Study of adoption rate of corn integrated crop management in Southeast Sulawesi

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Abstract. Dissemination of corn Integrated Crop Management (ICM) technology has been introduced to farmers, but its application is not widespread. The study aims to determine the level of adoption and socioeconomic factors that influence the opportunities for the application of corn ICM technology in Southeast Sulawesi. The study used a survey method with 90 respondents. Data analysis uses scoring techniques to determine the level of adoption of corn ICM, and logistic regression analysis to determine socioeconomic factors that influence farmers' opportunities to adopt the technology. The results showed that the level of adoption of the technology component of corn ICM in Southeast Sulawesi was included in the moderate category with a value of 56.05%. The relatively high corn ICM technology components were adopted by farmers, namely harvest technology (84.4%), superior varieties (83.33%), and quality and labelled seed technology (66.67%). While the technology that is less adopted by farmers is embedding (26.67%) and use organic fertilizer (18.89). There are socioeconomic factors that influence farmers' opportunities in implementing corn ICM technology, namely: age, farming experience, land area and farmers' perceptions of the characteristics of the technology. This indicates that the socio-economic factors of farmers (age, experience of farming, land area) and farmers' perceptions of technology are very important in making farmers' decisions to adopt corn ICM technology in Southeast Sulawesi.

1. Introduction
Efforts to increase corn production and productivity cannot be separated from the important role of technological innovation, including through the Integrated Crop Management (ICM) approach, which is an innovative and dynamic approach in an effort to increase farmers' production and income through participatory technology assembly with farmers. ICM is proven to be able to increase the productivity and efficiency of corn farming \cite{1,2}. Development of Integrated Crop Management (ICM) technology has been carried out through various government programs. Beginning with ICM Field Schools in 2008-2014, followed by the Integrated Crop Management Acceleration program in 2015 \cite{3,4}, which was carried out in 26 provinces development of corn, including Southeast Sulawesi with an area of 3000 ha \cite{5}.

Southeast Sulawesi Province is one of the potential regions to support the development of national maize, covering an area of 33,467.2 ha spread across 17 districts / cities in Southeast Sulawesi. The total corn production in Southeast Sulawesi in 2016 was recorded at 90.01 tons \cite{6}, with a productivity level of 2.92 t / ha, still low compared to productivity at the research level which can reach 5-10 t / ha. The productivity of corn which is not optimal, mainly because ICM technology has not been fully adopted by farmers.
Adoption is a stage of activities, mental processes and changes in a person's behavior in the form of knowledge, attitudes and skills towards innovation from knowing, putting interest, evaluating to accepting and implementing innovation. The manifestation of adoption can be observed both in the form of behavior as a reflection of changes: attitudes, knowledge, or skills [7,8,9,10].

In the adoption process, farmers do not take for granted the recommended technological innovations. The innovation adoption process concerns the decision-making process, where in this process many factors influence it [11]. Research results of Sumarno and Hiola, the level of education, farming experience, land area, access to credit, technology assistance, distance to the location of farming, markets, and sources of technology are socio-economic factors that significantly influence the adoption of corn ICM innovation in Gorontalo [12]. In addition the level of education, land area, farmer's accessibility to farm locations, markets, and technology sources are farmers' socio-economic factors that influence rice adoption of ICM in Bangka Belitung [13].

Information regarding the adoption of corn ICM technology and socio economic factors that influence the adoption opportunities still very limited. Therefore, the study aims to determine the level of adoption and socio-economic factors that influence the chances of applying corn ICM in Southeast Sulawesi. The results of the study are expected to provide information and input in the formulation and refinement of policies to increase corn production and productivity in Southeast Sulawesi.

2. Methodology

The research was conducted in March - November 2017. Location of activities in three districts: Muna, Konawe Selatan, and Konawe. The location is determined with the consideration that the area is the main center of corn development in Southeast Sulawesi. The type of data collected in this study consists of primary data and secondary data. Primary data consisted of characteristics of the respondent farmers (age, formal education level, number of family members), farming characteristics, farmers' perceptions of the components of corn ICM technology. Primary data was obtained through direct interviews with respondent farmers consisting of 30 respondents in each location so that the total number of farmers interviewed was 90 respondents. The selection of respondents was done randomly, with the provision of farmers who did corn farming and had participated in the corn development program (SL-PTT and GP-PTT).

