Factors affecting the implementation of intercropping technology of food crops on upland

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Abstract. Intercropping technology program has been implemented to support the achievement of food self-sufficiency. The intercropping technology namely “Turiman” technology is different from the intercropping that is commonly used by farmers before. The aim of this study were to analyze farmers’ perceptions of Turiman technology and to analyze the factors that affect the Turiman implementation. This study was conducted in 7 districts from April to October 2019. Data was collected through a survey method of 40 respondents. The data collected were farmers' perceptions after the implementation of intercropping technology regarding production increase, land optimization, reduced production costs and increased income, and also the desire of farmers to apply this technology independently and sustainably. The data obtained were analyzed descriptively and using multiple linear regression analysis. The results showed that 95% of respondents had the perception that Turiman technology was able to increase production, 87.5% of respondents had the perception that Turiman could optimize land, 62.5% had the perception that Turiman was able to save production costs, 90% of respondents had the perception that Turiman was able to increase income, so that 72.5% of respondents would like to implement the intercropping technology independently. Factors that significantly influence farmers in implementing turiman were age, experience and perceptions of farmers.

1. Introduction

National development is aimed to increase the capacity and welfare of society equally that currently has more emphasis on economic development and ease of investment. It causes the government to carry out a lot of development in the infrastructure sector that has an impact on land conversion in various regions, including the conversion of agricultural land to non-agricultural which generally occurs in Java [1]. The consequence of land conversion is the increase of planted area, especially for food crop commodities. As a result of limited productive land, agricultural systems face productive challenges, namely the importance of ensuring sufficient production for a population that always grows [2-4]. However, this productivity problem cannot be separated from the need for stability in production availability [5,6]. Weather and climate are the main drivers of agricultural production systems, so that food security is expected to deteriorate on a global scale, despite advances in technology and other fields [7-9].

Expansion to sub-optimal land, namely upland, is an alternative choice to address this. The potential of upland for agricultural development in Indonesia is estimated to reach 76 million hectares in the...
lowlands and uplands with wet and dry climates [10,11]. Furthermore, [12] stated that of the upland area in Indonesia that reaches 144.47 million ha, around 99.65 million ha (68.98%) becomes potential land for agriculture. Based on climatic conditions, especially rainfall, lowland Upland - Dry Climate (LKIK) is ± 9.32 million ha (6.45%), mainly in Nusa Tenggara, and a small part in eastern Sulawesi, eastern Java and Papua, eastern part around Merauke. Upland- Dry Climate covering an area of ± 1.43 million ha (0.99%), found in Nusa Tenggara and a small part found in eastern Java and Sulawesi [12].

Until now, the use of upland in Indonesia has not been optimal, so that productivity is still low [10,11]. The efforts to increase agricultural production can be done through optimizing land productivity for agricultural cultivation to increase the sustainability of agricultural land use [13]. One form of land productivity optimization is a mixed crop pattern by applying early maturing plants as intercrops. Mixed cropping patterns are agricultural land management technologies by combining crop intensification and diversification. The mixed cropping pattern that is usually used by farmers is the intercropping system that is the planting of more than one type of early-age plant in a regular row and the planting is done simultaneously in a plot of land [14].

The intercropping plants system is more profitable than the monoculture system because the land productivity is higher, the types of commodities produced are diverse, it is more efficient in the use of production facilities and may minimize the failure risk. This is in line with the results of research conducted by [14] with the intercropping system treatment throughout the year (namely, ginger + corn-soybean) showed an LER value of 2.45 with an increase in TLO (21.8 t ha\(^{-1}\)) that is, 2% higher than single ginger that increases the potential economic returns by 6%. Intercropping systems can also reduce erosion and maintain soil fertility. The results showed that small farmers in the Guinean Savanna practice cereal-legume inter-cropping to reduce the risk of crop failure in single cropping. Intercropping is more profitable on less fertile land and in more marginal environments, and it can still be relied on to provide food for farmer households. The productivity of cereal-legume intercrops can be affected by the spatial layout of the intercrops and soil fertility status [15].

Farmers carry out mixed or intercropping planting patterns on the grounds to fulfill family consumption [16], ownership of a narrow land area, availability of labor from the scope of the family and minimal farming costs. Currently, the intercropping technology namely Turiman (“Tumpang Sari Tanaman”) is different from the traditional intercropping done before, which is based on local wisdom. The Turiman technology manipulates the number of populations and the spacing so that in 1 hectare will be obtained 2 commodities with a population of 1 hectare each. In supporting the sustainability of this intercropping program, it is necessary to pay attention to farmers’ perceptions of Turiman technology and the factors that affect its application from the farmers view. Perception is a person's experience of objects, events, or relationships obtained by inferring information and interpreting messages [17].

