International Journal of Agricultural Technology 2024 Vol. 20(1):177-196
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Experimental study of extension intervention on farmers' perception of willingness to pay (WTP) for healthy seeds among Cambodian cassava farmers

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Moun, S., Kaewrahun, S., Janket, A., Nomura, H., Baba, T., Ito, K. and Jutagate, T. (2024). Experimental study of extension intervention on farmers' perception of willingness to pay (WTP) for healthy seeds among Cambodian cassava farmers. International Journal of Agricultural Technology 20(1):177-196.

Abstract Results showed that extension intervention enhanced farmers' perception of certified seedlings. However, educational extension treatment such as the distribution of posters and training with posters found to be limited evidence of a causal effect on WTP. The study found that the most common reasons for not adopting clean seeds before and after the intervention were lack of concern, inability to pay, need for information, preference for own stem, and intention to stop planting. Difference-in-difference model indicated that training with posters had interaction before and after the implementation of the intervention which decreased the price of WTP by about 500 riels. This study also noted that farmers who increased their knowledge of SLCMD decreased their WTP statistically by about 400 riels. It is suggested that facing severe diseases did not affect the acceptance of cleaned seeds. Additionally, it observed that farmers became more cautious of purchasing seeds after the training as they could use their seedlings for multiplication.

Keywords: Clean seedlings, Contingent Valuation Method, Extension intervention, Willingness to pay

Introduction

Cassava (*Manihot esculenta* Crantz) is the sixth largest important food crop in the world after wheat, rice, maize, potato and barley (Saranraj *et al*., 2019). Cassava is a vital food crop for millions of people in Africa and Asia, where it provides a source of dietary starch, income, and food security. This crop is widely grown for its ability to produce starch, flour, ethanol, animal feed, and

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biodegradable products (Nizzy and Kannan, 2022). Asia has doubled production over the past 30 years (Cock and Connor, 2021) and its production in Cambodia has increased rapidly since 2005, reaching 647,960 hectares in 2021 (MAFF, 2022). The average yield in Cambodia is 30 tons per hectare (ha), placing Cambodia as the second-highest yield in Southeast Asia after Laos (FAOSTAT, 2020). This expansion, second only to rice in importance, provides vital benefits like food security, income generation, and employment opportunities for the region (MAFF, 2022). However, pests and diseases pose serious threats to Cambodian farmers, especially cassava mosaic disease (CMD) (Tokunaga *et al.,* 2018).

CMD is caused by several species of cassava mosaic *geminiviruses*. Sri Lankan cassava mosaic virus (SLCMV; family *Geminiviridae*, genus *Begomovirus*) emerged for the first time in Cambodia in 2016 (Wang *et al.,* 2016). It has been transmitted by the whitefly vector (*Bemisia tabaci*) and the movement of infected stem cuttings by value chain actors. CMD causes yield losses ranging from 10 to 90%, depending on the environmental conditions, cassava variety, virus strain, and disease severity (Hareesh *et al.*, 2023). Recently, there have been no commercially available cassava varieties that are resistant to CMD. Using disease-free planting materials is a practical way to prevent self-infection by CMD since there are no commercially viable CMD-resistant varieties (Murray and Cohen, 2021). Encouraging farmers to use disease-free cassava planting material is a promising strategy for addressing the challenges posed by CMD. This approach has been shown to significantly reduce yield losses, particularly when using asymptomatic plants (Malik *et al.,* 2022). Chalil *et al.* (2018) reported that smallholders' willingness to pay (WTP) for seed marking services was influenced by their knowledge and perception. Furthermore, farmers' willingness to pay for improved agricultural technologies, including certified seeds, is positively affected by improved access to extension services (Shee *et al*., 2019).

Empirical studies have shown that the contingent valuation method (CVM) is an alternative approach for estimating WTP of small-scale farmers in agricultural sectors (Mutaqin and Usami, 2019; Adjei-Nsiah *et al*., 2022; Mwangi *et al*., 2022). CVM is a highly flexible method for the estimation of willingness to pay for non-market goods and services, including non-use values and values under uncertainty (Whitehead *et al*., 2015). A previous study on CVM model estimated that the average WTP for certified seeds is 1,000 Rupee per acre, which is significantly higher than the current market price of 600 Rupee per acre. The WTP is influenced by factors such as farm size, education level, income, and previous experience with certified seeds (Kaguongo *et al.,* 2014). Mwiti *et al.* (2020) have involved CVM with a choice experiment conducted with 1,200 sweet potato farmers in the two countries. The article found that farmers had a positive and significant WTP for clean planting material of both biofortified and non-biofortified varieties and that the WTP was higher for biofortified varieties than for non-biofortified varieties. In addition, WTP for genetically modified planting materials was 1,500 UGX per sucker, which is higher than the current market price of UGX 1,000 per sucker via using CVM (Kikulwe and Asindu, 2020). Assess the level and determinants of WTP for clean seed among smallholder sweet potato farmers in Kenya by Mwangi *et al*. (2022) using CVM showed that WTP increased with prior use of clean seed and experience in sweet potato production.

