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

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ABSTRACT

Sidimpuan snake fruit is one of the local specialties of Padangsidimpuan City in Sumatra. The fruit is known for its sweet, sour and astringent taste which differentiates it from Pondoh and Balinese snake fruit. However, snake fruit farmers have been experiencing an increasing failure rate of fruit-set during the off-season which has led to a decrease in production. Use fertilization and drip irrigation in the off-season has been suggested as a solution. This research investigates the use of these to overcome the failure of fruit set to optimize production of Sidimpuan snake fruit throughout the year by determining the optimal dosage of ammonium sulfate fertilizer and drip irrigation for fruit set and production in the off-season. This research used a split-plot design with the main plot for drip irrigation and the subplot for ammonium sulfate. Observation parameters include the number of flower and fruit bunches, fruit set percentage and a nutrient analysis of the leaves. The results revealed that drip irrigation had a significant effect on the observed variables of fruit set and number of harvested fruit bunches. Drip irrigation had a significant effect on the fruit set percentage and the number of harvested fruit bunches. The best combination of treatments was also discovered to be 400 g ammonium sulfate fertilizer per plant and drip irrigation 3000 ml/plant. The fertilization period of July-Sept gave an off season harvest that was able to match the fruit set percentage (10.76% difference) and number of fruit bunches that were formed (25.65% difference) by the April-June fertilization for the on-season harvest demonstrating that drip irrigation and ammonium sulfate can overcome fruit set failure in Sidimpuan snake fruit 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 of Padang Sidimpuan City which has a unique taste sweet, astringent and sour, differing from Pondoh snake fruit, Balinese snake fruit and other types of snake fruit. Sidimpuan snake fruit plants are spread throughout the sub-districts in the southern part of the Tapanuli Regency. The center of Sidimpuan snake fruit production is the Districts of Angkola Barat, East Angkola, South Angkola, and Marancar.

Sidimpuan snake fruit production has high development potential in South Tapanuli and covers approximately 19,155 ha with a production potential of up to 30 tons/ha (BPS, 2015). The application of optimal cultivation technology will enable this production potential to be achieved. At present, the crop suffers from high production fluctuations between the main harvest season (in

season) and a reduced harvest outside this harvest season (off season) which has been resulting in a continuous decline in production.

The reason for this decreasing production is fruit-set failure in the off season which could be caused by a number of less than optimal environmental factors. Rai et al. (2010) has found that failure of fruit set is caused by environmental factors that do not support the process, which include low rainfall and few rainy days, and low soil nutrient content so that the plants lack vital nutrients as indicated by low nitrogen, phosfor and potassium content in the leaves.

The solution to this problem is the use of off-season treatments to support the Sidimpuan snake fruit to bear well outside the main harvest season. These include supplementation of nutrients through the application of fertilizers and irrigation with a simple drip irrigation technique. Fertilization with ammonium sulfate and potassium chloride and simple drip irrigation are expected to meet nutritional and water requirements for Sidimpuan snake fruit out of season so increasing growth, fruit formation and production. Based of research Rai et al (2010), under drip irrigation has found the high percentage of fruit-set were 75.30%, while that no drip irrigation were 59.94% .

Ammonium sulfate fertilizer provides nitrogen and sulfur and potassium chloride fertilizer is a main source of potassium which plays a role in plant growth and development.
Sudaryono (2005) has stated the availability of nitrogen and sulfur nutrients by fertilizing ammonium sulfate at a dose of 300 g had increased Suwaru snake fruit production. The application of simple drip irrigation can meet water requirements for the plants efficiently and optimally.

This study was aimed to obtain the best dosage of ammonium sulfate fertilizer and simple drip irrigation techniques to optimize fruit set and increase the production of Sidimpuan snake fruit in the off-season so it can produce fruit optimally throughout the year.

