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Assessing farmers' adoption of ethylene stimulation in increasing Para rubber production in Ban Khai District, Rayong Province

Orsuwan, W., Suwanmaneepong, S.*, Llones, C. and Khuhaswanvej, S.

School of Agricultural Technology. King Mongkut's Institute of Technology, Ladkrabang, Thailand.

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Abstract The study found that only 50 percent of the trained rubber farmers have adopted the use of ethylene stimulation. Several factors that contributed to non-adopters' hesitance are perceived uncertainties of technology attributes, cost of implementation, and farmers' attitudes. From these factors, the increasing cost was the recurring reason expressed by farmers during the focus group discussion. Furthermore, a review of related studies revealed that there was an inadequate R&D investment in the rubber industry. Therefore, government supported in boosting the R&D of the country's rubber industry would require an immediately action and implementation that competed to rubber export countries for rapidly gaining in the competition.

Keywords: Rubber, Ethylene, Adoption

Introduction

Natural rubbers extracted from rubber trees *Hevea brasiliensis* has been an essential export product among many countries, mainly in tropical areas. In 2021, the global export value of natural rubber was USD 16.86 billion, wherein the top exporters are Thailand, Indonesia, Ivory Coast, Vietnam, and Malaysia (Workman, 2022). These top five exporters account for 32.7, 23.8, 10.6, 7.1, and 6.5 percent of the world's total export value of natural rubber, respectively (Workman, 2022). While Thailand holds the top spot, countries like Cambodia, Laos, Myanmar, and Vietnam (CLMV) show increasing growth in their natural rubber, which causes some loss to Thailand's global market share (Sowcharoensuk, 2021). The increasing supply from CLMV is partly due to the increasing investment by Chinese investors into developing rubber plantations for their steady natural rubber supply. At the same time, China is also producing more rubber products (Sowcharoensuk, 2021).

* **Corresponding Author:** Suwanmaneepong, S.; **Email:** ksuneeporn@gmail.com

Natural rubber production in Thailand takes a large share of the total agricultural export value next to the country's rice exportation, with China, Malaysia, the USA, Japan, and South Korea as the major export partners (Sowcharoensuk, 2021). For natural rubber production, approximately 86 percent were exported, and the remaining 13 percent were distributed domestically. The surplus of natural rubber has partly pulled down the average price of natural rubber in the global market. For example, the average price in 2011 was THB 190.51 per kilogram, down to THB 50-52 per kilogram in 2018-2019. In addition, Thailand shows a continuous increase in production despite the decrease in prices, which may further induce a price decrease. As small-scale plantations dominate rubber plantations, the price decrease greatly affected rubber farmers, given that the average production cost was THB 56-61 per kilogram (Sowcharoensuk, 2021).

The tropical climate in Thailand, especially in the southern and eastern regions, is suitable for rubber plantations. The country's rubber production can be divided into the upstream and downstream industries, as shown in

Figure ***1***. The upstream players comprised mainly small-scale rubber plantations that processed concentrated latex or coagulated rubber (Weerathamrongsak & Wongsurawat, 2013). For dry rubber, harvested field latex is mixed with chemicals and undergoes heating to make rubber harder and stronger (Sowcharoensuk, 2021). Whereas the cup lump is the lump of rubber found in the tapping cups attached to the rubber tree. The harvested latex, as well as the pre-processed latex, has undergone further processes (e.g., coagulation, granulation, drying, and smoking) into concentrated latex, technically specified rubber (TSR/STR), block rubber, ribbed smoked sheets (RSS) and compound rubbers. The RSS has been the mainstream in Thailand, however, production of lower value-added Standard Thai Rubber (TSR) is expanding partly due to increasing export in China that prefer cheaper materials (Yamamoto, 2015). These rubber products are distributed to the downstream players for export or domestic use, accounting for 86.7 percent and 13.3 percent of the total rubber products, respectively (Sowcharoensuk, 2021).

