BIOTROPIA Vol. 28 No. 2, 2021: 156 - 164 DOI: 10.11598/btb.2021.28.2.1280

SULFATE AMMONIUM FERTILIZER ON THE OFF-SEASON PRODUCTION OF SNAKE FRUIT (*Salacca sumatrana* Becc.)

RASMITA ADELINA[1*], IRFAN SULIANSYAH[2], AUZAR SYARIF[2], AND WARNITA[2]

[1]*Agrotechnology Study Program, Faculty of Agriculture, Universitas Graha Nusantara, Padangsidimpuan 22715, Indonesia*
[2]*Agriculture Science Study Program, Faculty of Agriculture, Universitas Andalas, Padang 25136, Indonesia*

Received 5 July 2019/Accepted 9 January 2020

ABSTRACT

Salacca sumatrana (Becc.), known locally as the Sidimpuan snake fruit, is one of the specialties prime local commodities of Padangsidimpuan City in Sumatra. The fruit is known for its sweet, sour and astringent taste which differentiates it from Pondoh and Balinese snake fruits. Recently, the snake fruit farmers have noticed a continuous decrease in production resulting from the failure in its fruit-setting, particularly during the off-season. The use of fertilization and drip irrigation in the off-season had been currently explored as part of the solution. Hence, this research investigates the use of these methods in overcoming the fruit setting failure and guaranteeing subsequent production of Sidimpuan snake fruit all-year round. Specifically, this study aimed to determine the optimal dosage of ammonium sulfate fertilizer and drip irrigation for fruit setting during the off-season. This research used a split-plot design with the main plot for drip irrigation and the subplot for ammonium sulfate. The observed parameters included the number of flower and fruit bunches, fruit set percentage and a nutrient analysis of the leaves. Drip irrigation significantly affected the fruit setting percentage and the number of harvested fruit bunches. The best treatment combination was at 400 g ammonium sulfate fertilizer per plant and drip irrigation of 3,000 mL/plant. The fertilization period in July-September produced an off season harvest that was comparable to the fruit set percentage (10.76% difference) and number of fruit bunches (25.65% difference) that were observed in the April-June fertilization for the on-season harvest. This indicated that applying ammonium sulfate with drip irrigation could overcome fruit set failure in Sidimpuan snake fruit, particularly, during the off-season.

Keywords: drip irrigation, off-season, production, snake fruit, sulfate ammonium

INTRODUCTION

Sidimpuan snake fruit (*Salacca sumatrana* Becc.) is one of the specialty products locally produced primary commodities of Padang, Sidimpuan City. The fruit is known for its uniquely sweet, astringent and sour taste, differing from the Pondoh and Balinese snake fruits and other types of snake fruits. The species is spread throughout the sub-districts in the southern part of the Tapanuli Regency, predominantly at the Districts of Angkola Barat, East Angkola, South Angkola, and Marancar.

Sidimpuan snake fruit production shows high development potential in South Tapanuli covering approximately 19,155 ha with a production potential of up to 30 tons/ha (BPS 2015). Hence, the development of an optimal cultivation technology is necessary. Currently, the crop production undergoes high fluctuations between the main harvest season (on season) and harvest outside this season (off season) resulting in a continuously declining production.

This decreasing production is due to the fruit-set failure in the off season which is caused by a number of adverse environmental factors, particularly, those which do not support the production process, including low rainfall and few rainy days, and low soil nutrient content resulting in the lack of vital nutrients as indicated by low nitrogen, phosphorus and potassium content in the leaves (Rai *et al.* (2010).

*Corresponding author, email: rasmita301271@gmail.com

For the Sidimpuan snake fruit to bear well outside the main harvest season, off-season treatments need to be applied. These would include nutrients supplementation through fertilizer application and simple drip irrigation technique. Fertilization with ammonium sulfate and potassium chloride and simple drip irrigation were tried to meet the nutritional and water requirements of Sidimpuan snake fruit in increasing its growth, fruit formation and production, out of season. Under drip irrigation, fruit-setting was at 75.30% while that of no drip irrigation it was at 59.94% (Rai *et al.* (2010).

Ammonium sulfate fertilizer provides nitrogen and sulfur and potassium chloride fertilizer as the main source of potassium which plays a role in plant growth and development. The availability of nitrogen and sulfur nutrients by fertilizing with ammonium sulfate at a dosage of 300 g had increased Suwaru snake fruit production (Sudaryono 2005) while the use of simple drip irrigation had efficiently and optimally meet the plants' water requirements.

