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Effect of various ethephon concentrations on flowering, yield, costs and returns of productions of four pineapple varieties

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Abstract Yields of ETP_5 [a mixture of 52% ethephon volume and urea fertilizer (12.5 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time was poured on top of the sucker for one time.] x Battavia and ETP_6 [a mixture of 52% ethephon volume and urea fertilizer (12.5 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time) was poured on the top of the sucker for two times; 5 days interval.] x Phechaburi1 were higher than the other varieties, mainly due to the highest fruit weight and fruit height. Because of the significantly higher fruit weight and fruit height, ETP_5 and ETP_6 yielded significantly higher than the rest of the varieties. Batavia gave the significantly highest yield, fruit weight, and fruit height; followed by Phechaburi 1, Phuket, and MD2, respectively. The total cost of production under the six ethephon concentration levels applied was similar; but benefits derived from each concentration levels were noticeably different due to the different yields obtained. The best concentration level was ETP_6 as it gained the highest returns.

Keywords: Pineapple, Battavia, benefit-cost-ratio

Introduction

Pineapple (*Ananascomosus* L.) is one of the economic plants in Thailand. There were 81,920 hectares (ha) with total yield of 1.94 million tons and average yield was 23.68 tons/ha (Seangsutta, 2014). The inducing of flower is a main problem in pineapple production as affected by the world's climate change. Most farmers in the provinces of Thailand, particularly in the eastern region (Rayong and Chonburi provinces) as well as in the western region (PrachuapKhiri Khan and Phetchaburi 1 provinces), reported that the flower induction pineapple is achieved by only about 30-50%. In fact, it used to obtain at least 80-90% (Klakhuy, 2011). As a result, yield per unit area was low; farmers opted for the use of chemical to induce flowering and therefore raised

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the cost of production, especially the cost of ethephon (2-chloroethylphosphonic acid). Ethephon is a substance which is in a form of liquid, but it can release ethelene gas which help stimulates flowering. The cost of production includes fertilizer, herbicide, water bill, manual labour, electric bill, and others. Moreover, farmers lose their opportunity of increasing the selling price for a higher income. It is necessary to focus on the proper use of ethephon concentration that influences flowering, yield, costs and returns of the four well-known pineapple varieties: Batavia, Phuket (a popular variety that farmers are presently growing in the above-mentioned planting areas), Phetchaburi 1, and MD2. The two latter pineapples are the new varieties that Thai farmers are currently interested on. The use of proper ethephon concentration can effectively induce the flowering of pineapples and lessen the problem encountered as mentioned ealier.

Objective: The study aimed to assess the flowering, yield, costs and returns of 4 pineapple varieties grown under the applications of ethephon with different concentration levels.

Materials and Methods

The experiment was conducted at the experiment station of Rajamangala University of Technology Tawan-Ok Chanthaburi Campus in Chanthaburi, Thailand. The experiment was laid out in a split-plot design in randomized complete block design, replicated 5 times; each time consisted of 30 suckers. Six levels of 52% ethephon volume occupied the main-plot treatments consiting of: (1) $ETP_{1,}$ a mixture of ethephon and urea fertilizer (10 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time) poured on top of the sucker for one time, which is the farmers' common practice; (2) $ETP_{2,}$ a mixture of ethephon and urea fertilizer (10 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time) poured on top of the sucker for two times with5 days interval; (3) $ETP_{3,}$ a mixture of ethephon and urea fertilizer (7.5 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time) poured on top of the sucker for one time; (4) $ETP_{4,}$ a mixture of ethephon and urea fertilizer (7.5 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time) poured on top of the sucker for two times with 5 days interval; (5) $ETP_{5,}$ a mixture of ethephon and urea fertilizer (12.5 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time) was poured on top of the sucker for one time; (6) $ETP_{6,}$ a mixture of ethephon and urea fertilizer (12.5 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time) was poured on the top of the sucker for two times; 5 days interval. While the four pineapple varieties, consisting of Battavia, Phuket, Phetchaburi 1, and MD2, were the sub-plot

treatments. The combination treatments of ethephon concentration level and pineapple variety are presented in Table 1.

