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Research article

Transformation towards Organic Cassava Production in Yasothon Province, Thailand

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Abstract

With the marked increase in consumer and commercial demand for organic foods and products, organic cassava production has become a viable alternative for small growers because it can lead to the sustainability of the agriculture and food production system. However, few studies have been conducted to enable a more comprehensive understanding of the factors that contribute to the transformation from chemical into organic cassava production systems. This study quantitatively aimed to identify socioeconomic, cassava profitability, and institutional factors that influence the cultural practice transformation towards organic cassava production in a district of Yasothon province, Thailand. We used a structured interview schedule to collect data from 283 sampled cassava growers comprising 236 chemical cassava growers and 47 organic cassava growers in the district during the period from August 2020 to November 2020. Quantitatively, we used the binary logistic regression method to identify the positive and negative factors contributing to the transformation of cassava production systems including growers' motivations for the transformation. The study findings indicated that income from organic cassava was taken as the main motivation for growers' decisions to transform (40.3%). We found that organic cassava farm gate price, access to formal credit, labor used and membership in growers' organizations were positive significant factors that affected the cultural practice transformation. Finally, small cassava growers as well as stakeholders should systemically be considered by policymakers and in strategic intervention through relevant institutions.

Keywords: transformation; organic cassava; chemical cassava; production

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1. Introduction

The impressive growth in global market demand for organic foods and products is believed to encourage the greater extent of production of foods and raw materials that are environmentally-friendly, safe to consume, and based on natural resources (Effa et al., 2024; Ogwu & Kulkarni, 2024). Organic cassava (*Manihot esculenta* L. Crantz) production systems are a reasonable alternative for sustainable rural livelihoods and household security (Cerilles, 2015; Pushpalatha & Gangadharan, 2020; Li et al., 2020). Hence, organic agriculture has been viewed as an alternative production option that could contribute to the Thai economy as well as to human and environmental health. Since 1992, organic crop production has gained interest from the public and various stakeholders in Thailand. Consequently, development strategies and plans have been formulated as a national policy in Thailand to transform chemical farming practices into an organic orientation. Various state policies and programs have been implemented to increase market opportunity for Thai organic foods and products to be recognized more widely by both local and international consumers (TDRI, 1992; FAO, 2018; OAE, 2020). In 2001, the Thai government established a series of concrete policies and strategies to promote organic agriculture (OAE, 2022). Subsequently, a national goal of agricultural production was set to increase the total organic farming area to 1.6 million hectares (ONESDC, 2022) according to the 13th National Economic and Social Development Plan (2023-2027). Cassava in Thailand has been an economic crop deserving the attention to be grown organically.

Cassava has demonstrated to be a major cash crop in resource-poor environments and has played a significant role in socio-economic development worldwide (Cerilles, 2015; McCallum et al., 2017; Muiruri et al., 2021). At the national scale, in Thailand's case, cassava production constituted roughly 10.1% of the agricultural GDP in 2018 (BOI, 2107; OAE, 2019). Thai cassava starch and products are preferred by many importing countries. Meanwhile, Thai cassava has been recognized as an industrial crop that creates a long value chain of cassava-based products and biorefineries, supplying around 67% of the global market with an annual export quantity of 6.94 million tonnes in 2020 (BOI, 2017; Piyachomkwan &Tanticharoen, 2011; OAE, 2021). Organic cassava is a new trend in agro-industrial crop production. It has been recognized as a means to raise the country's competitiveness as well as to increase market share. Furthermore, it has been driven by those consumers who have concerns about their health and environmental conditions. In 2020, organic cassava production covered approximately 2,500 hectares of agricultural land in Thailand (BOI, 2017; OAE, 2021).

Transforming to a new crop production system is recognized as a means to improve household livelihood and to support sustainable growth in rural areas (Barghouti et al., 2004; Thornton et al., 2018). For small growers to adopt and adapt to a new agricultural production system and participate in the new farming environment, several factors are known to interdependently influence their decisions. These factors include growers' access to markets; the state of domestic and international markets, market information tools, and farm-aid from public and private officers (Dankyi & Adjekum, 2007; Akyüz & Theuvse, 2020). Marketing information about prices and products is very important for the emerging new-system growers and helps growers make decisions and participate in new systems (Kulshreshtha, 2024). In terms of non-economic factors, farm size is an effective determinant of growers' decisions to adopt new practices that may need additional training and learning in various production skills to boost their productivity and farm income (Yee et al., 2004). Furthermore, government policies and subsidies can greatly enhance the capacity to access the new technologies, credit, and training needed to affect agricultural production changes, while marketing technique support for small growers is also meaningful (Thrupp, 2000; Khapayi & Celliers, 2016; Ouédraogo et al., 2017). Nevertheless, agricultural transformation may continue over time, even when various historical, cultural, and demographic factors are considered (Ang, 2015). Assuring future agricultural transformation and development is a major challenge for concerned actors and stakeholders to accomplish the goal. Thus, the research findings on agricultural transformation and development can be used for developing guidelines and making suggestions regarding desirable support and action-oriented policies to foster sustainable development (Wigboldus et al.,2016; Sartas et al., 2020). Meanwhile, to measure and predict the performance of the transition and transformation into an organic cassava production system, a set of indicators concerning the environment, crop protection, health, society, and the economy can be used (Trabelsi et al., 2016).

