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Adoption of mechanical seeder among rice farmers in Cagayan Valley Region, Philippines

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ABSTRACT
This study examines the adoption of mechanical seeder among rice farmers in Cagayan Valley Region, Phillippines. Mechanical seeder is a machine for planting rice. The mechanical seeder was initially introduced to rice farmers in the Cagayan Valley Region, Philippines. This study assessed the adoption factors regarding farmers' acceptance and utilization of the mechanical seeder. The respondents in this study were the farmer-users of the mechanical seeder for rice. All data were gathered through the use of an interview schedule. Data were analyzed using correlations, linear, and logistic regression. Results revealed that hearing/reading as an independent variable showed a significant correlation with technology acceptance and a highly significant correlation with attendance at promotional activities and training. A farmer who attended the promotional activities has a greater probability of accepting the technology. Attending promotional activities like lecture discussions, demonstrations, field days, seminars, and exhibitions by the farmer-users facilitated the acceptance of mechanical seeder technology. Attendance at promotional activities was also a significant predictor of a higher level of acceptance of the mechanical seeder among farmer users ($p<0.01$), and the size of the farm was a significant predictor of a higher level of utilization among farmer users ($p<0.01$). The different mechanical seeder attributes like ease of use, usefulness, and relative advantage positively affected farmer respondents' acceptance and utilization levels.

Contribution/Originality: This study investigates the factors influencing the adoption of mechanical seeder among farmers using correlations and linear and logistic regression analysis. The study has not seen any similar research before. The study contributes to development planners in formulating appropriate extension strategies for more effective implementation of mechanical seeder programs.

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1. INTRODUCTION

Rice planting is a labor-intensive activity in rice production in the Philippines. Mechanizing it is crucial to boost the productivity of rice production. Manual transplanting is the predominant practice in rice production in the Philippines, and it is considered laborious and costly (PhilRice, 2023). An alternative to transplanting is a direct seeding method where pre-germinated seeds are sown directly onto the soil surface. Direct seeding technology can help address high labor costs in rice farming, and direct-seeded rice matures earlier than transplanted rice. Therefore, it reduces the labor requirements, expenses, and time required for crop establishment and crop management (PhilRice, 2016).

In 2011, the Korean Project on International Agriculture (KOPIA) introduced the mechanical seeder to the Philippines through a collaboration with the Philippine Rice Research Institute (PhilRice).

On the other hand, in 2016, the Department of Agriculture-Region 2 (DARFO2) recommended the mechanical seeder for rice planting. Farmers' organizations in the Cagayan Valley Region, Philippines, utilized the mechanical seeder that was distributed to them. Some accepted and utilized the mechanical seeder well, and others encountered problems using the technology. Interestingly, the Department of Agriculture plans to promote mechanical seeder use nationwide extensively. To ensure the greater success of promoting the mechanical seeder nationwide among rice farmers, documentation and establishment of the factors of acceptance and utilization of the technology are required. Therefore, this research aims to determine the adoption factors, specifically the acceptance and utilization of mechanical seeders among the initial farmer-users of the technology.

2. METHODOLOGY

2.1. Time and Respondents of the Study

The Cagayan Valley Region, Philippines, hosted the research from January 2019 to February 2020. The respondents were all the farmers who used mechanical seeder's services.

2.2. Research Framework

The framework of this study (Figure 1) was based on the theory of the Technology Acceptance Model (TAM). Over time, various sectors have recognized the applications of TAM not only in predicting the acceptability of the information technology, but also in predicting the acceptability of agricultural technologies. The TAM can predict the acceptance of technology by the users' behavioral intention, which is, in turn, determined by the perception of technology's usefulness in performing the task and the perceived ease of its use (Marikyan & Papagiannidis, 2023). On the other hand, Flett et al. (2004) studied the application of the TAM to technology acceptance and use. The results shed light on the decision-making processes in an industry that prioritizes technology-driven productivity.

