REFEREED ARTICLE

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Farmers' Adoption and Willingness to Pay for Certified Aromatic Rice Seed in the Mekong River Delta, Vietnam

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ABSTRACT

As preferences and patterns of demand are shifting towards higher quality rice, Vietnam is exploring options to expand aromatic rice production. In recent years, there has been an intensified effort to promote high-quality seed adoption to produce better quality rice and therefore raise the value of exported rice. Financial indices, logit models were used to illustrate farmers' attitudes and expectations towards certified aromatic rice seed, to identify the factors influencing their adoption decision and willingness-to-pay. These issues were examined by drawing on a sample of 306 farmers in winter–spring 2016/2017 in the Mekong River Delta, Vietnam. Private company and farmer-saved seed were the main aromatic rice seed suppliers for the adopter group and the non-adopter group, respectively. Agricultural organisation membership, perceived profitability advantages, lower seed rate and greater availability of certified aromatic rice seed were the key incentives to the adoption of certified aromatic rice seed. Willingness-to-pay for certified aromatic rice seed was 11,986 VND/kg, which was lower than the current market price. Consequently, encouraging suppliers to guarantee certified aromatic rice seed availability at an affordable price and identifying solutions to increase the price of rice should be supported by government policy.

KEYWORDS: Adoption; Aromatic Rice; Certified Seed; Willingness-to-pay

1. Introduction

Vietnam has recorded remarkable achievements in its agricultural sector; for one, it has become the world's leading rice exporter after 25 years of participation in the export markets. However, its focus on volume has limited its access mainly to Asian rice markets, with low-quality rice constituting 76% of its total rice export volume (Vietnam Food Association, 2016). Although global rice consumption preferences and patterns are shifting towards higher-quality rice with the rise in household incomes, Vietnam's output of high-quality rice is limited and unable to meet consumers' requirements. Among other reasons is the prevalence of short-term cultivation practices using low-quality inputs, particularly low-quality seed and the overuse of chemicals. Lower-quality rice in Vietnam is traded in relatively stable markets while aromatic rice, which can command a high price, faces fluctuation in terms of volume and value (General Department of Customs, 2016). In addition, Vietnam's aromatic rice exports are facing stiff competition mainly from Thailand, India and Cambodia. On the marketing side, Vietnam has had its first specific standards for aromatic rice (TCVN 11889:2017) in 2017 (Ministry of Agriculture and Rural Development, 2017) but did not use important trademarks or other signals of quality to distinguish its aromatic rice in international market. In recent years, the Government has intensified its effort at increasing the adoption rate of certified seed (CS), especially of aromatic rice, to improve rice export in terms of quality and value. Certified seed is one of the key factor in producing high quality product given that grain quality is uniform, and the product from pure and right variety gives the characteristics such as aroma and shape that meet product specification. As the market is more developed and consumers' expectation to get products that meet their demand, CS will ensure that the consumers will meet quality products.

This study focused on farmers in the Mekong River Delta (MRD) who grew aromatic rice in winter-spring 2016/17 cropping season. The reasoning for selection the MRD because it is the main rice production area in Vietnam with more than 90% of rice export volume (General Statistic Office, 2016). Among three rice cropping seasons in Vietnam, winter-spring accounts for the largest volume of annual output. This season has favourable weather conditions for the production of high quality paddy taking up 38% of annual rice

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production in the MRD (General Statistic Office, 2017), and is selected for this study. The aromatic rice varieties covered in this study are Jasmine 85, RVT and Nang Hoa 9, which are classified under the Vietnam National Standard on Aromatic Milled Rice (Ministry of Agriculture and Rural Development, 2017). These are also the main aromatic varieties planted in the MRD (Vietnam Food Association, 2016). They have suitable traits for the diverse natural conditions in the MRD, are high-yielding and tolerant to diseases.

The Vietnam Seed Ordinance categorizes seed into four levels, namely breeder seed, pre-basic seed, basic seed and certified seed, classified from highest to lowest grades (National Assembly Standing Committee, 2004). Lower level seed must be propagated from upper-level seed according to the guidelines stipulated by the Ministry of Agriculture and Rural Development (MARD). All Vietnamese and international entities that conduct research, select and breed new plant varieties and produce the seed in the territory of Vietnam are required to meet quality standards prescribed under the National Technical Regulation on Seed Quality of Rice for each seed level (Ministry of Agriculture and Rural Development, 2011). Based on this standard, certified rice seed must meet germination rate $\geqslant 80\%$, foreign matterials e.g. straw, sand, etc. $\leqslant 1\%$, weed grain $\leqslant 10$ grain/kg, moisture content $\leqslant 13.5\%$ and genetic purity or percentage of other variety seed $\leqslant 0.3\%$.