MATERIALS AND METHODS

Time and location of research

The present study was conducted in Palopat Maria village Padangsidimpuan Hutaimbaru subdistrict, Padangsidimpuan City (between 010 28', 19'' – 010 18' 07'' Lintang Utara dan 990 18' 53'' - 990 20' 35'' Bujur Timur). The study was conducted from April 2018 until September 2018

Research methodology

The study used an experimental method with split plot design, consisting of three replications. The materials used in this study included 20 to 30-year-old productive snake fruit trees. The main plot used irrigation with the application of drip irrigation technique with either no irrigation (P_0) or 3000 ml/plant/ day (P_1). Equipment to make the simple drip irrigation installation included infusion

bottles, infusion tubes, drippers, plastic hoses and water pumps. Fertilizer subplots consisted of plots without fertilization (P_0), ammonium sulfate fertilizer 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), 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, 60 plants in all. Fertilization applications during this research were carried out in 2 periods were April - June 2018, fertilization had been carried out in March 14th and July - September 2018, fertilization had been carried out in July 22nd. Previously, fertilization had been carried out in August 2017 and December 2017.

Fertilization application 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 soil 50-60 cm from the base of the stem. Watering was a simple irrigation system that was water movement carried out by gravity. Drip irrigation equipment included a plastic tub 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. The watering volume was 3000 ml/day. The drip irrigating has given daily for 6 hours from 10 am - 4 pm, if it rains very heavily, the application of drip irrigation is not carried out.

The observed parameters were fruit-set percentage, number of flower and fruit bunches, number of harvested fruit bunches, relative water content (RWC) and Nitrogen, Phosfor and Potassium on leaves. The number of flower bunches and fruits counted once / two weeks on each sample plant. Analysis of leaf nitrogen, phosfor and potassium content was carried out once each fertilizer period. Three leaves from each sample plant were taken for laboratory analysis. Leaves were cleaned then dried with an oven at 70^0C, then blended and sieved with a sieve with a hole size of 0.5 mm. Determination of total nitrogen was done using the kjeldahl semi-micro method. Determination of phosfor and potassium content used the dry ashing method. phosfor concentration was measured with a UV-VIS spectrophotometer and potassium with a flame photometer. Data were analyzed using analysis of variance. If the F test showed the difference in treatment was significant, then it was further analyzed using Duncan's multiple range test.

RESULTS AND DICUSSION

Fruit set percentage (%)

In the April-June fertilization period (on season), it was found that the fruit set percentage had significantly affected by drip irrigation and the dose of ammonium sulfate fertilizer. The single factor treatment of drip irrigation application gave the highest response with the percentage of fruit formation of 76.949% compared to 68.673% for no irrigation. The fertilizer dosage that gave the best

response based on the percentage fruit set, was 300 g / plant, at 75.615%. Whereas, the lowest response was from no irrigation or fertilization (Table 1). Drip irrigation increased the relative water content of leaves. According to Sunarka (2015), the high fruit-set with drip irrigation is a result of the high relative water content (RWC) of leaves which has an impact on the content of chlorophyll and potassium. Watering the soil improves its chemical properties encouraging root growth and increasing physiological activity in snake fruit plants and these chemicals can then be utilized by snake fruit plants to improve fruit - set.

In the July-September fertilization period (off season), it was found that the fruit set percentage was not significantly affected by drip irrigation treatment. This was during the wet season, so the provision of additional water was not necessary. Adijaya et al. (2013) noted that number of bunches formed and flower fall is influenced by environmental factors. In the dry months, there is an increase in the flower fall reducing the number of bunches formed. Ammonium sulfate fertilization also had a statistically significant impact on fruit set with the highest response from 400 g per plant (77.792%).

In the second period of this study, it was found that the treatment of drip irrigation resulted in a significantly higher fruit set percentage. Drip irrigation is known to be helpful in out of season fruit production in dry conditions (Rai, et al. 2014). With drip irrigation, the percentage of fruit set was found to be 75.30% and 93.13 % respectively, compared to 59.94% and 61.67%, without irrigation.

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. However, it appeared that the combination of treatments that resulted in the best percentage of fruit set in the April-June fertilization period was a treatment of 350 g fertilizer per plant and drip irrigation (91.667%). Whereas, in the fertilization period of July-September, the highest percentage of fruit set was with 400 g and drip irrigation (83.997%) (Table 2). Zhong and Bai (2013) also found that a combination of nitrogen fertilizer and drip irrigation on cotton plants had significant effects on cotton yield. Moreover, the ratio of dry matter in nutritional organs to reproductive organs under medium irrigation was found to increase.

