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Attitude, Knowledge and Competency towards Precision Agricultural Practice among Paddy Farmers

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ABSTRACT

Previous research indicated that farmers' attitude, knowledge and competency influenced the adoption of technology. Realizing the truth, this study was carried out with the purpose to find factors and answers to questions that influenced the adoption of Precision Agricultural Practice (PAP). The study was carried out on 119 paddy farmers at IADA Barat Laut, Selangor. Results indicated that attitude, knowledge and competency significantly influenced the adoption of the PAP. Hence, to change the farmers' attitude, knowledge and competency are vital aspects in the adoption of the PAP.

Keywords: Attitude, knowledge, competency, technology and precision agricultural practice

INTRODUCTION

Since Malaysia's independence in 1957, food security and self sufficiency became the ultimate goals of the government policy in promoting agriculture as the third engine of economic growth. In the year 2003, the Ministry of Agriculture introduced an innovative measure known as the Precision Agricultural Practice (PAP), with the hope to achieve the aforementioned goals. The PAP was based on Rice Check Manual (RCM), and its purpose was to increase paddy productivity and minimize the dependency on imported rice from major rice exporting countries such as Thailand, Vietnam and Pakistan. Shibusawa (2002) argued that the adoption of the PAP would produce high crop, but minimize productivity and labour cost. Moreover, the adoption of the PAP also encouraged the conservation of the environment (Shibusawa, 2002). In the context of this study, PAP is a method of agriculture management which is a right practice. It refers to the right farming with the right implementation at the right place,

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following the right method and the right time based on RCM to get the optimum yield.

Based on the paddy productivity, however, Malaysia was indicated as having the lowest paddy yield among paddy producing countries in the world (FAO, 2008). This can be viewed as the adoption of the PAP in Malaysia only succumbed to partial success compared to other countries which are also adopting the PAP measure. For example, Australia managed to produce three times more the production of paddy even though the area of rice field in Australia is similar to the overall paddy fields in Malaysia (Husain Jahit, 2005). Thus, it is clear that the adoption of PAP in Malaysia has not shown an encouraging progress despite the support of the government in the PAP measure.

The partial success of this adoption might be influenced by farmers' attitude, knowledge and competency towards the adoption of PAP. In more specific, the farmers must be competent in technical efficiency and economical use of input in their rice farming system in order to maximize their productivity and income. Meanwhile, previous research has indicated that attitude, knowledge and competency of farmers are important factors in every level of agriculture agency (Chilonda & Van huylenbroeck, 2001; Burton *et al.*, 2003; Barham *et al.*, 2004). This means failure to follow the standard activities will affect low paddy productivity (Othman Omar, 2008).

According to Rogers (2003), diffusion of innovation occurs through a five–stage process, and is a type of decision-making process. The process occurs through a series of communication that is channelled over a period of time among members of a similar social system. Rogers (1964) categorizes the five stages, namely; awareness, interest, evaluation, trial, and adoption. One important characteristic of this model is that an individual has the right to reject an innovation during or after the adoption process. In the later version of the Diffusion of Innovations model, Rogers (2003) changed the five previous terminologies to knowledge, persuasion, decision, implementation and confirmation, respectively. However, the description processes of the categories have remained similar throughout this later version of the model.

In the knowledge stage, the individual is first exposed to an innovation, but lacks information about the innovation. It should be noted that during this process, the individual is not inspired to find more information about the innovation. In the persuasion stage, the individual develops an interest in the innovation, and actively seeks information about the innovation. In the decision stage, the individual makes a decision about the innovation, and weighs the advantages and disadvantages of the innovation while considering whether to adopt or reject the innovation. Due to the individualistic nature of this process, Rogers notes that it is the most difficult stage to obtain empirical evidence (1964, p. 83). In the adoption stage, the individual determines the practicality of the innovation to the context, and further employs the innovation in respect of the context. This stage still requires the individual to acquire further information about the innovation. In the confirmation stage, the individual finalizes the decision to continue using the innovation and may use the innovation to its fullest potential.

