salak Gula Pasir fruit in the market is seasonal. In the harvest season (on-season) the availability of Salak Gula Pasir fruit is very abundant, but the selling price is low, only between Rp. 8,000 to Rp. 10,000 / kg. On the other hand, there is no Salak Gula Pasir fruit available during off-season, if it is available; the selling price reaches Rp. 35,000 to Rp. 45,000/kg (personal communication with farmers and fruit sellers, 2013). The situation is not favourable in terms of agribusiness because of the abundant production is only at harvest time (December-February) and the time supply is very short, only 2-3 months. This short supply condition of the fruit is due to its short shelf life of Salak Gula Pasir fruit, only 7-10 days at room temperature storage (Arisusanti, 2013). With the short time supply and the short shelf life of the fruit, the bargaining position of farmers in the

marketing system of Salak Gula Pasir fruit is very weak which forcing farmers to immediately sell their crop products with low prices to avoid fruit rotting and wasting. Therefore, efforts to produce Salak Gula Pasir fruit out of season are needed to enable the supply-demand balance throughout the year to improve farmer's income.

The potential success for producing Salak Gula Pasir fruit out of season is large. Rai et al. (2010a) reported that naturally. Salak Gula Pasir is flowering once every three months or four times a year, i.e. in January (Raya flowering season), April (Sela I flowering season), July (Gadu flowering season), and October (Sela II flowering season). Of the four flowering seasons, harvesting or productions of good fruit only once a year at harvest Raya (December-February). At the three other flowering seasons (Sela I, Sela II, and Gadu) the flowers fail to produce fruit, or it is called fruit-set failure. Even if there are farmers who are capable to manage the flowers to become fruit, the percentage was very small, and hence, the amount of harvested fruits was very small too.

The failure of flower development into fruit of Salak Gula Pasir was caused by environmental factors (external) and plant physiological factors (internal) that were not supportive (Rai et al. (2010b). The external factors, i.e. low rainfall and rainy days caused low leaf Relative Water Content (RWC) that interfere with the metabolism process, while the physiological factor was lack of photosynthate in the flower which was shown by low sucrose, total sugar, and reduced sugar contents in the flower.

The low leaf RWC which caused the failure of fruit-set was indicated by a significant positive correlation between the percentage of fruit-set with leaf RWC ($r = 0.99$ *). The low leaf RWC was because Salak Gula Pasir of Karangasem is cultivated on dry land where farmers do not provide irrigation water but only relies on water rainfall. It was also found that the leaf RWC was positively correlated with leaf chlorophyll content ($r = 0.89$ **), flower sucrose ($r = 86$ *), flower total sugar ($r = 0.93$ **), and flower reduced sugar ($r = 0.88$ **).

Results of the above studies indicate that the low internal moisture content in the Salak Gula Pasir decreased chlorophyll content and photosynthesis yields allocated to the flower. Some other fruit researchers, such as Hanke et al. (2010) on avocado, Balta et al., (2007) on apricot, and Luis et al. (1995) on citrus also reported the important role of internal water in determining the success of the development of flowers into fruit. This study was conducted to elucidate the success of fruit-set on Salak Gula Pasir due to the effect of drip irrigation to produce fruit out of season.

Materials and Methods

A field experiment was conducted at the Salak Gula Pasir farm belonging to farmers of Sibetan Village, Bebandem District of Karangasem Regency from May to October 2013. Treatments tested for this study were drip irrigation (I) and without drip irrigation (TI).with sixteen replicates that resulting in thirty three plants

Plant samples were selected from one farmer. The selected plant samples were in one plot with uniform trees and similar maintenance history. For plant samples treated with drip irrigation, water in a tank was dripped to each tree with a pump machine. Pipes were set encircling the stem of plants at a distance of 20 cm. Pipes that wrapped around the stems of plants were drilled into small holes by the number four per tree, and the holes were fitted with water dropper nozzles. Droplets of water out through nozzles were arranged in such a way that the water content of the soil in the plant roots throughout the day was always in a field capacity condition. Variables observed included leaf RWC, fruit-set percentage, leaf chlorophyll content, fruit number and weight of fruit per plant, weight per fruit, and leaf N, P and K contents. All variables were observed in two seasons, i.e. Gadu (July) and Sela II (October), except for the leaf N, P and K contents that were measured only at Sela II season.

Results and Discussion

The results showed the percentage of fruit-set on a plant supplied with drip irrigation (I) was significantly higher that without drip irrigation (TI), both Gadu and Sela II seasons. Data presented in Table 1 show that the percentage of fruit-set in Gadu and Sela II for plants supplied with drip irrigation were 75.30% and 93.13%, respectively, while those without drip irrigation were only 59.94% and 61.67% respectively. This indicates that drip irrigation treatment increased the ability of the plant to prevent the failure of fruit-set so the percentage of fruit-set increased. Plant water content plays an important role in determining the success of the development of flowers into fruit. This is consistent with the results of a study reported by Kowalska (2008) on sunflower plant and Chauhan et al. (2006) on apple plant.

