Research article

The Current Status of Cassava Producers and Healthy Cassava Seed Production and Distribution Trial in Vietnam

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Abstract This study discusses the current status of cassava producers in Vietnam, the demand for healthy cassava seeds, and the potential for a healthy seed production and distribution system. Owing to the recent spread of Sri Lankan Cassava Mosaic Disease in South East Asia, the government-led agricultural extension system and the informal cassava production and distribution system in Vietnam have sought a "health" seed production system. To improve the existing system and contribute to sustainable cassava production in Vietnam, we conducted interviews using a structured questionnaire in Dong Nai, Gia Lai, and Tay Ninh provinces from April to December 2017 and received responses from 182 cassava producers. The results show that the majority of cassava producers rely on this crop for their income. Therefore, they are interested in purchasing healthy seeds, and their willingness to pay is statistically significantly higher than the purchasing price in all three provinces. Based on the results and the existing cassava production and distribution system in Dong Nai, this project instituted a monitoring system, polymerase chain reaction testing, and a healthy seed certification system. This study found that seed producers face several difficulties, including implementing a monitoring and management system. Thus, there is potential for establishing a healthy cassava seed production and distribution system in Vietnam.

Keywords cassava, seed production and distribution, Vietnam, willingness to pay

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of Vietnam's three most important food crops, with 532,600 ha of cultivated area, an annual average yield of 18.8 tons per ha, and fresh root production exceeding 10.27 million tons (GSO, 2018). Cassava is grown in as many as 40 of the country's 63 provinces. Vietnam ranks seventh in cassava production in the world (FAO, 2020).

The Sri Lankan Cassava Mosaic Disease (SLCMD) was first reported in Cambodia in 2015 (Wang et al., 2016) and was then found in Tay Ninh in 2018 (Uke et al., 2018). Since then, Vietnamese cassava producers have faced substantial challenges, as the disease drastically decreases cassava yields (Fargette et al., 1988; Fauquet and Fargette, 1990; Makeshkumar, 2016). According to Vietnam's Plant Protection Research Institute, the estimated annual cassava yield loss will be between 12.7 percent and 34.6 percent. The starch content is expected to decrease by 1.02 percent to 18.97 percent. SLCMD has spread rapidly using whiteflies as a vector; it is also spread through infected stem distribution as cassava can be quickly propagated from stems, which are transported as "seed" to multiple locations.

In Ratanakiri and Battambang provinces in Cambodia and Dak Lak and Tay Ninh provinces in Vietnam, informal and self-regulated seed distribution systems are managed by private producers and traders (Delaquis et al., 2018). Although these systems appear to work well in normal situations, once the stems are infected with SLCMD, the disease can rapidly spread through human factors, such as traders and transporters, who distribute cassava seeds over a wide range.

In Vietnam, it is essential to understand the current production and stem movement situation, including the socio-economic condition of cassava producers, to discuss the possibility of healthy seeds. The seeds are considered healthy if they are not detected positive for SLCMD in the polymerase chain reaction (PCR) testing. Thus, production and distribution should be carried out through the market mechanism.

Vietnam has a public extension system founded in 1993, organized into five levels—central, provincial, district, commune, and village or hamlet. All 63 provinces have their own extension centers (Tokunaga et al., 2018). Furthermore, an official cassava seed production and distribution system exist in addition to the informal, self-regulated distribution system. As part of the official system, the Hung Loc Agricultural Research Center (HLARC) in Dong Nai province in southern Vietnam breeds, produces and distributes cassava varieties. Private producers under HLARC propagate and distribute these stems among "general producers" who primarily cultivate cassava for its roots and potential buyers of healthy cassava seeds in the province. This system, however, has no monitoring methods, nor does it employ PCR testing or have any certification. Hence, there is a potential risk of the distributed stems becoming contaminated with viruses or phytoplasma, further spreading the disease.

Therefore, since 2016, we have been executing a project titled "Development and Dissemination of a Sustainable Production System Based on Invasive Pest Management of Cassava in Vietnam, Cambodia, and Thailand," supported by the Japan Science and Technology Agency and the Japan International Cooperation Agency. This project aims to improve the current cassava seed production and distribution system centered at HLARC and establish a sustainable production system that uses healthy seeds. This system can be established by developing a market-based dissemination model that supports the private sector, producers, and the government and devising a management system for invasive cassava diseases and pests. To improve the system, it is essential to first identify cassava producers' seed preferences, their demand for healthy cassava seeds, and the current situation of cassava production. However, sufficient information is not yet available.

