Factors affecting the decision of potato farmers in adopting superior seeds in Bener Meriah District

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Abstract. Potato (Solanum tuberosum L) is one of the horticultural commodities with excellent opportunities for agribusiness and agroindustry development. The use of high-quality seeds and appropriate technology is still far from the reach of farmers. Generally, potato farmers in the Bener Meriah District use potato seeds from the previous production, but some consistently use superior seeds in every cultivation activity. This study analyses the factors that made farmers adopt superior seeds for potatoes in Bener Meriah. Based on the study results, the variables of age, education level, length of farming, land area, and the number of dependents had no significant effect on adopting superior potato seeds in Bener Meriah. At the same time, the variables of access to capital and farmer participation have a significant effect on farmers' decisions to adopt superior potato seeds in Bener Meriah.

1. Introduction
Potato (Solanum tuberosum L.) is one of the most likely horticultural commodities for the development of agribusiness and agroindustry [1]. Potatoes are also an agricultural commodity with high demand, and high demand must be followed by increased production. Potato production in Indonesia in 2015-2018 decreased and increased in 2019. Based on data from the Central Statistics Agency [2], in 2015-2018, potato production decreased from 1,219,277 tons in 2015 to 1,213,041 tons in 2016. In 2017 it decreased to 1,164,738 tons and increased in 2018 to 1,284,762 tons. The average potato production in 2017 is based on data from the BPS of Bener Meriah District; the potato planting area reaches an area of 2,500 hectares. Thus, the need for potato seeds every year is up to 2,500 tons, and the average production is 15 to 20 tons/ha. However, potatoes in the Gayo highlands still cannot meet the enormous demand for potatoes in Aceh [3].

| No | Subdistrict | Harvested Area (ha) | Production (tons) | Productivity (tonnes/ha) |
|----|-------------|---------------------|------------------|-------------------------|
| 1  | Bukit       | 119                 | 2,032            | 17.07                   |
| 2  | Bandar      | 8                   | 95               | 11.8                    |
| 3  | Permata     | 551                 | 5,043.3          | 9.1                     |
| Total | 678         | 7,170.3             | 37.97            |
Bukit, Permata, and Bandar Subdistricts are the highest potato-producing areas in Aceh. The harvested area of Bukit Subdistrict is 119 ha; Permata Subdistrict is 8 ha; and Bandar Subdistrict is 551 ha. In Permata Subdistrict, high production yields reached 5,043.3 tons with a productivity of 91.5 tons/hectare. In Bandar Bukit Subdistrict, the yields obtained were 119 tons with a productivity of 17 tons/hectare; in Bandar Subdistrict, the production reached 95 tons with productivity of 11.8 tons/ha.

One of the critical factors that determine the level of crop yield is the seed. Seeds, along with other means of production such as fertilizer, water, light, climate, determine crop yields. Although there are sufficient other production facilities, if low-quality seeds are used, the result will be low. The limited role of the formal seed system, constraints on the supply side, high seed production costs, or logistical problems are the main obstacles that prevent farmers from buying seeds from superior seed sources [4].

The spread of innovation will last for several years from when it was first introduced until it is used evenly. The rate of adoption of innovation is also influenced by individual characteristics of farmers, such as age, education, and farming experience [5]. This study focuses on the factors that influence the decision of potato farmers in the Bener Meriah District to adopt superior seeds. By looking at the potential benefits of new technology, technology can only be realized when it is adopted and used; even the adoption decision involves a critical comparison of the perceived benefits and costs associated with the technology itself [6].

2. Research methods

2.1 Place and time of research
This research was conducted in Bandar, Permata, and Bukit Subdistricts in Bener Meriah District. The location of this research was determined deliberately considering that this place is the location of the largest potato crop producer in Aceh, according to BPS 2020 data. This research was carried out in March-May 2021.

2.2. Object and scope of research
The object of this research is potato farmer in Bener Meriah District. The scope of this research is to see what factors influence potato farmers in Bener Meriah District in adopting superior seeds for potato commodity.

