THE THAILAND RICE ECONOMY UNDER THE GOVERNMENT RICE-PLEDGING SCHEME:

THE CASE OF SUPHANBURI

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The Philippine Rice Research Institute (PhilRice) is a chartered government corporate entity under the Department of Agriculture. It was created through Executive Order 1061 on November 5, 1985 (as amended) to help develop high-yielding, cost-reducing, and environment-friendly technologies so farmers can produce enough rice for all Filipinos.

It accomplishes this mission through research, development, and extension work in its central and seven branch stations, coordinating with a network that includes 57 agencies and 70 seed centers strategically located nationwide.

PhilRice has the following certifications: ISO 9001 (Quality Management), ISO 14001:2004 (Environmental Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

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The International Rice Research Institute (IRRI) is the world's premier research organization dedicated to reducing poverty and hunger through rice science; improving the health and welfare of rice farmers and consumers; and protecting the rice-growing environment for future generations. IRRI is an independent, nonprofit, research and educational institute, founded in 1960 by the Ford and Rockefeller foundations with support from the Philippine government. The institute, headquartered in Los Baños, Philippines, has offices in 17 rice-growing countries in Asia and Africa, and more than 1,000 staff members.

Working with in-country partners, IRRI develops advanced rice varieties that yield more grain and better withstand pests and disease as well as flooding, drought, and other harmful effects of climate change. More than half of the rice area in Asia is planted to IRRI-bred varieties or their progenies. The institute develops new and improved methods and technologies that enable farmers to manage their farms profitably and sustainably, and recommends rice varieties and agricultural practices suitable to particular farm conditions as well as consumer preferences. IRRI assists national agricultural research and extension systems in formulating and implementing country rice sector strategies.

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PREFACE

In 1995, the International Rice Research Institute coordinated an international effort that looked into the causes of declining productivity trends in intensive irrigated rice systems in the Philippines, China, Indonesia, Thailand, Vietnam and India. A major feature of this study is the development of a database on input use, level of rice output, prices and detailed cost of rice production. In this study with the costs of producing rice in Central Luzon, Philippines were compared with those in Central Plain, Thailand; Mekong Delta, Vietnam; West Java, Indonesia; Tamil Nadu, India and Zhejiang, China. More than a decade has passed since then, and new government policies, as well as trade regimes, may have caused changes in relative prices. A cost structure of paddy production that is comparable across countries is in short supply. Thus, it is imperative to update the findings of the study.

Rice is intricately related to food security and international trade policies in major rice producing countries. As a result, the Philippine Rice Research Institute of the Department of Agriculture and the International Rice Research Institute, with the participation of the Philippine Council for Agriculture and Fisheries also of the Department of Agriculture jointly planned, designed and implemented a project entitled "Benchmarking the Philippine Rice Economy Relative to Major Rice–Producing Countries in Asia" . The Philippine government, through the Department of Agriculture, provided the full financial support for this undertaking.

The country monograph is one of the major outputs of this project. This monograph is intended for a general audience who would like to learn about the current status of rice production in Asian countries. It attempts to provide the most detailed information on rice farming in intensively cultivated irrigated rice areas of the major rice-producing countries in Asia. These countries include Indonesia, Philippines, Thailand, Vietnam, India and China. All of these countries are among the top 10 rice producers in the world. Data from each country were collected through interviews using electronic questionnaires, which included questions on paddy output, input use, cost of rice production for crop year 2013-14, as well as basic farm and household characteristics.

Each monograph contains a detailed description of each country's crop management practices, input use, labor using and labor-saving practices and various support and services provided by their government to enhance rice production. Given the impending implementation of the free trade agreement which is expected to increase the flow of rice trade among Asian rice bowls, these studies also evaluated the costs and profitability of producing paddy rice.

Results from this study can provide insights on how a country can further improve its competitiveness in rice production and marketing. We gain a perspective on the policies being implemented by our neighbors to make their respective rice industry competitive. By understanding the costs of producing and marketing rice amidst different government policy frameworks in major rice-producing countries, agricultural policymakers can make appropriate decisions on how to best position the country's interest in terms of rice food security. Policymakers and planners can use this information in crafting sustainable development programs for the rice industry.

Project Leaders

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ABSTRACT

This paper describes the status of rice production in intensively cultivated, irrigated areas of SuphanBuri, Thailand, under the government's rice-pledging scheme. Production practices, input use, yield, and partial factor productivity were evaluated and compared with previous findings of the 1999 project "Reversing the Trends in Declining Productivity". Cost of production and profitability during the rice-pledging scheme were documented and evaluated. Good farming practices and areas that need improvement were also identified. Primary data were obtained through surveys of farmers and key informants, supplemented by secondary data. Descriptive statistics were used to analyze data from 100 respondents covering the 2013 dry (DS) and wet seasons (WS). Rice yields increased over time. Land preparation, harvesting, and threshing, which are labor-intensive activities, were fully mechanized. The use of a combine harvester with a grain tank had eliminated postharvest activities such as cleaning and bagging. The use of engine-powered sprayers for direct seeding and fertilizer and pesticide application was gaining popularity among farmers. Increased labor productivity has been achieved through a highly mechanized rice farming system, which reduced labor inputs in rice farming. Most farmers have moved away from the use of their own seeds to high-quality seeds. High seeding rates and inefficient use of pesticides need further attention to lessen the cost of production. Farmers benefited from government support on credit, irrigation, and pledging prices of rice. The average cost of producing a metric ton of rice was US$206.60 in DS and US$190.20 in WS. Annual net income from rice farming, when compared with the national poverty line, was found to be sufficient to cover the food and basic nonfood expenditures of a household with five members.

INTRODUCTION

For nearly three decades, Thailand has been, traditionally, the world's largest rice exporter. Its total production is much higher than domestic consumption, creating a surplus of 6-10 million t for export per year. Rice exports peaked in 2011 when the country exported 10.67 million t. However, this was brought into a halt when the Thai government implemented a rice-pledging scheme (RPS) in October 2011. The scheme, which aimed to improve the income and living standard of farmers by raising the prices of domestic and exported rice, offered a guarantee price of US\$500 t^{-1} for white rice and US\$667 t^{-1} for fragrant rice. The success of the program hinges on the assumption that Thailand will have a big enough market power to influence the world's price of rice upward (Mahathanaseth and Pensupar, 2014). Unfortunately, the program backfired as other exporting countries such as India and Vietnam undercut Thailand's export and supplied rice at a cheaper price. This resulted in massive stockpiling of rice, which the government was not able to liquidate in the world market. Due to its high price, Thailand's rice export dropped to 6.72 million t in 2013 and the country lost its top rank as the world's biggest exporter (USDA-FAS, 2013). The program, which was proven to be too costly and which has led to huge losses for the government, ended in 2014 with the downfall of the ruling Shinawatra administration.

Amidst the backdrop of the RPS, rice farmers in intensively cultivated and irrigated areas stood to benefit the most from the program. After all, they have better yield, larger farms, and greater cropping intensity, resulting in higher production per farm that can be sold at a handsome price offered by the government. Hence, understanding their production system during the height of the RPS can give insights on how such a program affected farmers' production and marketing decisions.

The main objective of this paper is to describe the status of rice production in the intensively cultivated irrigated rice systems in Thailand during the implementation of the RPS. Specifically, it aims to (1) describe the sociodemographic profile of irrigated rice farmers; (2) document their input use, yield, productivity, cost, profitability, and marketing practices, including their best management practices, and areas for improvement; and (3) identify how the RPS affected the cost and profitability of rice farming in these areas. Along the way, major problems besetting the rice farmers were examined. Whenever possible, the current production system was compared with that during a period when the RPS was still not implemented in order to determine changes.

