32nd International Conference of Agricultural Economists
2-7 August 2024 I New Delhi I India

Willingness to Pay for Improved Planting Materials: An Application of Experimental Auction in Sri Lanka

Poorni Athapaththu[1], Jeevika Weerahewa[1]

1: Department of Agricultural Economics & Business Management, Faculty of Agriculture, University of Peradeniya, Sri Lanka

Corresponding author email: jeevika.weerahewa@agri.pdn.ac.lk

Abstract

This study evaluated the willingness-to pay (WTP) for quality mango planting materials of *TomEJC* cultivar and identified the variables that affect WTP and degree of adoption of the technology. A second price sealed bid auction was conducted among villagers in Thirappane, Anuradhapura district, Sri Lanka to determine WTP and a Heckman two-stage model was estimated to ascertain the determinants of WTP. The respondents were randomly divided in to two groups and one group was given information on growing of *TomEJC* before the experiment was conducted. The socio-economic characteristics of the respondents were gathered using a structured questionnaire. The findings showed that the pooled sample's mean bid for *TomEJC* planting materials was LKR 287.03 per plant and the WTP of group that received advance notice was higher by LKR 151.62. Heckman model first-stage results indicated that the decision to adopt was positively and significantly influenced by household type, mango availability in the home garden, education level, and desire to begin commercial mango cultivation. The second-stage results revealed that WTP was positively & significantly influenced by information provision and average monthly income. These results suggest that the first step in promoting new technology will be to raise awareness targeting the non-poor farmers.

Keywords: Improved planting materials, Experimental auction, Participation decision, willingness to pay, *TomEJC*

JEL Codes: O390, Q100, D440

INTRODUCTION

Adoption of new agricultural technology is a significant factor influencing the development of the agricultural sector, food security as well as the economic status of farm households regardless of developing or developed countries (Pasa, 2017; Channa *et al*., 2019). The most remarkable achievement of these technologies is the substantial increase in production and productivity while reducing costs and boosting farmers' income. A better understanding and knowledge of the drivers of adoption and farmers' willingness to pay (WTP) is essential for designing effective policies for encouraging and promoting technology adoption. However, the adoption rate of improved agricultural technologies remains low in many developing countries, which hinders the improvement of rural farm households' livelihoods. Therefore, it is important to adopt proven agricultural technologies to enhance both production and productivity. Farmers' perception of the consequences of the adoption of improved technology against their economic, social, and technical feasibility plays a vital role in their decision-making process (Chi and Yamada, 2002; Lavison, 2013; Kinyangi, 2014; Sennuga *et al*., 2020).

When farmers' WTP for new technology is low value and subsequent low adoption rates can be attributed to a lack of knowledge about the technology's benefits. Providing relevant information can increase adoption by helping farmers to understand the advantages of the new technology and it is a determinant factor of WTP (Channa *et al*., 2019). The information serves as a significant barrier to the adoption of improved technologies. Additionally, uncertainty about the technology's potential impact on production may deter farmers from adopting it. Therefore, providing information is essential for promoting the adoption of improved technologies.

In the fruit sector, mango cultivation has the potential to generate income and employment for both small and large-scale farmers in many developing countries with a tropical climate. This provides an opportunity for industry expansion. Most of the pre-harvest and post-harvest technologies associated with mango cultivation are bound with improved technology (Orden, 2004; Honja, 2014). Adopting these technologies can lead to higher prices for quality fruits. Mango growers have a medium-level adoption to the use of the technologies (Chonhenchob *et al*., 2011).

Mango growers cultivate both local and imported varieties that are most suited to their specific environmental and market conditions (Yue *et al*., 2017) while Sri Lankan commercial growers focus primarily on productive cultivars such as *'Karutha colomban,' 'Vellai colomban,'*

'Willard,' and '*Ambalavi*.' Recently, the '*TomEJC'* cultivar has been recommended because of its favorable fruit characteristics in terms of flavor, color, and size that meet the requirements of local and foreign fruit markets. According to Loevinsohn *et al*., (2013), new varieties or cultivars and management regimes consider as most common areas of improved technology development. Promoting such kind of improved technology can contribute to the sector's development more productively and profitably. However, most of the studies have a focus on consumer and intermediary preferences than the grower's preference and grower's WTP.

The WTP analysis can assess consumer preferences and determine the premium consumers are willing to pay for *TomJC* planting materials compared to traditional varieties. This analysis provides valuable insights into market dynamics and price sensitivity, aiding in understanding the market potential and demand for *TomJC* plants. Additionally, estimating the WTP is crucial for evaluating the economic viability of adopting *TomJC* cultivation for producers. It allows producers to understand the potential financial gains and price premiums they can expect to receive, enabling informed decision-making about shifting their practices to *TomJC* cultivation.

