Chapter 2

Rice quality and price relationships

2.1 Introduction

Rice is one of the most important food crop in the world being the staple food of over half of the world's people. In rice production, quality is one of the most important factors determining the income of farmers. The quality concerned in rice production, marketing and consumption is generally characterized as milling quality, cooking and eating quality and nutritional quality. Milling quality is determined by the amount of milled rice and percent head rice recovery (Brorsen *et al.*, 1984). For non-aromatic rice, head rice yield after milling is the main factor that influences the price of rough rice. In aromatic rice, however, aroma is the major determination for aromatic rice price. Juliano and Duff (1989) reported that physical properties and variety name mainly determine milling quality, whereas cooking and eating qualities were mainly determined by physicochemical properties. Rice quality has become an important issue that effects both domestic consumption and international trade.

Rice quality improvement could increase rural incomes and the welfare of consumers. In the market, high quality rice fetches twice the price of low quality rice. Furthermore, the price of traditional varieties is usually double the price of modern varieties. The premium paid for traditional varieties sharply exceeds the price of modern rice varieties with desirable taste characteristics such as Cisadane and IR64 (Juliano and Duff, 1989). Thai Jasmine or Thai Hom Mali is Thailand's special quality rice for which local consumers and export markets are willing to pay a

premium price. An announcement from the Ministry of Commerce of Thailand, decreed that the name 'Thai Jasmine' or 'Thai Hom Mali' can only be given to rice grown from specific varieties that have been officially approved by the Department of Agriculture, Ministry of Agriculture and Cooperatives (Ministry of Commerce Thailand, 2001). The leading approved variety for producing Thai Jasmine rice is Khao Dawk Mali 105 (KDML105), followed by RD15. Rice grown from KDML105, however, does not always receive the premium price from buyers. Traditionally prices for rice of the same grade vary with location where the rice has been grown. For example, a preliminary survey in the Chiang Mai rice retail market in 2002 found that milled rice (special grade, 100% head rice) from Phao, Sanpatong and Mae Chan retail prices were 22, 20 and 26 baht kg^{-1}, respectively. Further differentiation in price is determined by the percentage of whole grain or head rice. For example, the price of milled rice from Phao with 5% broken grain was 17 baht kg^{-1}, about 25% lower than 100% head rice grade (43 baht = 1 US$).

In this chapter, the relationship between rice quality parameters used by commercial rice buyers and price of rough rice from the farmers' fields were examined to establish what quality criteria are important in determining rice price in Thailand. Three places were chosen for this work, representative of the lower northern (Nakhonsawan, NKW) and upper northern (Chiang Mai, CM, and Chiang Rai, CR) paddy rice growing regions of Thailand. In the wet season, the main varieties grown in these areas are KDML105, but RD6 is only grown in the upper northern of Thailand.

2.2 Materials and methods

2.2.1 Materials

Survey 2.1: Farmer's field survey in Chiang Mai (CM) and Nakhonsawan (NKW) in the wet season 1999

The objective of this study was to evaluate the effect of growing area for KDML 105 from CM, and NKW (areas which mostly growing in the Northern and Central Thailand) farmers' fields on rough rice price and quality in the 1999 wet season crop (Figure 2.1). Twenty-seven samples of KDML105 from CM and twenty samples from NKW (500 g sample^{-1}), 1 sample per farmer, were collected randomly from the bulk grain on each farm, placed separately in paper bags and air-dried to approximately 14% wet basis (wb).

Survey 2.2: Farmer's field survey in Chiang Mai and Chiang Rai (CR) in the wet season 2002

This experiment was aimed to evaluate the quality characteristics for determining the rough rice price of KDML105 (non-sticky rice) and RD6 (sticky rice) from farmers' fields in San Kamphaeng (SKP) and Phao districts in CM, and Mae Chan (MC) and Phan districts in CR in the wet season 2002 (Figure 2.2). One kilogram of rough rice of the varieties confirmed by farmers as KDML105 and RD6 varieties were randomly harvested from the paddy fields, 2 replications each (Table 2.1). Grain moisture content of rough rice at harvest was measured by a Riceter series J999 grain moisture tester (Kett Electric Laboratory), measured twice for each sample. After moisture content reading finished, the samples were kept separately in net bags and air-dried to approximately 14% wb.