MARD's Department of Crop and Department of Agriculture and Rural Development have responsibilities to test and certify seeds and provide certified seeds through Seed Centres. Consequently, all commercial seeds must be certified by seed centres or organizations authorized by MARD. In the MRD, there are five certification bodies authorized to certify rice seed, namely Southern Seed Centre for Varieties and Crop Products (under the Department of Crop), Southern Seed Corporation, Kien Giang Agriculture, Forestry and Fishery Breeding Centre, Cuu Long Rice Research Institute, and An Giang Plant Protection Joint Stock Company (Loc Troi Company). The last one is the only private entity.

The MARD classifies seed production into two systems: formal and informal. In the formal system, research institutes and universities breed, release new variety, provide genetic materials and provide assistance – in techniques and methods – in varietal tests. Seed centres and extension centres play an important role in training farmers, monitoring, evaluating, certifying and testing new varieties, and marketing seeds. Private companies are the main stakeholder in contract farming with seed growers, grain production and collecting the paddy for the export market. In Vietnam, the informal seed system is also known as "farm-saved seed system" by the Decision-35/2008 (Ministry of Agriculture and Rural Development, 2008). This decision was to legalize and promote individual farmers, farmers' groups, seed clubs and cooperatives for breeding and selecting varieties, producing seed for household use, and exchanging and supplying seed at the district level. Among stakeholders in the informal system, seed clubs have made a significant contribution to multiplying, producing and marketing seeds within the community (Tin *et al*., 2011). Despite many benefits, there remain several constraints for farmers to use certified aromatic rice seed (CARS). These include non-surpassing seed quality, limited supply sources, farmers' own habits of keeping seed and the high price of CS. In line with the goals increasing and sustaining the production of high quality aromatic rice quality and increasing export values for aromatic rice in the MRD, this study aims at 1) identifying factors affecting CARS adoption and 2) determining farmers' willingness to pay (WTP) for CARS.

2. Materials and Methods

Adoption decision model

In the MRD during the winter-spring season, which is the main cropping season for quality rice, farmers generally use only one type of seed. Thus, the adoption decision can be classified into two choices, adopt and non-adopt CARS. The CARS adoption decision can be observed as a binary random variable; thus, the binary choice models are supposed to determine farmers' adoption decision. In previous studies, the logistic and probit models have been widely used to analyze factors affecting adoption of improved technology (Thu, 2014; Tin *et al*., 2011; Dung *et al*., 2015; Feleke and Zegeye, 2006). With the cumulative distribution assumption of ε_n being the logistic form then the binomial logit model is established. These studies report that the demographic characteristics (including age, education level, family size and sex) have a significant influence on adoption of improved varieties. Several other studies have also applied the same model to determine socio-economic characteristics (farm size, off-farm activities and livestock owned) and institutional characteristics (extension services, access to credit, membership in farmers' organization/group, contract farming), which affect the uptake of technology (Gregory *et al*., 2013; Okello *et al*., 2016; Udimal *et al*., 2017; Feleke and Zegeye, 2006).

Farmers' preferences regarding new technology play an important role in adoption (Trang and Napasintuwong, 2016; Ghimire *et al*., 2015). Based on consumer behaviour, when farmers decide to adopt improved or new technology, they expect to receive higher benefits compared to those associated with their existing situation (Ghimire *et al*., 2015). Rogers (2005) suggested that perceived advantage is one of the key factors influencing the adoption of technology. Many farmers still do not perceive substantial price differences between rice produced using uncertified and CS, even as CS is generally more expensive; this became the main constraint to CS adoption (Thu, 2014). Farmers who are informed about the marketability and higher prices of products from CS tend to adopt it faster than non-informed farmers. Farmers' expectations of potential yield also play a fundamental role in adopting a given variety (Langyintuo and Mekuria, 2008). If farmers perceive higher yield potential from a given variety or new technology than from the existing variety, the probability of adoption increases.

Random utility theory is often applied to indicate an individual's decision regarding the choice of an alternative that maximizes the perceived utility in adopting a technology (Train, 2009). However, the utility cannot be directly observed, as it is composed of a deterministic component, which can be expressed in terms of individual characteristics and a stochastic error term (ε). The utility

can be written as a linear random utility model, as in equation (1):

$$U_i = \beta_i X_i + \varepsilon_i \quad (1)$$

Where β_i are the parameters and X_i is the vector of individual characteristics.

We denote the utility of the individual adoption by U_{iA} and the utility of non-adoption by U_{iN} (equation 2):

$$U_{iA} = \beta_{iA} X_i + \varepsilon_{iA} \text{ and } U_{iN} = \beta_{iN} X_i + \varepsilon_{iN} \quad (2)$$

Where the individual will adopt if $U_{iA} > U_{iN}$ and will not adopt if $U_{iA} \leqslant U_{iN}$. The difference between the utility of adopters and non-adopters of CARS is called y* (equation 3):

$$y^* = U_{iA} - U_{iN} = (\beta_{iA} X_i + \varepsilon_{iA}) - (\beta_{iN} X_i + \varepsilon_{iN})$$
$$= (\beta_{iA} - \beta_{iN}) X_i + (\varepsilon_{iA} - \varepsilon_{iN}) = \beta X_i + \varepsilon \quad (3)$$