Based on this Diffusions of Innovations model, it is necessary to view farmers' attitude, knowledge and competency as the inherent characteristics of innovations that influence an individual's decision to adopt or reject an innovation. Hence, the purpose of this study was to investigate the relationship between the farmers' attitude, knowledge and competency toward the adoption of PAP at Integrated Agricultural Development Area (IADA) in Barat Laut, Selangor. The research framework to be tested is depicted in Fig.1.

The Precision Agricultural Practice Concept

The PAP is based on the recognition of the spatial and temporal variability in crop production. Blackmore (2000) defined precision agricultural as the management of arable variability to improve the economic benefit and reduce management impact on the environment. This definition serves a two-fold purpose. First, it identifies management of variability as the essential factor and not technology, as many people may seem to believe. Second, it aims to change the existing system and to improve economic returns, while reducing the impacts of management practices on the environment. Both of these purposes are aimed to improve the efficiency of the agricultural process.

According to Shibusawa (2002), precision agriculture refers to a management strategy used to increase productivity and economic returns with a reduced impact on the environment. It involves the application of information technology to the extent of variability in the field, variable-rate operations and decision-making system. This process has three technology levels and three strategies in the development of precision farming. According to Shibusawa

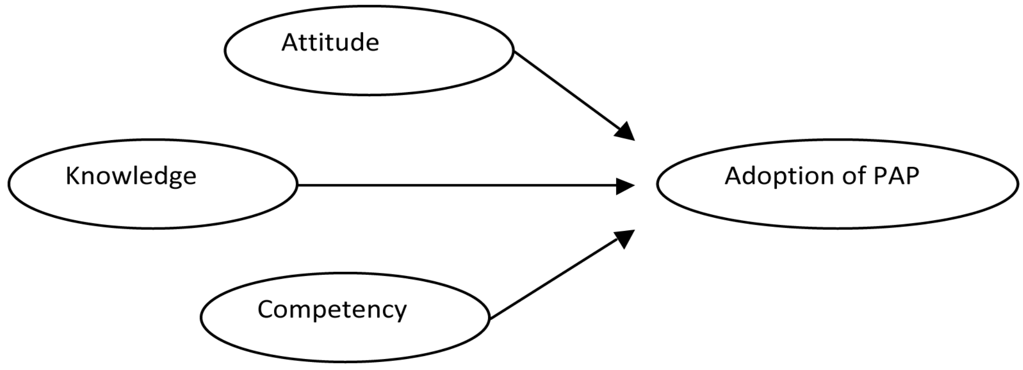

Fig.1: Research Framework

(2002), precision agricultural practices can be used on small farms as well as big farms. Shibusawa (2002) also mentions that precision agriculture plays an important role in rural development programmes which are integrated with the industry.

According to Batte and VanBuren (1999), PAP is not a single technology, but an integration of technologies permitting: (i) a collection of data on an appropriate scale at a suitable time, (ii) interpretation and analysis of data to support a range of management decisions, and (iii) implementation of a management response on an appropriate scale and at a suitable time.

In a study of PAP technologies in developed countries, Tran and Nguyen (2006) highlighted the following advantages to farmers. First, the adoption of the PAP increased the overall productivity. The precise selection of crop varieties, the application of exact types and doses of fertilizers, pesticides and herbicides, and appropriate irrigation meet the demands of crops for optimum growth and development. This led to an increase in productivity, especially in areas or fields, where uniform crop management practices were traditionally practiced.

Second, the adoption of the PAP technology improved efficiency. Advanced technologies, including machinery, tools and information, helped farmers to increase the efficiency of labour, land and time in farming. Third, the adoption of the PAP technology reduced production costs. The application of the exact quantities at the appropriate time was found to reduce the cost of agrochemical inputs in crop production (Swinton & Lowenberg-DeBoer, 1998). In addition, the overall high productivity reduced the cost per unit of output.

