Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

SUSTAINABLE AGRICULTURAL TEHCNOLOGIES ON RICE FARMING: Case of Subaks' in Bali Province, Indonesia

Wichaya Komin[1], Gede Sedana[2*]

[1]Social Research Institute, Chulalongkorn University, Thailand
[2]Faculty of Agriculture, Dwijendra University, Bali

ABSTRACT

Rice farming is very important to provide food for the population in the country. The increased rice productivity in Indonesia has been done since 1968 through the green revolution program. However, this program has brought the negative impacts for the physical environment which contributes to decreased productivity. Therefore, the effort to sustain the agricultural development should be taken by the government by applying sustainable agricultural technologies. The purpose of this study is to describe the implementation sustainable agricultural technologies, particularly on rice farming in Bali Province, Indonesia. The results of study pointed out that the sustainable agricultural technologies in rice farming could be done by implementing SRI, organic farming, and integrated pest management. These have an important role to ensure the increased productivity of rice. Besides, these could also support the economic activities in the upstream to the downstream sectors. It is recommended to government and other stakeholders to consider ecological and environmental aspects in the application of new agricultural technologies.

Keywords: Rice farming, productivity, environment, sustainable, agricultural

*Corresponding Author:
E-mail: gedesedana@gmail.com (Gede Sedana)
Faculty of Agriculture, Dwijendra University, Bali

1. INTRODUCTION

Agricultural sector has significant role in the economic development within developing countries (Oguzor, 2012; Salako and Lawrence, 2015). It has functions to provide food for the population, produce raw materials for the industry, and consume the industrial products and others. Most of the population has still consumed rice due to as a staple food. Therefore, the availability of rice must be secured in order to ensure the national stability. Increased production is more contributed by increased productivity compared to harvested area. Optimization of rice productivity in paddy fields is one of the opportunities to increase national grain production.

One of the agricultural commodities that has become a central issue in agricultural development in Indonesia is rice. The efforts to increase production and productivity of paddy fields in Indonesia were begun in 1968 by implementing agricultural modernization through an

Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

intensification program based on technology and is known as the green revolution. Today, modern agriculture has been known for its various successes, such as being able to provide food for a rapidly increasing population. But on the other hand, this success statement poses significant problems to the environment, namely soil erosion, deforestation, underground water contamination, decline in population of particulrar animals (Zilberman, *et., al*., 1997).

In agricultural modernization, there is a change in farm management from traditional to more advanced agriculture with the use of new technologies. Modernization can be interpreted as a transformation that is change. Modernization in agriculture in Indonesia is marked by fundamental changes in agricultural patterns, from traditional ways to more advanced ways. These changes include several things, including in the management of land, the use of superior seeds, the use of inorganic fertilizers and pesticides, the use of agricultural production facilities, and harvest time management. Realizing modern agriculture can be done by mobilizing more resources to develop modern agriculture, which is oriented towards agribusiness, including agro-industry.Meanwhile, Sumaryanto (2009) revealed that in increasing the availability of food production there were still various obstacles, namely: (i) the growth of harvested area was very limited due to the rate of expansion of new agricultural land was very low and the conversion of agricultural land to non-agriculture was difficult to control; (ii) degradation of water resources and irrigation performance as well as decreasing physical and chemical fertility levels of agricultural land. In addition, it has found the presence of symptoms of stagnation in the rice productivity growth because over intensification of agriculture that does not pay attention to the principles of sustainable agriculture (high cropping intensity, monoculture, excessive inorganic fertilizer doses, very less / without using fertilizer organic). Another impact of green revolution is the production instability due to pests and diseases and climate stress and decreased productivity due to degradation of land resources and water and environmental degradation (Las *et al*, 2006; in Praptono, 2010).

By looking at the contribution of rice planting in irrigated fields, efforts are needed to maintain the productivity of irrigated land so that it can produce sustainably by applying appropriate agricultural technology. Bali province should consider ensuring the sustainability of agricultural development since the tourism development has increased. This might bring about the problems and challenges for the government and farmers. This study aims to describe the implementation sustainable agricultural technologies, particularly on rice farming in Bali Province, Indonesia.

Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

2. SUSTAINABLE AGRICULTURAL TECHNOLOGIES

In this study, the sustainable agricultural technologies are those which have been introduced and applied at the farmer level in the connection with realizing sustainable agricultural development in Bali Province, Indonesia. The nature of sustainable agriculture development is commonly should include: (i) environmentally feasible; (ii) productive; (iii) economically feasible; (iv) culturally acceptable and desirable, and (v) technically can be carried out by farmers. In the study, the technologies implemented are: SRI (System of Rice Intensification); organic farming and integrated pest control management.

2.1. System of Rice Intensification

System of Rice Intensification (SRI) is a technique of rice cultivation that is able to increase rice productivity by changing the management of plants, soil, water and nutrients, proven to have succeeded in increasing rice productivity by 50% even in some places reaching more than 100% (Richardson, 2010; Chapagain, et al. 2011). Demonstration plots have been conducted by the provincial government within three regencies in Bali (Regencies of Tabanan, Karangasem and Buleleng). Farmers were interested in the application of SRI method, particularly in using seed, irrigation water and fertilizers. According to farmers, this method is simpler than the conventional method, and the yield is higher, too. Comparing to other researches and studies within other countries, this method could increase the rice productivity in Madagascar, it is from 2 tons/ha become more than 8 ton/ha, even some reach 20 tons/ha. Application of SRI might be solved the irrigation water fulfillment on rice farming.

The SRI method yields at least twice the yield compared to the methods commonly used by farmers. In Indonesia alone the first SRI pattern / technique trial was carried out by the Agricultural Research and Development Institute in Sukamandi, West Java in the dry season of 1999 with a yield of 6.2 tons / ha and in the rainy season of 1999/2000 producing an average of 8.2 rice ton/ha. SRI has also been implemented in several districts in Java, Sumatra, Bali, West Nusa Tenggara and East Nusa Tenggara which are mostly promoted by Non-Governmental Organizations (NGOs). The SRI method implemented in Bali has been used organic fertilizer, more efficient irrigation water. Therefore, this method could make better management of soil, plants and water based on environmentally friendly rules. With the increase in prices of chemical fertilizers and pesticides and the deterioration of the resource environment due to the continuous use of chemical fertilizers, it has encouraged farmers in several places to practice the System of Rice Intensification (SRI) method.

In general, in the concept of SRI make the crops are treated as living organisms as they should, not treated like

Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

machines that can be manipulated. All potential rice crops are developed by providing conditions that are suitable for their growth. This is because SRI applies the concept of synergy, where all components of SRI technology interact positively and mutually support so that the overall results are more than the sum of each part. Some studies also shown that there are several important components in the application of SRI, namely: (i) seedlings are moved in the field (transplantation) earlier (young seedlings); (ii) seedlings are planted one stem per planting hole; (iii) wide planting distance; (iv) soil conditions remain moist but not flooded (intermittent irrigation); (v) use of fertilizers from organic matter and local micro-organisms; and (vi) simple weeding.

The most basic thing in SRI cultivation is to apply intermittent irrigation which means that the dry wet cycle depends on land conditions, soil types and water availability. During the period of planting the land was not flooded but was messed up (wet but not flooded). This method can save water 46%. In addition, lack of water also prevents damage to plant roots. The higher the water the less dissolved oxygen, the impact is the plant roots are not able to bind oxygen so that the root tissue is damaged. In addition, if stagnant water causes natural enemies of rice pests cannot live while rice pests can live and can bring new rice pests that come from aquatic environments. Besides saving water, intensive cultivation also saves the use of seedlings, because only one planting hole is planted. In intensification, young seedlings were used 7 days after seedling and consisted of two leaves. The use of young seedlings has a positive impact because it is more adaptable and not easily stressed; this is because roots have not been long so planting does not need to be too deep enough 1-2 cm from the soil surface. To produce high quality young seeds, farmers prepare since sowing. The population in the 50 g /m2 nursery is intended to quickly grow large seeds, because there is no nutrient competition, so the seeds are ready for planting at the age of 7-10 days. Transplanting the young seedlings can reduce shocks and increase the ability of plants to produce stems and roots during vegetative growth.