This study used the farmer's farm profiles, exposure to extension, and promotional activities as independent variables. The study of Patel (2007) confirms that farmers' profiles, exposure to extension, and promotional activities have the most significant relationships with adoption across a broad range of innovation types. TAM intends to include other variables that account for change processes. Technology change will be implemented by adopting technology attributes that influence utilization by including relative advantage as one of the intervening variables (Rogers, 2003). The usefulness, ease of use, and relative advantage of the mechanical seeder are the technological attributes that influence the level of acceptance and utilization of the mechanical seeder.

Meanwhile, acceptance and utilization of mechanical seeder are the dependent variables that are influenced by the independent and intervening variables.

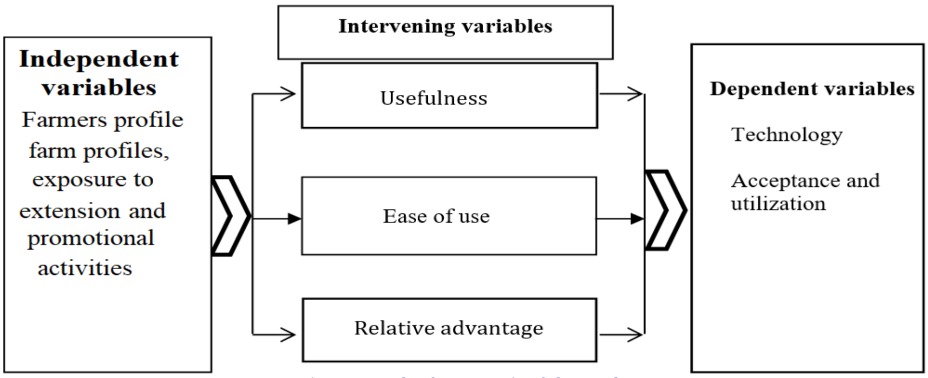

Figure 1. The framework of the study.

2.3. Research Instrument

The researcher used an interview schedule to gather information. The interview schedule for the farmer-users includes questions about their socio-demographic profiles of farmer-users, farm profile, their exposure to promotion and information delivery systems, technology acceptance, and utilization level.

2.4. Data Analysis

Data gathered from the farmer-users were tabulated and analyzed using appropriate statistical analysis. Statistical analyses were done through the Statistical Package for the Social Sciences (SPSS) system.

2.5. Spearman Rank Correlation

The Spearman rank correlation was used to present the relationships between the socio-demographic profiles of farmer users, farm profiles, farmers' exposures to promotion and information delivery systems, and the level of acceptance by the farmer users.

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

Where:

ρ= Spearman rank correlation.

di= The difference between the ranks of corresponding independent variables (socio-demographic profiles of farmer-users, their farm profiles, and exposure to information/promotion strategies mechanical seeder promotion among farmer-users).

n= Number of observations.

2.6. Ordinal Logistic Regression

Ordinal Logistic Regression was used to determine the relationships between the level of acceptance of the mechanical seeder among farmer-users and their socio-demographic profiles, farm profiles, and exposure to information/promotion strategies.

$$\ln\left(\frac{\gamma_i^{(j)}}{1-\gamma_i^{(j)}}\right) = \ln\left(\frac{P\left(Y_i \le j \mid x_1, x_2, \ldots, x_p\right)}{1-P\left(Y_i \le j \mid x_1, x_2, \ldots, x_p\right)}\right) = \tau_j - \left(\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p\right)$$

Where:

Y is the dependent or response variable with k-ordered categories,

Y_i is the level of acceptance of the mechanical seeder among farmer-users,

i=1,2,…,n j=1,2,…..,k-1;

$y_1^{(j)}$ is cumulative probability P(Yi ≤ j) = P(Y_i=1) + P(Y_i =2) +…..+ P(Y_i =j) for j=1,2,…k-1.

X_1, X_2… X_n are the independent variables, such as farmer-users' socio-demographic profiles, farm profiles, and exposure to information/promotion strategies.