Fourth, the adoption of the PAP technology encouraged better decision-making in agricultural management. Agricultural machinery, equipment and tools helped farmers to acquire accurate information, which was processed and analyzed for appropriate decision making, specifically in land preparation, seeding, fertilizer, pesticide and herbicide application, irrigation and drainage, and post-production activities.

Fifth, the adoption of the PAP technology reduces environment impact. The timely application of agrochemicals at an accurate rate avoided excessive residue in soils and water, and thus, reduced environmental pollution. Finally, the adoption of the PAP technology encouraged a better management of farmers' knowledge. All PAP field activities produced valuable field and management information, and the data are stored in tools and computers. Farmers can thus manage the knowledge about their farms and production systems to achieve a much better overall management.

The adoption of the PAP technology in Malaysia is still new. However, measures are taken by government agencies, such as Mimos Berhad, to improve the adoption of the PAP technology through wireless MEMS sensors. These sensors aim to assist farmers to measure humidity, warmth, acidity level, and soil temperature. These wireless MEMS sensors are also able to assist farmers to measure the level of soil fertility through measurement of the level of nitrate, phosphate and calcium in the soil.

According to Laupa Junus (2008), precision agriculture is a concept of agriculture which allows farmers to control modern-related activities, such as fertilization, irrigation, pest and others, through the use of technology. In other words, precision agriculture refers to implementing the right measures appropriately. Precision agriculture, including agricultural or livestock management methods that are integrated with new information technology, includes several basic factors by results system to enhance productivity and efficiency, thus providing returns the voucher. These basic factors include geographic information systems/ land, fertilizers/ animal feed, and immunization/ pesticides.

Precision agriculture requires new technologies, such as GPS, detector, satellite and information technology systems that can understand and evaluate conditions, such as: (i) a good time to plant seeds, (ii) the correct amount of fertilizer, and (iii) to predict the total harvest yield accurately. Othman Omar (2008) emphasized that neglecting compliance with these standard farming activities would result in low productivity.

Attitude, Knowledge and Competency towards Innovation

The success of precision agricultural on a smaller or a larger scale inevitably depends on these three factors of farmers' attitudes, knowledge and competency (Rogers, 2003). Generally, attitude refers to how people react to certain situations and how they behave in general. Attitudes are the base in developing people, focusing on developing the right attitudes before passing on to knowledge and competency. Knowledge is practical information gained through the learning process, experience or association. Finally, competency refers to the ability to perform specific tasks. Developing or changing someone's attitude requires much more work than developing a competence or gaining some knowledge. A knowledgeable individual will be more successful if that individual also has the right attitude. After developing the attitude, one should focus on competencies. Competencies come before knowledge because it is flexible and can be applied to many different situations.

In agriculture, attitude, knowledge and competency are among three important factors in farmers' decision to adopt innovation (Rogers, 2003). Attitude is stand of ideas, practice and goods (Breckler & Wiggins, 1992). In that conjunction, individual attitude can be positive or negative attitude (Shih, 2004). Meanwhile, research done by Tran *et al*. (2006) on several developed countries indicates that the adoption of PAP showed a positive effect in terms of paddy productivity. However, the paddy productivity in Malaysia is still at a very low level compared to other rice producers in the world. This situation is very unfortunate since the adoption of the PAP has been implemented for the past seven years (FAO, 2008).

Once again, this unsuccessful adoption of the PAP may be explained by farmers' attitudes, knowledge and competency in its adoption. As Othman Omar (2008) suggested, negligence to comply with these standard farming activities would affect the level of productivity.

Kondoh and Jussaume (2006) analyzed factors when farmers considered the advisability of incorporating new technology into their farming operation. These included how the innovations fit within the specific context of their farming operations and their own attitudes towards technology. Burton *et al*. (2003) also suggested that farmers' attitude towards the adoption of organic horticultural technology in the UK influenced the adoption of organic horticultural technology. Meanwhile, Cavani (2007) examined the influence of farmers' characteristics and their attitude towards improved maize and chemical fertilizer. The researchers found that the farmers' attitude influenced their adoption of chemical fertilizer. Earlier on, in a local study by Rahim and Mazanah (1994), the usefulness of innovation was still found to be low among farmers and this was also influenced by their attitudes towards innovation.