Table 1. Twenty four combination of ethephon concentration level and pineapple variety

Ethephon concentration level (ET)	Pineapple Variety (P)			
	Batavia	Phuket	Phetchaburi 1	MD2
ETP_1	ETP_1 x Batavia	ETP_1 x Phuket	ETP_1 x Phetchaburi 1	ETP_1 x MD2
ETP_2	ETP_2 x Batavia	ETP_2 x Phuket	ETP_2 x Phetchaburi 1	ETP_2 x MD2
ETP_3	ETP_3 x Batavia	ETP_3 x Phuket	ETP_3 x Phetchaburi 1	ETP_3 x MD2
ETP_4	ETP_4 x Batavia	ETP_4 x Phuket	ETP_4 x Phetchaburi 1	ETP_4 x MD2
ETP_5	ETP_5 x Batavia	ETP_5 x Phuket	ETP_5 x Phetchaburi 1	ETP_5 x MD2
ETP_6	ETP_6 x Batavia	ETP_6 x Phuket	ETP_6 x Phetchaburi 1	ETP_6 x MD2

The four pineapple varieties with similar sizes [thirty centimeter (cm) tall] and same sucker ages for each variety (900 suckers/variety, totalling of 3,600 suckers) were prepared for planting on the prepared ridge of sandy loam soil which consisted of 1.57% organic matter, pH 4.91, 3.40 mg P/kg, 48.58 mg K/kg, 232.37 mgCa/kg, and 17.81 mg Mg/kg (Suntarvirath *et al.*, 2016). Basal fertilizer was done by applying cow dung pellet with rock phosphate at the ratio of 5:1 by weight, 1,875 kg/ha as basal fertilizer for stimulating root emergence. All suckers were planted on August 14, 2015 and the ethephon were applied to all suckers on August of 2016. All pineapple fruits were lastly harvested (once harvest for each variety) on January 19, 2017. The duration of experiment was in total of 524 days (1 year, 5 months, and 9 days). Suckers with double row planting were implemented in the experimental fields, with double row spacing of 50 cm (the distance between row and row in a double row) and sucker spacing of 30 cm (the distance between sucker and sucker within a row). And the distance between the double row and the other double row was 100 cm. One sucker occupied the planting area of 0.225 m^2, totaling to 810 m^2 for 3,600 suckers [44,443 suckers/ha or plants/ha as the plant density]. First topdressed fertilizers (16-16-16 fertilizer mixed with 46-0-0 fertilizer (urea) at the ratio of 1:1 by weight at root emergence stage) were applied with 10 g/plant. Six months afer planting, second topdressed fertilizers were applied at the base of pineapple plants which consisted of mixture between 16-16-16 fertilizer and

21-0-0 fertilizer (ammonium sulphate) at the ratio of 1:1 by weight, 10 g/plant. Seventy-five days after applying the ethephon to the plants, third topdressed fertilizer with 0-0-60 (potassium chloride) 10 g/plant, were applied at the base of pineapple plants to increase fruit size and sweetness. Water pump with 1 HP (746 W), connected with 2 inches of PVC pipe attached with 9 sprinker heads and each head was placed away from each other for 3 m, was used to irrigate the pineapple plants for 6 times during the dry season, 30 minutes/time, totaling of 30 times; duration period was from November of 2015 to March of 2016. The irrigation was not applied to the pineapple plants during the harvesting period of dry season from November of 2016 to January of 2017. Weed control was done as necessary. No pests and diseases disturbance were observed for the entire growing period. Following is a list of the plant parameters gathered: Flowering durationwas the total number of flowering days counting from the first day of ethephon applied to induce a hundred percent of flowering in a unit of days. Percent of flowering was the total number of plants flowered multiple by a hundred and then divided by the total number of plants grown in a unit of percent (%). Ripening duration was counted from a hundred percent of flowering day to physiological maturity at harvest in a unit of days. Harvesting duration wascounted at the day of planting the suckers until it reached physiological maturity at harvest in a unit of days. Yield was measured by weighing all fruits harvested in the growing areas in a unit of ton/hectare (t/ha). Fruit weight was measured by sampling ten fruits, weighed all the fruits then computed for the average weight of one fruit in a unit of kg per fruit (kg/fruit). Fruit height was measured by using a verniercaliper from the base of fruit shoot to the bottom of the fruit in a unit of centimeter (cm). Fruit diameter was done by using a verniercaliper measured from one edge of a fruit to the opposite edge of the fruit through the center of the fruit in a unit of centimeter (cm). Core width of the pineapple was measured by using a ruler measured from the edge of a core to the other at the center of the fruit in a unit of centimeter (cm). Total soluble solids content (TSSC) was measured by dropping a few amount of extracted pineapple juice on a small glass reticle inside a hand refractometer then read the value of the liquid's refractive index in a unit of a percent brix (% brix). The gross benefits and gross costs were computed in the unit of baht per hectare per single growing season. After that, the benefit-cost ratio (B/C ratio) was also computed as it is the ratio of the gross benefits to the gross costs (Wiangsamut *et al.,* 2015). Returns (Net profit and net loss) were computed as the value of gross benefits minus the value of gross costs in the unit of baht per hectare per single growing season basis. All plant parameters were statistically analyzed through the software Statistix 7 (SXW). Means comparisons were done using the Duncan’s Multiple Range Test (DMRT) at the 0.05 probability

