J. ISSAAS Vol. 26, No. 1: 54-62 (2020)

COMPARISON OF GLUTINOUS RICE PRODUCTION SYSTEMS FOR SUSTAINABLE DEVELOPMENT IN SAKON NAKHON PROVINCE

Patcha Sattaka[*1], Suwannee Muengpak[1], Hoa Phan Xuan[1], and Thanyalak Mueangkhot[2]
[1]Glutinous Rice Research Unit, Faculty of Natural Resources and Agro-Industry
Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus,
Muang, Sakon Nakhon, 47000, Thailand
[2]Faculty of Liberal Arts and Management Science, Kasetsart University,
Chalermphrakiat Sakon Nakhon Province Campus,
Muang, Sakon Nakhon, 47000, Thailand
*Corresponding author: patcha.sat@ku.th

(Received: April 12, 2019; Accepted: April 1, 2020)

ABSTRACT

The costs and profits were compared of organic glutinous rice production, Good Agricultural Practice (GAP) production, and traditional production of 192 farmers. An interview schedule was used for collecting data at Sakon Nakhon Province in 2017. Which were analysed using one-way analysis of variance and Fisher's Least Significant Difference. The study found that most of the farmers grew glutinous rice using a single crop in rainfed areas. The rice breed used was essentially RD6, with the seed produced mainly by farmers. The farmers used transplanting and two applications of fertilizers. Most farmers harvested the glutinous rice by hand and had glutinous rice yields of about 2,100-2600 kg/ha. Organic production had an average cost of 596 USD/ha and profit of 141.36 USD/ha. GAP production had an average cost of 718.75 USD/ha and profit of 86.13 USD/ha. Traditional production had an average cost of 682.46 USD/ha and a profit of -155.17 USD/ha. The comparison of the three production systems indicated that the cost of organic production was lower than for GAP production and traditional production, whereas the profit from organic production was greater than for the other methods. Furthermore, the differences in total costs and profits of organic production, GAP production, and traditional production were significant at the .05 level.

Key words: glutinous rice, production system, sustainable development

INTRODUCTION

Glutinous rice is grown extensively in Lao PDR and Thailand. It is believed that local people began cultivating rice 6,000 years ago (Swiss Agency for Development and Cooperation 2007). In China, glutinous rice was known to be used to make ancient mortar for the construction of the Great Wall of China, with archaeological evidence suggesting that such mortar was in use, perhaps as much as 1,600 years ago. On the other hand, in Myanmar, glutinous rice is popular during the traditional festival known as Htamane. Several studies have found a close relationship between glutinous rice cultivation and consumption practices and a certain ethnic group—the Tai (Watanabe 1967; Golomb 1976; Falvey 2010; Sharma 2010). Glutinous rice distribution appears to be cultural and closely associated with the early southward migration and distribution of Tai ethnic group along the Mekong River basin, originating from Southwestern China.

In Thailand, glutinous rice is a strategic crop because it is associated with the way of life, food security, job security, and income security for millions of farmers, especially in the north-eastern region, where the local communities grow and consume glutinous rice as their staple food. Export of glutinous rice products has increased from 200,000 t in 2013 to 500,000 t in 2017. Moreover, glutinous rice an important component of the income of farmers and small community enterprises for more than 200 groups. From these points, it can be concluded that glutinous rice is a security crop regarding the quality of life for farmers. Thailand has an area of 2.78 million ha under glutinous rice cultivation areas, with total production of 6.72 million t, and average production of 2.41 t/ha. The north-eastern region has the largest proportion of glutinous rice cultivation on about 1.8 million ha. Glutinous rice is used for domestic consumption (5.97 million t) in the food industry (0.11 million t), and for seed (0.32 million t) (Varinruk 2017; Rice Department 2017). Moreover, it is used in food products including rice crackers, wine, desserts, and cereal bars and in non-food products such as cosmetics and packaging components. In the past, glutinous rice was not specifically mentioned, nor was it systematically managed. From 2015, the Ministry of Agriculture and Cooperatives in Thailand introduced a "Project to promote glutinous rice production and trade", with the aim of changing the production of glutinous rice to improve the quality and value of glutinous rice to make it a premium agricultural product. The government promoted reducing the cost of glutinous rice production by using a natural cultivation system and by ceasing the use of chemicals in organic glutinous rice production system (Patise 2015). In 2018, the Ministry of Agriculture and Cooperatives launched a policy to promote a project to create one million organic rice production areas.

