Turiman innovation dissemination strategy to improve cropping index

R Purnamayani¹, M Mardiharini¹ and H Syahbuddin²

¹ Indonesian Center for Agricultural Technology Assessment and Development, Bogor, Indonesia
² Indonesian Agency for Agricultural Research and Development, Jakarta, Indonesia

Email: rimacahyo@yahoo.com

Abstract. The main issue related to the role of innovations in the production of food crops is the lower adoption process, including in the cropping index innovation. One of the innovations in cropping index is the intercropping system of rice namely Turiman. The study aimed was to (1) analyze the factors that influence the process of Turiman innovation dissemination and (2) to formulate an alternate innovation dissemination strategy. The study was conducted through a survey approach in five provinces (Java and Outside Java) in Indonesia, from June to December 2019. The number of respondents (n) was 56 farmers. Data analysis was performed descriptively and inferential using Partial Least Square (PLS). The results of the study indicated that farmers interested in the culture technology components of the Turiman system, especially in the preparation and maintenance stages (indicated by higher loading factor values) than the technology components of harvest and post-harvest. The fit model has a value of AVE >0.5, CR >0.7, and R² = 82.80% (good). The future strategy needs to consider the support of the local government, farmers’ access to production facilities, capital, markets, and the dynamics of farmer groups.

1. Introduction
Agricultural technology is expected to increase the farmer’s welfare. Various agricultural technology innovations have been introduced and disseminated to farmers, but the process is still relatively slow. This is one of the obstacles to accelerating agricultural development in Indonesia. It is also considered as the cause of most rural farmers are left behind from urban communities. The agricultural environment concerning the biophysical and socioeconomic and cultural aspects and institutions is very diverse. The provision of innovation, as well as the dissemination and innovation adoption is a complex process. Farmers encountered various obstacles such as the limitations of facilities and infrastructure, knowledge, skills, as well as various socioeconomic and cultural constraints [1–2].

One of the indicators for successful dissemination of agricultural innovation is the level of adoption/application of innovation. The results of the study also showed that many innovations produced in particular by the Indonesian Agency for Agricultural Research and Development have not been well adopted and on a wide scale [1–2]. This indicates that the supply chain segment of innovation in delivery subsystems and receiving subsystems is a bottleneck that leads to sluggish information delivery and low adoption of innovation rates [3]. The issues of dissemination of agricultural innovation are generally related to the gap in the innovation adoption by farmers, with the socio-economic constraints of farmers [4].
One of the government’s efforts for increasing food production was increased the crop index. The crop index increasing was defined as an increase in the frequency of planting per season (timescale) and an increase in land use (space scale) at a time as well as an increase in the added value of commodities attempted on the scale of space and time through on-farm connections with industry [5]. To increase the crop index, one of the innovations is the polyculture system or Turiman. Turiman is one of the mixed plant patterns, which grows more than one type of short-aged plant in an orderly and concurrent planting line in a piece of land. In general, the Turiman system is more profitable than the monoculture system because the productivity of the land becomes higher, the types of commodities produced are diverse, the savings in the use of production facilities and the risk of failure can be reduced, and can reduce erosion, even successfully maintain soil fertility [6].

The objectives of increasing the crop index through Turiman system need to be reviewed through a fit innovation adoption model. If we find out the innovation adoption model that is appropriate in the Turiman implementation, we could expect that the adoption process of this innovation can run optimally following the target. This study aimed to analyze the factors that influence the process of Turiman innovation dissemination and to formulate an alternative strategy for innovation dissemination to increase the crop index through Turiman.

2. Methods

2.1. Approaches and concepts of innovation advisory model

This study was conducted through a quantitative approach and enriched with qualitative data. Survey and confirmation at the field level were based on developed theories and concepts. The concepts of adoption innovation are based on system theory, which explained that an activity is a form of association between various elements or subsystems. These elements of subsystems are organized and they work as a unity to produce certain benefit [7–8].

