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Knowledge and Attitude of Malaysian Fruit Growers on Integrated Pest Management (IPM)

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Integrated pest management (IPM) is a sustainable approach for pest control. However, the adoption of IPM remains low in Malaysia. The main objectives of this study were to identify the knowledge level and attitude of Malaysian fruit farmers on IPM. A total number of 150 respondents were selected through a non-random sampling method and the data was collected through an online questionnaire. The knowledge level and attitude of the respondents were accessed on a scoring scale of one to five. The respondents recorded a moderate knowledge of IPM with a mean score of 3.36. However, farmers showed poor knowledge on different modes of action of pesticides (2.25), and the ability to identify insect pests (2.25). The respondents showed a positive attitude on IPM with a mean score of 3.58. Among the attitude aspects, farmers displayed a positive attitude on the cost-effectiveness of IPM (3.53) and are willing to learn and adopt IPM practices (4.35). The Spearman's correlation test revealed that there was no significant correlation between age and educational level of farmers on their knowledge on IPM. The findings of this study could assist in the development of IPM programs for better country wide IPM adoption.

Keywords: Fruit farmers Malaysia; farmer knowledge and attitude; integrated pest management; alternative pest control

I. INTRODUCTION

Agriculture is an important sector in Malaysia which has contributed 7.3% to the national gross domestic product (GDP) in 2018 (Department of Statistics Malaysia, 2019). In 2018, the total area of land for fruit cultivation in Malaysia was 192,437 hectares, which resulted in a sum of 1,540,401.31 MT of production and RM 7.5 billion in revenue. According to the Department of Agriculture (2019), the top five local fruits with the largest cultivation areas are durian, banana, rambutan, pineapple and watermelon amounting to 83.4% of the total hectarage. In terms of production value, durian, banana and pineapple were the top three fruit crops that contributed 75% of the total fruit production of Malaysia.

The fruit industry continues to be a prominent sector in Malaysia because of two main factors: (i) increased consumer awareness and demand for fruits driven by a healthy-eating lifestyle (Suntharalingam & Othman, 2017), and (ii) expanding value of locally cultivated, high-value tropical fruits for the export market. These factors drive the livelihood of smallholder fruit farmers (Nik Rozana, Suntharalingam & Othman, 2014). However, fruit cultivation in Malaysia is generally still challenged by pests and diseases which have resulted in severe yield losses. For example, the bacterial dieback disease of papaya (*Erwinia* spp.) had destroyed approximately 1 million papaya trees and 200,000 MT of fruits (Mohd Taha *et al.*, 2019). The management of pests and diseases is therefore important to ensure the sufficient and sustainable production of high-quality food.

Pesticides are often used intensively to manage pests and diseases in developing countries including Malaysia where over 67,000 tonnes of pesticides were utilized in 2016, the major agrochemical groups being organophosphate (3.8%), phenoxies (8.8%), bipiridils (5.1%) and dithiocarbamates

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(5.6%) (Food and Agriculture Organization of the United Nations, 2020). Although the use of chemicals did increase crop productivity, extensive and indiscriminate use over the long term has led to adverse impacts on the environment and human health (Leong, Tan & Mustapa, 2017; Kamaruzaman *et al.*, 2020). Moreover, the intensive application of pesticides was found to exert a high selective pressure which promotes the development of resistance leading to more frequent pest outbreaks and resurgence (South & Hastings, 2018). For instance, the Pahang (PHG) population of *Bemisia tabaci* was recorded to have a very high resistant factor (354.7-fold) to diafenthiuron, as well as a resistant factor of 192.9-fold to pymetrozine (Shadmany, Omar & Muhamad, 2014). As such, efforts should be put into adopting a more sustainable approach for the control of pests and diseases such as integrated pest management (IPM).

Integrated pest management (IPM) is a holistic approach that incorporates biological, cultural, physical and chemical methods to prevent, manage and control pests and diseases (Ha, 2014). Under the concept of IPM, pesticide spraying could be reduced as it is a need-based practice instead of prophylactic practice, and it should only be applied as the last management option when the economic threshold level (ETL) is reached to prevent the pest population from causing economic injuries (Gibb, 2015). IPM programs were initiated in Malaysia since the late 1970s. In spite of the extensive promotion on IPM, the adoption and awareness of farmers in Malaysia remain low to date (Kabir & Rainis, 2015). Mohamed *et al.* (2016) reported that most of the paddy farmers (80%) in the main granary areas practised unsustainable farming with excessive use of pesticide up to 300% (litres) beyond the recommended dosage. In addition, some fruit and vegetable farmers were found depending solely on chemical pesticides as a pest management approach and tend to be ignorant on the safe use of pesticides (Halimatunsadiah *et al.*, 2016).

According to Azman *et al.* (2013), the knowledge and attitude of farmers are important factors in determining the successful adoption of sustainable agriculture practices. This is because a farmer is the practitioner and final-decision maker and it is therefore important for them to understand the pros and cons of implementing a particular agricultural practice. However, the knowledge level and attitude of Malaysian fruit growers on IPM are not well-documented. Hence, the present study was conducted to fill in this information gap. The findings of this study could serve as important preliminary data to assist in the development of IPM programs to better promote a country-wide adoption and development of IPM.

II. MATERIALS AND METHOD

A. Questionnaire Design

A questionnaire was constructed based on Pouratashi and Iravani (2012), Allahyari, Damalas and Ebadattalab (2017), Roy *et al.* (2017) and Kusumawardani *et al.* (2019) (available on request). The questionnaire was developed and proofread by the authors in three languages (English, Malay and Chinese). The questionnaire consists of five sections. Each question was developed in simple language to ensure farmers could understand and answer them accordingly.

Multiple choice questions and dichotomous questions were utilized to acquire information for the first three sections of the questionnaire. In Section 1, the demographic information of the respondents was collected, namely gender, age, educational level, farming experience, farming region, land tenure, land size and the types of fruits cultivated. In Section 2, the respondents were asked about the production cost of their farm and the key factor that affected their crop yield the most. In Section 3, the respondents were requested to provide information about their current pest management practices. These include their preference and usage of chemical pesticide, practice of pesticide mixing and the spraying regime.