Hence, this study was aimed to obtain the best dosage combination of ammonium sulfate fertilizer and simple drip irrigation techniques to optimize fruit setting and to increase the Sidimpuan snake fruit production in the off-season thereby optimally producing fruit throughout the year.

MATERIALS AND METHODS

Time and Location of Research

The present study was conducted in April 2018 until September 2018 at the Palopat Maria Village Padangsidimpuan Hutaimbaru Subdistrict, Padangsidimpuan City (between 010 28'19" - 010 18' 07" N and 990 18' 53" - 990 20' 35" E).

Research Methodology

Sixty (60) trees from among the 20 to 30-year-old productive snake fruit trees were measured in the study applying the split plot design, consisting of three replications. The main plot is the application technique either, with drip irrigation of 3,000 mL/plant/day (P_1) or with no irrigation (P_0). The simple drip irrigation installation included infusion bottles, infusion tubes, drippers, plastic hoses and water pumps. The subplots for the fertilization technique consisted of plots without fertilization (P_0) and plots with ammonium sulfate fertilizer applied at 250 g/plant + 40 g potassium chloride/plant (P_1), 300 g/plant + 40 g potassium chloride/plant (P_2), 350 g/plant + 40 g potassium chloride/plant (P_3), and, 400 g/plant + 40 g potassium chloride/plant (P_4). Hence, the study consisted of 10 treatment combinations with 3 replications and 2 plants per plot, totalling to 60 plants. Fertilizer applications were carried out in 2 periods; fertilization for the April - June 2018 period was carried out on 14 March 2018, while fertilization for the July - September 2018 period was carried out on 22 July 2018. Previously, fertilization had been done in August 2017 and December 2017.

Fertilization was carried out by immersing the appropriate amounts of ammonium sulfate and potassium chloride fertilizer according to treatment into a 10 - 15 cm deep fertilizer groove in the soil that is 50 - 60 cm from the base of the stem. Watering was a simple irrigation system that involved water movement carried out by gravity. Drip irrigation equipment included a plastic tube as a water storage container, an infusion hose installation equipped with a dripper at the end that released water at a rate of 250 mL/30 minutes with a watering volume of 3000 mL/day. The drip irrigation was given daily for 6 hours from 10 am - 4 pm. However, if it rains very heavily, the drip irrigation was not applied.

The observed parameters were the fruit-set percentage, number of flower and fruit bunches, number of harvested fruit bunches, relative water content (RWC) and the Nitrogen, Phosphorus and Potassium content on the leaves. The number of flower bunches and fruits were counted once every two weeks on each sample plant. Analysis of leaf nitrogen, phosphorus and potassium content was carried out once every fertilization period. Three leaves taken from each sample plant for laboratory analysis were cleaned, ovendried at 70 ^{o}C, then blended and sieved using a 0.5 mm grid sieve. The total nitrogen was determined using the Kjeldahl semi-micro method, while the dry ashing method was used for determining phosphorus and potassium content. Phosphorus concentration was measured with a UV-VIS spectrophotometer, while potassium

concentration was determined by using a flame photometer. Data were analyzed using ANOVA and if differences among treatments were significant, Duncan's multiple range test was applied.

RESULTS AND DICUSSION

Fruit Set Percentage (%)

During the April-June fertilization period (on season), the highest fruit set percentage was at 76.949% indicating a significant increased caused by using the drip irrigation (Table 1). The highest fruit set percentage of 75.615% also occurred at the 300 g/plant ZA dosage of ammonium sulfate fertilizer. The lowest response was from no irrigation (54.478%) nor fertilization (47.115%). Drip irrigation has increased the relative water content of the leaves. Hence, the high fruit-set percentage with drip irrigation was a result of the high relative water content (RWC) of leaves which in turn impacted the chlorophyll and potassium content (Sunarka 2015). Watering the soil then improves its chemical properties encouraging root growth and increasing physiological activity in the snake fruit plants, thereby improving their fruit-setting capacity.

In the July-September fertilization period (off season), the fruit set percentage (58.863%) was not significantly affected by drip irrigation treatment (68.673%). This was during the wet season, so the additional water was not necessary. The number of bunches formed and flower fall is influenced by environmental factors (Adijaya *et al.* 2013). In the dry months, the flower fall usually increases thereby reducing the number of bunches formed. The use of ammonium sulfate fertilizer also had a statistically significant impact on the fruit setting with the highest response at 400 g per plant (77.792%).

In another study, drip irrigation had significanly affected the out of season fruit production in dry conditions showing a fruit set percentage of 75.30% (off-season) and 93.13 % (on-season), compared to 59.94% and 61.67%, respectively, without irrigation (Rai *et al.* 2014). In the July-September fertilization period of this study, the drip irrigation resulted in a significantly higher fruit set percentage.