We cannot observe net utility, only whether it is made or not. Therefore, the observation is:

$y = 1$ if $y^* > 0$, $y = 0$ if $y^* \leqslant 0$

Pr ($y = 1$) = Prob ($y^* > 0$) = Prob ($\beta X_i + \varepsilon > 0$)=Prob ($\varepsilon > -\beta X_i$)

If ε is assumed to have a symmetric distribution, then:

Prob ($\varepsilon > -\beta X_i$) = Prob ($\varepsilon < \beta X_i$) = $F(\beta X_i)$

Hence, equation (4):

$$\text{Prob}(y = 1|X) = F(X, \beta) \text{ and}$$
$$\text{Prob}(y = 0|X) = 1 - F(X, \beta) \quad (4)$$

Where F(.) is the cumulative distribution function of the random variable, ε.

In this study, assume that the cumulative distribution of ε is the logistic form, then equation (5):

$$\text{Prob}(y = 1|X) = \frac{\exp(\beta X_i)}{1 + \exp(\beta X_i)} = \wedge(\beta X_i) \quad (5)$$

Where Λ(.) indicates the logistic cumulative distribution function.

Marginal Effect

The marginal effect of a predictor is defined as the partial derivative of the event probability with respect to the predictor of interest. A more direct measure is the change in predicted probability for a unit change in the predictor.

The probability model is a regression: Prob (y|X) = $F(\beta X_i)$

For the logistic distribution, the marginal effect is:

$$\frac{\text{Prob}(y = 1|X)}{\partial X} = \wedge(\beta X_i)[1 - \wedge(\beta X_i)] \cdot \beta \quad (6)$$

The variables used in the adoption model are listed in Table 1.

In the MRD, farmers who grow aromatic rice for commercial reasons were hypothesized to adopt CS. There were several government programs promoting the production of aromatic rice in place of normal lower quality rice. At the same time, rice exporting companies also initiated the contracts with farmers to obtain specific varieties and quality of rice; these companies often provide CS to farmers. Thus, farmers' contracts with millers or exporters were hypothesised to be one of the factors affecting the CS adoption. Furthermore, large field model in Vietnam was launched in the MRD in 2010 (Thang *et al*., 2017). The model is also known as small farms large field. The aim of large field model was

Table 1: Variables in the logistic model

Context	Description
Dependent variable	1= use certified aromatic rice seed, provided by a formal seed system that has met quality standards required by National Technical Regulation on Seed Quality of Rice; 0 = use uncertified aromatic rice seed, provided by an informal seed system that has not met quality standards required by National Technical Regulation on Seed Quality of Rice.
Independent variables	
Age	Age of the household head (years)
Education	Schooling of household head (years)
Labour	Number of family members working on rice farming (persons)
Aromatic rice experience	Number of years growing aromatic rice (years)
Cooperative	Farmer's membership in a cooperative (1: yes, 0: no)
Large Farm Field	Farmer's large farm field membership (1: yes, 0: no)
Contract	Farmer participates in company contract (1: yes, 0: no)
Availability of CARS	Availability of certified aromatic rice seed in the last three years (1: always, 0: otherwise)
Afford to purchase CARS	Farmer could afford to purchase enough certified aromatic rice seed for the total aromatic rice cultivation area in the last three years (1: always, 0: otherwise)
Area	Size of aromatic rice plot (ha)
Seed rate	Amount of aromatic rice seed used (kg/ha)
Perception of profit	Farmer perceives profit from using certified seed is higher than that from using uncertified seed (1 = agree, 0 = otherwise)
Perception of purity	Farmer perceives purity of certified seed is higher than that of uncertified seed (1 = agree, 0 = otherwise)
Perception of germination	Farmer perceives germination of certified seed is higher than that of uncertified seed (1 = agree, 0 = otherwise)

to established high quality rice production and was an important policy in promoting the application of new agricultural technologies. Although generally there is no specific size of farm to be considered ''large'' under this model, large field model supports the development of commodities associations, and cooperation between enterprises, research scientists, and farmers (Thang *et al.*, 2017). Along with the large field model, participation in agricultural cooperatives also play significant role in input procurement including quality seed.

Farmers' access to seed such as availability of CARS, and their affordability to purchase CARS in the last three years reflect whether their adoption is limited by seed system such as dissemination and pricing. That farmers' perceptions on CARS reflect their attitudes on aspects related to superiority and benefits of CARS was also hypothesised as having an influence on adoption.