With respect to Thailand's strategy, a sustainable organic agricultural production system is aimed at ensuring sustainable rural livelihood. Thus, this study was conducted to gain a better understanding of a set of socio-economic, cassava production, and institutional factors influencing the transformation of cassava production from chemical to organic farming by small-scale cassava growers. The findings will provide evidence for effective intervention and support towards sustainable cassava production systems.

2. Materials and Methods

2.1 Research framework

The study was framed around factors influencing the transformation from chemical into organic cassava production systems (Figure 1). The factors include three sets of interdependent internal factors, namely; socio-economic background, cassava cultural practices, and access to such institutional benefactors such as agricultural extension services, formal credit, and growers' organization membership. Binary logistic regression analysis was performed to determine the cassava cultural practice transformation. This study's findings could indicate the expected outcomes of those cassava growers who opted for organic-cultural practices, the enabling and impeding factors of the transformation, as well as the necessary subsidies and other support from government agencies and relevant stakeholders to help increase grower competency in farming practice transformation in the research area.

2.2 Research area

Yasothon province is a plain with some low hills and occupied approximately 384,154 ha. Both chemical and organic cassava production systems were practiced by some 11,780 farming households in the province. Cassava planted areas in Yasothon province increased rapidly over the period of 2009-2020 from 8,345 to 14,132 ha. The average cassava storage root fresh weight (marketable yield) was at the same level as the national average (OAE, 2020). The project of transformation into organic cassava production was implemented in 2017 and involved collaboration between the government (public sector) and a private cassava starch factory (the Ubon Bioethanol Company, UBE). The project was aimed at enhancing and improving growers' livelihood and global competitiveness. Kham Khuean Kaeo district was chosen because of its largest planted area and the highest yield of cassava in Yasothon province (Figure 2).