A five-point Likert scale was developed to assess the knowledge level and attitude of fruit farmers on IPM in Section 4 and Section 5 of the questionnaire. The knowledge level of the fruit farmers on IPM include the principle and meaning of IPM, the importance of agroecology, the harmful effects of chemical pesticides, awareness of alternatives to control pests, knowledge on the modes of action and pre-harvest interval of chemical pesticides, pest and beneficial insect differentiation, proper insect pest identification, as well as the decision of spraying based on observation and economic threshold. On the other hand, the attitude aspect refers to the cost, financial accountability, effectiveness, ability of IPM to reduce pest outbreaks and increase yield, and the willingness of farmers to adopt IPM in field.

B. Pilot Test

A pilot test was carried out through a convenience sampling method by inviting 12 Malaysian fruit farmers from Peninsular Malaysia to participate in the questionnaire (Ruel, Wagner III & Gillespie, 2016). The feedback was collected to improve the quality of the questionnaire before the actual survey was conducted.

C. Sampling Technique

The survey study was approved and conducted according to the guidelines by the UTAR Scientific and Ethical Review Committee (U/SERC/112/2020). A non-probability sampling technique was used in this research. A total number of 150 Malaysian fruit farmers was determined as the sample size and the online questionnaire generated using Google Form was disseminated through the Malaysia Fruit Farmers Association and social media applications including Facebook and Whatsapp. It should be noted that this survey was carried out during the COVID-19 pandemic in which physical visitations were not possible due to lockdown restrictions.

D. Data Analysis

The statistical analysis was completed using Microsoft Excel and Statistical Product and Service Solutions (SPSS) (IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA)). The mean and standard deviation of the score obtained from each Likert-scale question were calculated. The knowledge level of farmers on IPM was ranked in four levels, in which a mean score of 4.01– 5.00 is considered as "excellent" knowledge level; 3.50–4.00 as "good"; 2.50–3.49 as "moderate"; and "poor" knowledge level for a mean score of less than 2.49 (Allahyari, Damalas & Ebadattalab, 2017). On the other side, the attitude of farmers on IPM was ranked in three levels, in which a mean score of 3.50–5.00 is considered as a "positive attitude"; 2.50–3.49 as "neutral" attitude and a "negative" attitude for mean scores lower than 2.49 (Roy *et al.*, 2017).

The Spearman's correlation test was conducted to assess the relationship between farmer age and knowledge level on IPM. The strength of the correlation between the variables was interpreted according to the thumb rule of coefficient value by Schober, Boer and Schwarte (2018) with five levels of correlation, in which a coefficient value range of 0.90–1.00 is considered a "very high" correlation; 0.7–0.89 as a "high" correlation; 0.40–0.69 as a "moderate" correlation; 0.10–0.36 as a "low" correlation and the correlation is considered to be negligible with values lower than 0.10.

III. RESULT AND DISCUSSION

A. Demographic Information of the Respondents

The demographic information of the respondents (Table 1) shows that 93.33% of the farmers were male and 6.67% were female. The majority of the farmers were below sixty years old and received at least a secondary (41.33%) or tertiary education (50%). Most of the farmers (70%) have less than ten years of farming experience, while 15.33% of the farmers have more than twenty years of experience. The farms of respondents were distributed in four different regions of Peninsular Malaysia (95.33%) and 4.67% of the farms were located in East Malaysia, either from Sabah or Sarawak. A large group of farmers were planting fruit crops in their private lands (61.75%), and most of them were small scale fruit farmers with a land size of not more than two hectares. This is in line with a study by Taffesse and Isabelle (2019) who stated that most of the Malaysian fruit farmers are smallholders with an average farm size of 0.7 ha. Although a wide variety of fruits were being cultivated, durians and bananas (Figure 1) were the most popular due to their high economic value and huge market demand (Ahmad & Chua, 2008).

Table 1. Demographic information of the respondents.

Variables	Frequency	Percentage (%)
Gender		
Male	140	93.33
Female	10	6.67
Age (Years)		
20-30	23	15.33
31-40	38	25.33
41-50	36	24.00
51-60	39	26.00
>60	14	9.33
Educational Level		
No Formal Education	5	3.33
Primary Education	8	5.33
Secondary Education	62	41.33
Tertiary Education	75	50.00
Farming Experience (Years)		
<5	70	46.67
6-10	35	23.33
11-15	13	8.67
16-20	9	6.00
>20	23	15.33
Farming Region		
Northern Region	51	34.00
Central Region	29	19.33
East Coast	26	17.33
Southern Region	37	24.67
East Malaysia	7	4.67
Land Tenure		
Owned Land	105	61.75
Leased Land	48	28.24
Temporary Occupation License (TOL) Land	5	2.94
Others	12	7.06
Land size (ha)		
<1.0	41	27.33
1.0-2.0	34	22.67
2.1-4.0	29	19.33
4.1-10.0	21	14.00
>10.0	25	16.67

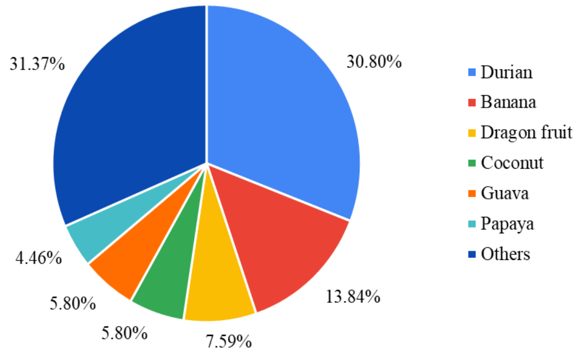

Figure 1. The types of fruit cultivated by the respondents

B. Main Cost of Production and Key Factor Affecting Crop Yield

According to the survey, the main farm production cost includes agrochemical inputs (i.e., fertilizers and pesticides) and farm labour (54%) (Table 2). On the other hand, the major factors that affect crop yield in a fruit farm were pest and disease (46.67%) as well as weather (27.33%), followed by plant nutrient and soil fertility (24.67%), with weed problems regarded as being the least concerned (1.33%). This is because pest and disease could cause pre- and post-harvest losses by deteriorating the quality and nutritional value of fruits. Moreover, the weather could influence important events such as flowering and pollination services, thus affecting the yield. For instance, dry weather stress is important to induce flowering of durian (Masri, 1999). Prolonged period of rain could reduce pollination as heavy rainfall may dilute the nectar and deter the pollinators from visiting the flowers (Lawson & Rands, 2019). The low pollination rate due to extreme weather could ultimately result in a lower fruit set.