Each of the various subsystems had inputs to carry out an activity (process) to produce output. Turiman innovation dissemination by Assessment Institute for Agricultural Technology/AIAT was a subsystem, grouped into: preparation for planting, maintenance, harvest and postharvest technology. The concept of the Turiman innovation dissemination model was explained in figure 1.

![Figure 1. Concept of Turiman innovation dissemination by AIATs.](image-url)
The model concept explains that the role of agriculture extension officers ($X_1$), Turiman Innovation ($X_2$), and Farmers Characteristics ($X_3$) are influence the rate of adoption by farmers ($Y_1$) and to produce benefits ($Y_2$). Each variable has indicators that can be measured and observed with notations that characterize the variables they represent.

2.2. Location and time of assessment
Survey at the farm level was carried out in selected locations (purposively) based on the cropping index improvement program in five provinces: Yogyakarta (Gunung Kidul District), East Kalimantan (Kutai Kertanegara and Samarinda District), Centre Java (Pemalang District), Lampung (Centre Lampung and Tenggamus District), and West Java (Sumedang District). The study was conducted in April-December 2019.

2.3. Collection data methods and determination of respondents
Primary data was collected using a structured questionnaire, with total respondents ($n$) = 56. All respondents are farmers participating in the cropping index improvement program. The characteristics of the respondent in this study were divided into two, namely Java and outside Java farmers. The profile of respondents in the study was characterized by age (years), an education level (years), non-formal education (training), farming experience (years), land tenure (ha) and land tenure status. Qualitative data collection was carried out through focus group discussions (FGD). FGD participants were farmers and local champion (as many as 5 to 10 people per location) members of farmer groups.

2.4. Data analysis
Data were analysed descriptively and inferentially. Confirmation of the model concept was analyzed using the Partial Least Square (PLS) with the SMART-PLS software. The advantage of this analysis tool is that it can simultaneously combine three analyses such as the Structural Equation Model (SEM), namely factor analysis, regression analysis and path analysis. Matjik and Sumertajaya [9] mentioned SEM as an integrated approach between data analysis and concept construction because the structure of the relationship forming or explaining causality between factors. A distinction in PLS analysis, the number of respondents ($n$) is relatively smaller (between 30-100) than in SEM (more than 200 respondents).

3. Results and discussion

3.1. Performance of respondent
The characteristics of the respondent in this study were showed in table 1. The average age of farmers was of productive age (under 60 years). Productive age was the capital to carry out farming activities. This condition will affect the pattern of decision-making and how to try farming. The age of the farmer will affect their activities in agriculture. The level of education of farmers was still below junior high school (average 7 years). Low-level education of the majority of farmers was the dominant feature of the agricultural and rural sectors that need to be improved. Non-formal education was described in participatory training, in which the majority of farmers have participated in one training in a year. Formal or non-formal education was one of the Farming experiences was quite good because the average farmer has been farming for more than 25 years. The farming experience will help farmers make decisions in doing farming. The longer the farming experience is possessed by farmers, the more likely it is to have the highest skills [10]. However, land tenure was still low, which was below 0.5 ha for Java Island and 0.5-1 ha for outside Java. Land tenure status in Java was dominated by tenants, meanwhile, the dominant land status is owned by themselves at outside Java. There were no significant differences of characteristics between Java farmers and outside Java farmers, except on land tenure.
Table 1. The characteristics of respondents from five provinces, 2019.