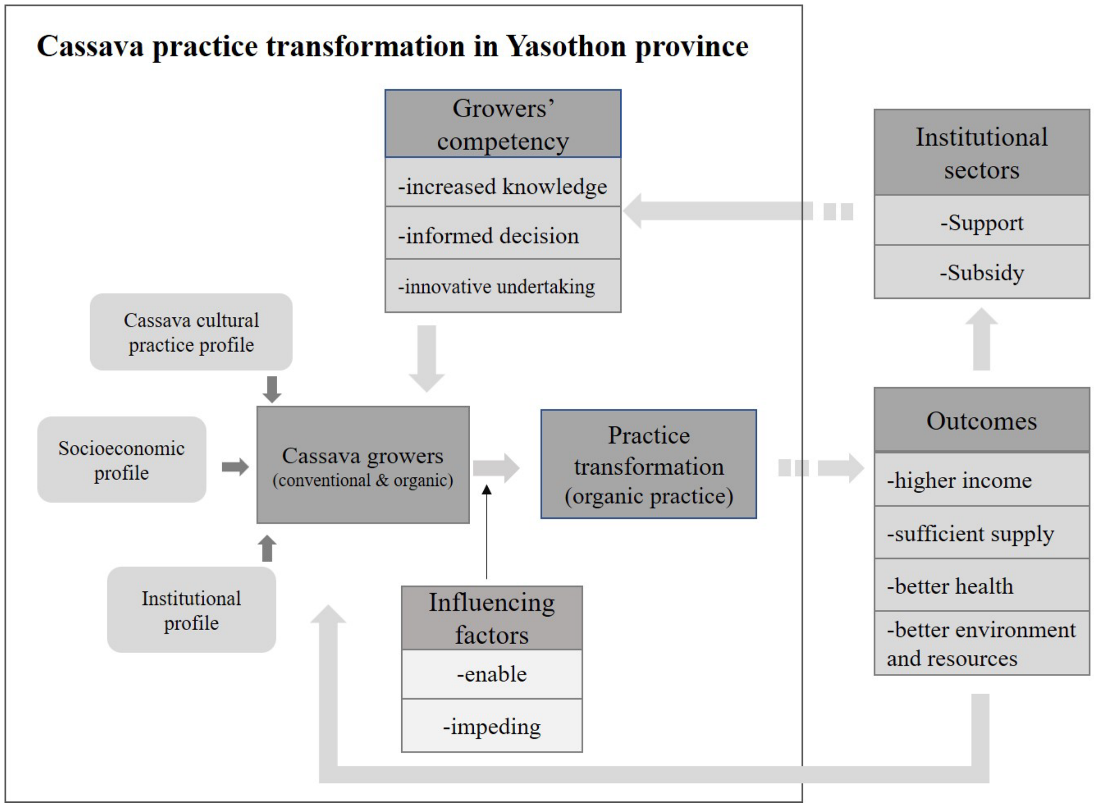

Figure 1. The research framework of the study in Yasothon province

Administratively, Kham Khuean Kaeo district consists of 13 sub-districts, with 65,703 population (National Statistical Office, 2021). Kham Khuean Kaeo areas represent the rainfed agricultural systems in Yasothon province and in Thailand. The local population manages available climatic, edaphic and other resources in such a way that their risks are minimized and some returns can be obtained. The major economy crop in the lowland zones is rice, and on the upland fields are field crops such as cassava and sugarcane. Chemical cassava production is a major economic crop in the upland fields where the soils are predominantly sandy, which provides a better drainage for the crop. In 2019, with the support of local government, the UBE and the Department of Agriculture (DOA), a project to introduce organic cassava production as an additional source of on-farm income was implemented.

2.3 Sample size and data collection

Total cassava growers in Kham Khuean Kaeo district were 578 and 53 in the chemical and organic systems, respectively. The sample size of growers to be randomly selected for data collection was determined using the formula of Yamane (Yamane, 1967), resulting in the selection of a total sample size of 283 growers covering 236 chemical growers and 47 organic growers at the 5% level of sampling error. The interview with growers was carried out during August 2020 to November 2020.

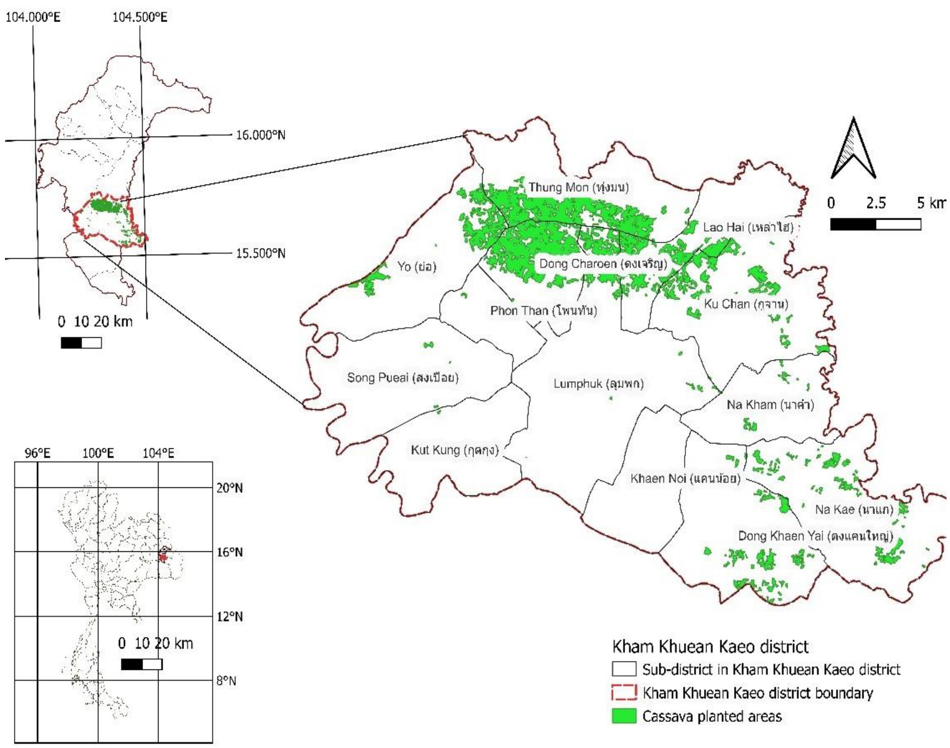

Figure 2. Location of the research areas with cassava planted areas in Kham Khuean Kaeo district, Yasothon province. (Source: Authors)