The distribution of rubber products in the downstream part of the supply chain can be aggregated into domestic and export use. Domestic demand has been growing, wherein the downstream players comprise mainly the rubber product industries that supply inputs for the auto, construction, electronics, and manufacturing industries. For auto industries, rubber products are used for tires, gaskets, and moldings, while constructions include roofing and sealants. In Thailand, the largest user of rubber is vehicle tires such as the Bridgestone, Michelin, and Goodyear (Weerathamrongsak & Wongsurawat, 2013). In addition, Thailand has been the manufacturing base for automakers such as

Toyota, Nissan, Suzuki, and Honda. At the same time, rubber exports are distributed mainly to China (57.9%), Malaysia (14.9%), the USA (4.2%), Japan (3.7%), and South Korea (2.1%) (Sowcharoensuk, 2021).

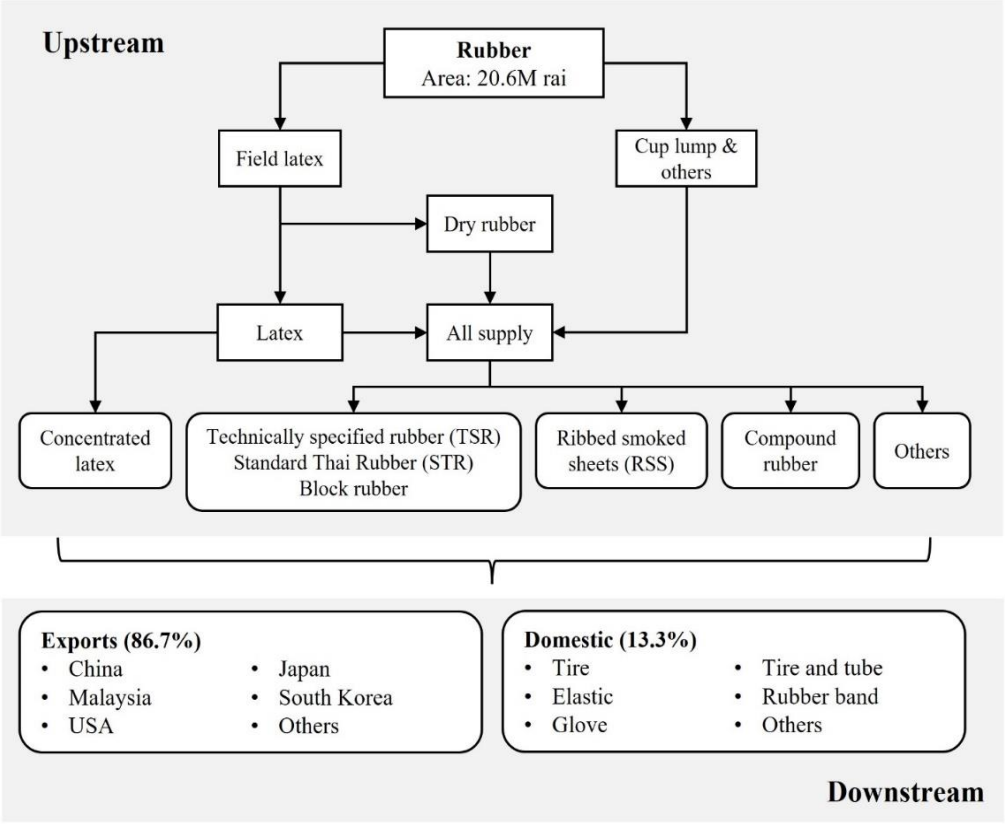

Figure 1. Rubber supply chain in Thailand. A simplified version of the supply chain diagram adopted from Sowcharoensuk, 2021, p. 2 Thailand Industry Outlook 2021-23: Natural Rubber Processing

The current situation prompts rubber farmers to increase productivity to cope with the global market's price drop. In response, the Rubber Authority of Thailand (RAOT) subsidized farmers for replanting high-yielding rubber trees through the Rubber Replanting Fund Act. The selection of high-yielding rubber trees resulted in a gradual improvement in rubber productivity. However, it is still below the suggested optimal yield of rubber trees (Tang *et al*., 2016). On the other hand, Thailand is experiencing a continuous decrease in the size of rubber plantations. This induces the adoption of an intensive frequency of rubber tapping that results in overexploitation and low labor productivity

(Chantuma *et al.*, 2011). However, reducing the tapping frequency has been difficult as it would result in farmers and tappers having no work. Therefore, in combination with tapping frequency, RAOT promotes ethylene stimulation among rubber farmers. As a result, the ethylene application to the tapping panel increased latex yield and reduced the tapping frequency, increasing land or labor productivity (Lacote *et al.*, 2010; Sainoi and Sdoodee, 2012).