Chirwa (2005) examined the agricultural policies that promoted the adoption of fertilizer and hybrid seed technologies as ways of improving productivity in maize farming by smallholder farmers in Malawi. The researcher found that fertilizer adoption was positively associated with higher levels of knowledge. Similarly, Ahmad *et al*. (2006) also investigated farmers' attitudes and skills of farm management, and found that two-thirds of the respondents perceived technical skills and enhancing their knowledge as the keys to success. In more specific, the farmers' attitude and skill influenced the willingness and ability to make successful changes to their management practice.

Meanwhile, Alene and Manyong (2007) investigated the effects of farmers' extension education and extension dealings on cowpea production under traditional and improved technology in northern Nigeria. The results revealed the farmers' knowledge affected the adoption of technology and significantly enhanced productivity. The factors supporting technology adoption would thus indirectly raise the minor contributions of farmers' education. This included schooling, participatory technology evaluation, improved seed supply, and market access. The results also indicated that education background not only enhances agricultural productivity, following technology adoption but also promotes the adoption itself. Hence, farmers' knowledge about innovation does influence a decision to adopt that technology (Napier *et al*., 2004b).

Recently, Useche *et al.* (2009) proposed a model of technology adoption that integrates the demand for individual traits of new technologies with the potential for heterogeneity based on the characteristics of farms and farmers. The results indicated that individual traits, heterogeneity of tastes for traits, and farm/farmers' characteristics shape adoption decisions.

Shibusawa (2002) found that precision agricultural practices can be used on small farms as well as big ones if farmers have skills, while farmers' skills play an important role in the adoption of technology in rural development programmes. Meanwhile, Barham *et al*. (2004) examined the dynamics of recombinant bovine somatotropin (rBST) implementation to recognize the characteristics that distinguish among non-adopters, and disadopters, as well as early and late adopters. The results confirmed that larger farms with better competency were more likely to adopt rBST.

METHODOLOGY

The total population of the study was 18,947, who were farmers in IADA in Barat Laut, Selangor, Malaysia. The determination of the sample size for this study was on the Statistical Power Analysis. According to Cappelleri and Darlington (1994), Cohen Statistical Power Analysis is one of the most popular approaches in the behavioural sciences in calculating the required sampling size. For this study, the required sample size was estimated using the G Power. Buchner *et al.* (1992) investigated the agreement between the G Power results and the tables published by Cohen in 1988. In general, Cohen (1988) and G Power agreed quite well. According to Buchner *et al.* (1992), a perfect two-digit agreement with G Power's accuracy mode results cannot be expected because most of the power values and sample size tables in Cohen (1988) are based on approximations. Using the G-Power software to identify the sample size, 119 farmers were selected. To achieve the objectives of the study, self-administered questionnaires were distributed using Convenience Sampling Method to 119 farmers during the series of extension programmes from October to December 2009. This sampling method was implemented because this particular research involved a large population in large area (Burns & Grove, 2001).

The topics of the questionnaire included farmers' demographic, attitude, knowledge, competency and the level of adoption of the PAP. The study used an adopted version of the farmers' attitude scale developed by Shaw dan Wright (1967) consisting of eight items. It was used to investigate the perception of farmers towards the adoption of the PAP. This attitude measure required the participants to rate on a 7-point Likert-type scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Farmers' knowledge and competency about PAP were adopted from Rogers and Havens (1961) which consisted of nine items each, and were used to investigate the level of farmers' knowledge and competency towards the adoption of the PAP. Meanwhile, PAP was adopted from Cavani (2007) with some modifications to the 23-item based on RCM. It was used to investigate the extent to which the farmers adopted the PAP in their farms. This measures required the participants to rate on the 7-point Likert-type scale, ranging from 1 (not at all) to 7 (too often).

