Seedling choices of perennial crops: The role of subjective belief of yield and risk behaviours

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Abstract

Seedling variety choice is one of the most important steps for perennial crop farmers as it is a key component of farm profitability over the long-term. Certified seedling varieties have become more common in recent years in developing country areas as a response to concerns about low-quality seedling and an increasing amount of climate variability for which new certified varieties may provide increased resilience. However, the adoption rate of certified seedling varieties in developing countries is generally low. Given the long-lived nature of such investments and the high level of uncertainty regarding both the climate to which they will be exposed as mature trees and the quality of the seedling there are clear linkages to farmers' subjective belief regarding yields differential between certified and uncertified seedling, their time and risk preferences. We consider these aspects using a recently developed survey-based toll for measuring risk and time preferences and link those to stated preferences and observations on the adoption of certified seedlings. Results show that there are differences in subjective belief of yield which strongly associated with the non-adopter farmers' intention to adopt. Time preferences play a role in adopter farmers' intention, but risk preferences do not significantly related to adoption behaviours.

JEL code: Q12, Q16

Keywords: risk behaviours; certified seedling; perennial crop; subjective belief, adoption

1. Introduction

Small-scale farmers in developing countries are vulnerable to a range of agricultural shocks, of which those associated with climate change risk are major emergent concerns. This vulnerability might be larger for those who are involved with perennial crops, which are characterised as investments with a long return period and high upfront investment cost (Zuo, Nauges et al., 2014; Adamson, Loch et al., 2017; Gunathilaka, Smart et al., 2018). With a long economic lifespan, these cropping regimes will likely be more affected by the risks to future weather outcomes driven by climate change (Lobell, Field et al., 2006; Lobell and Field, 2011; Adamson, Loch et al., 2017). Even though the farming practices, in general, are dynamic so that farmers will adapt to evolving climate condition to optimize their production (D'Agostino and Schlenker, 2016), perennial crops have less opportunities for crop switching to suit the crop types with particular climate condition due to a large irreversible investment in the farming system (Gunathilaka, Smart et al., 2018). Also, climate change issues are more challenging for the perennial crop farmers (Zuo, Nauges et al., 2014; Menapace, Colson et al., 2015) because these crops are typically planted in rain-fed land with lower irrigation support (Gunathilaka, Smart et al., 2018).

As the adaptation strategies to the climate issues, adjustment in farm management practices in the form of modifying existing methods or applying new technologies are often suggested (e.g., Quiggin, Adamson et al., 2010; Huang, Wang et al., 2015; Chavas, 2018). The use of improved varieties is one of the most popular recommendations for the risk-reducing strategies (e.g., Truelove, Carrico et al., 2015; Holden and Quiggin, 2016; Burnham and Ma, 2018; Nigussie, van der Werf et al., 2018) which mainly offer the advantages in term of better productivity, quality, resistance to pest and disease and adaptability to a certain climate shocks (Ellis, 1992; Doss and Morris, 2000). Yet, the potential advantages could be only obtained from high-quality seedling, where the certification process is normally used as a quality control assurance system. In the process, the seedling should meet four key attributes (genetic, physical, physiological and health quality) which can be achieved through the obedience to a series of technical procedures and regulations (McDonald, 1998; Gastel, Gregg et al., 2002; Bishaw, Niane et al., 2007). However, those strict procedures could increase the production cost of the certified seedling drastically. As the consequence, the certified seedling price becomes more expensive and farmers may seek an alternative by using the uncertified seedling[1] from 'informal sectors' which typically do not guarantee the quality of the seedling (Cavatassi, Lipper et al., 2011; Larsen, 2019). Especially for perennial crops which have a lengthy pre-harvesting phase (Gunathilaka, Smart et al., 2018), it could place the farmers in a risky situation because low quality of seedling might cause the seedling failures which sometimes could only be detected after couple years and has been spent costly investment.

Given the importance of using certified seedling for the perennial crop farmers, this paper examines the farmers' choices of the citrus seedling types. The farmers' decision to choose the certified or uncertified seedling could be considered as an adoption decision which has been widely analysed in a growing body of literature. Yet, the assessment of the issue remains challenging. First, farmers choices of crop seeds/seedlings or varieties are often only attributed to social-economic factors and institutional issues (e.g, Abebaw and Haile, 2013;

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[1] In this study, we differentiate the term of improved variety and certified seedling. Improved variety is a crop variety which resulted by scientific breeding research programs. While certified seedling is the seedling of improved variety which has followed the recommended procedures in the multiplication process (e.g., purity of the variety (rootstock and scion), free from pest and disease, etc.) and been certified by the seed supervisory authority.

Truelove, Carrico et al., 2015), as well as risk preferences (e.g., Menapace, Colson et al., 2012; Wossen, Berger et al., 2015; Gong, Baylis et al., 2016). In a risky or uncertain environment, however, farmers decision might be associated with their expectation of the outcomes about the seedling types as a motivational factor in their decision (Grisley and Kellogg, 1983; Ajzen, 1991; Nguyen-Van, Poiraud et al., 2017) which is barely considered in previous studies. Second, the literature mostly focus on annual crops where seed or variety choices might not be considered as a long-term investment decision (e.g., Truelove, Carrico et al., 2015; Holden and Quiggin, 2016; Burnham and Ma, 2018; Nigussie, van der Werf et al., 2018), so the farmers time preferences are barely examined of its association with the adoption behaviours. Also, the decision-making process regarding the long-term commitment of land use for the crops might depend on other risk behaviours (Miao and Khanna, 2017), such as subjective risk perceptions to the environmental shocks (i.e. climate change). Third, since the perennial crops have a long lifecycle, the dynamic of seedling use, such as adoption and dis-adoption behaviours, is relatively difficult to be analysed.