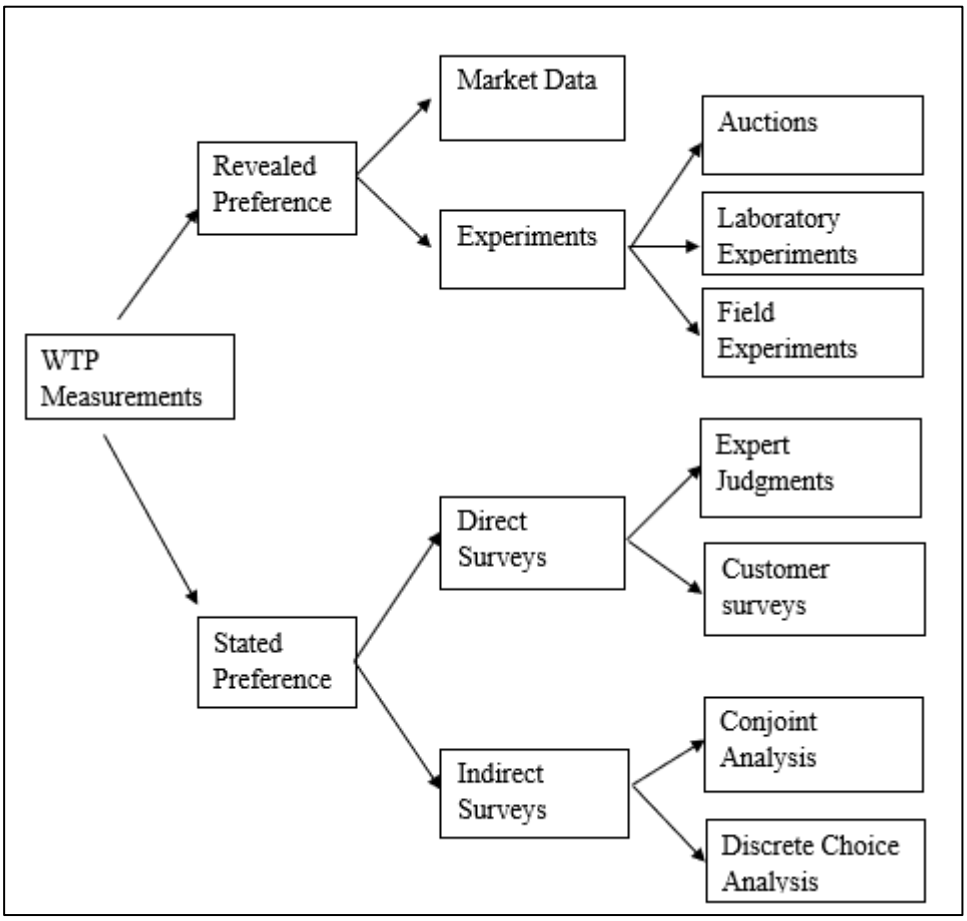
Moreover, the analysis can inform policymakers and stakeholders about the potential benefits of promoting the adoption of superior varieties in agriculture. If the WTP analysis demonstrates a significant price premium for *TomJC* plants, it strengthens the case for policy support and incentives to encourage farmers to cultivate these varieties, ultimately driving agricultural development and enhancing export competitiveness. Additionally, the estimation of WTP aligns with the broader objective of reducing food loss by improving produce quality. By understanding the value consumers place on quality improvements, the analysis can guide producers in adopting agronomic practices that maximize quality and minimize post-harvest losses.

This research study explores the adoption of improved agricultural technologies, particularly quality mango planting materials among small-holder farmers in Sri Lanka. The specific objectives are (i) to determine the average WTP of farmers for these materials, (ii) to assess the impact of prior awareness about the specific mango cultivar on farmers' WTP, and (iii) to examine the relationship between household and home garden characteristics and farmers' decision to participate in adopting the technology, as well as their WTP.

APPROACH

The maximum price a buyer accepts to pay for a given quantity of goods or services without losing their utility is defined as WTP (Hanemann *et al*., 1991; Kanninen, 1993). It provides

valuable market information about buyers' acceptance and pricing decisions. Breidert *et al*., (2006) presented hierarchical classification to organize existing methods to elicit WTP. Figure 1 shows the classification.



(Source; Breidert *et al.*, (2006))

Figure 1: Classification framework for methods to measure willingness-to-pay.

From the valuation techniques available to measure WTP, the revealed preference method is based on the actual behavior of individuals to value existing goods and services. Stated preference methods are not incentive compatible due to their hypothetical setup and no actual behavior is observed. Auctions can be applied to both field and laboratory experiments. In laboratory experiments, the purchase behavior is simulated by giving an amount of money to the respondents and ask them to spend the money to purchase a specific selection of goods. But in field experiments, it's not associated with the problem of the artificial setup. Depending on the experimental conditions, the respondents are aware of participating in an experiment or not

(Breidert *et al*., 2006). In survey-based techniques for elicit WTP, direct and indirect surveys can be used for collecting the relevant data (Louviere *et al*., 2000).