Analysis of variance indicated that the effect of the combination of drip irrigation treatment and ammonium sulfate fertilizer dosage on the percentage of fruit formation was not significant (Table 2). However, the treatment combination that resulted in the best fruit set percentage in the April-June fertilization period was at a dosage of 350 g fertilizer per plant with drip irrigation (91.667%) (Table 2). Whereas, in the fertilization period of July-September, the highest percentage of fruit set was with 400 g with drip irrigation (83.997%) (Table 2). In another study, the combination of drip irrigation and nitrogen fertilizer had also significantly increased the yield of cotton plants (*Gossypium hirsutum*) (Zhong & Bai 2013). Moreover, under medium irrigation, the ratio of dry matter in nutritional organs to reproductive organs was also increased (Zhong & Bai 2013).

Table 1 The average percentage of fruit set, number of flower bunches, fruit and number of harvested fruit bunches with drip irrigation treatment and different dosages of ammonium sulfate fertilizer applied in April - June and July - September 2018

Treatment	Fruit Set (%)		Number of bunches				Number of harvested fruit bunches	
			Flower		Fruit			
	Apr-Jun	Jul - Sept	Apr-Jun	Jul- Sept	Apr-Jun	Jul- Sept	Apr-Jun	Jul- Sept
Without irrigation	54.478^{a}	58.863	19.267^{b}	15.000	10.533	8.467	9.933	12.467^{a}
Drip irrigation	76.949^{b}	68.673	16.467^{a}	14.267	12.733	9.467	12.067	18.200^{b}
Without fertilizer	47.115^{a}	52.620^{a}	16.333	16.333	7.667^{a}	7.833^{a}	10.500	13.000
ZA 250 g	59.708^{ab}	57.800^{ab}	17.833	13.500	0.500^{ab}	7.667^{a}	9.000	14.667
ZA 300 g	75.615^{b}	68.620^{ab}	18.667	14.833	14.167^{b}	10.000^{ab}	11.000	13.833
ZA 350 g	74.443^{b}	62.008^{ab}	18.333	14.167	12.833^{b}	8.167^{ab}	10.167	18.000
ZA 400 g	71.687^{b}	77.792^{b}	18.167	14.333	13.000^{b}	11.167^{b}	14.333	17.167

Note: Means with different superscripts within a column are significantly different at P≤0.05, with comparisons performed using DMRT.

The application of ammonium sulfate fertilization and drip irrigation had increased the percentage of fruit set in both fertilization periods. This indicated that these production techniques will be able to minimize the production fluctuations in snake fruit between the harvest season (on season) and small harvests (off season). Other study results also showed that both irrigation and nitrogen fertilization promoted cotton growth and yield (Zhuan *et al.* 2017). Drip irrigation technique had also increased the fruit set percentage of Gula Pasir snake fruit during the off season in a dryland (Rai *et al.* 2014).

Number of Flower Bunches

During the April - June (off season) fertilization period, the flower formation was significantly affected by the drip irrigation as a single factor (Table 1). No irrigation treatment resulted in the most numerous flower bunches formed (19.267). Ammonium sulfate fertilizer dosage at 300 g/plant also produced the highest average number of flower bunches (18.667) (Table 1).

During the July - September (on season) fertilization period, the drip irrigation nor the fertilization did not significantly influence the flower formation (Table 1). However, there was a tendency for more flower bunches with the no-irrigation treatment. This absence of significant difference with the irrigation technique is similar to that found by Jose *et al.* (2013) who used regulated deficit irrigation techniques to improve fruit size. Reduced irrigation and fruit thinning were found to affect carbon allocation within the tree by altering a number of interrelated factors (photosynthesis, location and number of competing sinks, storage capacity, and transport) that control the carbon partitioning in fruit trees. Other factors affecting flowering could be interspecific differences and different crop seasons which was probably caused by variable atmospheric conditions during vegetation periods (Greiner & Kohl 2014).

No significant relationship exists between fertilizer dosage and flower formation. In a study on sweet orange plants, the application of certain dosages phosphorus and potassium compound fertilizer had only a small effect on the number of flowers formed (Ramadhan *et al.* 2015). Other factors that cause unfertilized plants to flower as prolifically as those treated with fertilizer could be the irrigation and less than optimal water management.

