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Original Research Article

Influence of Effort Expectancy on Precision Farming Technology Acceptance among Pineapple Growers in Malaysia

Jasmin Arif Shah*, Fatin Nabihah Rasib, Nur Atikah Ismail, Nur Bahiah Mohamed Haris & Norida Mazlan

Department of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia,
43400, Serdang, Selangor, Malaysia

**Corresponding Author: jasmin.arifshah@upm.edu.my*

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Abstract. The digital transformation of agriculture has accelerated the adoption of precision farming technologies (PFT) to enhance agricultural productivity, optimise resource utilisation, and support sustainable farming practices. Despite these potential benefits, the acceptance of PFT among Malaysian pineapple growers remains relatively limited, constraining the wider implementation of digital agriculture. This study examines the influence of effort expectancy on precision farming technology acceptance among pineapple growers in Malaysia. A quantitative research design was employed using a structured questionnaire administered to 184 pineapple growers. Data were analysed using descriptive statistics, Pearson correlation, and multiple regression analysis. The findings revealed that respondents reported a high level of effort expectancy ($M = 3.16$, $SD = 0.76$). Pearson correlation analysis indicated a strong positive relationship between effort expectancy and precision farming technology acceptance ($r = 0.72$, $p < 0.01$). Multiple regression analysis further demonstrated that effort expectancy significantly influenced technology acceptance ($\beta = 0.420$, $t = 4.916$, $p < 0.001$), indicating that growers who perceived precision farming technologies as easier to learn and use were more likely to accept them. This study extends the application of the Unified Theory of Acceptance and Use of Technology (UTAUT) by providing empirical evidence on the role of effort expectancy in shaping acceptance of precision farming technology among Malaysian pineapple growers. The findings suggest that strengthening farmer training, digital extension services, and user-friendly technology design may accelerate precision farming technology acceptance among pineapple growers in Malaysia.

Keywords Precision farming technology; effort expectancy; technology acceptance; pineapple growers

Introduction

The advancement of digital technologies has accelerated the transformation of agricultural systems worldwide, positioning precision farming technology (PFT) as a key driver of sustainable and efficient agricultural production (FAO, 2022; Monteiro et al., 2021; Getahun et al., 2024). Precision farming integrates digital tools such as Global Positioning Systems (GPS), unmanned aerial vehicles (UAVs), sensors, the Internet of Things (IoT), and data-driven decision support systems to enable site-specific crop management and optimise agricultural operations (Monteiro et al., 2021; Getahun et al., 2024). By facilitating precise input application and real-time field monitoring, these technologies improve production efficiency, reduce resource wastage, and enhance environmental sustainability (FAO, 2022; Getahun et al., 2024). Consequently, precision farming has become an integral component of smart agriculture and is increasingly recognised as a strategic approach to improving agricultural productivity and food security (FAO, 2022).

In Malaysia, the adoption of precision farming technologies has gained increasing attention as part of the national agenda to modernise the agricultural sector (Ministry of Agriculture and Food Security Malaysia, 2021). Among the country's major horticultural commodities, pineapple (Ananas comosus L. Merr.)

contributes significantly to both domestic consumption and export markets (Department of Agriculture Malaysia, 2024). Despite continuous expansion in pineapple cultivation, productivity remains inconsistent. National statistics indicate that the cultivated area increased from 13,274.45 hectares in 2019 to 18,275.72 hectares in 2023, while pineapple production declined from 537,231.40 metric tonnes in 2022 to 440,848.47 metric tonnes in 2023 (Department of Agriculture Malaysia, 2024). These trends suggest that increasing cultivated land alone is insufficient to sustain productivity, highlighting the need for more efficient farming practices supported by technological innovation.

Precision farming technologies offer practical solutions to improve production efficiency through site-specific crop management, real-time monitoring, and data-informed decision-making (FAO, 2022; Getahun et al., 2024). Technologies such as drones, remote sensing, GPS-guided equipment, and digital farm management systems enable farmers to optimise input use, minimise production costs, and improve operational efficiency (Monteiro et al., 2021; Getahun et al., 2024). However, despite their potential benefits, the adoption of these technologies among Malaysian pineapple growers remains relatively limited. This indicates that the availability of advanced technologies alone does not necessarily encourage their acceptance. Rather, farmers' perceptions of technology characteristics play a crucial role in shaping their willingness to embrace digital agricultural innovations (Venkatesh et al., 2003).