| No | Descriptions                                      | Java Frequency | Java (%) | Outside Java Frequency | Outside Java (%) |
|----|---------------------------------------------------|----------------|----------|-------------------------|------------------|
| 1  | Number of respondents (n)                         | 26             | 100.0    | 30                      | 100.0            |
| 2  | Age of respondents (years)                        | 52.53          | 100.0    | 50.85                   |                  |
| 3  | Formal education (years)                          | 7.73           | 100.0    | 7.46                    |                  |
| 4  | Non formal education (number of training)         |                |          |                         |                  |
|    | • Never participate                               | 4              | 15.38    | 10                      | 33.33            |
|    | • Participate (1)                                 | 17             | 65.38    | 11                      | 36.67            |
|    | • Participate (2)                                 | 5              | 19.23    | 7                       | 23.33            |
|    | • Participate (>3)                                | 0              | 0        | 2                       | 6.67             |
| 5  | Farming experience (years)                        | 27.84          | 100.0    | 26.08                   |                  |
| 6  | Land tenure (hectare)                             | 0.49           | 100.0    | 0.70                    |                  |
| 7  | Land tenure status                                |                |          |                         |                  |
|    | a. Owner                                          | 9              | 34.62    | 18                      | 60.0             |
|    | b. Tenants (sharing)                              | 17             | 65.38    | 12                      | 40.0             |

The descriptive analysis showed the technological innovations that are known and applied were new superior variety application, quality and healthy seeds as well as soil cultivation by ploughing or rotary utilization and harvesting methods. Over 80% of respondent farmers have already known and applied Turiman technology. There are quite a lot of Turiman technologies that were known but not applied by respondent farmers, namely soybean treatment seeds, rice population per hectare, soybean planting time, soybean population, soybean fertilization and weed weeding on corn (table 2). The reason for not applying this technology was disbelief and they have to see the evidence first. Turiman corn and gogo rice has been implemented in Bengkulu which showed that there was an increase in farmers’ knowledge of Turiman technology innovation through field meeting activities of 128% [11]. However, further assessment of other counselling methods such as demonstrations and farming courses and studies on the effectiveness of indirect communication on improving knowledge.

Table 2. Percentage of farmers at the level of knowing and implementing Turiman innovation, 2019.

| No | Technology components of Turiman               | Knowing (%) | Implementing (%) |
|----|------------------------------------------------|-------------|-----------------|
| 1  | New superior variety application               | 83.93       | 85.71           |
| 2  | Quality and healthy seeds                      | 92.86       | 96.43           |
| 3  | Soil cultivation by plowing / rotary           | 89.29       | 89.29           |
| 4  | Rice seed treatment                            | 55.36       | 53.57           |
| 5  | Pest control                                   | 58.93       | 55.36           |
| 6  | Soybean treatment seeds                        | 42.86       | 37.50           |
| 7  | Rice population per hectare                    | 41.07       | 35.71           |
| 8  | Corn population                                | 55.36       | 50.00           |
| 9  | Soybean planting time                          | 42.86       | 39.29           |
| 10 | Soybean population                             | 42.86       | 35.71           |
| 11 | Rice fertilizing                               | 53.57       | 53.57           |
| 12 | Corn fertilizing                               | 66.07       | 58.93           |
| 13 | Soybean fertilization                          | 44.64       | 39.29           |
| 14 | Weeding                                       | 46.43       | 41.07           |
| 15 | Weeding on soybean                             | 53.57       | 48.21           |
| 16 | Weeding on corn                                | 53.57       | 33.93           |
| 17 | Soil piled up on corn                          | 62.50       | 55.36           |
| 18 | Harvesting methods                             | 89.29       | 87.50           |
3.2. Factors influenced the process of Turiman innovation dissemination

Analysis showed that implementation of the Turiman pattern significantly influenced the rate of farmers adoption, it would greatly affect to enhance knowledge, attitude and farmers skills (figure 2).

In the implementation of Turiman innovation dissemination, demonstration plot (demo-plot) strategies had a considerable influence toward outputs of dissemination, which were an increased adoption by farmers.

