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Comparison of cost and return for rubber farmers on innovations to increase latex production in Ban Khai District, Rayong Province, Thailand

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Abstract The findings revealed important distinctions between the two groups of farmers. Rubber farmers who opted for ethylene gas incurred a total cost of 13,973.50 baht, comprising a total fixed cost of 1,202.02 baht and a total variable cost of 12,771.48 baht. These farmers achieved a total return of 17,955 baht per rai. On the other hand, rubber farmers who refrained from using ethylene gas reported a significantly different financial performance. For this group, the total cost amounted to 9,813.49 baht, consisting of a total fixed cost of 1,202.02 baht and a total variable cost of 8,611.48 baht, while the total return per rai amounted to 10,299.57 baht. Statistical analysis indicated that the total variable costs and returns for rubber cultivation significantly differed between the two groups of farmers at a significant level of .05. However, there was no statistically significant difference in the total fixed costs. Extension services and training programmes should be provided to educate farmers on the proper and safe use of ethylene gas to maximise its benefits and minimise potential risks. Furthermore, further research could explore the long-term sustainability and environmental impact of using ethylene gas in rubber cultivation to better understand its overall implications for the industry.

Keywords: Rubber, Innovation, Latex, Cost, Return

Introduction

Rubber is an economically important crop in Thailand, with approximately one million farming families and businesses being involved in rubber planting areas expanding across every region of the country (Rubber Authority of Thailand, 2020). At the same time, the development of the country's rubber industry has continued to progress, and Thailand has become one of the top rubber exporters in the world (Rubber Authority of Thailand, 2020). However, from 2008 to 2020, the price of rubber showed a continuously decreasing trend (Sowcharoensuk, 2021), significantly affecting the income of rubber farmers (Rubber Authority of Thailand, 2021). The problem could be

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solved by reducing inappropriate planting areas, increasing productivity, and strengthening farmers' agricultural knowledge (Adultananusak and Sangsana, 2019.). Moreover, there is a need to promote industrial-scale rubber farming among growers and find strategies to reduce costs while increasing productivity (Rubber Authority of Thailand, 2020).

Rubber production in Thailand is regarded as one of the country's most significant economic crops compared to other crops (e.g., rice, copra, corn). For example, Rayong Province is a suitable location for cultivating para rubber. Furthermore, rubber trees are easy to grow and require minimal maintenance. The geographical features of Rayong Province are conducive to rubber cultivation. In recent years, rubber production has increased by 0.9% annually. However, in 2024, the Rayong Provincial Finance Office projected a shrinkage in rubber production of 4.7% due to a decrease in the areas open for tapping. In addition, rubber farmers are facing challenges from falling latex prices, nighttime attacks by wild elephants, and the decreasing production of rubber trees throughout their lifespan (Rubber Authority of Thailand, Rayong Province, 2021).

In response, the Rubber Authority of Thailand Rayong is promoting the use of ethylene gas to increase latex production (Rubber Authority of Thailand, 2022). Latex production using ethylene gas was initiated by Malaysian rubber in 1991 to address the labour shortage in Malaysia (Research Institute Rubber Research Institute of Malaysia: RRIM). Similarly, rubber farmers in the southern region of Thailand help to manage produce in the rubber plantation using ethylene gas to stimulate the activity of the ATPase enzyme, which makes the latex flow longer than usual, increasing latex production per tapping time as well as farmers' income (Sdoodee *et al*., 2015).

The current situation compels rubber growers to increase productivity to combat price reduction on the global market. The Rubber Replanting Fund Act was created in response to a request by the Rubber Authority of Thailand (RAOT) to support farmers in the transplantation of high-yielding rubber plants. The selection of high-yielding rubber trees has led to a gradual rise in rubber output, with the RAOT encouraging ethylene stimulation among rubber growers in conjunction with tapping frequency. Land or labour productivity has risen because of the enhanced latex output and decreased tapping frequency brought about by the application of ethylene to the tapping panel (Lacote *et al.,* 2010; Sainoi and Sdoodee, 2012). Given the current situation, the study aimed to assess the viability of using ethylene gas as a yield-inducing innovation in Ban Kahi District, Rayong Province.