Table 2 Average fruit set percentage (%) with the combined drip irrigation and ammonium sulphate fertilization in April-June 2018 and July-September 2018

Treatment	Dosage of ammonium sulfate fertilizer (gram)										Average	
	0		250		300		350		400			
	I*	II**	I	II	I	II	I	II	I	II	I	II
Without irrigation	34.140	44.330	50.437	52.503	67.603	65.157	57.220	60.740	62.990	71.587	54.478	58.863
Drip irrigation	60.090	60.910	68.980	63.097	83.627	72.083	91.667	63.277	80.383	83.997	76.949	68.673
Average	47.115	52.620	59.708	57.800	75.615	68.620	74.443	62.008	71.687	77.792		

Notes: * = fertilization in April–June 2018; ** = fertilization in July-September 2018

Table 3 Average number of flower bunches with ammonium sulfate fertilizer treatment

Treatment	Dosage of ammonium sulfate fertilizer (gram)										Average	
	0		250		300		350		400			
	I*	II**	I	II	I	II	I	II	I	II	I	II
Without irrigation	16.667	19.333	19.667	12.000	18.667	16.333	21.667	14.333	19.667	13.000	19.267	15.000
Drip irrigation	16.000	13.333	16.000	15.000	18.667	13.333	15.000	14.000	16.667	15.667	16.467	14.267
Average	16.333	16.333	17.833	13.500	18.667	14.833	18.333	14.167	18.167	14.333		

Notes: * = ammonium sulfate fertilization in April-June 2018; ** = ammonium sulfate fertilization in July-September 2018.

The combination of drip irrigation and the different ammonium sulfate dosages did not significantly affect the number of flower bunches. Similar results were observed when new flower buds formed spontaneously every 1 - 1.5 months at the base of the leaf midrib but were uninfluenced by the combined irrigation and fertilization treatments (Adelina 2017). Furthermore, it was then assumed that the two treatments would influence the formation of new flower buds, later, when the fruit bunches were formed and until finally, when the fruit bunches were harvestable (Table 3). The application of certain dosages of compound fertilizer phosphorus and potassium had also a minimal effect on the number of flowers in sweet orange plants (Ramadhan *et al.* 2015)

Number of Fruit Bunches

The number of fruit bunches in the April-June fertilization period was not significantly affected by the drip irrigation in which the irrigated plants produced an average of 12.733 bunches per plant. In contrast, drip irrigation had a significant effect on both growth traits and fruit production indicating that it was important in zones with water limitations (Loewe & Delard 2016).

The different dosages of ammonium sulfate fertilizer has significantly affected fruit bunch formation but the best dosage appeared to be at 400 g with 13.000 bunches of fruit per plant, and the 250 g at only 10.500 bunches (Table 1).

In the July-September fertilization period, the drip irrigation had no significant effect on the number of fruit bunches formed but it appeared to give a slightly higher number of fruit bunches (9.467) compared to the no-irrigation technique (8.467) (Table 1). During this period, there was sufficient rain so the effect of irrigation in the formation of fruits seemed neligible. The drip irrigation was more effective during the dry season rather than on the rainy season (Biswas *et al.* 2016). The same effect happened in the increased yield of tomato associated with the increasing amount of irrigation water (Biswas *et al.* 2016).

The optimal dosage of ammonium sulfate fertilization for fruit bunch formation was at 400 g with 11.167 bunches and the 250 g only yielding 7.667 bunches, showing a statistically significant difference (Table 1). The use of nitrogen fertilizer and optimal water application were also recommended for the summer production of cotton (Zhuan *et al.* 2017).

In the April-June fertilization period, the combined treatments that resulted in the formation of the largest number of fruit bunches was drip irrigation with the 300 g fertilizer that produced 15.667 bunches (Table 4). This interaction between irrigation and fertilization influenced most of the plant physiological functions and growth (Wang *et al.* 2018). The same results indicating better economic production were observed in the use of fertilizer with daily drip irrigation for corn growing on a semi-arid area (Chauhdary *et al.* 2017).

Number of Harvested Fruit Bunches

In the April-June fertilization period, neither drip irrigation nor dosages of ammonium sulfate fertilizer significantly affected the number of harvested fruit bunches. However, drip irrigation with 12.067 bunches and 400 g of fertilizer with 14.333 bunches appeared to give the best fruit harvest compared to 9.000 bunches from the 250 g of fertilized plants (Table 1). Ammonium sulfate fertilizer, as the main source of nitrogen, is crucial in increasing the crop production process. Nitrogen application has increased the seed yield of coriander (*Coriandrum sativum* L.) in a linear manner and the application of 60 kg/ha has improved the yield by 40% (Alil *et al.* (2015).