Developing these challenges, we seek to gain new insights on small-scale citrus farmers' decision making and its relationship with their risk behaviours and climate change issues. We applied a set of the framed field experiment to small-scale citrus farmers in East Java, Indonesia. The survey sites are noticeably affected by climate change issues so that the farmers are particularly vulnerable to the issues. Also, in order to promote the using of the certified seedling and to help the government or related industries for the policy design, we also pay specific attention to the role of extension and advisory services in the certified seedling adoption behaviours.

This paper structured as follows. We present the research method in the next section. Section 3 presents the empirical data and followed by the econometric approach in section 4. Section 5 provides the result of the empirical analysis and the discussion of the finding is presented in section 6, followed by a conclusion in section 7.

2. Methods

We conducted a series of choice experiment to elicit the farmer's risk preference, time preference and subjective belief of yield for certified and uncertified citrus seedling. Risk and time preferences were elicited through a hypothetical multiple price list (MPL) experiment and self-assessments (willingness to take risks and willingness to give up something today) which developed based on Falk, Becker et al. (2016) (See supplementary materials for more details)

[2]. Following Falk, Becker et al. (2018) and Falk and Hermle (2018), risk and time preferences are calculated based on the weighted of MPL and self-assessment which obtained from the regression coefficients of observed choices in the experimental validation on the respective survey items as follows:

$$\textit{Risk preferences} = 0.4729985 \times \textit{Staircase risk} + 0.5270015 \times \textit{Willingness to take risks} \quad (1)$$

$$\textit{Time preferences} = 0.7115185 \times \textit{Staircase patience} + 0.2884815 \times \textit{Willingness to give up something today} \quad (2)$$

We measured the farmer's subjective belief of yield for certified and uncertified citrus variety seedling[3] which modified from the seed game by Smith and Mandac (1995); Barham, Chavas et al. (2015). In the seedling games, we asked the farmers to allocate ten tokens to each box showed the different level of the possible yield of certified and uncertified seedlings based on how much chance they think to get the yield that they can expect from each seedling type (See supplementary materials for more details). Then we calculate the farmer's subjective belief of yield for each seedling type as follows:

$$SBY_x = \sum_{i=1}^{n} p_{xi}\bar{u}_{xi} \quad (3)$$

where SBY_x is farmer's subjective belief for each seedling types, and p_{xi} is the chance/probability for a range level of citrus yields (u_{xi}).

In order to understand the role of climate risk perception on the seedling choices, we calculated the risk perception index (RPI) of climate events (increasing air temperature, dry season period and rainy season period). The RPIs are calculated as a simple mean of the two elements of risk perception (perceived likelihood of climate change event types and perceived severity of outcome of specific climate change events on citrus farming, each element is measured in 5-scale of Likert).

[2] In the real experiment, following Miyata (2003) and Falk, Becker et al. (2016), we avoided to use the "lottery" term because gambling activities is illegal and prohibited in the most culture and religious affiliation in the survey site. Practically, our enumerators explained to the respondents that the experiments are the scientific method to elicit the behavioural toward risk.

[3] In the seedling games, farmers had to compare their subjective belief of yield of certified and uncertified seedling for the same citrus cultivar. For example, if the games for certified seedling is using "Keprok" cultivars, then the games for uncertified seedling must be "Keprok" cultivars.

3. Empirical data

3.1. Descriptive statistics

We use primary household and plot-level data from citrus farming[4] households survey and experiments in 3 districts (Banyuwangi, Jember and Malang), East Java Province, Indonesia. This province is one of citrus production centre which has a fast-growing and high adoption rate including small-scale farmers so that very important for rural development (Pusdatin, 2015). We conducted the survey and experiments to 500 citrus households from September - October 2017.

Among the 500 citrus households, only 24.6 percent of them adopt certified citrus variety seedling which implies that the majority of our sample have never used the certified seedling yet. Table 1 presents the variation between the two groups with respect to the household characteristics, agricultural assets and farmer support systems. Certified seedling adopters have significantly a lower experience in citrus farming which implies that the new-comer in citrus tends to adopt the certified seedling. Adopter groups have higher household members which might provide more household labour for citrus farming. This group also have higher income both form citrus farming and other sources. The average age and education of the sample were 53.35 and 7.5 years, respectively, and was not statistically different between the groups.

We also asked the respondents whether they plan to use the certified seedling for the next planting period. We found that 41.8 percent of the respondents plan to adopt certified seedling. However, only 37.14 percent of non-adopters plan to use the certified seedling. On the other hand, 43.9 percent of the adopters do not plan to use the certified seedling in their next planting periods. This phenomena then we analyse to assess the determinant of farmers planning/intention in the use of type of seedling by creating new variable in four categories: certified-certified (CC) for who are using the certified seedling and plan to use certified seedling, certified-uncertified (CU) for who are using the certified seedling and do not plan to use certified seedling, uncertified-uncertified (UU) for who are using the uncertified seedling and do not plan to use certified seedling, and uncertified-certified (UC) for who are using the uncertified seedling and plan to use certified seedling. The data distribution regarding the planning categories is shown in Table 2.

[4] We define a citrus farmer as a household who manage at least 25 citrus trees, following National Statistic Agency (BPS)'s definition.