However, research carried out the regression analysis by pooling two rounds of payment card data in CVM recommended that the strategy relies on the assumption that all explanatory variables have stayed the same during the survey. This suggested that difference-in-difference (DID) could be a better choice for data analysis in two data sets (Chen *et al*., 2023). While currently under-utilized in epidemiologic research, the DID method is a useful tool to examine the effects of population-level exposures but relies on strong assumptions (Caniglia and Murray, 2020). Rulisa *et al.* (2023) have assessed the farmer demand for larviciding in rice fields, which is a malaria vector control intervention CVM to elicit WTP of rice farmers for larviciding, and compared the WTP between three groups of farmers: one group that sprayed their fields under expert supervision, one group that organized the spraying themselves, and a control group that did not spray. This study also used a DID approach with propensity score matching to control for potential confounding factors and selection bias. Until now, no previous studies have used CVM implication to elicit WTP for cassava planting materials in two periods before and after extension intervention within the control group and treatment group.

The study aimed to determine the effect of different extension treatments (distributing posters and training with posters) on the farmers' willingness to pay (WTP) for cassava healthy seeds in two periods (before and after the intervention).

Materials and methods

Description of the research area

Battambang was the target of the research location, which is the province with the highest cassava production in northwest Cambodia. Battambang has 145,894 hectares of cassava farming, accounting for 22% of Cambodia's total cassava production area (MAFF, 2021). Battambang is the same as the national climate condition that influences tropical monsoon climate which consists of two main seasons: rainy and dry. The rainy season starts in May and ends in October, while the dry season is from November to April. The province has a yearly average temperature of 27.7 °C and an annual rainfall of 1,322 mm (PDAFF-BTB, 2020; Nut *et al*., 2021). Bavel District (13° 15' N, 102° 52E) and Rotonak Mondol District (12°9' N, 102° 96' E) were the target areas for conducting the experimental study.

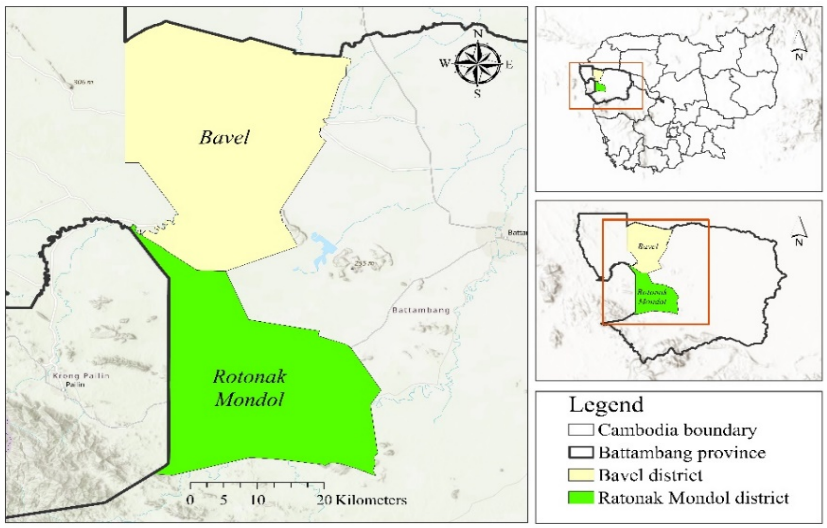

Figure 1. Map of Cambodia country showing districts (yellow and green) in Battambang province from which farmers were observed

Research design and data collection

The research was conducted from June to October 2019 and November 2019 to February 2020. During the first phase of the observation, 468 farmers were chosen at random to participate in the study. Following an analysis of their "initial" Knowledge Attitude Practice (KAP) and Willingness to Pay for cassava seedlings, all 468 farmers were randomly assigned to 3 equal groups "Control," "Treatment1," and "Treatment2," using Stata software version 16. (Table 1). This result ensured equal distribution of sex, age, education, and knowledge among the groups by randomizing the farmers within each commune. The educational and survey flow is shown in Figure 2. Reading educational materials (REMs) in the form of posters were distributed to "Treatment1" participants. Individuals in "Treatment2" were given REMs as posters and were educated through educational training. Individuals in "Control" received no sensitization material. In the second period of observation, the "second" WTP was analyzed to estimate the influence of interventions implemented in the first period. The respondents were involved from 310 of the 468 persons and 158 did not grow cassava during the second observational period.