The study employed a quantitative method using a structured interview schedule for one-on-one interview sessions with sampled cassava growers. The questionnaire covered the influencing transformation factors that were grouped into (1) socio-demographic profiles: age, gender, years of formal education, and non- farm income; (2) cassava production characteristics including year in cassava production, cassava planted area per household, labor used, cassava farm gate price, and profit from cassava production; and (3) institutional variables that contribute to cassava cultural practice transformation comprising access to agricultural extension services, access to formal credit, and membership in growers' organizations. The detailed explanatory variables that were used are given in Table 1. Growers' opinions about their motivations for the transformation from chemical cassava production to organic cassava production system were also asked.

2.4 Data analysis

We used a binary logistic regression equation to find the best-fitting model. The model was then used to describe the relationship between the explained and explanatory variables (Madala, 2005; Agresti, 2007; Ziegel & Menard, 2012; Conteh et al., 2016; Lee et al., 2016; Mustapha et al., 2017). The explained variable for this research was the transformation of the chemical to organic production by cassava growers, which was 0 for no transformation and 1 for transformation. The logit formula used to estimate the probability of the transformation into organic production is as follows;

Table 1. Explanatory variables and their descriptions for the transformation of cassava production

Explanatory Variable	Description	Variable Type
X1 (Age)	Age of growers (years)	Continuous
X2 (Gender)	0=female, 1=male	Dummy
X3 (Year in formal education)	Number of years (formal education)	Continuous
X4 (Year in cassava production)	Years of cassava production	Continuous
X5 (Cassava planted area)	Hectare (ha)	Continuous
X6 (Labor used)	Number of labors used in cassava production (man-days/ha)	Continuous
X7 (Cassava price above average)	1 If a grower gets a farm gate price higher than the average, otherwise 0	Dummy
X8 (Profit from cassava production)	Profit from cassava production (baht/ha)	Continuous
X9 (Non-farm income)	Total income from non-farm activity (baht/year)	Continuous
X10 (Access to agricultural extension service)	Access to agricultural extension services 1 if grower has access to agricultural extension service, otherwise 0	Dummy
X11 (Access to formal credit)	Access to formal credit 1 if grower has access to credit, otherwise 0	Dummy
X12 (Growers' organization membership)	Membership in growers' organization 1 if grower is a member of growers' organization, otherwise 0	Dummy

Source: Authors

$$\text{Logit}(P_y) = {}_o+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9+b_{10}X_{10} +b_{11}X_{11}+b_{12}X1_2 \quad (1)$$

where: Py is the probability of the presence of transformation into organic practice. The logit transformation is defined as the logged odds (Q_y):

$$P_y=\frac{e^{b_0+b_1X_1+\ldots+b_{12}X_{12}}}{1+e^{b_0+b_1X_1+\ldots+b_{12}X_{12}}} \quad (2)$$

$$Q_y=1-P_y \quad (3)$$

$$\text{and } Q_y = \log\left(\frac{P_y}{1-P_y}\right) \quad (4)$$

Where b_0 is an intercept term, and the parameters b_i (i=1, 2, …, 12) are the coefficients of each explanatory variable to be estimated, which can reveal the possible impact of each explanatory variable exerted on the explained variable (Madala, 2005; Minetos & Polyzos, 2009; Ullah et al., 2015).

3. Results and Discussion

3.1 Socioeconomic characteristics

Based on the survey, we found 44.9% of the sampled cassava growers were in the 46-55 years old age group. The average ages of the chemical and organic cassava growers were 54.5 and 51.5 years old, respectively. Both chemical and organic growers demonstrated a higher portion of growers in the elderly age group, which meant they had an equal farming ability to perform cassava production. It was also observed in another study (Minetos & Polyzos, 2009) that most elderly people concentrated more on farming than on non-farm activities. Organic cassava growers had a slightly higher mean number of years in school (8.4 years) than chemical cassava growers (7.1 years) as shown in Table 2.

Overall, 58.7% of the surveyed growers were female. The similar proportions of female and male cassava growers in both chemical and organic cassava groups indicated that gender was not an effective factor for cassava cultural practice transformation. This was in contrast with the reports by Jerumeh & Omonona (2020) and Okeyo et al. (2020), who reported that gender was an influencing factor in farming practice.

In terms of formal education, 64.0% of the surveyed cassava growers received elementary education, i.e., six-years of primary schooling.