$\beta_1, \beta_2, \ldots, \beta_p$ correspond to the regression coefficients for the respective independent variables.

r_j are the cut-off points between categories.

2.7. Multiple Linear Regression

Multiple linear regression was used to determine the relationships between the mechanical seeder's utilization level among farmer-users and their socio-demographic profiles, farm profiles, and exposure to information/promotion strategies. Multiple regression generally explains the relationship between multiple independent or predictor variables and one dependent or criterion variable. Dependent variables are modeled as a function of several independent variables with corresponding coefficients and the constant term. The previously explained multiple regression equation assumes the following form:

$$y = b_1x_1 + b_2x_2 + \ldots + b_nx_n + c$$

Where:

y = Level of utilization of the mechanical seeder among farmer-users.

X_n = Independent variables like tenurial status and read/hear mechanical seeder from media.

b_i*'s* (i=1,2…n) are the regression coefficients, representing the Value at which the criterion variable changes when the predictor variable changes.

2.8. Pearson Correlation

Pearson Correlation was used to analyze the relationship of technology attributes to technology utilization.

$$r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\ \sqrt{n\sum y_i^2 - (\sum y_i)^2}}$$

Where:

r_{xy} = Pearson r correlation coefficient between x and y.

n = Number of observations.

x_i = Value of x (for ith observation), percent of rice area planted using mechanical seeder for first and second harvest season, 2018.

y_i = Value of y (for ith observation), technology attributes like ease of use, usefulness, and relative advantage.

3. RESULTS AND DISCUSSION

3.1. Level of Acceptance of Mechanical Seeder and its Relationship with the Socio-Demographic Profiles of Farmer-Users, Their Farm Profiles, and Exposure to Information and Promotion Strategies

Table 1 shows the correlation between independent variables and technology acceptance. The independent variables included in the analysis were farmers' age, educational attainment, attendance at training, involvement in agricultural programs, reading/hearing about mechanical seeder through media, and attendance at mechanical seeder promotional activities.

The independent variables that showed a significant correlation with technology acceptance were reading/hearing the mechanical seeder through media ($p<0.05$), and highly significant correlation variables were attendance to promotional activities and attendance to training ($p<0.01$).

According to Rogers (2003) before an innovation is accepted by a group of people, a group member must be aware that the innovation exists. Thus, at this point, the individual has been exposed to the idea but still requires more information about the innovation and lacks the motivation to further explore it. Therefore, at this stage, the individual only has basic knowledge of the innovation and the decision to accept the technology. Following exposure to promotional activities, training, and media exposure to the mechanical seeder, the individual is prepared to either accept or reject the innovation. The attendance of farmer users at promotional activities helped them better understand the use and value of this technology in their farming activities and affected its acceptance. This study's result is similar to the findings of Kumar, Jha, and Ghorai (2007) who state that acceptance and adoption of technology have a remarkable impact on farmers who attend training and participate in demonstrations. This is also consistent with Hinnou, Obossou, and Adjovi (2022) findings that the enabling factors for accessing agricultural machinery include the promotional offer of equipment and donation of agricultural machinery to farmers' organizations.

Table 1. The correlation coefficient between the independent variables and technology acceptance.

Independent variables	Correlation coefficient	Significance
Attended training	0.333	0.006**
Involved in agricultural program	0.074	0.553
Read/Heard mechanical seeder	0.243	0.050*
Attended promotional activities	0.493	0.000**
Age of farmers	-0.174	0.162

Note: **Significant at 1% level of significance. *Significant at 5% level of significance.