Willingness to pay for certified aromatic rice seed

One of the reasons that farmers did not adopt CARS could be the affordability or that the market price of CARS may be higher than their willingness to pay (WTP). Of the total 306 respondents, only farmers who did not adopt CARS in winter–spring 2016/17 (n=73) were selected to elicit their WTP for CARS in the next crop. In this study, the decision to adopt could be expressed in terms of WTP for CARS. Price of all certified and un-CARS in the market were obtained from websites of seed companies, quotations from seed centres and seed clubs, and from other secondary data sources to pre-test the ranges of WTP. The pre-test was conducted in September 2017. To ensure that the bid price to elicit the farmers' WTP is suitable, bid prices were based on the actual market prices of CARS during winter-spring 2017/18. The hypothetical price bid P* was set up between the un-CARS and CARS price in the market. The interviewer selected the reference aromatic rice variety (Jasmine 85, Nang Hoa 9 or RVT) based on the variety that is commonly grown in the province; to ensure that farmers understand the same variety, the characteristics and tolerance traits of the reference variety were explained. The actual average CARS price of Jasmine 85, Nang Hoa 9, and RVT was about 15,000 VND[3]/kg and that of the un-CARS price of the same varieties was about 8,500 VND/kg. The hypothetical bid price, P*, was randomly drawn by the interviewer from tickets between the approximate market prices of certified (15,000 VND/kg) and un-CS (8,500 VND/kg) at 500 VND/kg interval and given to farmers. Each farmer was asked to elicit their WTP for CARS given a single bid price. ''If the price of CS of Jasmine 85 (or Nang Hoa 9 or RVT) in winter–spring 2017/18 is P* VND/kg, are you willing to pay for CS of Jasmine 85 (or Nang Hoa 9 or RVT)?'' There are two possible responses.

$$\mathrm{Y_i}(Yes) = WTP \geq P^* \text{ and } \mathrm{Y_i}(No) = WTP < P^* \quad (7)$$

If the answer is Yes, it means the price farmers are WTP for CS of Jasmine 85 (or Nang Hoa 9 or RVT) was from the bid being asked for CARS price in the market. If the answer is No, it means the price that farmers are WTP for CS of Jasmine 85 (or Nang Hoa 9 or RVT) was lower than the bid price being asked. This follow-up question was then asked: ''What specific maximum price are you willing to pay for CARS in winter–spring 2017/18?'' The response indicates the farmer's WTP. To check whether the information about CARS standard affect the WTP, the specified maximum price question was repeated after the interviewer had provided more information about CARS such as germination rate ($\geqslant$80%), foreign materials ($\leqslant$1%), weed grain ($\leqslant$10 grain/kg), moisture ($\leqslant$13.5%) and genetic purity or percentage of other variety seed ($\leqslant$0.3%) based on the standard of National Technical Regulation on Seed Quality of Rice.

[3] Prices of seed were collected from July to December 2017; Approximately 1 USD = 23,099 VND, 1 euro = 27,305 VND, and 1 GBP = 30,654 VND according to the State Bank of Vietnam.

Data collection and sampling

A farm survey of 306 farmers growing aromatic rice was conducted in the MRD using face-to-face interviews and a multi-stage random sampling procedure in winter–spring 2016/17. In the first stage, from the total area of 381,386 ha in the 13 provinces in the MRD, the provinces with the highest adoption rate of each of the aromatic rice varieties in winter–spring 2016/17 were selected, namely, Soc Trang for RVT (76,578 ha), Kien Giang for Jasmine 85 (54,533 ha) and Tien Giang for Nang Hoa 9 (15,880 ha). These three provinces had about 40% of the total aromatic rice area in the MRD (Kien Giang Department of Agriculture and Rural Development, 2017; Soc Trang Department of Agriculture and Rural Development, 2017; Tien Giang Department of Agriculture and Rural Development, 2017). In the second stage, districts were stratified by their CARS adoption rate, as provided by the Department of Agriculture and Rural Development of each province. One district was selected with a high adoption (higher than the average rate of the province) of CARS and another was selected with a low adoption (lower than the average rate of the province) of CARS. In total, 306 farmers were selected randomly from six selected districts in three provinces including Kien Giang (Giong Rieng and Chau Thanh districts), Soc Trang (Nga Nam and Tran De districts) and Tien Giang (Go Cong Tay and Go Cong Dong districts) based on the list prepared by the head of each village. For farmers who cultivated aromatic rice in more than one plot, the largest plot of the same variety and same type of seed was selected. For those who produced different aromatic rice varieties and/or use different types of seed, the largest plot of each variety and of each type of seed were selected. There were 309 plots in total.

3. Results and Discussion

Socioeconomic and characteristics of aromatic rice farmer

The CARS adopters and non-adopters were generally similar in terms of age, education, ethnicity, agricultural work, number of household members and rice experience (Table 2).

Support provided by agricultural supply shops has enabled farmers to purchase inputs for the crop and make pre-payments, so that only 30% of the respondents had to apply for a loan. On average, the amount of loan was noticeably much larger among non-adopters.