Rice Economy

Thailand is one of the top 10 rice-producing countries in the world. It ranked 6th in terms of paddy production, with a 5.20% share in world rice production (FAO-UN, 2013). Since the launching of the Green Revolution in Asia, rice production in Thailand has grown from 22 million t in 1995 to 38 million t in 2013 at an annual growth rate of 3.03%. The main factor behind this growth was the expansion of area harvested: from 9.11 million ha in 1995 to 12.37 million ha in 2013 at an annual rate of 1.62%. (FAO-UN, 2013). The increase in harvested area was also a result of the higher prices of rice in the world market, which encouraged farmers to grow more rice per crop year.

Yield has a minimal contribution to the increased rice production of Thailand. This is evident in the low annual growth rate of 1.30%, from a mere 2.42 t ha^{-1} in 1995 to only 3.13 t ha^{-1} in 2013 (FAO-UN, 2013). The low yield is attributed to the large harvest area under rainfed ecosystems and to farmers' preference to grow high-quality but low-yielding traditional varieties that command a premium price in the domestic and world markets. Figure 1 shows the trends in production, area harvested, and rice yield in Thailand from 1995 to 2013.

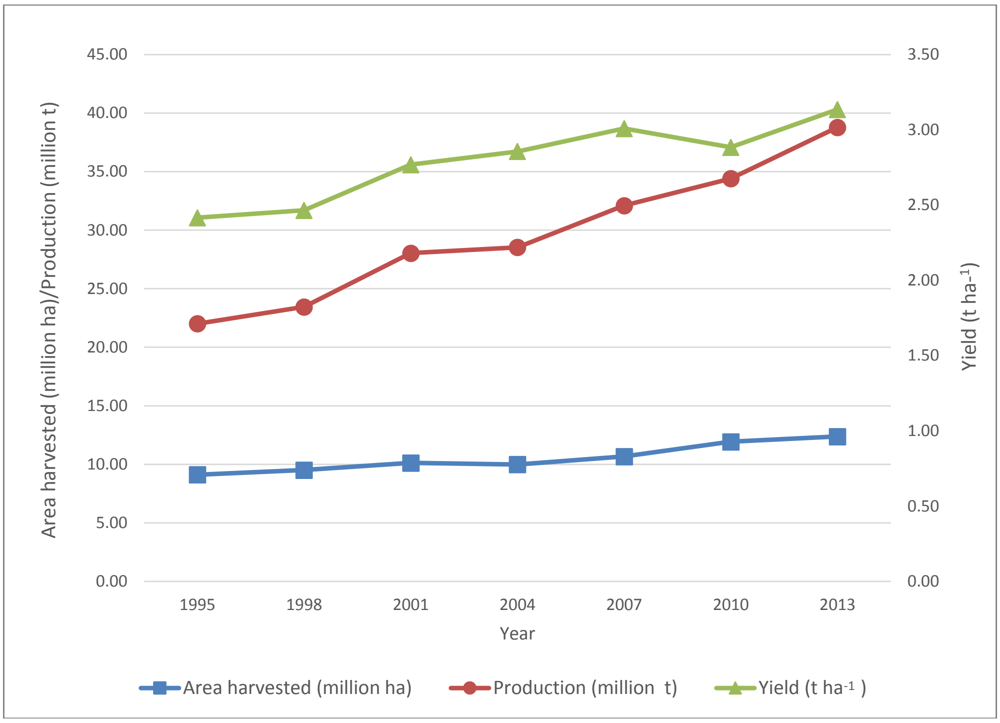

Fig. 1. Trends in area harvested, production, and yield, SuphanBuri, Thailand, 1995-2013 (FAO-UN 2014).

A major crop in Thailand, rice, occupies almost half of the total agricultural production area. It is grown throughout all regions in the country. While only 33% of the country's 13.33 million ha devoted to rice cultivation is irrigated, it remains one of the major sources of rice surplus for export. Thus, examining the cost and profitability of rice farming in these areas could give a glimpse of Thailand's ability to export rice competitively in the absence of the RPS. The Central Plain, where more than one-fifth of the total rice land of the country is located, has the most developed rice areas. Average farm size is large and farmers have good access to irrigation facilities, allowing many of them to grow two rice crops in a year. Almost 75% of the dry-season (DS) rice grown under irrigated conditions is found in the Central Plain and the main rice surplus for export comes from this region.

Almost one-third of the land and nearly half the rice land of Thailand are located in the northeastern region. It has smaller farms compared with those in other regions and irrigation potential is limited due to undulating topography. It is a drought-prone area, has poor soil fertility, and has sandy soil with limited waterholding capacity. The northern region accounts for one-fourth share of the rice area. The region is mostly mountainous and farmers here have small farmholdings. Lowland rice is grown mainly in the lower valleys and on some terraced fields where water is available. The southern region has only 6% of the total rice land, and shortage of rice for local consumption always occurs (GRiSP, 2013).

Exported rice, other than the high-quality and fragrant or special rice from the northeast, comes mostly from the intensively cultivated irrigated areas of the central region.

Thailand's rice pledging scheme

The RPS is a price support program implemented by the government that aims to improve income and living standards of Thai farmers by raising domestic and export prices of Thai rice. The government believes that Thailand has market power in the global rice market, which enables the country to increase the export price of rice and improve the terms of trade by stockpiling and decreasing the quantity of rice exports (Mahathanaseth and Pensupar, 2014). The program offered prices at US$500 t^{-1} (Thai baht [THB] 15,000 t^{-1}) for white rice and US$667 t^{-1}(THB 20,000 t^{-1}) for fragrant rice, which was 50% above market prices (WB, 2012).

A modern rice mill in Suphan Buri that packages rice in one-ton sack for export.

Registered farmers take their paddy to designated millers and receive a receipt, which they use to redeem payment from the Bank of Agriculture and Agricultural Cooperatives (BAAC). The amount farmers receive would depend on the grade and moisture content as determined by millers. Around 2,000 millers in the country are hired by the government to mill the pledged rice; they are given 7 days upon receipt to deliver the milled rice to government warehouses. Given the limited storage facilities of the government, big millers with high storage capacity receive rent for storing the milled rice. Milled rice was sold by the government through open bidding to rice traders or through government-to-government transactions. Under this scheme, the government bears the costs of pledging, milling, operation, and interest.

This policy became very controversial and was highly criticized for its high costs, causing huge government losses and knocking the country out as the world's top rice exporter. India and Vietnam surpassed Thailand as the world's top rice exporters in 2012 as the Thai government stockpiled rice to avoid even bigger losses. India's and Vietnam's export prices for rice were lower than that of Thailand.

In June 2013, the government announced a 20% reduction of the pledging price and limited the amount of rice pledges to approximately 40-45 t per rice farm household valued at US$16,130 (THB 500,000) (The Establishment Post, 2013). However, this was not pushed through as the Thai Farmers Association threatened to descend on Bangkok if the old rate were not restored. This price support program ended in February 2014, following the stepping down of the prime minister who introduced the RPS.

METHODOLOGY

The study site

SuphanBuri Province is one of the highly irrigated rice domains in central Thailand. Its rice production has increased by 2.74% annually and reached 1.79 million t in 2012 from 1.10 million t in 1995. Similarly, rice area harvested increased at an annual rate of 2.59%, from 0.24 million ha in 1995 to 0.39 million ha in 2012. Nevertheless, rice yield in SuphanBuri has been nearly stagnant for the past 17 years with an annual growth rate of only 0.14%. Average yield in 1995 was 4.19 t ha^{-1}, which increased slightly to 4.61 t ha^{-1} in 2012 (FAO-UN, 2013). The increase in rice production in this province is primarily due to the expansion of area harvested resulting from increased cropping intensity (Fig. 2).