level. Data on costs and benefits of four pineapple varieties derived from different ethephon concentration levels were completed using Simple Benefit-Cost Analysis.

Results

Flowering duration and percent of flowering were observed to have no interaction between ethephon concentration level and pineapple variety after applying ethephon as they could be able to induce a hundred percent of flowering for all the pineapple varieties tested at about 36 days (Tables 2 and 3). There was also no significant difference between the flowering duration and percent of flowering of the four pineapple varieties. The different ethephon concentration levels had no effect on flowering duration and percent of flowering as well.

Ripening duration and harvesting duration had no interaction between ethephon concentration level and pineapple variety (Tables 4 and 5). Ripening duration and harvesting duration at different ethephon concentration levels were not statistically different. Batavia had the significantly longest ripening duration and harvesting duration, followed by MD2, while the significantly shortest ripening duration and harvesting duration were observed with the varieties of Phuket and Phetchaburi1, and their ripening duration and harvesting duration were not statistical difference.

Yield, fruit weight, and fruit height were found to have an interaction between ethephon concentration level and pineapple variety as ETP_5 x Batavia and ETP_6 x Phetchaburi 1 gave yield, fruit weight, and fruit height higher than the rest of the varieties (Tables 6, 7 and 8). Yield, fruit weight, and fruit height under ETP_5 and ETP_6 were significantly higher than those under ETP_1, ETP_2, ETP_3, and ETP_4. Batavia had the significantly highest yield, fruit weight, and fruit height, followed by Phetchaburi 1, Phuket, MD2, respectively.

Fruit diameter and core width of the pineapple were influenced by ethephon concentration level and pineapple variety as fruit diameter and core width of the pineapple under ETP_2 x Phetchaburi 1 and ETP_6 x Phetchaburi 1 were wider than those of the other varieites. While fruit diameter and core width of the pineapple under ETP_1 x MD2 were the narrowest (Tables 9 and 10). Fruit diameter and core width of the pineapple under ETP_6 were found to be wider than those of the other varieties. Phetchaburi1 had the widest fruit diameter and core width of the pineapple, followed by Batavia, Phuket and MD2, respectively.

Total soluble solids content was affected by ethephon concentration level and pineapple variety as ETP_6 x Phuket revealed the highest value (20.40 %

Brix), followed by ETP_2 x Phetchaburi 1(19.32 % Brix) as compared with the rest of the varieties (Table 11). While ETP_3 x MD2 had the lowest value (14.28 % Brix). Ethephon concentration levels had no significant effect on total soluble solids content; the values ranged from 16.64-17.26 % Brix. Total soluble solids contents of Phuket and Phetchaburi 1 were higher than those of Batavia and MD2.

The gross cost of pineapple production under the six different ethephon concentration levels (ETP1, ETP2, ETP3, ETP4, ETP5 and ETP6) was similarly ranged from 234,936 to 241,792 baht/ha (Table 12). ETP_6 contributed to have the highest return (net profit) of production, followed by ETP_5, ETP_2, ETP_4, ETP_1, and ETP_3, respectively. This was mainly in relation to their yields and positively associated with their benefit-cost ratio values.

Table 2. Flowering duration (days)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	36.00^{a}*	36.00^{a}	35.80^{a}	36.00^{a}	35.95^{a}
ETP_2	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}
ETP_3	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}
ETP_4	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}
ETP_5	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}
ETP_6	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}	36.00^{a}
Mean**	36.00^{a}	36.00^{a}	35.97^{a}	36.00^{a}	

*In the table of ETxPV means with the same letter is not significantly different.
**In the column of PS means with the same letter is not significantly different.
***In the row of V means with the same letter is not significantly different.