Hearing and reading the mechanical seeder through media positively correlates with technology acceptance. Hearing and reading the mechanical seeder from media like print media, radio broadcasts, and advertising improved the diffusion and utilization of the mechanical seeder. The results align with the findings of Ahmed and Bagchi (2004) which suggest that acquiring new knowledge or information about agricultural technologies significantly influences the diffusion and adoption of these technologies. Wang, Drabik, and Zhang (2023) also confirm that information campaigns through radio and the government (through its face-to-face channels) are positively associated with farmers' adoption of technology. Table 2 shows the parameter estimates from ordinal regression of the socio-demographic profiles of farmer users, their farm profiles, and exposure to information/promotion strategies with the level of acceptance of mechanical seeder. Attendance to promotional activities (0-not attended, 1-attended) showed a significant effect on technology acceptance ($p<0.01$), with parameter estimates equivalent to -3.639. This showed a decrease in the average acceptance odds if a farmer-user has not attended the promotional activities, with all other independent variables held constant.

Table 2. Parameter estimates from ordinal regression of the independent variables with the level of acceptance of mechanical seeder.

Parameters	Independent variables	Estimate	Std. error	Wald	Df	Sig.
Threshold	[Techaccept = 3.00]	-4.188	1.735	5.825	1	0.016*
	[Techaccept = 4.00]	-1.203	1.610	0.559	1	0.455
Location	[Attendpromo=.00]	-3.639	0.969	14.086	1	0.000**
	[AttendTrg=.00]	-0.666	0.606	1.206	1	0.272
	[Readhear=.00]	-1.266	0.902	1.968	1	0.161
	[Education=1.00]	-0.516	2.117	0.059	1	0.807
	[Education=2.00]	0.689	1.828	0.142	1	0.706
	[Education=3.00]	2.305	1.886	1.495	1	0.221
	[Education=4.00]	0.651	1.608	0.164	1	0.685
	[Education=5.00]	0.266	1.688	0.025	1	0.875
	[Education=6.00]	-1.983	1.727	1.318	1	0.251

Note: **Significant at 1% level of significance. *Significant at a 5% level of significance.

3.2. Relationships of Attendance to Promotional Activities and Level of Acceptance

Table 3 shows the cumulative probability from the ordinal regression of mechanical seeder promotional activities on the level of acceptance. The level of acceptance is presented as the dependent variable using a five-point Likert scale from 1 with very low acceptance to 5 with very high acceptance.

Table 3. Cumulative probability from the ordinal regression of mechanical seeder promotional activities on the level of acceptance.

Cumulative probability parameters	Level of acceptance		
Not attended mechanical seeder promotional activities	3	4	5
Cumulative logit	-	(0.55)	2.44
Cumulative odds [Exp(cum.logit)]	-	0.58	11.43
Cumulative proportion [1/(1+exp(Cum.logit))]	1.00	0.63	0.08
Category probability	0.37	0.55	0.08
Attended mechanical seeder promotional activities	3	4	5
Cumulative logit	-	(4.188)	(1.203)
Cumulative odds [Exp(cum.logit)]	-	0.02	0.30
Cumulative proportion [1/(1+exp(Cum.logit))]	1.00	0.99	0.77
Category probability	0.01	0.22	0.77
Odds ratio (Not attended mechanical seeder promotional activities/Attended mechanical seeder activities)		38.05	38.05
Odds ratio (Attended mechanical seeder activities/Not attended mechanical seeder promotional activities)		0.03	0.03

The odds of farmers having attended the promotional activities for a higher level of acceptance were 38.05 times that of farmers having no attendance to promotional activities. Similarly, the odds of farmers having no attendance to promotional activities for a higher level of acceptance were 0.03 times that of farmers with attendance to promotional activities. Farmers who did not attend the promotional activities for mechanical seeder were more likely to have a lower level of acceptance than those who did. The relationship above shows that farmers not attending promotional activities for mechanical seeder are less likely to accept the use of mechanical seeder.

The probability that a farmer with no attendance to mechanical seeder promotional activities will have a level of acceptance of 3 is 37%, a level of acceptance of 4 is 55%, and a level of acceptance of 5 is 8%. The probability that a farmer with attendance to mechanical seeder promotional activities will have a level of acceptance of 3 is 1%, a level of acceptance of 4 is 22%, and a level of acceptance of 5 is 77%.