The components of corn ICM technology which analyzed the level of adoption included basic and choice technology. Basic technology consists of: (1) New, hybrid or composite superior varieties, (2) Quality and labelled seeds, (3) Population 66,000-75,000 plants ha and (4) Fertilization based on plant needs and soil nutrient status (balanced fertilization). While the technology of choice consists of (1) land preparation, (2) administration of organic matter, (3) planting, (4) controlling pests and diseases, and (5) timely harvesting and immediate drying.

To determine the level of adoption of funding for the components of corn ICM technology, an analysis using an ordinal scale was used by referring to the Likert scale [14]. Likert scale is used to measure attitudes, opinions, and one's perceptions of social events or symptoms, specifically referred to as research variables [15], and for the purposes of analysis, each statement item is given the scorer. Score 1, if applying the recommended technology and a score 0, if not applying the recommended technology.

To find out the level of adoption of corn ICM, the formula used is:

\[
TA = \frac{\text{Total Score}}{\text{Ideal Score}} \times 100 \%
\]

- \(TA\) = The level of adoption of corn ICM technology expressed as a percentage (%)
- Total Score = Value obtained (skor)
- Ideal score = expected maximum ideal value (skor)
To reveal the socio-economic factors that influence the chances of farmers applying corn farming technology, it was analyzed by a logistic regression model. Logistics model is a modelling procedure that is applied to model the response variable (Y) which is categorized based on one or more precursor variables (X), both those which are categorical and continuous [16]. Furthermore, the logit function has been used and discussed in detail [17,12].

The logit function equation is used as follows:

\[
\ln \left( \frac{p_i}{1 - p_i} \right) = \alpha + \beta_1 X_1 + \epsilon_i
\]

By including variable factors, the logit function model to determine the socio-economic factors determining the adoption of corn ICM innovation in this study are as follows:

\[
\ln \left( \frac{p_i}{1 - p_i} \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon
\]

Information:
- \( P(\cdot) \) = opportunities for farmers to adopt / implement technology
- \( 1 - P(\cdot) \) = Opportunities for farmers do not adopt / implement technology
- \( X_1 \) = age (year)
- \( X_2 \) = education (year)
- \( X_3 \) = number of family members (soul)
- \( X_4 \) = experience of corn farming (years)
- \( X_5 \) = Land area (ha)
- \( a \) = Konstanta
- \( B1 \) = Regression coefficient
  \( i = 1,2,3,4,5 \)

3. Results and Discussion

3.1. Farmer Characteristics

Farmers' conditions such as age, formal education, farming experience, farm area, availability of family labor, are socioeconomic factors that can influence farmers' considerations in making decisions to implement recommended technology. The complete socio-economic characteristics of farmers are shown in Table 1. The mean age of respondent farmers was 44.24 years. This shows that farmers are still classified as productive age (less than 56 years). Productive farmers have a tendency to think patterns and reasoning that are relatively open and quickly accept new innovations [18]. In accordance with Soekartawi; Prabayanti that farmers who are classified as young, faster and better at accepting / adopting technological innovations [19,20].

Based on the educational aspect the average level of education of the respondent farmers was 6.53 years, equivalent to the level of elementary school education. This indicates that most of the respondent farmers have a relatively limited level of education. According to Soekartawi [19], farmers with low education, it is rather difficult to implement innovation adoption quickly, and vice versa those with higher education are relatively faster in implementing innovation adoption. Although the level of formal education of farmers is relatively low, farmers' knowledge can be increased through training and learning activities obtained from government programs, such as SLPTT. In addition, an understanding of farming technology is widely obtained by farmers from farming experience.
Table 1. Characteristics of respondent farmers in Southeast Sulawesi, 2017