**Figure 2.** Factors influenced the process of Turiman innovation dissemination based on PLS analysis.

The result of the analysis using Partial Least Square (PLS) show that the factors that significantly influence the Turiman innovation adoption are the character of Turiman innovation components that is introduced. The influence of the Turiman package introduced on innovation adoption is very strong (0.910), according to the regression equation in the following PLS:

\[
\text{Rate of Adoption} = 0.910 \times \text{Character of Turiman innovation}; R^2 = 82.80\%
\]

It can be explained that the interest of farmers in adopting the introduced Turiman innovations is not directly caused by the role of extension officers and the characteristics of farmers. Farmers are very interested in the components of intercropping plant cultivation technology, especially in the preparation and maintenance stages (indicated by a higher loading factor value), compared to the components of harvest and post-harvest technology.

The technological components at the preparation stage include: use of varieties, quality and healthy seeds, soil processing, seed treatment, and population numbers. Maintenance technology components include: fertilization methods, controlling plant pests, weeding or controlling weeds, and fertilizing. Harvest and post-harvest technology components include: harvest age, harvest method, and post-harvest handling methods. Harvest and post-harvest technology component are also significant to attract farmers, but has a relatively small loading factor value. This is presumably because only a few farmers have applied (used it).

This model shows that the role of extension officers and farmer characteristics does not significantly affect the adoption process. This can be understood, because this study was conducted while the program was still running, meaning that all program activities were still accompanied by officers (researchers and extension agents) from AIATs, with a structured technology package to be implemented. The adoption of innovation in this study is still limited to the application of various technological components by farmers. The attractiveness of farmers to apply components of cultivation technology at the preparation and maintenance stages shows that farmers have high hopes for Turiman innovation.

Previous studies regarding determinants factors for innovation dissemination related to farmer characteristics particularly education level and farming experience [12–13], the courage to take a risk [14]. Meanwhile, the determinant factors for farmer’s awareness and adoption toward innovation could also be influenced considerably by extension access [15].

The R² value (refers to adoption level and farming cost efficiency) was relatively high, which is 82.8%. It means this model is relatively good at explaining the relationship between variables and the
indicators that build it. The relative magnitude of the $R^2$ value also shows that this model can be used as a reference in the dissemination of Turiman innovations. However, for the study of sustainable adoption of Turiman innovation, it is necessary to consider factors that do not directly influence this model (the role of extension officers and farmer characteristics), as well as other factors that have not been accommodated in this study. These factors include: local government support, farmers' access to production facilities, capital, markets, and the dynamics of farmer groups.

Despite low value of $R^2$, the model was judged to be fit and can be used as a guide for the advisory model in the development of agricultural zones with corporation based. The model is assumed to be fit according to PLS analysis when the value of Average Variance Extracted (AVE) >0.5 and Composite Reliability (CR) >0.7. The results of the analysis in this study can be seen in table 3.

### Table 3. Analysis for model fit based on the value of AVE dan CR.

| Average Variance Extracted (AVE) | Composite Reliability (CR) |
|----------------------------------|-----------------------------|
| $X_2$                            | 0.834                       |
| $Y_1$                            | 0.632                       |
| $X_2$                            | 0.938                       |
| $Y_1$                            | 0.834                       |

*valid AVE value >0.5  
*valid CR value >0.7

3.3. Turiman innovation dissemination strategy

The main activity in dissemination innovation conducted by AIATs is dominant as demonstration plot strategy, especially for the application of components preparation and maintenance. It was almost all of the activities carried out by AIATs in cooperation with the farmers or farmers groups. What is often overlooked is that the regional extension officers are not involved. Based on the fit model, the results of this study indicate this phenomenon.

According to the analysis result above, this study identified some strategies for future Turiman dissemination innovation to improve cropping index, based on sub system and the actors involved during the process, as shown in table 4.

