Modified Off–Season Technology to the Flowering Time and Fruit Yield of *Arumanis* Mango (*Mangifera indica* L.)

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Abstract. The purpose of this study was to observe the technology of mango fruit production at off-season used growth regulators. The research was conducted with three treatments namely: i) Paclobutrazol dosage (control, 5 mL L^{-1} per tree, 10 mL L^{-1} per tree and 15 L^{-1} per tree). ii) Ethephon dosages (0 mL L^{-1} per tree, 400 mL L^{-1} per tree, 600 mL L^{-1} per tree and 800 mL L^{-1} per tree) that applied 1 mo after paclobutrazol addition. iii) Paclobutrazol (P) and organic fertilizer (F) application in combination as follows: (control, 5 mL + 10 kg, 10 mL + 15 kg, 15 mL + 20 kg) Randomized Completely Block Designed (RCBD) with five replications was used. The results indicated that i) Paclobutrazol application accelerated the flowering age, shortens the panicle length, and increased fruit yield of the tree. ii) Giving Ethephon accelerated the flowering period, enhanced both the panicles number and yields. The treatment of ethephones 600 mL L^{-1} produced the highest fruit weight, 182.60 kg, respectively iii) The Paclobutrazol and organic fertilizer application indicated significantly ($p < 0.05$) to the panicles number and the fruit weight yield is higher than the control.

Keywords: Ethephon, forcing, organic fertilizer, paclobutrazol, ripener

1 Introduction

Indonesian mango production was increase 2 203 793 t in 2017 to 2 624 791 t in 2018 and the rank is 6th in the world after India, China, Thailand, Pakistan and Mexico [1]. While, in 2011 mango production reached 2 129 608 t, while the exports were 1 485 t, and imports were 989 t. This gap in mango production and export volume indicated that Indonesia's mango is less competitive in the global market [2]. This condition is caused due to i) incompatibility of Indonesian mango quality specifications to world market demand,

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ii) there isn't available comprehensive seed testing system, which able to guarantee the product uniformity, iii) there isn't sustainable breeding program, iv) the farmers didn't apply technological innovation yet, and v) there isn't an institutional system which integrates mango agribusiness component.

Arumanis-143 is one of Indonesia's mango varieties that able to meet market needs for both domestic and export demand. This variety was released in 1985 and in 1990 began to expand widely with the plantation scale business establishment. It was followed in the next 5 yr, *Arumanis*-143 dominated fruit business. However, the productivity and quality of *Arumanis* variety are still low. Technological innovation is needed in regulation out-of-season fruit and fruit wrapping which is still ignored by farmers in Indonesia.

Paclobutrazol is a plant growth regulator and retardant member of triazole fungicide which has antagonist reaction with gibberellin biosynthesis by blocking oxidation from kauren to acid. Paclobutrazol is mainly located in the xylem and accumulated in the leaf [3]. Paclobutrazol can be used to regulate the flowering and fruiting season of *Arumanis* mangoes one week earlier. It is able to enhance flowering branches 8 % to 10 % but has not been able to increase fruiting branches [4]. The Paclobutrazol + organic fertilizer and Ethephon have not been applied yet on *Arumanis* mangoes. Moreover, the addition of fertilizer also important for improving plant growth by repairing soil fertility [5]. This study aimed to determine the technology of mango fruit production at off-season used growth regulators namely Paclobutrazol, Ethephon, and Paclobutrazol + organic fertilizer application on the Arumanis mango plant.

2 Material and methods

The study was conducted in the mango plantation owned by PT. Friga in Pasuruan Regency, Indonesia. The agro-ecological conditions of the location were ± 50 m.a.s.l, the soil type was complex Lathosol soil, climate type D, rainfall 1 332 mm yr^{-1} with 99 rainy days, average temperature 27 ºC (21 ºC to 34 ºC) and 65 % relative humidity. The study was conducted in March to October 2018. The maturity of mango plants that used was 25 yr old. The main materials for plant nutrition were used manure, urea, SP-36, KCL, ZK, NPK and for plant protection used active ingredients azoxitrobil 200 g L^{-1}, diphenoconazole 125 g L^{-1}, moncozeb 80 % with concentration 2 cc L^{-1} to control fungi. The pest control used sipertrin 50 g L^{-1} with concentration 2 cc L^{-1}. The equipment of the pest control used hand sprayer, power sprayer, bucket, stirrer, scale, measuring cup, brush, knife, pruning scissors, and chainsaw), hose, caliper, ruler, scales, bags, plastic, and plant labels.