Table 1 The average percentage of fruit set, number of flower bunches, fruit and number of harvested fruit bunches in response to each drip irrigation treatment and dosage of ammonium sulfate fertilizer application period 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 within a column followed by different letters are significantly different and same letters are no significantly different at $p \leq 0.05$, with comparisons performed using DMRT.

The application of ammonium sulfate fertilization and drip irrigation appeared to increase the percentage of fruit set in both periods of fertilization. It is expected that the application of production techniques of this season would later be able to minimize the fluctuations in snake fruit production between the harvest season (on season) and small harvests (off season). Experimental results showed that both irrigation and nitrogen fertilization promoted cotton growth and yield obviously. (Zhuan et. al, 2017). Drip irrigation application was also found to increase in the percentage of fruit set of Gula Pasir snake fruit off season dryland (Rai et al, 2014).

Number of flower bunches

During the fertilization period of April - June, it was found out that flower formation was significantly affected by drip irrigation treatment as a single factor (Table 1). No irrigation resulted in the best flower formation of 19.267 bunches. Ammonium sulfate fertilizer at 300 g gave the highest average number of flowers with18.667 bunches.

Table 2 Average fruit set percentage (%), in response to combination of dripp irrigation treatment and Ammonium Sulphate fertilizer dosage fertilization period April – June 2018 (I) and July - September 2018 (II)

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		

During the period of fertilization July – September, it was found that flower formation was not significantly influenced by drip irrigation or fertilizer dosage (Table 1). However, there was a tendency for more flower bunches with no irrigation. This absence of significant difference with irrigation is similar to that found by Jose et al. (2013) who used regulated deficit irrigation techniques to improve fruit size. Deficit 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 could probably be caused by variable atmospheric conditions during vegetation periods (Greiner and Kohl, 2014).

There was no significant relationship between fertilizer dose and the number of flowers formed. Ramadhan et al. (2015), also found that the application of phosfor and potassium compound fertilizer at certain doses only had a small effect on the number of flowers in sweet orange plants. Other factors that cause unfertilized plants to flower as prolifically as those treated with fertilizer could be irrigation factors and less than optimal water management.

Table 3 Average amount of flower bunches, in response to combination of drip irrigation treatment and dosage of fertilizer Ammonium Sulfate fertilization period April - June 2018 (I) and July - September 2018 (II).

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		

There was no significant effect on the number of flower bunches from the combination of drip irrigation and ammonium sulfate fertilizer dosage. New flower buds formed spontaneously every 1 - 1.5 months at the base of the midrib leaf (Adelina, 2017), uninfluenced by the combination of irrigation and fertilization treatments. Furthermore, it had been assumed that the two treatments would influence when the new flower bunch buds grew until the fruit bunches were formed until finally, the fruit bunches were ready to harvest (Table 3). Ramadhan et al. (2015) also found that the application of compound fertilizer for phosfor and potassium at certain doses had minimal effect on the number of flowers in sweet orange plants.

Number of fruit bunches

Analysis of variance showed that drip irrigation had no significant effect on the number of fruit bunches in the April-June fertilization period. Irrigated plants produced an average of 12.733 bunches. In contrast, Loewe and Delard (2016), found irrigation had a significant effect both on growth traits and fruit production and concluded that drip irrigation was important in zones with water limitations.

The dosage of ammonium sulfate fertilizer did have a significant effect but the best dose appeared to be 400 g of 13.000 bunches of fruit, with 250 g of fertilizer only 10.500 bunches of fruit were formed (Table 1).

During the July-September fertilization period, it was found that drip irrigation had no significant effect on the number of fruit bunches but drip irrigation appeared to give a slightly higher number of fruit bunches (9.467) compared to no irrigation (8.467) (Table 1). In the July-September fertilization period, there is sufficient rain so irrigation was not expected to be important in determining the number of fruit formed. Biswas, et., al. (2016) stated The application of drip irrigation is effective during the dry season rather than the rainy season of irrigation were significantly. The yield of tomato increased with the increasing amount of irrigation water.