Table 4 Average number of fruit bunches with combined drip irrigation and ammonium sulfate fertilizer treatment

Treatment	Dosage of ammonium sulfate fertilizer (gram)										Average	
	0		250		300		350		400			
	I*	II**	I	II	I	II	I	II	I	II	I	II
Without irrigation	5.667	7.667	10.000	6.333	12.667	11.000	12.000	8.000	12.333	9.333	10.533	8.467
Drip irrigation	9.667	8.000	11.000	9.000	**15.667**	9.000	13.667	8.333	**13.667**	**13.000**	**12.733**	**9.467**
Average	7.667	7.833	10.500	7.667	14.167	10.000	12.833	8.167	13.000	11.167		

Notes: * = combined treatment in April-June 2018; ** = combined treatment in July-September 2018.

In the July-September 2018 fertilization period, drip irrigation had resulted in a statistically significant 18.200 harvested fruit bunches while any dosage of the ammonium sulfate fertilizer did not. The plants applied with the drip irrigation also produced a higher number of harvested bunches compared to those plants that were not given (Rai *et al.* 2013). The best yield was at the 350 g fertilizer dosage with 8.000 bunches of harvested fruit compared to 12.467 bunches from the non-irrigated unfertilized plants (Table 1).

The non-significant effect observed on the combined irrigation and ammonium sulfate fertilizer treatment on the number of harvested fruit bunches implied that no real interactions existed between the two treatments. However, 22.667 fruit bunches resulted from a combination of 400 g fertilizer with drip irrigation and 7.000 bunches from the 250 g with no-drip irrigation (Table 5). The lack of influence of ammonium sulfate fertilization suggested that drip irrigation alone can meet certain needs of Sidimpuan snake fruit plants. The use of organic fertilization has also increased the fruit set percentage (ability to bear fruit) of snake plants (Dewi 2014). The failure of fruit development from the flowers of the Gula Pasir snake fruit was more likely due to other environmental and plant physiological factors rather than the application of fertilization (Rai *et al.* 2010).

The development pattern of snake fruit plant production and distribution is strongly influenced by physiographic environments such as the altitude, land, rainfall, and air temperature (Cahyani *et al.* 2013). These environmental factors include particularly, low rainfall and number of rainy days which lower the relative water content (RWC) of leaves thereby disrupting the metabolic processes.

The average RWC of leaves in the July-Sept 2018 period was higher than those of leaves in the April-June period (Fig. 1). The positive impact resulted in a higher average number of fruit bunches harvested in the July-September period using the drip irrigation. This application of irrigation also resulted in greater fresh biomass, fresh leaf yield, and dry leaf yield in stevia plants (Benhmimou *et al.* 2018). The higher leaf RWC with the drip irrigation treatment showed that irrigation increased the water content of the plant tissues thereby positively affecting the physiological processes as indicated by the increased plant ability to take up nutrients (Rai *et al.* 2014).

The nitrogen, phosphorus, potassium content and RWC of leaves in the July-September fertilization period was higher than those of the April-June 2018. Very high differences were found in the nitrogen content and RWC of leaves (Fig. 1). The leaf nitrogen content in the July-September fertilization period was higher (2.194%) than in the April-June fertilization period (1.384%). Nitrogen content and the RWC varied in a similar way to the percentage of fruit set and the highest number of fruit bunches obtained in the July-September fertilization period compared to those of the April-June 2018. The low productivity of Gula Pasir snake fruit was influenced by the low level of nitrogen in the leaves (Rai *et al.* 2010; Dewi 2014). This nutrient deficiency has influenced the plant physiological processes resulting in the failure of flower development into fruit due to photosynthate deficiency indicated by sucrose content, total sugar, and reducing sugars in the

Table 5 Average number of harvested fruit bunches with the combined drip irrigation and ammonium sulfate fertilizer treatments in April-June 2018 and in July-September 2018

Treatment	Dosage of ammonium sulfate fertilizer (gram)										Average	
	0		250		300		350		400			
	I*	II**	I	II	I	II	I	II	I	II	I	II
Without irrigation	10.000	11.667	**7.000**	12.000	9.000	11.000	8.333	16.000	15.333	11.667	9.933	12.467
Drip irrigation	11.000	14.333	11.000	17.333	13.000	16.667	12.000	20.000	**13.333**	**22.667**	**12.067**	**18.200**
Average	10.500	13.000	9.000	14.667	11.000	3.833	10.167	18.000	14.333	17.167		

Notes: * = combined treaments in April-June 2018; ** = combined treatments in July-September 2018.