Materials and methods

Study area and data collection

Rayong Province is known for its conducive geography and climatic conditions, marking it as a hub for para rubber cultivation. Outperforming other commercial crops, para rubber stands out not only for its economic significance but also because it is easy to cultivate and requires minimum maintenance.

The study involved the collection of data from 25 rubber farmers in Ban Khai District, Rayong Province, divided into two groups: 13 farmers who use ethylene gas and 12 who do not. The questionnaire used to collect information from the target rubber farms consisted of two parts: the social and economic conditions of rubber farmers, and cost-return information on rubber production. The latter included variable costs, fixed costs, total cost per rai (baht per rai), total cost per kilogram, yield per rai (kilogram per rai), and returns.

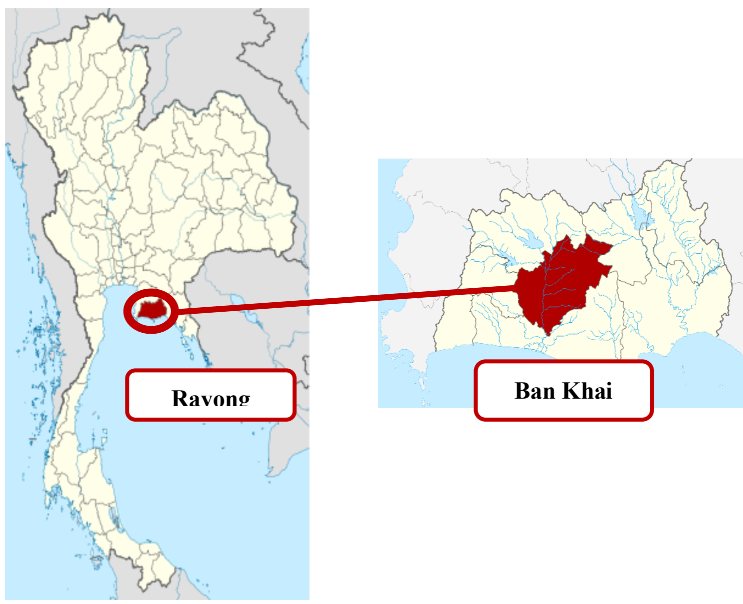

Figure 1. Rayong province map. Accessed from the Wikipedia page, link: https://th.wikipedia.org/wiki/rayong province

Data analysis

The study focused on assessing the financial viability of using ethylene gas in rubber farming, using cost and return analysis. In the analysis, the total cost (TC) refers to direct cash outlays and indirect (non-cash) costs incurred by farmers during the entire cropping period. A key distinction in the analysis is between fixed costs (FCs) and variable costs (VCs). FCs remain the same no matter how much rubber is produced, while VCs change depending on the volume of rubber output. Furthermore, all the expenses are categorised into two types: cash and non-cash. Cash costs represent direct out-of-pocket expenses for farmers, while non-cash costs refer to indirect expenses or imputed costs that do not involve a direct cash payment.

The total revenue (TR) captures the entire income farmers receive from selling their produce during a specific cropping cycle. The study derives the profit by subtracting the TC from the TR, representing the farmers' actual earnings. To measure the efficiency of the farming operation, the profit percentage is calculated by dividing the profit by the TR.

Another valuable tool is break-even analysis, which revealed the point at which the revenue from sales equals the TCs, indicating a no-profit-no-loss situation. This tool is crucial since it helps farmers identify the minimum they need to produce or the price that must be charged to cover their costs. All monetary values in this analysis are expressed per unit area, specifically per rai, for clarity and consistency. The associated formulas are:

$$TC = TVC+TFC \tag{1}$$

$$TR = TR-TC \tag{2}$$

$$\text{Break-even yield} = TC/Price \tag{3}$$

$$\text{Break-even price} = TC+TQ \tag{4}$$

Results

Sociodemographic characteristics of rubber farmers

The findings found that the sociodemographic characteristics of rubber farmers in Ban Khai District, Rayong Province which grouped as the group utilising ethylene gas, the gender distribution equated to 32% males and 20% females. A significant portion of this group (20%) fell within the age range of 61–70 years. Notably, the primary education level among the majority was elementary school (20%). The rubber cultivation at 20% of farmers had 26–30 years of experience.