### Table 4. Strategies for future Turiman dissemination innovation to improve cropping index.

| No | Sub system | Indicators and strategies | Actors |
|----|------------|---------------------------|--------|
| 1. | Turiman Innovation | Readiness and accuracy of Innovation: | IAARD, PERHIMPI (professional organization) |
|    | a. Preparation | - To arrange a planting calendar that is integrated with the design of water harvesting and water management | AIATs |
|    |             | - To develop the water balance concept and recommended and site-specific reservoirs | |
|    |             | - Land processing, selection of varieties, and planting systems according to recommendations and specific locations | |
|    |             | - To determine planting time and water management (efficient irrigation system) in detail | |
|    |             | - To determine the dose and method of fertilization and pest control according to recommendations and specific locations | |
|    | b. Maintenance | - Mechanization to overcome labor limitations | |
|    |             | - Best practices for water management and water harvesting need to be carried out, using an accurate design analysis | |
|    | c. Harvest and post-harvest | - Mechanization to maintain product quality | |
| No | Sub system                          | Indicators and strategies                                                                 | Actors                                                      |
|----|------------------------------------|------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| 2  | Research Institute                 | The number of innovations adopted by users quickly:                                       | IAARD/AIATs                                                |
|    |                                    | - Improvements in the research planning process, especially identification of user needs and clarity of output, outcome, and potential impacts |                                                             |
|    |                                    | - Ensuring technological readiness at the research institute                              |                                                             |
|    |                                    | - It has been assessed in a specific location                                            |                                                             |
| 3  | Farmers, farmer groups and local champions | Increasing the number of adoption and diffusion of Innovation by independent farmers. | Farmers, Farmer Group, Local extension officers and Agency for Agric. Extension (BPPSDMP) |
|    |                                    | - To increase the capacity of farmers to work in groups through field schools and training on group dynamics and institutions |                                                             |
|    |                                    | - Changes in the approach to developing group activities, by giving more value to the application of innovations and increasing the welfare of group members as a result of the application of innovation |                                                             |
| 4  | Extension officers and local extension workers | - Involving farmer groups and local extension officers since need an assessment on technology, advisory process, monitoring and evaluation | Local extension officers and Agency for Agric. Extension (BPPSDMP) |
|    |                                    | - To increase the capacity, integrity and commitment of extension providers in a sustainable manner, through coordination meetings and internal consolidation of extension institutions and externals with related extension institutions (From the very beginning, extension agents are involved in the process of implementing research and developing models or prototypes from the results of the study) |                                                             |
|    |                                    | - Educating independent extension workers, through increasing the competence of advanced/ progressive farmers and young farmers to be more professional |                                                             |
| 5  | Government support                 | - To Support infrastructure                                                             | Central and Local Government                                |
|    |                                    | - Pro-farmer policy or regulation of input prices and agricultural product prices         |                                                             |
|    |                                    | - Replicating participatory demplot/demfarm in a field owned by independent extension agents/progressive farmers |                                                             |

4. Conclusions
The performance of Turiman innovation dissemination among locations in five provinces was still diverse, according to the inter-AIATs management. The Turiman dissemination activity was demonstration plot or farm (dem-plot/dem-farm). The results of the Turiman innovation were demonstrated through an increase in adoption (knowledge, attitudes and skills) and the implementation of several Turiman technologies such as new superior variety application, quality and healthy seeds as well as soil cultivation by ploughing / rotary and harvesting methods.

The result of the analysis using Partial Least Square (PLS) show that the factors that significantly influence the Turiman innovation adoption are the character of Turiman innovation components that is introduced indicated the importance of improving the internal management of implementing agents (AIAT). The study indicated that farmers are interested in the culture technology components of the Turiman system, especially in the preparation and maintenance stages (indicated by higher loading factor values) than the technology components of harvest and post-harvest. The fit model has a value
\( R^2 = 82.80\% \) (good), which shows that this model can be used as a reference in the dissemination of Turmudin innovations to improve the cropping index. The future strategy needs to consider the support of the local government, farmers’ access to production facilities, capital, markets, and the dynamics of farmer groups.