OBJECTIVE

This study aims to discuss the current status of cassava producers and stem distribution in southern Vietnam, including their cassava seed preferences. Further, the potentiality of a healthy cassava seed production and distribution system is also discussed, and producers' willingness to pay (WTP) for healthy seeds is estimated. Finally, the improved cassava seed production and distribution system developed by the project is explained, and challenges are discussed.

MATERIAL AND METHODS

Study Site

A series of semi-structured interviews based on a questionnaire was conducted in southern Vietnam's Dong Nai, Gia Lai, and Tay Ninh provinces (Fig. 1) from April to December 2017. First, we checked the government census database and contacted local government offices to determine the cassava producer population of the provinces; however, we discovered it to be fluctuating. However, the purpose of the study was to capture the potential for seed production, the selection of seed farmers, and willingness to pay. Thus, we used purposive sampling with equal selection based on cassava plantation area to categorize the respondents into three groups: less than 1 ha, between 1 ha and less than 5 ha, and more than 5 ha. As a result, the total number of respondents was 182—60 in Dong Nai, 61 in Gia Lai, and 61 in Tay Ninh.

The three provinces mentioned above are the primary cassava cultivation areas in Vietnam (GSO, 2018). Tay Ninh and Gia Lai have the largest (64,800 ha) and second-largest (61,600 ha) cassava production areas among all provinces and produce 2,024,000 tons and 1,207,100 tons, respectively. Dong Nai stands at the 10th position among the country's 58 provinces and contains five municipalities with 15,700 ha of cassava production area and 399,700 tons of production. The main cassava production center in Dong Nai is the Xuan Loc district, and in Tay Ninh, it is the Tan Chau district. In Gia Lai, the Dak Po and Krong Pa districts are the two leading cassava production centers. Therefore, these locations were chosen for surveying.

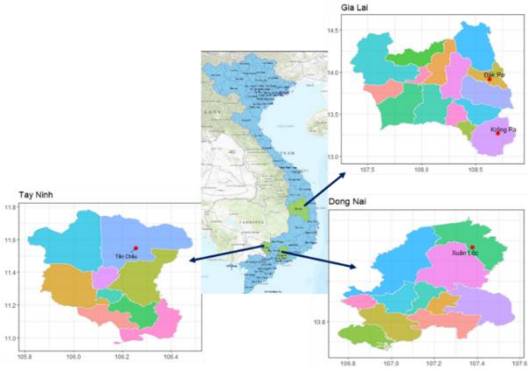

Fig. 1 Survey areas in Vietnam

Theoretical Model

The concept of WTP is derived from the Hicksian welfare measure of compensating variation (CV). The CV measure asks what compensating payment or offsetting change in income is necessary to make an individual indifferent to an increase in price. This is often interpreted as the new price set. The concept can be illustrated by following the standard economic theory of indirect utility function (Bateman et al., 2002), which can be written in the general form:

$$V = (Y, P, Q) \tag{1}$$

where (V) describes the economic wellbeing or maximum amount of utility a respondent can derive from their income (Y), given the prices of goods they face (P) and the level of environmental quality (in this case, getting healthy, clean seeds not infected by pests or disease $[Q]$). WTP is defined as the amount that must be taken away from a person's income while keeping this utility constant:

$$V\ (Y - WTP, P, Q_1) = V(Y, P, Q_0) \tag{2}$$

where (Q_0) and (Q_1) are the alternative levels of the good or quality indexes ($Q_1 > Q_0$, indicating that (Q_1) refers to improved environmental quality).

The WTP was estimated following Mitchell and Carson (1981, 1984), and the payment card method of contingent valuation was used to estimate the WTP for healthy seeds. Producers were asked how much they would be willing to pay to obtain a certified healthy cassava seed.

However, an open-ended payment card CVM question can generate a high number of zero responses (Green et al., 1998). In that case, the distribution of WTP could be censored by the left to a zero value. To address this, Halstead et al. (1991) recommended using the Tobit regression model as the more theoretically correct econometric model for the open-ended CVM format.