The Unified Theory of Acceptance and Use of Technology (UTAUT) developed by Venkatesh et al. (2003) is one of the most widely adopted frameworks for explaining individuals' acceptance of new technologies. The model proposes four key determinants of technology acceptance: performance expectancy, effort expectancy, social influence, and facilitating conditions. Among these constructs, effort expectancy refers to the degree to which individuals perceive that a technology is easy to understand, learn, and use (Venkatesh et al., 2003). In agricultural settings, this perception is particularly important because precision farming technologies often require farmers to acquire new knowledge and technical competencies before they can be effectively integrated into routine farming activities (Getahun et al., 2024). When technologies are perceived as simple to operate and require minimal learning effort, farmers are generally more willing to accept and utilise them (Venkatesh et al., 2003).

Previous studies have consistently demonstrated that effort expectancy contributes to technology acceptance across various digital contexts, including agricultural technologies (Talukder et al., 2020; Getahun et al., 2024). Nevertheless, much of the existing literature has focused on comparing multiple determinants of technology acceptance, with relatively limited attention given to understanding the specific contribution of effort expectancy within particular agricultural subsectors. In the Malaysian pineapple industry, empirical evidence examining how perceived ease of learning and using precision farming technologies influences growers' acceptance remains scarce. Given the increasing emphasis on agricultural digitalisation, further investigation into this relationship is needed to support evidence-based strategies for promoting precision farming technologies among pineapple growers.

Although the Unified Theory of Acceptance and Use of Technology (UTAUT) has been widely applied to explain technology acceptance across various sectors, most existing agricultural studies have examined multiple determinants simultaneously, including performance expectancy, social influence, facilitating conditions, and effort expectancy (Venkatesh et al., 2003; Talukder et al., 2020). Consequently, the specific contribution of effort expectancy is often overshadowed by other explanatory variables. Furthermore, empirical evidence focusing specifically on precision farming technology acceptance among pineapple growers in Malaysia remains limited despite the strategic importance of the pineapple industry in the country's agricultural digitalisation agenda. By isolating effort expectancy as the primary explanatory variable, this study provides focused empirical evidence on its influence on precision farming technology acceptance among Malaysian pineapple growers and offers practical insights for agricultural extension programmes and technology dissemination strategies.

Therefore, this study aims to examine the influence of effort expectancy on precision farming technologyacceptance among pineapple growers in Malaysia. Specifically, the study seeks to provide empirical evidence on the role of perceived ease of learning and using precision farming technology in encouraging technology acceptance. The findings are expected to contribute to the literature on agricultural technology acceptance while providing practical recommendations for policymakers, agricultural extension agencies, and technology developers to strengthen precision farming adoption in Malaysia.

Methodology

This study employed a quantitative cross-sectional survey design to examine the influence of effort expectancy on precision farming technology acceptance among pineapple growers in Malaysia. A structured questionnaire was used to collect quantitative data from respondents, enabling the measurement of growers' perceptions regarding the ease of learning and using precision farming technologies. The study was guided by the Unified Theory of Acceptance and Use of Technology (UTAUT), with particular emphasis on the effort expectancy construct as the key explanatory variable**.**

Study Area and Sampling

The study was conducted among registered pineapple growers under the Malaysian Pineapple Industry Board (Lembaga Perindustrian Nanas Malaysia, LPNM) in Johor, Selangor, and Kedah. These states were selected because they represent the major pineapple-producing regions in Malaysia and exhibit variations in farm characteristics, access to extension services, and digital infrastructure. According to LPNM records, the target population comprised 2,318 registered pineapple growers. A proportionate stratified random sampling technique was employed to ensure adequate representation from each state. The minimum sample size was determined using the Raosoft Sample Size Calculator at a 95% confidence level and a 5% margin of error, which recommended a minimum of 131 respondents. However, the study obtained 184 completed questionnaires, thereby exceeding the minimum requirement and improving the reliability and representativeness of the findings.