The scale's alpha coefficient in this study demonstrated a high reliability for attitude ($\alpha = .86$), knowledge ($\alpha = .84$), competency ($\alpha = .94$) and PAP ($\alpha = .86$). Meanwhile, the assessment of the content validity in this study was developed based on an extensive review of the literature and detail evaluations comprising of two committee members, who are professionals and experts in the related fields.

RESULTS

As shown in Table 1, from the total number of respondents analyzed, results indicated that the average of the respondent age was 52.05 years old. As for the size of land area, farmers harvesting rice average 2.53 hectare area with a standard deviation of 2.24. Meanwhile on average, the rice production in the Integrated Agricultural Development Area Barat Laut Selangor (IADABLS) is at a good rate, which is 5.83 tons per hectare. This rate is much better than the average production of rice for the whole country which is at 3.38 tons per hectare.

TABLE 1
Mean and Standard Deviation of the Demographic and Productivities

Variable	Mean	SD
Age	52.05	13.04
Land size	2.53	2.24
Productivity (tan per/hectare)	5.83	0.82

Based on the results presented in Table 2, the total mean of 5.60, with a standard deviation of 1.01, indicates that the attitude of farmers in this study was at a good level. Similarly, the result for the level of knowledge was also indicated as quite high, with *M* = 5.51, *SD* = 0.84. Meanwhile, the level of competency was found to be slightly lower than knowledge, with *M* = 5.47, *SD* = 0.85, but it could still be considered as a good result. Finally, the adoption of PAP indicated a high level, with *M* = 5.90, *SD* = 0.69.

TABLE 2
Means and Standard Deviation of the Variables

Variables	Mean	SD
Attitude	5.60	1.01
Knowledge	5.51	0.84
Competency	5.47	0.85
Adoption of PAP	5.90	0.69

In this study, the correlation between the farmers' attitude, knowledge and competency with the adoption of PAP was also calculated. The results indicated a moderate positive correlation between the farmers' competency and the adoption of PAP ($r = .607, p < .01$). This finding indicated that higher ratings on the competency scale were associated with the higher ratings on the adoption of PAP.

TABLE 3
Correlation among the Variables

	1	2	3	4
1. Attitude	1			
2. Knowledge	0.532**	1		
3. Competency	0.467**	0.673**	1	
4. PAP	0.496**	0.532**	0.607**	1

Meanwhile, other correlations were also found to be significantly related. The result showed that attitude ($r = 0.496$, $p < 0.01$) was a positive predictor to the adoption of the PAP. This finding is consistent with that of Ahmad *et al*. (2006) who also found that the attitude towards innovation possessed a significant relationship with the adoption of an innovation. This finding also revealed that the farmers' attitude towards the adoption of the PAP would influence the adoption of the PAP. Finally, this study also found a significant relationship between knowledge and the adoption of the PAP ($r = 0.532$, $p < .01$). This finding is consisted with that of the study conducted by Alene *et al*. (2007).

To determine the best set of predictor variable in predicting PAP, a stepwise regression method was used. Based on the stepwise method used, only two predictors were found to be of significance in explaning PAP. The two predictor variables are attitude (X_1) and competency (X_3). Knowledge (X_2) was excluded because it did not contribute in significance ($t = 1.318$, $p = 0.190$) to the variation of the dependent variable (PAP).

As depicted in the coefficient table (*see* Table 4), the estimated of the model coefficients for b_0 is 2.607, b_1 is .235 and b_3 is .408. Therefore, the estimated model is as below:

$$Y = 2.607(b_0) + .235\ (b_1) + .408\ (b_3) + e^*$$

The R^2 of 0.435 implies that the two predictor variables explain about 43.5% of the variance/variation in the PAP. This is quite a good and respectable result. The ANOVA table reveals that the F-statistic ($F = 29.539$) is very large and the corresponding p-value is highly significant (0.0001) or lower than the alpha value of 0.01. This further indecates that the slop of the estimated linear regression model line is not equal to zero and confirms that there is a linear relationship between PAP and the two predictor variables.