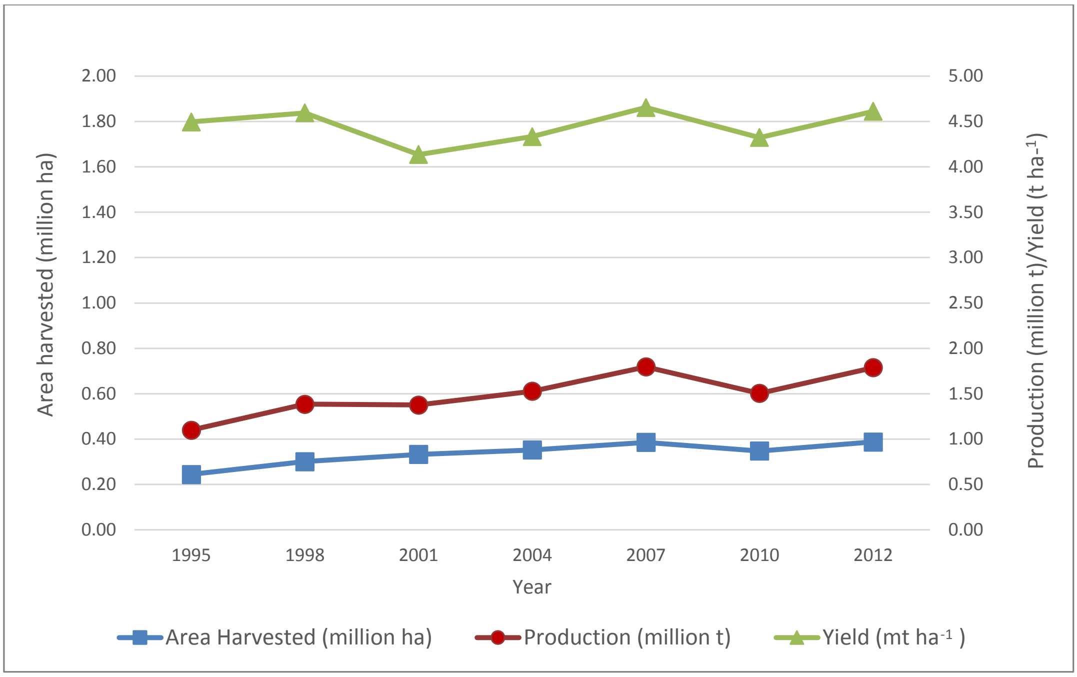

Fig. 2. Trends in production, area harvested, and yield in SuphanBuri, Thailand, 1995-2013, (IRRI 2015).

As SuphanBuri is an important rice producer in the Central Plain, it was selected to represent an intensively cultivated irrigated area for the International Rice Research Institute's project "Reversing the Trend in Declining Productivity" that was implemented in 1995-1999 (Olk and Moya, 1998). By revisiting the same site, it is possible to make a comparison between rice farming in the late 1990s and rice farming at present.

SuphanBuri, which is just a hundred kilometers away from Bangkok, occupies a total area of 5,358 km^2 and is administratively divided into 10 districts: Muang, Doem Bang Nang Buat, Bang Pla Ma, Sri Prachan, Song Phi Nong, Sam Chuk, U Thong, Don Chedi, Dan Chang, and NongYa Sai. The province has a tropical climate, with warm and humid weather (average temperature 28 °C), except during December until February. Annual rainfall is about 1,400 mm and soils are mostly fertile alluvial (Satawathananont, 2004). In this area, rice is mostly grown in a double-crop monoculture system, especially after the popular variety RD7 was released in 1975. Farmers were also able to plant rice five times a year, but the Thai government restricted rice cultivation to two crops per year in April 2011 (Tobias et al., 2012).The two main cropping seasons are the major crop of rice or the wet-season (WS) rice and the second crop of rice or the dry-season (DS) rice. The former is grown from May to October, while the latter is usually cultivated from November to April.

Data collection

A farm household survey was conducted in the three districts of Sri Prachan, Don Chedi, and Muang (Fig. 3). Ten villages were covered within these three districts. The dry and wet cropping seasons in 2013 were also covered.

Data gathering through personal interview guided by a structured questionnaire and aided by translator.

Previous sample respondents of the RTDP project were revisited for interviews using structured electronic questionnaires. However, farmers who were not available during the interview were replaced with respondents from the same area, provided they have two rice crops in a year and have at least 10 years' rice farming experience. A quota sample of 100 farmers was interviewed during the DS.

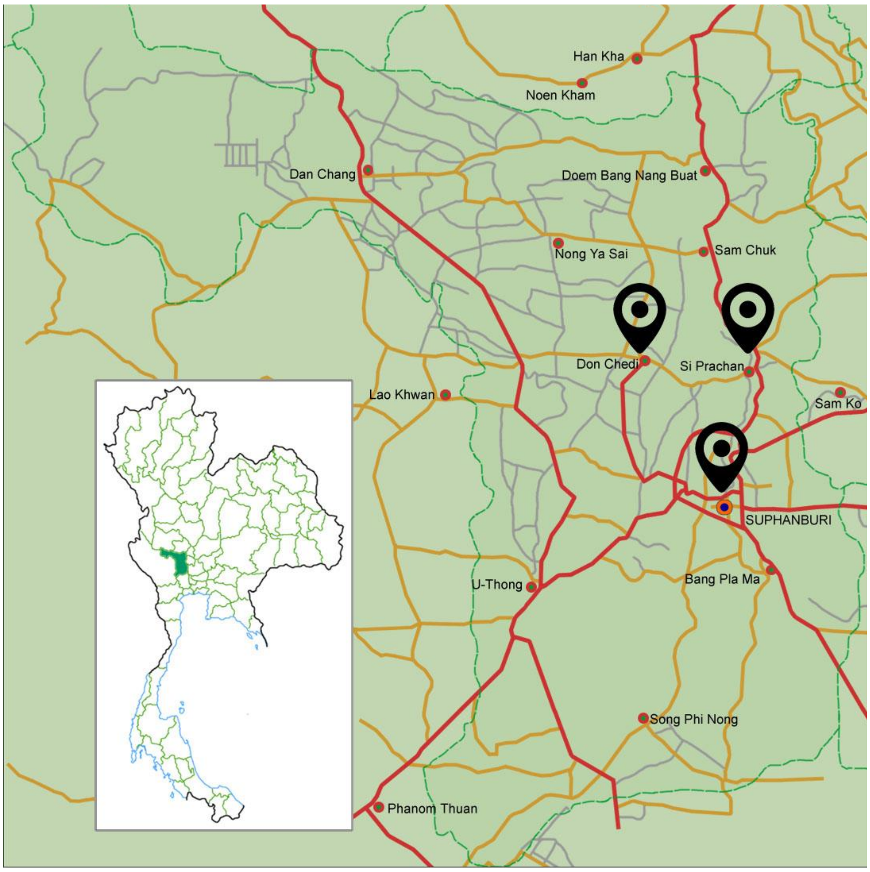

Figure 3. Location of study sites, SuphanBuri, Thailand
(Source: www.thailandmaps.net).

However, 13 respondents were replaced again during the WS because some were unavailable during the survey period and others were reluctant to further participate in the study. Some were hired as farm workers in nearby provinces where harvesting was ongoing.