Despite the potential benefits of ethylene in increasing latex harvest, several rubber farmers are not adopting ethylene stimulation. In Thailand, rubber farmers' hesitance was due to the perceived additional cost of adopting the ethylene stimulation, especially given the considerable decrease in rubber prices in the global market. Non-adoption of new technology and innovation related to financial constraints is widely studied. However, in the case of the rubber industry, there is a small availability of studies investigating the perceived impact of ethylene stimulation on natural rubber production. Hence, the objective was aimed to investigate rubber farmers' impact and observed changes in adopting ethylene stimulation on rubber production.

Materials and methods

Study area

The southern and eastern areas of Thailand comprise the largest chunk of the country's total natural rubber production. Rayong, a province in the eastern part of Thailand, is known for growing medicinal plants and is a hub for rubber plantations. The province has produced an average of 104,751 tons of natural rubbers in previous years. However, in the year 2022 the Rayong provincial office expected a 4.7 decrease in rubber yield due to several factors, such as the decreasing price of latex, the impacts of climate change, and the problem of wild elephant encroachment.

The problems brought by wild elephant encroachment are particular to the study area. Several cases were reported of rubber tappers being attacked by wild elephants causing a labor shortage of skilled rubber tappers. Rubber farmers explored different strategies to minimize the tapping frequency while at the same time increasing the productivity of rubber production. RAOT promoted the use of ethylene stimulation to achieve lower tapping frequency while maximizing productivity. The application of ethylene stimulation in the study area in Rayong province is shown in Figure 2.

Figure 2. Rubber farmer demonstrating the application of ethylene stimulation in increasing rubber yield. The photos were taken by the authors during site visits to different rubber farms in Rayong province

Data collection and analysis

Primary data were obtained through face-to-face interviews and surveys among the adopter and non-adopter of ethylene stimulation. In addition, the study relies on the in-depth focus group discussion to understand the observed changes in rubber production brought by the application of ethylene stimulation among rubber farmers. The adoption of ethylene stimulation in the study area was relatively new and analyzing impact pathways was not yet possible in the current condition of rubber farms. Alternatively, the focus group discussion allowed the farmers to share their experiences and the observed changes before and after adopting the ethylene stimulation in the early stages to increase rubber yield.

In addition, descriptive analysis, Pearson's chi-squared test, and Fisher's exact test were employed to compare the characteristics between adopters and non-adopters of ethylene stimulation. The chi-squared test can be expressed as:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \quad (1)$$

Where O_i refer to the ith observed value, E_i represent the ith expected values and the χ^2 is the obtained chi-squared values. The following sections show the analysis results and discuss the study's implications.

Results

Sociodemographic characteristics

Using Pearson's chi-squared test and Fisher's test, sociodemographic characteristics (e.g., gender, age, educational attainment, and marital status) between adopters and non-adopters of ethylene stimulation do not differ significantly, as summarized in Table 1. It revealed that the two groups of para rubber farmers, the adopter and non-adopter of ethylene stimulation as comparable. Most sampled farmers are married and had been engaged in para rubber production for over 40 years. The aging population of farmers reflected the decreasing availability of younger labour in the agricultural sector and the increasing interest of the younger generation in Thailand's industry and manufacturing sectors. In addition, a rubber farmer's educational attainment indicated a potential factor in their decision to adopt the Ethelyn stimulation for rubber production. Most ethylene adopters showed higher education attainment (e.g., high school /diploma to college) than non-adopters at the elementary level.