Research Instrument

Data were collected using a structured questionnaire adapted from the Unified Theory of Acceptance and Use of Technology (UTAUT). Although the original questionnaire measured several technology acceptance constructs, this study focuses exclusively on the effort expectancy construct and on acceptance of precision farming technology. The questionnaire comprised two sections relevant to this study. The first section collected respondents' demographic and farming characteristics. The second section measured effort expectancy and precision farming technology acceptance using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher mean scores indicated stronger agreement with each statement.

Validity and Reliability

The questionnaire was reviewed by agricultural technology specialists and extension officers from the Malaysian Pineapple Industry Board (LPNM) to establish content validity and ensure that the measurement items were appropriate for the study context. A pilot study involving 36 pineapple growers was subsequently conducted to assess the clarity and reliability of the instrument. The reliability of the measurement instrument was evaluated using Cronbach's alpha coefficient. The effort expectancy construct recorded Cronbach's alpha values of 0.949 during the pilot study and 0.957 in the actual survey, indicating excellent internal consistency. Likewise, the precision farming technology acceptance construct achieved Cronbach's alpha values of 0.934 and 0.931, respectively. These values exceeded the recommended threshold of 0.70, confirming that the instrument was reliable for the present study.

Data Collection

Data were collected using a structured questionnaire developed through Google Forms. Although the questionnaire was administered electronically, the data collection process was conducted through field visits to pineapple farms in Johor, Selangor, and Kedah. The researchers worked closely with extension officers from the Malaysian Pineapple Industry Board (LPNM), who facilitated access to registered pineapple growers and coordinated the field data collection activities. During the visits, respondents were approached personally and invited to complete the questionnaire using the Google Forms platform. This approach enabled the researchers to provide clarification whenever necessary, thereby improving response accuracy and data completeness. Before data collection, all respondents were informed about the objectives of the study, the voluntary nature of their participation, and the confidentiality of the information provided. Respondents were also informed that they could withdraw from the study at any stage without any consequences. Informed consent was obtained from all respondents before the questionnaire was administered. Participation in the study was voluntary, and all completed questionnaires were screened before being exported to IBM SPSS Statistics for subsequent analysis.

Data Analysis

The data were analysed using IBM SPSS Statistics. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to describe respondents' characteristics and determine the level of effort expectancy. Pearson correlation analysis was performed to examine the relationship between effort expectancy and precision farming technology acceptance. Multiple linear regression analysis was subsequently conducted to determine the influence of effort expectancy on precision farming technology acceptance. Statistical significance was established at $p < 0.05$.

The Findings

Respondents' Profile

A total of 184 registered pineapple growers participated in this study. Table 1 presents the demographic characteristics of the respondents. The majority of the respondents were male, accounting for 87.5%, while female respondents represented 12.5% of the sample. In terms of age, most respondents were between 40 and 49 years old (29.0%), followed by those aged 30–39 years (25.1%) and 50–59 years (24.6%), indicating that the study was largely represented by economically active and experienced farmers.

Table 1. Demographic characteristics of respondents (N = 184)

Variable	**Category**	**Frequency (n)**	**Percentage (%)**
Gender	Male	161	87.5
	Female	23	12.5
Age Group (Years)	Below 30	22	12.0
	30–39	46	25.1
	40–49	53	29.0
	50–59	45	24.6
	60 and above	17	9.3
Ethnicity	Malay	166	90.2
	Chinese	14	7.6
	Indian	1	0.5
	Others (Orang Asli, Siam)	3	1.7
State of Operation	Johor	102	55.4
	Kedah	61	33.2
	Selangor	21	11.4
Education Level	Primary School	7	3.8
	Secondary School	95	51.6
	Diploma	33	17.9
	Bachelor's Degree	34	18.5
	Other Qualifications	15	8.2

With respect to ethnicity, the majority of respondents were Malay (90.2%), followed by Chinese (7.6%), while respondents from other ethnic groups constituted only a small proportion of the sample. More than half of the respondents operated their farms in Johor (55.4%), followed by Kedah (33.2%) and Selangor

(11.4%), reflecting the concentration of pineapple production in these major producing states. Regarding educational attainment, 51.6% of the respondents had completed secondary education, while 18.5% possessed a bachelor's degree and 17.9% held a diploma. These demographic characteristics indicate that the respondents represented active pineapple growers with diverse educational backgrounds across the principal pineapple-producing regions in Malaysia. Overall, the respondents represented active pineapple growers from the major pineapple-producing states in Malaysia, providing a suitable basis for examining the influence of effort expectancy on precision farming technology acceptance.