Data on sociodemographic characteristics of farmers, yield, input use and other production practices, prices of inputs and output, major problems related to rice production, and government support and subsidies received by farmers were gathered. The survey data were complemented with data from key informant interviews on mechanization and rice marketing practices. Secondary data on trends and status of rice production, area harvested, and yield in Thailand and SuphanBuri were also used to supplement the primary data.

Data limitations

The dataset has limitations that should be considered. First, the accuracy of these information, especially estimates of amount of inputs and farm expenditures, is affected by the farmers' ability to recall the said data for each cropping season. Second, the study proponents are foreigners in Thailand, and the language barrier thus made data collection challenging. Third, the accuracy of the data gathered is dependent on the ability of the hired translators. Lastly, the information gathered are from intensively irrigated areas; hence, results on farm practices and farm budget analysis do not totally reflect conditions in other ecosystems and areas that also have large amounts of rice produced. Despite these limitations, the dataset remains the most updated and useful source of information on rice production in SuphanBuri.

Analytical methods

Farm budget structure for rice production was constructed using actual prices. The cost structure was disaggregated by season. The relevant costs included seed, fertilizer, pesticides, herbicides, irrigation fees, machine rental, including fuel and oil, transportation, labor (land preparation, crop establishment, crop care and maintenance, harvesting and threshing, and postharvest), and rental value of land. Using the farm budget structure, the cost of rice production and profitability of rice farming were compared across seasons. Costs and prices were given by the farmer-respondents in the local currency but these were converted into dollars at the exchange rate of US$1=THB 30.73, which is the prevailing exchange rate in 2013 (IMF, 2015).

Descriptive statistics such as means and frequency distribution were used in analyzing the data. T-tests were used to discern significant differences in average yield, input use, and costs across seasons. The partial factor productivity of labor (L) and nitrogen (N) were also computed by taking the ratios of grain yield to total labor used and grain yield to total N used in rice production for both seasons (Moya et al., 1998).

RESULTS & DISCUSSION

Socioeconomic and demographic profile of rice farm households

Table 1. Sociodemographic profile of farmers and farm characteristics, SuphanBari, Thailand, 2013.

Item	Value (n=113)	
Age (yr)	54.7	
Education (yr)	5.2	
Household Size (no. of persons)	4.7	
Sex (% male)	55.0	
Tenure (% owner)	50.0	
Organization (% member)	82.0	
Training (% trained)	51.0	
Gross household income (US$ yr^{-1})	25,248.6	
Rice income (%)	81.0	
Capital (% of borrowers)	63.0	
Farm Characteristic	DS	WS
Parcels (no.)	2.3	2.3
Total farm size (ha)	4.5	4.3
Size of largest parcel (ha)	2.8	2.6

From the responses of 113 unique respondents, Table 1 was constructed to show the sociodemographic characteristics of sample farmers across the three districts. On average, farmers were 55 years old. Though majority had attained some level of formal schooling, the educational level was low (median was school grade 5). The sample was almost equally divided between male and female respondents. Half of them owned the rice land that they till and paid a minimal fee for land tax yearly at US$1.02 ha^{-1} (THB 31.25 ha^{-1}).

Majority of them were members of farm organizations and a little more than half had attended rice-related production training from 2008 to 2013. On the average, a farming household has five family members and most (81%) of the household income came from rice farming. A farmer typically operated two farm parcels with sizes ranging from 0.36 to 14.91 ha, with a combined total of 4.46 ha during DS and 4.33 ha during WS. The average size of the largest parcel operated by farmers was 2.76 ha for DS and 2.62 ha for WS. Most farmers owned small and inexpensive machines such as two-wheel tractors, pumps, and engine-powered sprayers that are used for direct seeding and fertilizer and pesticide applications.

State irrigation canals were the primary source of water of rice farms in SuphanBuri. The irrigation system was maintained through government revenue. Thus, there was no charge for using irrigation water from the canals, considered as government support. However, water pumps were used in paddy fields located in higher grounds or in places that need to pump-out excessive water during WS.

Farm-to-market roads were mostly made of cement and asphalt and the distance of farms to nearest input and output markets ranged from 0.2 to 25 km. Generally, villagers, especially rice farmers, have their own motorcycles. As local roads are fairly good, moving farm products or buying farm inputs was not a problem.

Input use and management practices

Variety, seed, and crop establishment

Modern rice varieties were already widely planted in both DS and WS in irrigated areas of SuphanBuri (Isvilanonda et al., 2001). This has been carried on until 2013. The popularity of modern inbred rice varieties in the province can be attributed to the proximity of the area to a rice breeding institution, the SuphanBuri Rice Experiment Station.

Table 2. Percentage distribution of farmers, by major varieties planted by season, SuphanBuri, Thailand, 2013.

Variety	DS	WS
RD 47	25	29
Phitsanulok 2	22	14
RD 31	12	9
RD 41	11	15
Pathum Thani 80	6	2
Pathum Thani 1	4	13
Phitsanulok 41	1	6
Others	19	12

RD47 was the most popular variety, planted by more than one-third of the farmer-respondents both in the DS and WS. Phitsanulok2, a resistant variety released in year 2000, was more commonly grown during DS (22%) than during WS (14%). Varieties bred by the Rice Department such as RD31 and RD41 were also popular in both seasons due to their high resistance to brown planthoppers. Pathum Thani 1, a nonphotoperiod-sensitive rice variety that has similar characteristics with Jasmine rice, was planted by 13% of the sample farmers during WS and by 4% during DS. It was widely planted during its early years of promotion, but it became vulnerable to brown planthoppers. Pathum Thani 80, a fragrant strain of rice, was planted by 6% of the farmers during DS and by 2% during WS (Table 2).

Table 3. Technology use of farmers in SuphanBuri, Thailand, 2013.

Technology	DS (n=100)	WS (n=100)
Use of seed (%)		
Hybrid	0	0
Certified and registered seed	80	90
Farmer's seed (%)	20	10
Crop establishment (%)		
Transplanting	0	1
Direct seeding	100	99
Use of combine harvester (%)	100	100

Table 3 shows the use of seed technology by farmers in the 2013 cropping seasons. SuphanBuri farmers may not have used hybrid rice, but a greater majority used tagged seed (i.e., certified and registered seed) of inbred varieties. Majority (93-95%) of them bought high-quality seed from seed growers and merchants in the area. The increasing reliance of farmers on commercial seed could be attributed to the decreasing participation of family labor in the cleaning of their own seed. The average price of seed was US$0.72 kg^{-1}.

Direct seeding of pregerminated seed was very popular among rice farmers as practiced by almost all the farmers during DS and WS. As a result, seeding rate was very high at 196-197 kg ha^{-1}. This was the same practice during the 1994-99 surveys. This is more than double the recommended seeding rate for direct seeding at 40-60 kg ha^{-1} (PhilRice, 2002b). Table 4 shows the input use in rice production in SuphanBuri.

Table 4. Input use in rice production, by season, Thailand, 2013.

Item	DS	WS	Difference	
Area (ha)	2.76	2.62	0.14	
Seeds (kg ha^{-1})	195.8	197.0	-1.21	
N (kg ha^{-1})	78.9	87.6	-8.63	*
P (kg ha^{-1})	20.6	21.6	-1.00	
K (kg ha^{-1})	10.3	10.4	-0.17	

Note: *, **, *** indicate significance at 90%, 95%, and 99% confidence level, respectively.