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

Table 4 Average amount of fruit bunches, in response to combination of drip irrigation treatment and dosage of fertilizer Ammonium Sulfate fertilization period April - June 2018 (I) and July - September 2018 (II)

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		

245

246 During the April-June fertilization period, the combination of treatments that resulted in the
247 largest number of fruit bunches formed was drip irrigation with 300 g fertilizer (15.667 bunches of
248 fruit) (Table 4). Wang et., al. (2018), resulted that, the interacted and coupled effects of irrigation
249 and fertilization influenced most of the physiological indicators and growth indexes. The same results
250 were in the study of Chauhdary, et., al. (2017), recommended that corn should be fertilized with
251 daily drip irrigation frequency for economically better production in the semi-arid area.

252

253 **Number of harvested fruit bunches**

254 In the April-June fertilization period, it was found that neither drip irrigation or dose of
255 ammonium sulfate fertilizer had a significant effect on number of harvested fruit bunches. However,
256 drip irrigation and 400 g of fertilizer appeared to give the best results with 12.067 and 14.333 bunches
257 of harvested fruit respectively compared to 9.000 bunches from the 250 g of fertilized plants (Table
258 1). Ammonium sulfate fertilizer is the main source of nitrogen nutrients has an important role in the
259 process of increasing crop production, as the results of research Alil et al., (2015) nitrogen application
260 increased seed yield in a linear manner and 60 kg ha-1 improved yield by 40% as compared to control.

261 In the period of July - September fertilization, drip irrigation had a statistically significant
262 effect on number of fruit bunches while dose of ammonium sulfate fertilizer did not. Drip irrigation
263 resulted in 18.200 bunches. Rai et al. (2013) also found that plants given drip irrigation treatment
264 produced a higher number of harvest bunches compared to plants that were not given drip irrigation.
265 In ammonium sulfate fertilizer dose which appeared to give the best yield was 350 g (8.000 bunches
266 of harvested fruit) compared to 12.467 bunches from non-irrigated unfertilized plants (Table 1).

267 No significant effect was observed from the combination of irrigation treatment and
268 ammonium sulfate fertilizer dosage on the number of harvested fruit bunches which means that there
269 were no real interactions between the two treatments on the number of harvested fruit bunches.
270 However, 22.667 fruit bunches resulted from a combination of 400 g fertilizer with drip irrigation
271 and 7.000 bunches from no drip irrigation and 250 g (Table 5). The lack of influence of ammonium
272 sulfate fertilization suggests that drip irrigation alone able to meet the needs of Sidimpuan snake fruit
273 plants. This opinion was supported by the results of research conducted by Dewi (2014) who found
274 out that the effect of organic fertilization on snake fruit plants were increasing the percentage of fruit
275 sets (fruit ability to be fruit). Rai et al. (2010) found that the failure of developing flowers to become

fruit on Gula Pasir snake fruit was more likely to be caused by other environmental and physiological factors of plants than application of fertilization.

Table 5 Average harvest fruit bunches, in response to combination of drip irrigation treatment and dosage of fertilizer Ammonium Sulfate fertilization period April - June 2018 (I) and July - September 2018 (II)

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	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		

Cahyani et al. (2013) found that the pattern of production and distribution of snake fruit plant development is strongly influenced by physiographic environments such as altitude, land, rainfall, air temperature. The environmental factors referred to, include low rainfall and rainy days which cause the Relative Water Content of leaves to be low so that it disrupts the process of metabolism, whereas physiological factors namely photosynthetic deficiency are indicated by sucrose content, total sugar, and reducing sugar at low interest.

In figure 1, the average relative water content (RWC) of leaves in the July-Sept period is higher than the relative water content of leaves in the April-June period. The positive impact resulted in a higher average number of fruit bunches harvested in the July-Sept period with the application of drip irrigation. The results of Benhmimou et al (2018) have also shown that irrigation applications resulted in an increase in greater fresh biomass, fresh leaf yield and dry leaf yield in stevia.. 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 ability of plant to uptake nutrients (Rai et al. 2014).

