International Journal of Agriculture Innovations and Research
Volume 6, Issue 5, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 15/03/2018 | Accepted on: 24/03/2018 | Published: 29/03/2018

Factors Influencing Farmers' Decision-Making on the Adoption of High Yielding Varieties of Rice in Indonesia

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***Abstract* – The problem encountered in the adoption of Rice High Yielding Varieties (HYV) is that the introduction of this technology often neglects the crucial factors affecting the adoption. This study was aimed to identify the factors influencing farmers' decision-making on the adoption of high yielding varieties (HYV) of rice in South Sulawesi, Lampung and West Java Provinces, as rice production centres in Indonesia. Primary data was collected through in-depth interviews of 200 farmers in 2016. The logistic regression model was employed to analyse the factors influencing farmers in making decision. The results showed that total production, farmers' income and rice field area were significantly and positively influencing farmers' decision-making on the adoption of HYV of rice (in the context of Ciherang, Inpari and Mekongga). Whereas formal education and dummy of crop season (rain and dry season) did not significantly determine farmers' decision to adopt HYV of rice.**

***Keywords* – High Yielding Variety, Rice, Decision-Making, Adoption.**

I. INTRODUCTION

Rice productivity is influenced by several factors where high yielding variety (HYV) alleged is one of the most essential factors to increase the productivity [1]–[2]–[3]. Indonesian Agency for Agricultural Research and Development (IAARD) has released hundreds of new HYV, implemented field-trial in different sites as well as initiated several programs in collaboration with many stakeholders to introduce and accelerate the adoption of HYV. Though it has an important role, the adoption level of HYV remains low and slow [4]–[1]–[5].

A number of empirical studies across the world have found that there are different factors, which influencing the adoption of agricultural technologies including HYV technology. A study conducted in Ghana reported that significant determining factors on modern agricultural technologies adoption are farm size, expected benefits, age, education, gender, and access to information and extension services [6]. Similar results also mentioned that there was a strong and positive correlation between education status and the adoption of innovation in dairy farms in Turkey [7], and another study conducted also found that education and farm size have significantly influenced farmers on the adoption of innovation in West Kalimantan, Indonesia [8]. Regarding to the adoption of new improved varieties, it was reported that level of education, farm size, yield potential, extension services and seed access play important role in the adoption decisions of HYV in Central Nepal [9].

Those study results proved that there is a serious issue needs to be addressed in order to improved the rate of adoption, and as a result will increase the rice productivity of the country. However, studies about the reason why farmers choose particular varieties are still limited especially related the rice characteristics. This paper aims to provide information of existing varieties and characteristics of rice demanded by farmers and to analyze the factors influencing farmers' decision-making process on the selection of HYV in three provinces of rice production centres in Indonesia. It is expected that this study could be used as reference for composing strategy in increasing the adoption rate of HYV in Indonesia.

II. METHODOLOGY

A. Time, Location and Respondents

The study was conducted in three provinces namely South Sulawesi, Lampung and West Java Provinces from April to December 2016. These locations were selected purposively [10] with the consideration as rice development centres in Indonesia. South Sulawesi, Lampung and West Java in aggregate contributed around 29.4% per year of the total rice production in Indonesia within last 20 years [11]. The respondents in South Sulawesi, Lampung and West Java were 70, 60 and 70 farmers respectively, so that the total respondents in three research sites were 200 rice farmers. Those farmers were randomly selected using simple random sampling method without differing the rice varieties used in their rice farming. It was expected to provide an overview of the HYV implementation at the farmer level in current phase.

B. Sources of Data and Data Analysis

The data collection consisted of secondary and primary data. The secondary data was gathered through desk study and literature review from the previous relevant researches, from the Assessment Institute of Agricultural Technology (AIAT) of South Sulawesi Province, AIAT of West Java and AIAT of Lampung and from agricultural offices at the district level as well. The primary data was collected through in-depth and individual interview with farmer using a structure questionnaire. These data included farmers' characteristics, production and productivity data at the farmer level, data of HYV distribution, information of rice farming system and farmers' preferences of HYV as well.

The secondary data was analyzed descriptively and enriched with simple descriptive statistic methods such as percentages and average. In order to analyze the factors influencing farmers' decision as an output variable, the logistic regression model was employed. The output variable represented two possibilities, which are the probability of occurrence to choose and not to choose. This typical variable could be categorized as a dichotomous variable that distinguishes a logistic regression from other regression approaches [12]–[13]–[14]. Logistic regression is also differed from the linear regression in term of parametric selections and assumptions [12]. This method was used in some researches with the relevant discussion of adoption as in [15]–[16]–[17]–[18]–[19]–[20].