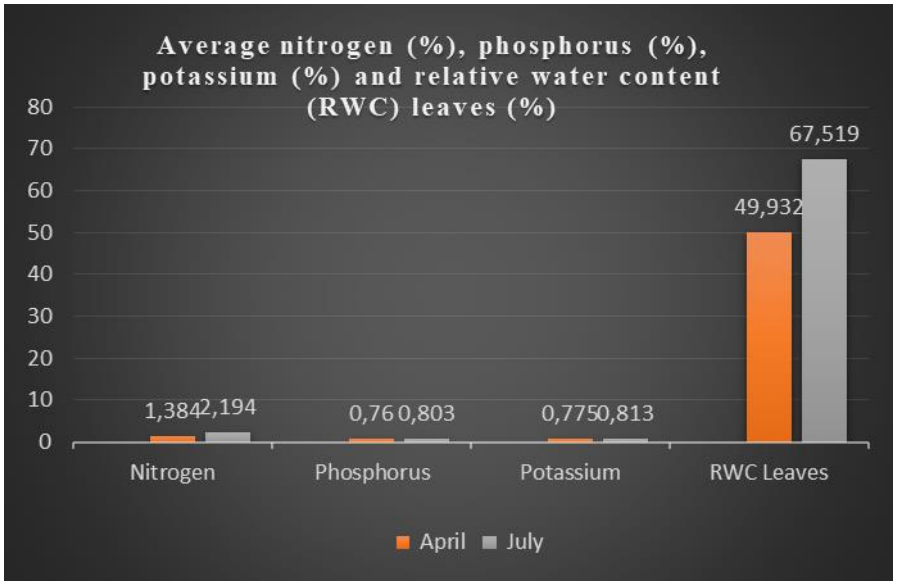

Figure 1 Average nitrogen, phosphorus, potassium and relative water contents of leaves

leaves at low interest due to high competition in fighting photosynthesis. Fruit weight and fruit yield have been found to be significantly and positively correlated with nitrogen, phosphorus, potassium, iron, zinc and copper contents of the citrus var. *Kinnow mandarin* leaf (Kaul *et al.* 2014).

Leaf nutrient content is one indicator of nutrient availability which is critical in plant growth and development (Marschner 1986). If the production process is not balanced with the availability of nutrients, in general it will cause a decrease in production. The nitrogen and phosphorus contents of Sidimpuan snake fruit leaves were found to be higher than those of pondoh and sumedang leaves but the potassium content was lower (Islami 2014). Nitrogen status is related to leaf water content which also influences chlorophyll formation (Fig. 1). Drip irrigation increased the maximum chlorophyll content and photosynthetic nitrogen use efficiency (Wang *et al.* 2018). For chlorophyll production, a schedule combining drip irrigation with 300 kg Nitrogen/ha has provided the highest average chlorophyll production at an increase of 62% above non-irrigated levels (Perez-Ortola *et al.* 2016). Nitrogen when absorbed by plants could play an important role in the chlorophyll formation as indicated by an increase in the green leaf color (Pangaribuan *et al.* 2018).

Fertilization increases the soil nutrient availability for the plants to absorb. The average nitrogen and potassium levels of the Sidimpuan snake fruit leaves were increased after the application of ammonium sulfate fertilizer (Adelina *et al.* 2018). The higher the frequency of fertilization, the more secured is the availability of soil nutrients for plant growth and development (Vargas & David 2015). The lack of plant response to fertilizer in this research may have been due to the plants' need for a continuous supply of nutrients throughout the year. Hence, a better result may have been achieved if fertilizers were given more often. For further research, it is recommended to increase the dosage of ammonium sulfate and potassium chloride fertilizers to determine a possible increase in the the fruit set percentage and production of Sidimpuan snake fruit.

CONCLUSSION

Drip irrigation during the off season in July-September has improved both the fruit set percentage and the number of harvested fruit bunches of the Sidimpuan snake fruit. The best treatment, as compared to no drip irrigation, was the irrigation with 3000 mL/plant/day. As a single separate factor, the ammonium sulfate fertilizer treatment and the drip irrigation application significantly influenced the fruit set percentage and number of formed fruit bunches. No significant interaction existed between irrigation and fertilization. However,

based on the average number, the combined treatments that gave the best response was obtained at the ammonium sulfate fertilizer dosage of 400 g/plant. With drip irrigation, the off-season harvest in July-September was comparable to that of the fruit set percentage and number of fruit bunches formed with fertilization, during the main harvest season in April-June.

ACKNOWLEDGEMENTS

This research was funded by DP2M Dikti, through a doctoral dissertation grant in the 2018 implementation year. The researchers, therefore, would like to express their deepest gratitude to the Director of DP2M Dikti for the funding support.