**Acknowledgments**
Authors wishing to acknowledge for colleagues and financial support from ICATAD, IAARD.

**References**

[1] Kuntariningsih A and Maryono J 2014 Adopsi teknologi pertanian untuk pembangunan pedesaan: sebuah kajian sosiologis (in Bahasa) *Agrikonomika* 3 180-191 https://doi.org/10.21107/agrikonomika.v3i2.453.g424

[2] Basuno E 2003 Kebijakan Sistem Diseminasi Teknologi Pertanian: Belajar dari BPTP NTB (in Bahasa) *Analisis Kebijakan Pertanian* 1 238-254

[3] Syakir M A 2016 Pemantapan inovasi dan diseminasi teknologi dalam memberdayakan petani (in Bahasa) https://pse.litbang.pertanian.go.id/ind/pdf/files/prosiding.../0_1.pdf diakses 14 Februari 2019

[4] Irawan, Dariah A dan Rachman A 2015 Pengembangan dan diseminasi inovasi teknologi pertanian mendukung optimalisasi pengelolaan lahan kering masam (in Bahasa) *J. Sumber Daya Lahan* 9 37-50

[5] Syahbuddin H dan Purnamayani R 2020 Revitalisasi Peningkatan Indeks Pertanaman Mewujudkan Lumbung Pangan Dunia *Bukti Nyata Peningkatan Indeks Pertanaman: Fondasi Lumbung Pangan Masa Depan* (in Bahasa) Syahbuddin H, Kushartati, Mardiharini M dan Purnamayani R, ed

[6] Turmudi E 2002 Kajian pertumbuhan dan hasil tanaman dalam sistem tumpang sari jagung dengan empat kultivar kedelai pada berbagai waktu tanam (in Bahasa) *Jurnal Ilmu-ilmu Pertanian Indonesia* 4 82-96

[7] von Bertalanffy 1968 *General System Theory: Foundations, Development, Applications* Cluster New York p.54

[8] Sumardjo, Lubis D P, Mulyani E S and Mulyandari R S H 2011 Manfaat sistem informasi berbasis teknologi informasi dan komunikasi untuk keberdayaan petani sayur (in Bahasa) *Informatika Pertanian* 20 14-29

[9] Matjik A A and Sumertajaya I M 2011 *Sidik Peubah Ganda dengan Menggunakan SAS* (in Bahasa) IPB Press 423 p

[10] Dewi Ni L P R, Utama M S and Yuliarmi Ni N 2017 Faktor-faktor yang mempengaruhi produktivitas usaha tanam dan keberhasilan program Simantri di Kabupaten Klungkung (in Bahasa) *E-Jurnal Ekonomi dan Bisnis Universitas Udayana* 6 701-728

[11] Harta L, Silviyani E and Musaddad D 2019 Peningkatan pengetahuan dan persepsi petani terhadap inovasi teknologi tumpang sari tanaman jagung padi gogo melalui temu lapang di Kabupaten Bengkulu Tengah (in Bahasa) *Prosiding Temu Teknis Jabatan Fungsional Non Peneliti*, Malang

[12] Indraningsih K S 2018 Strategi diseminasi inovasi pertanian dalam mendukung pembangunan pertanian (in Bahasa) *Forum Penelitian Agro Ekonomi* 35 107-122

[13] Nuryanti S, Dewa D dan Swastika K S 2011 Peran kelompok tani dalam penerapan teknologi pertanian (in Bahasa) *Forum Penelitian Agro Ekonomi* 19 115–128

[14] Adawiyah C R, Sumardjo N and Mulyani E S 2018 Faktor-faktor yang mempengaruhi peran komunikasi kelompok tani dalam adopsi inovasi teknologi upaya khusus (Padi, Jagung, dan Kedelai) di Jawa Timur (in Bahasa) *Jurnal Agro Ekonomi* 35 151-170

[15] Keil A, D’souza A and McDonald A 2017 Zero-tillage is a proven technology for sustainable wheat intensification in the Eastern Indo-Gangetic Plains: what determines farmer awareness and adoption? 9 723–743