Table 2.1 Number collected samples of KDML105 and RD6 from CM and CR in the wet season 2002

Province	Distric	Number of rice samples	
		KDML105	RD6
CM	San Kamphaeng	5	6
	Phao	7	7
CR	Mae Chan	9	10
	Phan	8	15

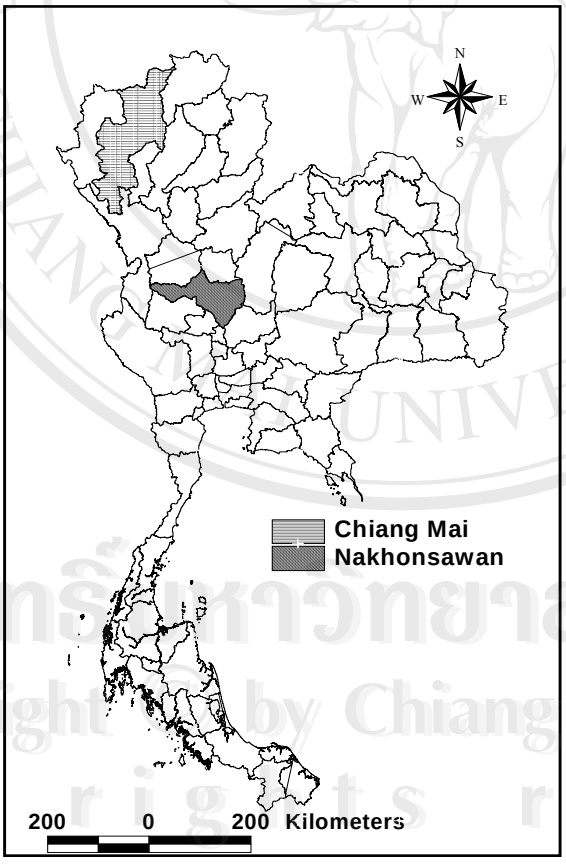

Figure 2.1 Map of KDML105 rice sampling areas in farmers' field in Chiang Mai and Nakhonsawan in the wet season 1999.

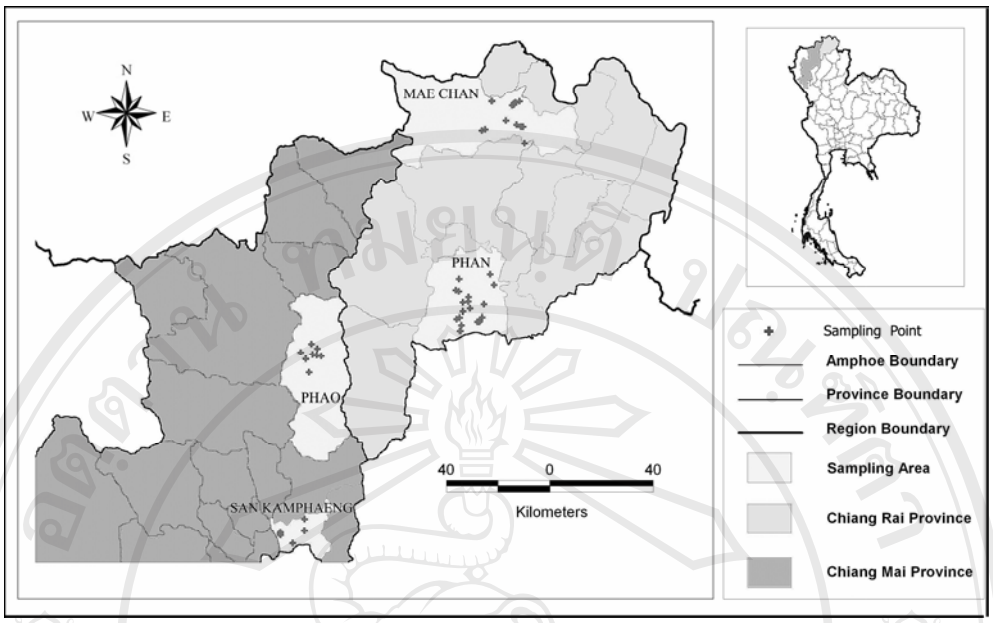

Figure 2.2 Map of KDML105 and RD6 rice sampling areas in farmers' field in Chiang Mai and Chiang Rai in the wet season 2002.

2.2.2 Milling quality and price evaluation

Each sample of rice in the two experiments was divided into 2 portions. The first portion (100 g) was used for milling quality evaluation and the second portion, 100 g in experiment 2.1 and 500 g in experiment 2.2, was evaluated for quality characteristics and price by a commercial rice buyer.

Rough rice of the first set was dehulled (sheller series P-1, Ngek Seng Huat LTD., Thailand) and the resulting brown rice was polished for 30 seconds (miller series K-1, Ngek Seng Huat LTD., Thailand) to obtain the milled rice. The milled rice was separated into head rice and broken rice by a broken rice separator (series I-1, Ngek Seng Huat LTD., Thailand) and weighed separately. The percent unbroken rice was calculated: in term of percentage of head rice per milled rice weight. The head rice of experiment 2.2 was analyzed for N concentration by titration after Kjeldahl digestion (Yoshida *et al.*, 1976).