Sakon Nakhon province is located in the north-eastern region and has led the organic rice policy at the provincial level. It has 165,400 rice farmers and the second-largest glutinous rice growing area in Thailand (244,174 ha), with a glutinous rice yield of 485,296 t and an average yield of 1.98 t/ha (Rice Department, 2017). Sakon Nakhon province aims to produce aromatic glutinous rice and has “Hang Rice” which is a geographical indication of the province. The cultivation systems consist of a traditional system, a Good Agricultural Practice (GAP) system and organic rice systems. GAP rice production covers 48 ha and organic rice production in 11,200 ha for glutinous rice (Sakon Nakhon Provincial Statistical Office 2017). Under the government policy to promote organic rice production Sakon Nakhon province has promoted organic rice production on about 240,000 hectares to develop its production potential, reduce the cost of production, and to support market demand. However, most of the farmers have continued to practice traditional rice production and hard to change their production system. Thus, the study of glutinous rice production system for sustainable development can provide guidelines for the farmers and interested persons making decisions before implementing changes to the rice production system to achieve food and job security, and sustainable development.

METHODS AND APPROACH

Study areas, population, and sample. The study area of the population involved three glutinous rice production groups comprised of organic production, GAP production, and traditional production in Sakon Nakhon province. Therefore, the total population comprised 137,684 farmers in traditional production, 304 farmers in GAP production, and 76 farmers in organic production. For sample sizes, the required numbers were determined to be 64 farmers in each group, based on the Taro Yamane formula at the 95 percent confidence level (Yamane 1973).

Data collection. An interview schedule was constructed including baseline socio-economic information and details on the glutinous rice production system, glutinous rice production costs, and returns and profit. The draft interview schedule was edited and corrected and pre-tested by farmers, before the final version was produced for data collection. Data were collected using the simple random sampling method in organic rice production (64 farmers), GAP production (64 farmers), and traditional production (64 farmers).

Data analysis. After collecting the data and checking the data for errors, the statistics of percentage and arithmetic mean were used for analysis. Comparisons among the glutinous rice production systems used one-way analysis of variance (one-way ANOVA) and Fisher's Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Baseline socio-economic information on glutinous rice farmers. **M**ost of the respondents were female, with an average age of 55 years. More than 70 percent of the respondents had completed junior high school education and more than 50 percent owned 1-2 ha, with an average area of 2.5 ha. On average, there were 4 persons per family. Sakon Nakhon Provincial Statistical Office (2017) reported that the population in Sakon Nakhon had females more than males and even though most of the farmers were male, a female was the manager of the household and therefore most of respondents were female as they had the relevant information. The level of education attained (elementary) is the basic level of education in Thailand. Department of Agricultural Extension (2016) reported that the Thai farmers on average owned 2.87 ha which was more than for the respondents in Sakon Nakhon (0.16 ha). The number of family members (4) was consistent with the report on farmers by Khunthongjan (2016).

Glutinous rice production systems

Organic glutinous rice production. The study found that most of farmers grew glutinous rice using a single cropping system and in rainfed areas, with only 18.75 percent using double crops with an average glutinous rice planting area of 1.70 ha. Approximately 99 percent of farmers used specially bred rice varieties with RD6 accounting for 79.69 percent. Glutinous rice seed was produced mainly by farmers (51.56%) from previous crops, while 21.88 percent purchased their seed mainly from governmental organizations and 17.19 percent purchased from within the community. Most farmers used transplanting (48.44 percent) and broadcasting (35.94 percent). Of the farmers, 60.94 percent applied two applications of chemical fertilizer 20-30 days after transplanting and then 30 days before flowering. Approximately 28.12 percent of farmers applied one application of chemical fertilizer. Most farmers harvested their glutinous rice by hand (60.94%) and had a glutinous rice yield of more than 2,500 kg/ha (31.25%) with the average yield being 2,430 kg/ha (Table 1).