| Variable                  | Description | Konawe | Muna | Konsel | Mean  |
|---------------------------|-------------|--------|------|--------|-------|
| Age (tahun)               | Minimum     | 17.00  | 27.00| 25.00  | 23.00 |
|                           | Maximum     | 71.00  | 79.00| 65.00  | 71.67 |
|                           | Mean        | 42.53  | 45.67| 44.53  | 44.24 |
| Formal education level (years) | Minimum | 0.00   | 0.00 | 1.00   | 0.33  |
|                           | Maximum     | 12.00  | 12.00| 5.00   | 9.67  |
|                           | Mean        | 8.30   | 8.70 | 2.60   | 6.53  |
|                           | Minimum     | 1.00   | 1.00 | 1.00   | 1.00  |
| Farming experience (years) | Maximum     | 34.00  | 20.00| 40.00  | 31.33 |
|                           | Mean        | 10.27  | 9.43 | 15.43  | 11.71 |
| Number of family dependents (person) | Maximum | 6.00   | 5.00 | 4.00   | 5.00  |
|                           | Mean        | 2.53   | 1.93 | 1.87   | 2.11  |
|                           | Minimum     | 0.25   | 0.25 | 0.35   | 0.28  |
| Land area (hectare)       | Maximum     | 4.00   | 5.00 | 2.50   | 3.83  |
|                           | Mean        | 1.69   | 1.54 | 1.25   | 1.49  |

The experience of farming shows the length of time a farmer practices corn farming. Table 1 shows, the average farm experience of respondents was 12 years. This means that the respondent farmers already have sufficient experience in corn farming, so they are expected to be able to make good decisions in managing their production factors and are more skilled in developing their farming. Furthermore, the amount of family workforce is related to potential resources that can be developed to assist the head of the family in managing their farming. The potential is in the form of the number of farm family members who are able to be actively involved in farming activities. Table 1 shows, the average number of respondent farm family members involved in corn farming was 2 people. This shows that the potential for family labor is relatively available. Base on the aspect of the farm area, the survey results show that the average area of maize farming for respondents is 1.5 ha. The more land owned by farmers, usually the braver to try technological innovations that are recommended.

3.2. The Rate Of Adoption Of Corn Integrated Crop Management (ICM) Technology

Identification of the application of corn farming technology refers to the component of corn Integrated Crop Management (ICM) technology. The results of the analysis of the level of adoption of corn farming technology are shown in Table 2.

Table 2. Adoption rate of corn ICM technology in Southeast Sulawesi, 2017.

| Corn ICM Technology                  | The Rate Of Adoption Of Corn ICM Technology |
|-------------------------------------|---------------------------------------------|
|                                     | Adoption Value | Adoption Category |
| Superior varieties                  | 83.33          | high              |
| Quality and labeled seeds           | 66.67          | high              |
| Land preparation                    | 62.22          | medium            |
| plant population                    | 57.78          | medium            |
| Balanced fertilization              | 47.78          | medium            |
| Provision of organic ingredients    | 18.89          | low               |
| Soiling                             | 26.67          | low               |
| Pest & disease control              | 56.67          | medium            |
| Harvest on time                     | 84.44          | high              |
| Mean                                | 56.05          | medium            |
Table 2 has shown that the adoption rate of corn ICM technology components including moderate adoption with an adoption score of 56.05%. This means the application of corn ICM technology in Southeast Sulawesi not optimal. This also indicates, although ICM technology has long been introduced to corn farmers in Southeast Sulawesi it is still limited to being applied by farmers.

3.3. Socio-Economic Factors That Influence the Adoption of Corn ICM Technology

Socioeconomic factors that allegedly influenced the adoption of corn ICM technology consisted of age (X1), level of formal education (X2), number of family dependents (X3), corn farming experience (X4), area of corn farming (X5), and farmers’ perceptions of corn ICM technology (X6). The results of the logit function analysis of socio-economic factors that influence the adoption of corn ICM in Southeast Sulawesi show that the Nagelkerke R square (R2) value obtained was 0.70. This value means that the variation of the independent variable is able to explain 70% of the total variation of the logistic model in this study. The influence of external factors not included in the model is only 30%. It also means that the 70% chance of farmers adopting corn ICM technology is influenced by the variables in the model (Table 3).