This means that a farmer who attended the promotional activities has a greater probability of accepting the technology. The farmer-users' attendance at promotional activities like lecture discussions, demonstrations, field days, seminars, and exhibitions facilitated the acceptance of mechanical seeder technology. The decision to accept the mechanical seeder was greatly influenced by the information they got from attendance at promotional activities.

3.3. Utilization of the Mechanical Seeder and its Relationship with the Socio-Demographic Profiles of Farmer-Users, their Farm Profiles, and Exposure to Information and Promotion Strategies

Table 4 shows the correlation between the socio-demographic profiles of farmer-users, their farm profiles, and exposure to information and promotion strategies and technology utilization for the first cropping season. Results revealed that only the size of the farm and reading and hearing mechanical seeder through media ($p<0.01$) were considered for the final linear regression model.

Table 4. The correlation coefficient between the independent variables and utilization mechanical seeder for the first cropping season.2018.

Independent variables	Correlation coefficient	Significance
Age of farmers	-0.01	0.934
Educational attainment	0.097	0.436
Tenurial status	0.076	0.545
Attended training	0.027	0.828
Involved agricultural program	0.151	0.225
Read/Hear mechanical seeder	0.358	0.003**
Attend promotional activities	0.133	0.288
Size of farm	0.385	0.001**
Experience labor shortage	0.025	0.844

Note: **Significant at 1% level of significance.

Table 5 presents the final regression model to predict the mechanical seeder's utilization level for the first cropping season of 2018. Results showed that the farm size was a highly significant predictor of mechanical seeder utilization for the first cropping season ($p<0.01$).

Table 5. Regression model for using mechanical seeder for the first cropping season, 2018.

Model	Unstandardized coefficients		Standardized coefficients	T	Sig.
	B	Std. error	Beta		
(Constant)	-1.334	0.418	-	-3.193	0.002
Size of farm	1.039	0.227	0.494	4.578	0.000**
Read/Hear mechanical seeder	0.627	0.426	0.159	1.471	0.146

Note: **Significant at 1% level of significance.

Table 6 presents the correlation between the socio-demographic profiles of farmer-users, their farm profiles, exposure to information and promotion strategies, and technology utilization for the second cropping season of 2018. Results revealed that only the size of the farm ($p<0.01$) and tenurial status ($p<0.05$) were used for the final linear regression model to determine the predictor variables.

Table 6. The correlation coefficient between the independent variables and technology utilization of mechanical seeder for the second cropping season 2018.

Independent variables	Correlation coefficient	Significance
Attended training	0.003	0.979
Involved in agricultural program	0.062	0.623
Read/Hear mechanical seeder	0.187	0.132
Attended promotional activities	0.099	0.430
Age of farmers	-0.151	0.226
Educational attainment	0.021	0.869
Size of farm	0.757	0.000**
Experience labor shortage	0.212	0.087
Tenurial status	0.283	0.022*

Note: **Significant at 1% level of significance. *Significant at 5% level of significance.

Table 7 shows the regression model for using mechanical seeder for the second cropping season. The results revealed that the size of the farm was a highly significant predictor of mechanical seeder utilization for this cropping season.

Table 7. Regression model for using mechanical seeder for the second cropping season 2018.

Model		Unstandardized coefficients		Standardized coefficients	T	Sig.
		B	Std. error	Beta		
	(Constant)	-2.96	1.295	-	-2.287	0.026
	Size of farm	3.276	0.615	0.567	5.326	0.000**
	Tenurial status	-0.066	0.678	-0.01	-0.098	0.922

Note: **Significant at 1% level of significance.

The positive correlation results for both cropping seasons imply that as the farm size increases, the mechanical seeder utilization increases. These findings were consistent with several studies conducted where larger farm sizes showed positive influences on adopting and utilizing farm mechanization technologies (Akudugu, Guo, & Dadzie, 2012; Ghosh, 2010).