Table 2. The main cost of production and the key factors that affect crop yield

Aspects	Frequency	Percentage (%)
Main cost of production		
Neither agrochemical inputs nor farm labour	10	6.67
Both agrochemical inputs and farm labour	81	54.00
Agrochemical inputs only	41	27.33
Farm labour only	18	12.00
Factor that most affect the crop yield		
Pest and disease	70	46.67
Plant nutrition and soil fertility	37	24.67
Weather	41	27.33
Weed problem	2	1.33

C. Current Pest Management Practices

According to Table 3, more than half (55.33%) of the farmers in this survey depend solely on chemical pesticides for pest and disease management, and 52.67% of them would prefer a chemical approach to other alternative measures. This is mainly due to the effectiveness and accessibility of chemical pesticides for pest control (Sharifzadeh *et al.*, 2018).

Most farmers use 'cocktail' pesticides by mixing more than one type of pesticides for a single application (Table 3). The use of 'cocktail' pesticides is widely adopted as it is claimed to be labour- and time-saving by controlling multiple pests in one application, and some farmers suggested that it would actually increase the effectiveness for pest control than the use of a single type of pesticide. (Sun *et al.*, 2019). It was recorded that 66.67% of the farmers would spray chemical pesticides immediately once pests were observed, regardless of the population size of pests (Table 3). This could be due to the concept of 'prevention is better than cure', in which spraying is done as a preventative measure to avoid pest damage and outbreaks (Halimatunsadiah *et al.*, 2016).

Table 3. Current pest management practices of the respondents

Practices	Yes (%)	No (%)
Depend solely on the application of chemical pesticides for pest and disease control.	83 (55.33)	67 (44.67)
Prefer practising chemical control than other approaches.	79 (52.67)	71 (47.33)
Pesticide mixing in a single application	98 (65.33)	52 (34.47)
Spray chemical pesticides immediately after observing any pests	100 (66.67)	50 (33.33)

D. Knowledge Level of the Respondents on IPM

The respondents in this study recorded a moderate knowledge on IPM with an average score of 3.36 (out of five) based on the nine knowledge aspects queried (Table 4). The farmers appeared to have excellent knowledge on the meaning of IPM and the benefits of conserving an agroecosystem, as well as the harmful effects of chemical pesticides. However, the farmers have a moderate awareness of the alternatives for pest management (Table 4). This may be due to the general lack of involvement of various parties including the government, institutions and private sectors in IPM technology, especially in terms of biological control (Yazid *et al.*, 2020). The adoption of biological control in Malaysia is still in its infancy, lacking mass-producing facilities of biological control agents. The lack of exposure may lead to farmers perceiving chemical control is the only viable option to curb pests and diseases. This phenomenon was also observed in other developing countries including Pakistan and Sri Lanka, in which the farmers appeared to have poor understanding on the implementation of alternative control measures and they claimed that chemical control is the only feasible and effective option (Jayasooriya & Aheeyar, 2016; Khan & Damalas, 2015).

Despite the reliance and high usage of synthetic pesticides, the respondents showed a poor understanding in the modes of action (MOA) of different pesticides (Table 4). There are numerous active ingredients with the same MOA. For instance, cypermethrin, lambda-cyhalothrin and deltamethrin all belong to the same MOA of sodium channel regulator (Insecticide Resistance Action Committee, 2020). As a result, the farmers were merely be switching pesticides with the same MOA of different trade names (Moinina *et al.*, 2018). In addition, farmers with low literacy or without formal agriculture education may find the information of MOA difficult to understand, and often refer to advice from licensed pesticide dealers. Unfortunately, some pesticide dealers may also be poorly equipped in terms of technical knowledge, and thus, providing misleading information to farmers (Lekei, Ngowi & London, 2014). Profit-oriented dealers are only interested in boosting their sales instead of sharing their knowledge of MOA and the appropriate use of pesticides (Rijal *et al.*, 2018). The situation worsens when the farmers themselves could not identify insect pests and disease symptoms, and apply pesticides with the same mode of action for a long period of time.

The results of this study (Table 4) indicated that local fruit farmers were relatively poor (mean score 2.25 out of 5) in identifying insect pests in their farms. The farmers are generally unaware of the causal agents of damage and may misinterpret insect damage as plant diseases or plant stress symptoms (Munyuli *et al.*, 2017). Likewise, less-informed farmers tend to categorize different insect pests as the same species based on their feeding habits or characteristics. The studies conducted by Abang *et al.* (2014) in Cameroon, and Kalule *et al.* (2006) in Uganda have reported the same findings, in which the farmers with poor knowledge of insect pests would tend to recognize defoliator insects and stemborers as caterpillars, while all flying insects are seen as flies. In this survey, the respondents appeared to have moderate knowledge in differentiating pests and beneficial insects (Table 4) with the ability to recognize common generalist predators such as ladybeetle and dragonfly. These farmers may not be able to distinguish complicated insect groups such as predatory thrips and pest thrips which are often smaller in size (Wyckhuys *et al.*, 2018). This may be attributed to the lack of formal training among our local farmers who may not understand the difference between insect pests and beneficial insects. According to a survey study conducted by Mazlan and Mumford (2005), only 1% of the respondents have received formal trainings for farm management.

On the other hand, the respondents only recorded a moderate knowledge level in terms of decision-led spraying based on observation and economic threshold level (ETL) (Table 4.2). Farmers may find the concept of ETL complicated and hard to be practised (Kusumawardini *et al.*, 2019). This is because a spraying decision based on ETL would require frequent field scouting to monitor and observe for pest manifestation. However, this is an issue for farmers who are poor in pest identification, leading to data inaccuracy and ultimately affecting the effectiveness of the assessment. Nonetheless, the respondents in this study have shown a good understanding on pre-harvest interval (PHI) with a mean score of 3.77 (Table 4). The PHI is important to allow pesticides to degrade to a safe level for consumption (Yap & Jarroop, 2018). This is to ensure that the maximum residue limit (MRL) is not exceeded, as it is a strict criterion for crops destined for export (Amekawa *et al.*, 2017).