The rough rice of the second set was rated for quality characteristics and priced by a commercial rice buyer, Chiangmai Chaiwiwat Ricemill Co., LTD. The buyer did not play attention for the sources of rice samples. Quality characteristics determined included grain moisture, percent head rice, aroma, vitreousness and translucency. Grain moisture was measured by a Riceter series L grain moisture tester (Kett Electric Laboratory). A small sample (100 g) of rice was milled, and ratings between 0 (nothing), 1 (low), 2 (medium) and 3 (high) were given by an experienced rice buyer to aroma, vitreousness and translucency, and the percent head rice was roughly estimated by visual. The criteria included percent head rice (head rice yield), quality characters (aroma, vitreousness and translucency), grain moisture

content and percentage of contamination (genotype impurity) were used for determining KDML105 price, but only percent head rice for RD6 price.

2.2.3 Statistical analysis

Data were analyzed by analysis of variance (ANOVA) and linear regression. Significantly different among means were tested at $P < 0.05$ by the least significant difference (LSD). The price and quality characteristics scores made by rice buyer were generated for multiple linear regression equations. All of statistical analyses were made with commercial software (Statistix V. 7.1, Analytical Software, Inc.).

2.3 Results

Survey 2.1: Farmer's field survey in Chiang Mai and Nakhonsawan in the wet season 1999

Grain moisture content did not exceed the required standard 14% in any of the samples, those from CM ranged from 13.3 to 14.0% and the range for NKW was 11.2 to 12%. The rough rice, KDML 105, samples from CM was priced at 7,672 (range 7,400 to 7,900) baht ton^{-1}. The rice price of CM based on the percent head rice only (equation 2.1) because all samples received the full score for aroma, vitreousness and translucency score (Table 2.2). Although the percent unbroken rice ranged from 40 to 90%, all of the rough rice from CM could be sold as premium price (Table 2.3). In contrast, rough rice samples from NKW were more varied and the price ranged from 5,000 to 7,200 baht ton^{-1}. Only 10% of the samples from NKW were considered as premium quality and price was more than 7,000 baht ton^{-1}, 35% was good quality (6,501-7,000 $baht.ton^{-1}$), 15% was fair quality (5,500-6,500 $baht.ton^{-1}$) and 40% were

poor quality and price was less than 5,500 baht ton^{-1}. Price of NKW samples were determined primarily based on their aroma and vitreousness scores. It was shown that percent unbroken rice and translucency having relatively minor effects (equation 2.2). The range of percent unbroken rice was 50 to 85%. The average percent unbroken rice of NKW was higher than for CM but gave lower in vitreousness, translucency and aroma. From prices set by the rice buyer, rice samples from CM had a better price than NKW samples.

$P = 6{,}969 + 11PUB$ $r = 0.96^{***}$ (2.1)

$P = 3{,}260 + 29PUB^{*} + 404ARO^{*} + 357VIT^{*} + 72TRA^{ns}$ $r = 0.91^{***}$ (2.2)

P = rough rice price PUB = percent unbroken rice

ARO = aroma score VIT = vitreousness score TRA = translucency score

Table 2.2 Percent unbroken rice, grain moisture content, quality characteristic score and rough rice price of KDML105 from Chiang Mai and Nakhonsawan

Location	Number of samples	Percent unbroken rice	Grain moisture content (% wb)	Quality characteristic score†			Rough rice price (baht ton^{-1})
				Aroma	Vitreous-ness	Translu-cency	
CM	27	62 (3)‡	13.6 (0.1)	3.0 (0.0)	3.0 (0.0)	3.0 (0.0)	7,672 (32)
NKW	20	72 (2)	11.6 (0.1)	1.0 (0.2)	0.9 (0.2)	1.1 (0.2)	6,125 (180)

† Rice quality scored by miller; 0 = non, 1 = low, 2 = medium and 3 = high

‡ Standard error

Table 2.3 Price classification of rice samples from Chiang Mai and Nakhonsawan by the rice buyer

Location	Price† (baht ton^{-1})	Number of samples	Relative value
CM	<5,500	0	0
	5,501–6,500	0	0
	6,501–7,000	0	0
	>7,000	27	100
NKW	<5,500	8	40
	5,501–6,500	3	15
	6,501–7,000	7	35
	>7,000	2	10

† Grouping of rice quality by price (maximum price is 8,000 baht ton^{-1})

<5,500 baht ton^{-1}	Low quality
5,501-6,500 baht ton^{-1}	Fair quality
6,501-7,000 baht ton^{-1}	Good quality
>7,000 baht ton^{-1}	Premium quality

Survey 2.2: Farmers' field survey in Chiang Mai and Chiang Rai in the wet season 2002

Grain moisture at harvest and N concentration in head rice

Grain moisture at harvest of both varieties ranged from 18 to 26% wb (Table 2.4). The grain moisture at harvest of both varieties was about 18 % in Phao, and 25% in SKP, MC and Phan. In KDML105, head rice N concentrations were highest (1.4%) in rice from MC, and lowest (1.2%) in rice from Phan, but in RD6, head rice N concentration was highest (1.45%) in rice from Phan, and lowest (1.2%) in rice from SKP. Percent unbroken rice ranged from 26 to 40% in KDML105, being lowest in rice samples from Phan and highest in rice from SKP. In RD6, the percent unbroken rice was more than double that for KDML105. Grain moisture at harvest had no significant effect on percent unbroken rice of KDML105 or RD6 (Figure 2.3). In KDML105, head rice N concentration was positively correlated with percent unbroken rice (Figure 2.4), but not in RD6 (Figure 2.5).