This research applied Randomized Completely Block Designed on three stages namely: i) Paclobutrazol doses application, (control, 5 mL L^{-1} per tree, 10 mL L^{-1} per tree and 15 mL L^{-1} per tree. ii) Ethephon doses treatment (control, 400 mL L^{-1} per tree, 600 mL L^{-1} per tree, and 800 mL L^{-1} per tree) that applied at 1 mo after paclobutrazol application, and iii) Combination of paclobutrazol (P) and organic fertilizer (F) application (control, 5 mL P + 10 kg F, 10 mL P + 15 kg F, 15 mL P + 20 kg F). Paclobutrazol was applied in dosage according to the treatment and splashed around the plants. Before application, the surrounding soil was cleaned from weeds and other impurities, and implemented in the morning. The parameters observed consisted: i) Flowering (flowering time, flower panicles number, panicle length, panicle width and a number of immature panicles), and ii) crop yields (fruit number, fruit total weight, fruit length and diameter). Furthermore, the data were analyzed by Analysis of Variance (ANOVA) and followed by Least Significant Difference test (LSD).

3 Results and discussions

3.1 Effect of paclobutrazol on flowering and mango yield

The results showed that paclobutrazol accelerated flowering and increased mango yield compared to control (Table 1 and Table 2). The data indicated that faster flowering time after paclobutrazol application, higher more panicles, but crammed panicle widths and a smaller number of immature panicles than without paclobutrazol (control). This result, in accordance to the Totapuri cultivar [6]. Paclobutrazol application gave a significant effect on the fruit number and total weight. But it was no significant difference in the fruit length and diameter. The results were consistent with the study that the application of paclobutrazol 5 mL L^{-1} on a 5 yr old hybrid mango could accelerate the flowering time and increased the number of fruits [7]. Moreover, it also increased Alphonso cultivar [4], Miska cultivar, Mohmoudi cultivar, Totocombo culviar [8] Lechi yield [9]. In Uba mango, paclobutrazol branch tip pruning also enhanched the flowering up to 30 % [10].

Table 1. The effect of paclobutrazol to the flowering parameters

Paclobutrazol (mL L^{-1})	Flowering Parameter				
	Flowering time (d)	Number of panicles	Panicles length	Panicles width	Immature panicles
0	51.27 b	55.6 a	51.27 b	25.4 b	21.6 c
5	49.40 ab	454.6 b	49.40 ab	20.1 a	17.3 ab
10	47.13 a	438.2 b	47.13 a	20.0 a	18.8 b
15	50.13 b	499.6 b	50.13 b	19.4 a	16.1 a
LSD 5 %	2.75	125.95	2.75	3.74	2.24

Noted: The value followed by the same letter in the same column wasn't significantly different according to Duncan's Test ≤ 5 %

Table 2. The effect of paclobutrazol to the fruit yields

Paclobutrazol (mL L^{-1})	Fruit number	Total weight (g)	Length (cm)	Diameter (cm)
0	4.8 a	2.3 a	14.17 a	7.91 a
5	166.6 b	62.7 b	13.26 a	7.48 a
10	176.4 b	65.5 b	13.28 a	7.63 a
15	145.6 b	56.0 b	13.75 a	7.73 a
LSD 5 %	57.12	19.88	1.58	0.36

Noted: The value followed by the same letter in the same column wasn't significantly different according to Duncan's Test ≤ 5 %

3.2 Effect of ethephon on flowering and mango yield

The results indicated that ethephon application increased the number of flower panicles compared without ethephon (control). It also was significantly enhanced the fruit number and yields per tree. Ethephon was reported as one of the buds dormancy breakers that could accelerate flowering in mango [4]. Giving ethephon 400 mL L^{-1} and 600 mL L^{-1} showed a higher yield of mangoes (Tables 3 and Table 4). Blaikie et al. explained that dormant plants could not initiate flowers even though flower buds were induced [3]. The solution is plants have been induced should be given a dormant-breaking agent, therefore it can accelerate the emergence of flower buds. Tandel et al. concluded that spraying ethephon one month after giving paclobutrazol to mangoes, produced the most flowers than control [4]. Giving 400 mL L^{-1} ethephon, a month after being treated with paclobutrazol produces the highest number of flower buds and the fastest flowering time.