Table 1. Sampled Para rubber farmers' sociodemographic characteristics

Variable	Adopter [a]	Non-adopter [a]	P-value [b]
Gender			0.60
Male	8 (62%)	6 (50%)	
Female	5 (38%)	6 (50%)	
Age			0.50
31-40 yrs	2 (15%)	1 (8.3%)	
41-50 yrs	0 (0%)	2 (17%)	
41-60 yrs	4 (31%)	3 (25%)	
61-70 yrs	5 (38%)	6 (50%)	
71-80 yrs	2 (15%)	0 (0%)	
Education			0.11
Elementary	5 (38%)	9 (75%)	
Junior High School	1 (7.7%)	2 (17%)	
High School/Diploma	4 (31%)	1 (8.3%)	
Bachelor's degree	3 (23%)	0 (0%)	
Status			0.20
Single	0 (0%)	1 (8.3%)	
Married	13 (100%)	10 (83%)	
Divorced/ widowed	0 (0%)	1 (8.3%)	

Notes: [a] n sample (% proportion); [b] Pearson's chi-squared test; Fisher's exact test

Para rubber farming and market distribution

In Thailand, the RRIM 600 is the widely used rubber variety for adopters and non-adopter of ethylene stimulation. Two primary tapping system is widely

applied in the study area, the half-spiral (S/2) and the one-third spiral (S/3). The result showed that almost 50 percent of the sampled rubber farms prefer the S/3 tapping cut over the S/2 cut, as demonstrated in Figure 3. The preference of rubber farmers over the S/3 cut can be attributed to rubber farmers compensating for the high tapping frequency on bark consumption that could limit the lifespan of the rubber plantation. On the other hand, in terms of rubber tapping frequency, ethylene adopters applied two days intervals (48 percent) while non-adopters (20 percent) used three days. Only ethylene non-adopters tried rubber tapping every other day among sampled para rubber farmers.

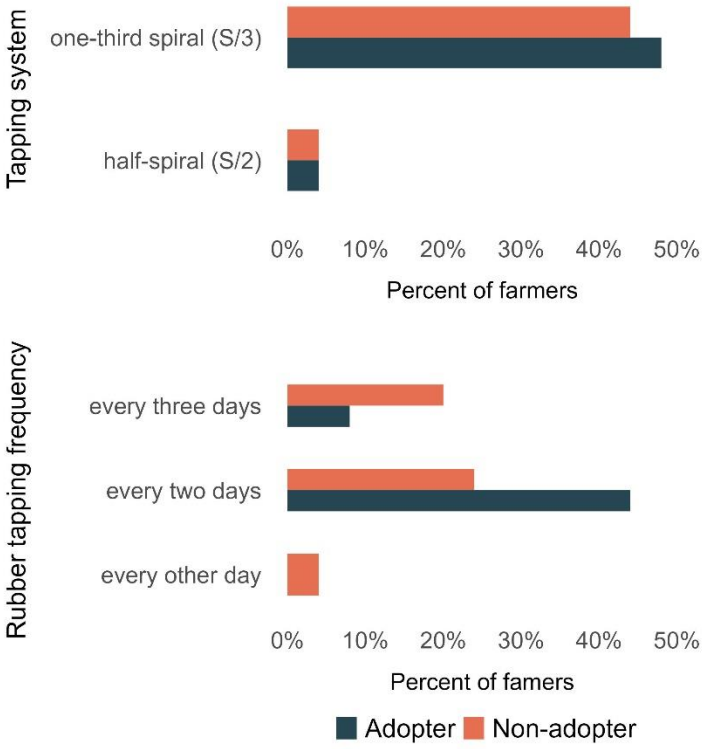

Figure 3. Para rubber tapping system and tapping frequency in Rayong province

Harvested para rubber is sold as rubber cup lumps to traders, middlemen, or merchants. Since most rubber farmers are small-scale, they rely on middlemen or merchants to sell the harvested rubber cup lump. A large

percentage of the sampled farmers prefered middlemen and merchants for convenience.

On the other hand, 20 percent of the ethylene adopters and non-adopters supplied farmer groups and cooperatives. These farmers were members of cooperatives and farmer groups that benefit from membership, such as a secured market through the group's collective marketing and other production subsidies.