The Tobit regression model considers both the censored and continuous observations in the process of estimation. Following Kim and Cho (2002), the Tobit regression model can be expressed by:

$$WTP_i^{Tobit} = X_i'\beta + e_i \tag{3}$$

where WTP_i^{Tobit} is the unobserved continuous dependent variable; $X_i^{'}$ is a vector of explanatory variables; β is a vector of coefficients; e_i is an independently distributed error term, assumed to be

normal with zero mean and constant variance σ^2; and i $= 1, 2, \ldots, n$ denotes individuals in the sample. The observed WTP variable is given by:

$$WTP_i = \begin{cases} X_i'\beta + e_{i.} & if\ WTP_i^{Tobit} > 0 \\ 0 & if\ WTP_i^{Tobit} \leq 0 \end{cases} \quad (4)$$

Empirical Model and Hypothesis

The Tobit regression model can be expanded to include the socio-economic variables being hypothesized to influence producers' willingness to pay for healthy cassava seeds ($WTP_{healthyseedling}$). The empirical model is presented in the following:

$$WTP_{healthyseedling}^{Tobit} = \beta_0 + \beta_1 gender + \beta_2 TayNinh + \beta_3 GiaLai + \beta_4 tocaha + \beta_5 fulltime + \beta_6 experience + \beta_7 catimes + \beta_8 camain + \beta_9 labor + \beta_{10} dactualpurchase + \beta_{11} dwillingness + \beta_{12} dstemsupplier + e_i \quad (5)$$

where the dependent and independent variables are defined in Table 1, $\beta_0\ to\ \beta_{12}$ are coefficients, and e_i is the error term $\sim N\ (0, \sigma^2)$.

The study hypothesizes that older producers, experienced producers, producers with larger land areas devoted to cassava, producers with more family members engaged in cassava production, and producers who would like to be healthy seed producers will have higher $WTP_{healthyseedling}$.

RESULTS AND DISCUSSION

Status of Cassava Producers in Southern Vietnam

Table 1 shows the socio-economic situation of the respondents. Among the cassava producers surveyed, 86 percent were men and the rest were women; the average age of the respondents was 48.63 years. Their total cassava plantation area was 2.90 ha. Sixty percent of the respondents were full-time producers and had an average of 23.82 years of general farming experience. They had planted cassava 11.43 times on average, and 63 percent of them cited cassava production as their main source of income.

Table 1 Descriptive summary

Variables		Mean	Std. dev.	Min.	Max.
gender	(1=male, 0=female)	0.86	0.35	0	1
age	(years)	48.63	10.48	23	70
DonNai	Province (Don Nai=1, otherwise=0)	2.01	0.82	1	3
TayNin	Province (Tay Nin=1, otherwise=0)				
GiaLai	Province (Gia Lai=1, otherwise=0)				
tocaha	Total cassava cultivated area (ha)	2.90	2.55	0.4	17
fulltime	General farm working status (1=full time, 0=part time)	0.60	0.49	0	1
experience	Years of farming experience (years)	23.82	9.67	2	50
catimes	Number of cassava plantings done before 2016/2017 cycle (times)	11.43	6.38	0	31
camain	Cassava as main income source (1=yes, 0=no)	0.63	0.49	0	1
labor	Number of family members engaged in cassava farming	2.10	0.97	1	7
dactualpurchase	Purchased seeds for the 2016/2017 cycle (1=yes, 0=no)	0.27	0.44	0	1
dwillingness	Want to buy healthy seeds (1=yes, 0=no)	0.66	0.48	0	1
dstemsupplier	Want to be a producer of healthy seed (1=yes, 0=no)	0.35	0.48	0	1

Note: N=182

The average family consisted of 4.51 members, of which 2.10 were engaged in cassava farming. This information shows that our respondents were introduced to cassava production recently, and for some of them, it has become an important cash source, making it a sort of family business. In other words, they depend on cassava production for a living. In addition, 27 percent of the respondents purchased seeds for the 2016/2017 farming cycle, and 66 percent of them were interested in purchasing healthy seeds if they were available in the market; moreover, 35 percent of the producers wanted to make a business of producing healthy seeds.

Cassava Varieties

The cassava varieties used by the producers are shown in Table 2. Since these producers can cultivate different varieties simultaneously, the total number is not equal to the number of respondents. Whereas 17.4 percent of the respondents mentioned the variety of cassava they cultivated as "Unknown," others answered with specific variety names. In Dong Nai, KM325 (21 cases) and KM140 (20 cases) were preferred. In Tay Ninh and Gia Lai, KM419 and KM94 were the major cassava varieties. Although this study could not confirm their claimed variety, it was found that the KM series was the most popular choice in southern Vietnam.

