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The determination of organic practice and adoption in sugarcane farming in Thailand

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Abstract

Organic production at sugarcane farms facilitates increased food safety and environmental sustainability; however, the number of organic sugarcane farms in Thailand is still low. The purpose of this research is to determine organic practice standards and their adoption in sugarcane farming in Thailand. A purposive sample of 414 sugarcane farmers from Kanchanaburi and Suphanburi provinces using a non-probability technique and 30 certified organic sugarcane farmers from Nakhon Ratchasima was collected. Data were collected by conducting face-to-face interviews with individual respondents. The findings revealed that the most difficult organic practices are (1) informing the Organic Agriculture Certification Thailand (ACT) of any change in production (2) stopping the use of all chemical inputs for 1 year (3) no burning after harvest (4) cleaning all equipment before use and (5) record keeping for all of the process from the farm to the mill. The adoption results revealed that gender, the number of agriculture information channels, debt, land right certificates, asset value and organic training were significantly important factors in organic practice while sugarcane plantation experience, household labor, farm size and training from millers had no influence on adoption. It is recommended that employees organize additional practical training programs on organic standards, and organic certification should be simple to process and cost less. The ownership of land will support more organic practice. Moreover, the benefits of organic production should also be promoted to female sugarcane farmers. The government could also offer support to farmers in regard to loan repayments.

Introduction

The sugarcane industry plays an important role in the global economy with over a hundred countries in the sugarcane supply chain involving sugarcane farms, sugar mills, transportation, byproducts from sugarcane, related industries and distribution to consumers around the world (Nhan, 2014). Thailand is the second largest exporter in the global market and earns USD7.81 billion a year and employs 1.5 million people (Preecha, Jungtrakool, Srikongpetch, & Ratavetchakul, 2017). Customers from around the world import sugar from Thailand, but they

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have now become increasingly concerned about the quality, as well as social and environmental sustainability for the entire supply chain. There are various sugarcane standards such as organic, bonsucro and SUSFARM, which focus on how to manage the environment, community and consumers sustainably. Organic farming is generally a best practice form of management that improves the health of the agro-ecosystem. Generally, it focuses on the use of organic manure, green manure and the management of pests and diseases without the use of artificial pesticides and other chemicals (Kshirsagar, 2006). The benefits of organic farming include the health of the soil, the environment in general, the consumers, and the farming communities. Organic farming has the possibility to raise net returns, decrease the risk of crop failure and reduce environmental impacts (Patil, Reidsma, Shah, Purushothaman, & Wolf, 2014). Furthermore, in terms of the economy, it was found that sugarcane farmers can obtain higher prices for green sugarcane from sugar millers. Additionally, the global demand for organic sugar is likely to increase by about 15.55 percent during the forecast period of 2017–2022 (Reportlinker, 2017).

In Thailand, a national organic strategy and policy started in 2008, and the policy to encourage organic agriculture in Thailand between 2017 and 2021 aims to increase organic production to over 1 million rai by 2021 (Posttoday, 2017). Organic sugarcane is the main agriculture product that the government supports to expand organic sugar exports. Organic standards have been established in some provinces such as Nakohn Ratchasima, Lopburi, Kanchanaburi and Suphanburi. However, only sugarcane farmers in Nakhon Ratchasima and Lopburi have become certified and deal with organic sugar millers. 101 farmers have joined the organic program and 50 percent have become certified organic farms. The rest of the farmers are transitioning to organic farm production (Kuldilok, 2019). The advantages of organic sugarcane farming are that farmers can acquire a benefit of around 100–120 baht/ton (3.12–3.75 USD/ton) from green sugarcane harvesting, higher commercial cane sugar (CCS) and higher prices. Moreover, the sugarcane yield increased by approximately 1–3 ton/rai after farms completing the transition to organic practices (Wangkanai, personal interview, March 21, 2018). Thai organic sugarcane is certified according to the Thailand Organic Standard, USDA-NOP, the Japan Agriculture Standard (JAS) and the Korean organic standard (Posttoday, 2017), which represent the main international customers. However, the quantity of organic sugarcane production is a small proportion of total production and is still not extensive in Thailand. In addition, organic practice is quite difficult with complicated processes, which are composed of five main aspects: production, harvesting, transportation, recordkeeping and labor management (Office of Organic Agriculture Standards, 2017). As a result of increasing health and environmental concerns and higher demand for organic sugar, Thailand has the opportunity to increase organic sugar supply to gain higher income and good health for sugarcane farmers. The use of organic practices by sugarcane farmers will support the high demand for organic sugar and will assist the Thai government, sugar millers, and other stakeholders in policy implementation. This research aimed to determine the factors influencing the adoption of the organic standards in Thailand.