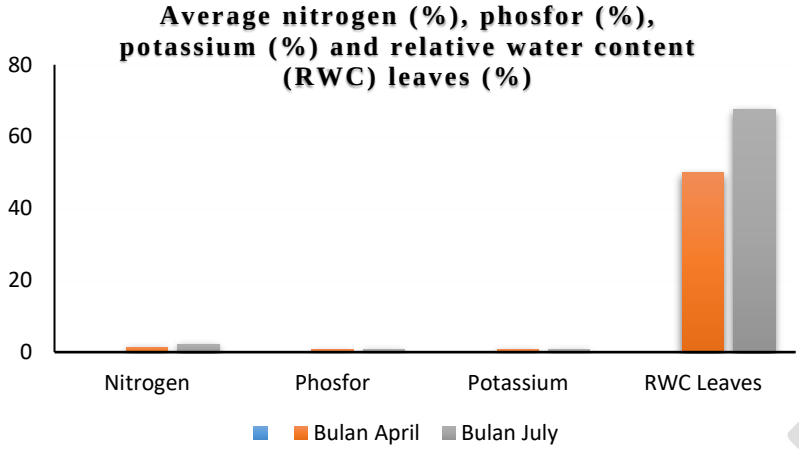

Figure 1 Average content of nitrogen, phosfor, potassium and relative water content of leaves in the April-June and July-September 2018 fertilization period

The nitrogen, phosfor, potassium content and relative water content of leaves in the July-September fertilization period was higher than that of April - June 2018. Very high differences were found in the nitrogen content and relative water content of leaves (Fig. 1). The leaf nitrogen content in the July-September fertilization period was 2.194% higher than the April-June fertilization period which was 1.384%. Nitrogen content and relative water content 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 the fertilization period April-June 2018. Rai et al. (2010) and Dewi (2014) both found that low productivity of Gula Pasir snake fruit was influenced by the low nutrient level of nitrogen in the leaves. This nutrient deficiency influences the physiological processes of plants which causing failure of flowers to develop into fruit due to photosynthate deficiency indicated by sucrose content, total sugar, and reducing sugars in the 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, phosfor, 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 plays a role in plant growth and development (Marschner 1986). If the production process is not balanced with the management of nutrients generally, it will cause a decrease in production. Nutrient content of nitrogen and phosfor for Sidimpuan snake fruit leaves has been found to be higher than the nutrient content of nitrogen and phosfor for leaves of pondoh and sumedang but the potassium content was lower (Islami, 2014). Nitrogen status is related to leaf water content (Fig. 1) which also influences the formation of chlorophyll. Wang et., al. (2018) has shown that drip irrigation, increased the maximum chlorophyll content and photosynthetic nitrogen use efficiency. For chlorophyll production a schedule combining drip irrigation with 300 kg Nitrogen ha^{-1} was shown to provide the highest average chlorophyll

production (an increase of 62% above non-irrigated levels (Perez-Ortola et al. 2016). Nitrogen can then be absorbed by plants and play a role in the chlorophyll formation which is indicated by an increase in the green color of the leaf (Pangaribuan et al. 2018).

Fertilization increases the availability of soil nutrients for the plants to absorb. Adelina et al., (2018) who found that the average nitrogen and potassium levels of Sidimpuan snake fruit leaves before fertilization were lower than after application of ammonium sulfate fertilization. The higher the frequency of fertilization, the more guaranteed the availability of nutrients in the soil for the plant to draw on for plant growth and development (Vargas and David, 2015). The lack of response to fertilizer in this research may be because the plants need nutrients continuously throughout the year so 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 fertilizer. Hence, it may be possible to increase the fruit set and production of Sidimpuan snake fruit.

CONCLUSION

Drip irrigation over the off season (July-Sept) improved both fruit set and the number of harvested fruit bunches. The best treatment was found to be drip irrigation application of 3000 ml / plant / day, compared to no drip irrigation. As a single factor, each ammonium sulfate fertilization treatment and drip irrigation application significantly influenced the percentage of fruit sets and number of fruit bunches formed. There was no statistically significant interaction between irrigation and fertilization. However, based on the average number, the combination of treatments that gave the best response was obtained at the fertilizer dose of ammonium sulfate 400 g / plant. Through the application of drip irrigation, it was found that the off-season harvest (July-Sep) was able to match the fruit set percentage and number of fruit bunches formed in April-June fertilization, main harvest season.

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