Farmers' WTP for cassava clean seedlings with different three groups were elicited by using the double-bounded dichotomous choice CVM followed by open-ended questions. Open-ended questions CVM is a technique to estimate the economic value of non-market goods and services, such as environmental quality, health care, or cultural heritage which ask respondents to state their maximum WTP or minimum willingness to accept (WTA) for a change in the provision or quality of a good or service (Whitehead *et al*., 2015). Hypothetical WTP for an art print elicited using an open-ended willingness to pay question is two times larger than an actual WTP (Loomis *et al*., 1996). This approach has several benefits over conventional valuation questions: it accounts for possible valuation uncertainty, enables interpretation of uncertainty, and most importantly, reveals a wealth of information about individual's preferences. Additionally, this open-ended WTP format is advantageous for cross-country surveys (Hakansson, 2008). Getnet *et al*. (2022) estimated the smallholder farmers' WTP for sustainable irrigation water use in northwestern Ethiopia using open-ended question CVM. The study found that about 98% of the farmers were willing to pay for sustainable irrigation water use via constructing water storage, allocation, and distribution channels. Therefore, the target farmers were asked a yes-no question to elicit their WTP for healthy cassava seeds. If they answered yes, they were asked to choose a price range that reflected their WTP. They were also invited to indicate the maximum price per unit that they were willing to pay. If they answered no, they were asked to explain the main reason for their unwillingness to accept healthy seeds.

Table 1. Sample of households by groups in the first and second surveys

Groups	Communes			Observations	
				First survey[/1]	second survey[/2]
Treatment1	Plov Meas	Sdao	Treng	231	165
Treatment2	Ampil 5 Derm	Kdol Tahen	Reaksmey Sangha	157	90
Control	Khleang Meas	Onderk Herb	-	80	51

[1]/ Result of randomization at the commune level in the first survey (n=468)

[2]/ 310 farmers were involved in the intervention and interviewed in the second survey

Intervention design

The REMs distributed as posters included text, photos, illustrations, and brightly colored spaces to capture readers' attention (supplement 1). Most of the information on the posters was about Sri Lakan Cassava Mosaic Disease

(SLCMD). SLCMD causes, effects, and prevention measures. The disease's transmission mechanisms were highlighted in a prominent section of the poster. Images and text were used to convey information about the devastating effects of SLCMD in Cambodia. Cartoons were used to illustrate SLCMD prevention and control measures, making the poster more accessible. Furthermore, the method for selecting free-disease planting material and its significance is discussed. The size of the posters (A3) was carefully chosen to allow farmers to easily hang them on walls and/or fold them in half during group/community information-sharing sessions.