Literature Review

Many studies on adoption in agriculture have been conducted in regard to technology and innovation, agricultural machines and standard agricultural practices. Moreover, adoption studies can be conducted in many types of agriculture, such as the adoption of fruit and vegetable standards. Adoption can be analyzed by employing various models such as the logit model, the ordered logit model, the probit model, multi regression modeling and the chi-square test. Regarding technology and invention adoption, Diederen, Meijl, Wolters, and Bijal (2003) compared frontrunners (innovators and early adopters) and laggards (late adopters and non-adopters) in regard to the adoption of innovations by farmers in the Netherlands using a nested logit model. Jerop et al. (2018) studied the factors that affected the level of use of different innovations (improved varieties, conservation tillage, integrated pest and weed management, and group marketing) on the production and marketing of the crops of finger millet producers in Kenya. Diederen et al. (2003) and Jerop et al. (2018) revealed that farm size and financial credit affected the adoption of technology although the age of farmers (Diederen et al., 2003), off-farm income and agricultural extension services were different (Jerop et al., 2018). Photchanaprasert, Kuldilok, and Athipanyakul (2018) identified the factors affecting the adoption of agricultural machines by sugarcane harvesters in Thailand using the probit model and found that the significant factors affecting adoption by sugarcane harvesters were farmers' income in sugarcane production, labour shortage, farmers' awareness of the positive impacts of the use of sugarcane harvesters, and farmers' attitudes to risk when investing in agricultural machines.

Similar results were found in other studies that focused on adoption. Boz (2014) studied the determinants of best practices and innovations for 170 beef cattle farmers and their adoption in the Eastern Mediterranean region of Turkey. The results revealed the following socio-economic

factors: cooperative membership, investment, farm size, owning improved breeds, income, information-seeking by reading newspapers, using the internet, contact with extension personnel, and contact with private veterinarians. Farm size, income, and contact were also identified by Diederen et al., (2003), Jerop et al. (2018) and Photchanaprasert et al., (2018). In the case of Thailand, most standard adoption studies have been related to fruit and vegetables. In addition, the adoption of agricultural practices has been studied in regard to good agricultural practice (GAP) and organic farming. The Thai government attempts to promote standards, and research shows that the adoption of standard practices in Thailand has occurred in rice (Chanhathai, Suneeporn, & Panya, 2016), rambutan (Pettong & Thanaphanyaratchawong, 2009), mango (Ritdet, 2003), chili (Athipanyakul & Pak-Uthai, 2012) and sugarcane production (Photchanaprasert et al., 2018). The common factors influencing the adoption of standards (Good Agricultural Practice (GAP) and organic practices) were found to be gender (especially females), participation in training, knowledge, farm size, age and income. For instance, the adoption of organic rice standards by farmers under the sustainable agricultural network in Sanam Chai Khet District, Chachoengsao Province in Thailand (Chanhathai et al., 2016) and the adoption of GAP for rambutan production at Nasan District, Surat Thani Province, Thailand (Pettong & Thanaphanyaratchawong, 2009) both identified the role of females as a positive factor. Although the adoption of organic sugarcane production practices has not been examined in previous research in Thailand, the factors identified in other previous agriculture research were employed to analyze standards for organic sugarcane production.

Methodology

The research was a quantitative research on organic practice and the factors that affect the adoption of organic practices by sugarcane farmers. Data collection and data analysis are presented below.