Table 2 Cassava varieties used by producers

Varieties	Dong Nai	Tay Ninh	Gia Lai	Total	Percent
KM419	5	48	13	66	35.9
KM94	7	8	9	24	13.0
KM325	21	1	1	23	12.5
KM140	20	1	1	22	12.0
KM98-5	1	2	6	9	4.9
KM95	0	0	4	4	2.2
KM98	0	0	2	2	1.1
KM505	0	1	0	1	0.5
KM96	1	0	2	1	0.5
Unknown	5	2	25	32	17.4

Note: N=184

Among the respondents, 72.5 percent did not purchase cassava seeds for planting or replanting and instead used stems from the previous cycle. Of the remaining producers, 52.0 percent bought stems from their neighbors or relatives. These community-level stem exchanges are dominant in Vietnam and Cambodia (Delaquis et al., 2018). Another 46.0 percent bought stems from seed dealers because they wanted to explore new varieties with higher starch content. In Dong Nai, one cassava producer bought stems from the HLARC. Based on our interviews, most seed dealers were from the Tay Ninh province. This fact is consistent with a previous study's finding that Tay Ninh is "the highly commercialized 'cassava seed basket' of Southern Vietnam" (Delaquis et al., 2018).

Healthy Cassava Seed and Distribution System

We also asked the respondents whether they would purchase healthy stems if they were available in the market, and 65.9 percent of the producers answered yes, of which the percentages for Dong Nai, Tay Ninh, and Gia Lai were 23.08, 18.68, and 24.18, respectively. In contrast, 28.03 percent of producers would not purchase healthy stems, of which the percentages in Dong Nai, Tay Ninh, and Gia Lai were 4.95, 14.84, and 8.24, respectively. Another 6.05 percent of producers would like to have more information about the growth status, yield, and starch content of healthy varieties before making a decision.

Further, we found that the respondents' WTP for healthy cassava seeds was significantly higher than the actual purchasing seed price in all three provinces (Table 3). Thus, we confirmed that there is a potential market for healthy cassava seeds.

Table 3 Purchase, seed price, and WTP for healthy cassava seeds by province

Province	Purchase for cassava seed % (producers)			Mean of seed price (95% C.I.)	Mean of WTP (95% C.I.)	t statistic
	Yes	No	Other			
Dong Nai	23.08 (42)	4.95 (9)	4.95 (9)	18546 (16837-20255)	24091 (19630-28552)	2.61
Tay Ninh	18.68 (34)	14.84 (27)	0.00 (0)	11528 (8418-14637)	22875 (17140.45-28609.55)	4.2
Gia Lai	24.18 (44)	8.24 (15)	1.10 (2)	12593 (10578-14607)	17500 (15841-19159)	3.64

Note: Price in VND, 22500 VND ~ 1 USD

Table 4 presents the factors that influence producers' $WTP_{healthyseedling}$. The results show that the number of cassava plantings done before the 2016/2017 cycle influences $WTP_{healthyseedling}$. When we run the pair-wise regression, older producers, producers with larger cassava land area, producers with more family members engaged in cassava production, and producers who would like to be healthy seed producers had higher $WTP_{healthyseedling}$ at the statistically significance level of p<0.10. However, the effects of these individual factors diminish with the number of times they had previously planted cassava. There was a strong correlation between number of years planting cassava and age, so we excluded age. Apart from that there were no other strong correlations. Thus, we can conclude that when producers are experienced with cassava cultivation, they understand the importance of purchasing healthy seeds and perhaps the high risk of purchasing unknown seeds that could spread pests and disease. You may as well say that older people prefer to purchase healthy certified seeds.

Table 4 Determining factors that influence producers' WTP

VARIABLES	$WTP_{healthyseedling}$	
gender	2,551	
	(3,153)	
TayNinh	2,008	
	(2,632)	
GiaLai	-2,364	
	(2,463)	
tocaha	464.4	
	(362.3)	
fulltime	-392.7	
	(2,071)	
experience	10.84	
	(106.7)	
catimes	313.8	*
	(161.6)	
camain	-395.5	
	(1,975)	
labor	-710.3	
	(907.2)	
dactualpurchase	-1,541	
	(2,158)	
dwillingness	7,635	
	(7,407)	
dstemsupplier	2,659	
	(1,979)	
var(e.willprice)	9.803e+07	***
	(1.298e+07)	
Constant	9,355	
	(9,918)	
Observations	114	114

*Note: *** p<0.01, ** p<0.05, and * p<0.10, respectively*

Thus, following the current situation and the existing cassava production system centered at the HLARC, our project tested the healthy seed production system. We did so because the organization has played an important role as a cassava center, and producers and traders in Dong Nai and Tay Ninh provinces buy cassava seeds from the HLARC (Fig. 2). As a "stock seed production field," the HLARC produce healthy seeds after careful field monitoring and PCR testing, and it sold seeds to three producers in Dong Nai province in 2018 (Producer A, Producer B, and Producer C). These producers found business prospects in healthy cassava seed production and were trained periodically on how to monitor cassava fields and to execute such monitoring by themselves. They also received pest and disease information packages and were expected to become proficient at healthy seed production.