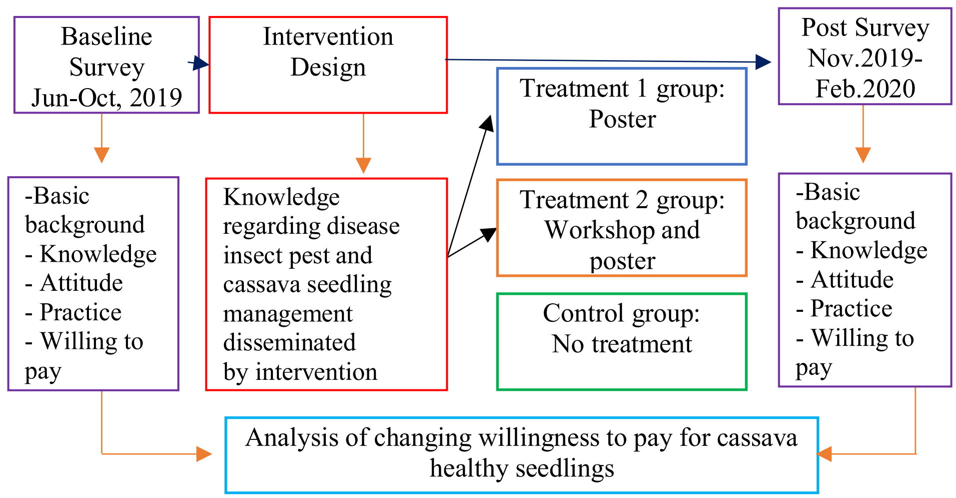

Figure 2. Overview of experimental study design for knowledge transfer

The multifaceted intervention included using REMs as posters and a workshop. The workshop was held to help participants improve their knowledge of insect pests and disease management. The workshop information was compiled based on previously identified gaps in farmers' understanding, attitudes, and practices. The gaps were discovered during the first survey. Like the poster design process, the workshop content was created by agronomics experts from the National University of Battambang. The experts considered the farmers' language, culture, and literacy. During the first phase of our investigation, we collected social data from farmers. Furthermore, the workshops included a question and answer (Q & A) session in which audience misunderstandings were clarified. The audience was also allowed to share their experiences with SLCMD. We also used the workshops to gather more data on SLCMD by asking farmers what they face daily.

The questionnaire was divided into five sections: the first dealt with the correspondents' characteristic status; the second, third, and fourth sections focus on the participant's knowledge, attitudes, and practices; and the final section focused on understanding farmers' willingness to pay for healthy cassava seedlings (supplement 2).

Data analysis

Stata version 16 was used to analyze the data. We scored the answers from the ex-ante data (first survey) and the ex-post data (second survey) as 1 for correct and 0 for incorrect. If respondents chose more than one answer to a multiple-choice question, it was automatically classified as incorrect and scored as 0 in terms of knowledge measurement. The characteristics of cassava farmers' households were analyzed using descriptive statistics and tested using statistical methods. A chi-square test was applied to the categorical variables, and an independent sample t-test was applied to the continuous variables. The yes-no responses indicated the percentage of farmers willing to purchase healthy cassava seeds. The price of WTP was tested with a t-test for each group before and after the intervention. Additionally, the reasons for the farmers' unwillingness to purchase healthy seeds were analyzed to assess the proportion of the intervention before and after its implementation.

To estimate the effects of the two knowledge interventions (REMs and multifaceted intervention) on WTP, data from the first and second surveys were analyzed using a DID analysis between the treatment groups (Treatment1 and Treatment2) and compared to "Control" using a t-test (Table 2). Here, the change in the price of willingness to purchase healthy seeds in treatment groups compared to the price of willingness to purchase healthy seeds in the control group measures the treatment effect. The difference in the impact of extension interventions can be performed from the price before treatment. This difference is called "first difference" The same difference in outcome between the treatment and control groups after the conclusion of the implement extension intervention is called "second difference." The present study adopted the DID estimate from Samuel *et al*. (2021).

Table 2. DID analysis in impact assessment of WTP before and after in treatment groups vs. control group

Particular	Treatment groups[/1]	Control group[/2]	Difference Across Group
After	Ta	Ca	Ta -Ca
Before	Tb	Cb	Tb-Cb
Difference Across Time	Ta – Tb	Ca-Cb	Double difference (Ta- Ca) - (Tb-Cb)

[1]/ Ta is treatment groups (treatment1 and treatment2) after conducted intervention
Tb is treatment groups (treatment1 and treatment2) before conducted interventions
[2]/ Ca is the control group after conducted intervention
Cb is the control group before conducted intervention

The DID model

The causal relationship between dependent and independent variables reveals the truth rather than the correlation. The DID strategy was first adopted by Ashenfelter (1978). Beneficiaries and non-beneficiaries were compared using the DID estimation in terms of economic benefits and social benefits (Lechner, 2011; Dalton *et al.,* 2014). The DID model was used to estimate the price of willingness to purchase healthy seeds for each group and their interaction by performing a regression analysis as follows:

$$D_{WTPi} = \beta_0 + \beta_1 treat_i + \beta_2 post_t + \beta_3\ treat_i \times post_t + \beta_4\ D_K + \varepsilon_{it} \qquad (1)$$

Where D_{WTPi} is the dependent variable denoting for the difference between WTP for the healthy seedling in the first survey and the second survey of the respondent i; $treat_i$ is an indicator for the treatment group 1 and 2, $post_t$ is an indicator variable for time t being after the intervention change, D_K is the continuous variable which respectively denotes the differences in the knowledge score between the second data survey and the first data survey knowledge variables and ε_{it} is the error term.