This study was aimed to analyze farmer perceptions on the Turiman technology that has been applied and to analyze the factors that influence farmers in implementing the technology.

2. Research methods

2.1. Location and time

The study was carried out in 7 districts in 5 provinces, namely Yogyakarta (Gunung Kidul Regency), East Kalimantan (Kutai Kertanegara Regency and Samarinda Regency), Central Java (Pemalang Regency), Lampung (Central Lampung and Tanggamus Districts), and West Java (Sumedang Regency), from July - November 2019. Determination of districts based on the region that was a representative of the province implementing the Turiman program accompanied by the Agricultural Institute for Technology Assessment (AIAT). The selection of sub-districts and villages was determined purposively with criteria referring to the location assisted by AIAT for the Turiman program.

2.2. Data collection and data analysis

The data were collected through survey methods by interviews with 40 respondents and literature studies. The selection of respondent farmers was carried out by purposive random sampling, with the
criteria being farmer cooperators of AIAT activities in implementing the Turiman program. The data collected was primary data obtained through questionnaires (a list of written questions related to research variables studied) and interviews. Primary data consisted of respondent characteristic data and farmer perception data. Data collected on the characteristics of respondents included age (years), farming experience (years), formal education (years), sources of capital, the area cultivated land (ha) and land ownership status. Data on farmers' perceptions were perceptions after the implementation of Turiman technology regarding increased production, land optimization, reduced production costs and increased income, and also the desire of farmers to apply this technology independently and sustainably.

The data obtained were then analyzed using the Guttman scale, the score of 1 states Agree and a score of 0 states disagree. The formula used to measure perception is as follows [18]:

\[ X_i = \frac{n_i}{N} \times 100\% \]  

(1)

Description:

\( X_i \) = perception
\( n_i \) = the number of respondents who give the statement
\( N \) = total respondent

Analysis of factors that influence farmers' opportunity of implementing Turiman technology using multiple linear regression analysis with the following equations:

\[ Y = a + bx_1 + bx_2 + bx_3 + bx_4 + bx_5 + bx_6 + bx_7 \]  

(2)

Examined parameters:

\( Y \) = the application of Turiman
\( X_1 \) = age (years)
\( X_2 \) = farming experience (years)
\( X_3 \) = farmer education (years),
\( X_4 \) = source of capital (score / ordinal scale)
\( X_5 \) = area of cultivated land (ha)
\( X_6 \) = land ownership status (score)
\( X_7 \) = farmers' perceptions of intercropping technology (score / ordinal scale)

To find out whether a regression model is feasible or not, it can be seen in the Significant column of ANOVA table. The regression model is stated to be feasible if the significance level at ANOVA is <0.05 [19] and the independent variable is stated to be significant if \( t < 0.05 \).

3. Results and discussion

3.1. Respondent characteristics

The existing condition describes the existing technology implemented by the respondent farmers of Turiman system. Table 1 shows the results of the synthesis of the existing conditions at the study site and the conditions after the implementation of Turiman technology. The implementation of Turiman technology has changed the monoculture cropping system to a mixed cropping pattern, as well as the introduction of water management technology (pumping and piping) because the introduction of technology was carried out in Planting Season III or the dry season.

**Table 1.** Synthesis of farming performance of respondent farmers on upland in 5 Provinces, 2019.

| No. | Aspect                  | Turiman technology                                      |
|-----|-------------------------|--------------------------------------------------------|
|     |                         | Before                                                  |
| 1   | Planting System         | Plant various commodities (rice, maize, Green beans /  |
|     |                         | peanut) on several plots, in one planting season        |
|     |                         | After                                                   |
|     |                         | Plant various commodities (rice-maize, rice-soybean,   |
|     |                         | maize-soybean, maize-peanut) on the same plot of land, |
|     |                         | regularly in one                                        |
The results of the survey in 7 districts in 5 provinces showed that the majority or 60% of the respondents ranged from 31-59 years and can be categorized as productive age and have physical potential to support farming activities, were dynamic, and quickly accept new technological innovations [20], whereas farmers over 59 years of age have advantages in terms of experience, consideration, work ethic and commitment to quality, but they are often considered less flexible and reject new technology [21].

Respondents in this study with formal education until Elementary School level were 47.5%. Education is one of the main indicators in improving the quality of human resources. Formal education is very important as capital for farmers to carry out activities to increase experience and knowledge [17]. According to [22], education is a means of learning that will further instill a favorable attitude towards the use of more modern agricultural practices. The low level of formal education for farmers can be overcome through non-formal education such as training or through communication with outsiders and conducting visits related to group needs, so that they have an innovative attitude.