Fertilizer and nutrient management

Inorganic fertilizer application did not vary across seasons, except in the use of N where 88 kg ha^{-1} was used during WS versus the 79 kg ha^{-1} during DS. The 9 kg ha^{-1} difference across seasons was found to be statistically significant. N use had decreased when compared with the RTDP results 15 years ago. Farmers used to apply N at rates ranging from 100 to 112 kg ha^{-1}. The use of phosphate slightly increased to 20.6-21.6 kg ha^{-1} in 2013 from an average of 19 kg ha^{-1} in the 1994-99 cropping seasons. While potassium (K) was only applied in farms where complete fertilizer was used in 1999, farmers now applied a low rate of 10.3-10.4 kg ha^{-1}.

Fertilizers were commonly applied using three splits in DS and WS (Table 5). The most common grades of fertilizer used by farmers included ammonium phosphate (16-20-0), urea (46-0-0), and two types of complete (15-15-15 and 16-16-16). Several compounds or mixed fertilizers were used by farmers in small amounts. Among the commonly used fertilizers, complete (15-15-15 and 16-16-16) were the most expensive, at US$0.59 kg^{-1} and US$0.55 kg^{-1}, respectively. Ammonium phosphate and urea had the same price at US$0.50 kg^{-1}.There were no government subsidies on fertilizers, but there was a credit program where farmers can avail of fertilizers through credit cards provided by the BAAC.

Very few farmers left rice straw in the field for soil incorporation during land preparation as 68% and 50% of them commonly burned rice straw during DS and WS, respectively.

Pesticide use

Table 5 shows the percentage distribution of farmers, by frequency of pesticide application and season. Farmers in SuphanBuri relied heavily on pesticides for crop protection. Pesticides were often applied as a cocktail of insecticides, herbicides, fungicides, and growth hormones. These chemicals were often used as a preventive rather than curative measure. All farmers used pesticides, but only 20% of them reported pest infestations. The lax pesticide marketing regulations and the huge insecticide imports (above US$120 million per annum) have promoted rampant insecticide misuse (Soitong and Escalada, 2011).

Weeds were common in direct-seeded rice and almost all farmers resorted to herbicide application to control the weeds. Mechanical weeding is not possible for direct-seeded rice, while manual weeding is

Table 5. Distribution of farmers, by frequency of fertilizer and pesticide application and by season, SuphanBari, Thailand, 2013.

Frequency	DS (n=100)	WS (n=100)
Fertilizer		
Once	1	0
Twice	38	44
Thrice	60	49
Four times or more	1	7
Herbicide		
None	1	1
Once	21	8
Twice	63	82
Thrice	12	8
Four times or more	3	1
Insecticide		
None	0	1
Once	5	3
Twice	12	10
Thrice	38	28
Four times or more	45	58
Fungicide		
None	4	8
Once	23	28
Twice	34	19
Thrice	22	23
Four times or more	17	22
Molluscicides		
None	96	98
Once	3	1
Twice	0	0
Thrice	0	1
Four times or more	1	0
Rodenticides		
None	91	88
Once	4	10
Twice	3	2
Thrice	2	0
Four times or more	0	0
Other chemicals		
None	53	25
Once	18	25
Twice	10	22
Thrice	11	12
Four times or more	8	16

Left: A man applying pesticide using a power sprayer. Right: A closer look to a power sprayer.

costly due to high farm wages and predominant shortage of farm labor in the area. Around 63-82% of the farmers applied herbicides twice in their rice crops during DS and WS.

Almost half (45-58%) of the farmers applied insecticides four or more times, while the number of farmers who applied fungicides once to four or more times was almost equal. Molluscicides and rodenticides were not popularly used as shown by the low percentage of farmers who applied in both seasons. SuphanBuri farmers also applied growth hormones, but they rarely knew the effects of these chemicals on the rice plant.

Farmers' practices on pesticide use did not change over the years. This is evident in the previous study that showed 92-96% of respondents using insecticides and 92-100% using herbicides. The big amount of active ingredients (0.80-0.99 kg ai ha^{-1}) that farmers applied in 1996 (Moya et al., 1998) also indicates their heavy reliance on pesticide. It was also stated in the study that pesticide use in Thailand in 1996 was the highest among the countries covered and this was followed by Indonesia.

A notable finding of the 2013 survey was that farmers did not know the recommended dosage or formulation of pesticide to be applied to their plants. They often followed other farmers' recommendations. Some farmers received information and advice from sales agents and input dealers. As they relied on input dealers on the formulation and mixing of pesticides, some of them were unaware of the brands and common names of pesticides that they used during the cropping seasons. This made it difficult to estimate the amount of active ingredients used in this study. Furthermore, classification in terms of toxicity of pesticides used was difficult to evaluate. The magnitude of pesticide use can be partly explained by the numerous applications made by the farmers during the two cropping seasons covered. Inefficient use of pesticides does not only increase production costs and pose a threat to human health and the environment, it also causes pests to develop or build resistance to specific chemicals and maintain that resistance even when dosages are increased.

Labor use and mechanization

Source of labor

Table 6 shows the labor input use in rice production. Labor was supplied by both hired and operator, family labor, and exchange labor (OFE) with almost equal contribution in all major farm operations, except for harvesting and threshing. Labor on certain activities done by the operator himself, members of the family, and exchange workers was valued using the prevailing daily wage rate of US$9.76 (THB 300) or the corresponding contract rates of a particular specific activity. Another major finding of this study is that most of the farm operations such as land preparation, direct seeding, transplanting, fertilizer and pesticide application, harvesting and threshing were done by contractual arrangements by custom-mechanized service providers in the area.

Table 6. Labor inputs (man-days ha-1) in rice production, by season, SuphanBari, Thailand, 2013.[a]

Item	DS	WS	Difference	
Hired labor	**4.71**	**5.12**	**-0.41**	
Land preparation	0.75	0.68	0.07	
Crop establishment	0.55	0.77	-0.22	*
Crop care and maintenance	2.77	2.94	-0.17	
Harvesting and threshing	0.64	0.72	-0.08	*
Postharvest	0	0	0	
Operator, family, and exchange labor	**4.97**	**6.01**	**-1.46**	
Land preparation	1.04	1.09	-0.47	
Crop establishment	0.35	0.44	-0.09	
Crop care and maintenance	3.52	4.40	-0.87	
Harvesting and threshing	0.06	0.09	-0.03	
Postharvest	0	0	0	
Total labor	**9.68**	**11.13**	**-1.45**	*
Land preparation	1.79	1.77	0.02	
Crop establishment	0.90	1.21	-0.31	**
Crop care and maintenance	6.30	7.34	-1.05	
Harvesting and threshing	0.70	0.81	-0.11	**
Postharvest	0	0	0	

[a] *, **, *** indicate significance at 90%, 95%, and 99% confidence level, respectively.

A four wheel tractor commonly used for land preparation.

Labor use, by activity and level of mechanization
High adoption of machines is one of the outstanding features of rice production in the Central Plain, particularly in SuphanBuri. Labor migration from agriculture to other economic sectors had created a shortage in agricultural labor (Poapongsakorn, 2012). This raised farm wage rates, which drove farmers to adopt labor-saving technologies such as direct seeding and mechanization.

High wage rates and farm mechanization resulted in decreasing labor inputs in rice production. The average total labor input in rice production in 2013 requires only 10-11 mandays per hectare (md ha^{-1}). This slightly decreased from the 14 md ha^{-1} in the RTDP days.