The government plays an important role in elevating the knowledge level of the farmers on IPM by establishing constructive IPM policies and tangible action plans. In Switzerland, IPM is recognized as the key strategy for crop protection and the Swiss government has supported actively in funding research and providing incentives for the farmers who meet the ecological standards in their farms. According to Barzman *et al.* (2014), 90% of the farmland in Switzerland is now cultivated based on IPM-based integrated production system (80%) or organic guidelines (10%).

The success story from Switzerland could serve as a valuable model policy for reference and adoption in Malaysia. This includes providing grants and incentives to drive stakeholders, specifically the scientific community and private sectors to spur research and development related to IPM. For instance, research on the biodiversity and taxonomy of insect pests and their natural enemies are vital for the implementation of biological control in IPM, especially considering the rich diversity of local flora and fauna in Malaysia (Hamid, Noor & Lo, 2005).

In addition, the pesticide reduction policy could be implemented by phasing out highly hazardous chemical pesticides and imposing a higher tax on hazardous chemical pesticides. For instance, the Cambodian government has banned the registration of new pesticides which belong to the WHO Class Ia or Ib group (Schreinemachers *et al.*, 2015). The tax revenue from pesticides could be reinvested into IPM training programs to enhance the farmers knowledge on insect ecology and biology (Lamers *et. al.*, 2013; Khan & Damalas, 2015). Simple activities such as insect zoos and agroecological drawings are effective in helping the smallholders to differentiate insect pests and beneficial insects (Wyckhuys *et al.*, 2018). The insect zoo approach has been utilized in several developing countries to educate the traditional and resource-poor farmers on insect pest management including Philippines (Palis, 2006), India and Kenya (Williamson *et al.*, 2003).

Table 4. Knowledge Level of the Respondents on Integrated Pest Management

Aspect	Mean	Standard deviation
1. Principle and meaning of IPM	4.05	0.84
2. Importance of agroecology	4.03	0.95
3. Harmful effects of chemical pesticides	4.45	0.88
4. Awareness of alternatives to control pests	2.85	1.25
5. Knowledge on chemical pesticides (Mode of action)	2.24	1.05
6. Pest and beneficial insect differentiation	3.45	1.38
7. Proper insect pest identification	2.25	1.27
8. Decision on spraying based on observation and economic threshold	3.17	1.32
9. Knowledge on chemical pesticides (Pre-harvest interval)	3.77	1.22
Average	**3.36**	**1.13**

E. Attitude of the respondents on IPM

The respondents show an overall positive attitude towards IPM with a mean score of 3.58 (Table 5). Farmers in this study appeared to have a positive attitude on the cost-effectiveness of IPM and a "good" level of willingness to learn and adopt IPM in the field (Table 5). This result was contrary to the findings of interview survey conducted by Roy *et al.* (2017) in Bangladesh and Jayasooriya and Aheeyar (2016) in Sri Lanka. Such difference could be due to the larger proportion of young respondents in this study who tend to be more tech-savvy, acceptive and enthusiastic in learning new knowledge (Patel, Chauhan & Korat, 2007; Li *et al.*, 2020). Moreover, the younger generations are generally well-informed about the importance of environmental preservation and sustainability in agriculture (Rahman, 2020). The respondents believed that IPM practices could reduce the cost and dependence on synthetic pesticides by minimizing unnecessary spraying, as well as utilizing cost-effective alternatives for pest control.

However, the respondents displayed a neutral attitude on the financial accountability and effectiveness of integrated pest management (IPM) with a mean score of 3.17 and 3.31 (Table 4.3). Farmers are sceptical that IPM practices could improve profits. They have preconceived notions that the transition period of changing from solely depending on chemical pesticides to implementing IPM practices is too long and could involve a high investment cost and labour expenditures. In addition, some respondents perceive that IPM practices are not guaranteed as they have not seen any successful cases of IPM-integrated farms. This was not true because several studies showed that IPM farmers with fewer pesticide input achieved a higher profit compared to non-IPM farmers (Halder *et. al.*, 2018; Muriithi *et. al.*, 2016; Gautam *et al.*, 2017). Additionally, farmers who are farming on leased land or TOL land might not be willing to spend such an amount of time and money to invest their farm as the tenancy is not secured. This is supported by local study (Tiraieyari, Hamzah & Abu Samah, 2014), as well as foreign research in Ghana, India, and Bangladesh that land tenancy is one of the key factors that influence the adoption of good agricultural practices and technologies by the farmers (Pandit *et. al.*, 2017; Abdulai, Owusu & Goetz, 2011; Kabir & Rainis, 2014).

It was clear from the result that farmers were doubtful that IPM could reduce pest and disease outbreaks and simultaneously increase yield (Table 4.3). Some respondents claimed that pest and disease outbreaks occur more easily with less application of chemical pesticides. This is because they think that the complete elimination of pests is required to prevent outbreaks, instead of merely suppressing the pest population to an acceptable level (El-Shafie, 2020). Farmers might also perceive that the use of chemical pesticides is the key factor to ensure high yield, not knowing that the use of synthetic pesticide could only help to reduce crop losses rather than increasing the potential yield (Petrescu-Mag *et. al*., 2019; Popp, Pető & Nagy, 2013). Hence, the farmers see no need for a change as they could achieve high yield using high agrochemical inputs that are relatively affordable and easily available compared to environmentally-sound IPM practices.

There are several initiatives that could be taken to enhance the attitude of farmers on IPM practices. Firstly, the government could set up 'model IPM farm' to demonstrate the effectiveness and positive impacts of IPM to the non-IPM farmers. The concept of model farm is established in many European countries including Germany and Czech Republic so that the IPM practices can be easily communicated to the public via activities such as field trips and field open exhibition (Gross & Gündermann, 2016; Šťastná *et al*., 2019). According to Rezaei and Ganjikhanloo (2020), result demonstration is correlated to the perceived usefulness of IPM by farmers. Farmers could understand and generate positive attitudes on the effectiveness of IPM when they observe significant results from the model farm.

In addition, subsidy and incentives are important for the farmers especially during the transition period to integrating IPM practices in the field. Farmers may be willing to change, but without monetary support to compensate for their losses during this critical period, they have no options but to stick to their existing practices including prophylactic spraying. The government could provide subsidy to help the farmers in acquiring alternative sustainable non-chemical tools such as biopesticides for pests and diseases control at an affordable price.