On the other hand, the group was not using ethylene gas which presented an equal gender distribution of males and females at 24%. Like their counterparts, the majority in this group (24%) that belonged to the 61–70 age bracket. Elementary school education was also predominantly found with a higher count of 36% of the sampled individuals. From an experience perspective, the most represented category (16%) consisted of farmers with 16–20 years of tenure in rubber cultivation.

Table 1. Sampled Para rubber farmers' sociodemographic characteristics

	Ethylene gas (n=13)		Non-Ethylene gas (12)	
	Frequency	Percentage	Frequency	Percentage
Gender				
Male	8	32	6	24
Female	5	20	6	24
Age				
31-40	2	8	1	4
41-50	0	0	2	8
51-60	4	16	3	12
61-70	5	20	6	24
71-80	2	8	0	0
Education				
Primary	5	20	9	36
Junior High School	1	4	2	8
Senior High School	4	16	1	4
Bachelor	3	12	0	0
Experience				
1-5	1	4	0	0
6-10	1	4	0	0
11-15	1	4	3	12
16-20	2	8	4	16
26-30	5	20	3	12
31-35	1	4	0	0
36-40	2	8	2	8
Rubber variety				
RRIM 600	13	52	12	48

Rubber farmers' ethylene gas user cost and return

The findings revealed that farmers faced an average total expenditure of 11,713.48 baht per rai. This cost is segmented into VCs of 9,811.46 baht per rai, occupying 83.76% of the total, and FCs of 1,902.02 baht per rai, contributing to 16.24%.

VCs, the labour cost for preparing the land averages equated to 704.11 baht per rai, capturing 6.01% of the TC, with cash expenses and non-cash costs constituting 4.42% and 1.59%, respectively. Rubber cultivation presented an average cost of 1,893.40 baht per rai, making up 16.16% of the variable expenses. This figure involved a cash component of 187.73 baht per rai and considerably higher non-cash of 1,705.67 baht per rai. Maintenance of the rubber plantation incurred 1,078.15 baht per rai, equating to 9.20% of the variable cost. The distribution of this cost consisted of 242.35 baht per rai in cash and 835.80 baht per rai in non-cash expenses.

In terms of harvest and post-harvest processes, the costs increased to 3,837.70 baht per rai, a significant 32.76%. Cash costs for this process consisted of 326.92 baht per rai, whereas non-cash costs were notably higher at 3,510.78 baht per rai. Lastly, production factors, including various costs such as seeds, fertilisers, chemicals, and ethylene gas, equated to 2,298.10 baht per rai (19.62%). The ethylene gas was a major cost component at 1,200 baht per rai. Regarding the FCs, the land tax was relatively minimal at 4.92 baht per rai, forming 0.04% of the total FCs. The opportunity cost relating to land use, a non-cash expense, was 995 baht per rai, accounting for 8.49% of the FCs. Equipment depreciation was another substantial cost, amounting to 902.10 baht per rai, split into 700 baht for cash costs and 202.10 baht for non-cash costs. In terms of returns, the farmers' average rubber yield was 378 kilograms per rai, with a potential selling price of 47.50 baht per kilogram. This would lead to a revenue of 17,955 baht per rai and a net profit of 6,241.52 baht per rai. Significantly, both the yield and selling price were found to surpass the break-even metrics, indicating that the farmers' returns on investment were higher than their production expenses, underscoring the profitability of rubber farming, as detailed in Table 2.