Data Collection

Data were collected from 414 sugarcane farmers in Kanchanaburi and Suphanburi using a non-probability technique with a purposive sampling method. These provinces are major areas of sugarcane production in the central part of Thailand (Office of Cane and Sugar Board, 2019) and the sugarcane farmers are in the chemical sugarcane plantation sector. The sample included small farms of 1–59 rai, moderate-sized farms of 60–199 rai, large farms of 200–499 rai, and very large farms greater than 500 rai. The sample was approximately selected according to the proportions of sugarcane farm sizes across Thailand: 80 percent small-scale and moderate-scale farms, 15 percent large-sized farms, and 5 percent very large farms (Sriroth 2016). The 30 certified organic sugarcane farmers were from Nakhon Ratchasima, which is a major area of organic sugarcane plantation with sugar miller collaboration. Face-to-face interviews were conducted by using a structured questionnaire based on the main organic standard activity indicators.

Data Analysis

Empirical model

In this study, adoption is identified by employing weighted scores. The ordinal logit model was employed to explain the model. Adoption studies rely on a random utility model, as in the following Equation (1) (Train, 2002):

$$y_i^* = \beta' x_i + \varepsilon_i \quad (1)$$

where x_i represents the vector of independent variables explaining the adoption of the organic standard at each level, β' is the vector of the observed variables to be estimated, ε_i is the vector of the logistically-distributed error term, and y_i^* is the level of organic standard adoption (Train, 2002). y_i^* is unobserved, but y is observed to be related to the latent variable as measured by the adoption level (Rogers, 2003). The level of organic standard adoption in this study is measured as a weighted score. The total score is 100 points, meaning that if farmers adopt all practices under 18 indicators as explained earlier, they will receive 100 points. If a farmer completes only one practice in each indicator, the score is weighted by the total number of practices. These are divided into 4 parts including 18 indicators followed by Office of Organic Agriculture Standards (2017) in the following details;

Firstly, organic sugarcane production concerns 9 indicators. (1) possessing a land right certificate is an indicator to prove that farm lands are not areas of the primary ecosystem and public forest and they are legal lands.; (2) There are no contaminated sugarcane farms or neighboring areas and; (3) There is no history of contaminated water system.; (4) Water is not brought from chemical farms.; (5) Farmers need to inform neighbors when changing or increasing the sugarcane production area. Four indicators indicate protection and avoidance of practices that will cause pollution to the environment.; (6) Farmers are not allowed to use genetically-engineered organisms (GMOs) in organic sugarcane production. GMOs are not grown under natural conditions or processes,

and are not considered compatible with organic production.; (7) Establishing diversity of plants at the sugarcane farm by practicing crop rotation and growing cover crops and/or other diverse plant species is required.; (8) Buffer areas prevent chemical contamination and the buffer area has at least a 1-meter width/earth bund/drainage.; (9) The ACT is informed of any change in the production of the farm, such as an increase or decrease in the farmland, change of crop type, etc.; (10) Sugarcane farms are certified by ACT and the certified lands must not convert back and forth between organic and chemical production.; (11) No chemical inputs are used for 1 year. The chemical inputs that are not allowed to be used include artificial fertilizers, pesticides, and hormones. Secondly, harvesting and transportation is focused on the environment and hygiene (2 indicators); (12) all sugarcane must be harvested without burning. Green harvesting is cost effective and plant waste can remain on the soil surface and; (13) all vehicles must be kept clean before use to stop the contamination. Third, in regard to cleaning there are two indicators; (14) all sugarcane production equipment must be cleaned before use and; (15) sugarcane farmers should be well-prepared for farm layout between chemical and organic parts by separating agricultural equipment or cleaning before use. Lastly, recordkeeping (3 indicators) is compulsory and includes; (16) sugarcane product sales and selling price; 17) purchasing documents including origin, type and quantities of inputs; (18) all production stages including planning, maintenance, use of inputs, harvesting and post-harvesting.

After the calculation of the adoption score, adoption is classified into three levels according to that score. Boz (2014) also classified the best practice of adoption in his research into three levels. The level is classified by using the minimum score, maximum score, mean score, and standard deviation. They are coded as 0 for a low adoption level (<30) (Minimum < Score ≤ Mean), 1 for a moderate adoption level (30–60) (Mean < Score ≤ Mean + *SD*), and 2 for a high adoption level (61–90) (Mean + *SD* < Score ≤ Maximum). The variable description, measurement type, and expected sign are presented in Table 1.