Table 3. The effect of ethephon to the flowering parameters

Ethephon (mL L^{-1})	Flowering parameter				
	Number of panicles	Panicles length	Panicles width	Panicles diameter	Immature panicles
0	49.20 a	50.00 c	24.67 a	4.56 a	20.80 b
400	384.40 b	44.27 a	24.53 a	4.48 a	17.27 a
600	315.40 b	45.27b	22.93 a	4.36 a	18.13 a
800	286.80 b	47.67 bc	24.11 a	4.51 a	19.13 a
LSD 5 %	122.80	3.18	2.63	0.15	2.48

Noted: The value followed by the same letter in the same column wasn't significantly different according to Duncan's Test ≤ 5 %

Table 4. The effect of ethephon to the fruit yields

Ethephon (mL L^{-1})	Fruit number	Fruit weight (g)	Weight/tree (kg)
0	59.40 a	397.26 a	23.54 a
400	173.60 b	414.80 a	70.50 bc
600	182.60 c	420.60 a	88.00 c
800	107.60 b	409.60 a	45.00 ab
LSD 5 %	66.84	25	33

Noted: The value followed by the same letter in the same column wasn't significantly different according to Duncan's Test ≤ 5 %

3.3 Effect of paclobutrazol + organic fertilizer on flowering and mango yield

The application of Paclobutrazol followed by the addition of organic fertilizer into the soil markedly accelerated the flowering and mango yield (Tables 5 and Table 6). The results of this study were in accordance with the previous study. Husen et al. stated that the application of paclobutrazol 5 mL L^{-1} on a 5 yr old hybrid mango could accelerate during flowering, and increased the number of fruit yield [5]. Furthermore, Sarker et al. stated that paclobutrazol could improve fruit yield, quality, and accelerate flowering in Amaprali varieties [2]. This result, was similar to the mangosten [11] and Tommy Atkins mango in Ethiopia [12]. Moreover this is due to Paclobutrazol able to increase the total phenolic of

terminal buds, and alter the phloem to xylem ratio. This alteration is important in vegetative growth resticting and increasing flowering by assimilate partitioning and nutrient supply [12]

Table 5. The effect of paclobutrazol (p) and organic fertilizer to the flowering

Treatment	Flowering Parameter				
	Flowering time (d)	Number of panicles	Panicles length	Panicles width	Immature panicles
Control	71.80 b	19.4 a	51.2 a	28.6 b	22.6 b
P 5ml + F10kg	58.20 a	160.8 ab	36.2 b	25.8 b	29.6 c
P 10ml + F 15kg	56.40 a	238.0 b	33.4 a	19.6 a	23.2 b
P 15ml + F 20 kg	57.60 a	210.6 b	36.4 b	18.6 a	18.4 a
LSD 5 %	2.91	150.24	2.39	3.74	4.05

Noted: The value followed by the same letter in the same column wasn't significantly different according to Duncan's Test ≤ 5 %

Table 6. The effect of paclobutrazol (p) and organic fertilizer (f) to the fruit yields

Treatment	Diameter (cm)	Length (cm)	Total weight (g)	Fruit number	Total weight (kg)
Control	7.44 a	11.90 a	347.8 a	26.4 a	11.6 a
P 5ml + F10kg	7.42 a	11.98 a	388.2 ab	96.4 b	38.1 b
P 10ml + F 15kg	7.51 a	12.34 a	435.6 c	86.2 b	36.1 b
P 15ml + F 20	7.62 a	12.24 a	421.2 bc	142.4 b	52.2 b
LSD 5 %	0.34	0.76	45.03	60.82	21.03

Noted: The value followed by the same letter in the same column wasn't significantly different according to Duncan's Test ≤ 5 %

4 Conclusion

Based on the result, it can be concluded that:

i. Paclobutrazol application accelerated flowering parameters (flowering time, panicle number, panicle length, panicle width, and immature panicle), and increased fruit yield (fruit number and fruit weight) significantly, but insignificant on the length and diameter of fruit.
ii. Giving ethephon accelerated the flowering period, a number of panicles and fruit yields per tree compared to controls. Ethephon concentrations of 400 mL L^{-1} and 600 mL L^{-1} produce the highest weight of the fruit per tree, respectively 70.50 kg and 88.00 kg.
iii. The combination of paclobutrazol and organic fertilizer gave significant effect, and produce higher number of panicles and the fruit yield than control, but insignificant on the fruit diameter and length.

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