In this study, it can be seen that the majority of farming experiences range from 11-20 years and 31-40 years. From the research results of [23] that there is a significant relationship between the adoption rate and farming experience. In other words it can be concluded that the longer the experience in farming, the higher the response rate to a technology. Meanwhile, according to [24] having sufficient experience in performing business can provide negative values for the formation of perceptions. It is because the higher the farming experience, the farmers are accustomed to facing risks and knowing how to solve problems if they experience difficulties in farming. From the characteristics of these respondents, farming experience was included in the response category to a technology.

Land is one of the important production factors in farming [25]. According to [26], farmers who have large areas of land will find it easier and faster to adopt new technologies, while farmers who have narrow land tend to maintain their existing cropping patterns. This situation is caused by thinking about big risks and uncertainty of production.

Land tenure has a negative effect, meaning that the smaller the area of land tenure will increase the opportunities for farmers to adopt technology. Another explanation is that farmers with large areas of land do not necessarily have high adoption rates because farmers are afraid of failure [27]. The area of land tenure in this study varies, the majority ranges from 0.25 - 1 Ha and most of them are self-owned. The land ownership area in this study was classified as narrow because generally they acquire and divide land as inheritance.

The sources of capital obtained by farmers were vary. In this study, majority respondents have sources of capital that come from previous farming products. It indicates that the respondent was already independent and that previous production is sufficient as a source of capital. It is different from the results of research in Pandeglang Regency, Banten Province, where the majority of respondents obtained a combination of capital sources, loans and government assistance because they wanted to optimize the process of lowland rice cultivation by using better inputs to obtain greater profits compared to using the production facilities as it is [28].
3.2. Analysis of respondents' perceptions of the implementation of plant intercropping technology in upland

Farmer understanding of technological innovation certainly requires mental readiness to make decisions for the adoption of useful and applied technology through a perceptual process. The characteristics of innovation have a positive effect on the level of adoption of innovations, meaning that an innovation will be accepted if a new technology has advantages, benefits and more easily adopted. Technology that can be adopted by the community must meet several conditions, including being economically profitable, technically easy to learn and implemented, as well as socially acceptable to the community [29]. In this study, the results of the analysis of respondent perceptions of the implementation of intercropping technology in upland are presented in table 2.

Table 2. Respondent perceptions of the Turiman technology in upland, 2019.

| No | Question Variable                                      | Respondent Perception (%) |
|----|--------------------------------------------------------|----------------------------|
| 1  | The intercropping system is able to increase production | 95                         |
| 2  | The intercropping system is able to optimize the land   | 87.5                       |
| 3  | The intercropping system can save production costs     | 62.5                       |
| 4  | The intercropping system is able to increase income    | 90                         |
| 5  | Implement technology independently and sustainably     | 72.5                       |
|    | Average                                               | 81.5                       |

Source: Processed primary data, 2019

The results of the analysis showed that 95% of respondents had the perception that intercropping technology can increase crop production. This increase in production occurs because resources such as light, water and nutrients were fully absorbed and converted to plant biomass by intercropping systems as a result of differences in the competitive ability to absorb these growth resources [30]. From several studies with an intercropping system of soybean-maize through modification the population number per hectare or spacing, it can increase the yield of maize by 140%, while soybean has an increase of 15.98% [31]. The benefits of the intercropping cropping pattern are 81% higher than those grown in monoculture [32].

Respondents also had the perception that the Turiman system was able to optimize land use. It is in accordance with the results of research conducted by [33] that showed that the land equality ratio (NKL) was 1.45 for maize and soybean intercropping. It means that the total productivity in this intercropping system increase 45% advantage over the maize monoculture cropping system. Thus, to produce dry maize and soybeans in Turiman, 1.45 ha of land is required for soybean monoculture system. It showed that the intercropping of hybrid maize and soybeans was more profitable than monoculture system which provides efficiency in land use.

As many as 62.5% respondents had a perception that Turiman was able to save production costs and 90% had a perception that Turiman was able to increase their income. This was confirmed in several studies that analyze farming on intercropping technology. The profit of soybean-maize cultivation was 41% greater than the soybean monoculture system, with an R / C ratio > 1 [34]. Even the treatment combination of 80 cm × 20 cm spacing on sweet maize and soybean (Burangrang) had an R / C value of 3.20 [35].

From four perceptions item, as many as 72.5% of respondents want to implement Turiman technology independently and sustainably. The same research results were found in the introduction of other Balitbangtan technologies including super jarwo technology, PTKJS technology (Integrated Management of Healthy Citrus Gardens) [36,37].