Level of Effort Expectancy

The overall level of effort expectancy among pineapple growers was determined using descriptive statistical analysis. Table 2 presents the distribution of respondents according to the predetermined interpretation levels of effort expectancy. The findings revealed that all respondents (100.0%) were classified as having a high level of effort expectancy, while no respondents were categorised under the low or moderate levels. The overall mean score for effort expectancy was 3.16 with a standard deviation of 0.76, indicating a high level of effort expectancy among the respondents.

Overall, the findings indicate that pineapple growers generally perceived precision farming technology as relatively easy to understand, learn, and operate, reflecting a favourable level of effort expectancy.

Table 2. Level of effort expectancy among pineapple growers (N = 184)

Level	Frequency (n)	Percentage (%)
Low (1.00–2.33)		
Moderate (2.34–2.67)		
High (2.68–5.00)	184	100.0

Descriptive Analysis of Effort Expectancy Items

Table 3 presents the descriptive statistics for the six items measuring respondents' perceptions of effort expectancy. Overall, all six items recorded high mean scores, ranging from 3.12 to 3.20, indicating that pineapple growers generally perceived precision farming technology as easy to understand, learn, and operate.

The highest mean scores were recorded for the statements "I understand quickly when taught" (M = 3.20, SD = 0.73) and "I can learn with basic training" (M = 3.20, SD = 0.74). These findings indicate that respondents generally perceived precision farming technology as relatively easy to learn when appropriate guidance and basic training were provided. In contrast, the statement "The system is user-friendly" recorded the lowest mean score (M = 3.12, SD = 0.74), although it remained within the high interpretation level. Similarly, respondents agreed that the technology was easy to use (M = 3.13, SD = 0.80), expressed confidence in operating the system (M = 3.15, SD = 0.77), and indicated that they did not find it difficult to adapt to the technology (M = 3.17, SD = 0.75).

Overall, the consistently high mean scores across all six items indicate that pineapple growers generally perceived precision farming technology as easy to understand, learn, and operate, demonstrating a favourable perception of effort expectancy.

Table 3. Descriptive statistics of effort expectancy items (N = 184)

Statement	Mean	SD	Level
Precision farming technology is easy to use.	3.13	0.80	High
I understand precision farming technology quickly when taught.	3.20	0.73	High
Precision farming technology is user-friendly.	3.12	0.74	High
I can learn to use precision farming technology with basic training.	3.20	0.74	High
I am confident in operating precision farming technology.	3.15	0.77	High
I do not find it difficult to adapt to precision farming technology.	3.17	0.75	High

Pearson Correlation Analysis

Pearson correlation analysis was conducted to examine the relationship between effort expectancy and acceptance OF precision farming technology among pineapple growers. The results presented in Table 4 indicate a positive and statistically significant relationship between effort expectancy and acceptance of precision farming technology ($r = 0.720$, $p < 0.01$). Based on Guilford's (1956) interpretation of correlation coefficients, the strength of the relationship can be classified as strong. This finding indicates that respondents who perceived precision farming technology as easier to understand, learn, and operate were more likely to demonstrate higher levels of technology acceptance.

Table 4. Pearson correlation analysis between effort expectancy and precision farming technology acceptance

Variables	r	p-value	Strength of Relationship
Effort Expectancy and Precision Farming Technology Acceptance	0.720	<0.001	Strong Positive

Note. Correlation is significant at the 0.01 level (2-tailed).

Regression Analysis

Regression analysis was conducted to determine the influence of effort expectancy on precision farming technology acceptance among pineapple growers. The results presented in Table 5 indicate that effort expectancy significantly influenced precision farming technology acceptance ($\beta = 0.420$, $t = 4.916$, $p < 0.001$). The positive regression coefficient indicates that higher levels of effort expectancy were associated with higher levels of precision farming technology acceptance. These findings suggest that pineapple growers who perceived precision farming technology as easy to understand, learn, and operate were more likely to accept the technology.