GAP glutinous rice production. Most farmers who used the GAP glutinous rice production system had a single crop (89.06 %) and only 6.25 percent used a double crop in rainfed areas. Most of farmers had a cropping area of 1-2 ha (43.75%) with an average of 1.58 ha. Most farmers used RD6 rice seed (93.75 percent). Glutinous rice seeds were produced mainly by farmers (46.88%) while 32.81 percent purchased mainly from governmental organizations and 10.94 percent purchased from neighbors. Most of these farmers had two applications of chemical fertilizers (84.37 percent). The farmers harvested their glutinous rice using labor (73.44 percent) and by machinery (26.56 percent). Most farmers had glutinous rice yields of 2,001-2,500 kg/ha (34.38%) with the average yield being 2,557 kg/ha (Table 1).

Traditional glutinous rice production. Most of the farmers using traditional glutinous rice production grew glutinous rice in a single cropping system in rainfed areas (90.62%). Approximately 43.75 percent had a glutinous rice planting area less than 1 ha with the average being 1.48 ha. Most farmers used RD6 seed (82.81). Glutinous rice seed was produced mainly by the farmers (62.50%) while 17.19 percent purchased mainly from governmental organizations and 10.94 percent purchased from neighbors. Most of these farmers used either two applications of chemical fertilizers (75.0 %) or three applications (10.94 %). The farmers harvested their glutinous rice using labor (73.44 percent) and by machinery (26.56 percent). Most farmers had glutinous rice yields of 1,501-2,000 kg/ha (35.94%) with the average yield being 2,111.64 kg/ha (Table 1).

Table 1. Glutinous rice production in Sakon Nakhon Province, Thailand in 2017

(Organic, n = 64); (GAP, n = 64); (Traditional, n = 64)

Glutinous rice production	Glutinous rice production					
	Organic		GAP		Traditional	
	Number	%	Number	%	Number	%
Production area (ha)						
Less than 1 ha	26	40.62	24	37.50	28	43.75
1-2 ha	22	34.38	28	43.75	22	34.38
More than 2 ha	16	25.00	12	18.75	14	21.88
Organic: mean = 1.70, min = 0, max = 5.60, SD = 1.35						
GAP: mean = 1.58, min = 0.48, max = 7.68, SD = 1.17						
Traditional: mean = 1.48, min = 0.32, max = 6.24, SD = 1.01						
2. Variety of rice						
RD6	51	79.69	60	93.75	53	82.81
Son Pa Tong	4	6.25	0	0	0	0
RD 15	3	4.69	3	4.69	7	10.94
RD10	3	4.69	0	0	1	1.56
Local variety	1	1.56	1	1.56	0	0
RD12	0	0	0	0	3	4.69
3. Seed source						
Produce own seed	33	51.56	30	46.88	40	62.50
Purchase from government organizations	14	21.88	21	32.81	11	17.19
Purchase from community	11	17.19	4	6.25	7	10.94
Exchange with neighbors	3	4.69	7	10.94	6	9.38
Buy from private sector	0	0	1	1.56	0	0
Borrowed from relatives	1	1.56	1	1.56	0	0
4. Growing method						
Transplanting using labor	31	48.44	46	71.87	31	48.44
Broadcasting	23	35.94	16	25.00	21	32.81
Wet broadcasting	5	7.80	2	3.13	7	10.93
Transplanting using laborers	1	1.56	0	0	1	1.56
Dropping	2	3.13	0	0	1	1.56
5. Number of fertilizer applications						
None	2	3.13	0	0	0	0
1	18	28.12	7	10.94	8	12.50
2	39	60.94	54	84.37	48	75.00
3	5	7.81	1	1.56	7	10.94
More than 3	0	0	2	3.13	1	1.56
6. Water source						
Rainfed	33	51.56	57	89.06	58	90.62
Irrigation	27	42.19	4	6.25	3	4.69
Pond	2	3.13	2	3.13	0	0
Groundwater	0	0	0	0	3	4.69
Creek	0	0	1	1.56	0	0
7. Harvesting method						
Manual labor	39	60.94	47	73.44	47	73.44
Mechanized	23	35.94	17	26.56	17	26.56
8. Yield						
Less than 1,000 kg/ha	3	4.69	4	6.25	4	6.25
1,000-1500 kg/ha	15	23.44	9	14.06	13	20.31
1,501-2,000 kg/ha	11	17.19	10	15.63	23	35.94
2,001-2,500 kg/ha	15	23.44	22	34.38	10	15.63
More than 2,500 kg/ha	20	31.25	19	29.69	14	21.88
Organic: mean = 2,429.58, min = 0, max = 5,000, SD = 1107.39						
GAP: mean = 2,557, min = 500, max = 1,8750, SD = 2,261						
Traditional: mean = 2,111.52, min = 562, max = 5,000, SD = 1,048						