In the experimental setting, real products and real money are exchanged. Therefore, participants can reveal their true values for the product than in a hypothetical survey setting (Lusk and Shogren, 2007). The data obtained from this method is less biased by non-responses (Fox *et al*., 2019). The mechanisms associated with different types of auctions available to elicit WTP in previous studies such as Vickrey second price, Random nth price, English, and BDM auctions, are given in Table 1.

Table 1: Comparison of the mechanism in different types of Auctions

	English Auction	**Second price Auction**	**Random nth Price auction**	**BDM auction**
Participation procedure	Sequentially offer ascending bids	Simultaneously submit sealed bids	Simultaneously submit sealed bids	Simultaneously submit sealed bids
Who is the winning bidder?	Participant who offers the last bid	Participant with highest bid	All participants with bid greater than a randomly drawn (nth)bid	All participants with bid greater than a randomly drawn price
Number of winners	1	1	n-1	0 to all participant
Winning price	Last bid offered	Second highest bid	nth highest bid	Randomly drawn price
Market feedback	Yes	Yes, with multiple rounds	Yes, with multiple rounds	No
References	Coppinger *et al*., (1980)	Vickrey, (1961)	Shogren *et al*., (2001)	Becker *et al*., (1964)

(Source; Abeykoon *et al*., (2014))

This study used second price sealed-bid auction. It is a demand-revealing mechanism and a dominant strategy for bidders to bid their true value (Vickrey, 1961). Most of previous studies were done using the stated preference methods such as the contingency method and choice model. For example, Gbénou-Sissinto *et al*., (2018) used a choice experiment to study the Farmers' WTP for new storage technologies for maize in Northern and Central Benin. To study the WTP of agricultural inputs including crop varieties (Waldman, Kerr, and Isaacs, 2014) quality seeds (Morgan *et al*., 2020), and storage bags (Channa *et al*., 2019), extended experimental auction methods were used. WTP for eco-labeled forest products in Northern Ireland was evaluated using second price, sealed-bid, Vickrey auction.

Even though mango can be cultivated in all three climatic zones known as wet zone, dry zone, and intermediate zone in Sri Lanka, it is mostly grown in dry zone compared to the other areas. Therefore, *Thirappane* area which belongs to the dry zone was selected as the study site. The households that are living in six *Grama Niladhari* (GN) divisions in *Thirappane* Divisional Secretariat (DS) division, Anuradhapura District, Sri Lanka was considered as the target population. The selected GN divisions were 539-*Wellamudawa,* 540-*Mahakanumulla*, 550-*Sembukulama*, 547-*Indigahawewa*, 554-*Paindikulama*, and 562-*Walahgambahuwa*. From that population, households were randomly selected to collect primary data. The unit of analysis was the individual household. Then again, the sample was randomly divided into two groups. The first group was considered as the control group and the second group was the treatment group. The treatment group was provided with information related to the cultivation of *TomEJC* prior to the interview.

The following steps were involved in the conduct of the experimental auction. Households residing in six GN divisions were invited to participate in the auction. Before the bidding process, participants were asked to complete a pre-auction survey to gather relevant information. The characteristics of a high-quality *TomEJC* mango plant in terms of size, age, health condition, and reputation were described to the participants. Additionally, the treatment group received information on cultivation techniques, technology, and market trends related to the *TomEJC* cultivar. Clear instructions were provided to the participants, emphasizing the importance of not sharing their bid values with others outside their household. They were advised to bid their actual value, considering that bidding too high could lead to overpayment and bidding too low could reduce their chances of winning. Participants then proceeded to place their bids, indicating the amount they were willing to pay per plant. The collected bids

were randomly divided into ten groups, and winners were determined within each group based on the highest bid, at the second highest price.

The questionnaire survey was guided by a pre-tested structured questionnaire, which consisted of five main sections. The first section collected general information about the respondents, including gender, age, education level, and occupation. The second section focused on household characteristics such as family size, average monthly income and expenditure of the household, size, and ownership of the home garden, and proximity to main roads and markets. The third section explored farming characteristics, including mango availability, types of mango grown, marketing information, and cultivation techniques. The fourth section gathered data on extension services related to farming. The final section assessed the social networking of the farmers. Further, a participant information sheet was provided, explaining the purpose of the research, researcher information, voluntary participation, and the confidentiality of the data.

The average WTP was calculated using the equation shown below.

$$\text{Average WTP} = \sum_{i=o}^{n} \frac{\text{Participant's bid value}}{\text{No.of participants}} \quad \text{------ (1)}$$

It indicates that the average WTP value can be calculated by dividing the total bid values for the *TomEJC* planting materials by the number of participants in the auction for this given context.