Table 3. Percent of flowering (%)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	100*	100	100	100	100
ETP_2	100	100	100	100	100
ETP_3	100	100	100	100	100
ETP_4	100	100	100	100	100
ETP_5	100	100	100	100	100
ETP_6	100	100	100	100	100
Mean**	100	100	100	100	

No statistical analysis was made when the values of percent of flowering were same as showed *In the table of ETxPV, **In the column of PS, and ***In the row of V".

Table 4. Ripening duration (days)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	119.00[a]*	93.00[a]	92.80[a]	107.00[a]	132.95[a]
ETP_2	119.00[a]	93.00[a]	93.00[a]	107.00[a]	133.00[a]
ETP_3	119.00[a]	93.00[a]	93.00[a]	107.00[a]	133.00[a]
ETP_4	119.00[a]	93.00[a]	93.00[a]	107.00[a]	133.00[a]
ETP_5	119.00[a]	93.00[a]	93.00[a]	107.00[a]	133.00[a]
ETP_6	119.00[a]	93.00[a]	93.00[a]	107.00[a]	133.00[a]
Mean**	119.00[a]	93.00[c]	92.97[c]	107.00[b]	

*In the table of ETxPV means with the same letter is not significantly different.
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***In the row of V means with the same letter is not significantly different.

Table 5. Harvesting duration (days)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	524.00[a]*	498.00[a]	497.80[a]	512.00[a]	507.95[a]
ETP_2	524.00[a]	498.00[a]	498.00[a]	512.00[a]	508.00[a]
ETP_3	524.00[a]	498.00[a]	498.00[a]	512.00[a]	508.00[a]
ETP_4	524.00[a]	498.00[a]	498.00[a]	512.00[a]	508.00[a]
ETP_5	524.00[a]	498.00[a]	498.00[a]	512.00[a]	508.00[a]
ETP_6	524.00[a]	498.00[a]	498.00[a]	512.00[a]	508.00[a]
Mean**	524.00[a]	498.00[c]	497.97[c]	512.00[b]	

*In the table of ETxPV means with the same letter is not significantly different.
**In the column of PS means with the same letter is not significantly different.
***In the row of V means with the same letter is not significantly different.

Table 6. Yield (t/ha)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	59.49[ab]*	33.00[efg]	38.25[de]	16.82[i]	36.89[b]
ETP_2	48.28[bcd]	31.28[efgh]	47.56[bcd]	24.59[fghi]	37.93[b]
ETP_3	41.95[cde]	37.79[de]	36.71[def]	22.97[ghi]	34.86[b]
ETP_4	54.25[abc]	32.91[efg]	41.77[cde]	22.06[ghi]	37.75[b]
ETP_5	63.11[a]	34.00[efg]	53.71[abc]	18.99[hi]	42.45[a]
ETP_6	59.49[ab]	39.42[de]	62.66[a]	24.23[fghi]	46.45[a]
Mean**	54.43[a]	34.73[c]	46.78[b]	21.61[d]	

*In the table of ETxPV means with the same letter is not significantly different.
**In the column of PS means with the same letter is not significantly different.
***In the row of V means with the same letter is not significantly different.

Table 7. Fruit weight (kg/fruit)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	1.34^{ab}*	0.74^{efg}	0.86^{de}	0.38^{i}	0.83^{b}
ETP_2	1.09^{bcd}	0.70^{efgh}	1.07^{bcd}	0.55^{fghi}	0.85^{b}
ETP_3	0.94^{cde}	0.85^{de}	0.83^{def}	0.52^{ghi}	0.78^{b}
ETP_4	1.22^{abc}	0.74^{efg}	0.94^{cde}	0.50^{ghi}	0.85^{b}
ETP_5	1.42^{a}	0.76^{efg}	1.21^{abc}	0.43^{hi}	0.96^{a}
ETP_6	1.34^{ab}	0.89^{de}	1.41^{a}	0.55^{fghi}	1.05^{a}
Mean**	1.22^{a}	0.78^{c}	1.05^{b}	0.49^{d}	

*In the table of ETxPV means with the same letter is not significantly different.
**In the column of PS means with the same letter is not significantly different.
***In the row of V means with the same letter is not significantly different.