Table 1. Descriptive statistics of certified seedling adopters and non-adopters

Variables	Description	Total		Adopter		Non-adopter		Sig.
		Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	
No. observation		500		123		377		
Household Characteristics								
Gender	Dummy: 1 if head of household is male	0.974	-	0.992	-	0.968	-	
Age	Age of the head of household (year)	53.352	11.125	53.520	11.621	53.297	10.974	
Experience	Experience in citrus farming (year)	15.010	10.224	12.374	10.426	15.870	10.022	***
Education	Formal education completed (year)	7.552	4.036	7.301	4.145	7.634	4.002	
HH size	Number of household member (person)	3.870	1.477	4.114	1.494	3.790	1.465	**
Citrus income	Income from citrus farming in a year (million IDR)	17.259	34.128	21.586	39.135	15.848	32.260	*
Total income	Total income in a year (million IDR)	63.156	68.676	73.602	73.298	59.748	66.848	**
Agricultural assets								
Land	Ownership of agricultural land (hectare)	1.077	2.374	1.060	1.566	1.082	2.585	
Citrus	Ownership of citrus (trees)	393.622	403.176	447.602	349.484	376.011	418.129	**
Generator	Ownership of generator (unit)	0.102	0.309	0.130	0.338	0.093	0.300	
Farmer support system								
Mobile-phone	Dummy: 1 if had mobile-phone	0.940	-	0.935	-	0.942	-	
Internet	Dummy: 1 if had access to internet	0.648	-	0.691	-	0.634	-	
Direct access	Dummy: 1 if had direct access to gov. authority to ask about citrus	0.218	-	0.195	-	0.225	-	
Training	Dummy: 1 if attended citrus training	0.056	-	0.122	-	0.034	-	***
Extension	Dummy: 1 if attended citrus extension	0.212	-	0.333	-	0.172	-	***
Climate	Dummy: 1 if attended climate extension	0.054	-	0.098	-	0.040	-	**
Farmers group	Dummy: 1 if part of citrus farmers group	0.160	-	0.301	-	0.114	-	***
Cooperative	Dummy: 1 if part of cooperative	0.056	-	0.073	-	0.050	-	
Citrus credit	Dummy: 1 if had citrus credit	0.266	-	0.260	-	0.268	-	
Citrus info	Dummy: 1 if citrus technology information source was other farmers	0.750	-	0.626	-	0.790	-	***
Climate info	Dummy: 1 if farmers had no climate information source	0.614	-	0.553	-	0.634	-	

Note: ‘*’, ‘**’, ‘***’ significant at 10%, 5%, and 1% probability level, respectively, computed by a two-sided *t*-test for continuous variables and chi2 test for dummy variables

Table 2. Distribution of farmers planning to use the type of seedling

Seedling type planning	Frequency	Percent	Cumulative
Certified-certified (CC)	69	13.80	13.80
Certified-uncertified (CU)	54	10.80	24.60
Uncertified-certified (UC)	140	28.00	52.60
Uncertified-uncertified (CU)	237	47.40	100.00

3.2. Risk and time preferences

Figure *1* displays the distribution of risk preferences. Even though we had considered the linguistic structure to adjust with the respondent's religious affiliation as also suggested by Falk, Becker et al. (2018), two of our respondents refused to participate in the experiments because of the religious reasons. This situation was also happened in other risks experiment studies such as Uganda (Ubfal, 2016) and Indonesia (Miyata, 2003; Goldbach and Schlüter, 2018). In line with previous studies (e.g., Gong, Baylis et al., 2016; Fischer and Wollni, 2018), we find that the majority of our respondent farmers could be categorised as risk-averse. Figure 2 shows the distribution of the citrus farmer’s time preferences where the lowest level of time preferences indicate the highest patience levels of the farmers for delayed payment, vice versa. Most of our respondents could be categorised as least patient for future payments which imply that the farmers are more likely to prefer a high discount rate for the payment in the future. This finding indicates that they had a low willingness to invest more money for a higher payment in the future. In term of the adoption of certified seedling, the lower patience might cause the lower adoption of the certified seedling which has a higher price.