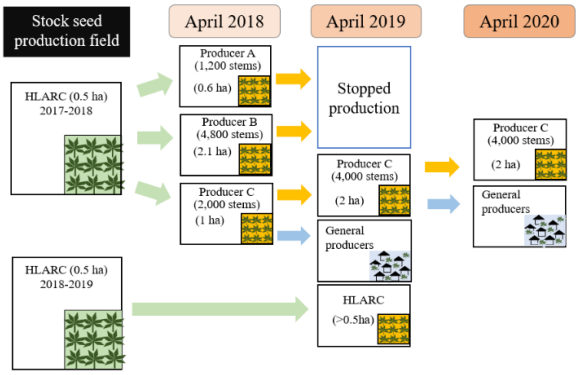

Fig. 2 Healthy cassava seed distribution system centered at HLARC

The project faced several challenges. In the existing system, the HLARC issues seeds to producers for free, along with necessary tools such as production techniques, fertilizers, and chemicals, because it does not have enough fields to test new varieties and wants producers to propagate and test them. Although, as part of our project, we wanted the HLARC to "sell" seeds to producers so that our system could work in a market-based manner in future, the producers who used to get seeds for free from the HLARC did not want to "purchase" them. In addition, producers were more interested in "higher starch content" than "healthy" seeds. It was complicated to make them understand how healthy seeds are essential for sustainable production.

Furthermore, the monitoring system needed to produce healthy seeds had not been properly implemented by the seed producers from the beginning. Our project provided them with information packages and training on pests and diseases, including how to treat them, and tried to train them to monitor cassava fields to avoid infections, pests, and their spread. As cassava has grown well for a long time without monitoring, seed producers were averse to the idea of monitoring their fields. This prevented the early mitigation of infected seeds when SLCMD spread in Dong Nai province in 2018. Consequently, although the HLARC and seed producers inspected their fields and removed suspicious seeds about two months after the planting in which the infection was detected, its spread became worse in the province. Even the higher level of monitoring afterwards failed to completely contain the spread of the infection.

Facing these challenges, however, Producer C produced healthy seeds for at least three cycles and sold them to general producers, whereas Producers A and B stopped production. The reason for this was that they were both producers in Dong Nai. Producers A and B were not following the monitoring protocol because the disease was not found in Dong Nai in the same year as in Tay Ninh. Consequently, when the producers found their cassava infested, they could not continue harvesting healthy cassava as the disease rapidly spread to other provinces, including Dong Nai. In contrast, Producer C had predicted the status of SLCMD. Therefore, he followed the protocol and his cassava production remained healthy. Although there is room for improvement in the monitoring done by Producer C, the current findings show that our healthy seed production and distribution system following the existing system could work. To develop the system, it is essential for HLARC and the project to provide every possible assistance to seed producers, teach them the importance of monitoring and management of healthy seeds for sustainable cassava production, and effectively implement a monitoring and management system.

CONCLUSION

This study analyzed the current status of cassava producers, their demand for healthy cassava seeds, and the potential of a healthy seed production and distribution system in Vietnam. Cassava producers depend on cassava production for their livelihood and tend to use varieties that are predominant in their communities. In addition, they have a preference for the KM series, which indicates that the variety is well-accepted as a healthy seed in the area. A production and distribution system of healthy seeds has a potential market because the respondents in all three provinces were interested in purchasing healthy seeds, and their WTP was statistically higher than their actual seed purchasing price. Our project created a healthy seed production system in Dong Nai province. Although there were many challenges, such as low awareness among seed producers about the importance of following the monitoring protocol and the rapid spread of SLCMD, one seed producer succeeded in propagating healthy seeds by monitoring their production. Considering the existing system and producers' preferences, we continue to explore ways to implement an efficient monitoring and management system to mitigate the impact of SLCMD and distribute healthy seeds.

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