Increased ability of the plants to cope with the failure of fruit-set was associated with the increase of leaf relative water content (RWC). Data presented in Table 1 show that the leaf RWC of plants treated with drip irrigation was significantly higher than that without drip

irrigation, both in Gadu and Sela II seasons. The leaf RWC values in Gadu and Sela II season for plants treated with drip irrigation were 74.56% and 77.76% respectively, while those without drip irrigation were 63.84% and 71.32% respectively.

The high leaf RWC value in drip irrigation treatment showed that application of drip irrigation increased the water content of the plant tissue that positively affected physiological processes as indicated by the increased chlorophyll formation and ability of plant to uptake nutrients. The chlorophyll content of leaves in drip irrigation treatment was significantly higher than that without the drip irrigation, both in Gadu and Sela II seasons. In Gadu season, leaf chlorophyll content in plants treated with drip irrigation was 87.27 SPAD, while that without drip irrigation was 80.85 SPAD.

Table 1. Differences in the effect of drip irrigation (I) and without drip irrigation (TI) on a variety of variables observed on the season and Sela Gadu II

No	Observed variables	Gadu Season		Sela Season II	
		I	TI	I	TI
1	Number of flower bunches per plant	6.125 a	5.625 a	4.63 a	4.56 a
2	Number of fruit bunches per plant	4.56 a	3.56 a	4.19 a	3.19 b
3	Percentage of fruit set (%)	75.30 a	59.94 b	93.13 a	61.67 b
4	Leaf RWC (%)	74.56 a	63.84 b	77.76 a	71.32 b
5	Leaf chlorophyll content (SPAD)	87.27 a	80.85 b	77.20 a	65.64 b
6	Number of fruits per plant	4.82 (24.50) a	3.70 (15.25) a	2.43 (6.38) a	2.05 (5.75) a
7	Weight of fruit per plant (g)	15.48 (287.51) a	13.53 (215.56) a	7.89 (94.08) a	4.66 (50.89) a
8	Weight per fruit (g)	3.42 (12.48) a	3.94 (18.81) a	2.89 (9.87) a	1.71 (3.15) a
9	N content (%)			1.8488 a	1.8088 a
10	P content (%)			0.2588 a	0.2350 a
11	K content (%)			0.8813 a	0.7363 b

Remarks: - The numbers are followed by the same letter in the same lane in each season indicates not significant at the 5% level T test. - In a variable number of fruits per plant, fruit weight per plant and weight per fruit, the figures show the results of the transformation confined to $\sqrt{x + 1}$, while the figure in front of the parentheses is the number of observations.

Similarly, in Sela II season the chlorophyll content of leaves at drip irrigation treatment was 77.20 SPAD, while at the control treatment was only 65.64 SPAD. In addition, application of drip irrigation significantly increased the leaf K, N and P contents although the differences were statistically not significant. Leaf N, P and K contents at drip irrigation treatment were 1.8488%, 0.2588% and 0.8813%, respectively, while those at the control treatment were only 1.8088%, 0.2350% and 0.7363%, respectively. These conditions favour the increased formation of chlorophyll in the leaves as indicated by the higher chlorophyll content in plants receiving drip irrigation significantly than that in plants without drip irrigation.

The increase in leaf RWC, leaf chlorophyll content, and plant nutrient uptake improved metabolic processes in plants receiving drip irrigation, which in turn increased the percentage of fruit-set. This caused the number of harvested fruit per plant, fruit weight per plant and weight per fruit in plants receiving drip irrigation treatments tended to be higher than without drip irrigation, in both Gadu and Sela II seasons.

For fruit crops, a relatively long dry period is needed to initiate flower, then after flower is initiated and induced, it needs sufficient water so that the flowers can grow and produce fruit (Hempel et al., 2000; Pidkowich et al., 1999; Bernier et al., 1985; Kinet et al., 1985). A similar result was obtained by Ogaya and Penuelas (2007) that Oak Mediterranean plants treated with 15%reduced soil moisture of field capacity caused the fruit-set percentage dropped 30%.

Several studies have shown that fruit-set failure is caused by unfavorable growing environmental factors such as inadequacy of water (Robinson et al., 2000, Balta et al., 2007), nutrients (Saleem et al., 2005), and carbohydrate content (Luis et al., 1995; Ruan, 1993) that hinder the process of plant physiology.

Conclusion

Drip irrigation can be applied to produce Salak Gula Pasir fruits out of season planted on dry land. Under drip irrigation, the percentage of fruit-set in Gadu and Sela II seasons were 75.30% and 93.13% respectively, while that without drip irrigation were 59.94% and 61.67%, respectively. The high percentage of fruit-set can produce fruit out of season.

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