Table 8. Fruit height (cm)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	14.98^{bcd}*	11.78^{efghi}	12.34^{defgh}	8.14^{k}	11.81^{b}
ETP_2	13.94^{cdef}	11.66^{efghi}	12.56^{defgh}	9.54^{hij}	11.93^{b}
ETP_3	12.50^{defgh}	11.04^{fghij}	10.40^{ghij}	9.00^{ijk}	10.74^{c}
ETP_4	14.26^{bcde}	12.48^{defgh}	12.38^{defgh}	8.50^{jk}	11.91^{b}
ETP_5	15.44^{a}	13.60^{cdef}	14.70^{bcd}	8.08^{k}	12.96^{a}
ETP_6	15.24^{ab}	12.92^{defgh}	15.94^{a}	9.26^{ijk}	13.34^{a}
Mean**	14.39^{a}	12.25^{c}	13.05^{b}	8.75^{d}	

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Table 9. Fruit diameter (cm)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	11.46^{bcde}*	10.26^{ghi}	11.50^{bcd}	8.40^{k}	10.41^{c}
ETP_2	11.02^{cdefg}	10.44^{efghi}	12.68^{a}	9.42^{ijk}	10.89^{ab}
ETP_3	10.58^{defgh}	11.04^{cdefg}	11.90^{abc}	9.42^{ijk}	10.74^{bc}
ETP_4	11.30^{cdef}	10.38^{fghi}	11.80^{abc}	9.66^{hij}	10.79^{b}
ETP_5	11.44^{bcde}	10.60^{defgh}	12.44^{ab}	9.22^{jk}	10.93^{ab}
ETP_6	11.36^{cdef}	10.92^{cdefg}	12.82^{a}	9.64^{hij}	11.19^{a}
Mean**	11.19^{b}	10.61^{c}	12.19^{a}	9.29^{d}	

*In the table of ETxPV means with the same letter is not significantly different.
**In the column of PS means with the same letter is not significantly different.
***In the row of V means with the same letter is not significantly different.

Table 10. Core width of the pineapple (cm)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	3.06^{abcd}*	$2.54^{efghijk}$	2.96^{bcdef}	2.12^{k}	2.67^{c}
ETP_2	2.94^{bcdef}	2.74^{defghi}	3.42^{a}	2.24^{jk}	2.84^{ab}
ETP_3	$2.68^{defghij}$	2.84^{cdefg}	3.08^{abcd}	2.32^{ijk}	2.73^{bc}
ETP_4	2.98^{abcde}	$2.64^{defghij}$	3.20^{abc}	2.34^{hijk}	2.79^{abc}
ETP_5	2.90^{bcdefg}	2.48^{ghijk}	3.00^{abcd}	2.24^{jk}	2.66^{c}
ETP_6	2.96^{bcdef}	2.78^{cdefgh}	3.32^{ab}	2.52^{fghijk}	2.90^{a}
Mean**	2.92^{b}	2.67^{c}	3.16^{a}	2.30^{d}	

*In the table of ETxPV means with the same letter is not significantly different.
**In the column of PS means with the same letter is not significantly different.
***In the row of V means with the same letter is not significantly different.

Table 11. Total soluble solids content (% Brix)

Ethephon concentration(ET)	Pineapple Variety (P)				Mean***
	Batavia	Phuket	Phetchaburi 1	MD2	
ETP_1	15.36^{bcdefg}*	18.64^{abcde}	$17.28^{abcdefg}$	$16.52^{abcdefg}$	16.95^{a}
ETP_2	15.44^{bcdefg}	$17.68^{abcdefg}$	19.32^{ab}	$16.60^{abcdefg}$	17.26^{a}
ETP_3	14.56^{fg}	18.68^{abcde}	19.04^{abcd}	14.28^{g}	16.64^{a}
ETP_4	15.24^{cdefg}	18.76^{abcde}	$17.48^{abcdefg}$	15.80^{bcdefg}	16.82^{a}
ETP_5	15.64^{bcdefg}	18.36^{abcdef}	19.16^{abc}	15.84^{bcdefg}	17.25^{a}
ETP_6	14.84^{efg}	20.40^{a}	18.44^{abcdef}	15.12^{defg}	17.20^{a}
Mean**	15.18^{b}	18.75^{a}	18.45^{a}	15.69^{b}	

*In the table of ETxPV means with the same letter is not significantly different.
**In the column of PS means with the same letter is not significantly different.
***In the row of V means with the same letter is not significantly different.