We found that cassava growers in both groups had comparable levels of formal education. However, a significant difference in cassava growing experience implied that there was a considerably different ability to access and choose appropriate information and innovation. Efforts in the future might be needed to improve knowledge and innovation skills for chemical growers who had relatively lower education level. Based on findings by Oluwasola (2010) and Ntshangase et al. (2018), growers with a high level of formal education were likely to transform.

3.2 Cassava production characteristics

The study results clearly revealed that years in cassava production, cassava planted area, labor used, and the price of organic cassava were statistically significantly different between tradition and organic growers (Table 3). Organic cassava growers had a mean year in cassava production of about 16.6 years, higher than that of chemical growers which was 12.5 years. This was in line with Oluwasola (2010) and Ntshangase et al. (2018), who found that growers with a high cassava growing experience were likely to transform due to the fact that they could understand relevant information, explore financial resources and manage resources to stabilize their agricultural output (Lapar & Ehui, 2004; Sodjinou et al., 2015).

Table 2. Socioeconomic characteristics of chemical and organic cassava growers

Characteristic		Chemical (n=236) n (%)	Organic (n=47) n (%)	Total (n=283) n (%)
Age	25-35	4 (1.7)	0 (0.0)	4 (1.4)
	36-45	28 (11.9)	11 (23.4)	39 (13.8)
	46-55	105 (44.5)	22 (46.8)	127 (44.9)
	56-65	69 (29.2)	10 (21.3)	79 (27.9)
	66-75	25 (10.6)	4 (8.5)	29 (10.2)
	>75	5 (2.1)	0 (0.0)	5 (1.8)
Gender	Female	139 (58.9)	27 (57.4)	166 (58.7)
	Male	97 (41.1)	20 (42.6)	117 (41.3)
Formal education	No schooling	3 (1.3)	0 (0.0)	3 (1.1)
	Elementary school	162 (68.6)	19 (40.4)	181 (64.0)
	Lower secondary	64 (27.1)	25 (53.2)	89 (31.4)
	Upper secondary school	5 (2.1)	3 (6.4)	8 (2.8)
	Higher education	2 (0.9)	0 (0.0)	2 (0.7)

Source: Field survey

The results also revealed that the average farm gate price of organic cassava was 2.8 baht/kg, higher than that of chemical cassava, which was 1.6 baht/kg (Table 3). This was also found by Hall & Mogyorody (2001), who noted that a high price of organic products was a buyer' strategy used to motivate growers participating in the new alternative technology. Finally, we found that non-farm incomes between chemical and organic growers were not statistically different (Table 3).

The average amounts of labor used in chemical and organic cassava production were 35.7 and 60.6 man-days, respectively. Chemical growers allocated labor to five major activities, i.e., 32.4% for fresh root harvesting, 21.0% for weed control, 17.5% for fertilizer application, 15.9% for planting, and 13.2% for stem cutting before harvesting, while organic growers allocated labor as follows: 33.3% for weed control, 28.9% for fresh root harvesting, 15.3% for planting, 14.3% for fertilizer application, and 8.2% for stem cutting before harvesting. The finding demonstrated clearly that most labor used under organic production was for weed management. According to Sarker & Itohara (2008) and Li et al. (2020), organic crop production utilized non-chemical inputs and was labor-intensive, and especially requiring more time and effort to control the weed population. The expanding planted area can imply an increase in labor requirements.

Concerning cassava planted areas, chemical growers had a larger average cassava planted area than organic growers. Some 68.1% of organic growers cultivated their organic cassava in less than 1 ha of land, while most chemical growers planted the crop in a larger area (Table 4). According to the findings of Kidane & Zwane (2022), organic growers usually perform their production in small farm sizes.

Table 3. Selected descriptive statistics of sampled cassava producing households of chemical and organic cassava growers

Factor		Chemical Growers (n=236)	Organic Growers (n=47)	t-test
Year in cassava production (years)	Mean	12.5	16.6	0.01*
	S.D.	8.8	10.8	
Cassava planted area (ha)	Mean	1.5	0.9	0.00**
	S.D.	1.0	0.6	
Labor used (man-days/ha)	Mean	35.7	60.6	0.00**
	S.D.	7.7	23.8	
Cassava farm gate price (baht/kg)	Mean	1.6	2.8	0.00**
	S.D.	0.1	0.4	
Non-farm income (baht/year)	Mean	13,057.0	20,557.5	0.35
	S.D.	53,077.3	30,398.5	

Remarks: S.D. = Standard deviation; **=significant at 1%; *=significant at 5%
Source: Field survey

Table 4. Cassava planted area per household (ha) of chemical and organic cassava growers.