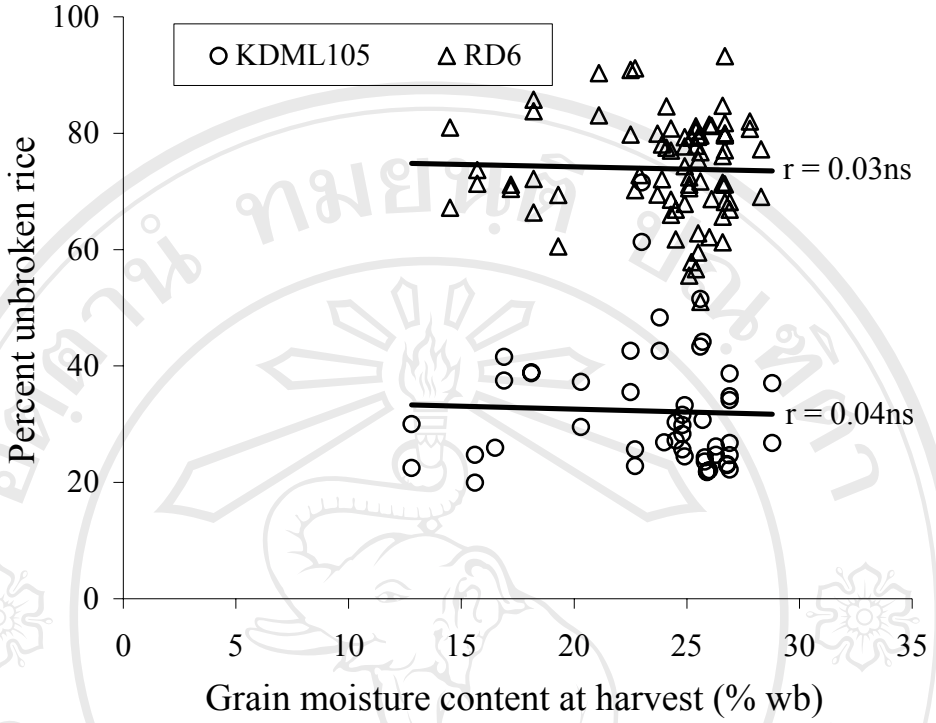

Figure 2.3 Relationship between grain moisture content at harvest and percent unbroken rice of KDML105 and RD6.

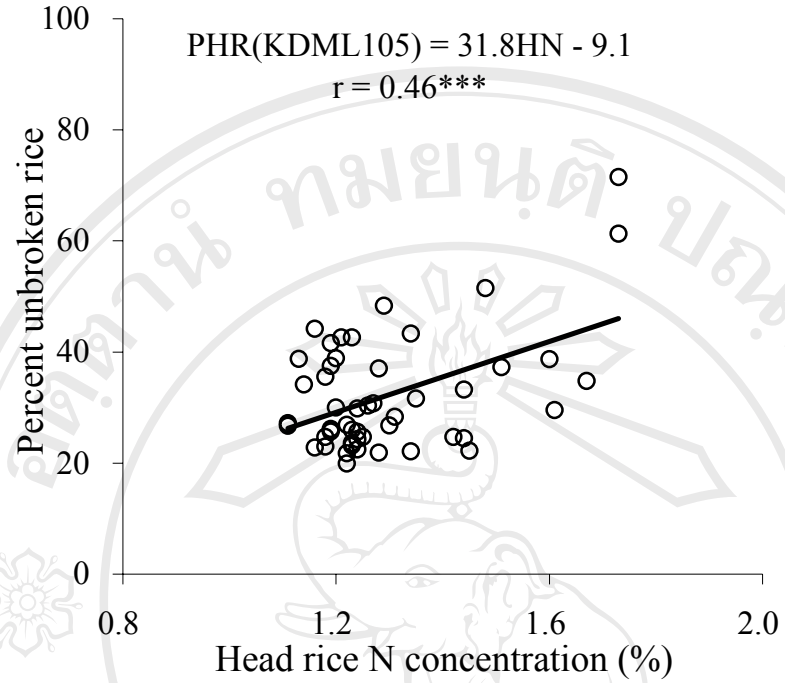

Figure 2.4 Relationship between head rice N concentration and percent unbroken rice of KDML105.