2.2. Organic farming

As an alternative to sustainable agriculture, organic farming aims to increase sustainable crop production by improving soil fertility through the use of natural resources (Eyhorn, *et al*, 2018; Kennvidy, 2011; Singh, *et al*, 2017; Mendoza, 2004). Organic farming is an attempt to return to nature, limiting the use of inorganic fertilizers and other chemicals (Karyani *et al*, 2019; Surekha, *et al*, 2010). Therefore, the principles of ecology of organic agriculture are (i) to improve soil fertility by managing organic matter, adding organic fertilizer and increasing soil biological life; (ii) to optimize the availability and balance of nutrient cycles through nitrogen fixation, addition and cycle of fertilizers from outside the farm;

Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

(iii) to manage water use and micro-climatic agriculture to limit crop loss due to climatic influences such as heat flow, air and water; and (iv) to control of plant pests through preventive and safe efforts. Organic farming and natural agriculture are two agricultural systems that glorify nature, and restore the function of nature to grow, maintain and maintain plant fertility. This should be the key to the sustainability of the agricultural cultivation system (Lubis, 2009; Linawati, 2011).

In this study, the organic farming has been done by some farmers' group or *subak*s as a traditional irrigation system (Sedana *et al*., 2014; Roth and Sedana, 2015; Sedana and Astawa, 2017). According to the government officials at the provincial level, the application of organic farming has been done within several *subak*s' areas in the entire regencies (9 regencies). Kinds of organic farming implemented are using organic materials for fertilizers and pesticides (bio pesticides). The agricultural extension worker provided extension and training concerning the meaning of organic farming, benefits of organic farming, methods of organic farming, including making organic fertilizer and bio-pesticide.

Farmers were interested in the extension and training activities due to the interesting learning process, benefits of subject matters and efficient cost for having organic farming. They had learned on the rice field as a demonstration plot for training. During the training, farmers applied organic farming, particularly in using fertilizers and bio-pesticides. They were directly invited to practice what they have learnt in the class. The main purposes of this training were to enhance farmers' knowledge, strengthen their capacities and increase farmers' skill related to organic farming.

2.3. Integrated Pest Management

The concept of integrated pest management (IPM) is a thought or method of pest control approach that is in principle different from conventional pest control concepts that are highly dependent on the use of pesticides. The concept of IPM arises and develops all over the world due to human awareness of the dangers of increasing use of pesticides for the welfare of society and the environment/ecology (Dara, et al, 2019; Peterson, *et al* 2018). Integrated pest management or integrated pest control is an new approach to integrate various types of pest control methods which is addressed to reduce the pest population to the below level of economic damage (Rezaei, *et al*, 2019).

Global awareness of the importance of environmental quality as part of the fulfillment of the well-being of life has urged the need for a fundamental change in the use of hazardous chemicals such as pesticide (Larkin, 2008). If the use of pesticides must be reduced, the problem that then arises and is faced by farmers is how to use pesticides can be reduced but the loss of yield or loss due to pests can be avoided. The concept of IPM is an appropriate alternative to answer the

Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

dilemma, because IPM aims to limit the use of pesticides as little as possible but the target quality and quantity of agricultural production can still be achieved. IPM is a wise pest control approach using methods that guarantee it will provide satisfying results in economic, ecological and social terms (Pretty and Bharucha. 2015).

In this study, the IPM was firstly introduced by the government official from the Agriculture Service at the Provincial level. Aside from to reduce and control the pests, this IPM is expected to produce the healthy agricultural products. The consumers, especially in Denpasar city and other international tourism destinations have good awareness to the organic and healthy food. At the beginning, there was a positive response from the farmers and consumers as happening in other countries which is needed free of pesticides residue. Extension and training activities on integrated pest management have been conducted with the farmers groups under the *subak* system. *Subak* has a strict rule for the members to follow the government programs with the social sanctions and stopping irrigation water subject to a member who break the rule. One of the techniques implemented by the government is having the plot demonstration for demonstrating the IMP to the farmers. They could directly see; practice; learn the application of IMP after getting learning process in the class.