Cassava Planted Area (ha)	Chemical Growers (n=236)		Organic Growers (n=47)	
	Frequency	%	Frequency	%
0.00-1.00	84	35.6	32	68.1
1.01-2.00	97	41.1	14	29.8
2.01-3.00	35	14.8	1	2.1
3.01-4.00	15	6.4	0	0.0
4.01-5.00	3	1.3	0	0.0
>5.00	2	0.8	0	0.0
Average	1.5		0.9	
Min	0.2		0.2	
Max	5.3		2.7	
S.D.	1.0		0.6	

Source: Field survey

3.3 Institutional characteristics

Organic cassava growers clearly showed a high proportion of access to agricultural extension services (95.7%) and access to formal credit (93.6%) as compared to their chemical cassava growers (Table 5). With respect to their membership of grower organizations, the majority of both chemical and organic growers who were not members of any grower organization were 94.1 and 66.0%, respectively. Our findings agreed with the results reported by Okeyo et al. (2020), Mmbando & Baiyegunhi (2016) and Othman et al. (2020), conducted in Kenya and Tanzania.

Table 5. Institutional characteristics of chemical and organic cassava growers

Variable		Chemical Growers (n=236) n (%)	Organic Growers (n=47) n (%)	Total Growers (n=283) n (%)
Access to agricultural extension services	No	76 (32.2)	2 (4.3)	78 (27.6)
	Yes	160 (67.8)	45 (95.7)	205 (72.4)
Access to formal credit	No	58 (24.6)	3 (6.4)	61 (21.6)
	Yes	178 (75.4)	44 (93.6)	222 (78.4)
Growers' organization membership	No	222 (94.1)	31 (66.0)	253 (89.4)
	Yes	14 (5.9)	16 (34.0)	30 (10.6)

Source: Field survey

3.4 Growers' motivations for the transformation

The decision to transform cassava production from a chemical to organic system was revealed to be shaped by six main motivations (Table 6). The first motivation frequently mentioned by growers in both groups (40.3%) was the desire to earn a higher income. Based on previous reports by Hall & Mogyorody (2001); Kidane & Zwane (2022) & Riar et al. (2017), a favorable selling price was a powerful inducing factor for organic crop production, especially for medium and small growers, as was risk reduction from high production costs.

The second motivation was the compatibility of the new technology, organic cassava, with the chemical cassava production (36.0% of the sampled households). Growers recognized the slight difference in the production management from planting to harvesting between chemical and organic cassava production. For organic cassava production, only organic inputs can be used and should be locally produced. Thus, it was compatible and very simple to transform for growers with access to organic inputs and with understanding the benefits of organic production systems (Sarker & Itohara, 2008).

Thirdly, about 12.4% of sampled households mentioned the importance of the cost of cassava production. This was also in line with reports by Pannell et al. (2006), Andres et al. (2016) and Yigezu et al. (2018), which indicated that the cost of alternative practice establishment and implementation can rapidly speed up the technology transformation.

The remaining three motivation factors for adoption of organic cassava were improved land productivity, a practice of healthy livelihood and access to a secure market, which were mentioned by 6.0, 3.2 and 2.1% of the sampled households, respectively.

3.5 Subsidies and supports for the transformation

The growers cited subsidies and support from the government and the private sectors for the transformation to organic cassava production, and growers considered several kinds of support to be helpful. Organic fertilizers such as granular fertilizers, green manure, and compost were viewed as necessary for organic production. However, 32.2% of total sampled growers made it clear that availability of organic fertilizers was limited and the costs varied widely across organic input types. Relevant government agencies should help secure low cost and easy-to-access granular organic fertilizers at the community level (Table 6).

Table 6. Motivations and supports for farming practice transformation by two groups of cassava growers

Statement	Chemical Growers (n=236) n (%)	Organic Growers (n=47) n (%)	Total Growers (n=283) n (%)
I. Motivations for practice transformation			
1. Income from organic cassava	91 (38.6)	23 (49.0)	114 (40.3)
2. Compatibility of organic cassava	98 (41.5)	4 (8.5)	102 (36.0)
3. Cost of production of organic	27 (11.4)	8 (17.0)	35 (12.4)
4. Improved land productivity	13 (5.5)	4 (8.5)	17 (6.0)
5. Healthy livelihood	2 (0.9)	7 (14.9)	9 (3.2)
6. Secured market	5 (2.1)	1 (2.1)	6 (2.1)
II. Subsidies and supports from stakeholders			
1. Availability of organic fertilizers	82 (34.7)	9 (19.1)	91 (32.2)
2. Technical understanding	65 (27.5)	3 (6.4)	68 (24.0)
3. Local trading sites	61 (25.9)	0 (0.0)	61 (21.6)
4. Guaranteed price	20 (8.5)	24 (51.1)	44 (15.5)
5. No need for it	5 (2.1)	6 (12.8)	11 (3.9)
6. Credit	3 (1.3)	5 (10.6)	8 (2.8)

Finally, the growers mentioned the need of technical training courses such as compost fertilizer-making process, organic production technologies (cassava variety and nutrient management), and farm management for organic certification. In terms of marketing, growers required an increased number of cassava buyers in their local area to have more market choices and a higher level of competition for better farm gate prices.