Land preparation
Only 2 md ha^{-1} were required for land preparation, which is usually done using a big tractor with 45 horsepower (hp) engine during rototilling and plowing. Service providers offered contract rates ranging from US$37 to US$61 ha^{-1}, which included expenses for fuel, rent of machine, and payment for the machine operator. The owner of the machine pays the operator US$4.07 ha^{-1} (THB 125 ha^{-1}). Harrowing, leveling, and construction of water canalets within the field were done using a two-wheel tractor with 9-12-hp engine, mostly owned by the farmers. In case a farmer would hire for the secondary land preparation, contract rates ranged from US$37 to US$61 $ha^{-1}$and the machine operator was paid on a daily basis, even if he worked less than 8 h a day.

Crop establishment
Direct seeding required only 0.9 md ha^{-1} during DS. It was done manually and with the use of an engine-powered sprayer with a 3-hp engine. The contract rates for direct seeding for both manual and use of engine-powered sprayer ranged from US$6 to US$16 ha^{-1} (THB 187.5-500 $ha^{-1)}$. During the WS, labor use for crop establishment increased slightly to 1.21 md ha^{-1}. Transplanting was practiced by only 1% of the farmers. Transplanting was done using a mechanical transplanter, with a contract payment that ranged from US$244 to US$264 ha^{-1}. The costs of seeds and seedling management were included in the contract fee.

Crop care and maintenance
Crop care and maintenance required 6-7 md ha^{-1}. Among the farm operations, crop care and maintenance had the largest labor requirement as it includes the application of fertilizer, herbicides, insecticides, fungicides, molluscicides, and other chemicals such as growth hormones. Other activities such as weeding, irrigation, and drainage were also part of crop care and maintenance operation. It was observed that more OFE labor was employed in this operation for both seasons. Fertilizer was applied either manually or by using an engine-powered sprayer with 3-hp engine, the same one used in direct seeding. Pesticide was also applied using an engine-powered sprayer with less than 1 hp.

Farmers used pumps when canal water was not sufficient. More than 50% of them used pumps during DS and WS. Majority of them also used pumps to drain or pump out water in lower lying farms in both seasons. They commonly used axial flow pumps connected to the engine of two-wheel tractors.
It was observed that women were also active in the different rice farm activities. They were involved in fertilizer and pesticide applications and also direct seeding. However, women faced a greater health risk because they were more exposed to pesticides as they hold the nozzle of the sprayer during application, whereas the men carry the heavy engine-powered sprayer tank, which has a capacity of 25 liters.

Harvesting and threshing
Harvesting and threshing were fully mechanized with the use of a combine harvester. This machine fuses harvesting, threshing, and hauling into a single activity. The combine harvester in SuphanBuri has a grain-collecting tank or bin so that farmers need not put their harvest in sacks. The grain tank has a capacity of 2.5 t and has a conveyor that transfers paddy into a trailer truck.The combine harvester is usually operated by one person, but the machine owner still hires one to two persons who will manually

Rice combine harvester in Suphan Buri, Thailand.

harvest the rice along the sides and corners of the field, which the combine machine can hardly reach. Harvesting, threshing, and hauling using a combine harvester require a minimal labor input of 0.7 to 0.8 md ha^{-1}. Combine harvesters can be hired through a custom service system with contract rates ranging from US$92 to US$102 ha^{-1}.

Postharvest and marketing practices

As a result of the wide adoption of combine machines in the Central Plain, postharvest activities such as cleaning, bagging, and drying were eliminated. Results of the survey show that all farmers sold the newly harvested rice directly to millers. The moisture content of the newly harvested rice was 24% during DS and 25% during WS. Millers picked up about 84% and 52% of the rice harvest during DS and WS, respectively, from designated locations. Millers also provided trucks for hauling and transporting the harvested rice and they usually shouldered the transport expenses to encourage farmers to bring their pledged rice to them[1]. But, for farmers who opted to deliver their rice harvests to the miller, they paid an average transportation cost of US$3.25 t^{-1}, depending on the distance of the farm to the rice mill. The distance of the farm to the nearest market of inputs and output ranged from 0.2 to 25 km and farm-to-market roads in the Central Plain were highly accessible and developed as these were mostly made of asphalt or concrete.

Farmers in SuphanBuri did not retain a portion of their harvest for home consumption. This is because they usually buy milled rice with better eating quality and has less pesticides such as the *Hom Mali* (Jasmine rice) coming from the north and northeast regions.

Credit and financing

Capital is an enabling input in rice production and credit is an important source of capital for rice farmers in any region. About 63-65% of the sample farmers borrowed to finance their rice production in both seasons. They usually availed of loans from formal credit institutions like banks (17-22%) (BAAC was most

1 The more volume of pledged rice brought to a certain mill, the higher the opportunity to earn more money. This is because, during RPS implementation, the government contracted out private millers to mill the pledged rice and paid them for storage cost.

commonly mentioned by farmers) and cooperatives (15-19%) where farmers are registered members. Loans from these institutions were disbursed as cash and credit cards were allotted for fertilizers, with 7% annual interest rate. Some input dealers in the community also loaned out agricultural inputs such as fertilizers and pesticides. Other farmers borrowed from informal lenders, including family and relatives who usually do not charge interest rates on loans. Average monthly interest rate was very low, 0.38% for DS and 0.37% for WS.

Formal credit institutions with reasonable interest rates became more accessible to farmers when the government established BAAC in 1966. Since its establishment, the share of informal lenders in the credit market has enormously declined in the previous decades. Currently, 65% of farm credit is provided by formal institutions (Isvilanonda, 2012).

Yield and partial factor productivity

Table 7. Yield, nitrogen, labor and partial factor productivity, by season, SuphanBuri, Thailand, 2013.

Item	DS	WS
Yield (kg ha^{-1})	5689	6093
N (kg ha^{-1})	79	88
Labor (mandays ha^{-1})	9.68	11.13
Partial factor productivity of N (kg paddy N^{-1})	72	70
Partial factor productivity of Labor (kg grain md^{-1})	588	548

Table 7 shows the average yield and partial factor productivity of N and labor. The yield data were calculated using farmers' estimates of production and area for the largest parcel. The moisture content levels of paddy right after harvest were estimates of farmers, averaging 22% during DS and 25% during WS. The average yield obtained by farmers in WS (6.09 t ha^{-1}) was significantly higher than the 5.69 t ha^{-1} during DS. This is in contrast to the usual findings that yield is higher during DS. This could be partly explained by the problem of insufficient water supply as reported by more farmers during DS. Higher usage of NPK at 88-22-10 kg ha^{-1} could have also led to higher yield during WS. More farmers obtained yields more than 5 t ha^{-1} during the DS (81%) than in WS (70%). Moreover, 2% of the farmers obtained yields below 3 t ha^{-1}during DS compared with those in the WS where all farmers obtained yields greater than 3 t ha^{-1}(Fig. 4).

The 2013 average yields of farmers were higher compared with those obtained in the RTDP sites in 1995-99—5.17 t ha^{-1} in the high-yielding season and 5.08 t ha^{-1} in the low-yielding season (Moya et al., 2004). When converted into 14% moisture content, average yield was 5.16 t ha^{-1} during DS and 5.31 t ha^{-1} during WS. This was even higher than the average provincial yield of 4.61 t ha^{-1} in 2012 (IRRI-WRS, 2015).

The partial factor productivity of N is an index of the efficiency of N fertilizer application. The estimated average partial factor productivity for N was 72 and 69 kg grain per kg N during DS and WS, respectively. These estimates were higher than the N productivity in the RTDP sites in 1999 at 48-50 kg paddy kg N^{-1}. The current N rates used by farmers were more efficient than those used 15 years ago perhaps due to more frequent application of fertilizers in three splits compared with the previous practice of only one to two splits. By distributing fertilizer application across the growing season, the rice plant could have a better absorption rate, which increased the yield (PhilRice, 2002a).