Results and Discussion

The criteria for practicing organic sugarcane production are presented in Table 2 and are divided into four parts: organic sugarcane production, harvesting and transportation, cleaning and recording. This study determined the application levels of organic standard practices in sugarcane farms. From the table, the most applied items in organic sugarcane production were land owners with land use right certificates (94.82%), no contaminated sugarcane areas (91.67%), using a water system without contamination (88.74%), using water at the farm that is not from chemical farms (79.05%) and informing neighboring farms when the size of the farm changes (64.86%). The least applied organic sugarcane production practices were organic certificate (7.88%), using no chemical inputs for at least 1 year (7.66%) and changing farm land with Organic Agriculture Certification Thailand (ACT)'s permission (5.41%). In the case of harvesting and transportation, it was found that farmers still burned their sugarcane before harvesting in more than 50 percent of farms and they did not clean all types of vehicle before use at around 61.04 percent.

In only 12.39 percent of sugarcane farms did farmers

Table 1 Characteristics of sugarcane farmers and the measurement type

Variable	Description	Measurement type and code (unit)	Expected sign
1. Dependent variable: Y	Adoption level	Ordinal scale	
2. Interdependent variables			
Gender	Gender of sugarcane farm owner	Dummy (1=Male; 0=Female)	+/-
Experience	Number years of sugarcane production	Continuous (Years)	+/-
Household Labor	Number of hired laborers working on the farm	Continuous (Persons)	+
Information channel	Number information channels	Continuous (Channels)	+
Debt	Debt for farms	Dummy (1=Yes; 0=No)	+/-
Land Use Right Certificate	Own land with land use certificate	Dummy (1=Yes; 0=No)	+
Farm size	Sugarcane farm size (Rai)	Continuous (Rai)	+/-
Asset value	Value of agricultural fixed assets (Baht)	Continuous (Thai baht) (1 USD = 32 Baht)	+
Organic Training	Taking organic course training	Dummy (1=Yes; 0=No)	+
Training from factory	Supported by miller officers	Dummy (1=Yes; 0=No)	+

Table 2 Adopters and non-adopters for each organic practice criterion

Standard practices	Applied Number	Percent Applied (%)	Number Not applied	PercentNot applied (%)
Organic Sugarcane Production				
1.Owner of land with land use right certification	421	94.82	23	5.18
2.The sugarcane farm / the neighboring area does not have a contamination history	407	91.67	37	8.33
3.The water system does not have a contamination history	394	88.74	50	11.26
4.Water is not brought from chemical farms	351	79.05	93	20.95
5.Informing neighbors when changing or increasing the sugarcane production area	288	64.86	156	35.14
6. Non-use of genetically-engineered organisms and products in organic sugarcane production	209	47.07	235	52.93
7. Establish diversity of plants at the sugarcane farm by practicing crop rotation and growing cover crops and/or other diverse plant species.	106	23.87	338	76.13
8. Set up buffer areas to prevent chemical contamination. The buffer area has at least 1-meter width/earth bund/drainage	109	24.55	335	75.45
9. The ACT is informed of any change in the production in the farm, such as an increase or decrease of the farm land, change of crop type, etc.	24	5.41	420	94.59
10. Sugarcane farms are certified by ACT	35	7.88	409	92.12
11. Chemical inputs are not used for 1 year	34	7.66	410	92.34
Harvesting and Transportation				
12. No burning of sugarcane before harvesting	187	42.12	257	57.88
13. Cleaning vehicles before carrying sugarcane	173	38.96	271	61.04
Cleaning				
14. All equipment is cleaned before use at sugarcane farms	55	12.39	389	87.61
15. Well prepared for farm layouts between chemical and organic farm	45	10.14	399	89.86
Recordkeeping				
16.Recordkeeping of sales of all organic sugarcane products and price before transferring to quota leaders or sugarcane millers	162	36.49	282	63.51
17. Recordkeeping and/or purchasing documents that specify the origin, type and quantity of purchased inputs	166	37.39	278	62.61
18. Recordkeeping of all production stages from planting, maintaining, using of inputs, harvesting to post-harvest cropping	124	27.93	320	72.07
Total	444			

clean all agricultural equipment before use, and only 10.14 percent of farm layouts were organized to separate chemical and organic parts of the farm. Record keeping is also important in organic practice, but it was found that only 36.49 percent of sample farms recorded sales and the price of the sugarcane sold. Record-keeping is a major requirement in maintaining standards; however, the results showed that only around one third of farmers recorded their inputs, outputs and sales.