2.3 Population and sample
The population in this study were all potato farmers in Bandar, Permata, and Bukit Subdistricts in the Bener Meriah District. Because there is no accurate data regarding the exact number of potato farmers, the number of samples in this study was determined by the quota sampling method, which was 60 farmers.

2.4 Types and methods of data collection
The types of data used in this study are primary data and secondary data. Primary data collection was conducted by interviewing and distributing questionnaires to potato farmers in Bandar, Permata, and Bukit Subdistricts in Bener Meriah District. Secondary data in the form of documents obtained from BPS Bener Meriah, the Plantation Office of Bener Meriah District, scientific journal articles, literature reviews of previous research, and websites on the internet related to the research conducted.

2.5 Data analysis
2.5.1 Descriptive analysis. Descriptive analysis is used to announce and explain the variables and characteristics of the respondents. Descriptive analysis describes an object of research based on the sample or population data collected [7].
2.5.2 Binary logistics regression. Logistic regression is part of the regression analysis used to analyse the dependent (bound) variable which is categorical, and the independent variable (independent) which is categorical, continuous, or a combination of both [7]. This study uses binary logistic regression because the dependent variable (Y) is a binary variable, where there are only two categories, namely (1) = if farmers use superior seeds and (0) = if farmers do not use superior seeds. The logit model is derived based on the probability function as follows:

\[ P_i = \frac{1}{1 + e^{-(a + bX_i)}} \]  

Then the equation can be reversed using algebra to become:

\[ e^{Z_i} = \frac{P_i}{1 - P_i} \]  

The variable in the above equation is referred to as odds, which is often termed risk or probability, which is the ratio of the probability of the occurrence of choice 1 to the probability of the occurrence of alternative 0. The logit estimation model parameters must be estimated using the maximum likelihood method. The parameter e in the above equation represents the base number of the natural logarithm (ln). If the equation is transformed by the natural logarithm, then:

\[ Z_i = \ln \frac{P_i}{1 - P_i} \text{ where } Z_i = a + bX_i \]  

The general equation for the two-choice logistic regression (Binary Logistic Regression) results is stated as follows:

\[ L_i = \ln \frac{P_i}{1 - P_i} = Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \mu_i \]  

Where,
P : Opportunities for farmers to adopt superior seeds  
Y : Potato Farmer's Decision  
X_1 : Education Level (years)  
X_2 : Age (years)  
X_3 : Farming Experience (years)  
X_4 : Number of Dependents (person)  
X_5 : Land Area (Ha)  
X_6 : Access to Capital Credit  
0 : Not using  
1 : Using  
X_7 : Farmer Participation  
0 : Not Following  
1 : Following  
\mu_i : Error Terms  
0, 1, 2, 3, 4, 5, 6, 7, 8: Parameter constants

2.5.3 Test criteria. The model suitability test, namely the analysis of the suitability of the logit model with the data to be estimated, is carried out in two ways, namely (1) by comparing the percentage correct predicted value for each observed value and (2) by comparing the data distribution and the logit distribution.

a. Classification determination test

The classification determination test shows the accuracy of the predictions of the regression model. In logit, the parameter chosen is the parameter that can maximize the predictions of the observed values,
and the parameter that can provide the highest percentage correct is the best. The binary logit model has two sample values, namely 0 and 1, so what is desired is the percentage valid for the two observations.

b. Hosmer and Lemeshow test

This test compares the distribution of observation data with the distribution of theoretical data (model suitability test). The hypothesis of this test is:

Hypothesis:

\[ H_0 : K = (1-B) = 1, \text{ there is no difference between the distribution of observation data and the distribution of theoretical data (the model is quite capable of explaining the data/model according to the data).} \]

\[ H_1 : K = (1-B) 0, \text{ there is a difference between the distribution of observation data and the distribution of theoretical data (the model is not sufficient to explain the data/model does not match the data).} \]

The test criteria are as follows:

a. If the sig value > p-value, then accept H0 reject H1
b. If the value of sig < p-value, then accept H1 reject H0

B is the ratio value of 1, while the Hosmer and Lameshow tests are an alternative to the chi-square test, which results are better, primarily if continuous covariates exist in the model or the sample size is small. A nominal value indicates that the model fits (adequately fits).