Table 2: Demographics of aromatic rice farmers, Mekong River Delta, winter–spring 2016/17

Item		Unit	CARS Adopters	Non-CARS Adopters	Total	
Head_age		Year	52.21 ± 10.71	52.77 ± 10.81	52.35 ± 10.72	ns
Head_sex	Female	%	0.05	0.10	0.06	
	Male		0.95	0.90	0.94	
Head_education		Year	7.12 ± 3.46	6.04 ± 3.41	6.87 ± 3.47	**
Ethnicity	Kinh	%	0.85	0.73	0.82	
	Hoa		0.01	0.01	0.01	
	Khmer		0.14	0.26	0.17	
Head_job	Agri	%	0.91	0.93	0.92	
	Other		0.09	0.07	0.08	
Loan	Yes	%	28.39	36.99	30.42	
	No		71.61	63.01	69.58	
	Amount	Mil.VND	59.79	180.07	94.34	
Labour	Household	Person	2.47 ± 1.00	2.66 ± 1.19	2.52 ± 1.05	ns
	Male		1.39 ± 0.68	1.58 ± 0.80	1.44 ± 0.71	*
	Female		1.08 ± 0.66	1.08 ± 0.75	1.08 ± 0.68	ns
Rice experience		Year	27.58 ± 11.27	29.18 ± 12.01	27.96 ± 11.45	ns
Aroma rice experience		Year	10.05 ± 6.74	10.92 ± 6.50	10.25 ± 6.68	ns
Number of observations			**233**	**73**	**306**	

Data are shown as mean ± standard deviation.
**,* Significant difference at 5% and 10% confident level, respectively; ns non-significant between two groups using a t-test.

Table 3: Aromatic rice farming characteristics, Mekong River Delta, winter–spring 2016/17

Items	Unit	CARS Adopters	Non-CARS Adopters	Total	
		Mean	Mean	Mean	
Total area	ha	2.59 ± 4.67	3.46 ± 2.59	2.80 ± 4.28	ns
Rice area	ha	2.44 ± 4.60	3.34 ± 2.55	2.65 ± 4.22	ns
Rice plot	plot	1.83 ± 1.23	2.64 ± 2.16	2.03 ± 1.54	***
Aroma area	ha	2.27 ± 3.80	3.25 ± 2.49	2.50 ± 3.55	**
Aroma rice plot	plot	1.78 ± 1.22	2.56 ± 2.14	1.96 ± 1.52	***
Largest aromatic rice plot	ha	1.55 ± 1.97(1)	2.27 ± 1.71(2)	1.72 ± 1.93(3)	***
Number of observations		**233**	**73**	**306**	

Data are shown as mean ± standard deviation. Number of observations (n): (1)n=236; (2)n=73; (3)n=309.
***, ** Significant difference at 1% and 5% confident level, respectively; ns non-significant between two groups using a t-test.

This loan reflect for all agricultural activities. Non CARS adopters may be engaged in other crops and aquaculture which require higher investment. Most respondents had a formal education to secondary school because younger rural residents with higher education mostly had left to find non-agricultural jobs in the cities. In rural areas, agriculture is the primary source of employment: 90% of respondents are working in agriculture, the rest are employed as local officers, teachers, civil servants and other jobs. The labour supply of each household averaged from two to three people with more males than females engaged in agricultural activities. Nowadays, most farmers utilize machinery in most the stages of rice production so that labour is no longer much of a constraint as it had been in past decades. Some activities however such as weeding, post-sowing and spraying chemicals or applying fertilizers remain labour- intensive. The MRD is considered as the main rice region in Vietnam so many farmers have been growing rice there for nearly 30 years, while aromatic rice varieties (such as Jasmine 85, VD20, RVT and Nang Hoa 9) have only been popular for around 15 years (since 2004). However, the number of years growing aromatic rice also was not significantly different between the adopter and non-adopter groups.

The characteristics of aromatic rice farming are reported in Table 3. The total agricultural area is larger than total rice area which is also larger than the total aromatic rice area, implying that generally farmers who grow aromatic rice also cultivate other types of rice and engage in other agricultural activities. From the selected largest plots of the same aromatic rice variety using the same seed type (representative area), there were 309 plots of aromatic rice. The size of aromatic rice plot cultivated using CARS was significantly smaller than that of non-CARS plots. Furthermore, area is expected to have considerable impact on CARS adoption because the larger the area a farmer has, the higher the input investment required, especially seed (Chi, 2002).

The main varieties grown in winter–spring 2016/17 included Jasmine 85, Nang Hoa 9 and RVT with shares of 33.3%, 27.5%, and 25.9%, respectively. In the formal seed system, the seed centre is considered as the main supplier of CS. However, in the 236 plots under CARS, the percentage of farmers buying the seed directly from seed centres was only 3%; most farmers bought CARS from private companies (65% from seed company's shop and 30% from input retail shop) (Figure 1). The majority of non-adopters kept the seeds (73 plots) and only 18% bought or exchanged seeds with their