Heckman (1979) proposed a two-step estimation method to overcome the sample selection bias arising from estimations carried out using the observed variable in the sample. This is also known as the 'Heckit model'. Heckman two-stage model observes the process in a two-stage decision, and it allows the use of different sets of explanatory variables in both stages of estimation. The Tobit model uses one-step procedure and assumes that the explanatory variables affecting the decision to participate and the WTP are the same. Therefore, this is viewed as a generalized version of the Tobit Model. To analyze the willingness-to-pay, the typical approach in the existing literature is to divide this into two stages as participation decision in this case it would be the decision on whether to bid for the quality *TomEJC* mango plant at all and how much to pay (WTP).

In this model, the first stage is a probit estimation. The second stage is estimated using OLS estimation. The two steps produce efficient estimates of the parameters, standard errors, and a consistent estimator. The residuals of the selection equation indicate the selection bias control

factor. It is named Lambda (λ) and it is the Inverse Mill's Ratio. Moreover, it is a summarizing measure that reflects the effect of all unmeasured characteristics.

There are a couple of equations associated with this model. Therefore, the participation equation is indicated below,

$$Pr\ (\ Z_i =1|\ w_i,\alpha) = \Phi(\ h(w_i,\alpha)) + \mathcal{E}_i \text{ ----- } (2)$$

Where, Z_i is an indicator variable for participation while, Φ is the standard normal cumulative distribution function; w is a vector of factors affecting participation; α is a vector of coefficients to be estimated; and ε_i is the error term assumed to be distributed normally with a mean of zero and variance of σ^2. The variable Zi takes the value of 1 if the household i get participated in the auction is greater than zero, and zero otherwise.

$$Z_i^* = \alpha w_i + v_i \text{ …… } (3)$$

$$Z_i = \begin{cases} 1 \text{ if } Z_i = 1 \text{ if } Z^*_i > 0 \\ 0 \text{ if } Z_i = 0 \text{ if } Z^*_i \leq 0 \text{ …… } (4) \end{cases}$$

Where, Z^*_i= Latent dependent variable (bid value for *TomEJC* mango planting materials. $v_i \sim N(0, 1)$.

The inverse mills ratio (IMR) is added as a regressor in the second stage. It is used to correct for potential selection bias. Only the households who participated in the experimental auction were included in the second stage, the IMR is computed as follows.

$$\lambda` = \frac{Ø(h(wi, \alpha`)}{\Phi(wi, \alpha`)} \text{ ……(5)}$$

Where, Ø is indicated the normal probability density function.

The second stage equation is given below by incorporating the IMR as well.

$$E(Y_i| Z = 1) = f(X_i,\beta) + \Upsilon(\ Ø(h(w_i,\alpha`)\ )/(\Phi(w_i,\alpha`))\text{…...(6)}$$

Where, E is the expectation operator, Y is the bid values for the mango planting materials, X is a vector of independent variables affecting sales, and β is the vector of the corresponding coefficients to be estimated. Therefore, Y_i can be shown as the below equation.

$$Y_i = \beta X_i + \Upsilon\lambda + \upsilon_i \text{ ……. } (7)$$

Where, $\upsilon_i \sim N(0, \sigma\mu)$, Y_i^* is only observed bid values. ($Z_i=1$), in which case $Y_i=Y_i^*$

RESULTS

Demographic Profile

The demographic profile of the participants in the two groups was summarized, revealing a majority of female participants in both groups. The age range of respondents spanned from 21 to 70 years, with the highest concentration observed within the 30 to 40 years age category, accounting for approximately 35% of the total sample. Conversely, the proportion of respondents in the above 60 years age category was comparatively lower. Notably, all participants had received a formal education, with the prevailing highest educational qualifications being the completion of G.C.E O/L, followed by G.C.E A/L. Regarding occupation, a substantial portion of respondents in both groups identified farming, particularly crop cultivation, as their primary occupation.

The selected sample consisted of different family sizes, and the findings revealed that a substantial majority (63% overall) consisted of three or four members. To differentiate between agricultural and non-agricultural households, the analysis classified them as farm families and non-farm families respectively, with crop cultivation being the primary farming activity. Examining the income distribution among respondents, the highest proportion (35% of the total sample) fell within the LKR 31,000 - LKR 50,000 income category.

Among the respondents, the majority of households have a home garden with a size of 0.5 acres or smaller and is owned by a single individual. Nearly all households (93%) had at least one mango plant in their home garden, with various varieties such as *Karutha colomban*, *Willard*, and *Kohuamba*. A higher percentage (41%) of the households bring their harvest to the market which is located within 10 km. Furthermore, a significant portion (37%) of households transported their produce to the renowned Dambulla Dedicated Economic Center. Additionally, they bring their harvest to other markets such as *Thirappane, Eppawala, Maradankadawala, Gonapathirawa*, and *Thamuththegama*.

The primary sources of extension services for the respondents were the Agrarian Service Center and the Department of Agriculture. However, it is concerning that a majority of them did not receive adequate extension services. Interestingly, over half of the sample (54%) expressed a strong preference for engaging in commercial mango cultivation specifically using the *TomEJC* cultivar. This preference was significantly influenced by the provision of information pertaining to this particular cultivar.