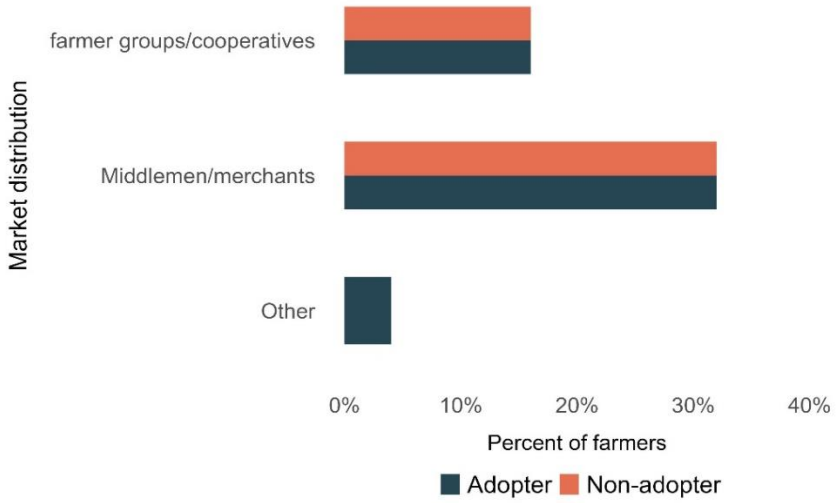

Figure 4. Para rubber farmer's market distribution

Farmer's perceived changes in ethylene adoption

Using a focus group discussion and survey, the study sought to understand the perceived impact of ethylene stimulation on rubber production. It provided a deeper investigation of farmers' experiences upon the adoption of the stimulation technology on various aspects such as production, cost, marketing, and farmer organization.

Result showed the observed effects of the ethylene stimulation among adopters, as discussed during the focus group discussion (Figure 5). Firms and rubber plantations tended to locate their operation closer to the production area. It allowed more efficient management of transporting raw materials for processing and reduce logistic cost. Hence, the focus group discussion results showed that the distance between rubber farms to household greatly influenced their decision to adopt. Farmers farther away from rubber farms tended to incur high costs, making them cost-sensitive to the additional cost of adopting

ethylene stimulation in their production. Acknowledging farmers' different views and perceptions on ethylene stimulation, RAOT conducted a series of training and farm demonstrations. However, results revealed that approximately only 50 percent of trained farmers adopted the use of ethylene stimulation, despite the results of a 30 percent increased in production against a 10 percent increased in cost brought by ethylene stimulation in rubber production.

Furthermore, the results indicated a need for further studies to investigate deeper the attitude and perceptions of farmers' decisions regarding their resistance to adoption despite the stimulation technology's positive effect.

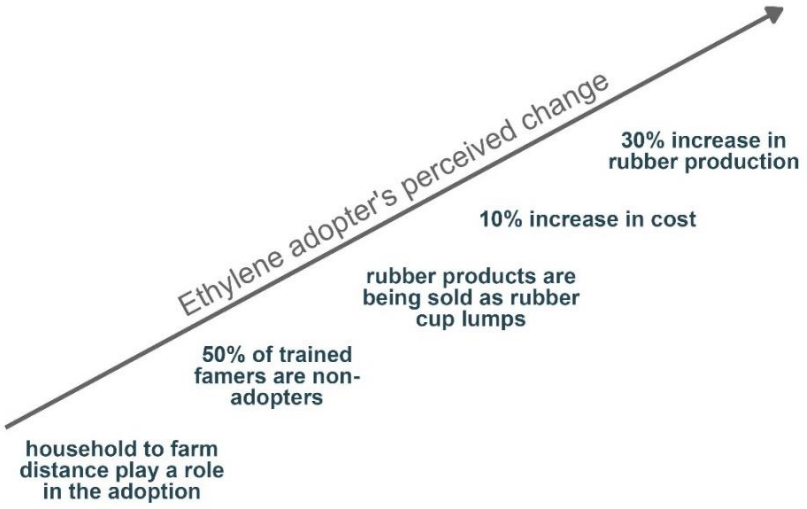

Figure 5. Para rubber farmer's perceived effects of ethylene stimulation adoption as revealed by the focus group discussion

Discussion

Although the country remained the top rubber exporter in 2021, several studies revealed that while total production of the country is increased, however, at a decreasing rate (Chantuma *et al*., 2011; Sowcharoensuk, 2021). For instance, Chantuma *et al.* (2011) showed that rubber yield in Thailand was high in kilogram per area but low in kilogram per tapper per area. This can be attributed to the country's recent decreasing latex yield of rubber trees. In addition, there is a recurrent shortage of skilled rubber-tapping labour. To remedy the situation, the Rubber Authority of Thailand (RAOT) promoted

ethylene stimulation in the tapping panel to increase latex yield and improve output to labour productivity (Lacote *et al.*, 2010; Sainoi and Sdoodee, 2012).