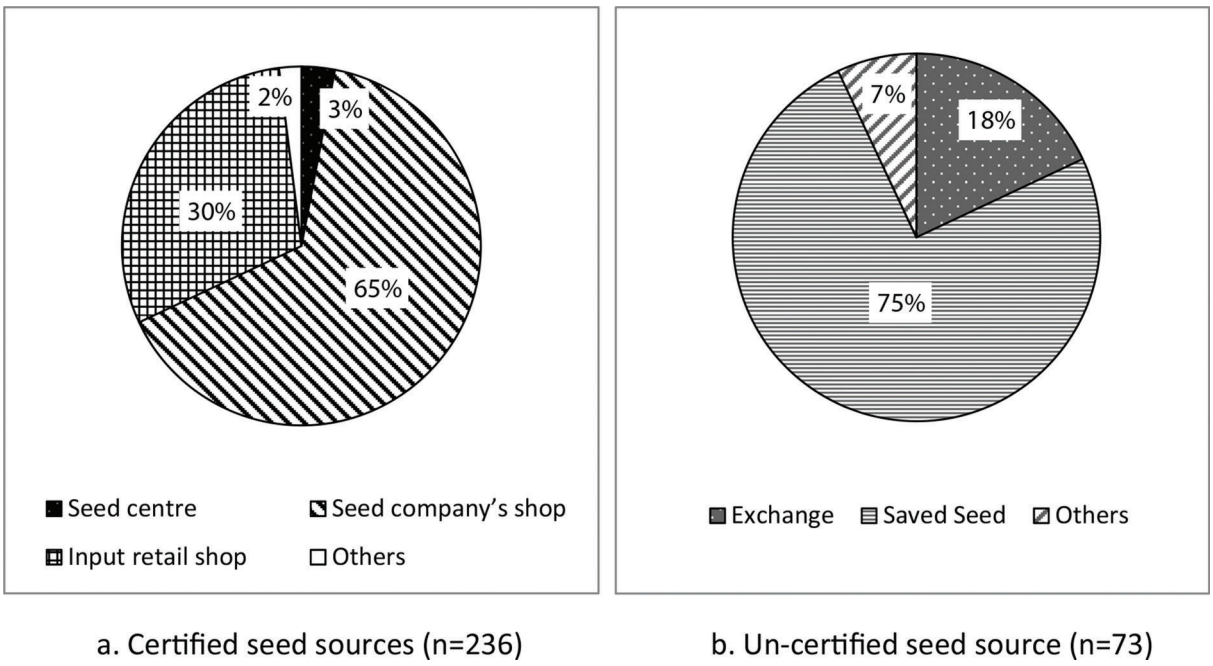

Figure 1: Sources of certified and uncertified aromatic rice seed, Mekong River Delta, winter–spring 2016/17

neighbors. Most of the farmers did not believe in other seed producers or other farmers so they would buy basic seed to produce on their own small area for the next season. The non-adopters of CARS self-produced seed and used it for the next two crops, whereas the CARS adopters purchased seeds for every crop from CS suppliers.

All CARS adopters and some non-adopters who reported changing seed during the survey season (253 farmers) were asked for the reason that they want to change the seed (buying CS) was determined by asking the question "Why do you want to replace the seed?" A farmer could select one or more of the answers, including starting to have disease problems, high growth of weeds and contamination, wanting to grow new variety, and other reasons. The main reason the farmers cited for changing the seed was to reduce the weed rate; 44.7% of the farmers agreed with that statement. This is because weed is one of the common problems of uncertified rice seed. The CS offers farmers with cleanliness ($\leqslant$1% of foreign materials), and the weed grains must be less than 10 grains per kilogramme (National Technical Regulation on Seed Quality of Rice, 2011). Changing the seed to improve tolerance to diseases and to change the variety were mentioned by 37.9% and 19.8%, respectively. Specifically, farmers believed that if they kept the seed for many crops without good field inspection, their rice field would be more susceptible to disease and there would be more weeds in the next crop (Figure 2).

Factors affecting certified aromatic rice seed use

The coefficient estimates from the logistic adoption model and their marginal effects are shown in Table 4. All independent variables were tested for correlation and reported no multicollinearity problem (less than 0.35) (Hinkle *et al.*, 2003). There were seven factors with a significant influence on the probability of adopting CARS. Availability of CARS, membership in social organizations, and perceived difference in profitability were positively related to the probability of adopting CARS, while the seed rate and area factors reduced the probability of CARS adoption.

Being a member of a social organization, specifically cooperatives, large farm field program, contract farming with private companies had a positive effect on CARS use. Organizations were expected to provide training courses, facilitate exchange of knowledge and make farmers more aware and gain a better understanding of the benefits of using CARS. These results imply that if farmers perceive that CARS provide a greater profit, the probability of using CARS increases. The positive influence of perception on profitability advantage was also found by Chi (2002) in a farming systems context. The marginal effect indicated that farmers were 16.80% more likely to use CARS in rice cultivation compared to un-CARS when they believed that CARS would provide greater benefit according to the logit model. Similarly, farmers are more likely to adopt CARS if CARS were always available when farmers wanted to use it. In Vietnam, the current rice seed system allows un-CS to be exchanged and distributed in local areas e.g. within the commune of the seed farms. Only CS is legally permitted for commercial purpose. In Thailand, for example, quality declared seed is used in rice seed system so private seed companies only need to ensure that commercial seed has met minimum standards (Napasintuwong, 2018), and need not be certified by the government or certification body. Chaowakul (2016) also suggested that a more efficient way to ensure quality seed is the certification at field level. Due to the high cost of a certification system (about 120 USD for one seed batch)[4], options of quality declared seed system similar to Thailand could provide greater access to quality seed by allowing allow private seed companies to take a

[4] The cost of field certification is 1,500,000 VND/field less than 5 ha plus sample collection fee of 780,000 VND/2 samples plus lab test of 600,000 VND/all 5 certified seed standards.