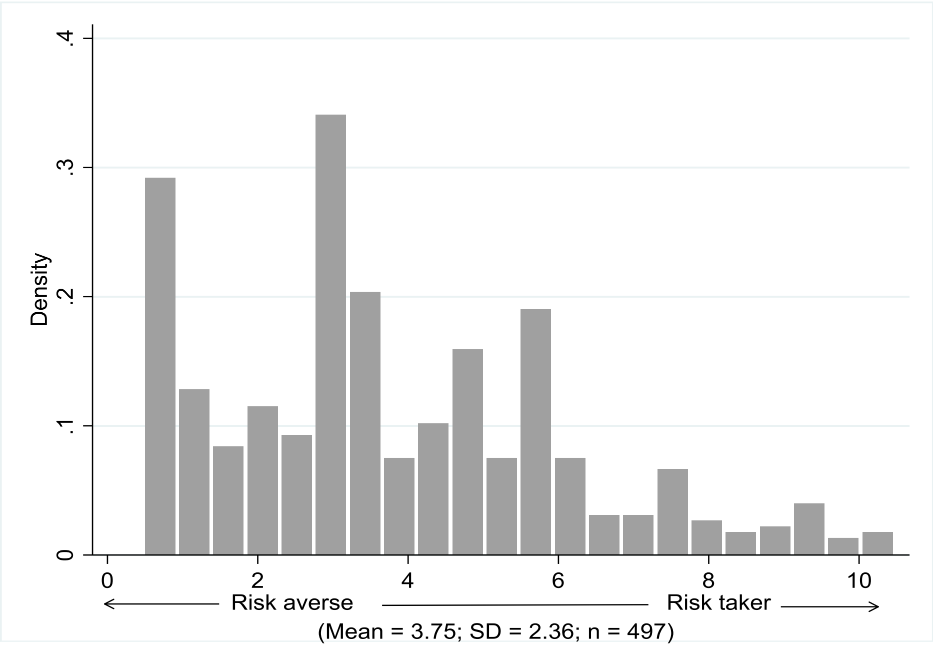

Figure 1. Distribution of the farmer's risk preferences

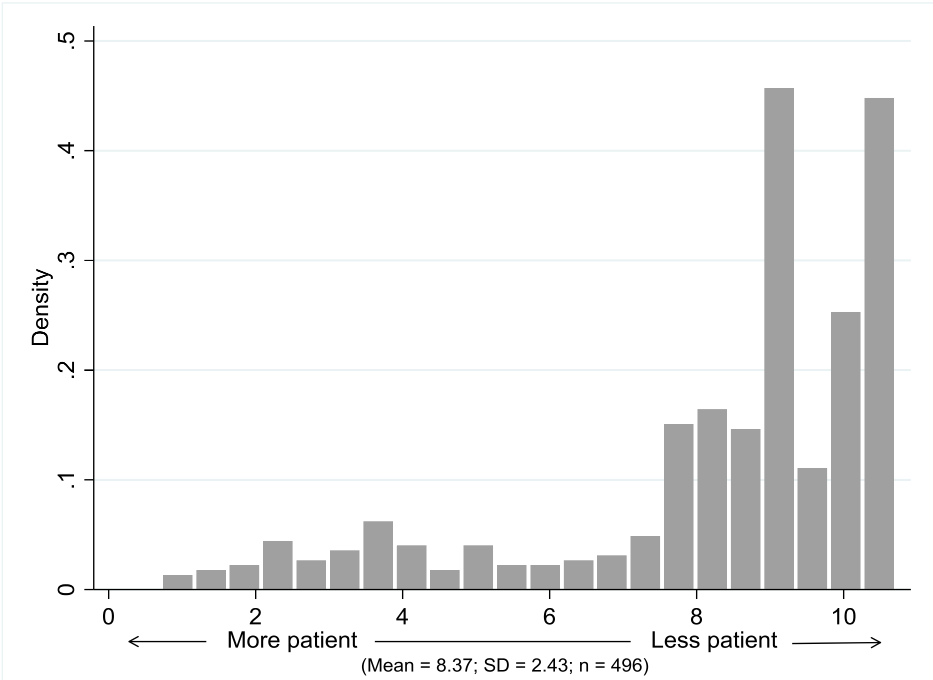

Figure 2. Distribution of the farmer's time preferences

3.3. Subjective believe of yield

In the seedling games, 12 of the respondents refused to participate in the games, especially with the certified seedling game because they have no idea with the type of seedling since they never know about the seedling. Figure 3 shows the distribution of farmers' subjective belief of yield for certified and uncertified citrus variety seedling. Based on paired t-test, we find that certified seedling was believed significantly to have a higher yield than an uncertified seedling. The mean of subjective belief of yield for certified seedling was 6.68 ton/ha, while the uncertified seedling was 6.20 ton/ha.

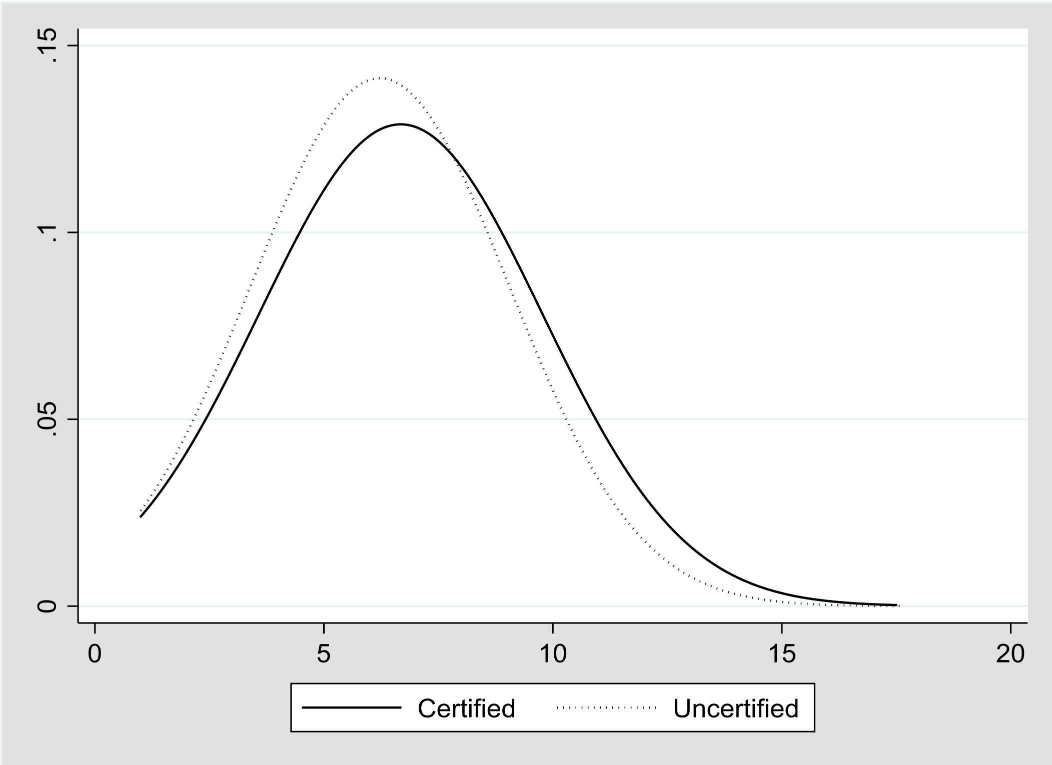

Figure 3. The normal distribution of respondents' subjective belief of yield for certified and uncertified citrus seedlings

3.4. Climate risk perception index

Figure 4 shows the citrus farmers RPI for three climate change events. The RPI of increasing rainy season period is the highest amongst others, but only statistically higher than increasing dry season period. The RPI of increasing rainy season period was 2.46, increasing dry season period was 2.31 and increasing air temperature was 2.37. Since the value of the RPIs was higher than 2, the three climate events are perceived as high risks, particularly related to citrus farming. Figure 4 also indicates that the RPIs was dominantly constructed by the farmers' perceived impact of the climate change events on citrus farming.