Average WTP for TomEJC planting materials using results of the experimental auction.

The average WTP was determined by analyzing the bid values provided by the participants. The bid values were collected from two distinct groups: the "with prior information" group and the "without prior information" group. The range of bid values spanned from LKR 50 to LKR 750. Participants who did not submit any bids during the auction were excluded from the calculation of the average bid value. Among the remaining participants, the minimum bid value observed in the group without prior information was LKR 50, whereas in the group with prior information, it was LKR 100. Conversely, the maximum bid value recorded in the group without prior information was LKR 500, while in the group with prior information, it reached LKR 750.

Table 2 presents the summary statistics of bids placed for *TomEJC* planting materials in two groups: the information provided group and the control group. The mean bids differed between the treatment group (information provided) and the control group.

Table 2: Summary statistics of bids for *TomEJC* planting materials.

Summary statistics	Without information	With information	Combined
Mean bid (LKR)	213.72	365.34	287.03
Std. dev.	100.83	170.77	157.91
Maximum bid (LKR)	500	750	750
Minimum bid (LKR)	50	100	50
No.of Observations	47	44	91

Factors affecting participation decision and WTP

The results obtained from the multiple empirical specifications such as OLS, Tobit, and Heckman model are used to identify the factors affecting participation decision and WTP. To determine the factors influencing the bids, OLS regression analysis was conducted initially. The regression results, presented in Table 3, indicated that several variables significantly influenced the farmers' WTP for quality planting materials. At 5% significant level, information provision, type of household, average monthly income, and the preference to initiate commercial mango cultivation exhibited a positive relationship with the farmers' WTP.

Additionally, extension services had a significant influence on WTP at 10% significant level. On the other hand, variables such as level of education, family size, size of the home garden, mango availability, and average distance to the market did not demonstrate any significant impact on the farmers' WTP, according to the model.

The tobit model was also estimated to identify the factors that influence the bids in the study. This Tobit model was employed due to zero values have been placed by several participants who were not willing to buy mango planting materials. The Tobit regression results (Table 3) revealed that the farmers' WTP for quality mango planting materials is significantly influenced by information provision, type of household, average monthly income, and the preference for initiating commercial mango cultivation at 5% significant level while extension services and family size at 10% significant level. Those variables showed a positive relationship with farmers' WTP for quality planting materials. However, variables such as level of education, size of the home garden, mango availability, and average distance to the market did not exhibit any significant influence on WTP, according to this model.

Table 3: Results of OLS regression and Tobit regression

Variable	OLS Regression Coefficient (Std. Err)	Tobit Regression Coefficient (Std. Err)
Information provision	94.15** (32.38)	84.32** (35.52)
Household Characteristics		
- Education level	5.47 (20.62)	12.04 (22.9)
- Family size	20.05 (13.24)	24.84* (14.9)
- Type of household	64.32** (31.71)	80.43** (35.02)
- Average monthly income	48.21** (15.32)	58.35** (16.99)
Farm Characteristics		
- Size of home garden	3.72 (22.64)	2.21 (24.87)
- Mango availability in home garden	78.21 (65.54)	101.93 (74.53)
Average distance to the market	−0.89 (0.82)	−1.12 (0.89)
Extension services	59.02* (31.4)	68.91** (34.23)
Preference for initiate commercial cultivation	66.88** (33.16)	93.84** (36.05)

R- Squared	0.3163	0.0337 (Pseudo)
No.of observations	107	107
Left-censored observations		16
Uncensored observations		91

** and * indicate statistically significant at 5% and 10%, respectively

The first stage results of the Heckman model (Table 4) indicated that the participation decision is positively and significantly influenced by education level, and preference to initiate commercial cultivation using *TomEJC* cultivar at 5% significant level. Additionally, the type of household and mango availability in the home garden positively and significantly influenced participation decisions at 10% significant level.

Moving to the second stage of the model, the results revealed that information provision and the average monthly income of the household had a positive and significant relationship with the farmers' WTP for quality mango planting materials at 5% significant level. However, the preference to initiate commercial mango cultivation showed a negative and significant association with farmer WTP at 10% significant level. Conversely, variables such as family size, size of the home garden, the average distance to the market, and extension services did not demonstrate any significant influence on either the participation decision or WTP according to this model.

Table 4: Heckman selection model two-stage estimates results of WTP

	Participation Decision		**Willingness-to-pay**	
Factors	**Coefficients**	**Standard Error**	**Coefficients**	**Standard Error**
Information provision	–	–	154.37**	30.16
Education level	0.59**	0.25	–	–
Family size	–	–	9.48	14.14
Type of household	0.81*	0.42	17.86	33.19
Average monthly income	–	–	37.1**	14.09

Size of home garden	−0.03	0.27	–	–
Mango availability in home garden	1.37*	0.76	–	–
Average distance to the market	−0.01	0.01	–	–
Extension services	0.39	0.41	–	–
Preference for initiate commercial cultivation	1.9**	0.53	−77.46*	45.57
Mills | lambda rho	−148.63* −1	83.87		

** and * indicate statistically significant at 5% and 10%, respectively; Wald $\chi 2$ (5) = 37.46; Censored observations = 16; Uncensored observations = 91; Probability > $\chi 2$ = 0.000.