Table 3. Results of estimating logistic regression models of socioeconomic factors that influence adoption of corn ICM in Southeast Sulawesi, 2017

| Variable socioeconomic factors          | Exp(B) | Significance |
|----------------------------------------|--------|--------------|
| a constant                             | 0.007  | 0.012        |
| Age                                    | 0.963  | 0.056*       |
| Formal education                       | 1.138  | 0.675        |
| Farming Experience                     | 1.174  | 0.006*       |
| Number of family dependents            | 1.404  | 0.243        |
| Land area                              | 2.665  | 0.055*       |
| Farmer's perception                    | 21.113 | 0.001*       |
| Nagelkerke R square                    | 0.70   |              |

Note: * significant at α level 5%, ns = not significant at α level 5%.

Furthermore, the results of the estimation of the coefficient and the variable significance test showed that, of the six independent variables included in the model, there were four independent variables that had a significant effect (<0.05%) on the application of corn farming technology; namely age, corn farming experience, area of land ownership and farmers’ perceptions. Of the four variables, there are three variables whose influence is positively related, namely, farming experience, land area, and farmers’ perceptions, while age variable has a negative relationship. Two other explanatory variables, namely formal education and the number of family dependents, do not significantly affect the adoption of corn farming technology because the significance value is greater than 0.05.

Age of farmers negatively influences the adoption of corn ICM because it has an odds ratio of less than 1 (0.938). This means that increasing the farmer's age by one year will reduce the opportunity to implement corn ICM amounted to 0.938 times the original. The age of the farmer increases, the physical ability and productivity of work also decreases and will affect the decisions of farmers in applying corn farming technology. Some research results show that farmers’ age has a negative effect on technology adoption [21,22]. Older farmers usually tend to be very conservative in responding to changes in technological innovation. In contrast to younger farmers. The younger the farmer age, usually has a curious spirit and try to implement technology faster.

Farming experience has a positive effect on the adoption of corn ICM technology because it has an OR value of 1.107. This means that every time there is an increase in one-year farming experience will increase the chances of farmers applying corn farming technology one-fold. Farming experience is related to the length of time a farmer stays on a farm, the longer the farm experience, the more references, abilities and expertise in running his farm. The length of time a farmer is engaged in farming can also affect the farmers’ decision to apply technology. The results showed that farming
experience ranged from 1-40 years, with an average of 12 years. This shows that the respondent’s experience in corn farming is relatively long.

The area of land has a positive effect on the adoption of corn ICM technology with an OR value of 2,628. The meaning is every increase in land area one level will increase the opportunity for farmers to apply corn farming technology by two times. In line with the opinion of Saragih [23], which states that the size of the land area is always positively related to the level of adoption of farmers, the more land owned by farmers, the faster it will adopt because of the better economic capacity.

Farmers’ perception has a positive effect on the adoption of corn ICM technology because it has an OR value of 6.755, meaning that every increase in one perception score of farmers will increase the chances of farmers in implementing the suggested corn farming technology by 6 times. This shows the opportunity for farmers to apply corn ICM is quite large. A correct perception of an object is needed because perception is the basis for forming attitudes and behavior [24]. Hendayana [25] states that farmers’ perception of recommended technology is a key factor influencing farmers’ appreciation of technological innovation. No matter how good the recommended technology will not be responded by farmers if the farmers’ perception of the technology is not good.

4. Conclusion
The adoption rate of corn ICM technology components in Southeast Sulawesi is the medium category with an adoption value of 56.05%. Components of corn ICM technology that were classified as high levels of adoption were: harvest technology (84.4%), superior varieties (83.33%), and quality and labelled seed technology (66.67%). While the technology which is categorized as low in the level of adoption is embezzlement (26.67%) and provision of organic material (18.89%).

Socio-economic factors that influence the opportunities of farmers in implementing the technology component of corn ICM, namely: age, the experience of farming, land area and farmers’ perceptions of technological characteristics. This indicates that the socio-economic factors of farmers (age, farming experience, land area) and farmers’ perceptions of the technology component of corn ICM are very important in making decisions to adopt corn ICM technology in Southeast Sulawesi.

To increase corn productivity, the adoption of corn ICM technology continues to be improved. Efforts to improve the application of technology can be more focused on technologies that are still less adopted by farmers by taking into account socio-economic factors that influence the opportunities for adoption of corn ICM technology.

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