Farmers had two annual glutinous rice-growing periods (the wet-season and the dry-season) depending on the water system. Sakon Nakhon Provincial Statistical Office (2017) reported approximately 86% and 13% rain-fed system and irrigation, respectively. Therefore, it was not surprising that most farmers grew glutinous rice in the wet-season using the RD6 variety in rain-fed areas. Glutinous rice seed was produced by themselves or purchased mainly from governmental organizations. The survey information was consistent with the report of Sakon Nakhon Rice Research Center via Sakon Nakhon Provincial Statistical Office (2017) wherein most of the Sakon Nakhon farmers planted glutinous rice using RD6 that was produced by the farmers themselves and some of farmers purchased from governmental organizations and local rice centers. Most of the glutinous rice farmers used transplanting and had two applications of fertilizers. For dropping system, few farmers used direct seeding where seeds are sown directly in the field. Harvesting used labor more than machinery because of the differences in harvest maturity and the limited availability of harvesting machines. GAP production had higher glutinous rice yields than organic and traditional production because the GAP system applied chemical fertilizer, changed to new seeds every 3 years, and had good management processes such as soil improvement before the rice planting season. However, organic rice production had no chemical fertilizer application and required approximately 3 years for glutinous rice yields to increase.

Glutinous rice production cost. Total cost of glutinous rice production and fixed cost for land was in the range 117-180 USD (Table 2). Traditional rice production system had the highest value of about 179 USD/ha. Labor was the main variable cost with the highest being for the GAP production system (160 USD/ha), followed by the organic production system (140 USD/ha), and the traditional production system (111 USD/ha). Seed was the lowest cost especially in organic production systems (9 USD/ha), then traditional production (9.17 USD/ha) and the most expensive was in GAP production (16.09 USD/ha). The range in variable cost production was 719 USD/ha for GAP production, 683 USD/ha for traditional production, and 596 USD/ha for organic production. The glutinous rice income was highest for organic production at 815 USD/ha with 141.36 USD/ha of profit because the organic farmer sold both grain and seed. GAP production had a total return of about 814 USD/ha with 86.23 USD/ha of profit, while traditional production had a return of about 449 USD/ha from grain and made a loss of 155.17.

Table 2. Total cost, return, and profit of glutinous rice from organic production, GAP production, and traditional production.

Cost	Average price (USD/ha)		
	Organic	GAP	Traditional
1. Fix cost			
Land	150.65	117.34	178.66
2. Variable cost			
Seed	8.98	16.09	9.17
Labor	140.19	160.44	111.19
Soil preparation	91.80	124.65	105.31
Fertilizer	37.31	106.67	129.73
Energy	19.54	31.20	34.12
Others (transportation, food, telephone, water etc.)	147.79	162.36	114.27
Total cost	596.26	718.75	682.46
3. Return			
Glutinous rice grain	500.09	502.85	448.64
Glutinous rice seed	315.17	311.41	0
Total return	815.26	814.26	448.64
4. Profit	141.36	86.23	-155.17

Organic rice production had the lowest cost of production because chemical fertilizer was not applied and there was less soil preparation based on appropriate areas. GAP production was the highest because of higher labor cost and good soil preparation compared to organic and traditional production. Chemically fertilized rice had a greater total production cost than organic rice production (Ketpirune 2013). Moreover, the principles to reduce rice cost production comprised appropriate soil preparation, using good seed quality, good management of pest and weed control, appropriate fertilizer application, and good household accounting (Viriyangkul 2014).