DISCUSSION

WTP estimates the amount of money that individuals would give up in order to purchase quality mango planting materials. This may be helping to decide the appropriate pricing strategy. Specifically, the inclusion of information resulted in higher maximum and minimum bids, indicating a clear relationship between information provision and WTP. These results confirm the findings of Channa *et al*., (2019).

The results showed that the mean bid for the group without information provision was LKR 213.72, whereas the mean bid for the group with information provision was significantly higher at LKR 365.34. When combining both groups, the overall average WTP for the planting materials was LKR 287.03. These findings suggest that farmers who received information about the new technology had a greater WTP compared to those without access to such information. Therefore, it underscores the importance of raising awareness and disseminating information about the new technology as an initial step in promoting its adoption. By increasing

farmers' knowledge and understanding of the benefits associated with the new technology, it is more likely that they will place higher value and be willing to invest in the *TomEJC* mango planting materials.

The findings from the OLS and Tobit regression models, it is evident that the variables namely, education level, size of the home garden, mango availability, and average distance to the market, do not exhibit a significant influence on the willingness-to-pay (WTP) for quality planting materials in either model. In those two models, the same set of variables has a significant impact on the WTP for planting materials. However, a notable distinction between the two models arises regarding family size. In the Tobit model, family size demonstrates a positive and significant effect on WTP. This suggests that as the household size expands, the needs and decision-making dynamics within the family become more influential. Family members' perspectives and preferences are likely taken into account when making decisions about WTP. Moreover, larger households may possess a greater availability of labor, which can alleviate labor constraints and consequently impact the WTP.

By providing information on cultivation techniques and market aspects of the new cultivar, households become more aware of the significance of acquiring such planting materials. This heightened awareness can positively impact their willingness to pay a higher price for these materials. Farm families, who are actively engaged in crop cultivation, possess firsthand knowledge of the profitability and importance of using high-quality planting materials. As a result, they are more inclined to allocate a larger budget for purchasing such materials compared to non-farm families. This inclination can stem from their own experiences in recognizing the value and benefits associated with quality planting materials.

Moreover, households with higher average monthly incomes generally have greater purchasing power. Consequently, they may be more inclined to invest a larger amount of money in acquiring the quality planting materials they desire.

Households that are aware of the availability of reliable extension services, which offer essential knowledge and support following the purchase of quality planting materials, are more likely to exhibit a higher willingness to pay (WTP). The existence of such extension services acts as a guarantee for households, assuring them of the assistance they will receive after acquiring the planting materials. Consequently, they are more inclined to pay a higher amount and proceed with the purchase.

Furthermore, the preference to engage in commercial mango cultivation demonstrates a positive and significant relationship with WTP. This preference reflects the curiosity and interest of households in adopting this new cultivar. Not only does it increase their WTP, but it also serves as an incentive for them to embrace the new cultivar by investing in quality planting materials.

The results obtained from the Heckman two-stage selection econometric model (Table 4) indicate the presence of sample selectivity bias, as evidenced by the statistically significant Inverse Mills Ratio (IMR). The result shows Lambda (IMR) or selectivity bias correction factor has a negative impact on WTP. The negative sign of the IMR shows that there are unobserved factors that are negatively affecting both participation decisions and WTP. Moreover, rho is negative, which indicates that unobservable factors are negatively correlated with one another.

Farm households with higher levels of education are more likely to participate in the adoption of improved planting materials compared to those with lower levels of education. This is likely because educated households have better access to market information, enabling them to make informed decisions. Being a farm family also positively influences participation, potentially due to the experience and diversification strategies employed by farmers to increase their income. These results confirm the findings of Mastenbroek *et al.* (2021), Morgan *et al.* (2020), Ayenew *et al*. (2020), and Asrat *et al*. (2010) on the influence of household and education level on participation or the adoption decision.

Additionally, if farmers have encountered issues with their current cultivar, they are more inclined to adopt a new cultivar. This highlights the impact of previous experiences on participation decisions. Similarly, the presence of mango trees in the home garden has a positive and significant effect on participation decisions. Households with existing mango trees are familiar with market information related to mangoes and may increase their cultivation to maximize profits. However, if there is a low demand for the existing mango variety, they may be motivated to adopt a new cultivar.

The preference to engage in commercial mango cultivation plays a crucial role in the decision-making process for smallholder farmers. These entrepreneurs prioritize gathering market and cultivation-related information and are more likely to participate in comparatively non-preferred households. This supports the notion that risk attitudes can play a significant role in shaping economic decisions. Therefore, it confirms the findings of Elabed and Carter, (2015) related to the risk-taking behavior.

