The Indonesian Green Technology Journal **E-ISSN. 2338-1787**
DOI: *10.21776/ub.igtj.2019.008.01.04* **ISSN. 2355-4010**

Evaluation of the Lowland Rice Sustainability Based on the Dimensions of Biological Control in Besur Village, Lamongan District

Aminudin Afandhi [1], Wilda Al Aluf [2], Budi Prasetya[3]

[1]Department of Plant Pest and Diseases, Faculty of Agriculture, Brawijaya University, Malang
[2]Master Program of Environmental Resource Management and Development, Graduate, Brawijaya University, Malang
[3]Department of Soil Science, Faculty of Agriculture, Brawijaya University, Malang

Abstract

The biological control strategy in Besur Village of Lamongan District aims to increase the augmentation of micro and macro natural enemies and the application of biological pesticides. Excessive application of chemical pesticides inhibits the sustainability of lowland rice. This study aims to evaluate the sustainability of lowland rice based on biological control dimensions using Rap-Farm approach with the Multidimensional Scaling (MDS) technique. The results of the MDS analysis showed that lowland rice is sufficiently sustainable with an augmentation of macroorganism natural enemies by 1.96; the application of biological pesticides by 3.99 and the augmentation of microorganism natural enemies by 2.00. The application of biological pesticides plays a very important role in the sustainability of lowland rice in Besur Village of Lamongan district. It is recommended to improve the natural enemies augmentation of predators, parasitoid and insect pathogens to support the sustainability of lowland rice.

Keywords: Biological Control, Besur, Lowland Rice, Sustainability

INTRODUCTION

Rice fields as a center for rice production largely function to ensure food security and public health, especially in Lamongan, East Java. It's main function is as a provider of rice. One of the rice production centers in Lamongan is Besur Village.

Since 2016, rice productivity in Besur Village has increased. Rice production has continued to increase for almost 2 years. The production of lowland rice in Besur Village reaches 10.3 tons/ha of dry harvested rice or equivalent to 8.94 tons/ha dry unhusked rice in 2017.

The major reason behind the rice production increase is the practice of rice cultivation based on the principle of biological control. However, efforts to increase production are hampered by intensive cultivation practices. The excessive use of pesticides by farmers hinders the sustainability of wetland rice. Excessive chemical pesticides cause a decrease in natural resources and soil quality [1].

Based on the Government Regulation of the Republic of Indonesia Number 6 of 1995 concerning Plant Protection, biological control is a safe and effective technique so as not to endanger human safety, the ability of natural resources and environmental preservation, as well as maintain and increase crop production. Biological control takes precedence over control processes that run naturally (non-pesticides): includes the right cultivation techniques; utilization of natural enemies such as parasitoid, predator and pathogen pests; utilize organic fertilizers and vegetable pesticides [2].

The diversity of natural enemies affects the quantity and quality of the products produced [3]. The balance of populations of pests and natural enemies in ecosystems is influenced by the application of chemical pesticides. The use of biological control agents as biological pesticides has the potential to control pests, is safe for natural enemies and environmentally friendly [3].

The sustainability of lowland rice is determined by biological control, namely the augmentation of macroorganism natural enemies, the application of biological pesticides and augmentation of microorganism natural enemies. The sustainability of lowland rice can be separated into 4 categories of biological control. Discontinued status shows the augmentation of macroorganism natural enemies is very low, there has never been an application of biological pesticides and augmentation of microorganism natural enemies is very low. Less status shows that the augmentation of macroorganism natural enemies is low, there is rarely an application of biological pesticides and augmentation of microorganism natural enemies is low. Sufficient

Author's correspondence:
Aminudin Afandhi
Email : aaf_fp@ub.ac.id
Alamat : Jl. Raya Sengkaling Gg. Sidodadi No. 6 RT 2 / RW 10 Mulyoagung Dau Malang

status shows that the augmentation of macroorganism natural enemies is moderate and the application of biological pesticides frequently happen and augmentation of microorganism natural enemies is moderate. The very continuing status shows that the augmentation of macroorganism natural enemies is high, the applications of biological pesticides very often occur and augmentation of microorganism natural enemies is high.

This research is a preliminary study of the evaluation of the lowland rice sustainability based on the dimensions of biological control. Problems that arise can affect the sustainability productivity of lowland rice in Besur Village, considering that the Besur Village as one of the rice barns in Lamongan.