Results

Characteristics of experimental respondents

The general characteristics of 468 smallholder cassava farmers in Battambang province are indicated in Table 3. All respondents consist of 40.73% male and 59.27 % female. The mean age of farmers was 43 years. Most participants had low education levels, showing that 40.15 % had no education and 35.41% had finished primary school. Survey results indicated that participants worked in farms or agriculture for an average of about 17 years and in cassava planting was about 4.5 years. During the primary growing season, farmers planted cassava was an average of 3.34 ha during an average farm size of about 5.65 ha. Majority of farmers used their stems for planting about 74.23 % and 22.37 % of them asked for the stems from their neighbors. Other sources from relatives were 4.58 % and 4.74 % from the middleman. The result of the independent sample t-test and Pearson's chi-square test showed no significant differences in gender, age, education, average cassava planting, total farm size, total cassava land size and source of cassava seedlings. Nevertheless, the results showed significant differences in average years of farming when compared to the control group with treatment group 2 ($P \leq 0.1$).

Table 3. Descriptive statistics of households following independent sample t-test and Pearson's chi-square test

Variable	Control (n=51)		Treatment1 (n=165)		Treatment2 (n=94)		All participants (n=310)		Control vs Treatment1[/1]		Control vs Treatment2[/1]	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Difference	*P*-value	Difference	*P*-value
Gender (%)[/2]										0.59[ns]		0.58[ns]
Male	39.20	-	42	-	41	-	40.73	-				
Female	60.80	-	58	-	59	-	59.27	-				
Age of participants (years)[/3]	42.25	14.42	41.87	13.59	44.08	14.00	43.22	14.34	0.65	0.72[ns]	-1.56	0.42[ns]
Education (%)[/2]										0.27[ns]		0.66[ns]
None	49.02	-	37.58	-	33.84	-	40.15	-				
Primary school	29.41	-	44.85	-	31.96	-	35.41	-				
Second school	13.73	-	12.12	-	14.10	-	13.31	-				
High school	7.84	-	5.45	-	8.46	-	7.25	-				
Average of farming (years)[/3]	17.17	11.50	15.34	8.62	20.98	12.84	17.35	10.80	1.83	0.22[ns]	-3.81	0.08*
Average of cassava planting (years)[/3]	4.38	2.53	4.68	2.81	4.20	2.11	4.49	2.58	-0.30	0.32[ns]	0.18	0.51[ns]
Total farm sizes (ha)[/3]	5.22	7.82	5.34	10.59	6.44	7.24	5.65	9.26	-0.11	0.91[ns]	-1.21	0.18
Total Cassava land sizes (ha)[/3]	2.74	4.89	3.57	5.62	3.27	3.73	3.34	5.00	-0.82	0.18[ns]	-0.52	0.30[ns]
Source of cassava seedlings (%)[/2]										0.10[ns]		0.46[ns]
Own stem	72.55	-	71.43	-	78.72	-	74.23	-				
Relative stem	1.96	-	7.53	-	4.25	-	4.58	-				
Neighbour stem	20.55	-	23.17	-	23.40	-	22.37	-				
Middleman	7.84	-	2.12	-	4.25	-	4.74	-				

[1]/ Significance denoted by ns= non-significant, * = significantly different at $P \leq 0.1$
[2]/ Variables using Pearson's chi-square test
[3]/ Variables using independent sample t-test

Willingness to pay for healthy seed

The primary target variable to study the impact is changing perception of willingness to pay for healthy cassava seedlings. The change of perception is calculated in two steps. The first percentage of willingness to pay is the frequency of acceptance with yes-no questions before and after implementing interventions. It is expected that after applying treatment1 (poster), treatment2 (workshop and poster) compared to the control group after receiving the educational extension will increase the price of purchasing cassava clean seeds. Farmers used their stems even though they were infected with severe diseases before conducting extension treatments. The result of this analysis showed that there was a significant difference between all groups even though the control group. There was increased 24.50% in the control group, treatment1 (21.80%) and treatment2 (22.30%) after analyzed both observations (Figure 3). Additional steps of the calculation, paired t-test is performed to analyze the mean of the price of willingness to pay (WTP) before and after implementing treatments. The result in table 4 showed different statically of the mean before and after intervention implemented all groups of the WTP for a bunch (20 stems). There is increased about 887.931 riels (0.22 USD) in the control group, whereas treatment1 increased 550 riels (0.14 USD), treatment2 increased average to only 380.435 riels (0.09 USD).