The provision of information has a positive and significant impact on the WTP for quality planting materials. When participants are provided with information about the cultivar, their knowledge and awareness increase, leading to a better understanding of the benefits and importance of using improved planting materials. This, in turn, influences bidders to place higher bids, as they are guided by the market information and other relevant details.

Participants with higher average monthly income tend to place significantly higher bids compared to those with lower incomes. The higher purchasing power of individuals with higher incomes allows them to be more willing to pay a premium for the planting materials they desire. Conversely, the preference to initiate commercial mango cultivation has a negative and significant effect on WTP. This could be attributed to entrepreneurs aiming to minimize their expenses, particularly when purchasing a large number of plants. They may be more focused on the unit price, leading to a lower WTP. These findings confirm the previous literature of Channa *et al.* (2019), Morgan *et al*. (2020), De Groote *et al.* (2014), and Higgins *et al*. (2020).

Among the three models analyzed, the Heckman model provides more generalizable results in terms of both the participation decision and WTP. This model takes into account the sample selectivity bias, providing more robust and reliable estimates. Therefore, the findings from the Heckman model can be considered more reliable for understanding the factors influencing participation decisions and WTP in the study.

CONCLUSIONS

This study makes a valuable contribution to our understanding of smallholder farmers' adoption of new technologies, particularly in the context of improved planting materials. It provides insights into the farmers' willingness to pay for these materials and identifies the factors that influence their decision to participate in the adoption process. It highlights that while farmers may be willing to adopt new technologies, it is crucial to provide them with the necessary information and awareness about the technology to ensure its successful implementation and maximize the benefits derived from it.

By confirming the factors that impact both the participation decision and the willingness to pay for improved planting materials, this study offers valuable guidance for policymakers and stakeholders involved in promoting and facilitating the adoption of new technologies among smallholder farmers. It underscores the significance of targeted awareness-building initiatives and the provision of relevant information to enhance the adoption process and ultimately improve agricultural practices and outcomes.

Based on the study findings, several practical recommendations can be made for those who are interested in establishing plant nurseries, particularly in the price determination process. It also guides for policymakers to make well-informed decisions and raise awareness, ultimately increasing the success rate of promoting new technologies. Further research is suggested to explore the differences in information provision mediums, such as text messages, audio messages, or video messages, and their impact on participants' decision-making and willingness to pay.

REFERENCES

Abeykoon, M.N.D.F., Weerahewa, J., Weligamage, P. and Silva, G.L.L.P., 2014. Willingness to pay for chicks of different indigenous chicken types: an application of experimental auctions. Tropical Agricultural Research, 26(1), pp.162-174.

Asrat, S., Yesuf, M., Carlsson, F. and Wale, E., 2010. Farmers' preferences for crop variety traits: Lessons for on-farm conservation and technology adoption. Ecological Economics, 69(12), pp.2394-2401.

Ayenew, W., Lakew, T. and Kristos, E.H., 2020. Agricultural technology adoption and its impact on smallholder farmers' welfare in Ethiopia. African Journal of Agricultural Research, 15(3), pp.431-445.

Becker, G.M., DeGroot, M.H. and Marschak, J., 1964. Measuring utility by a single-response sequential method. Behavioral science, 9(3), pp.226-232.

Breidert, C., Hahsler, M. and Reutterer, T., 2006. A review of methods for measuring willingness-to-pay. Innovative marketing, 2(4), pp.8-32.

Channa, H., Chen, A.Z., Pina, P., Ricker-Gilbert, J. and Stein, D., 2019. What drives smallholder farmers' willingness to pay for a new farm technology? Evidence from an experimental auction in Kenya. Food policy, 85, pp.64-71.

Chi, T.T.N. and Yamada, R., 2002. Factors affecting farmers' adoption of technologies in farming system: A case study in Omon district, Can Tho province, Mekong Delta. Omonrice, 10, pp.94-100.

Chonhenchob, V., Kamhangwong, D., Kruenate, J., Khongrat, K., Tangchantra, N., Wichai, U. and Singh, S.P., 2011. Preharvest bagging with wavelength-selective materials enhances

development and quality of mango (Mangifera indica L.) cv. Nam Dok Mai# 4. Journal of the Science of Food and Agriculture, 91(4), pp.664-671.

Coppinger, V.M., Smith, V.L. and Titus, J.A., 1980. Incentives and behavior in english, dutch and sealed-bid auctions. Economic inquiry, 18(1), pp.1-22.

De Groote, H., Chege, C.K., Tomlins, K. and Gunaratna, N.S., 2014. Combining experimental auctions with a modified home-use test to assess rural consumers' acceptance of quality protein maize, a biofortified crop. Food Quality and Preference, 38, pp.1-13.

Elabed, G. and Carter, M.R., 2015. Compound-risk aversion, ambiguity and the willingness to pay for microinsurance. Journal of Economic Behavior & Organization, 118, pp.150-166.