2.5.4 Testing the significance of models and parameters. The following tests to test the significance of the model and parameters:

a. Omnibus test or synchronous test

The omnibus test was conducted to determine whether all independent variables had a significant effect on the dependent variable by comparing the independent variable model with the dependent variable. The hypothesis in this test is as follows:

\[ H_0 : \beta_1 = \beta_2 = ... = \beta_p = 0, \text{ there is no x variable that significantly affects the y variable.} \]

\[ H_1 : \beta_j \neq 0, j = 1,2,...,p, \text{ there is at least one x variable that significantly affects the y variable.} \]

By statistical test:

\[
G = -2 \ln \left( \frac{\text{likelihood (model B)}}{\text{likelihood (model A)}} \right)
\]

(5)

1) Model A = a model that only consists of constants
2) Model B = model consisting of all variables

With rejection: reject H0 if the value of \( G > \chi^2_p \) where p is the number of statistical variables in the model or p-value < and is the significance level.

b. Wald test or partial test

A partial variable test was conducted to determine whether there was a significant effect on each independent variable on the dependent variable. The hypothesis of this test is as follows:

\[ H_0 : \beta_j = 0, (\text{variable X does not significantly affect variable Y}) \]

\[ H_1 : \beta_j \neq 0, j = 1,2,...,p, (\text{variable X significantly affects variable Y}) \]

By statistical test :

\[
W (wald) = \frac{\beta_j}{SE (\beta_j)}
\]

(6)

Rejection area: reject H0 if W > 0.05 or p-value < 0.05. With 5% significance level. If H0 is rejected, it means that the parameter is statistically significant at the significance level.

2.5.5 Odd Ratio value interpretation. Logistic regression also produces an odds ratio associated with the value of each predictor variable. The odds ratio is the probability of a condition occurring divided by the likelihood of a situation not occurring.
3. Results and discussion

3.1. Overview of research sites
Bener Meriah District is one of Aceh, Indonesia, and this district is the result of the division of Central Aceh District. Based on data for 2020, the air temperature in the Bener Meriah District ranges from 20⁰C to 23⁰C. The ideal air temperature for potatoes ranges from 15-18 degrees Celsius at night and 23-30 degrees Celsius during the day. With its fantastic climate, Gayo land is one of the supporting factors for developing horticultural crops such as potatoes[3].

Bener Meriah District has an area of 1,919.69 km² consisting of 233 villages and 10 Subdistricts. This research was conducted in three subdistricts, namely Bandar, Bukit, and Permata Subdistricts. From a geographical point of view, Bener Meriah District is one of the regencies in Aceh Province, with a location between 4°33'50" - 4°54'50" North Latitude (LU) and 96°40'75" - 97°17'50" East Longitude (BT). Vegetable crop production with the highest number is potato, cayenne pepper, and tomato.
3.2. Farmer characteristics

The characteristics of the respondents are a general description of the identity of the farmers in the research area. Respondents taken were all farmers, totalling 60 people, where the sample was potato farmers in the Bener Meriah District.

| Table 2. Characteristics of Bener Meriah District farmers. |
|-----------------------------------------------|
| Variable | Really Merry | Percentage (%) |
| Age (years) | Min | Max | Average |
| Education | 19 | 60 | 38.4 |
| a. No school | 6 people | 10% |
| b. Primary school | 15 people | 25% |
| c. Junior high school | 5 people | 8.3% |
| d. Senior High School | 30 people | 50% |
| e. College | 4 people | 6.7% |
| Experience (years) | 1 | 32 | 8.5 years |
| Number of Dependents (person) | 1 | 3 | 3 people |
| Land Area (Ha) | 0.12 | 2 | 0.77 (ha) |

3.2.1 Age. The average age of the potato farmers in the central highlands was productive age 38.4 (under 60 years). Formative age is the capital to carry out farming activities. This condition will affect the adoption of agricultural innovations delivered by extension workers, from print and electronic media [8].