3.6 Factors affecting the transformation of the cassava production system

Based on our model in equation (1), we found that all continuous and categorical explanatory variables, both internal and external, were linearly related to the logit of the explained variable and no multicollinearities were founded. The fitted model was highly significant, ($\chi2 = 175.77$, $p = 0.00$), with 78.0% of the variance in the transformation of cassava production explained by the logistic regression model. The logistic regression model correctly classified the outcome for 95.1% of the cases as compared to 83.4% of the baseline model. The logistic regression results, including goodness of fit and other model performance statistics, are presented in Table 7.

Table 7. Factors affecting the transformation of cassava production in Kham Khuean Kaeo district

Variables	Coefficient	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for Odd Ratio Lower	95% C.I. for Odd Ratio Upper
1. Age	-0.06	0.04	1.77	1	0.18	0.95	0.87	1.03
2. Gender	0.23	0.65	0.13	1	0.72	1.26	0.35	4.56
3. Education	0.11	0.11	1.04	1	0.31	1.12	0.90	1.38
4. Year in cassava production	0.07	0.04	2.76	1	0.10	1.07	0.99	1.16
5. Cassava planted area	-0.72	0.50	2.03	1	0.15	0.49	0.18	1.31
6. Labor used	0.09	0.03	11.73	1	0.00**	1.10	1.04	1.15
7. Cassava price above average	3.70	0.75	24.36	1	0.00**	40.50	9.31	176.11
8. Profit from cassava production	-0.15	0.74	0.04	1	0.84	0.86	0.20	3.65
9. Non-farm income	0.21	0.87	0.06	1	0.81	1.23	0.22	6.81
10. Access to agricultural extension service	1.26	0.97	1.71	1	0.19	3.53	0.53	23.48
11. Access to formal credit	3.38	0.99	11.65	1	0.00**	29.30	4.21	203.89
12. Growers' organization membership	2.12	0.86	6.12	1	0.01*	8.33	1.55	44.67
13. Constant	-10.04	2.92	11.85	1	0.00	0.000		
Goodness of fit and Model performance statistics								
Number of observations					283			
-2 Log Likelihood					78.71			
Likelihood Ratio (LR) Chi square					175.77**			
Classification accuracy of the baseline model					83.4			
Classification accuracy of the fitted model					95.1			
Nagelkerke (Pseudo) R^2					0.78			

Notes: S.D. = Standard deviation; **=significant at 1%; *=significant at 5%

We also found that four of the twelve explanatory variables were statistically significant in explaining the cultural practice transformation, i.e., labor used (p=0.00), cassava farm gate price (p=0.00), access to formal credit (p=0.00), and growers' organization (p=0.01). We also found that labor use positively influenced cultural practice transformation. An increase of one man-day of labor in cassava production was associated with growers being more likely to transform their farming practice from the chemical to the organic cassava production by about 10%. However, new technologies can be labor intensive and may influence the adoption. Increased demand of labor in organic cassava production can influence the adoption (Moser & Barrett, 2006), as organic crop production is a more labor-demanding endeavor to enhance crop productivity (Mattila et al., 2012). The significant differences of labor used between chemical and organic cassava production were recognized (Table 3). In general, hired labor was the alternative option for growers to handle the labor situation. Rogers (2003) reported that innovative growers were able to find practical solutions to overcome labor constraint, such as investment in small tractors and equipment for weed control and fertilizer application, which reduced production costs and increased profit (Danso-Abbeam et al., 2017; Ouédraogo et al., 2017; Jerumeh & Omonona, 2020; Pushpalatha & Gangadharan, 2020). Currently, no investment available for science and technology research into organic cassava growing in Thailand. This is despite the fact that 13th National plan called for an increase of the total organic farming area to 320,000 hectares (ONESDC, 2022).