Although Thailand's rubber production is higher than major competing countries, such as CLVM and Indonesia, competition is getting intense, and rubber exporting countries are expanded their areas for rubber production. Therefore, to maintain Thailand's current top spot, the country needs to boost its research on improving rubber varieties to further the production and upskill farmers' technical knowledge to be competitive against leading growing production of competing countries like Malaysia and Germany (Sowcharoensuk, 2021).

The rubber authority in Thailand has increased its efforts in training rubber farmers in ethylene stimulation in tapping rubber panels throughout rubber plantations across the country (Sowcharoensuk, 2021). However, despite such efforts, study results showed that approximately only 50 percent of the trained rubber farmers had adopted the use of ethylene stimulation. Several factors that contributed to non-adopters hesitance are perceived uncertainties of technology attributes, cost of implementation, and farmers' attitudes. From these factors, the increasing cost was the recurring reason expressed by farmers during the focus group discussion.

In addition, the effect of an increased production cost was worsened because of the continuous decrease in rubber prices. For instance, the RSS3, considered an industry reference price, has significantly decreased from 190 baht per kilogram in 2011 to 50-52 baht per kilogram in 2018-2019 (Sowcharoensuk, 2021). As comparison to the average production cost of 56-61 baht per kilogram, the situation further pulled down the merger earnings of rubber farmers. Therefore, improving rubber yield through ethylene stimulation was the primary coping strategy promoted by RAOT to offset the decreased rubber price experienced in recent years.

Moreover, replanting mature rubber trees over 25 years is necessary for rubber production to increase latex harvest. The rubber tree cultivation period is estimated to be 1-6 years, and the harvesting period is from the 7^{th} to the 25^{th} year. Under the Rubber Replanting Fund Act of 1960, recently repealed under the Rubber Authority of Thailand Act in 2015, farmers are subsidized for replanting rubber trees 25 years or older. The subsidized amount is partly funded by the export tax collection, which charges exported rubber products THB 1-5 per kilogram (RAOT Act, 2015).

On the other hand, given that the export use of rubber in Thailand takes more than 80 percent of the total production, the future of the rubber sector is highly volatile to the global market. In addition, its export market of Thailand is concentrated in a small number of countries such as China, Malaysia, the USA,

Japan, and South Korea, which makes the country reliant on the demand from these countries. In the total rubber exportation of Thailand, China remains the country's top market, which takes 57 percent share of the total export value. Although China has invested in expanding rubber plantations in CLMV countries in recent years, Thailand is faced with a threat to its current dominance in rubber production by neighbouring ASEAN countries, especially the CLMV (Sowcharoensuk, 2021).

The study found that it was still a low technology adoption among rubber companies. This can be attributed to the typical "wait and see" behaviour, where a farmer's willingness to adopt require immediate and concrete results of proposed technology before deciding to invest in adoption (Llones and Suwanmaneepong, 2021). This is one of the farmer's strategies to minimize risk in their farm operation (Llones *et al.*, 2022; Shikuku *et al.*, 2017). Thus, organizing interventions for knowledge transfer require the use of the innovation to demonstrate the actual concrete results and impact of the proposed innovation. Moreover, aside from developing the production side, upskilling farmers' marketing and financial knowledge will be valuable to equip farmers in informed decision-making.

Lastly, similar to other related studies (Chantuma *et al.*, 2011; Sowcharoensuk, 2021; Weerathamrongsak & Wongsurawat, 2013) tackling the rubber industry of Thailand, there is a consensus that the country has an inadequate number of R&D (Weerathamrongsak & Wongsurawat, 2013). Hence, government support in boosting the R&D of the country's rubber industry requires immediate action and implementation given that competing rubber export countries are rapidly gaining in the competition.

Acknowledgments

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