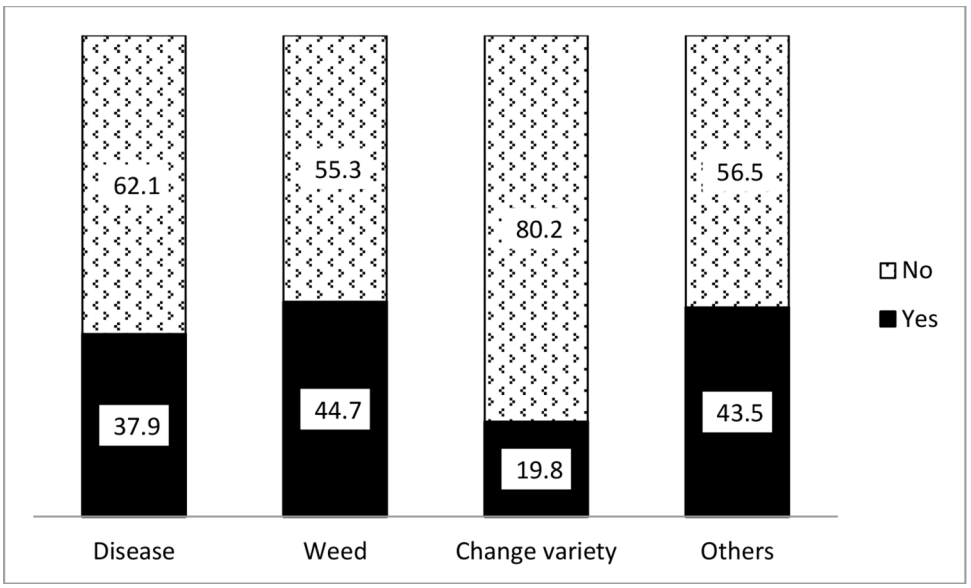

Figure 2: Reasons for replacing aromatic rice seed, Mekong River Delta, winter–spring 2016/17 (n=253)

Table 4: Coefficient estimates and marginal effects of certified aromatic rice seed adoption, Mekong River Delta, winter–spring 2016/17

Variable	Coefficient		Marginal Effect	
Age	-0.0126		-0.0015	
Education	0.0164		0.0020	
Labour	-0.1382		-0.0169	
Aromatic rice experience	-0.0165		-0.0020	
Cooperative	0.7357	*	0.0797	**
Large Farm Field	0.9286	**	0.1002	**
Contract	1.6729	**	0.1541	***
Availability of CARS	1.1510	**	0.1846	**
Afford to purchase CARS	0.5086		0.0696	
Area of aromatic rice plot	-0.1561	**	-0.0191	**
Seed Rate	-0.0202	***	-0.0025	***
Perception of profit	1.2110	***	0.1680	***
Perception of purity	0.7217		0.1081	
Perception of germination	0.0719		0.0089	
Constant	2.3120			
Number of observations	309			
LR chi2(13)	91.27			
Prob > chi2	< 0.0001			
Log likelihood	-123.2995			
Pseudo R^2	0.2701			

Note: *, **, *** statistic is significant at 10%, 5% and 1% level, respectively.

greater role in producing and marketing of quality seed. Furthermore, authorized local farmers associations capable of certifying rice seed could take on responsibility of seed certification especially for aromatic rice varieties suitable to specific local areas to provide the right variety seed at the right time for farmers. This finding is similar that of Ghimire *et al*., (2015), who found that the adoption of new and improved rice varieties is positively influenced by the availability of and farmers' easy access to seeds in local stores.

In contrast, the higher is the rate of seed use, the lower is the probability of adopting CARS. The probability of a farmer using CS went down when the seed rate increased by one kilogramme per hectare. This might have been associated with the higher production cost from a higher seed rate, especially as the price of CS was higher, which farmers perceived as a major cost disadvantage (Thu, 2014). The results also showed that some farmers with large areas of aromatic rice were less likely to adopt CARS in the winter-spring season; the probability of adoption dropped by 1.91%. The average market price of CARS was nearly twice the price of un-CARS during the time of interview (about 15,000 VND/kg vs 8,500 VND/kg). Generally seed takes only about 22% of cash cost of rice production in the MRD (Liese *et al*., 2014), but by adopting CARS the cost of seed can be a significant investment for farmers. In the adoption model, the seed rate and size of plot was from the largest aromatic rice plot of each seed type of each variety, it shows that farmers intended to use CS for smaller plots, but may use un-CS for the larger plots.