Furthermore, the land policy is crucial to elevate the confidence of farmers to invest IPM technologies in their farms. The government could strengthen the land tenure by lengthening the leasing period of government leased land and temporary occupation license (TOL) land, so that the farmers could secure the land tenancy and therefore be encouraged to invest and adopt IPM practices in the farm (Oostendorp & Zaal, 2012). According to a study conducted by Gao *et al.* (2019), the enhanced land tenancy security in China has improved the adoption of sustainable plant protection control by the farmers.

Moreover, smart farming technology such as Internet of Things (IoT) could be integrated to enhance the adoption of IPM, especially in large farms. This is because these farmers often perceive that the labour intensive and time-consuming IPM are not feasible on a large scale (Rahman, 2020; Singh, *et al.,* 2008). However, it has been shown that the adoption of IoT could actually reduce labour work. For instance, an IoT-based sensor system by Rustia and Lin (2011) in Taiwan to scout whitefly and fruit fly populations reduced the need for manual data recording of these insect pests. The data collected by the sensors also useful to implement a precise pest management approach using IPM solutions. A study conducted by Tackenberg *et al.* (2018) in Germany showed that the application of fungicides on winter wheat (*Triticum aestivum*) has reduced as much as 45% after the adopting the sensor-controlled fungicide application method.

Table 5. Attitude of the Respondents on Integrated Pest Management

Aspect	Mean	Standard deviation
1. IPM and cost	3.53	1.06
2. Willingness to adopt IPM in field	4.35	0.94
3. Financial accountability of IPM	3.17	1.17
4. Effectiveness of IPM	3.31	1.19
5. IPM and pest outbreaks	3.36	1.21
6. IPM and yield	3.49	1.22
Average	**3.58**	**1.13**

F. Relationship between Age, Educational level and IPM knowledge of Farmers

There was no significant correlation between farmer age, farmer educational level with their knowledge of integrated pest management (IPM) (Table 6). This indicated that older farmers are generally not resisting changes, but they are just used to the traditional practices which are tried-and-true. This conservative approach could be due to the sense of insecurity towards the adoption of newer approaches. As such, unlike age and educational level, agricultural education on pest management is likely the key factor in a farmer's knowledge of IPM in this study. This is also shown in the study of Parsa *et al.* (2013), stating the the inadequate training and technical support is the primary reason for the poor understanding and adoption of IPM in developing countries.

A non-formal education is needed to enhance the knowledge level of farmers on IPM especially for farmers who have lower literacy level. The participatory extension approach could be implemented to disseminate the concept of IPM to the farmers. Under the participatory extension approach, the farmers are the key player in setting goals and agendas and they would learn through hands-on activities such as field experiments and trials, demonstrations and group sharing sessions, instead of formal lectures (Knook *et al.*, 2018). This helps in empowering farmers in decision-making so that the farmers could be independent, flexible and adaptive in solving problems using different IPM practices.

Farmer field schools (FFS) is one of the participatory extension approaches which helps in improving farmer knowledge and adoption of IPM (Mariyono *et al.*, 2013). FFS has been implemented in Malaysia, however, it is not widely adopted in the country. This may be due to the lack of trained or experienced facilitators, low level of participation, and lack of monitoring (Roy, Farouque & Rahman, 2013). In order to enhance the sustainability of FFS, the facilitators should be recruited based on their leadership and communication skills, as well as their knowledge and experience in farming, rather than emphasizing their educational and literacy levels. This enables the facilitators to utilize the bottom-up method to disseminate agricultural knowledge to the farmers (Waddington *et al.*, 2014). Furthermore, extension programs should be tailored according to the needs of the farmers and scheduled properly by avoiding the peak period of cultivation to encourage farmers' participation. Follow-up plans and impact assessment of the program could be carried out frequently to identify FFS that requires additional support. Frequent monitoring activities are necessary to analyse how extension services could be improved in future in empowering the farmers towards the adoption of IPM.

Table 6. Spearman's Correlation Coefficient between Age and Educational Level with the Knowledge Level of Integrated Pest Management

N=150	**p-value**	**R**	**R-square**
Age and knowledge level of IPM	0.330	NS*	NS*
Educational level and knowledge level of IPM	0.405	NS*	NS*

Note: NS*: Not significant at 0.05 level.

IV. CONCLUSION

The respondents were shown to have a moderate knowledge of integrated pest management (IPM) with a mean score of 3.36, with poor knowledge of the different mode of action of pesticides, and a weak capability to identify the types of insect pests. These are likely to be caused by the lack of involvement of policy support, as well as insufficient field training and education of chemical pesticides. On the other hand, the respondents recorded a positive attitude on IPM with a mean score of 3.58. The result showed that the respondents have a positive attitude towards the cost-effectiveness of IPM and possessed a high willingness to learn and adopt IPM practices in the field. However, the farmers only displayed a neutral attitude on the effectiveness and financial accountability of IPM, as well as the reliability of IPM to reduce pest outbreaks and increase yield. The possible reasons of such sceptical attitude include the lack of monetary support, insecure land tenancy and limited evidence on the successful cases of IPM. The government plays an important role in enhancing the knowledge and attiude of farmers through supportive policies and tangible actions. These include providing research grant for IPM-related studies, phasing out highly hazardous chemical pesticides, establishing model IPM farms, subsidizing the farmers during the transition period to integrating IPM practices, as well as strengthening the land tenure of the farmer. There was no significant correlation between the farmers' age and education level with the knowledge of IPM. Nonetheless, farmers education on pest management is important and the participatory extension programs such as farmer field school was suggested to empower and educate the farmers on IPM in local fruit cultivation. Frequent monitoring and support from the agriculture extension officers are also crucial to assist farmers who are facing challenges in the implementation of IPM in their farms.

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VI. REFERENCES

Abang, AF, Kouamé, CM, Abang, M, Hanna, R & Fotso, AK 2014, 'Assessing vegetable farmer knowledge of diseases and insect pests of vegetable and management practices under tropical conditions', International Journal of Vegetable Science, vol. 20, no. 3, pp. 240–253.

Abdulai, A, Owusu, V & Goetz, R 2011, 'Land tenure differences and investment in land improvement measures: theoretical and empirical analyses', Journal of Development Economics, vol. 96, no. 1, pp. 66–78.

Ahmad, I & Chua, PC, 2008, 'Trends in production and trade of tropical fruits in ASEAN countries', Acta Horticulturae, vol. 975, pp. 559–580.