Organic and GAP production had higher returns, but organic rice had a lower yield than GAP production because organic rice had a lower cost and the organic glutinous rice yield had a higher price than from GAP production. Thus, organic glutinous rice production had a higher profit than the GAP and traditional production systems. Traditional glutinous rice production was not profitable because these famers had the lowest average yields, produced for their own consumption and sold only the surplus. This suggests there is a challenge for these farmers to adopt organic rice production to increase their return because the demand for and volume of organic rice has increased due to consumer consciousness of health and environmental factors (Yaniga and Pornthipa 2016; Karim 2018).

Glutinous rice production cost comparison. The fix cost of glutinous rice was highly significantly different at the .01 level, *p*=0.000. Post hoc analyses using the LSD indicated that differences at the.05 level (*p*=0.000) were significant for fixed costs among organic production, GAP production, and traditional production as were the variable costs of glutinous rice production among the three systems at the .01 level, (*p*=0.005). Post hoc analyses using the LSD indicated that the variable costs between organic production and GAP production were different at the .01 level (*p*=0.001), and GAP production and traditional production were different at the .05 level (*p*=0.044) (Table 3). Therefore, total costs of organic production, GAP production, and traditional production were significantly different at the .05 level (*p*=0.037).

Table 3. Comparison of costs of glutinous rice production systems

Glutinous rice production systems	n	$\bar{x}$	S.D.	F	*P-Value*
1.Fixed cost				109.765	.000**
Organic	64	150.70	19.69		
GAP	64	117.37	14.03		
Traditional	64	178.71	32.63		
2. Variable cost				5.351	.005**
Organic	64	445.61	322.36		
GAP	64	601.41	258.93		
Traditional	64	503.81	226.79		
3.Total cost				3.356	.037*
Organic	64	596.26	322.36		
GAP	64	718.75	258.93		
Traditional	64	682.47	226.79		

*p < .05, **p < .01

The study clearly indicated that the total costs of organic production, GAP production, and traditional production were significantly different, and organic rice had the lowest cost of production. These results were consistent with Ketpirune (2013) and Suwannakit and Prempree (2016) who reported that the costs of organic rice farming were lower than those of chemical rice farming resulting in significant difference between the revenues and costs of organic and chemical rice farming. Given that in Thailand, organic rice is grown in only 834.92 ha to the international organic rice standard in 2017 and is expected to increase to 44,800 ha in 2019, what are the factors affecting the transformation by farmers from chemical rice production to organic rice production? Phitthiyaphinant and Thongkaemkaew (2018) reported that production cost, indebtedness, individual and family-related health problems, soil degradation, and extension services were the important factors that affected a transformation. Moreover, the farmers needed to properly understand the actual cost of rice production to come up with an informed decision to transform, adjust, and use appropriate inputs. Stakeholders in the both government and non-government sectors should plan with regard to climate change that will affect rice production due to flooding and drought.

Glutinous rice production profit comparison. The glutinous rice yield was not significantly different among systems but there was a significant difference for the total return at the .01 level (*p*=0.006). Post hoc analyses indicated that the total returns between organic production and traditional production were significantly different at the .05 level (*p*=0.019), as well as GAP production and traditional production at the .05 level (*p*=0.002). The profits from the three glutinous rice production systems were significantly different at the .01 level, (*p*=0.004). Post hoc analyses indicated that the profits from glutinous rice production between organic production and traditional production were significantly different at the .01 level (*p*=0.002), and between GAP production and traditional production were different at the .05 level (*p*=0.010) (Table 4).

Table 4. Glutinous rice production profit comparison

Glutinous rice production systems	n	$\bar{x}$	S.D.	F	*P-Value*
1.Yield				1.257	0.259
Organic	64	2,429.59	1,107.40		
GAP	64	2,557.62	2,261.41		
Traditional	64	2,111.52	1,048.83		
2.Total return				5.290	.006**
Organic	64	737.62	401.03		
GAP	64	804.98	720.77		
Traditional	64	527.29	284.89		
3.Profit				5.737	.004**
Organic	64	141.36	405.30		
GAP	64	86.23	746.42		
Traditional	64	-155.17	333.18		