Table 5: Willingness to pay for certified aromatic rice seed, Mekong River Delta, winter–spring 2017/18

Variety	WTP (1,000 VND/ha)	Mean	STD	Max	Min	P-value
Jasmine 85 (n=35)	Without information	11,629	1,725	16,000	9,000	0.811 ^{ns}
	With information	11,729	1,767	16,500	9,000	
RVT (n=30)	Without information	12,200	2,490	16,000	8,000	0.715 ^{ns}
	With information	12,433	2,431	16,000	8,500	
Other (n=8)	Without information	12,750	2,171	15,000	9,000	1.000 ^{ns}
	With information	12,750	2,171	15,000	9,000	
Total (n=73)	**Without information**	**11,986**	**2,123**	**16,000**	**8,000**	**0.682** ^{ns}
	With information	**12,130**	**2,115**	**16,500**	**8,500**	

Farmers' willingness to pay for certified aromatic rice seed in winter–spring 2017/18

Of the 309 aromatic rice growers, 73 did not use CARS in winter–spring 2016/17. Of these non-CARS adopters, 67% reported WTP for CARS in the next crop. The rest accepted the lower bid price. The results in Table 5 show that farmers' WTP for Jasmine 85 was lower than for the RVT variety because Jasmine 85 is a popular variety in the MRD. Its popularity owes to the diversified seed suppliers and a lower price than for RVT, which has fewer seed suppliers. In general, the WTP for CARS was 11,986 VND/kg. This WTP price lies between the recent market price of CARS (14,337 VND/kg) and un-CARS (8,941 VND/kg) prices paid in the previous winter–spring. However, after farmers gained more information on CARS, based on the certified rice seed standard, the WTP increased from 11,986 to 12,130 VND/kg. Nevertheless, the WTP for CARS is significantly below the current market price. This implies that farmers may not have enough information about the CARS quality and may not sufficiently perceive the benefits associated with seed quality such as higher grain quality from higher genetic purity and lower cost from lower weeding. Trust in seed certification system may be another possible reason for non adoption; they would be relulctant to use CARS if they did not believe that CARS is a better quality seed than the un-CARS and give higher benefits that can compensate for its higher price. To increase CARS adoption, it is important to increase farmers' awareness, knowledge and understanding of the essential attributes of good quality seed and benefits of using CS especially those that have a strong influence on their WTP. In addition, if the price of CS is higher than what farmers can afford, lowering the cost of producing and certifying the seeds can significantly contribute to promoting the adoption of CARS. To increase CARS adoption, it is important to increase farmers' awareness and knowledge of the quality and benefits of using CS. In addition, for those who are not at present adopting CS, seed price is the main factor in deciding whether they are willing to use CS. Access to quality seed with affordable price is another key factor in promoting the adoption of CARS.

4. Conclusion

A growing consumer preference for aromatic rice is happening in the world market. To meet the expected increase in demand for aromatic rice and compete better in the export market, Vietnam's policy to encourage quality aromatic rice production is being vigorously promoted. The policy includes, among others, measures that encourage farmers to adopt good varieties and use CARS, which would ensure quality and uniformity of rice products. To compete with other aromatic rice exporters, Vietnam must consider its options for improving rice quality; expanding the use of CARS is an essential condition for high-quality rice production. The results revealed that CARS adopters purchased CS mainly from seed companies (65%) while 75% of the farmers who are un-CARS users used their own seed. The findings from the CARS adoption model suggest that seed rate, area planted to aromatic rice, membership in social organizations, positive perception of comparative profitability, and availability of CS have influenced farmer's adoption of CARS. By reducing the amount of seed used, farmers can save on costs and likely have a higher return, resulting in a greater probability of adopting CARS. This is consistent with current government policy to reduce the costs of production by using the optimal seed rate and high-quality seed (Ministry of Agriculture and Rural Development, 2016). Availability of quality seed was one of the biggest factors mentioned in previous studies and was supported by our results. Many farmers who were not able to access CARS at the appropriate time and those with a greater rice cultivation area tended not to adopt CARS in order to save costs. By using the elicit method, it was revealed that the WTP for CARS was 11,986 VND/kg, which was lower than the current market price of CARS.

Our results also suggest that policies should move towards delivering quality seed to guarantee its availability at an affordable price so that farmers can obtain their seed in time and easily. The relevant information on CS standards should be shared with farmers to make them aware and clearly understand the benefits from adopting CARS. The results also show that farmers who joined social organizations were more likely to adopt CARS. Provided that farmers are willing to pay higher for CARS after they are informed about the quality and other positive attributes, it is important to educate farmers on the benefits of using CARS. It would be more efficient to provide the extension messages through farmers' organizations. The findings from the adoption model also confirm that farmers' perception of a relatively higher profitabilty increases the adoption of CARS.

This study is limited to three varieties of aromatic rice and the selected plot is the largest plot of the household. Future study may consider broaden the scope to include other types of rice and all rice plots which may yield different results. In addition, the study did not reveal whether cost of adopting CS is compensated by the increasing benefits; the evidence of benefit cost comparison between CARS and un-CARS will add key information for policy maker in future promotion of CARS.

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