Allahyari, MS, Damalas, CA & Ebadattalab, M 2017, 'Farmers' technical knowledge about integrated pest management (IPM) in olive production', Agriculture, vol. 7, no. 12, pp. 1–9.

Amekawa, Y, Ng, CC, Lumayag, LA, Tan, GH, Wong, CS, Abdulrauf, B, Tan, HB, Tai, WX, Tan, SM, Liu, CH & Chee, JL 2017, 'Producers' perceptions of public good agricultural practices and their pesticide use: the case of MyGAP for durian farming in Pahang, Malaysia', Asian Journal of Agriculture and Rural Development, vol. 7, no. 1, pp. 1–16.

Azman, A, D'Silva, JL, Samah, BA, Man, N & Shaffril, HAM 2013, 'Relationship between attitude, knowledge, and support towards the acceptance of sustainable agriculture among contract farmers in Malaysia', Asian Social Science, vol. 9, no. 2, pp. 99–105.

Barzman, MS, Bertschinger, L, Dachbrodt-Saaydeh, S, Graf, B, Jensen, JE, Joergensen, LN, Kudsk, P, Messéan, A, Moonen, AC, Ratnadass, A & Sarah, JL 2014, 'Integrated pest management policy, research and implementation: European initiatives' eds R Peshin & D Pimentel, in Integrated Pest Management, Springer: Dordrecht, pp. 415–428.

Department of Agriculture 2019, Fruit crops statistics Malaysia 2018, Department of Agriculture, viewed 13 June 2020, < http://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_awam/maklumat_pertanian/perangkaan_tanaman/perangkaan_buah_2018.pdf>.

Department of Statistics Malaysia 2019, Selected agriculture indicators Malaysia 2019, Department of Statistics Malaysia, viewed 13 June 2020, <https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=72&bul_id=SEUxMEE3VFdBcDJhdUhPZVUxa2pKdz09&menu_id=Z0VTZGU1UHBUT1VJMFlpaXRRR0xpdz09>.

El-Shafie, HAF 2020, 'Insect pest management in organic farming system', eds J Moudrý, J Bernased, KF Mendes, RN Sousa & RDS Teixeira, in Multifunctionality and impacts of organic and conventional agriculture, IntechOpen, London, UK, pp. 137-156.

Food and Agriculture Organization of the United Nations 2020, FAOSTAT statistical database- pesticide use, Food and Agriculture Organization of the United Nations, viewed 17 July 2020, < http://www.fao.org/faostat/en/#data/RP >.

Gao, Y, Liu, B, Yu, L, Yang, H & Yin, S 2019, 'Social capital, land tenure and the adoption of green control techniques by family farms: evidence from Shandong and Henan Provinces of China', Land Use Policy, vol. 89, pp. 1–11.

Gautam, S, Schreinemachers, P, Uddin, MN & Srinivasan, R 2017, 'Impact of training vegetable farmers in Bangladesh in integrated pest management (IPM)', Crop Protection, vol. 102, pp. 161–169.

Gibb, TJ 2014, Contemporary insect diagnostics: the art and science of practical entomology, Academic Press, Cambridge, UK.

Gross, J & Gündermann, G 2016, 'Principles of IPM in cultivated crops and implementation of innovative strategies for sustainable plant protection', eds AR Horowitz & I Ishaaya, in Advances in insect control and resistance. Springer, Switzerland, pp.9–26.

Ha, MT 2014, 'A review on the development of integrated pest management and its integration in modern agriculture', Asian Journal of Agriculture and Food Science, vol. 2, no. 4, pp. 336–340.

Halder, J, Sardana, HR, Krishnan, N, Pandey, MK, Bhat, MN & Banerjee, K 2018, 'Synthesis and area-wide validation of adaptable IPM technology and its economic analysis for bitter gourd (*Momordica charantia*) in a farmers' driven approach', Indian Journal of Agricultural Sciences, vol. 88, no. 9, pp. 1378–1382.

Halimatunsadiah, AB, Norida, M, Omar, D & Kamarulzaman, NH 2016, 'Application of pesticide in pest management: the case of lowland vegetable growers', International Food Research Journal, vol. 23, no. 1, pp. 85–94.

Hamid, MN, Noor, MRM & Lo, LN 2005, 'Malaysia' ed PAC Ooi, in Nonpesticide methods for controlling diseases and insect pesticides. FAO: Bangkok, pp. 154–160.

Insecticide Resistance Action Committee, 2020. IRAC mode of action classification scheme, Insecticide Resistance Action Committee, viewed 20 December 2020, <https://irac-online.org/modes-of-action/>.

Jayasooriya, HJC & Aheeyar, MM 2016, 'Adoption and factors affecting on adoption of integrated pest management among vegetable farmers in Sri Lanka', Procedia Food Science, vol. 6, pp. 208–212.

Jors, E, Aramayo, A, Huici, O, Konradsen, F & Gulis, G 2017, 'Obstacles and opportunities for diffusion of integrated pest management strategies reported by Bolivian small-scale farmers and agronomists', Environmental Health Insights, vol. 11, pp. 1–14.

Kabir, MH & Rainis, R 2014, 'Adoption and intensity of integrated pest management (IPM) vegetable farming in Bangladesh: an approach to sustainable agricultural development', Environment, Development and Sustainability, vol. 17, no. 6, pp. 1413–1429.

Kalule, T, Khan, ZR, Bigirwa, G, Alupo, J, Okanya, S, Pickett, JA & Wadhams, LJ 2006, 'Farmers' perceptions of importance, control practices and alternative hosts of maize stemborers in Uganda', International Journal of Tropical Insect Science, vol. 26, no. 2, pp. 71–77.

Kamaruzaman, NA, Leong, YH, Jaafar, MH, Khan, HRM, Rani, NAA, Razali, MF & Majid, MIA 2020, 'Epidemiology and risk factors of pesticide poisoning in Malaysia: a retrospective analysis by the National Poison Centre (NPC) from 2006 to 2015', BMJ Open, vol. 10, no. 6, pp. 1–9.

Khan, M & Damalas, CA 2015, 'Factors preventing the adoption of alternatives to chemical pest control among Pakistani cotton farmers', International Journal of Pest Management, vol. 61, no. 1, pp. 9–16.