3.2.2 Level of education. From the data, it can be found that almost half of the respondents studied in the Bener Meriah District have a high level of education; this can affect the adoption rate of farmers, especially potato farmers, to the use of superior seeds in the Bener Meriah District.

3.2.3 Farming experience. The results showed that the respondent's farming experience ranged from 1 year to 35 years, and the average experience of respondents farming is 8.5 years [9]. The results of this study show that most farmers have, on average, a long experience of farming potatoes; with such a long experience, farmers already have relatively high abilities and skills in developing their farming.

3.2.4 Number of family dependents. All respondent farmers have families ranging from 1 to 5 people with an average of 3 dependents. The number of family members is taken from the number of dependents imposed on the head of the family, such as the wife, children, parents, and other family members, including the head of the family.

3.2.5 Land area. The area of land tenure in this study is the area of the farmer's land tenure in square meters, either owned, rented, or bought. Based on Table 1, that all respondents have land with narrow criteria, which has land with an area average of 0.77 hectares.

3.3. External factors

3.3.1 Access to capital credit. The availability of capital will increase the ability to fulfil the need for purchasing inputs, field equipment, and handling seeds. In addition, money is also needed to finance the purchase of seeds, thus generating sufficient profits to cover operational costs [10].
Table 3. Results of analysis of access to capital credit.

| No | Information               | Number of people | Percentage (%) |
|----|---------------------------|------------------|----------------|
| 1  | Using Capital Credit      | 27               | 45             |
| 2  | Not Using Capital Credit  | 33               | 55             |
|    | Amount                    | 60               | 100            |

Table 3 shows that farmers who do not use access to capital credit are slightly more dominant, namely 33 people or as much as 55% of the total respondents. Meanwhile, farmers who use access to capital credit are almost half of the total respondents, namely 27 people or as much as 45% \([11,12]\). This shows that almost half of potato farmers who do not use access to credit capital to do potato farming.

3.3.2 Farmer participation. Processing and marketing of agricultural products become easier if farmers participate in groups and are involved in technology.

Table 4. Results of analysis of access to capital credit.

| No  | Information     | Number of people | Percentage (%) |
|-----|-----------------|------------------|----------------|
| 1   | Participate     | 12               | 20             |
| 2   | Not Participating | 48              | 80             |
|     | Amount          | 60               | 100            |

Based on table 4, most farmers still do not participate in agricultural activities with a percentage of 80%, amounting to 48 people from all respondents. While the rest have a rate of 20%, amounting to 12 people. These agricultural activities include extension programs, farmer groups, and so on.

3.4. Logistics regression analysis results

The data obtained from the respondents were then processed using SPSS. To answer the hypothesis by using a logistic model. The logistics model is applied to model the categorical response variable \(Y\) based on one or more predictor variables \(X\), which are flat or continuous.

Table 5. Logistics regression analysis results.

| Variable                      | B   | SE  | Wald | df | Sig. | Exp (B) |
|-------------------------------|-----|-----|------|----|------|---------|
| Level of education            | -1.863 | 1.036 | 3.237 | 1  | .072 | .155    |
| Age                           | .056 | .042 | 1.827 | 1  | .177 | .945    |
| Farming Experience            | .020 | .058 | .126 | 1  | .723 | 1.021   |
| The number of dependents      | -.110 | .475 | .054 | 1  | .816 | .896    |
| Land area                     | -2.348 | .961 | 5.971 | 1  | .015 | .096    |
| Access to Capital Credit      | 2.539 | 1080 | 5.526 | 1  | .019 | 12.663  |
| Farmer Participation          | 4.423 | 2.999 | 2.182 | 1  | .140 | 83350   |

From the results of the logistic regression analysis, the following logistic regression equations are obtained:

The equations obtained from the results of the analysis of Table 1 are:

\[
Y = \ln \frac{P_i}{1-P_i} = -17.458 -1.863X_1 - 0.056X_2 + 0.020X_3 - 0.110X_4 - 0.443X_5 - 2.348X_6 + 2.539X_7
\]