Table 3 illustrates the adoption level of farms of each size. Most farms, small farms (60.9%), moderate farms (56.8%), large farms (50.8%) and very large farms (39.3%) were at low levels of practice.

The results of the ordered logit estimates for organic adoption (Table 4) revealed that the dependent variable was measured at three levels of adoption: low level, medium level, and high level. Ten explanatory variables were entered into the model and five were significant at the 0.05 level of probability or lower and one was significant at the 0.1 level of probability. The chi-square test for the empirical ordered logit is 92.80 with statistical significance, which rejects the null hypothesis. The factors affecting the adoption of organic standards included gender, number of information channels, debt, land right certification, asset value and organic training. However, the sugarcane planting experience of respondents, household labor, farm size and training from sugar millers had no influence on adoption.

Gender was an independent variable that had a negative relationship with the adoption probability, indicating that female farmers were more likely to adopt organic practices than males perhaps because female farmers tend to be more ready to adopt new methods and tools on the farm such as technology or complex practices. This supports Bindlish

and Evenson (1993), who studied technological adoption by male and female farmers in Kenya and Chanhathai et al. (2016), who found that females were more likely to adopt organic practices for rice farming.

The number of information channels was another factor that had a significant influence on adoption. This finding verified that farmers tended to receive information from many channels and this affected the adoption of organic standards. Debt was also found to significantly affect the adoption of organic farming because with low debt, farmers may be more willing to adopt organic practices. They may focus on other benefits instead of income. Diederen et al. (2003) also stated that credit constraints may hamper the adoption of innovations. Land right certificate impacts the adoption of organic standards at the 0.1 percent significant level. Mozzato et al. (2018)

Table 3 Adoption levels by size of farm

Organic Standard Level	Sugarcane farm size								Number of sugarcane farms	Percentage of sugarcane farms
	Small farm (1–59 rai)		Moderate farm (60–199rai)		Large farm (200–499 rai)		Very large farm (>500 rai)			
	No.	Percentage of adoption	No.	Percentage of adoption	No.	Percentage of adoption	No.	Percentage of adoption		
Low practice level	126	60.9	84	56.8	31	50.8	11	39.3	252	56.76
Moderate practice level	49	23.7	44	29.7	23	37.7	10	35.7	126	28.38
High practice level	32	15.5	20	13.5	7	11.5	7	25.0	66	14.86
Total	207	100	148	100	61	100	28	100	444	100
Average score = 39.76										
Minimum score = 5.26										
Maximum score = 89.47										
Standard Deviation = 15.26										

Table 4 Ordered Logit Estimates for Organic adoption

Variable	Coefficient	Standard error	*p*	Very Low Level < 30	Marginal Effects Medium Level 30–60	High Level 60–90
Gender (M, F)	-0.46198**	0.231877	0.0460	0.11462	-0.06217	-0.05245
Experience (Ys)	-0.00957^{NS}	0.007728	0.2150	0.00236	-0.00137	-0.00099
Household labor (No.)	0.01158^{NS}	0.086246	0.8930	-0.00285	0.00166	0.00119
Information channels (No.)	0.01229**	0.005761	0.0330	-0.00303	0.00176	0.00127
Debt (Y/N)	-0.59770***	0.229113	0.0090	0.14800	-0.07902	-0.06899
Land Right Certificate (Y/N)	1.04280*	0.540155	0.0540	-0.22743	0.15184	0.07559
Farm size (Rai)	0.00034^{NS}	0.000425	0.4250	-0.00008	0.00005	0.00004
Asset value (Baht)	0.00000009**	0.000000	0.0210	0.000002	0.0000012	0.0000009
Organic Training (Y/N)	2.19982***	0.299785	0.0000	-0.47158	0.09128	0.38030
Training from factory (Y/N)	0.34788^{NS}	0.243619	0.1530	-0.08637	0.04747	0.03890
Cut1	1.124117	0.5980088				
Cut2	2.909865	0.615418				
Log likelihood				-380.27512		
LR chi2(10)				92.8		
Prob > chi2				0.000000		
Pseudo R^2				0.1087		