Labor productivity was high at 588 kg paddy md^{-1} during DS and 548 kg paddy md^{-1} during WS. Since 1999, a substantial increase in the productivity of labor has been observed. Results of the previous study showed that labor productivity was only 340 kg paddy md^{-1} and 361 kg paddy md^{-1} during DS and WS, respectively.

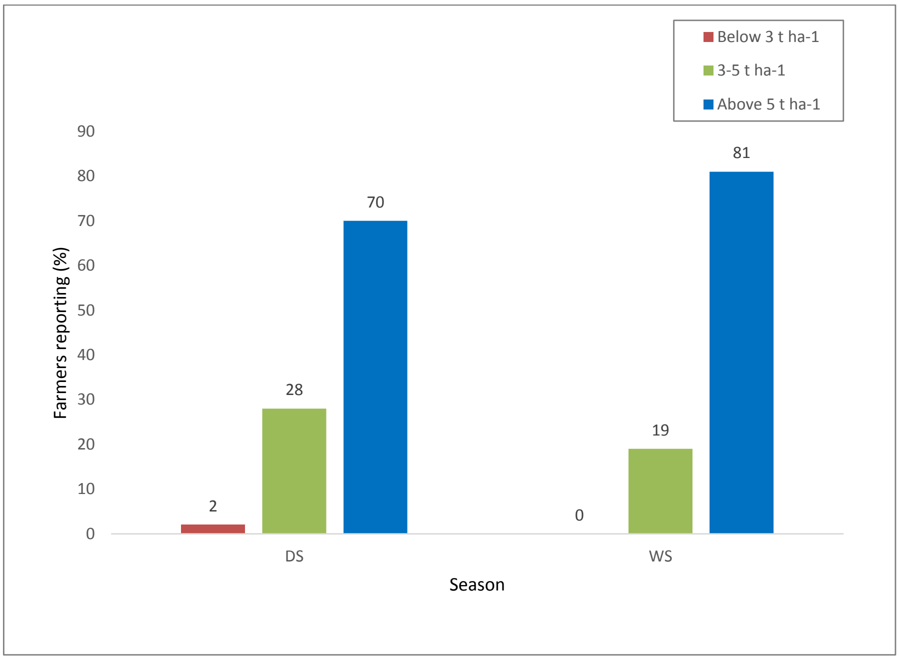

Fig. 4. Percent distribution of farmers, by yield level, SuphanBuri, Thailand, 2013.

The increase in labor productivity was a result of the decreasing labor inputs in rice production through the adoption of machines and other labor-saving technologies.

Cost and profitability

Table 8 shows the costs and returns of rice production based on the data collected. Although the government had set the price of paddy during the RPS, farmers received different prices ranging from US$0.24 to0.46 kg^{-1} during DS and US$0.19 to 0.49 kg^{-1} during WS due to different grain quality and moisture content. The average prices received were US$0.40 kg^{-1} and US$0.39 kg^{-1}during DS and WS, respectively, and the difference was statistically significant at 95% confidence level. More farmers during DS received higher prices than during WS. Some of the farmers in WS were not able to sell their produce under the government's RPS because harvesting time did not coincide with the time of program implementation. Some farmers intentionally did not sell under the scheme because they preferred to receive payment in cash in contrast to late payment when rice is sold under RPS. As a result, farmers received average gross returns of US$2,277.20 ha^{-1}during DS and US$2,350.10 ha^{-1} during WS.

The total cost of rice production was US$1,175.50 ha^{-1} during DS and US$1,159.00 ha^{-1} during WS. Among the cost items, land rent, which was paid in kind, had the largest share (26-27%) of total cost in both seasons (Fig. 5.). Land rent is the amount paid by the lessee or renter to the landowner for the use of land in rice production. Farmers who are renters of land in SuphanBuri paid rent in the form of paddy. Imputed land rent, which was the average land rent of lessees, was used for farmers who own the land they cultivated. The average land rent at US$310 ha^{-1} was high because it was valued using the price of rice, which was influenced upward by the RPS.

Since rice production in SuphanBuri is highly mechanized, about 16-19% of the total cost of production was expended on machine rental, including fuel and oil used in the operation. Fertilizer costs contributed 16-17%, whereas seed share was about 12% of total cost. The high seeding rates, coupled with the use of high-quality seed, led to higher seed cost in both seasons. Pesticides had about 9-10% contribution to production cost, while hired and OFE labor had equal but minimal cost share of 7% in both seasons.

Table 8. Cost and returns in rice production, SuphanBuri, Thailand, 2013 DS and WS.[a]

Item	Value DS (n=100)	Value WS (n=100)	Difference	
Returns				
Yield (kg ha^{-1})	5,689	6,093	-404	**
Paddy price (US$ kg^{-1})	0.40	0.39	0.01	**
Gross revenue (US$ ha^{-1})	2,277	2,350	-72.91	
Costs (US$ ha^{-1})				
Seed	138	138	-0.52	
Fertilizer	187	199	-12.31	
Chemicals	110	113	-2.75	
Hired labor	83	79	3.13	
Operator, family, & exchange labor	77	82	-4.29	
Machine rent	222	188	33.76	***
Irrigation	15	19	-3.32	
Food	6	6	0.27	
Transportation	20	17	3.05	
Tax	0	0	-0.04	
Land rent	310	310	0.29	
Interest on capital	7	8	-0.77	
Other inputs	0	0	0.00	
Total cost (US$ ha^{-1})	1,175	1,159	16.48	
Cost per unit (US$ mt^{-1})	207	190	16.41	**
Net income from rice farming (US$ ha^{-1})	1,102	1,191	-89.39	
Net income from rice farming with own land and capital (US$ ha^{-1})	1,419	1,509	-89.88	

[a] *, **, *** indicate significance at 90%, 95%, and 99% confidence level, respectively.

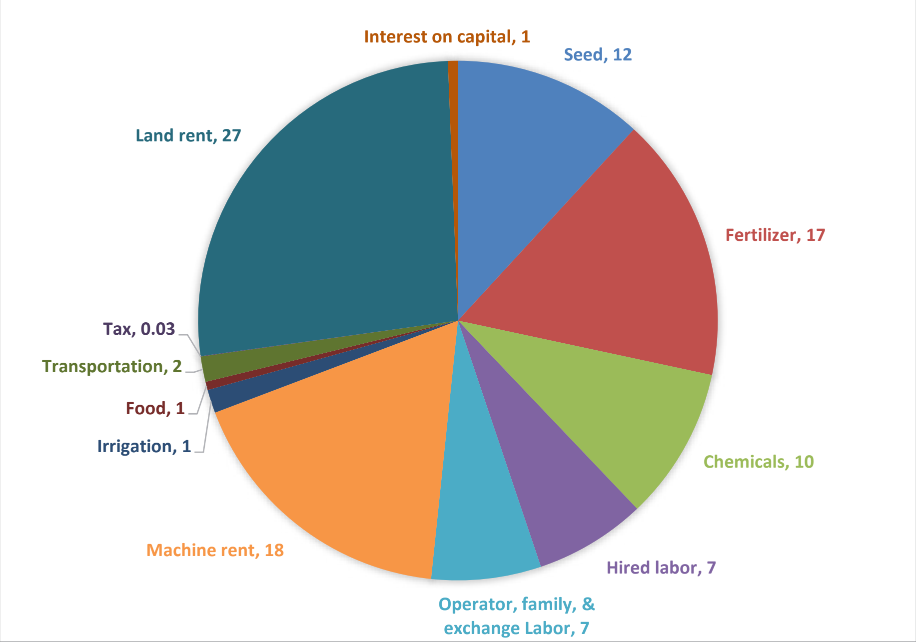

Fig. 5. Cost share (%) in total cost of paddy production in SuphanBuri, Thailand, 2013.