*p < .05, **p < .01

Even though the glutinous rice yields from organic, GAP and traditional rice production were not significantly different, GAP production had a higher yield than either organic or traditional production. GAP production enabled farmers to produce rice under a quality management system, with a high yield and a product safe from toxic chemical residues (Phyu et al. 2012; Fakkhong and Suwanmaneepong 2017). Moreover, GAP production involved effective principles of production to control the rice planting process and used appropriate chemical fertilizers so the farmers obtained high yields. Moreover, the study indicated that the costs of organic rice production were lower than those of chemical rice production. On the other hand, the profit of organic rice farming was higher than chemical rice production as was also reported by Ketpirune (2012) and Suwannakit and Prempree (2016) who determined that the costs of organic rice farming were lower than chemical rice farming. Additionally, the profits from organic rice farming were higher than those from chemical rice farming (Ketpirune, 2012; Suwannakit and Prempree. 2016). Moreover, a significant difference in the costs and returns between organic and chemical rice farming has been reported (Suwannakit and Prempree 2016).

Sustainable development in Thailand has been guided by the Sufficiency Economy Philosophy (SEP), conceived by His Majesty the late King Bhumibol Adulyadej. The SEP is the core principle of the National Economic and Social Development Plan and can serve as an approach to support the realization of the sustainable development goals (SDGs). Thus, Thailand strives to ensure sustainable development through promoting sustainable agricultural practices through organic farming and “New Theory Farming” under the SEP concept, with the target to increase the area of sustainable agricultural farming by 80,000 hectare per annum. Therefore, shifting into organic production should be relatively straightforward based on differences in areas, the environment, and water systems. This can result in significant differences in rice yields and management practices because the water required for rice production is influenced more strongly by site conditions than by farming methods (Donaldson and Moore 2013; Lin and Fukushima 2016). Moreover, the influence of training appeared to be an important decision-making factor for farmers deciding to adopt organic rice production. The factors influencing the farmers' decisions to apply organic production are their concerns for their own health, water accessibility, farm-gate price, and attitude to conventional production problems, followed by the success of neighboring organic farms, excellent export opportunities, and continued support from their agricultural network, respectively (Pornpratansombat et al. 2011; Jierwiriyapant et al. 2012).

CONCLUSIONS AND RECOMMENDATION

Sakon Nakhon has much suitable land for growing quality glutinous rice in northeastern Thailand because the farmers there are changing to organic production systems. The total costs and profits from organic production, GAP production, and traditional production were significantly different. GAP production had the highest production because farmers used more labor and had a high cost of soil preparation compared to organic and traditional production systems. Organic and GAP production had high returns, but organic rice production had a lower yield than GAP production. Organic rice had the lowest cost of production and a high profit. However, the farmers who want to implement changes to organic rice production need to have the knowledge on achieving organic rice certification and methods to increase organic rice yields during the transformation period. Moreover, study areas where face the strong effects climate change on rice production especially drought leading to a decline in rice yield and quality. Thus, the farmers need to develop rice growing techniques by using good seed quality with higher yield under water shortage, and water management for enough allocation of water demand in-season rice.

ACKNOWLEDGEMENT

The authors thank sincerely the Faculty of Natural Resource and Agro-Industry, Kasetsart University Chalermphrakiat Sakon Nakhon province campus, Thailand and the SVITA Foundation, Thailand for invaluable support.

REFERENCES CITED

DAE [Department of Agricultural Extension]. 2016. Farmer database. Department of Agricultural Extension, Thailand. Retrieved from http://www.agriinfo.doae.go.th/.

Donaldson, J. and J. Moore. 2013. Going green in Thailand: Upgrading in global organic value chains. Going Green in Thailand (Working Paper), 1-26.

Fakkhong, S. and S. Suwanmaneepong. 2017. The implementation of Good Agricultural Practice among rice farmers in eastern region of Bangkok, Thailand. International Journal of Agricultural Technology 13(7.3), 2509-2522.

Falvey, L. 2010. History of rice in Southeast Asia and Australia. In S. D. Sharma (Ed.), Rice: Origin, antiquity and history. USA: Science Publishers. 183-224.