An infinite gratitude from the researchers is also extended for the collaboration of the research team from the Department of Agrotechnology, Faculty of Agriculture, Graha Nusantara Padangsidimpuan University, as well as to the analytical staff at the Soil Department laboratory, Faculty of Agriculture, Andalas University, Padang, Indonesia.

REFERENCES

Adelina R, Irfan S, Auzar S, Warnita. 2017. Study of Sidimpuan Salak Cultivation (*Salacca sumatrana* Becc.). Grahatani Journal 3(1):434-43.

Adelina R, Irfan S, Auzar S, Warnita. 2018. Evaluation Nutrients Content in Salak Sidimpuan Leaves (*Salacca sumatrana* Becc.). IJAIR 6(5).

Adijaya IY, Mahaputra NIK, Rai IMY, Sukadana IM, Kertawirawa PA, Sugiarta P, Priningsih PY. 2013. Nursery Studies, Increased Productivity and Quality of Gula Pasir Salak. Final report. Bali Agricultural Technology Research Institute. 29 p.

Adijaya IN, Rai IMY. 2014. Increasing The Salak Production of Gula Pasir Variety (*Salacca edulis*) With Inovation of Cow Fertilizer. Proceedings of the National Seminar on Bogor Organic Agriculture, June 18-19, 2014, Bali Institute of Agricultural Technology (BPTP), Ngurah Rai Pesanggaran, Denpasar.

Adiwijaya IY, Rai IMY. 2014. Increased Production of Gula Pasir Salak (*Salacca edulis*) With Fertilization Innovations Cow manure. BPTP. Bali.

Alil H, Gohar A, Ehsan E, Muhammad S, Saeed A, Nazeer A, 2015. Response Of Coriander (*Coriandrum sativum* L.) to Different Nitrogen Levels and Sowing Dates. Asian J Agri Biol 3(4): 155-8.

Arteca RN. 1996. Plant Growth Substance Principles and Application. Pennsylvania (US): Springer Science Business Media Dordrecht. 332 p.

Benhmimou A, Mohammed I, Chaouki A, Fatima G, Naima S, Fatima ZA, Mounira L. 2018. Effects of Water Stress on Growth Yield Quality and Physiological Responses of Two Stevia (*Stevia rebaudiana* Bertoni) Varieties in Rabat Region Morocco. Asian J Agri Biol 6(1):21-34.

Biswas S.K, Akanda AR, Rahman MS, Hossain MA. 2015. Effect of drip irrigation and mulching on yield water-use efficiency and economics of tomato. Plant Soil Environ 61(3):97-102 doi: 10.17221/804/2014-PSE

BPS TAPSEL. 2015. South Tapanuli Regency in Figures. South Tapanuli Regency Central Office of Statistic.

Cahyani NK, Suryadi WM, Treman IW. 2013. Distribution of Salak Gula Pasir (*Zalacca* sp. var. *amboinensis*) in Bebandem District, Karangasem Regency. (A Spatial Approach). Department of Geography Education, FIS Undiksha. 10 p.

Chauhdar JN, Allah B, Muhammad A, Muhammad M. 2017. Effect of Different Irrigation Aand Fertigation Strategies on Corn Production Under Drip Irrigation. Pak J Agri Sci 54(4):855-63. doi: 10.21162/PAKJAS/17.5726

Dewi KACJ. 2014. Application of Several Types of Organic Fertilizers and Mycorrhizal Doses to Increase Production and Quality of Salak Granulated Sugar Out of Season. [Thesis]. Denpasar (ID): Dryland Agriculture Study Program, Universitas Udayana. 94 p.

Fitchett JM, Stevan WG, Dave IT. 2015. Plant phenology and climate change: Progress in methodological approaches and application. Prog Phys Geogr 39(4):460-82.

Greiner S, Köhl K. 2014. Growing Evening Primroses (Oenothera). Front Plant Sci 5:38. https://doi. org/10.3389/fpls.2014.00038.

Harahap H, Sartii ME, Luthfi B, Siregar AM. 2013. Identification of Morphological Characteristics of North Sumatra Salak (*Salacca sumatrana* Becc.) In Some Regions of South Tapanuli Regency. Online Journal of Volume Agroecotechnology 1(3).

Intrigliolo DS, Castel JR. 2010. Response of grapevine cv. 'Tempranillo' to timing and amount of irrigation: water relations, vine growth, yield and berry and wine composition. Irrig Sci 28:113-25.

Jose M, Rosalı JJ, Francisco P, Pierre V, Francoise L, Emilio N. 2013. Combined Effects of Water Stress and Fruit Thinning on Fruit and Vegetative Growth of a Very Early-Maturing Peach Cultivar: Assessment by Means of a Fruit Tree Model. Quali Tree Irrig Sci 31:1039-51. doi 10.1007/s00271-012-0385-6

Kartasapoetra AG. 2016. Climatology: Effects of Climate on Land and Plants. Jakarta (ID): PT. Bumi Aksara Publisher.