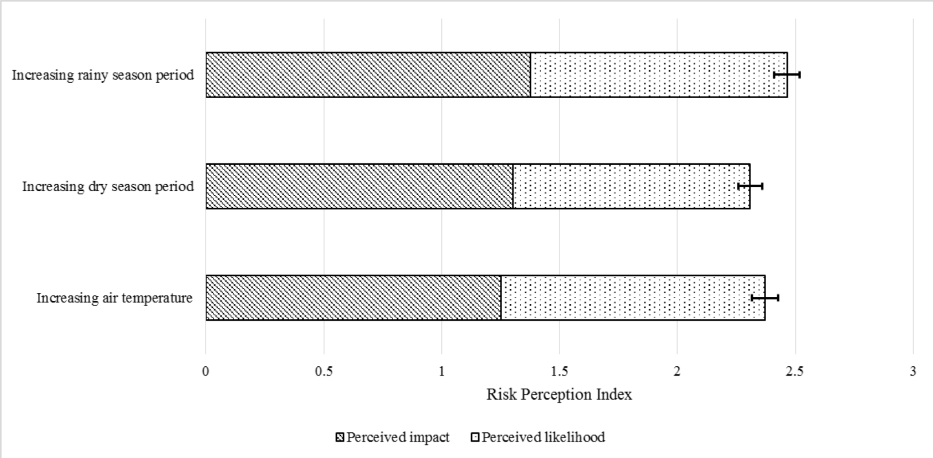

Figure 4. Risk perception index of climate change events

4. *Econometric approach*

We assumed that the farm households would consider using certified citrus seedling with the expectation of higher benefit compared with the uncertified seedling which could be in the form of higher yield and/or reduce cost (e.g., more resistance to pest/disease and climate shocks. Hence, following Di Falco, Adinolfi et al. (2014) and Wossen, Berger et al. (2015), the certified seedling choice could be framed with the standard theory of technology adoption, so that could be estimated by using a probit model specification:

$$Y_i^* = \beta_0 + \beta_1 X_i + \beta_2 W_i + \beta_3 Z_i + \mu_i \quad (4)$$

where Y_i^* is a latent variable which the estimation is based on the observed decision of the farmers whether they used certified citrus variety seedling or not. X_i includes household characteristics, assets, institutional and social capital variables, W_i includes risk and time preferences, and climate risk perception, and Z_i covers the subjective belief of certified and uncertified citrus variety seedling.

As we used the social capital variables in the model which largely considered to cause an endogeneity issue (Wossen, Berger et al., 2015; Wuepper, Yesigat Ayenew et al., 2018), hence we controlled for the endogeneity problem by using instrumental variables probit (ivprobit) regression model. We addressed the farmer's direct access to the government authority to ask about citrus as a social capital variable which is considered to be endogenous (Wossen, Berger et al., 2015; Wuepper, Yesigat Ayenew et al., 2018). Since neighbour networking potentially affect the farmer's behaviours (Aida, 2018), following Andersson, Chege et al. (2015), we used the neighbour direct access rate as the instrument. We calculated the neighbour direct access rate as:

$$A_i = \begin{cases} \frac{B_i - 1}{C_i - 1}, \ if\ respondent\ i\ had\ a\ direct\ access \\ \frac{B_i}{C_i - 1}, \ if\ respondent\ i\ had\ no\ a\ direct\ access \end{cases} \quad (5)$$

where A_i is neighbour direct access rate, B_i is total sampled farmers in the same village who had a direct access to government authority, and C_i is total sample in the village. Hence, the determinant of direct access could be specified as follows:

$$X_{i1} = \alpha_0 + \alpha_1 W_i + \alpha_2 Z_i + \alpha_3 A_i + \varepsilon_i \quad (6)$$

where X_{i1} is direct access variable as a part of social capital, and A_i is a vector of instruments that are correlated with the direct access, but not with the error term of the model of certified seed adoption as shown in Eq. (4). Given the direct access variable was measured as a binary variable, following Wossen, Berger et al. (2015), we use 2SLS method to estimate the Eq. (7) with a probit specification. With this approach, we first ran the Eq. (7) in the first stage, then used the residual from Eq. (7) to address the endogeneity to the main model (Eq. (4)), so that the endogeneity correction model is specified as follows:

$$Y_i^* = \beta_0 + \beta_1 X_i + \beta_2 W_i + \beta_3 Z_i + \beta_4 R_i + \mu_i \quad (7)$$

where R_i is a vector of residual obtained from Eq. (6).