Where,

\(P_i\) : Opportunities for farmers to adopt superior seeds

\(Y\) : Potato Farmer's Decision

\(X_i\) : Education Level (years)
X₂ : Age (years)
X₃ : Farming Experience (years)
X₄ : Number of Dependents (person)
X₅ : Land Area (Ha)
X₆ : Access to Capital Credit, where 0: Not using and 1: Using
X₇ : Farmer Participation, where 0: Not Following and 1: Following
μ i: Error Terms

3.4.1 Model fit test

a. Hosmer and Lemeshow test

The suitability of the distribution of observations with the distribution of data required the Hosmer and Lemeshow test.

| Test                  | Hosmer and Lemeshow |
|-----------------------|----------------------|
| Chi-square            | 9.682                |
| Sig.                  | 0.288                |

Table 6 shows that the Chi-square value obtained is 9.682 with a significance value of 0.288 (0.288 > 0.05). Then accept H0, reject H1, meaning that there is no significant difference between the data and the predicted results of the logistic regression model, or the model can predict the observed value of the logistic regression model and the corresponding model.

b. Nagelkerke R Square test

The Nagelkerke R Square test shows the ability of the independent variable to explain the dependent variable. These values are also known as Pseudo R-Square, or if in linear regression (OLS), it is better known as R-Square. From the results of the study obtained the value of Nagelkerke R Square as in table 3.

| Step | -2 Likelihood Logs | Cox & Snell R Square | Nagelkerke R Square |
|------|--------------------|----------------------|---------------------|
| 1    | 43,281             | 0.244                | 0.386               |

Table 7 shows the value Nagelkerke R Square of 0.386; this indicates that independent variables' ability to explain the dependent variable is equal to 38.6%, and other variables outside the model explain 61.4%.

3.5. Significant model testing

3.5.1 Omnibus test. The omnibus test was conducted to determine whether all independent variables had a significant effect on the dependent variable by comparing the independent variable model with the dependent variable.

| Omnibus Test of Model Coefficients | Chi-square | df | Sig. |
|-----------------------------------|------------|----|------|
| Step 1                            | 16.768     | 7  | .019 |
| Block                             | 16.768     | 7  | .019 |
| Model                             | 16.768     | 7  | .019 |
Table 8 shows that the Chi-square value obtained is 16.768 with a sig value of 0.019 <0.05. The test decision is to reject H0. It can be concluded that there is at least one independent variable that significantly affects the dependent variable in the logistic regression model.

3.5.2 Wald test. Wald's test was conducted to determine whether each independent variable had a significant effect on the dependent variable. The results of the Wald test on the use of superior seeds in the Bandar, Bukit, and Permata Subdistricts is as shown in Table 9.

| Variable                    | B     | SE  | Wald  | df  | Sig.  | Exp (B) |
|-----------------------------|-------|-----|-------|-----|-------|---------|
| Level of education          | -1.863| 1.036| 3.237 | 1   | 0.072 | 0.155   |
| Age                         | -0.056| 0.042| 1.827 | 1   | 0.177 | 0.945   |
| Farming Experience          | 0.020 | 0.058| 0.126 | 1   | 0.723 | 1.021   |
| The number of dependents    | -0.110| 0.475| 0.054 | 1   | 0.816 | 0.896   |
| Land area                   | -0.443| 0.821| 0.291 | 1   | 0.590 | 0.642   |
| Access to Capital Credit    | -2.348| 0.961| 5.971 | 1   | 0.015 | 0.096   |
| Farmer Participation        | 2.539 | 1080 | 5.526 | 1   | .019  | 12.663  |
| Constant                    | 4.423 | 2.999| 2.182 | 1   | 0.140 | 83.350  |

Table 8 shows the significant value of each independent variable (education level, age, farming experience, number of dependents, land area, access to capital credit, and farmer participation) on the dependent variable (use of superior seeds).

a. Level of education
Partially the independent variable level of education has no significant effect on the level of adoption. The regression coefficient is -1.863, the exp value (B) is 0.155 and the significance value is 0.072 > 0.05 (α 5%). The level of education has no significant effect on the adoption rate and is not significant at the 95% confidence level. So H1 is rejected.