The early logistic regression model in this paper could be describe as

$$P(xi) = \frac{1}{1 + e^{\beta 0+\beta 1x1+\beta 2x2+\beta 3x3+\cdots..+\beta kxk}}$$

This equation was nonlinear in the parameters. Furthermore, this equation was transformed into a linear model through logistic transformer, so that it turned into:

$$Ln(\frac{P(Xi)}{1-P(Xi)}) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$

$$Zi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$

Annotations:

Zi = The probability of occurrence to choose high yielding varieties (1) and the probability of occurrence not to choose HYV (0).

X_1 = Farmer's education (years).

X_2 = Production (ton).

X_3 = Farmers' income for agriculture (IDR).

X_4 = Farm size (ha).

X_5 = Dummy of planting season, which are 1 = rainy season, 0 = dry season.

β_0, β_1, β_2, β_3, β_4, β_5, are coefficient values for the variables obtained using Maximum Likelihood Estimation (MLE) method, which allowing to increase the probability of resulted parameters are close to the observed data [12].

III. Results and Discussions

A. Farmers Characteristic in Research Site

Farmers' characteristics are interesting to be observed since they can influence farmers' decisions on learning and adopting technologies. The characteristics include age, education, number of family members, farming experiences and land ownership. The result of the study showed that the average age of farmers was is 47.62 years old, indicating that they are still on a productive age (Table 1). Productive age means a potency to adopt innovations because farmers still have ability and opportunity to develop their rice farming. This result confirmed with similar studies [21] – [9], though it was different from the result [22]. Moreover, age was indicated having correlation with an adoption as suggested in some previous studies [20]–[23]–[24]–[25] which mentioned that age had a positive influence towards the process of adoption.

The average of farmers' education was 10 years representing the respondent had fulfilled the minimum formal education requisition in Indonesia, which is 9.7 years. This can imply that farmers are expected to be more receptive to new information and technologies. Education was founded as a driven factor for farmers to adopt innovation [26]. In spite of a higher education might encourage farmers to work on non-agricultural sector [21].

Meanwhile, the average number of family members was 4.23 (person/household). Family members beside represent the number of dependants it also describes the potency of labour sources including supporting rice farming. Farmers sometimes face with difficulties to find labour lease because the limited numbers of agricultural labours and cash capital to hire workers. Thus, the existence of dependants plays an important role, including actively involved in various activities on rice farming such as spraying and fertilizing (Table 1).

Farming experience is one of farmers' characteristics. In general, farmers in research site had experienced with rice farming as shown by the average of farming experience around 21.84 years. This condition described that rice farming was not a new activity for respondents and known by farmers. The possibility of adoption is higher for farmers who have a longer experience since they are already familiar with the system.

From the analysis, the main source of income comes from on farm business, which constituted about 84.56%. Meanwhile, the land for rice farming in the study site was wetland (irrigation land) and in general these land was owned by farmers with average farm size of 0.84 ha/farmer, whilst others leased the land with average farm size was 0.64 ha/farmer. In more detail, the farmers' characteristics are presented in Table 1.

Table 1. Characteristics of respondents in research location, Indonesia, 2016.

No.	Variables	Average
1.	Age (years)	47.62
2.	Education (years)	9.70
3.	Number of family members	4.23
4.	Farming experiences (years)	21.84
5.	Net income (IDR)	
	a. Agriculture	37,500,366.85
	b. Non agriculture	6,846,214.42
6.	Average of farm size (ha)	
	a. Own lands	0.84
	b. Non own lands	0.64

Source: primary data (processed), 2016

Annotation: IDR = Indonesian Rupiah; (in 2016, 1 USD ≈ 13,369 IDR).

B. Existing Varieties and the Plant Characteristics Demanded by Farmers

As rice production centres in Indonesia, farmers in South

Sulawesi, Lampung and West Java have used the technologies including HYV and labelled seed (blue label representing as an extension seed). Wide application of this type of seed is one of the driven factors to increase productivity. However, amongst many rice varieties, Ciherang appears to be the dominant variety planted by farmers. Ciherang had been released in 2000, which means that it already sustained at the farmer level around 16 years due to its high yield, the availability of seed, and the resistance to pests and diseases. These characteristics are the most demanding by farmers in research sites. IAARD has released Inpari 30 less than 5 years ago, which has similar characteristics with Ciherang [27]. It is believed that the similar characteristics to be the main reason of the acceleration of its dissemination at the farmer level.