Table 5. Regression analysis of the influence of effort expectancy on precision farming technology acceptance

Predictor	B	SE	β	t	p-value
Constant	0.946	0.248	–	3.819	<0.001
Effort Expectancy	0.439	0.089	0.420	4.916	<0.001

Note. Dependent variable: Precision farming technology acceptance.

Discussion

The findings of this study indicate that pineapple growers demonstrated a high level of effort expectancy towards precision farming technology, suggesting that they generally perceived the technology as easy to understand, learn, and operate. This finding reflects growers' positive perceptions regarding the usability of precision farming technology and suggests that respondents did not consider the technology overly difficult to use. According to the Unified Theory of Acceptance and Use of Technology (UTAUT), effort expectancy refers to the degree of ease associated with the use of a technology and is one of the primary determinants influencing technology acceptance, particularly during the early stages of adoption (Venkatesh et al., 2003). Similarly, Davis (1989) argued that technologies perceived as easy to use are more likely to be accepted because users require less physical and cognitive effort to understand and operate them. These theoretical perspectives support the present findings, indicating that perceived ease of use plays an essential role in encouraging pineapple growers to embrace precision farming technologies (Venkatesh et al., 2003; Talukder et al., 2020; Rehman et al., 2022; Ravindran et al., 2024).

The item-level analysis further revealed that respondents strongly agreed that precision farming technology could be learned through basic training and that they were able to understand the technology quickly when appropriate guidance was provided. One possible explanation is that practical guidance reduces farmers' uncertainty when interacting with unfamiliar digital technologies. Precision farming technologies often require users to understand digital interfaces, interpret field data, and operate modern agricultural equipment (Monteiro et al., 2021; Babar & Akan, 2024; Aashu et al., 2024). When learning opportunities are supported through hands-on demonstrations and extension guidance, farmers are more likely to perceive these technologies as manageable rather than technically complex, thereby increasing their confidence in using them. These findings suggest that the availability of structured training programmes and practical learning opportunities may reduce the perceived complexity of precision farming technology (Rehman et al., 2022). Similar observations have been reported by Caffaro et al. (2020), who found that farmers were more willing to adopt agricultural technologies when they perceived them as manageable and easy to integrate into their existing farming practices. Likewise, Rehman et al. (2022) highlighted that improving farmers' digital literacy and technological competency through continuous training could substantially enhance their readiness to adopt precision farming innovations (Mohamed Haris et al., 2025). The systematic literature review on precision agriculture technologies also concluded that interactive training programmes, digital extension services, and mobile-based learning platforms significantly improve farmers' preparedness to utilise precision farming technologies (Rehman et al., 2022).

The Pearson correlation analysis demonstrated a strong positive relationship between effort expectancy and precision farming technology acceptance, indicating that growers who perceived the technology as easier to understand and operate were more likely to accept it. This finding is consistent with the Technology Acceptance Model (TAM), which proposes that perceived ease of use positively influences users' acceptance of new technologies (Davis, 1989). Similar findings have also been reported by Venkatesh et al. (2003) and Venkatesh et al. (2012), who concluded that effort expectancy significantly influences behavioural intention and technology acceptance across organisational and consumer contexts. Within agricultural settings, previous studies have likewise shown that farmers are more inclined to adopt digital and precision farming technologies when these technologies are perceived as simple, user-friendly, and compatible with their existing farming routines (Gebbers & Adamchuk, 2010; Caffaro et al., 2020; Lowenberg-DeBoer & Erickson, 2019; Rehman et al., 2022; Getahun et al., 2024; Ravindran et al., 2024). This finding suggests that simplifying technology operation may be as important as demonstrating its technical capabilities. Farmers who perceive a technology as easy to understand are generally more willing to experiment with and integrate it into routine farming activities. Therefore, reducing perceived complexity should be considered an important strategy for increasing technology acceptance among agricultural communities (Rehman et al., 2022).