Knook, J, Eory, V, Brander, M & Moran, D 2018, 'Evaluation of farmer participatory extension programmes', Journal of Agricultural Education and Extension, vol. 24, no. 4, pp. 309–325.

Kusumawardani, A, Martono, E, Trisyono, YA & Putra, SN 2019, 'Farmers' knowledge and attitudes towards the integrated pest management principles in paddy rice in Banyumas Regency', Asian Journal of Scientific Research, vol. 12, no. 1, pp. 105–111.

Lamers, M, Schreinemachers, P, Ingwersen, J, Sangchan, W, Grovermann, C & Berger, T 2013, 'Agricultural pesticide use in mountainous areas of Thailand and Vietnam: towards reducing exposure and rationalizing use' eds HL Fröhlich, P Schreinemachers, K Stahr & G Clemens, in Sustainable land use and rural development in Southeast Asia: Innovations and policies for mountainous areas. Springer, Berlin, pp. 149–173.

Lawson, DA & Rands, SA 2019, 'The effects of rainfall on plant–pollinator interactions', Arthropod-Plant Interactions, vol. 13, pp. 561–169.

Lekei, EE, Ngowi, AV & London, L 2014, 'Pesticide retailers' knowledge and handling practices in selected towns of Tanzania', Environmental Health, vol. 13, no. 1, pp. 79–81.

Leong, KH, Tan, LB & Mustafa, AM 2007, 'Contamination levels of selected organochlorine and organophosphate pesticides in the Selangor River, Malaysia between 2002 and 2003', Chemosphere, vol. 66, no. 6, pp. 1153–1159.

Li, H, Huang, D, Ma, Q, Qi, W & Li, H 2020, 'Factors influencing the technology adoption behaviours of Litchi farmers in China', Sustainability, vol. 12, no. 1, pp. 1–13.

Mariyono, J, Luther, GC, Bhattarai, M, Ferizal, M, Jaya, R & Fitriana, N 2013, 'Farmer field schools on chili peppers in Aceh, Indonesia: Activities and impacts', Agroecology and Sustainable Food Systems, vol. 37, no. 9, pp.1063–1077.

Masri, M, 1999, 'Flowering, fruit set and fruitlet drop of durian (*Durio zibethinus* Murr.) under different soil moisture regimes', Journal of Tropical Agriculture and Food Science, vol. 27, pp. 9-16.

Mazlan, N & Mumford, J 2005, 'Insecticide use in cabbage pest management in the Cameron Highlands, Malaysia', Crop Protection, vol. 24, no. 1, pp. 31–39.

Mohamed, Z, Terano, R, Shamsudin, MN & Abd Latif, I 2016, 'Paddy farmers' sustainability practices in granary areas in Malaysia', Resources, vol. 5, no. 2, pp. 1–17.

Mohd Taha, MD, Mohd Jaini, MF, Saidi, NB, Abdul Rahim, R, Md Shah, UK & Mohd Hashim, A 2019, 'Biological control of *Erwinia mallotivora*, the causal agent of papaya dieback disease by indigenous seed-borne endophytic lactic acid bacteria consortium', Plos One, vol. 14, no. 12, pp. 1–20.

Moinina, A, Lahlali, R, MacLean, D & Boulif, M 2018, 'Farmers' knowledge, perception and practices in apple pest management and climate change in the Fes-Meknes Region, Morocco', Horticulturae, vol. 4, no. 4, pp. 42–61.

Munyuli, T, Cihire, K, Rubabura, D, Mitima, K, Kalimba, Y, Tchombe, N, Mulangane, EK, Birhashwira, O, Umoja, M, Cinyabuguma, E & Mukadi, TT 2017, 'Farmers' perceptions, believes, knowledge and management practices of potato pests in South-Kivu Province, eastern of Democratic Republic of Congo', Open Agriculture, vol. 2, no. 1, pp. 362–385.

Muriithi, BW, Affognon, HD, Diiro, GM, Kingori, SW, Tanga, CM, Nderitu, PW, Mohamed, SA & Ekesi, S 2016, 'Impact assessment of integrated pest management (IPM) strategy for suppression of mango-infesting fruit flies in Kenya', Crop Protection, vol. 81, pp. 20–29.

Nik Rozana, NMM, Suntharalingam, C & Othman, MF 2017, 'Competitiveness of Malaysia's fruits in the global market: revealed comparative advantage analysis', Malaysian Journal of Mathematical Sciences, vol. 11, pp. 143–157.

Oostendorp, RH & Zaal, F 2012, 'Land acquisition and the adoption of soil and water conservation techniques: a duration analysis for Kenya and the Philippines', World Development, vol. 40, no. 6, pp. 1240–1254.

Palis, FG 2006, 'The role of culture in farmer learning and technology adoption: a case study of farmer field schools among rice farmers in central Luzon, Philippines', Agriculture and Human Values, vol. 23, no. 4, pp. 491–500.

Pandit, U, Nain, M, Singh, R, Kumar, SHIV & Chahal, V 2017, 'Adoption of Good Agricultural Practices (GAPs) in Basmati (Scented) rice: A study of prospects and retrospect', Indian Journal of Agricultural Sciences, vol. 87, no. 1, pp. 36–41.

Parsa, S, Morse, S, Bonifacio, A, Chancellor, TC, Condori, B, Crespo-Pérez, V, Hobbs, SL, Kroschel, J, Ba, MN, Rebaudo, F & Sherwood, SG 2014, 'Obstacles to integrated pest management adoption in developing countries', Proceedings of the National Academy of Sciences, vol. 111, no. 10, pp. 3889–3894.

Patel, MC, Chauhan, NB & Korat, DM 2007, 'Consequence of farmers attributes on their attitude towards integrated pest management strategy', Karnataka Journal of Agricultural Sciences, vol. 20, no. 4, pp. 797–799.

Petrescu-Mag, RM, Banatean-Dunea, I, Vesa, SC, Copacinschi, S & Petrescu, DC 2019, 'What do Romanian farmers think about the effects of pesticides? Perceptions and willingness to pay for bio-pesticides', Sustainability, vol. 11, no. 13, pp. 1–16.

Popp, J, Pető, K & Nagy, J 2013, 'Pesticide productivity and food security. A review', Agronomy for Sustainable Development, vol. 33, no. 1, pp. 243–255.