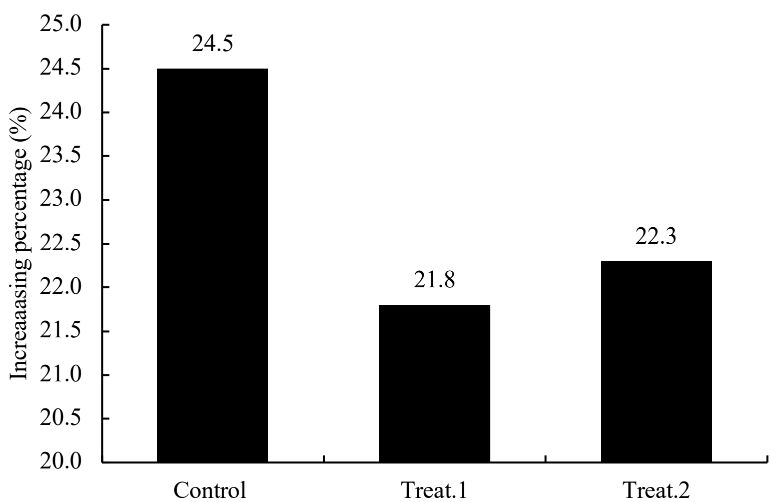

Figure 3. The percentages of increasing willingness to pay for cassava healthy seed after receiving extension intervention in each group

Table 4. Paired t-test analysis of WTP in each group

Variable	Control (n=29/51)		Treatment1 (n=80/165)		Treatment2 (n=46/94)	
	Mean	*P*-value /1	Mean	*P*-value /1	Mean	*P*-value /1
Before	2206.897	0.0025***	1987.5	0.0005***	2163.043	0.0526*
After	3094.828		2537.5		2543.478	
Difference	887.931		550		380.435	

1/ Significance denoted by * and *** = significantly different at $P \leq 0.1$ and $P \leq 0.01$, respectively

Cause of unwillingness to pay

In both surveys, we also collected information that participants would not buy the clean seedlings with certification of non-infection. There are several points to note concerning the results (Figure 4). In the first observation, 131 respondents were not willing to buy clean seeds for some main reasons, including no worry (42%), cannot pay (17%), needing more information (20.67%), using only own their stem (14.33%) and stop planting (6%). In addition, in the second observation, 61 respondents reported the reason for unwillingness to pay is the same as the first observation following; no worry (25.67%), cannot pay (30.67%), need more information (18%) and using only own stem (25.67%). It is noted that participants seemed not to worry about the infected stems in the first observation and they started to be concerned after they received an extension intervention. However, they prefer to use their stems even though their stems are infected or surrounding their farm are also infected.

Difference-in-difference (DID) of WTP results

The DID estimation was used to quantify and understand the awareness of willingness to pay for clean seedlings due to extension activities of poster distribution and workshops with posters. To check the discrepancies between the time points from the first and second surveys, for the Treatment1 vs. Control and Treatment2 vs. Control groups, we conducted a t-test at 95 % CI (Table 5). Unfortunately, both comparisons among Treatment1 vs. Control and Treatment2 vs. Control showed no significant differences. Nevertheless, DID model estimation was significantly associated in treatment2 by time with the increased knowledge related to the SLCMD and the information from posters ($P \leq 0.1$) (Table 6).