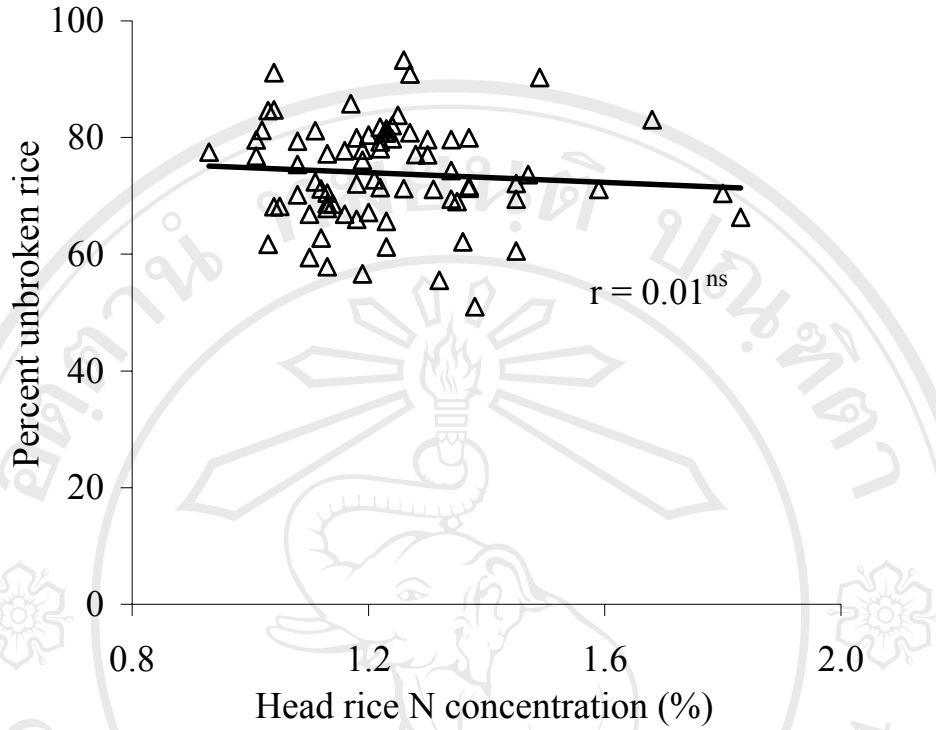

Figure 2.5 Relationships between head rice N concentration and percent unbroken rice of RD6.

Table 2.4 Grain moisture content at harvest, head rice N concentration and percent unbroken rice of KDML105 and RD6 from San Kampaeng (SKP), Phao, Mae Chan (MC) and Phan

Location	Number of farmers	Grain moisture content at harvest (% wb)	Head rice N concentration (%)	Percent unbroken rice
	KDML105			
SKP	5	24.5 (0.4)†	1.27 (0.03)	38.5 (2.9)
Phao	7	18.8 (1.1)	1.27 (0.04)	31.7 (1.8)
MC	9	24.8 (0.9)	1.41 (0.05)	29.1 (2.5)
Phan	8	25.6 (0.6)	1.22 (0.02)	26.1 (1.8)
Mean		23.4 (1.6)	1.3 (0.05)	31.3 (2.7)
	RD6			
SKP	6	25.5 (0.2)	1.17 (0.04)	70.5 (2.8)
Phao	7	17.7 (0.6)	1.46 (0.06)	74.7 (2.3)
MC	10	25.6 (0.3)	1.22 (0.04)	74.2 (2.3)
Phan	15	25.3 (0.3)	1.19 (0.02)	74.7 (1.3)
Mean		23.5 (1.9)	1.26 (0.07)	73.5 (1.0)

† Standard error

Rice quality evaluation and prices determined by commercial rice buyers

Grain moisture content at harvest of KDML105 ranged from 13.5 to 15 % wb and from 13.5 to 16% in RD6 (Table 2.5, 2.6). The percent head rice ranged from 23 to 28% in KDML105 and 30 to 39% in RD6. For KDML105, the quality characteristics were judged for high vitreousness, translucency and aroma. Another criteria such as contamination of glutinous rice is also account for KDML105 quality. Results showed that KDML105 samples obtained from different places had percent contamination of glutinous rice ranged form 1.7 to 6.5%.

Rough rice price of KDML105 ranged from 4,200 to 4,800 baht ton^{-1} (Table 2.5) and 4,400 to 5,100 baht ton^{-1} for RD6 (Table 2.6). The rough rice prices of the two varieties were closely related to the percent head rice (Figure 2.5). However, the price of KDML105 was negatively correlated with the percentage of glutinous rice contamination (equation 2.3). Rough rice price and percent head rice were not affected by grain moisture content and quality characteristics. However, the percent unbroken rice of KDML105 was positively correlated with the percent head rice (Figure 2.7) but not in RD6 (Figure 2.8).

$$P = 2048.4 + 98.8PHR^{***} - 25.2CON^{***} \qquad r = 0.99^{***} \qquad (2.3)$$