In order to understand the dynamic of certified/uncertified seedling use, we assess the farmer's intention/planning to use the certified seedling in their next planting period by applying a multinomial logit model. As presented in Table 2, there are four alternatives which indicate the mutually exclusive choice of farmer's intention to use the certified seedling or not. In our analysis, farmer i has an intention among the four alternatives: (1) CC, (2) CU, (3) UC, and (4) UU. Then, the probability of farmer i chosing alternatives j (P_{ij}) will be:

$$P_{ij} = \frac{e^{x_i' \beta_j}}{\sum_{l=1}^{4} e^{x_i' \beta_l}}, \qquad j = 1, \dots, 4 \quad (8)$$

Following Nguyen-Van, Poiraud et al. (2017), we also applied the two-step analysis to test the endogeneity for the multinomial logit model by using the instrument used in the probit model (Eq. (6)). For the analysis, we focus on the marginal effect of the multinomial logit model to understand the choice probabilities of a change in the explanatory variables for a given individual.

5. *Results*

Table 3 shows the econometric estimation of explanatory variables on the certified seedling adoption in the household (HH) and plot levels. Due to missing values for some variable, the sample size for the model in HH levels is 487. Since the citrus farmers mostly had more than one citrus plot, the sample size of the model in plot levels achieves 1,009. The Wald tests of the exogeneity of the instrumented variables are not significant for certified seedling adoption model in HH levels (P-value = 0.12), but significant in plot levels (P-value = 0.02). It implies that there is no adequate information for endogeneity issue of the adoption model in HH levels, so that the standard probit model may be appropriate to estimate the adoption models in this level. However, for the plot levels, the issue exists, thus it suggests to use the ivprobit for the model estimation.

The results show that the adoption of certified citrus variety seedling in HH levels seems likely not associated with the farmers' risk behaviour as well as their subjective belief of the yield of the certified/uncertified seedling. Social capital variables such as direct access to government authority and citrus technology information sources had a negative and significant relationship with the adoption. It means that if the farmer had direct access, the probability to adopt the certified seedling was lower. Moreover, a farmer who obtained citrus information technology from other farmers as a farmer to farmer extension might have a lower probability to use certified seedlings.

In plot levels, the RPI of increasing dry season period and increasing rainy season period had significant relationships with the adoption of certified citrus seedling, but with different signs (Table 3). The RPI of increasing dry season period has a positive relationship, while the RPI of increasing rainy season is negative. We also find the significant role of the subjective belief of yield, where the farmer who has a higher subjective belief of certified seedling yield is more likely to adopt the certified seedling. In term of the role of farmers' support systems, the ownership of mobile phone was likely to have a negative relationship with the adoption, similar with the farmer without climate information source variables and direct access to the government authority. On the other hand, farmer's involvement in citrus extension and training has a positive relationship with the adoption in plot levels.

Table 3. Citrus certified seedling adoption model in household and plot levels

Variables	Household levels (Probit)	Plot levels (IV-Probit)
Risk behaviours and subjective belief		
Risk preferences	0.01	0.03
	(0.03)	(0.02)
Time preferences	-0.01	0.03
	(0.03)	(0.02)
Risk perception index of increasing air temperature	0.06	0.11
	(0.12)	(0.09)
Risk perception index of increasing dry season period	0.21	0.19*
	(0.13)	(0.10)
Risk perception index of increasing rainy season period	-0.16	-0.22**
	(0.13)	(0.10)
Subjective belief of certified seedling potential yield	0.00	0.05*
(ton/ha/yr.)	(0.04)	(0.03)
Subjective belief of uncertified seedling potential yield	0.01	-0.02
(ton/ha/yr.)	(0.04)	(0.03)
Extension and advisory services		
Mobile phone (unit)	-0.06	-0.14**
	(0.08)	(0.06)
Internet access (1 if yes)	0.12	0.12
	(0.20)	(0.16)
Citrus training (1 if yes)	0.29	0.41*
	(0.34)	(0.23)
Citrus extension (1 if yes)	0.28	0.32**
	(0.22)	(0.16)
Climate extension (1 if yes)	-0.05	0.13
	(0.33)	(0.22)
Farmers group membership (1 if yes)	0.08	-0.17
	(0.24)	(0.17)
Cooperative membership (1 if yes)	0.33	0.31
	(0.33)	(0.23)
Citrus credit (1 if yes)	-0.16	-0.11
	(0.17)	(0.13)
Direct access to gov authority (1 if yes)	-0.35*	-0.53**
	(0.19)	(0.21)
Citrus technology information source (1 if other farmers)	-0.43**	-0.21
	(0.18)	(0.13)
Climate information source (1 if none)	-0.25	-0.20*
	(0.16)	(0.12)
No. Observation	486	1009
AIC	461.03	744.78
Wald test of exogeneity (Prob > chi2)	-	0.02**

Note: Standard error in parentheses. *', '**', '***' significant at 10%, 5%, and 1% probability level

The Wald test of the exogeneity of the instrumented variables is not significant for the multinomial logit model (P-value = 0.87), indicated there is no endogeneity issue in the model, hence we use the standard specification of multinomial logit model for the estimation. Table 4 presents the average marginal effect of explanatory variables of the multinomial logit model for the farmer's planning to use a certain type of citrus seedling. These results show that the farmer's risk behaviour, subjective belief of yield, and extension and advisory services could contribute to each alternative in the model differently. First, time preferences show a negative sign for CC which indicates that more patient farmers have a higher probability to stay to adopt the certified seedling. The RPI of dry season period contributes to a higher probability of CU, while the RPI of rainy season period vice versa. Second, a higher subjective belief of yield for the certified seedling can increase the probability of UC, and decrease the probability of UU.