Rubber farmers non- ethylene gas use cost and return

When assessing the costs faced by rubber farmers who did not use ethylene gas, the data pointed to an average total expense of 9,813.50 baht per rai. This expenditure can be divided into two main categories: VCs, equating to about 8,611.46 baht per rai, and FCs of 1,202.02 baht per rai. VCs accounted for a substantial 87.75% of the total, split into cash costs of 2,371.13 baht per rai (24.16%) and non-cash costs of 6,240.33 baht per rai (63.59%). Several factors contributed to these costs, such as labour for land preparation, rubber cultivation, maintenance, and harvest. Additionally, various production costs amounted to a total of 1,098.10 baht per rai.

In terms of FCs, the land tax accounted for a minimum of 4.92 baht per rai, whereas the cost of using the land and indirectly expense were notably higher at 995 baht per rai. Equipment-related costs and indirect were pegged at 202.10 baht per rai. In terms of revenue, the scenario remained optimistic for rubber farmers not using ethylene gas. They achieved an average yield of 223 kilograms per rai, with a selling price of 47.50 baht per kilogram, translating to get income of approximately 10,592.50 baht per rai. Consequently, these farmers secured a profit margin of 779 baht per rai, with the yield and price metrics both surpassing the break-even threshold.

Table 2. Cost-return table for rubber producers who employ the invention to use ethylene gas to boost rubber production

Items	Cash costs		Non-cash costs		Total cost	
	Amount	%	Amount	%	Baht	%
Variable costs	3,571.13	30.49	6,240.33	53.27	9,811.46	83.76
Labor costs for land preparation	517.65	4.42	186.46	1.59	704.11	6.01
Area adjustment fee	488.71	4.17	181.17	1.55	669.88	5.72
Cost of adding soil improvement materials	17.06	0.15	4.40	0.04	21.46	0.18
Cost of spraying herbicides	11.88	0.10	0.89	0.01	12.77	0.11
Labor costs for rubber planting	187.73	1.60	1,705.67	14.56	1,893.40	16.16
Digging, planting, and fertilizing	187.73	1.60	1,705.67	14.56	1,893.40	16.16
Cost rubber plantation maintenance	242.35	2.07	835.80	7.14	1,078.15	9.20
Weed management costs	234.05	2.00	766.67	6.55	1,000.72	8.54
Fertilizer management cost	5.22	0.04	66.47	0.57	71.69	0.61
Pests management cost	3.08	0.03	2.66	0.02	5.74	0.05
Harvest and post-harvest	326.92	2.79	3,510.78	29.97	3,837.70	32.76
Cost of tapping rubber	234.1	2.00	2,052.33	17.52	2,286.43	19.52
Latex storage cost	92.82	0.79	1,458.45	12.45	1,551.27	13.24
Cost of production factors	2,296.48	19.61	1.62	0.01	2,298.10	19.62
Seedling	68.85	0.59	1.12	0.01	69.97	0.60
Organic fertilizer cost	7.22	0.06	0.50	0.00	7.72	0.07
Cost of biological fertilizer	15.30	0.13	-	-	15.30	0.13

Chemical fertilizer cost	771.55	6.59	-	-	771.55	6.59
Cost of chemical and organic fertilizers	11.88	0.10	-	-	11.88	0.10
Cost of herbicides/pests/hormones	3.61	0.03	-	-	3.61	0.03
Gasoline cost	154.18	1.32	-	-	154.18	1.32
Ethylene gas value	1,200	10.24	-	-	1,200.00	10.24
Other expenses	63.89	0.55	-	-	63.89	0.55
Fixed costs	704.92	6.02	1,197.10	10.22	1,902.02	16.24
Land tax	4.92	0.04	-	-	4.92	0.04
Opportunity cost of land use	-	-	995.00	8.49	995.00	8.49
Depreciation	700	5.98	202.10	1.73	902.10	7.70
Total cost (baht/rai)	4,276.05	36.51	7,437.43	63.49	11,713.48	100.00
Total sales (baht/rai)	17,955.00					
Average yield (kg/rai)	378					
Product price (baht/kg.)	47.50					
Net profit (baht/rai)	6,241.52					
Break-even yield (kg/rai)	246.60					
Break-even price (baht/kg.)	30.99					