This study evaluates the sustainability status of lowland rice by determining biological control status. Biological control is an important aspect in the sustainability of lowland rice as a center for rice production in Besur Village, Lamongan.

METHODOLOGY

Time and Location

This research was conducted in Besur Village, Sekaran Sub-district, Lamongan District, East Java Province. It was carried out for two months (September-October 2018).

Procedure

Data were analyzed using Rap-Farm approach with the Multidimensional Scaling (MDS) technique. The Rap-Farm approach is modified from Rapfish (Rapid Assessment Techniques for Fisheries) developed by Fisheries Center, University of British Columbia [4]. The analysis was carried out through several stages, including: (1) determining the dimensions and attributes that include the sustainability of lowland rice; (2) assessing each attribute on an ordinal scale; (3) preparing indexes and sustainability status; (4) reviewing sensitive attributes affecting sustainability by using leverage sensitivity; (5) examining the effects of errors in calculations using Monte Carlo analysis [5]. The attributes of the biological control dimension were taken from the ecological dimension attributes, namely the augmentation of macroorganism natural enemies and technological dimension attributes, that is the application of biological pesticides and augmentation of microorganism natural enemies referring to several literature studies from previous studies (Table 1).

Table 1. Dimensions and sustainable attribute of lowland rice.

Dimensions	Attributes
A. Ecology	1. Pest attack intensity (IH) ***)
	2. Disease attack intensity (IP) ***)
	3. Augmentation of macroorganism natural enemies ***)
	4. Organic material usage*)
	5. Utilization of agricultural waste ****)
	6. Crop rotation***)
	7. Concerted plant
	8. Plant pest organisms management
	9. Land resource management
	10. Agrochemical management
	11. Biodiversity**)
B. Technology	1. Application of resistant varieties ***)
	2. Augmentation of microorganism natural enemies ***)
	3. Application of chemical pesticides*)
	4. Land management
	5. The way to apply fertilizer***)
	6. Application of biological pesticides
	7. Protective crop planting ***)
	8. Weed control technology ***)
	9. Product processing technology ***)
	10. Agricultural waste processing technology ****)

Description : *) (2017) [6]
**) (2012) [7]
***) (2017) [8]
****) (2012) [9]

Goodness of fit of MDS calculation is indicated by the amount of the stress value [10] while the validity of the model is indicated by the amount of the coefficient of determination (R^2) [11]. The coefficient of determination (R^2) shows the relationship between the system and the attributes used (Saida, 2011). Stress values can be accepted if the value <0.25 (25%) and the coefficient of determination (R^2) is better if approaching 1.0 and categorized good and appropriate if the value is more> 80% [12].

Data Collection Method

This was quantitative research by using primary and secondary data. Primary data collection is carried out directly in the field, through interviews and observations with farmers and discussions with stakeholders regarding the management of rice fields in Besur Village. In addition, searching of secondary data from various literature sources, such as previous studies, theses, journals, reports and other documents related to the title of the research as well as information and data from the relevant agencies.

RESULTS AND DISCUSSION

Based on the MDS analysis, the sustainability of lowland rice continues with the augmentation of microorganism natural enemies of 1.96 (ecological dimension) (Figure 1); the application of biological pesticides 3.99 and augmentation of microorganism natural enemies 2.00 (technology dimension) (Figure 2). Among the attributes of the biological control dimension, the application of biological pesticides has the most influence on the sustainability of lowland rice as a center for rice production.