Irrigation cost comprised expenses on fuel and oil for pumps used in irrigating and draining of water contributed only 1-2% of total cost. The share of interest expense was minimal due to low interest rates of credit providers. Other costs such as those for transportation and food for hired labor were also negligible.

The cost of producing a metric ton of rice in WS was US$190.20 ha^{-1} and was significantly lower than DS's US$206.60 ha^{-1}. Although average price received during DS was higher, gross returns and net income were still higher for WS because of the higher yield obtained by farmers.

Net income from rice production from a 1-ha farm land was US$1,101.70 ha^{-1} for DS and US$1,191.10 ha^{-1} for WS, with a total annual income of US$2,292.80.

When farmers own the land and capital and when opportunity cost of OFE labor was not included in the cost structure, net income from rice farming would further increase to US$1,496.30 ha^{-1} during DS and US$1,590.50 during WS, and total annual income would be US$3,086.80 ha^{-1}.

Since a Thai farmer operated an average of 4.40 ha, his annual income from rice farming would be US$10,088.40, which is more than enough to cover expenditures on food and other non-food basic necessities of a family with five members. The per capita income from rice farming at US$1,925.30 yr^{-1} was compared with the country's national poverty line at US$78.82 per capita mo^{-1} (THB 2,422 per capita mo^{-1}), which was equivalent to US$946 yr^{-1} (NSO, 2013). When costs of land, capital and OFE labor were not included, annual rice income amounted to US$13,581.70 and per capita income reached US$2,591.90.

Costs and returns of rice production without the pledging scheme were also computed. The prices of paddy for both seasons were adjusted by getting the average prices received by farmers who did not sell under the government RPS. Among the costs of production, only land rent, which is dependent on the price of rice, was adjusted. Average land rent in the form of paddy was obtained and valued using paddy price of farmers who did not sell under RPS. With adjusted prices at US$0.30 kg^{-1} and US$0.29 kg^{-1}, gross returns were US$1,732.99 ha^{-1} and US$1,753.08 ha^{-1} during DS and WS, respectively. The adjusted land rent declined to US$236.10 ha^{-1} during DS and US$231.20 ha^{-1} during WS. Net income without the pledged prices decreased to US$631.65 ha^{-1} during DS and to US$672.82 ha^{-1} during WS.

Common problems in rice production

For both seasons, majority of the respondents reported not having any problems when it comes to rice farming (Table 9). More farmers reported it during WS (66%) than during DS (41%). However, some farmers (11-14%) were disgruntled with the RPS. They complained mainly about the delay in payments, which lasted as long as 4 months. During the survey, farmers who tilled small lands said that they were not given priority by the government and thus payment for their harvest was delayed.

Of those who reported rice farming problems, 8-31% complained of pest infestations. During DS, most farmers had to deal with damage caused by brown planthoppers and borers. In the WS, farmers mentioned a variety of pest problems brought about by insects, weeds, and rats.

Although credit is accessible, not all of the farmers were able to avail of it as 5-10% of them mentioned lack of capital as one of their problems. Flooding was experienced by 12% of the farmers during WS. This was brought about by heavy rains in the area, particularly during WS, which caused their crop to lodge.

During the DS, some farmers reported that the high cost of inputs (11%), particularly of pesticides and fertilizers, made rice farming problematic. This problem is aggravated by the tendency of farmers in the area to apply high doses of chemicals following the advice of input dealers. It should be noted though, that insecticides and fertilizers were hardly used in the 1970s in the area (Sriswasdilek et al., 1975).

Table 9. Common problems reported by farmers, 2013 WS and DS, SuphanBari, Thailand.

Problem*	DS (n=100)		WS (n=100)	
	No.	%	No.	%
Pest incidence	31	31	8	8
High cost of inputs	11	11	2	2
Issues on government rice mortgaging scheme	11	11	14	14
Lack of capital	10	10	5	5
Insufficient water supply	7	7	2	2
Unreliable quality of seeds	6	6	0	0
Low paddy price	6	6	1	1
Flooding	3	3	12	12
Low yield	3	3	0	0
Poor soil	2	2	0	0
Weather too hot	1	1	0	0
No problem	41	41	66	66

*Multiple responses.

SUMMARY & IMPLICATIONS

This paper describes the current status of rice production in intensively cultivated irrigated areas of SuphanBuri under the rice pledging scheme of the government. Rice yield, input use, cost of production, partial factor productivity, and income from rice farming were evaluated and compared with RTDP results. Yield had remarkably increased in the last 15 years and so did partial factor productivity of N and labor.

Mechanization is one of the outstanding features of rice production in SuphanBuri. Amidst rising farm wages and prevalent shortage of farm labor, use of farm machinery became popular among rice farmers, which tremendously reduced labor use. Labor-intensive operations such as land preparation, harvesting, and threshing are already fully mechanized. A combine harvester with a grain tank is widely used, thereby eliminating postharvest activities like cleaning, bagging, and drying. Direct seeding and fertilizer applications are also being mechanized, with the use of engine-powered sprayers gaining popularity among farmers. Even with the introduction of mechanical transplanters, the less costly direct seeding is widely practiced by farmers.

Other than mechanization, the use of few but high-yielding varieties and good-quality seeds is one of the best practices followed by farmers in SuphanBuri. However, high seeding rate is still observed, which increases production cost. Lower seeding rate should be promoted to further reduce production cost.

The injudicious use of pesticides is one aspect in the Thai rice production program that needs great attention. Farmers rely heavily on pesticides for crop protection, mostly as a preventive and not a curative measure. Pesticides are applied as a cocktail of insecticides, herbicides, fungicides, molluscicides, and growth hormones. Most farmers depend on input dealers for advice on dosage, formulation, and timing of application of pesticides that they use. The inefficient use of pesticides does not only increase production cost but also constitutes a risk to human health and the environment. This may threaten Thailand's reputation as a major rice exporter, when importing countries demand testing for pesticide residues as a result of rising food safety concerns. Farmers are aware that pesticides are essential inputs for higher production, but they do not know the optimal recommended doses. Thus, it is imperative to have an effective dissemination of research findings by the extension service to ensure proper adoption of these technologies. Farmers must be made more aware of chemical toxicity and its harmful effects on the environment and human health.

The aging farmers, along with the shunning away of the younger generation from rice farming (due to availability of non-farm jobs in the cities) was also observed. Family labor is becoming scarce and the farm labor force is rapidly declining.

Farmers in SuphanBuri enjoyed government support in terms of credit and rural infrastructure such as irrigation and farm-to-market roads. Most of the farmers have benefitted from the availability and accessibility of credit at reasonable interest rates charged by both commercial private banks and government-managed banks. Farmers are not only provided with free irrigation water by the government; they are also blessed with good farm-to-market roads, which made transport of farm inputs and outputs efficient and lessened transportation cost.

The RPS that offered a price higher than the prevailing market price has benefitted farmers in SuphanBuri by increasing their income in rice production. However, such a policy caused Thailand to lose its rank as the world's top rice exporter because of the higher export prices of Thai rice compared with those from other exporting countries. In the absence of such a scheme, prices of paddy would be stabilized and competitiveness in the world market would be further enhanced. Thai farmers should find ways to lessen their cost of production in order to maximize their profits.

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