P = rough rice price PHR = percent head rice

CON = percentage of glutinous rice contamination

Table 2.5 Grain moisture content, percent head rice, quality characteristic score and rough rice price of KDML105 from San Kampaeng, Phao, Mae Chan and Phan, as determined by rice buyer

Location	Number of farmer	Grain moisture content (% wb)	Percent head rice	Quality characteristic score†			Contamination (%)	Rough rice price (baht ton^{-1})
				Vitreous ness	Translucency	Aroma		
SKP	5	14.9 (0.2)‡	28.0 (1.7)	3 (0.0)	3 (0.0)	3 (0.0)	2.5 (0.7)	4,765 (171)
Phao	7	13.5 (0.1)	24.0 (1.0)	3 (0.0)	3 (0.0)	3 (0.0)	6.5 (2.1)	4,273 (111)
MC	9	14.4 (0.1)	24.4 (1.9)	3 (0.0)	3 (0.0)	3 (0.0)	1.7 (0.7)	4,525 (162)
Phan	8	15.2 (0.1)	22.8 (1.0)	3 (0.0)	3 (0.0)	3 (0.0)	2.5 (1.3)	4,219 (110)
Mean		14.5 (0.4)	24.8 (1.1)	3 (0.0)	3 (0.0)	3 (0.0)	3.3 (1.1)	4,445 (125)

† Rice quality scored by miller; 0 = not and 3 = high

‡ Standard error

Table 2.6 Grain moisture content, head rice yield and rough rice price of RD6 from San Kampaeng, Phao, Mae Chan and Phan, as determined by the rice buyer

Location	Number of farmers	Grain moisture content (% wb)	Percent head rice	Rough rice price (baht ton^{-1})
SKP	6	15.8 (0.2†)	38.7 (1.1)	5,100 (85)
Phao	7	13.4 (0.1)	30.4 (2.1)	4,493 (188)
MC	10	15.3 (0.2)	30.7 (0.8)	4,430 (94)
Phan	15	15.7 (0.6)	33.2 (0.9)	4,620 (83)
Mean		15.0 (0.6)	33.3 (1.9)	4,661 (152)

† Standard error

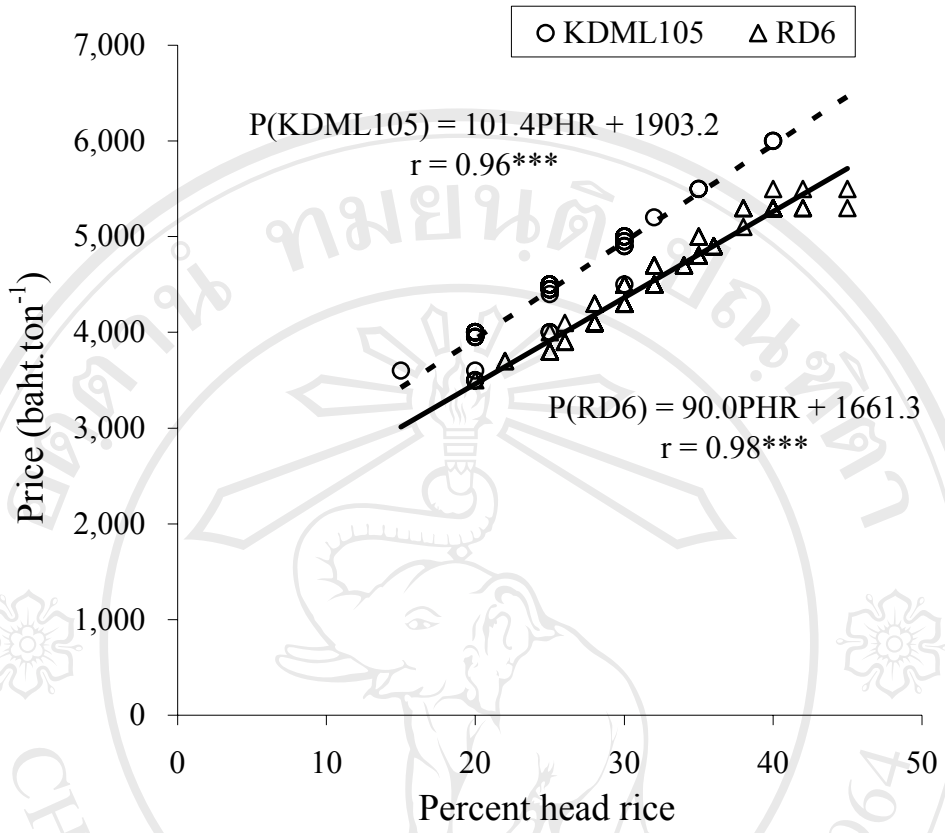

Figure 2.6 Relationship between percent head rice and price of KDML105 and RD6, evaluated by rice buyer.