3.3. Factors affecting the respondents in implementing Turiman Technology

The implementation of intercropping technology by respondents was influenced by several factors, one of which was technology users. Table 3 shows the results of the ANOVA factors that influence
respondents in applying Turiman technology. The regression model had a significant effect because sig <0.05. It means that the independent variables used in this study had a significant effect on the implementation of Turiman technology.

Table 3. The results of multiple regression test.

|                      | Sum of Squares | Df | Mean Square | F     | Sig. |
|----------------------|----------------|----|-------------|-------|------|
| Regression           | 5532.311       | 7  | 790.330     | 6.192 | .000 |
| Residual             | 2935.431       | 23 | 127.627     |       |      |
| Total                | 8467.742       | 30 |             |       |      |

The results of the regression analysis of the factors that influence the application of Turiman technology are presented in Table 4. The results of the regression analysis showed that the variables that significantly influence the application of technology were age, experience, and farmer perceptions, with the equation:

\[ Y = 0.009X1 - 0.009X2 - 0.005X3 + 0.42X4 - 2.879E-0.06X5 + 0.81X6 + 0.2X7 \]

This regression model had \( R^2 \) value of 0.653, it means that only 65.3% of the distribution of these variables can be explained by the independent variable, the remaining 34.7% cannot be explained by the independent variable or the error component, so it can only be explained by variables outside the independent variable.

Table 4. The results of linear regression analysis of the influencing factors on the application of turiman technology.

|                          | Model                      | B   | T        | Sig  |
|--------------------------|----------------------------|-----|----------|------|
| (Constant)               | -1.355                     | -2.777 | 0.009   |
| Age                      | 0.009                      | 2.114 | 0.042*   |
| Experience               | -0.009                     | -2.139 | 0.040*  |
| Education                | -0.005                     | -0.244 | 0.809   |
| Source of Capital        | 0.42                       | 0.889 | 0.381    |
| Area of cultivated land  | -2.879E-0.06               | -0.379 | 0.707   |
| Land ownership status    | 0.81                       | 0.868 | 0.392    |
| Perception               | 0.20                       | 8.067 | 0.000*   |
| R Square                 | 0.653                      |      |          |

Description: *Significant (Sig<0.05).

Age becomes the factor that influences the respondent desire to apply Turiman technology. As previously explained, age was related to the ability to adopt an innovation. Age of farmers will affect physical abilities and responses to new things in running their farming, as well as decision making and follow-up on the adoption of a person's innovation [38]. Based on BPS (2018), the productive age is 15-64 years, where farmers will more easily accept the new knowledge and innovations developed in agriculture compared to older farmers. However, it is different from the statement of Ginanjar [39] in his research which found that the age variable had no significant effect on farmer decision making.

According to [40], the farmers experience in farming affects how to respond the innovation. The longer the business experience, the higher the response rate to a technology. However, other research states that farming experience has no significant effect on the level of technology adoption, it can provide a negative value for the formation of perceptions of a technology. It is because farming activities are carried out from generation to generation, so that farmers already have their own concept or way of doing business. In addition, there is a possibility that the level of technology adoption is determined by
the amount of information and knowledge about technology that is owned and considered beneficial to farmers themselves [24, 41].

Perception is important thing that influences the application of technology. Perception is a stimulus received by individual farmers, so that technological innovation is meaningful and useful and it is an activity that is integrated within the individual before making a decision to behave [42].

In this stage, individual will find out in more detail about a new innovation and the benefits of using this information. At this stage a potential adopter will be more psychologically involved with the innovation and will form a general perception of the innovation. Positive perceptions from farmers / users will lead to higher levels of application. This was thought to be the cause of other factors (education, source of capital, area and land ownership status) which do not significantly affect the application of Turiman technology, namely because the level of acceptance has only reached the persuasion stage.

Communication, media and dissemination methods were appropriate for the users to increase the stage in the process of Turiman technology implementation. From the second stage of the adoption process, it is expected that it can increase the next stage. There were several factors that influence the innovation decision process, namely: previous practices; a feeling of need; innovativeness; and norms in the social system which “Acceptance of a technology” means not just "knowing" but actually being able to properly implement or apply it in the farming business.

4. Conclusion
The results of descriptive analysis showed that respondents' perceptions of Turiman technology can increase production by 95% of respondents, able to optimize land by 87.5%, able to save 62.5% of production costs and may increase income by 90%. As many as 72.5% of respondents wish to apply Turiman technology independently and sustainably. The results of regression analysis showed that the variables that had a significant effect on the application of technology were age, experience and farmer perceptions with a regression coefficient of 0.653. Communication, media and dissemination methods were appropriate for the users to increase the stage in the process of Turiman technology implementation.

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