Dissemination pattern and adoption of HYV at the farmer level was depended on the seed availability. The low adoption of HYV was influenced by the ability of the varieties to compete with the existing varieties, lack of interest in the seed industries for commercialization and the problem of availability [28]. It is also in line with the study of adoption on cocoa commodity showed that the farmers' preference towards seed availability significantly influenced to adopt a high yielding variety [29]. The lack of seed availability caused farmers to re-use their previous varieties.

This study also revealed that plant characteristics were also play as determining factors of the farmers' preference on rice HYV (Table 2), implying that it is important to take farmers' preferences into consideration in the design of a research and development agenda. At least there were three categories of plant characteristics considered by farmers to choose rice variety, (i) plant attributes, (ii) yield attributes and (iii) marketing attributes. Plant attributes consisted of several aspects, for instance the plant shape, plant height, productive tillers, leaves colours, panicle length and resistant to pests and diseases. Productive tillers, plant age and resistant to pest were the most essential plant attributes that should be existed within rice varieties. Farmers had chosen 72.34%, 69.19% and 66.21% of these attributes respectively. Productive tillers were related to the grain weight, which was respecting to productivity [30]. Plant age was considered as an important plant attribute since according to farmers it would effect the harvest time. Farmers preferred varieties that had a moderate age about 115 – 120 days. Meanwhile, resistant to pests are related to the total grain and yield.

As can been in Table 2, yield attributes were form of grain/rice, grain colours, average yield, rice extraction, percentage of broken rice, rice colours, rice textures, rice flavour and fluffy capabilities. Average yield was deliberated as the crucial aspect related to yield attributes where around 84.28% respondents mentioned this as the main consideration to choose varieties. It is a sensible reason since average yield will influence the production. The higher yield is expected to result a higher production and gross income. The next attribute that important is form of grain/rice. In general, there four types of form of grain/rice, which are slender, medium, bold and round. Form of grain/rice is related to the post-harvest activities (drying and milling process). This attribute constituted about 71.51%. Meanwhile, concerning rice extraction, 58.21% respondents stating this attribute is also taken into account when selecting varieties to plant. Rice extraction represents weight percentage of the weight of the grain to milling results grinded. This attribute is important, since the depreciation of the rice due to harvesting and post harvesting process can be estimated in order to calculate the total quantity of rice.

Table 2. Plant characteristics as consideration for farmers to choose HYV in research location, Indonesia, 2016.

No.	Description	Percentage (%)
1.	Consideration related to plant attributes	
	Plant shape	44.45
	Plant age	69.19
	Plant height	54.23
	Productive tillers	72.34
	Leaves colours	32.96
	Blades	49.06
	Panicle length	60.66
	Loss level	33.63
	Resistant fall	61.67
	Resistant to pests	66.21
	Resistant to diseases	61.36
	Resistant to drought	27.85
2.	Consideration related to yield attributes	
	Form of grain/rice	71.51
	Grain colours	56.53
	Average yield	84.28
	Rice extraction	58.21
	Percentage of broken rice	32.23
	Rice colours	52.21
	Rice textures	52.44
	Rice flavour	28.56
	Fluffy capabilities	28.28
3.	Consideration related to marketing attributes	
	Price of grain	67.73
	Ease of selling products	64.12

Source: primary data (processed), 2016

The consideration related to marketing attributes was identified from price of grain and easiness to sell at the market. Rice is a staple food in Indonesia causing the high demand of this commodity, so that the price and market are relatively stabile. The finding during the research shows that price and market access only comprised 567.73% and 64.14% in the marketing attributes indicating an established market for rice (Table 3).

C. Factors Influencing Farmers' Decisions on Choosing High Yielding Varieties

A decision and a perspective basically can be obtained through thinking and learning processes that are influenced by various internal and external of characteristics. Using a logistic regression model, size of farming for rice, the increasing yield from using HYV and the frequency of extension related to HYV were some factors that determined the adoption of rice varieties in Nigeria [31]. The result of logistic regression analysis showed that the

farmers' decision on adoption of HYV (in the context of Ciherang, Inpari and Mekongga rice varieties) in research site was influenced by several factors.

Based on the logistic regression, the paddy field areas measured in hectare and owned by farmers, the farmers' income from rice farming and production significantly and positively influenced farmers' decision in using HYV, which were Ciherang and Mekongga. It shows that for every increasing area of land, the probability for farmers to use these varieties also increase. Nor at the outset of farmers' income from agriculture activities in particular rice farming, it increased the likelihood for farmers implementing HYV in their farming systems. Meanwhile, production also confirmed as a positive and significant variable in influencing farmers' decision. The increasing production will be the driving factor increasing the chances of farmers to use HYV in their farming activities (Table 3).