b. Age
Based on the regression results, the age variable has no significant effect on the level of adoption, with a regression coefficient of -0.056, an exp (B) value of 0.945, and a significance level of 0.177 > 0.05 (α 5%). The age variable has no significant effect on the adoption rate of superior seeds (Y), so H1 is rejected.

c. Farming experience
The independent variable farming experience has no significant effect on the level of adoption with a regression coefficient of 0.020, Exp (B) value of 1.021, and a significance level of 0.723 > 0.05 (α 5%). The farming experience variable has no significant effect on the level of adoption. So H1 is rejected. The coefficient figure also shows a deficient level of relationship with farmers' decisions, where the coefficient of farming experience variable is in the interval 0.00-0.72 according to the interpretation of the strong correlation relationship.

d. Number of family dependents
The regression analysis results in table 8 show that the number of family dependents does not have a significant relationship with the level of adoption of superior seeds on the potato commodity where the regression coefficient value is -0.110, the Exp(B) value is 0.896. The significance level is 0.816 > 0.05 (α = 5 %). which means that the number of family dependents is large or small does not significantly affect the adoption rate of potato farmers for superior seeds.
e. Land area
Based on the regression results, the land area variable has no significant effect on the adoption rate, with a regression coefficient value of -0.443, the value of \( \exp (B) \) 0.624, and a significance level of 0.590 > 0.05 (\( \alpha \) 5%). The variable land area has no significant effect on the level of adoption, so H1 is rejected.

f. Access to capital credit
The regression coefficient for access to credit for farmers' capital is -2.348, and the value of \( \exp (B) \) is 0.096, which indicates an odds ratio of -2.348. The significance level is 0.015 < 0.05 (\( \alpha \) 5%). The variable of access to capital has a significant effect on the decision to adopt. So H1 is accepted. Usually, if the farmer does not have adequate capital, then the farmer borrows from collectors and intermediaries as working partners [13]. Almost half of the respondents (45%) obtained credit from banks and intermediaries. This study indicates that farmers who have access to credit tend not to use superior seeds. The loans they received were not enough to fund them to take advantage of superior seeds. So that the tendency of farmers who do not have capital loans are farmers who use superior seeds in their potato farming activities. Poor farmers, who cannot do much to increase their productivity, do not have sufficient buffer capacity to cope with price and weather variations, so they farm only to meet their needs[14].

g. Farmer participation
The regression coefficient for farmer participation is 2.539, and the \( \exp (B) \) value is 12.663. The significance level is 0.019 < 0.05 (\( \alpha \) 5%). The independent variable of farmer participation has a significant effect on the level of adoption. So H1 is accepted. Suppose farmers participate in agricultural extension or other agricultural activities so that a farmer's participation is high. In that case, the tendency to apply technology will also be high because, in extension activities, the things conveyed are in the form of applications from each stage of technology, especially the use of seeds. Superior to increase production yield. The high activity of participating in agricultural extension will accelerate the adoption of technology properly.

The results of this study follow the opinion of Suryantini [11] that non-formal education in the form of agricultural extension and training will improve the quality of farmers in terms of skills and knowledge so that the higher the activity of farmers in participating in agricultural extension, the faster the technology adoption process. Non-formal education in the form of farm extension will accelerate the process of adopting an innovation.

The spread of new ideas does not depend on print media or electronic media but also direct discussions between individuals or community groups [12]. Most of the goals of active farmers in agricultural extension activities are to increase their knowledge and skills in farming. Through counselling, farmers' aspirations can be conveyed and collected by extension officers. Thus, the high activity of farmers in participating in agricultural extension will positively contribute to the application of agricultural technology innovation.

4. Conclusions
Based on the research and discussion results, The variables of age, education level, length of farming, land area, and the number of dependents have no significant partial effect on adopting superior seeds for potato commodity in the Bener Meriah District. Variables of access to capital credit and farmer participation partially have a considerable impact in adopting excellent potato commodities sources in the Bener Meriah District. We hope that many potato farmers will take advantage of superior seeds so that these expectations can be realized. Farmers should actively participate in farmer group activities. The government can help increase the number of seed breeders in Aceh so that farmers can reach the price of superior seed in Aceh.
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