On the other hand, the subjective belief of yield for the uncertified seedling has the opposite probability for UC and UU. Third, mobile-phone ownership could contribute to a lower probability of CU and a higher probability of UC. On the other hand, internet access could contribute to a higher probability of CU. The involvement in citrus training has a positive relationship with the probability of CC, as well as increase the probability of UC. Also, the citrus training could decrease the probability of UU. The climate-related extension seems likely to contribute to non-adopters intention in seedling choices, where this variable could contribute to a higher probability of UC, as well as a lower probability of UU. The farmers' behaviour in their intention to use a certain seedling type is also related to their climate information source. The farmers without any climate information source could decrease the probability of CC and the probability of UC, and increase the probability of UU. If the farmer uses another farmer as the main source of citrus technology, it potentially decreases the probability of CC.

Table 4. The average marginal effects of multinomial logit model

Variables	Certified - certified (CC)	Certified - uncertified (CU)	Uncertified – certified (UC)	Uncertified-uncertified (UU)
Risk behaviours and subjective belief				
Risk preference	0.00	0.00	-0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Time preferences	-0.01 *	0.01	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
Risk perception index of increasing air temperature	0.02	-0.01	-0.02	0.01
	(0.02)	(0.02)	(0.03)	(0.04)
Risk perception index of increasing dry season period	-0.01	0.07 ***	-0.02	-0.03
	(0.02)	(0.02)	(0.03)	(0.04)
Risk perception index of increasing rainy season period	0.03	-0.06 ***	0.02	0.01
	(0.03)	(0.02)	(0.03)	(0.04)
Subjective belief of certified seedling potential yield (ton/ha/yr.)	0.01	0.00	0.03 ***	-0.03 ***
	(0.01)	(0.01)	(0.01)	(0.01)
Subjective belief of uncertified seedling potential yield (ton/ha/yr.)	0.00	0.00	-0.03 ***	0.02 **
	(0.01)	(0.01)	(0.01)	(0.01)
Extension and advisory services				
Mobile phone (unit)	0.02	-0.05 ***	0.04 *	-0.02
	(0.01)	(0.02)	(0.02)	(0.02)
Internet access (1 if yes)	-0.03	0.07 ***	-0.03	-0.01
	(0.04)	(0.04)	(0.05)	(0.05)
Citrus training (1 if yes)	0.11 *	-0.03	0.19 *	-0.27 **
	(0.06)	(0.06)	(0.11)	(0.13)
Citrus extension (1 if yes)	0.02	0.06	-0.07	0.00
	(0.05)	(0.04)	(0.06)	(0.07)
Climate extension (1 if yes)	-0.01	0.04	0.25 **	-0.28 **
	(0.06)	(0.06)	(0.11)	(0.14)
Farmers group membership (1 if yes)	0.05	-0.04	-0.01	0.00
	(0.04)	(0.04)	(0.07)	(0.07)
Cooperative membership (1 if yes)	0.08	-0.02	0.00	-0.06
	(0.06)	(0.07)	(0.09)	(0.11)
Citrus credit (1 if yes)	-0.05	0.02	-0.03	0.06
	(0.03)	(0.03)	(0.05)	(0.05)
Direct access to gov authority (1 if yes)	-0.03	-0.03	-0.01	0.07
	(0.04)	(0.03)	(0.05)	(0.05)
Citrus technology information source (1 if other farmers)	-0.05	-0.05 *	0.04	0.07
	(0.03)	(0.03)	(0.05)	(0.05)
Climate information source (1 if none)	-0.05 *	-0.01	-0.09 **	0.15 ***
	(0.03)	(0.03)	(0.04)	(0.04)

Note: Standard error in parentheses. *', '**', '***' significant at 10%, 5%, and 1% probability level

6. Discussion

6.1. Risk behaviours, subjective belief and seedling choices

Starting the discussion with the role of risk behaviour on the seedling choices, we hypothesised that this variable might have a strong association with certified seedling adoption. Since the certified seedling is expected to have a higher yield, risk-averse farmers should favour the seedling relative to the uncertified compatriot (e.g. Ward and Singh, 2015; Holden and Quiggin, 2016). However, our estimation results show that these risk and time preferences seem likely to have no correlation with the farmer's behaviour to choose the certified seedling, both in HH and plot levels. For the intention to adopt, time preferences seem to have a contribution for a higher probability to the intention of certified seedling adopters to continue to adopt the seedling.

Regarding the role of risk behaviours, risk and time preferences are not working alone in explaining the farmer's behaviours, since it also depends on how the perceived the risk related to their decision (Pennings and Wansink, 2004). Considering this assumption, we tested the association of climate RPI with the seedling choice which seems somewhat to have significant relationships. We find the different relationship of the RPI of increasing dry season periods and increasing rainy season period with the certified seedling in plot levels and the probability of dis-adoption intention for adopter farmers. Since the higher RPI are more likely to adapt the climate change issues (e.g., Mumpower, Liu et al., 2016; Khanal, Wilson et al., 2018), the different role of the RPIs could be understood since these climate events might have the opposite characteristics. Hence, if the certified seedling is perceived as an adaptation strategy to a specific event, it might be perceived to not suit with the other events (Arslan, McCarthy et al., 2015). Since the certified seedling are not designed to suit to certain climate situations, it is interesting that the seedling choices or intention to use a certain type of seedling to have a relationship with their risk perception of climate events. It implies that the types of seedling might be perceived as a climate risk reduction technology. Thus, it needs to promote how certified seedling has advantages in facing climate uncertainty.