Farm size facilitates economies of scale in using mechanization technologies, which apply to more extensive farm areas. Considering the capacity of the mechanical seeder, which is 3-4 hectares per day, its utilization would benefit rice farmers with large farm sizes.

3.4. Relationship of the Technology Attributes with the Level of Acceptance and Utilization as Perceived by the Farmer-Users

The study focused on three key technology attributes: usefulness, ease of use, and relative advantage. The usefulness of this study is the degree to which a farmer believes that using a mechanical seeder would enhance his/her farming performance. The ease of use is the degree to which a farmer believes that using a mechanical seeder would be free of effort or less effort. It is easy to use when it is easily understood, learns the methods, and accomplishes tasks readily. It is useful when positively impacted by information quality, swiftness, and ease of use (Moon, Lee, Shim, & Hwang, 2023).

The relative advantage is the degree to which a farmer believes that using a mechanical seeder will improve the quality of planted rice compared to usual practice, enhance the effectiveness and drudgery of planting the farm, reduce the production cost of planting rice, work well and better than usual practice, and enable them to accomplish planting more quickly.

The mechanical seeder level of awareness has a highly positive relationship ($p<0.01$) with farmer-users' perceptions of its usefulness, ease of use, and relative advantage. On the other hand, the mechanical seeder use, and relative advantage. Moreover, the level of utilization of mechanical seeder has a highly positive relationship ($p<0.01$) with the perception of farmers as to its usefulness, ease of use, and relative advantage (Table 8).

Table 8. Relationship of mechanical seeder attributes with the level of acceptance and utilization, 2018.

Dependent variables	Usefulness	Ease of use	Relative advantage
Mechanical seeder acceptance level	0.815**	0.782**	0.782**
Mechanical seeder utilization level - Percent of rice area planted using mechanical seeder (1st harvest season, 2018)	0.240**	0.219**	0.226**
Mechanical seeder utilization level - Percent of rice area planted using mechanical seeder (2nd harvest season, 2018)	0.671**	0.631**	0.621**

Note: **Significant at 1% level of significance.

This means that the usefulness, ease of use, and relative advantages of the mechanical seeder are positively related to farmers' level of awareness, acceptance, and utilization of the mechanical seeder. This is consistent with Rogers (2003) theory that technology characteristics or attributes determine the rate of adoption of innovations.

The relative advantages of a mechanical seeder, such as reduced production cost, usefulness, and ease of use, made the mechanical seeder acceptable to the farmers. The mechanical seeder can plant the seeds at equal distances and straight rows, with adjustable hill spacing and seeding rate. With these, mechanical seeder can also attain the recommended plant population because of the precise distance of plants between rows and hills. The seeds are placed slightly drilled, covered with soil, and compacted in one hill, resulting in good seedling emergence and crop growth (Oli, 2018).

Consistent with the findings of Zhang et al. (2018) direct rice seeding significantly improved the crop growth population and generally reduced seed usage and increased yield due to higher density and precise distance in planting. The International Rice Research Institute (IRRI, 2019) also reported that plant spacing is essential in planting rice. Proper spacing can increase the yield by 25–40% over improper spacing. This was supported by the findings of Gangaiah and Babu (2019) that direct wet seeding of rice had higher grain yield than transplanted rice.

4. CONCLUSION

This study assessed the adoption factors, specifically the acceptance and utilization of mechanical seeder in the Cagayan Valley Region, Philippines. Farmers attending the promotional activities are more likely to have a high level of acceptance of mechanical seeder. Attendance at promotional activities like lecture-discussion, demonstrations, field days, and seminars facilitated the mechanical seeder awareness and eventually convinced the farmer-users to accept the technology. Also, farmers of large farm sizes are more likely to utilize mechanical seeders at a high level. The different mechanical seeder attributes like ease of use, usefulness, and relative advantage positively affected farmer respondents' acceptance and utilization level.

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