Kaul MK, Bhatnagar P, Singh J. 2014. Response of Soil Nutrient Status on Leaf Nutrient Content and Fruit Yield of Kinnow Mandarin Under Drip Irrigation System. ISHS Acta Horticulturae 1015: International CIPA Conference 2012 on Plasticulture for a Green Planet. doi: 10.17660/ActaHortic.2014.1015.37

Loewe V, Delard C. 2016. Effect of irrigation in growth and fruit production in stone pine (*Pinus pinea* L.) in Chile. Acta Hortic 1130:537-44. doi: 10. 17660/ActaHortic.2016.1130.81.

Marschner H. 1986. Mineral Nutrition of Higher Plants. Orlando (US): Academy Press. 674 p.

Ortola MP, Andre D, Jerry WK. 2016. Modeling Irrigation and Fertilizer Use for Chlorophyll Production. (Abstract). Grassland Science 62(2). https://doi.org/10.1111/grs.12116

Pangaribuan DH, Kus H, Sheilla RE, Ade Y. 2018. The Effect of Organic Fertilizer and Urea Fertilizer on Growth Yield and Quality of Sweet Corn and Soil Health. Asian J Agri Biol 6(3):335-44.

Pérez-Ortolá M, Andre D, Jerry WK. 2016. Modelling irrigation and fertiliser use for chlorophyll production. Grassland Science 62(2):102-11. doi:101111/ grs.12116

Rai IN, Semarajaya CGA, Wiraatmaja IW. 2010a. Phenology Study of Fertilization of Salak Granulated Sugar as an Effort to Overcome Fruit-Set Failure. J Hort 20(3):216-22.

Rai IN, Wiraatmaja W, Semarajaya CGA, Astiari NKA. 2014. Application of Drip Irrigation Technology for Producing Fruit of Salak 'Gula Pasir' (*Salacca zalacca* var. *Gula Pasir*) off Season on Dry Land. JDMLM 2(1):219-22. doi: 10.15243/ jdmlm. 2014. 021.219.

Ramadhan RA, Baskara WM, Suryanto A. 2015. The Effect of Nitrogen Phosphor Potassium Fertilizer Treatment To The Fruit Set of Sweet Orange (*Citrus sinensis* Osb.) Var. Pacitan. Jurnal Produksi Tanaman 3(3).

Salisbury FB, Ross CW. 2012. Plant Physiology. 4th Edition. Terjemahan Lukman dan Sumaryono Jilid III. Perkembangan Tumbuhan dan Fisiologi Lingkungan. Bandung (ID): Penerbit ITB. 343 h.

Sudaryono T. 2005. The production technology of Salak Suwaru off season. Agricultural Sciences. [Disertation]. Yogyakarta (ID): Gajah Mada University.

Sukewijaya IM, Rai IN, Mahendra MS. 2009. Development of *salak bali* as an organic fruit. As J Food Ag Ind Special Issue: 37-43.

Sumantra IK. 2011. Increasing the Quality of Salak Granulated Fruit through the Supply of Water and Compound Fertilizers. Denpasar (ID): Faculty of Agriculture. Universitas Mahasaraswati.

Sunarka IK. 2015. Effect of Drip Irrigation and Antitraspirant Chitosan Concentration on Fertilization and Production of Salak Gula Pasir Off Season. [Thesis]. Denpasar (ID): Agrotechnology Study Program, Graduate Program, Universitas Udayana.

Vargas OL, David RB. 2015. Growth and Fruit Production of Highbush Blueberry Fertilized with Ammonium Sulfate and Urea Applied by Fertigation or as Granular Fertilizer. Hortscience 50(3):479-85.

Wang Z, Qingyong B, Jinzhu Z, Bo Z. 2018. Optimized Water and Fertilizer Management of Mature Jujube in Xinjiang Arid Area Using Drip Irrigation. Water J 10:1467.

Zhong D, Bai D. 2013. Effects of water and nitrogen regulation on the yield and water and nitrogen use efficiency of cotton in south Xinjiang, Northwest China under plastic mulched drip irrigation. Chin J Appl Ecol 24(9):2525-32.

Zhuan Y, Yang G, Shen XJ. 2017. Effects of nitrogen and irrigation water application on yield, water and nitrogen utilization and soil nitrate nitrogen accumulation in summer cotton. Chin J Appl Ecol 28(12):3945-54.