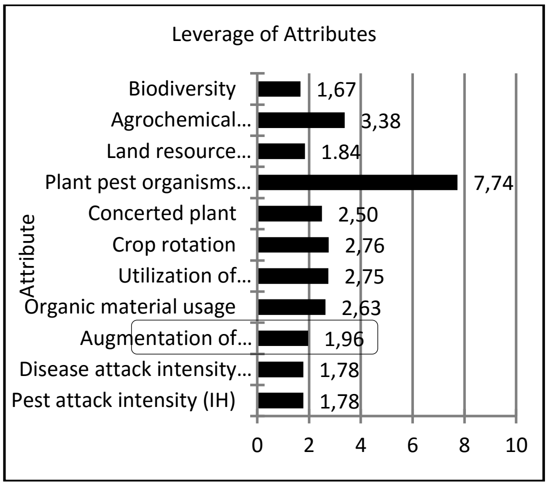

Figure 1. The RMS value is an ecological dimension attribute

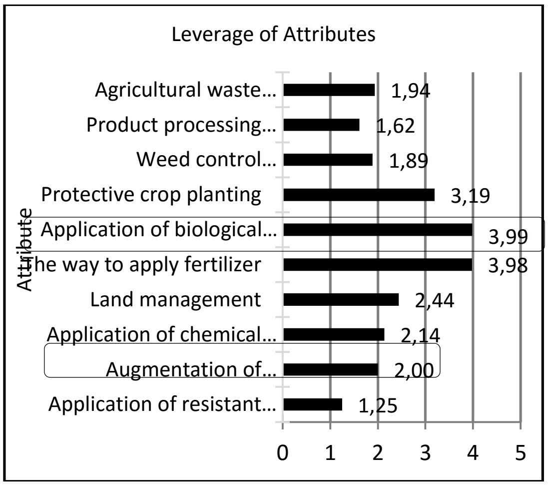

Figure 2. The RMS value is a technology dimension attributes

Based on the interview results with farmers, the type of macroorganism natural enemy frequently found in the rice fields is spiders and ladybugs [13]. In addition, weeds and spiders are also found on the surface of the rice ecosystem. Rice fields are planted with refugia plants such as sunflowers, wild cosmos (kenikir), and hibiscus function as a microhabitat to protect macroorganism natural enemies from controlling pests in rice plants. However, the augmentation of microorganism natural enemies is still low, this can be influenced by the practice of rice cultivation. The addition of flowering plants has not given a significant effect on increasing rice yield [14]. This is allegedly due to the plant varieties and agronomic parameters usually relatively constant. If given the same nutritional intake to grow and develop in an environment not much different then genetically will not be different [15].

Commonly, farmers in Besur Village often apply biological pesticides from microorganisms such as *Beauveria bassiana* and *Trichoderma* sp. fungi which has been packed in a bottle. The application of biological pesticides is generally carried out 15 days before planting and 30 days after planting. Biological pesticides are toxic substances derived from microorganisms (bacteria, fungi, nematode and viruses) or other plants that can be used to control pests and or diseases in plants and are environmentally friendly [3].

The farmers apply microorganism natural enemies by utilizing the *B. bassiana*, *Trichoderma* sp. fungi as a material for biological pesticides and *Rhizobacteria* as PGPR ingredients and other microorganisms for decomposers. Some types of microorganism natural enemies include fungi, bacteria, nematode, viruses, protozoa and rikettsia. By utilizing biological agents, the environment remains stable and there is a balance between natural pests and enemies [16].

The stress value of the ecological dimension is 0.16 and technology is 0.18, which means the stress values of the two dimensions are <0.25 so that the value of the analysis is quite good. If the smaller stress value, the better quality of the analysis carried out. While the coefficient of determination (R^2) of ecological dimension is 0.97 and technology is 0.96, meaning that the values of the two dimensions are close to the value of 1 (Table 2). The quality of analysis results is better if the value of R^2 approaches 1. Stress values can be accepted if the value is <0.25 (25%) and the coefficient of determination (R^2) approaches the 1.0 [11].

Table 2. The value of stress and R^2 in the dimensions of ecology and technology

Statistical parameter	Dimensions	
	Ecology	Technology
Stress	0.16	0.18
R2	0.97	0.96

The results of the Monte Carlo analysis with MDS show that there is a small difference in value between the MDS sustainability index and Monte Carlo values at the 95 percent confidence interval. A small difference in value between the MDS sustainability index and Monte Carlo values indicates that: (1) errors in making scores for each attribute are relatively small, (2) variations in scoring due to differences in opinion are relatively small, (3) stable MDS analysis process carried out repeatedly and (4) errors in entering data or the presence of missing data can be avoided [7]. Some parameters of the results of statistical tests in this study indicate that the Rap-Farm approach with the MDS technique is quite well used as one of the quantitative and rapid evaluation tools for the sustainability of lowland rice.

Table 3. The value of Monte Carlo and MDS analysis of the sustainability of wetland rice with a confidence interval of 95 percent

Dimensions	MDS	Monte Carlo	Difference
Ecology	70.92	71.11	0.19
Technology	77.49	77.55	0.06

CONCLUSION

Based on the biological control dimension, it is concluded that the sustainability of lowland rice sufficiently continues. The application of biological pesticides has the most influence on the sustainability of lowland rice. It is recommended to improve the natural enemies augmentation of predators, parasitoid and improve insect pathogens to support the sustainability of lowland rice.