Table 3. Cost-return for rubber producers who employ the invention of non-ethylene gas to boost rubber production

Items	Cash costs		Non-cash costs		Total cost	
	Amount	%	Amount	%	Amount	%
Variable costs	2,371.13	24.16	6,240.33	63.59	8,611.46	87.75
Labor costs for land preparation	517.65	5.27	186.46	1.90	704.11	7.17
Area adjustment fee	488.71	4.98	181.17	1.85	669.88	6.83
Cost of adding soil improvement materials	17.06	0.17	4.40	0.04	21.46	0.22
Cost of spraying herbicides	11.88	0.12	0.89	0.01	12.77	0.13
Labor costs for rubber planting	187.73	1.91	1,705.67	17.38	1,893.40	19.29
Digging, planting, and fertilizing	187.73	1.91	1,705.67	17.38	1,893.40	19.29
Cost rubber plantation maintenance	242.35	2.47	835.80	8.52	1,078.15	10.99
Weed management costs	234.05	2.38	766.67	7.81	1,000.72	10.2
Fertilizer management cost	5.22	0.05	66.47	0.68	71.69	0.73
Pests management cost	3.08	0.03	2.66	0.03	5.74	0.06
Harvest and post-harvest	326.92	3.33	3,510.78	35.78	3,837.70	39.11
Cost of tapping rubber	234.1	2.39	2,052.33	20.91	2,286.43	23.3
Latex storage cost	92.82	0.95	1,458.45	14.86	1,551.27	15.81
Cost of production factors	1,096.48	11.17	1.62	0.02	1,098.10	11.19
Seedling	68.85	0.70	1.12	0.01	69.97	0.71
Organic fertilizer cost	7.22	0.07	0.5	0.01	7.72	0.08
Cost of biological fertilizer	15.3	0.16	-	-	15.30	0.16
Chemical fertilizer cost	771.55	7.86	-	-	771.55	7.86

Cost of chemical and organic fertilizers	11.88	0.12	-	-	11.88	0.12
Cost of herbicides/pests/hormones	3.61	0.04	-	-	3.61	0.04
Gasoline cost	154.18	1.57	-	-	154.18	1.57
Ethylene gas value	63.89	0.65	-	-	63.89	0.65
Other expenses	4.92	0.05	1,197.10	12.20	1,202.02	12.25
Fixed costs	4.92	0.05	-	-	4.92	0.05
Land tax	-	-	-	-	-	-
Opportunity cost of land use	-	-	995.00	10.14	995.00	10.14
Depreciation	-	-	202.10	2.06	202.10	2.06
Total cost (baht/rai)	2,376.05	24.21	7,437.45	75.79	9,813.50	100.00
Total sales (baht/rai)	10,592.50					
Average yield (kg/rai)	223					
Product price (baht/kg.)	47.50					
Net profit (baht/rai)	779.00					
Break-even yield (kg/rai)	206.60					
Break-even price (baht/kg.)	44.01					

A comparative study of cost and return indicators between rubber farmers in Rayong Province, Thailand, who either employed or refrained from using ethylene gas as an innovation to boost latex output are shown in Table 4. The data indicated a TC of 14,213.48 baht per rai for farmers utilising ethylene gas. This encompassed VCs of 13,011.46 baht and FCs of 1,202.02 baht. Their total income was 17,955 baht per rai, resulting in a net profit of 3,741.52 baht per rai. Regarding break-even metrics, they achieved production at 299.23 baht and set their break-even price at 37.60 baht.

Conversely, those farmers were not leveraged the ethylene gas face TCs of 9,813.50 baht per rai, broken down into VCs of 8,611.46 THB and FCs of 1,202.02 baht. They get a total income of 10,592.50 baht per rai, leaving them with a net profit of 779 baht per rai after deductions. Their break-even production was found to be 206.60 baht, a price point was break-even of 44.01 baht.