Land area positively influenced adoption of rice innovation in Sukoharjo district, Central Java Province [32]. Other study on rice transplanting system and direct seedling system in Geragai sub district, Tanjung Jabung Timur district, Jambi province also revealed the similar result [33]. There were several factors influencing farmers to switch to direct seedling system. Through binary logistic regression test, the area of land, labour and farmers' revenue had significant influence with significant levels of less than 0.05, whilst other factors such as age of farmers and the use of capital did not have significant influences with a significance level greater than 0.05.

Table 3. Result of logistic regression on factors influencing farmers' decisions on choosing high yielding varieties in Indonesia, 2016

No.	Variables	Coefficient (B)	SE	z	P> |z|	Exp (B)
	Constanta	0.380767	1.214252	0.314	0.3821	1.463406
1.	Education (years)	-0.603197	0.649034	-0.929	0.1736	0.547060
2.	Total production (ton)	0.693098**	0.210102	3.299	0.0010	1.999900
3.	Farmers' income for agriculture (IDR)	0.000001**	0.000001	1.905	0.0287	1.000001
4.	Rice field area (ha)	0.400388**	0.182620	2.192	0.0143	1.492404
5.	Dummy of crop season	0.374339	0.280885	1.333	0.0918	1.454030
LR Chi square= 24.08 Loglikelihood= -120.774 Pseudo R^2= 0.5906 Number of Obs= 200						

Annotation: *) Significant at the level of alpha 1%; **) Significant at the level of alpha 5%; ***) Significant at the level of alpha 10%; ****) Significant at the level of alpha 15%; IDR = Indonesian Rupiah; (in 2016, 1 USD ≈ 13,369 IDR)

From Table 3, it can be seen that (formal) education surprisingly did not bring a significant influence in decision to use certain HYV, though the coefficient was positive. This is dissimilar with the different findings who mentioned that education influenced adoption [9]–[6]. In selecting rice varieties, farmers in the research area relied more on farming experiences than the education. The availability of HYV with accompanying information can be obtained in the seeds production seller at the research sites. In this context, the experience of farming would be an important factor in the decision of HYV.

This result was in line with the variable of season dummy (rain and dry seasons) that also influence positively to the increased a likelihood of farmers to choose and use HYV in their farming, though it was not significant. In this context, a good climate and environment will largely determine the growth of rice, so that farmers will consider varieties suited with the season. High yielding varieties will be selected farmers, since they expect the appropriate result. [34] The effort to discover and develop varieties that are superior and have better adaptability to the specific environment is one of the appropriate policies for the development of rice farming in more productive, effective and efficient ways in the future.

In order to gain the optimal result from new varieties, it requires an adaptive environment so that the potential results and advantages can be achieved [35]. To offer alternative choices of varieties, experiment test of several varieties in multi location need to be done, since it is related to the potency of varieties that will provide different results in various places and climates. In addition to the use of new varieties, the use of quality seed (certified seed) in paddy with integrated crop management approach could improve the yield [36], because the seeds with good quality will be able to grow on less favorable land conditions, free from seed-borne pests and diseases that will reduce the risk of crop failures.

Therefore, the probability of farmer decisions to select HYV will increase respectively of 2.00; 1.00; and 1.49 in line with the increase in rice production resulting from farming activities, income earned from agriculture activities, and rice field area (see Table 3). s

IV. Conclusion

HYV are believed to foster the increased productivity of rice. Therefore, the rate of adoption of HYV need to be continuously supported by the government through considering the factors that influence farmers to adopt HYV. Three policy recommendations are suggested in promoting the adoption of HYV. *First*, since the education plays an important role for the adoption of HYV therefore improving the knowledge and skill of farmers is required through non-formal education such as a farmer field school (FFS) approach, intensive information dissemination and demonstration plot. *Second*, the introduction of new HYV

should also be in line with the efforts to improve the seed availability, so that farmers can easily access to new HYV. *Third*, given the important role played by the characteristics of varieties demanded by farmers, therefore it is suggested to consider farmers' preferences in the rice research and development program.

ACKNOWLEDGMENT

With the immense of gratitude, the authors would like to thank to Prof. Erizal Jamal for the advice and support the study. We would like also to acknowledge to Dr. Ir. Adang Agustian, MSi for the advice in analysing the data and writing manuscripts, Kania Tresnawati, SP and Morina Pasaribu, SP for the assistances in collecting the data.

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