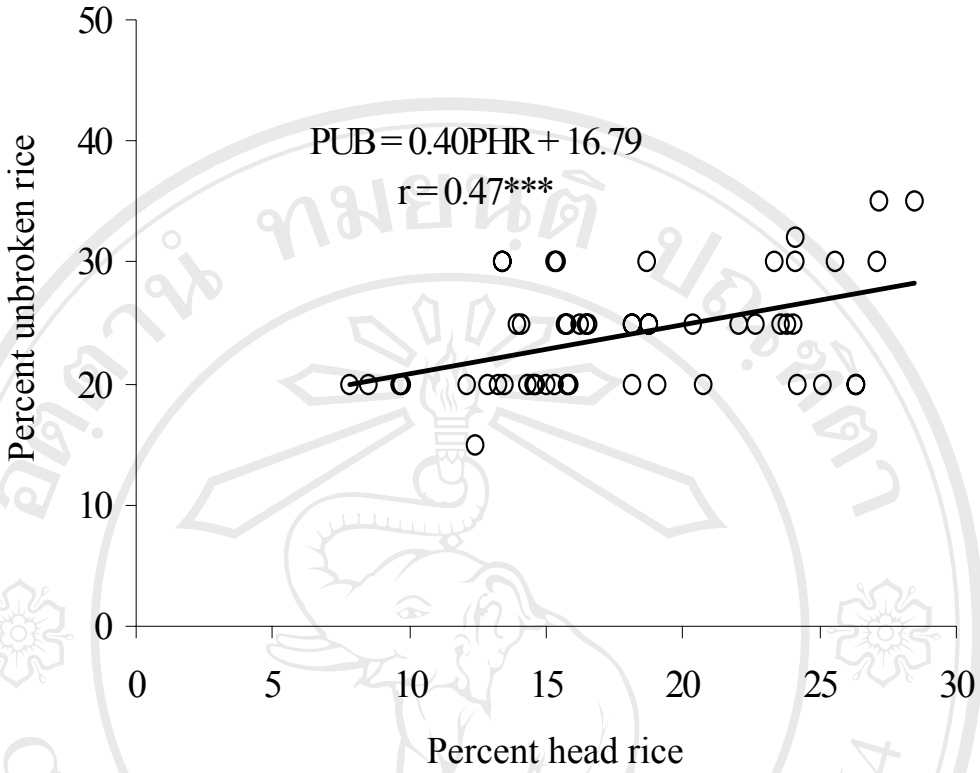

Figure 2.7 Relationship between percent head rice and percent unbroken rice of KDML105.

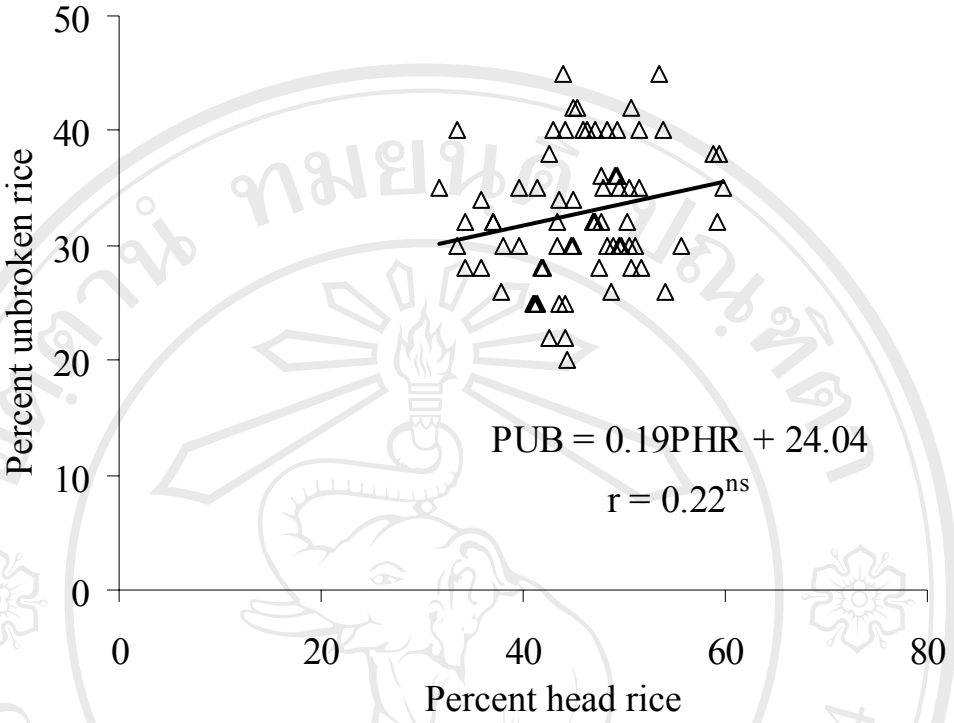

Figure 2.8 Relationship between percent head rice and percent unbroken rice of RD6.