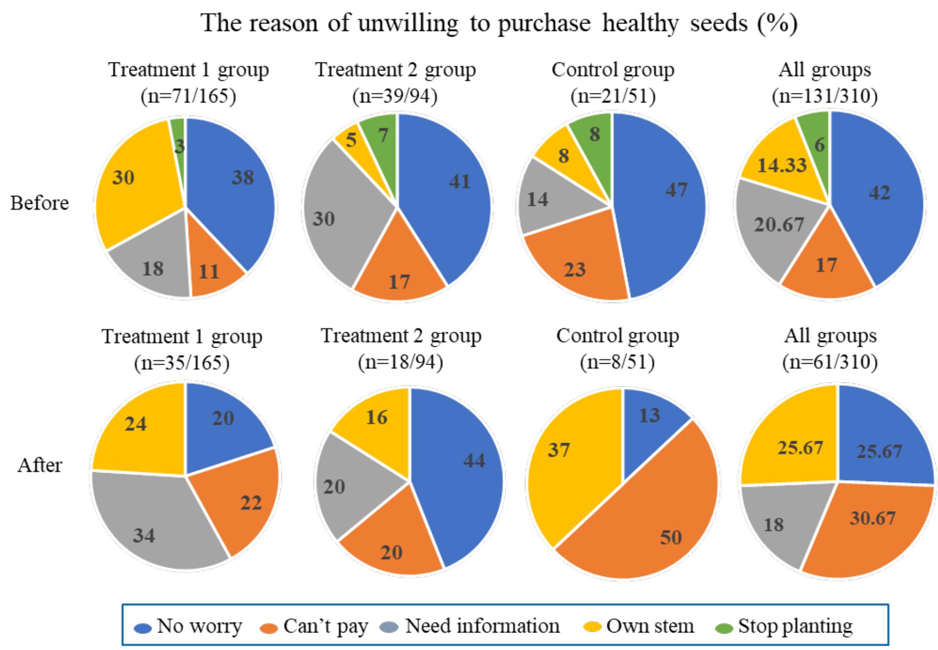

Figure 4. The percentages of the reasons for unwillingness to buy clean seedlings in each group before and after extension intervention (n= amount of interviewees who were unwilling in each sample group)

Table 5. DID analysis of WTP in each group

Variable	Definition of variable	Mean-Difference (2^{nd} – 1^{st})			Coefficients	
		Control (n=29)	T1 group (n=80)	T2 group (n=46)	Control vs. T1	Control vs. T2
WTP	Willingness to pay (Riel/bunch)	887.93	550	380.43	-252.824^{ns}	-131.656^{ns}

ns= non-significant

Table 6. DID Model estimation used knowledge variables of WTP

Variables	Coefficients	Standard error
treatment1	377.30^{ns}	483.65
treatment2	730.31^{ns}	528.67
time	922.73***	251.94
treatment1 x time	-408.59^{ns}	290.57
treatment2 x time	-533.90*	316.45
SLCMD	-417.78***	117.83
whitefly	90.92^{ns}	110.82
R^2	0.1140	
Probability value	0.0000	
Number of observations	428	

ns= non-significant, * and *** = significantly different at $P \leq 0.1$, and $P \leq 0.01$, respectively

Therefore, the intervention's double difference/impact is only negatively associated with treatment2 in the above first differences while adding knowledge variables estimated by DID model (Table 6). Participants who joined the workshop and received the poster increased their knowledge about SLCMD. Unfortunately, a negative significance showed that participants in treatment2 gained knowledge of SLCMD but it does not mean increasing willingness to purchase clean seedlings. It showed that about 534 riels decreased after they received the extension intervention by joining the workshop. It is exciting and it seems they think that SLCMD is very difficult to prevent due to rapid infection by whiteflies, even though they use healthy seeds related to the contents in the workshop and posters.

Discussion

The objective was examined willingness to pay (WTP) for healthy cassava seedlings to improve farmers' perception of using free-disease planting material via conducting extension interventions toward cassava disease prevention of smallholders in Battambang province, Cambodia. Our key findings are that educational extension interventions did increase knowledge and awareness of certified seedlings' benefits, but increased knowledge did not translate into a cheerful willingness to purchase healthy seeds. This finding is similar to other studies (De Groote *et al*., 2014; Morgan *et al*., 2020; Mastenbroek *et al*., 2020), which found that agricultural extension and educational activities failed to increase the WTP of rural farmers for certified crop seedlings. It found that participants in the control group and intervention treatment1 (poster) were WTP for certified seed by paired t-test analysis, but it was surprising that treatment2, who attended the training and received the poster did not increase their WTP. Gharib *et al*. (2021) also found that farmers in the control and educated groups were WTP a premium for seedlings purchased directly from the company. This study mentioned that without data on participant preferences, it could not increase preferences affected WTP for seeds. Additionally, intra-subsystem heterogeneity was a wide variety of factors influencing farmers' preferences towards these schemes, most related to farm/farmer socioeconomic factors and, to a lesser extent, physical farm factors (Villanueva *et al*., 2017). This heterogeneity is a challenge that we do not fully understand. In this study, we tried to control factors such as; gender, age, cassava experience, willingness to pay, cassava profit and baseline knowledge. This could suggest observing other heterogeneity variables more due to farmers' characteristics before designing intervention.