Based on our study, we found that if the price of cassava that farmers receive is higher than the average, farmers are 40.5 times more likely to change to do organic farming compared to when the price is not higher than the average. Sarker & Itohara (2008), Karki et al. (2011) and Awotide et al. (2016) previously reported that growers pursued organic farming as a viable alternative to chemical farming to improve their market opportunities. In our research areas, organic cassava products from transitioning cassava field received a price of 2.9 baht/kg, and 3.4 baht/kg for a certified organic cassava field product. This price and market opportunity that exhibited marketing stability was significant because a strong motivating factor for growers was the possibility of gaining higher income. in this research, 40.3% of total sampled cassava growers (Table 6) also mentioned higher income as motivating factor. In the future, the organic cassava price may change due to changes in the organic standard certification process and other requirements. Currently, the starch factory absorbed all certification costs as an incentive for organic cassava production transformation and agricultural extension costs for the organic cassava production system to meet the USDA (United States Department of Agriculture), NOP (National Organic Program), or EU (European Union) Organic Standards. With the change, small-scale growers may no longer be able to absorb the costly fees associated with certification. Therefore, introducing the group certification system to reduce the certification fees can result in a higher guaranteed price in the future. The decrease in certification fees means an increased opportunity for small-scale growers to be certified and a decrease in the starch factory's production costs.

With access to the formal credit and participation in growers' organization, the transformation was positively increased by 29.3 and 8.3 times, respectively. The presence of a large number of growers' access to formal credit can increase cassava production performance due to the adequate purchasing power for farm inputs. Similar findings were reported by Riar et al. (2017), Moser & Barrett (2006) and Teklewold et al. (2013), who concluded that the availability of credit increased the probability and therefore the adoption of sustainable technology.

With the opportunity to be a member of growers' organization, growers are better informed and can efficiently decide on adopting new innovations and market opportunities. While those growers without membership in growers' organizations may take a longer time to achieve their development goals. This was in line with Hall & Mogyorody (2001), Neill & Lee (2001) and Ugwumba & Okechukwu (2014), who indicated that growers can reduce risk exposure from their experience. The knowledge and information from engagement growers' organization is crucial for them to develop an innovation-decision process (Hall & Mogyorody, 2001; Arellanes & Lee, 2003; Dankyi & Adjekum, 2007; Karki et al., 2011; Andres et al., 2016; Awotide et al., 2016; Danso-Abbeam et al., 2017; Yigezu et al., 2018; Li et al., 2020; Pushpalatha & Gangadharan, 2020). Meanwhile, growers' organizations play a practical role in sharing knowledge and skills, and are likely to be a technology-pressure institutions that disseminate agricultural inputs, farm machines and credit, sharing and empowering small-scale growers with knowledge and techniques (Carney, 1996; Othman et al., 2020).

Access to extension services did not significantly influence the transformation in our research. However, In Thailand, this organization plays a key role to enforce small-scale growers engaged in agricultural production and facilitate their efforts at both individual small-scale growers and groups of growers in such a way of problem solving on crop production, link to local markets and other stakeholders in the agricultural supply chain to improve small-scale growers' livelihood. The extension organization can contribute to the effectiveness of growers' organization. This points to the need for further research, especially research done by teams that are keen in participatory action research approach. Moreover, this demonstrates a practical prototype to collaboratively establish partnerships between small-scale growers, private and public sectors, which might encourage growers to join growers' organization. The participation in growers' organization is a pathway for growers to improve their credit status.

Some socio-demographic including cassava production and institutional variables (age, gender, education, farming experience, non-farm income, cassava farm size, profit from cassava production and access to agricultural extension service) did not influence the practice transformation. This was due to factors' characteristics of chemical and organic cassava growers were not much different.

4. Conclusions

The transformation of cassava production systems from chemical into organic cassava was positively influenced by cassava farm gate price, access to formal credit, labor used and growers' organization membership. Formal credit institutions can contribute in the way of facilitating access to organic inputs. Labor plays an important role for organic growers, and farm machines and equipment can be applied to save labor expenses. Moreover, non-chemical technology that is cheap and effective for weed control can replace man-hours cost. Growers' organization can enhance growers' understanding for small-scale growers at the district level. In addition, the government subsidies and support from the private sector can play a key role in the transformation. Future expansion of sustainable organic cassava production to meet the demands can be achieved through the collaboration of both public and private institutions with relevant strategies, roles, services, and facilities with long term goals. Finally, research funding for efficient innovations, organic input availability, growers' organizations, export markets, and credit is greatly needed for the further sustainable transformation into organic cassava production systems.

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6. Conflicts of Interest

The authors report no conflicts of interest.

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