2.4 Discussion

2.4.1 Rice quality characteristics that determined rice price

This study has clearly shown the effect of location in determining grain quality, and therefore farmer's price, of Thai jasmine rice (non-glutinous) grown from the variety KDML105, at standard moisture content of around 14%. In two separate sets of samples from two different years, KDML105 grown in Chiang Mai was found to be of the highest grade with respect to grain vitreousness, translucency and aroma. The same was found in KDML105 grown in Chiang Rai. Once these characteristics for high quality are satisfied, milling quality (head rice yield) becomes the determinant for price. KDML105 samples from Nakhonsawan had significantly higher percent unbroken rice than Chiang Mai samples, on the other hand, exemplified the determination of price largely by aroma.

The rough rice price was closely correlated with head rice yield of KDML105 from all locations and RD6 from Chiang Mai and Chiang Rai. Brorsen *et al.* (1984) suggested that in the world rice markets, head rice is the most important factor that determines rough rice prices. In the rice retail market in Chiang Mai, Thailand, KDML105 with 100% head rice grade had a 25% higher price than 5% broken rice grade (rice that mixed with 95% head rice and 5% broken rice).

For rice price determination, the rice buyer used quality characteristics (e.g. percent head rice (head rice), aroma, vitreousness and translucency, grain moisture and percentage of glutinous rice contamination) to evaluated KDML105 price, but used only grain moisture, percent head rice and percentage of contamination with for glutinous rice RD6. Using these criteria, KDML105 samples from Chiang Mai had a higher price than Nakhonsawan samples. These results illustrated the effect of

ecological differences as well as production managements on rice quality. The Chiang Mai samples represent areas that produce rice with high quality characteristics in terms of aroma, translucency and vitreousness. In such a situation, attention to those factors that influence percent unbroken rice would ensure that farmers are paid premium prices for their harvest.

The survey in 1999 showed that KDML105 from Chiang Mai gained a higher price than rice from Nakhonsawan due to the aroma and vitreousness of KDML105. By contrast, rice samples from Nakhonsawan had more head rice yield than Chiang Mai. This suggested that aroma was the major indicator for aromatic rice price than head rice yield. Many works have been reported that aromatic substance, 2-acetyl-1-pyrroline (2AP), in aromatic rice is highly dependent on environment. Environmental factors that influence on aroma include temperature (Juliano, 1972; Mann, 1987), soil (clay, sandy or saline soil) (Singh *et al.*, 1998; Yoshihashi *et al.*, 2004), plant nutrition and fertilizer application (Suwanarit *et al.*, 1996). Together, these combine will create a unique environment for high aroma, such as in KDML105 production areas in the Northeastern of Thailand, especially in Tungkularonghai (Yoshihashi *et al.*, 2004).

2.4.2 Nitrogen and grain moisture at harvest on head rice yield

In KDML105, head rice N concentration was positively correlated with head rice recovery after milling. These findings are also supported by the results of other workers who have observed increases in head rice recovery due to the application of N fertilizer (Nangju and De Datta, 1970; Seetanum and De Datta, 1973). Furthermore, Cagampang *et al.* (1966) showed that brown rice with higher protein content was more resistant to abrasive milling than brown rice with lower protein

content in the same variety. Nangju and De Datta (1970) and del Rosario *et al.* (1968) found that head rice increased with application of N fertilizer up to 150 kg N ha^{-1}. They suggested that the effect of N on decreasing breakage might have been because protein bodies function as a binder for rice starch granules (this is explored further in Chapter 4). However, head rice N concentration was not correlated with percent unbroken rice of RD6. It was probably due to percent unbroken rice of RD6 was already > 70%.

Grain moisture content at harvest in Survey 2.2, did not affect percent unbroken rice of KDML105 and RD6. These results could be explained that high grain moisture content at harvest could be minimized percent unbroken rice of both rice varieties. Nangju and De Datta (1970) suggested that the optimum times of harvest for maximum grain and head rice yields was 28 to 34 days after heading (19 to 22% wb) in the dry season and 32 to 38 days after heading (18 to 21% wb) in the wet season. In Arkansas and Texas, rice is expected to harvest about 23 to 28% of grain moisture content resulted in maximum grain yields after drying and percent unbroken rice (Smith, 1983). Berrio and Cuevas-Perez (1989) reported that if delaying harvest for two weeks after 20-25% wb had been reached, head rice yield might be lost as much as 18% for 16 tested varieties.

In conclusion, the aromatic level of Thai fragrant rice i.e. KDML105 will play the important criteria for price was determination. However, aroma levels varied greatly due to its production areas. Crops were planted in upper northern gave more fragrant than in lower northern which difficult to control by crop managements. In additional to aroma, head rice yield was the main determinant for rough rice price of both non-aromatic and aromatic rice as well as glutinous rice. Any improvement in

head rice yield recovery after milling by applying N fertilizer in order to increase grain N concentration will be the another alternatives to increase farmers' incomes and food nutrition. The factors that affect on grain breakage during milling will be exploring in Chapter 3.