The regression analysis further confirmed that effort expectancy significantly influenced precision farming technology acceptance among pineapple growers. This finding indicates that reducing the perceived complexity of precision farming technologies can substantially improve their acceptance among growers. Rogers (2003) explained that innovations perceived as less complex are generally adopted more rapidly because potential users experience fewer barriers during the learning and implementation processes. In the context of pineapple farming, precision farming technologies often involve the use of drones, sensors, mobile applications, GPS, and data management systems, which may initially appear challenging, particularly for older growers or those with limited digital experience (Monteiro et al., 2021; Babar & Akan, 2024; Aashu et al., 2024). However, when these technologies are accompanied by appropriate guidance, technical assistance, and hands-on demonstrations, growers are more likely to develop confidence in using them and subsequently demonstrate greater acceptance (Rehman et al., 2022; Getahun et al., 2024). These findings also reinforce the importance of farmer-centred extension approaches. Rather than focusing solely on introducing new technologies, extension programmes should prioritise experiential learning, continuous mentoring, and practical problem-solving activities that enhance farmers' confidence in using precision farming technologies under actual farming conditions (FAO, 2022; Rehman et al., 2022).

These findings have important implications for agricultural extension practice in Malaysia. Extension agencies such as the Malaysian Pineapple Industry Board (LPNM) should strengthen practical field demonstrations, farmer coaching programmes, digital literacy initiatives, and continuous technical support to improve farmers' confidence in using precision farming technologies (Ministry of Agriculture and Food Security Malaysia, 2021; FAO, 2022; Rehman et al., 2022; Ravindran et al., 2024; (Mohamed Haris et al., 2025). Technology developers should also prioritise intuitive and user-friendly system designs that accommodate farmers with diverse educational backgrounds and varying levels of digital competency (Babar & Akan, 2024; Getahun et al., 2024; Mohamed Haris et al., 2025).

From a policy perspective, strengthening collaboration between government agencies, agricultural extension organisations, technology providers, and research institutions is essential to accelerate the adoption of precision farming technologies. Integrating farmer-centred training programmes with national agricultural digitalisation initiatives may enhance technology acceptance, improve farm productivity, and contribute to the long-term sustainability and competitiveness of Malaysia's pineapple industry (Ministry of Agriculture and Food Security Malaysia, 2021; FAO, 2022).

Despite its contributions, this study is limited to registered pineapple growers in three Malaysian states and examined only one determinant of technology acceptance. Future studies should investigate additional UTAUT constructs, employ longitudinal research designs, and compare different agricultural commodities to provide a more comprehensive understanding of precision farming technology adoption (Venkatesh et al., 2003; Rehman et al., 2022).

Conclusion

This study examined the influence of effort expectancy on the acceptance of precision farming technology among pineapple growers in Malaysia. The findings revealed that pineapple growers demonstrated a high level of effort expectancy, indicating that they generally perceived precision farming technology as easy to understand, learn, and operate. The study also found a strong positive relationship between effort expectancy and precision farming technology acceptance. Furthermore, the regression analysis confirmed that effort expectancy significantly influenced technology acceptance, suggesting that growers who perceived precision farming technology as easier to use were more likely to accept it.

These findings highlight the importance of reducing the perceived complexity of precision farming technologies to encourage greater acceptance among pineapple growers. Efforts to improve farmers' understanding and confidence through practical training, field demonstrations, and continuous technical support are likely to enhance the acceptance of precision farming technologies. In addition, developing user-friendly technologies that accommodate farmers with different educational backgrounds and levels of digital literacy may further facilitate technology acceptance.

The findings of this study provide useful insights for policymakers, agricultural extension agencies, technology developers, and other stakeholders involved in the digital transformation of Malaysia's agricultural sector. Strengthening extension programmes, improving digital competency among farmers, and promoting accessible precision farming technologies may contribute to increasing technology acceptance and supporting sustainable agricultural development.

Overall, this study concludes that effort expectancy plays a significant role in influencing the acceptance of precision farming technology among pineapple growers in Malaysia. Enhancing farmers' perceptions of the ease of learning and using precision farming technologies will be essential in accelerating technology acceptance and supporting the long-term development of a more productive, efficient, and sustainable pineapple industry.

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Conflicts of Interest: The authors declare no conflict of interest.

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