Note: *$p < .05$. **$p < .01$. ***$p < .001$.

found that ownership of land increases the adoption of environmentally-friendly farming practices. Next, asset value from fixed assets is another variable affecting adoption because having agricultural machines makes it easier to meet the standards such as weed removers, harvesting machines and irrigation systems. Boz (2014) found that farming investment supported increased willingness to adopt best management practices. In addition, the organic training variable was shown to substantially affect the adoption of organic standards at the 0.01 percent significant level. Chanhathai et al. (2016) revealed that participation in organic training was likely to encourage the adoption of organic rice farming.

The marginal effects of the ordered logit model were divided into low, medium and high adoption levels and interpreted as follows: for sugarcane farmers, being female increased the probability of a medium and high adoption level by 6.2 percent and 5.2 percent, respectively while for males, low level adopters decreased by 11.46 percent. Having more channels to receive agriculture information decreased the probability of low adoption levels by 0.30 percent, but it increased the possibility of medium and high level adopters by 0.18 percent and 0.13 percent, respectively. In contrast, lower debt increased the probability of medium and high adoption levels by 7.9 percent and 6.89 percent, respectively. Ownership of land increased the probability of high and medium levels of adoption by 15.18 percent and 7.56 percent, and decreased the probability of low level adoption by 22.74 percent. Next, the marginal effects for asset value of fixed assets had less effect on adoption. Lastly, those who had organic training by sugar millers were 0.9 percent and 2.28 percent of medium and high levels of adoption.

Conclusion and Recommendation

Organic practice is applied on some sugarcane farms in Thailand, and organic farming can yield both cash benefits and noncash benefits for farmers as well as support food safety and environmental sustainability. However, the number of organic sugarcane farms in Thailand is still small. This paper investigated the adoption of organic standards by sugarcane farmers in Thailand (Kanchanaburi, Suphanburi and Nakhon Ratchasima) with reference to demographic data and other factors involved in organic standard practices. The findings revealed that the most problematic organic standard practices are: (1) informing the ACT of any change in production; (2) stopping the use of all chemical inputs for 1 year; (3) not burning after harvesting; (4) cleaning all equipment before use, and (5) record-keeping for all process from the farm to the miller. The adoption results revealed that gender, information channel numbers, debt, land right certificate, asset value and organic training were significantly important factors for the adoption of organic standard practices while sugarcane plantation experience, household labor, farm size and training from factory had no influence on adoption. The results of the study verified that the adoption of organic standards by sugarcane farmers in Thailand occurred at a low level particularly in small (61.06%), medium (58.23%) and large farms (49.33%). Only very large farms could practice organic standards at a medium practice level. To increase the level of organic standard farming, knowledge has to be provided to female sugarcane farmers because they are more likely to adopt organic practices. More information and organic training should be given to sugarcane farmers. Finally, having lower levels of debt may encourage farmers to adopt organic methods even though organic sugarcane farming mostly delivers lower yields. The government could offer assistance by allowing low loan payment extensions.

Conflict of Interest

There is no conflict of interest.

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References

Office of Cane and Sugar Board. (2019). *Sugarcane farm statistic report 2019*. Retrieved from http://www.ocsb.go.th/upload/journal/fileupload/923-9040.pdf [in Thai]

Athipanyakul, T., & Pak-Uthai, W. (2012). Determinants of Good Agricultural Practices (GAP) adoption in the chili production system in Northeastern Thailand: A case of participatory approach. *International Journal of Environmental and Rural Development*, 3–2, 175–180.

Bindlish, V., & Evenson, R. (1993). *Evaluation of the Performance of T&V Extension in Kenya* (Technical Paper 208). Washington, DC: World Bank.

Boz, I. (2014). Determination of best management practices and innovations in beef cattle farming and their adoption in the eastern Mediterranean region of Turkey. *Bulgarian Journal of Agricultural Science*, *20*(3), 552–562.