As depicted in Table 4, the largest coefficient is 0.330, which is for competency. This means that this particular variable makes the strongest unique contribution to explaining the dependent variable (PAP), when the variance explained by all other predictor variables in the model is controlled for. Thus, it is suggested that one standard deviation increase in competency is followed by .408 standard deviation increase in the PAP. The Beta value for attitude is (0.235), suggesting that one standard deviation increase in attitude is followed by 0.235 standard deviation increase in the PAP.

Based on the collinearity diagnostic table obtained, none of the model demensions has the condition index above the threshold value of 30.0, none of tolerance values is smaller than 0.10, and the VIF statistics is less than 10.0, indicating that there is no serious multicollinearty problem among the predictor variables of the model.

TABLE 4
ANOVA Coefficients

	β	Std. Error	BETA	t	Sig.
Constant	2.607	.358		7.275	.000
Attitude	.159	.057	.235	2.795	.006
Knowledge	.109	.083	.132	1.318	.190
Competency	.330	.078	.408	4.246	.000
R^2	0.435				

DISCUSSION

This study examined the relationship between the farmers' attitude, knowledge, competency and the adoption of the PAP. This study confirmed that attitude, knowledge and competency were significantly and positively related to the adoption of the PAP. As noted by Cavani (2007), farmers' positive attitude towards innovation influenced the adoption of chemical fertilizer innovation in their farms. Therefore, this study verified that the farmers' attitude had positive and direct effects on the adoption of the PAP. It could be concluded that as the positive attitude towards innovation increases, the adoption of PAP will also increase. Unfortunately, to the researchers' knowledge, no study has specifically examined the direct relationship between attitude, knowledge, competency and the adoption of the PAP. Therefore, this study showed that knowledge has positive and direct effects on the adoption of the PAP. The results by Chirwa (2005) also revealed that innovation in fertilizer adoption was positively associated with higher levels of farmers' knowledge. This suggests that taking steps to enhance farmers' knowledge may be an effective way to increase the adoption of PAP. Therefore, this study has verified that the farmers' knowledge has positive and direct effects on the adoption of the PAP. Barham *et al*. (2004) have also suggested that farmers with competency are more likely to adopt innovation and new technology in their farms. According to many researchers, competency appears to be a key determinant of the adoption of innovation and technologies (Cummings & Teng, 2003; Alene & Manyong, 2007; Useche *et al.*, 2009). Similarly, this study also verified that the farmers' competency had positive and direct effects on the adoption of the PAP.

CONCLUSIONS AND IMPLICATIONS

On the whole, the findings are congruent with those of the previous studies, and hence, support the Diffusion of Innovation Theory by Rogers (2003). The adoption of the PAP among farmers in IADABLS is at a high level. This is because the IADABLS has received the earliest PAP programme organized by Malaysian Agricultural Research and Development Institute (MARDI) and Universiti Putra Malaysia (UPM). This high level of PAP shows that farmers in this study have good knowledge, attitude and competency in the adoption of PAP. In this study, competency is a big contributor towards the adoption of the PAP. This is evident when it appears from the findings that competency is the most powerful factor influencing the increase in the adoption of the PAP. Consequently, improvement efforts should be based on enhancing farmers' competency, for example, through more extension programmes. The authorities, particularly the Agriculture Department, should strive to maintain and further enhance the adoption of the PAP by improving the competency of farmers in terms of providing training besides changing them to have better attitude and knowledge. The researchers also suggest that future research should not only look the individual factors, but also cover the roles of the extension agents and the involvement of the agriculture organizations in this project. Other factors should be considered in future research to complement this study are such as the infrastructure, organizational support, local cultural factors, including the role and the influence of politicians in influencing the adoption of the PAP.

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