The forms of IPM applied by the farmers are crop rotation, less chemical fertilizers and pesticides uses, having bio-pesticides, and using the natural predators. Crop rotation is very important to discontinue the pest cycle on the rice field. The farmers under the *subak* system follow the cropping patterns defined by *subak*. It should be rice-rice/secondary crops-secondary crops or rice-secondary crops-rice/secondary crops, or rice-secondary crops-secondary crops. This is dependent on the availability of irrigation water at the weir and pest attack. During rainy season, all farmers in the study sites planted rice crop with particular varieties. The government official (agricultural extension worker) gave information about the variety which would be planted. There might be a potential pest attack during the planting season. Therefore, the farmers would follow the recommendation from the government relating to the variety of rice crop.

Less chemical fertilizers and pesticides uses were trained and demonstrated on the plot demonstration. The extension worker firstly gave knowledge about the organic and inorganic or chemical materials for the fertilizers and pesticides, the advantage and disadvantage of organic and inorganic or chemical fertilizers and pesticides, and the methods or techniques of their application. During the training, the farmers were fully involved in order that they could have good knowledge, attitude and skills toward application of organic fertilizers and pesticides. Besides, the farmers were also trained in the making process of organic fertilizers and bio-pesticides. The extension worker had a priority to use the local

Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

materials for fertilizers and pesticides. At the farmer level, the implementation of IPM is fully based on the principles of sustainable agricultural development. Management of pest control should also consider technical, ecological, economic, political and socio-cultural aspects. This means that the practice of pest control should not reduce the carrying capacity and environmental sustainability.

The government and farmers expected that IPM application could provide higher agricultural productivity, decrease pest populations and the damage or economically loss, and increase farmers' income. In other words, the IPM is aimed at eradicating and eliminating pests as much as possible so that the program to increase crop production is not disturbed. Therefore, the introduction and application of integrated pest management could have a positive impact on the behavior of farmers in the use of pesticides for their rice farming.

3. CONCLUSION

Sustainable agricultural technologies in rice farming, such as SRI, organic farming, integrated pest management have a significant role in increasing the productivity of rice cultivated by farmers. This new technology could also contribute to the development of businesses or activities in the upstream to the downstream sectors. Sustainable agriculture is successful resource management for agricultural businesses to help changing human needs while maintaining or improving the quality of the environment and conserving natural resources. Agricultural technology in environmentally friendly rice farming to support the realization of sustainable agricultural development includes the planting of SRI technique rice, organic farming and Integrated Pest Management.

In an effort to realize sustainable agriculture and provide benefits for future generations, all stakeholders such as the government, non-government institutions including farmers should always pay attention to ecological and environmental aspects in applying new technologies to their farms. Some technologies that are environmentally friendly and still provide relatively high productivity with long-term dimensions are the use of SRI technology, organic fertilizers and integrated pest control. In order to achieve this recommendation technology, extension agents need to understand agricultural management both in technical, economic, ecological and environmental aspects as well as farmer institutions so that integration occurs in the implementation of agricultural activities that are sustainable or sustainable.

REFFERENCES

Chapagain, T., A. Riseman; E. Yamaji. 2011. Assesment of System of Rice Intensification (SRI) and Conventional Practices under Organic and Inorganic Management in Japan. Rice Science, Vol.18, Issue4: 311-320

Dara, S.K. 2019. The New Integrated Pest Management Paradigm for the Modern

Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

Age . *Journal of Integrated Pest Management*, Volume 10, Issue 1:1-9.

Eyhorn, F., M.V. den Berg, C. Decock, H. Maat, and A. Srivastava. 2018. Does Organic Farming Provide a Viable Alternative for Smallholder Rice Farmers in India?. *Sustainability* 2018, *10*(12): 1-15.

Karyani, T., F Arifin, H. Hapsari, and E Supriyadi. 2019. Organic Rice Farming For Sustainable Development in The Nurani Sejahtera Farmers Group. IOP Conf. Series: Earth and Environemnetal Science 306 (2019) 012013.

Kennvidy, S. 2011. Organic Rice Farming Systems in Cambodia: Socio-economic Impact of Smallholder Systems in Takeo Province. Int. J. Environ. Rural Dev. Vol. 2, 115–119.

Larkin, R. P. 2008. Relative effects of biological amendments and crop rota-tions on soil microbial communities and soilborne diseases of potato. Soil Biol. Biochem. 40: 1341–1351.

Iinawati, L. 2011. Advancing Organic Agriculture in Indonesia: Future Opportunities and Challenges. Paper Workshop on Bina Sarana Bhakti Foundation. Bogor.