Pouratashi, M & Iravani, H 2012, 'Farmers' knowledge of integrated pest management and learning style preferences: implications for information delivery', International Journal of Pest Management, vol. 58, no. 4, pp. 347–353.

Rahman, HA 2020, 'Malaysian Youth and environmental sustainability: a review', Perspektif: Jurnal Sains Sosial dan Kemanusiaan, vol. 12, no. 2, pp.43–54.

Rahman, MS 2020, 'Determinants of integrated pest management (IPM) practices dis-adoption in vegetables production in Bangladesh', International Journal of Tropical Insect Science, vol. 2020, pp. 1–8.

Rezaei, R, Safa, L & Ganjkhanloo, MM 2020, 'Understanding farmers' ecological conservation behavior regarding the use of integrated pest management-an application of the technology acceptance model', Global Ecology and Conservation, vol. 22, pp. 1–18.

Rijal, JP, Regmi, R, Ghimire, R, Puri, KD, Gyawaly, S & Poudel, S 2018, 'Farmers' knowledge on pesticide safety and pest management practices: a case study of vegetable growers in Chitwan, Nepal', Agriculture, vol. 8, no. 1, pp. 16–26.

Roy, D, Farouque, MG & Rahman, MZ 2013, 'Problem confrontation of the FFS farmers in participating farmer field school training session', Progressive Agriculture, vol. 24, no. 1-2, pp. 273–280.

Roy, UK, Hossain, KZ, Islam, MR & Rahman, MS 2017, 'Farmers' attitude towards integrated pest management (IPM) practices in vegetable cultivation', Journal of Agriculture and Rural Research, vol. 1, no. 2, pp. 91–97.

Ruel, E, Wagner III, W & Gillespie, B 2016, The practice of survey research, SAGE Publications, Thousand Oaks, California.

Rustia, DJA & Lin, TT 2017, 'An IoT-based wireless imaging and sensor node system for remote greenhouse pest monitoring', Chemical Engineering Transactions, vol. 58, pp. 601–606.

Schober, P, Boer, C & Schwarte, LA 2018, 'Correlation coefficients: appropriate use and interpretation', Anesthesia & Analgesia, vol. 126, no. 5, pp. 1763–1768.

Schreinemachers, P, Afari-Sefa, V, Heng, CH, Dung, PTM, Praneetvatakul, S & Srinivasan, R 2015, 'Safe and sustainable crop protection in Southeast Asia: status, challenges and policy options', Environmental Science & Policy, vol. 54, pp. 357–366.

Shadmany, M, Omar, D & Muhamad, R 2015, 'Biotype and insecticide resistance status of *Bemisia tabaci* populations from Peninsular Malaysia', Journal of Applied Entomology, vol. 139, no. 1–2, pp. 67–75.

Sharifzadeh, MS, Abdollahzadeh, G, Damalas, CA & Rezaei, R 2018, 'Farmers' criteria for pesticide selection and use in the pest control process', Agriculture, vol. 8, no. 2, pp. 24–39.

Singh, SB, Mukherjee, I, Maisnam, J, Kumar, P, Gopal, M & Kulshrestha, G 2008, 'Determination of pesticide residues in IPM and non-IPM samples of mango (*Mangifera indica*)', Journal of Environmental Science and Health Part B, vol. 43, no. 4, pp. 300–306.

South, A & Hastings, IM 2018, 'Insecticide resistance evolution with mixtures and sequences: a model-based explanation', Malaria Journal, vol. 17, no. 1, pp. 1–20.

Šťastná, M, Peřinková, V, Pokorná, P & Vaishar, A 2019, 'New approach to sustainability in rural areas comprising agriculture practices–analysis of demonstration farms in the Czech Republic', Sustainability, vol. 11, no. 10, pp. 1–14.

Sun, S, Hu, R, Zhang, C & Shi, G 2019, 'Do farmers misuse pesticides in crop production in China? Evidence from a farm household survey', Pest Management Science, vol. 75, no. 8, pp. 2133–2141.

Suntharalingam, C & Othman, MF 2017, 'Competitiveness of Malaysia's fruits in the global market: revealed comparative advantage analysis', Malaysian Journal of Mathematical Sciences, vol. 11, pp. 143–157.

Tackenberg, M, Volkmar, C, Schirrmann, M, Giebel, A & Dammer, KH 2018, 'Impact of sensor-controlled variable-rate fungicide application on yield, senescence and disease occurrence in winter wheat fields', Pest Management Science, vol. 74, no. 6, pp. 1251–1258.

Taffesse, S & Isabelle, T 2019, Agricultural transformation and inclusive growth: the Malaysian experience, World Bank Group, viewed 16 October 2020, < http://documents1.worldbank.org/curated/en/617611574179512389/pdf/AgriculturalTransformation-and-Inclusive-Growth-The-Malaysian-Experience.pdf>.

Tiraieyari, N, Hamzah, A & Abu Samah, B 2014, 'Organic farming and sustainable agriculture in Malaysia: organic farmers' challenges towards adoption', Asian Social Science, vol. 10, no. 4, pp. 1–7.

Waddington, H, Snilstveit, B, Hombrados, J, Vojtkova, M, Phillips, D, Davies, P & White, H 2014, 'Farmer field schools for improving farming practices and farmer outcomes: A systematic review', Campbell Systematic Reviews, vol. 10, no. 1, pp. 155–161.

Williamson, S, Little, A, Ali, MA, Kimani, M, Meir, C & Oruko, L 2003, 'Aspects of cotton and vegetable farmers' pest management decision-making in India and Kenya', International Journal of Pest Management, vol. 49, no. 3, pp. 187–198.

Wyckhuys, KA, Bentley, JW, Lie, R & Fredrix, M 2018, 'Maximizing farm-level uptake and diffusion of biological control innovations in today's digital era', BioControl, vol. 63, no. 1, pp. 133–148.

Yap, CA & Jarroop, Z 2018, 'Residue levels and dissipation behaviors of chlorpyrifos in black pepper berries and soil', Food Research, vol. 2, no.6, pp. 587–593.

Yazid, SNE, Jinap, S, Ismail, SI, Magan, N & Samsudin, NIP 2020, 'Phytopathogenic organisms and mycotoxigenic fungi: Why do we control one and neglect the other? A biological control perspective in Malaysia', Comprehensive Reviews in Food Science and Food Safety, vol. 19, no. 2, pp. 643–669.