In term of the association of subjective belief of yield with the adoption, our result indicates that the farmer's subjective belief of yield for certified seedling had a significant relationship with the adoption in plot levels and the probability of the intention non-adopter farmers to use or not to use of certified seedling. This finding is in line with the previous study (e.g., Ghadim, Pannell et al., 2005; Lybbert, 2006; Barham, Chavas et al., 2015). The importance of subjective belief for the seedling adoption could be resulted through a farmer's learning process (Barham, Chavas et al., 2015), as the farmers could have a better knowledge about the advantage of the use of the certified seedling which attracts them to adopt the seedling. This implies that the citrus farmers need to learn to have a better knowledge about the certified seedling as this type of seedling potentially have a better yield and quality and lower production risk than the uncertified seedling so that it could increase the adoption rate of the certified seedling. Practically, government intervention by providing a demonstration plot in the production region as a learning facility for the farmers is highly recommended.

6.2. Extension and advisory services

One of the main problem in agricultural development in developing countries is a large gap of farming productivity and its potential because of the low adoption of good agricultural practices (Feder, Just et al., 1985), where the agricultural and advisory services take a role to close these gaps (Pan, Smith et al., 2018). In our case, the agricultural supporting system through advisory and extension services are expected to have an extensive role in order to promote the citrus technology information, such as the certified seedling to the farmers. Hence, in order to stimulate the using of certified seedling, we seek the opportunity to optimise the farmers support services. First, our analysis showed the extension service was significant to increase the probability of an adoption in plot levels. On the other hand, we found that our respondents mostly obtained citrus technology from other farmers (75 percent), which seems likely demote the using of the certified seedling. Perhaps, this was caused by the effect of learning from inappropriate sources as their neighbour farmers might have not adopted the certified seedling yet. However, this finding shows the importance of the neighbour effects as a learning sources or farmer to farmer's extension that potentially developed as a complementary for the formal extension services as shown in other studies (e.g. Doss, 2006; Kabunga, Dubois et al., 2012; Nakano, Tsusaka et al., 2018) by providing a better information about the advantage of the using of the certified seedling. Also, we find that the farmers' involvement in citrus training can be used as a trigger of farmer intention to use the certified seedling or not to use the uncertified seedling. It can be understood since a training could provide more intensive learning for farmers about citrus innovation, so it can be more effective for technology diffusion (Aida, 2018; Pan, Smith et al., 2018). On the other hand, citrus training could only cover very limited farmers and high cost.

Second, we find that farmers without a climate/weather information source tend to have a lower probability of certified seedling adoption as well as the lower probability farmer intention to use the certified seedling. It means, there is a tendency of the farmers who depend on their own experience for the climate information to use the uncertified seedling. This finding implies the importance of external climate information for the farmers which can encourage them to use the certified seedling. The importance of providing climate service for the farmers is also highlighted by previous studies (e.g. Chavas, Kristjanson et al., 1991; Tall, Coulibaly et al., 2018). They believe that in the complexity of the decision-making process, farmers may be base their decision on climate information. Moreover, this finding also supports the previous finding that certified seedling adoption decision probably has a relationship with climate issues.

Third, information and communication technology (ICT) could be optimised for the certified seedling campaign. The ownership of mobile-phone has a similar relationship with direct access. However, this variable has a positive relationship with the probability of the farmers to use the certified seedling in the next planting period. Also, the mobile-phone ownership could connect the farmers with adopters farmers which allowing them to learn and to obtain the information of certified seedling (Aker, 2011). On the other hand, internet access seems to have a different relationship which implies that farmers' access to the internet could not be utilised for the certified seedling promotion.

7. Summary and conclusion

In this study, we analysed the role of risk behaviours and subjective belief on the farmers' behaviours on the perennial crops seedling choice, in this case, certified citrus seedling. We combine survey data and economic preferences of farming household to test the importance of risk behaviours on the farmers' choices of the certified seedling. Since the low-level adoption of certified seedling is one of the important issues in citrus development in Indonesia (Supriyanto, Ratule et al., 2017), we also seek the opportunity of farmers' support system to promote the using of the seedling which potentially has many advantages that could improve the farmers' livelihood in the rural area which might be affected more severely by the climate change issues.

Based on the assumption that risk-averse farmers are more reluctant to involve in risky but profitable farming activities, and impatient people tend to avoid long term economic project such as perennial crops (Tanaka, Camerer et al., 2016), we find strong evidence the importance of time preferences in explaining the perennial crops farmers choice of seedling type. This finding expanding the adoption literature, since most of the previous studies focus on risk preferences and annual crops (e.g. Ward and Singh, 2015; Holden and Quiggin, 2016). We find a strong evidence that the subjective belief could increase the probability of the intention of non-adopter farmers to use the certified seedlings. The significant role of this variable implies the importance certified seedling campaign to inform the farmers about the advantages of the using certified seedling which offer better productivity as a policy implication of this study.

Even though, the climate change issues might not the main consideration in the seedling certification policy, however, the farmer's risk perception of climate change events and climate-related information seem to have a significant contribution on their decision to adopt and intention to adopt the certified seedling. This finding indicates that farmers might consider that the use of certified citrus variety seedling as one of the adaptation technology for climate change issues. The information and communication technology (ICT) might have a big opportunity to be developed for the promotion and learning of the certified seedling (Aker, 2011) which might encourage the farmers to use the seedling or at least the farmer's intention to use certified seedling or not to use uncertified seeling. Also, following for the formal extension services, farmer to farmer’s extension is potential to be developed as a complementary for the formal extension services.

This study uses the farmers planning/intention to use certified or uncertified seedling to examine the dynamic use of the seedlings which may illustrate the farmers’ interest in the certain type of the seedling. This information could be important for the government or seedling industry for citrus development. However, we suggest using the panel survey to obtain the real dynamic of the seedling use, even though it might be difficult since the citrus farming has a long life cycle (10 – 25 years).

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