Golomb, L. 1976. The origin, spread and persistence of glutinous rice as a staple crop in mainland Southeast Asia. Journal of Southeast Asia Studies. 7(1), 1-15.

Jierwiriyapant, P., O.-A, Liangphansakul, W. Chulaphun, and P. Satrapongs. 2012. Factors affecting organic rice production adoption of farmers in Northern Thailand. Chiang Mai University Journal of Natural Sciences. 11(1), 327-333.

Karim, M.R. 2018. Prospects of organic farming for sustainable agriculture and climate change mitigation in Bangladesh. SciFed Journal of Global Warming. 2(2), 1-10.

Ketpirune, O. 2013. Comparison of economic costs and returns structure of chemical and organic rice cultivation: A case study in Nong Sano sub-district, Sam Ngam district, Phichit province. Khon Kaen Agr. J. 41 (2), 171-180.

Khunthongjan, S. 2016. Pattern of income and spending, Household Rice Farmers in Ubon Ratchathani Province, Thailand. Silpakorn University Journal of Social Sciences, Humanities, and Arts. 16(1), 162-187.

Lin, H.C. and Y. Fukushima. 2016. Rice cultivation methods and their sustainability aspects: Organic and conventional rice production in industrialized Tropical monsoon Asia with a dual cropping system. Sustainability Journal. 8 (529), 1-33.

Patise, A. 2015. The reforming of glutinous rice production system by using agro-natural system. Paper presented at the glutinous rice meeting of Khon Kaen Rice Research. 21 April 2015. Thailand.

Phitthiyaphinant. P. and U. Thongkaemkaew. 2018. From chemical paddy fields to organic paddy fields on a self-sufficient path: Lessons learned from the traditional growing area for Sangyod rice in Phatthalung province. Journal of Community Development Research (Humanities and Social Sciences). 11(4), 64-74.

Phyu, K.M., P.Tuitemwong, K. Tuitemwong, W. Suntornsuk, and P. Ketkaew. 2012. Quality Assessment of Soil and Rice from Good Agricultural Practice Rice Crops. GMSARN International Journal. 6, 163 – 168.

Pornpratansombat, P., B. Bauer, and H. Boland. 2011. The adoption of organic rice farming in northeastern Thailand. Journal of Organic Systems. 6(3), 1-12.

Rice Department, 2017. Rice situation 2017/2018. Retrieved from http://www.ricethailand.go.th/web

Sakon Nakhon Provincial Statistical Office. 2017. Sakon Nakhon Provincial Statistical Report: 2017. Sakon Nakhon Provincial Statistical Office, Thailand. Retrieved from http://sakonnk.nso.go.th/

Sharma, S. D. 2010. Rice: Origin, Antiquity and History. CRC Press, Boca Raton. 11-12.

Suwannakit, C and K. Prempree. 2016. The comparison of costs and returns between organic rice farming and chemical rice farming. Veridian E-Journal. 9(2), 519-526. Retrieved from https://tci-thaijo.org/index.php/Veridian-E-Journal/article/view/66930/54660.

Swiss Agency for Development and Cooperation. 2007. Asia brief filling the rice basket in Lao PDR partnership results. 1-8. Retrieved from www.deza.admin.ch, March 3, 2014.

Varinruk, B. 2017. Thailand rice production and rice research and development on climate change. Workshop on Strengthening APEC Cooperation on Food Security and Climate Change, Hilton Hanoi Opera Hotel, Ha Noi, Viet Nam 19-21 April 2017. Retrieved from http://mddb.apec.org/Documents/2017/PPFS/WKSP1/17_ppfs_wksp1_008.pdf.

Viriyangkul, L. 2014. Rice product management for food security in Thailand. Devawongse Varopakarn Institute of Foreign Affairs, The Ministry of Foreign Affairs, Thailand. 36-40.

Watabe, T. 1967. Glutinous rice in northern Thailand. Centre for South East Asian Studies, Japan: Kyoto University. 38-39.

Yamane, T. 1973. Statistics: An introductory analysis. Harper and Row. New York, NYUSA: p.126.

Yaniga, P. and O. Pornthipa. 2016. The improvement of a Thai organic rice supply chain: A case study of a community enterprise. ICoA Conference Proceedings.3: 156-160.