Chanhathai, K., Suneeporn, S., & Panya, M. (2016). Factors affecting adoption of organic rice farming in sustainable agriculture network, Chachoengsao Province, Thailand. *International Journal of Agricultural Technology*, *12*, 1229–1239.

Diederen, P., Meijl, V. H., Wolters, A., & Bijal K. (2003). Innovation adoption in agriculture: Innovators, early adopters and laggards. *Cahiers d'Economie et de Sociologie Rurales*, *67*, 29–50. doi: 10.22004/ag.econ.205937

Jerop, R., Dannenberg, P., Owuor, G., Mshenga, P., Kimurto, P., Willkomm, M., & Hartmannn, G. (2018). Factors affecting the adoption of agricultural innovations on underutilized cereals: The case of finger millet among smallholder farmers in Kenya. *African*

Journal of Agricultural Research, *13*(36), 1888–1900. doi: 10.5897/AJAR2018.13357

Kshirsagar, K. G. (2006). Organic sugarcane farming for development of sustainable agriculture in Maharashtra. *Agricultural Economics Research Review*, *19*, 145–153.

Kuldilok, K. (2019). *Adoption of sustainability management under the standard of sugarcane production practices: Sugarcane farm case study*. (Research Report RDG61T0063). Bangkok, Thailand: Kasetsart University. [in Thai].

Mozzato, D., Gatto, P., Derfrancesco, E., Bortolini, L., Pirotti, F., Pisani, E., … Sartori, L. (2018). The role of factors affecting the adoption of environmentally friendly farming practices: Can Geographical content and time explain the differences emerging from literature? *Sustainability*, *10*(9), 3101. doi: 10.3390/su10093101

Nhan, P. (2014). *Sugar industry report: Change to survive*. Retrieved from http://fpts.com.vn/FileStore2/File/2014/07/03/Sugar%20industry%20report.pdf

Office of Organic Agriculture Standards. (2017) *Organic standards*. Retrieved from http://actorganic-cert.or.th/wp-content/uploads/2017/10/act_standards_2016_v4_revision24-02-17.pdf

Patil, S., Reidsma, P., Shah, P., Purushothaman, S., & Wolf, J. (2014). Comparing conventional and organic agriculture in Karnataka, India: Where and when can organic farming be sustainable? *Land Use Policy*, *37*, 40–51. doi: 10.1016/j.landusepol.2012.01.006

Pettong, P., & Thanaphanyaratchawong, J. (2009). Adoption of good agricultural practices for rambutan of farmers in Ban Nasan District, Surat Thai province. *Suranaree Journal of Science and Technology*, *3*(2), 109–126. [in Thai].

Photchanaprasert, N., Kuldilok, K., & Athipanyakul, T. (2018). *Supply Potential Demand, and Impact of Sugarcane Harvester Adoption in Thailand*. Paper presented at 6th IAPSIT International Sugar Conference, Sugar Crops Improvement, Biotechnology, Bio Refinery and Diversification: Impacts on Bio-based Economy, Udon Thani, Thailand.

Posttoday. (2017). *Organic sugarcane to organic sugar*. Retrieved from https://www.posttoday.com/economy/sme/517801 [in Thai].

Preecha, R., Jungtrakool, M., Srikongpetch, K., & Ratavetchakul, W. (2017). *New outlook of Thai sugar and cane industries*. Bank of Thailand Symposium, Khon Kaen, Thailand.

Reportlinker. (2017). *Global organic sugar market research report-forecast to 2022*. Retrieved from https://www.reportlinker.com/p05376951/Global-Organic-Sugar-Market-Research-Report-Forecast-to.html

Ritdet, B. (2003). *Adoption of mango cultivator group's member on mangoes CV "Nam Dok Mai" production standard in Doem Bang Nang Buat District, Suphan Buri Province* (Unpublished master's thesis). Graduate School, Kasetsart University, Bangkok, Thailand. [in Thai]

Rogers, E. M. (2003). *Diffusion of innovation* (5th ed.). New York, NY: The Free Press.

Sriroth, K. (2016). *Thai crop production where is it heading to?* Presentation at Cash Crop Conference 2016. Bangkok, Thailand.

Train, K. (2002). *Discrete choice methods with simulation*. Cambridge, UK: Cambridge University Press.