ACKNOWLEDGEMENT

Authors would like to thank the anonymous reviewers for their valuable suggestions on the manuscript. Thanks also to: Abdul Harissuhud, ST. as and H. Khamim Asy'ari, SP. for helping location sampling.

REFERENCES

[1]. Purwaningsih, Y. 2008. Ketahanan Pangan: Situasi, Permasalahan, Kebijakan dan Pemberdayaan Masyarakat. Jurnal Ekonomi Pembangunan. 9 (1): 1-27.

[2]. Roja, A. 2009. Pengendalian Hama dan Penyakit Secara Terpadu (PHT) Pada Padi Sawah. Makalah disampaikan pada Pelatihan Spesifik Lokalita Kabupaten 50 Kota Sumatera Barat, Payakumbuh, 7-18 Oktober 2009.

[3]. Nik, N. 2015. Model Penanaman dan Frekuensi Aplikasi Bio-Insektisida Sebagai Upaya Pengendalian Hama Terhadap Pertumbuhan dan Hasil Padi Sawah (Oryza sativa L.). Jurnal Pertanian Konservasi Lahan Miring. 1 (1): 51-53.

[4]. Fauzi, A. dan Suzy, A. 2005. Pemodelan Sumber Daya Perikanan dan Lautan untuk Analisis Kebijakan. Gramedia Pustaka Utama. Jakarta.

[5]. Dubrovsky, V. 2004. Toward System Principles: General System Theory and The Alternative Approach. J. System Research. 21 (2): 109-123.

[6]. Dzikrillah, G.F., Syaiful, A., dan Surjono, H.S. 2017. Analisis Keberlanjutan Usahatani Padi Sawah di Kecamatan Soreang Kabupaten Banten. J. Pengelolaan Sumberdaya Alam dan Lingkungan. 7 (2): 107-113.

[7]. Novita, E., Ida Bagus, S., Idah, A., dan Sukrisno, W. 2012. Analisis Keberlanjutan Kawasan Usaha Perkebunan Kopi (KUPK) Rakyat di Desa Sidomulyo Kabupaten Jember. J. Agritech. 32 (2): 126-135.

[8]. Sudiono, Surjono, H.S., Nurheni, W., Purnama, H., dan Rachman, K. 2017. Analisis Berkelanjutan Usahatani Tanaman Sayuran Berbasis Pengendalian Hama Terpadu di Kabupaten Tanggamus Provinsi Lampung. J. Hort. 27 (2): 297-319.

[9]. Suyitman, Surjono, H.S., dan Ade, D. 2012. Status Keberlanjutan Wilayah Berbasis Peternakan Sapi Potong Terpadu di Kabupaten Lima Puluh Kota Sumatera Barat. Jurnal Peternakan Indonesia. 14 (1): 318-336.

[10]. Pitcher, T.J., and David, P. 2001. Rapfish: A Rapid Appraisal Technique to Evaluate the Sustainability Status of Fisheries. Fisheries Research. 49(3): 255-270.

[11]. Kavanagh, P. and Tony, J.P. 2004. Implementing Microsoft Excel Software For Rapfish: A Technique for The Rapid Appraisal of Fisheries Status.University of British Columbia, Fisheries Centre Research Reports. 12 (2): 75.

[12]. Kavanagh, P. 2001. Rapid Appraisal of Fisheries (Rapfish) Project. Rapfish Software Description (for Microsoft Exel). University of British Columbia, Fishries Centre. Vancouver.
[13]. Bambaradeniya, C.N.B., and Edirisinghe, J.P. 2008. Composition, Structure and Dynamics Arthropod Communities in a Rice Agroecosystem. Journal Science (Bio Science) 37: 23-48.
[14]. Usyati, N., Kurniawati, N., Baehaki, S.E., dan Triny, S.K. 2012. Pengawalan Tanaman Padi di Dalam dan Sekitar Kebun Sukamandi serta Pengendalian Hama dengan Rekayasa Ekologi. Laporan Akhir Tahun. ROPP DIPA. Balai Besar Penelitian Tanaman Padi. Badan Penelitian dan Pengembangan Pertanian.
[15]. Gardner F.P., Brent, P., dan Roger, L.M. 2008. Fisiologi Tanaman Budidaya; Terjemahan dari Physiology of Crop Plants. UI Press Jakarta.
[16]. Sunarno. 2012. Pengendalian Hayati (Biologi Control) Sebagai Salah Satu Komponen Pengendalian Hama Terpadu (PHT). Journal UNIERA. 1 (2).