Lubis, AN. 2009. Risk Management and Reproduction Receipt of Semi Organic Rice: Study of Joint Farmers of Silih Asih Farmers Group in Ciburuy Village, Cigombong District, Bogor Regency. Bogor Agricultural Institute.

Mendoza, T.C. 2004. Evaluating the Benefits of Organic Farming in Rice Agroecosystems in the Philippines. J. Sustain. Agric. Vol. 24, 93–115.

Oguzor, N.S. (2012). Farm Organization, Ownership and Food Productivity in Nigeria. *Journal of Economics and Business Research, No. 1, 2012*: 63-72.

Peterson, R. K. D., L. G. Higley, and L. P. Pedigo. 2018. Whatever happened to IPM? Am. Entomol. 64: 146–150.

Praptono, B. 2010. Kajian Pola Bertani Padi Sawah Di Kabupaten Pati Ditinjau Dari Sistem Pertanian Berkelanjutan: (Studi Kasus di Kecamatan Pati). Tesis Program Magister Ilmu Lingkungan, Pascasarjana Universitas Diponegoro, Semarang.

Pretty, J., and Z. P. Bharucha. 2015. Integrated pest management for sustain-able intensification of agriculture in Asia and Africa. Insects. 6: 152–182.

Rezaei, R., L. Safa, C. A. Damalas, and M. M. Ganjkhanloo. 2019. Drivers of farmers' intention to use integrated pest management: integrating theory of planned behavior and norm activation model. J. Environ. Manage. 236: 328–339.

Richardson, M.N. 2010. Application of System Rice Intensification (SRI) in East Java. Australian Consortium for In-Country Indonesian Studies (ACICIS). Faculty of Social and Political Science. Muhammadiyah University. Malang.

Roth, D. and Sedana, G. 2015. Reframing Tri Hita Karana: From 'Balinese Culture' to Politics. *The Asia Pacific Journal of Anthropology, 16*(2): 157 - 175

Salako, M.A. and A. Lawrence. (2015). Agriculture, Economic Growth and Development Nexus: Var Variance Decomposition Evidence from Nigeria. *International Journal of Economics, Commerce and Management, Vol. III, Issue 6*: 460-473.

Sedana, G. I G.A.A.Ambarawati, and W. Windia. Strengthening 2014. Social Capital for Agricultural Development: Lessons from Guama, Bali, Indonesia. *Asian Journal of Agriculture and Development*. *Vol.11 No.2*:39-50.

Journal of Sustainable Development Science
Vol. 1, No. 1, December 2019, pp. 18-26
e-ISSN: 2715-9140

Sedana, G. and I N.D. Astawa. 2017. Revitalization of Farmers Organization Functions toward Agribusiness for its Sustainability: Ideas for Traditional Irrigation Organization in Bali Province, Indonesia. *International Journal of Development and Research. Vol.7, Issue 11:* 17020-17024.

Singh, D.K.; Akhtar, Z.; Gupta, S.; Srivastava, A.; Chakraborty, M. 2017. Production Strategies of Organic Basmati Rice in Tarai Region of Uttarakhand, India. Org. Agric. Vol. 7, 21–30.

Sumaryanto. 2009. Diversifikasi Sebagai Salah Satu Pilar Ketahanan Pangan**.** *Makalah disajikan dalam Seminar Memperingati Hari Pangan Sedunia yang diselenggarakan di Jakarta pada Tanggal 1 Oktober 2009.*

Surekha, K.; Latha, P.C.; Rao, K.V.; Kumar, R.M. 2010. Grain Yield, Yield Components, Soil Fertility, and Biological Activity under Organic and Conventional Rice Production Systems. Commun. Soil Sci. Plan. Vol. 41, 2279–2292.

Suzdaleva, S. Goryunova, A. Marchuk, and V. Borovkov. 2017. Mobilization strategy to overcome global crisis of water consumption Mobilization strategy to overcome global crisis of water consumption," *IOP Conf. Ser. Earth Environ. Sci.*, Vol. 90, No. 1: 012201.

Ziberman, D., Madhu K., and Leslie L. (1997). Economics of New Technologies for Sustainable Agriculture. In Australian Agricultuer and Resource Economics Society Inc. and Blackwell Publisher. Ltd.