Table 12. Simple cost and return of pineapple production under the different concentrations of ethephon used

Item	Number of Unit	Price/ Unit	Costs and Returns of Pineapple Production under Different Concentrations of Ethephon (Baht/ha)					
			ETP_1	ETP_2	ETP_3	ETP_4	ETP_5	ETP_6
1.Land preparation	1 ha	7,500 Baht	7,500	7,500	7,500	7,500	7,500	7,500
2. Pineapple sucker	44,443 suckers	2 Baht	88,886	88,886	88,886	88,886	88,886	88,886
3. Price of sucker	44,443 suckers	0.5 Baht	22,221	22,221	22,221	22,221	22,221	22,221
4. Ethephon 52%	1.33-3.33 L	250 Baht	333	665	249	499	416	833
5. Urea (46-0-0)	276-329 kg	9 Baht	2,484	2,961	2,484	2,961	2,484	2,961
6. 16-16-16 fertilizer	445 kg	12 Baht	5,340	5,340	5,340	5,340	5,340	5,340

Table 12. Continued…

Item	Number of Unit	Price/ Unit	Costs and Returns of Pineapple Production under Different Concentrations of Ethephon (Baht/ha)					
			ETP_1	ETP_2	ETP_3	ETP_4	ETP_5	ETP_6
7. 21-0-0 fertilizer	223 kg	11 Baht	2,453	2,453	2,453	2,453	2,453	2,453
8. 0-0-60 fertilizer	445 kg	12 Baht	5,340	5,340	5,340	5,340	5,340	5,340
9. Rock phosphate (0-3-0)	312.5 kg	2.5 Baht	781	781	781	781	781	781
10. Cow dung pellet	1,562.5 kg	8 Baht	12,500	12,500	12,500	12,500	12,500	12,500
11. Herbicide	19 L	400 Baht	7,600	7,600	7,600	7,600	7,600	7,600
12. Sprinkler with spin heads and pipes	6.25 set	5,000 Baht	31,250	31,250	31,250	31,250	31,250	31,250
13. Water pump (1 HP)	6 piece	3,500 Baht	21,000	21,000	21,000	21,000	21,000	21,000
14. Electricity bill	67 units	6 Baht	402	402	402	402	402	402
15. Harvest wage	19 persons	500 Baht	9,500	9,500	9,500	9,500	9,500	9,500
16. Transportation based on fruit weight	34,860-46,450 kg	0.50 Baht	18,445	18,965	17,430	18,875	21,225	23,225
Costs (1)			236,035	237,364	234,936	237,108	238,898	241,792
Benefits (2)			295,120	303,440	278,880	302,000	339,600	371,600
Returns (Profit or loss)=(2)-(1)			59,085	66,076	43,944	64,892	100,702	129,808
Benefit-Cost Ratio=(2)÷(1)			1.25	1.28	1.19	1.27	1.42	1.54
Assumption :								
Number of plant/hill			1	1	1	1	1	1
Number of plants (or fruits)/ha(plant)			44,443	44,443	44,443	44,443	44,443	44,443
Times of production			1	1	1	1	1	1
Average yield/ha(kg)			36,890	37,930	34,860	37,750	42,450	46,450

Table 12. Continued…

Item	Number of Unit	Price / Unit	Costs and Returns of Pineapple Production under Different Concentrations of Ethephon (Baht/ha)					
			ETP_1	ETP_2	ETP_3	ETP_4	ETP_5	ETP_6
Average weight/fruit (kg)			0.83	0.85	0.78	0.85	0.96	1.05
Cost/fruit (Baht)			5.31	5.34	5.29	5.34	5.38	5.44
Cost/fruit weight (Baht/kg)			6.40	6.26	6.74	6.28	5.63	5.21
Price of fruits (Baht/kg)			8	8	8	8	8	8