Fox, J.A., Shogren, J.F., Hayes, D.J. and Kliebenstein, J.B., 2019. Experimental auctions to measure willingness to pay for food safety. Valuing food safety and nutrition, pp.115-128.

Gbénou-Sissinto, E., Adegbola, Y.P., Biaou, G. and Zossou, R.C., 2018. Farmers' Willingness to Pay for New Storage Technologies for Maize in Northern and Central Benin. Sustainability, 10(8), p.2925.

Hanemann, M., Loomis, J. and Kanninen, B., 1991. Statistical efficiency of double-bounded dichotomous choice contingent valuation. American journal of agricultural economics, 73(4), pp.1255-1263.

Heckman, J.J., 1979. Sample selection bias as a specification error. Econometrica: Journal of the econometric society, pp.153-161.

Higgins, K., Hutchinson, W. G. and Longo, A. (2020) 'Willingness-to-Pay for Eco-Labelled Forest Products in Northern Ireland: An Experimental Auction Approach', Journal of Behavioral and Experimental Economics, 87(April), p. 101572. doi: 10.1016/j.socec.2020.101572.

Honja, T., 2014. Review of mango value chain in Ethiopia. Journal of Biology, Agriculture and Healthcare, 4(25), pp.230-239.

Jain, R., Arora, A. and Raju, S.S., 2009. A novel adoption index of selected agricultural technologies: Linkages with infrastructure and productivity. Agricultural Economics Research Review, 22(1), pp.109-120.

Kanninen, B.J., 1993. Optimal experimental design for double-bounded dichotomous choice contingent valuation. Land Economics, pp.138-146.

Kinyangi, A.A., 2014. Factors influencing the adoption of agricultural technology among smallholder farmers in Kakamega north sub-county, Kenya (Doctoral dissertation, University of Nairobi).

Lavison, R.K., 2013. Factors influencing the adoption of organic fertilizers in vegetable production in Accra (Doctoral dissertation, University of Ghana).

Loevinsohn, M., Sumberg, J. and Diagne, A., 2013. Under what circumstances and conditions does adoption of technology result in increased agricultural productivity? Protocol. London EPPI Centre, Social Science Research Unit.

Louviere, J.J., Hensher, D.A. and Swait, J.D., 2000. Stated choice methods: analysis and applications. Cambridge university press.

Lusk, J.L., Shogren, J.F., 2007. Experimental Auctions: Methods and Applications in Economic and Marketing research. Cambridge Universal Press, Cambridge.

Mastenbroek, A., Sirutyte, I. and Sparrow, R., 2021. Information Barriers to Adoption of Agricultural Technologies: Willingness to Pay for Certified Seed of an Open Pollinated Maize Variety in Northern Uganda. Journal of Agricultural Economics, 72(1), pp.180-201.

Morgan, S.N., Mason, N.M. and Maredia, M.K., 2020. Lead-farmer extension and smallholder valuation of new agricultural technologies in Tanzania. Food Policy, 97, p.101955.

Orden, M.E.M., 2004. Economic Effects of Pruning and Bagging Technologies in Mango Production in Selected Major Producing Areas in the Philippines. Current Applied Science and Technology, 4(1), pp.216-237.

Pasa, R.B., 2017. Technological Intervention in Agriculture Development. Nepalese Journal of Development and Rural Studies, 14(1-2), pp.86-97.

Peiris, K.H.S., 2016. The mango in the Democratic Socialist Republic of Sri Lanka, in book: Mango Tree Encyclopedia (pp.337-370) Chapter: 19

Sennuga, S.O., Baines, R.N., Conway, J.S. and Angba, C.W., 2020. Awareness and Adoption of Good Agricultural Practices among Smallholder Farmers in relation to the Adopted Villages

programme: The Case Study of Northern Nigeria. Journal of Biology, Agriculture and Healthcare, 10(6), pp.34-49.

Shogren, J.F., Margolis, M., Koo, C. and List, J.A., 2001. A random nth-price auction. Journal of economic behavior & organization, 46(4), pp.409-421.

Vickrey, W., 1961. Counterspeculation, auctions, and competitive sealed tenders. The Journal of finance, 16(1), pp.8-37.

Waldman, K.B., Kerr, J.M. and Isaacs, K.B., 2014. Combining participatory crop trials and experimental auctions to estimate farmer preferences for improved common bean in Rwanda. Food Policy, 46, pp.183-192.

Yue, C., Zhao, S., Gallardo, K., McCracken, V., Luby, J. and McFerson, J., 2017. US growers' willingness to pay for improvement in rosaceous fruit traits. Agricultural and Resource Economics Review, 46(1), pp.103-122.

ACKNOWLEDGEMENT

This work was financially supported by the project grant of ACIAR of the program titled Developing food loss reduction through smart business practices into mango and tomato value chains in Pakistan and Sri Lanka.