Result in DID analysis failed to increase in both treatment groups and DID model showed a negative relationship in treatment2 at $P \leq 0.1$. It showed that participants in treatment group 2 who received workshop and poster increased their awareness of the disease (SLCMD) but unfortunately, the price of willingness was decreased. The results were directly compared with the previously reported findings on using the information treatment as an intervention variable for knowledge was not adequate on willingness to pay, suggesting that even though farmers are information-constrained, these constraints do not affect the adoption of certified seed directly (Mastenbroek *et al*., 2020). The other finding implies that the treatment1 group required more information, and the treatment2 group wanted to manage using their own stem of their unwillingness to pay. The finding of Kaguongo *et al*. (2014) was also surprising that used to certify the seed previously which had not impacted on WTP. Their research expressed that perhaps many without experience with certified seed had the same impression as those who planted it. The study extends the evidence suggesting that information is not a critical constraint in the adoption process of yield-enhancing products (Ashraf *et al*., 2013; De Groote *et al*., 2016). A study in Turkey found that over 58% of wheat producers adopt certified crop seedling, highlighting a relatively high adoption rate in developed countries (Cevher and Altunkaynak, 2020). On the other hand, in developing countries like Vietnam, the adoption rate is lower, with only 30% of farmers using certified aromatic rice seed (Pham and Napasintuwong, 2020). Factors influencing this disparity include the adequacy of seed support, high seed prices, and the availability of alternative seed varieties (Cevher and Altunkaynak, 2020). The adoption rate of certified climate-resilient crop seedling varieties in developing countries is generally low (Hasibuan *et al*., 2021). The availability and effectiveness of extension services, education levels, access to inputs, and socio-economic status are also key determinants of adoption (Acevedo *et al*., 2020). In the case of climate-resilient potato varieties in Kenya, access to information, quality seeds, training, group membership, and agroecological variations were found to be significant factors (Kimathi *et al*., 2020). In Tanzania, poor adoption of climate-smart varieties is attributed to a lack of awareness, a volatile farming environment, and poor integration of the seed business into public-private partnerships (Bilaro *et al*., 2022).

Furthermore, the high incidence of SLCMD is a big challenge in clean seedlings propagation. According to MAFF (2019), about 12 provinces were infected of SLCMD including Battambang province, which rapidly spread via insect vector (whitefly). The participants were trained in this information about the pandemic, it may concern another reason of participants in treatment2 who joined the training and not interested in clean seedlings of long growing periods due to SLCMD spreading. Cassava may be harvested as early as 7 months after planting but generally from 8 to 12 months (Ekanayake *et al*.,1997). Additionally, our findings showed that most farmers used their own stems about 74 %. Previous studies also showed that farmers were satisfied with the quality of seeds from their self-supply system (Sperling and McGuire, 2010). This farmer-to-farmer seed system provided 80-90% of seedlings through sales or own savings (Sperling *et al*.,2013; Delaquis *et al*.,2018). On the other hand, the threats from SLCMD led farmers to consider clean seedlings to increase their WTP. However, Kiros-Meles and Abang (2008) and Hamelin *et al*. (2021) suggested that farmers' knowledge of crop diseases and the optimal control of plant disease epidemics can significantly impact their WTP for clean seeds. Therefore, while the absence of serious diseases in crop fields may not directly increase farmers' willingness to pay for clean seeds, their understanding of disease management and the potential benefits of using clean seeds can play a crucial role in shaping their attitudes and behaviors.

The research investigated farmers' WTP for healthy certified seedlings under treatment effects and disease pressure scenarios. Using educational activities extension in intervention treatment groups compared to the control group under CVM method design and DID analysis, we find little evidence that exposure to extension treatments significantly impacts farmer WTP awareness. Educational extension intervention does not push farmers to purchase clean seeds. Farmers who had joined the workshop and received posters were more careful to purchase seeds from others and were satisfied with their stems. The study also revealed that there was a high degree of heterogeneity among the farmers in terms of their preferences, socioeconomic factors, and farm characteristics, which influenced their WTP and adoption decisions. We suggest that providing information and education alone may not be sufficient to induce behavioral change among the farmers and that other factors, such as seed availability, affordability, accessibility, and quality, need to be addressed as well. This study has limitations that should be acknowledged. The study did not control for other factors that may have influenced the WTP and adoption of the farmers, such as weather, market conditions, and social norms. So, we suggested that the heterogeneity of participants should be considered in future studies in order to assess the potential for a market for certified clean seedlings in areas affected by or at risk of CMD.

Acknowledgements

This research was financially supported by the Science and Technology Research Partnership for Sustainable Development (SATREPS) in collaboration with the Japan Science and Technology Agency (JST, JPMJSA1508) and Japan International Cooperation Agency (JICA). The authors would like to thank the National University of Battambang for providing great opportunities for the first author to obtain this scholarship under the Higher Education Improvement Project (HEIP) (credit No. 6221—KH), World Bank, Ministry of Education Youth and Sport, and Cambodia government. Grateful acknowledgement is given to the Faculty of Agriculture, Ubon Ratchathani University, Thailand, for supporting and facilitating the project.

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(Received: 23 March 2023, Revised: 4 August 2023, Accepted: 29 December 2023)