Discussion

Ethephon is a substance that can release ethylene. As six levels of 52% ethephon volume were poured on top of the pineapple plants, the substance could be infiltrated and transported into the plant via the phloem. Consequently it simulated the pineapple plants to flower closely with each variety, making it easy to maintain and harvest.This had no effect on physiological maturity of the fruits as well as on the harvesting time. However, the ripeness and harvesting time of each pineapple varied due to the genetic characteristics of each variety. Batavia had the longest ripening duration of 119 days after flowering and the longest harvesting duration of 524 days after planting, which was followed by MD2, 107 days after flowering and 512 days after planting. While Phuket and Phetchaburi 1 had the shortest ripening duration and fastest harvesting duration, 93 days after flowering and 498 days after planting, respectively. The yield of pineapple was positively correlated with the core width of the pineapple, fruit diameter, fruit height, fruit weight, ripening duration, and harvesting duration. This means that as the yield increases, the core width of the pineapple, fruit diameter, fruit height, fruit weight, ripening duration and harvesting duration also increase. The yield, fruit weight, and fruit height were influenced by the ethephon concentration level and pineapple variety as the yield under ETP_5 x Batavia and ETP_5 x Phetchaburi 1 was higher than those of the other varietiesdue to their higher fruit weight and fruit height obtained. Moreover, the fruit diameter and core width of the pineapple under ETP_6 x Phetchaburi1 were also higher than those of the rest of the varieties. The yields under ETP_5 and

ETP_6 were significantly higher than ETP_1, ETP_2, ETP_3, and ETP_4 mainly due to the high fruit weight and fruit height. Nevertheless, the fruit diameter and core width of the pineapple under ETP_6 were the widest. A mixture of ethephon and urea fertilizer (12.5 ml to 400 g dissolved in 20 L water = 60 ml/sucker/time), or $ETP_{6,}$ was poured on the top of the sucker for two times with 5 days interval. ETP_6 was the best practice to induce flowering of the pineapple as it is considered a good agricultural practice to increase the use of ethephon concontration level together with increasing the use of 46-0-0 urea fertilizer to fulfill a need of the pineapple plants to flower and consequently obtained the high yield. Batavia gave the highest yield because of the highest fruit weight and fruit height, followed by Phetchaburi 1, Phuket and MD2, respectively. Phetchaburi 1 had the second highest yield due to its widest fruit diameter and core width obtained in the pineapple; howeverit having low fruit weight and fruit height, resulted in a lower yield compared with that of Batavia. Total soluble solids content (TSSC) of pineapple was not associated with its yield as the pineapple variety that gave the high yield but with low TSSC, while the variety that had the low yield but with high TSSC. This was mainly due to the genetic characteristics of each pineapple variety. Based on the study, it was concluded that Battavia, Phuket, Phetchaburi 1, and MD2 were able to flower one hundred percent (with flowering age close to each variety), about 36 days after ethephon application. Yields of ETP_5 x Battavia and ETP_6 x Phechaburi 1 were higher than those of the other varieties mainly due to their highest fruit weight and fruit height obtained. ETP_5 and ETP_6 yielded significantly higher than ETP_1, ETP_2, $ETP_{3,}$ and ETP_4 because of the significantly higher fruit weight and fruit height. Battavia gave the significantly highest yield, fruit weight, and fruit height; followed by Phechaburi 1, Phuket, and MD2, respectively. The gross cost of production under the six ethephon concentration levels applied was similar; but benefits derived from each concentration levels were noticeably different due to the different yields obtained. ETP_6 was the best agricultural practice as it gained the highest returns followed by ETP_5, ETP_2, ETP_4, ETP_1 (a farmers' common practice) and ETP_3, respectively, and as indicated by the benefit-cost ratio (B/C ratio). ETP_6 was the most feasible for investment in pineapple production as found in this study indicated by the highest B/C ratio at 1.54. The results agreed with Tongaram (2004); Bangchaud (2001) and Wiangsamut *et al.* (2013) who stated that most of investors would select a project that could gain the net profits based on the value of B/C ratio.

The value of B/C ratio determines the feasibility of the investment: more than 1 could mean that the project is more feasible; equal to 1 could mean that the project is still feasible; whereas the value is less than 1 could mean that it is not feasible for investment because of a possible loss.With this result, it is suggested that ETP_6 could replace the farmers' common practice (ETP_1) in inducing flowering of pineapple, including its lowest cost/fruit weight, highest yield, and better returns of pineapple production.

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