In comparing the financial indicators between these two categories of farmers showed significantly differences which emerged in their cost and return figures, as evidenced by the T-test values. Notably, while the most indicators display a significant difference at the .05 level, the FCs for both groups remained statistically non-significant. This insight could have broader implications for understanding rubber farmers' fundamental economic challenges in the region, regardless of whether they use ethylene gas.

Table 4. Comparison of ethylene gas users' cost and return indicators in boosting latex output among Rayong province, Thailand rubber farmers

	Ethylene gas	Non-ethylene gas.	T-test
Total cost	14,213.48	9,813.50	5.46
Variable costs	13,011.46	8,611.46	4.914
Total income	17,955	10,592.50	3.87
Net profit	3,741.52	779	1.52
Break-even production	299.23	206.60	5.42
Break-even price	37.60	44.01	12.73

Discussion

In recent years, the agricultural sector has seen a surge in technological and methodological advancements to optimise the production and profitability. One such innovation, the use ethylene gas to boost latex output, has garnered attention among rubber farmers in Ban Khai District, Rayong Province, Thailand. The cost-benefit dynamics associated with this method are investigated in this study by contrasting them with traditional practices that do not use ethylene gas.

The findings indicated that while farmers employing ethylene gas face higher initial costs, averaging 11,713.48 baht per rai, they get benefit from a considerable profit margin, with an average profit of 6,241.52 baht per rai. Conversely, despite incurring a lower total average cost of 9,813.50 baht per rai, those who abstained from using ethylene gas reap a markedly diminished average profit of just 779 baht per rai. This disparity represented in a difference in profit of approximately 5,435.52 baht per rai, highlighted the economic viability of integrating ethylene gas into rubber production, despite the initial increased expenditure. It could be argued that the higher costs associated with the use of ethylene gas could deter farmers from its adoption. However, the consequent elevation in profit margins offered a compelling argument in its favour (Anwar *et al*., 2021; Keil *et al*., 2020; Suwanmaneepong *et al*., 2020). The significant difference in profitability between the two groups suggested that the returns garnered from this innovation significantly outweigh the initial investment.

This observation aligned with the broader narrative of the agricultural industry, where involved in strategic investments, although sometimes risky, yield long-term benefits (Llones and Suwanmaneepong, 2021; Sowcharoensuk, 2021). Adopting new agricultural practices and technologies often appeared to be necessitates an initial financial outlay but promises returns that outweigh the investment (Effiong and Effiong, 2015; RAOT, 2017). The key lies in identifying which innovations aligned with the local context and offer the most significant economic advantage (Llones *et al*., 2022; Sowcharoensuk, 2021). This present study resonated with the findings of Worapongapt and colleagues (2023), who tackled the lean production system as a means for curtailing production costs in creating gel-type hunger control products. Their conclusions reinforced the concept that implementing strategic innovations, even if they demanded an upfront investment, can lead to substantial cost reduction in the long run (Weerathamrongsak and Wongsurawat, 2013).

Drawing from these insights, it is evident that the future of agriculture, not just in Rayong Province but globally, hinges on the willingness of farmers and stakeholders to embrace change. Resistance to innovations, often stemming are concerned about initial costs or lack of understanding that can potentially hinder growth and profitability (Fosso and Nanfosso, 2016; Kakinuma, 2022). Farmers must be informed of these advancements and supported to integrate them into their operations.

In conclusion, as the agricultural sector has continued to evolve in the face of global challenges, the emphasis on adopting proven technologies and methodologies would become paramount. The case of ethylene gas usage among rubber farmers in Ban Khai District is shown to be a testament to the potential of such innovations in reshaping the economic landscape of farming. For policymakers and agricultural authorities are ensured such findings to reach the grassroots, enabling farmers to make informed decisions that bolster their profitability and sustainability. Furthermore, the continued research and collaboration with institutions can pave the way for the future discovery, dissemination of more cost-effective, and innovative farming practices.

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