“Small farmer large field”, a new model to developing and improving adoption of hybrid rice technology in Indonesia

Y Widyastuti1*, Satoto1, I A Rumanti1, B P Wibowo1, A Ruskandar1, Widyantoro1, Rachmawati1, and Z Zaini2

1Indonesian Center for Rice Research, Jalan Raya 9 Sukamandi, Ciasem Subang West Java 41256, Indonesia
2International Rice Research Institute Representative for Indonesia, Jalan Merdeka No 147, Central Bogor, Bogor City, 16111 West Java.

Corresponding author: yuniweicrr@gmail.com

Abstract. At present, the international market prefers to rice with some specific characters such as long slender shape, soft with 22-24% amylose content, a high percentage of head rice, and also aromatic. To fulfill rice with export standard, the farmers who involve have to apply good agricultural practices (GAP). Therefore need a high yielding variety, one of those varieties is hybrid rice variety possessing long slender shape, soft, a high percentage of head rice, and aromatic. Small Farmers, Large Field (SFLF) scheme was assumed précised and local specific for low land rice cultivation. This concept was integrated for farmers with small land holding to increase benefit collectively. The concept also integrated all cultivation system starting from planting up to marketing which was done together by some stakes holders. The objectives of this study are to (1) identify the hybrid rice productivity in large scale, (2) verify and validate the development of hybrid rice technology in small farmer large field’s model, and (3) analyze the preference of farmers to hybrid rice varieties. The research activities consisted of SFLF approach by using hybrid rice varieties with Jarwo Super system in large scale. Adoption survey and preference test for the farmer in term of rice plant performance, quality of grain paddy and rice which was done simultaneously in subak Tajen, Penebel sub-district, Tabanan district, Bali province. Dem-farm was conducted at 50 ha with hybrid rice varieties from ICRR and private company. Average hybrid rice yield is about 7.5 ton/ha to 13.5 ton/ha. The results of participatory varietal selection showed that the yield potential, performance of the plant, tolerance to pest and disease, and quality of grain from hybrid rice varieties had a positive influence on farmers’ preference.

1. Introduction

Rice has a special meaning in Asia, where about 90% of the rice is produced and consumed as a staple food. Indonesia, with the total population, predicted to reach 318.9 million in 2045, one of the urgent challenges is to fulfill the demand for rice as a major food crop. However, the ability to produce food is quite threatened due to limited natural and human resources, land conversion to modern industry, and global climate change because drought, flood, etc.

Considering the problems, then to increase rice production should be implemented by increasing rice productivity. Therefore, the development of high yielding varieties (HYVs) is a priority policy framework. Conventional technology to improve new HYVs using inbreed method becomes more difficult due to limited genetic differences. Responding to this challenge, hybrid rice technology
should be developed as an alternative technology to increase national rice productivity. The term “hybrid” is used to refer to the first generation of a cross between two genetically diverse parents. The commercial hybrid refers to a superior F1, which not only outperforms the better parent but also shows significant (at least 1 ton ha\(^{-1}\)) yield superiority over the best high-yielding inbreed variety of similar duration and possesses acceptable grain quality.

Indonesian Center for Rice Research until 2019, has been released 21 new hybrid rice varieties. Hipa 18 and Hipa 19 are hybrid rice which has resistance to bacterial leaf blight (BLB) and brown planthopper (BPH) [1]. In 2019, Hipa 20 and Hipa 21 were released that having the potential for high yield, resistant to BLB and BPH, with a seed production potential of more than 2 t ha\(^{-1}\). Hybrids in Indonesia have the heterosis of 10-25% higher than the popular inbred varieties, such as Ciherang, Mekongga, IR64 [2]; [3].

The adoption of hybrid rice in Indonesia is still very low, around 0.34 – 3.39% during 2013 – 2017 (ICRR, 2017). Compared to other countries, this adoption rate is low, it is due to (a) gap yield between hybrid and non-hybrid is not significant, whereas hybrid rice seed price is much higher; (b) grain quality lower than non-hybrid variety; (c) seed production rate is still low which imply higher seed price; (d) limited information to the farmers about hybrid rice; (e) distribution channels that are not ready to absorb hybrid rice technology from producers to the farmers ([4]; [5]; [6]; [7]; dan [8].

The Ministry of Agriculture provides a grant of certified seed to smallholder farmers to improve adoption of hybrid rice varieties and accelerate the increase on rice production in major rice-producing provinces. In 2019 there was 100,000 hectare of paddy area which received the grant of hybrid rice seed with volume 1,500,000 Kg [9].

[10] reported that the Small Farmers, Large Field (SFLF) scheme have received attention in Vietnam. The SFLF is the solution to the problems of mechanization of smallholders and lack of bargaining power in the input and output markets. Through this scheme, farmers who organize themselves into groups and synchronize their operations by adopting a single rice variety to be planted, establishing group nurseries, and planting and harvesting in the same time, so that when changing. The “Small Farmers, Large Field” allows small farmers to benefit from economies of scale by organizing themselves and integrating their small rice areas into one large field. This way, they can increase their bargaining power input companies, such as fertilizer, pesticides, etc.

Therefore, the objectives of this article are: (1) identify the hybrid rice productivity in large scale, (2) verify and validate the development of hybrid rice technology in small farmer large field’s model, and (3) analyze the preference of farmers to hybrid rice varieties.

2. Material and method

2.1. Demonstration farm

Demonstration farm of the Small Farmers, Large Field (SFLF) technology was conducted at Subak Tajen, Penebel, Tabanan Bali Province in Indonesia. The covered area of hybrid rice’s planting field is about 50 ha consisted of 36 ha (dem-farm only for HIPA 18, Hipa 8, and Hipa 5 Ceva from ICRR), 2.5 ha (display of varieties), and 11.75 ha (dem-farm private company).

Seven hybrid rice varieties were tested in this dem-farm that presented in Table 1. The total area of dem-farm was about 12.6 hectares. Other inputs like fertilizer (NPK and organic fertilizer) were given based on crop need by soil tool kit for P and K, and leaf color chart for urea in integrated site-specific nutrient management (SSSNM). While water supply to rice crop followed intermittent irrigation technique based on crop growth stages and synchronized with traditional water irrigation in Bali (Subak). Chemical to control pest and diseases was based on economic threshold unless there were endemic attacks.
Table 1. Type and source of rice varieties, and planted area in Tajen Penebel Tabanan Bali, 2017.

| No | Variety   | Area (acre) | Institution                                      |
|----|-----------|-------------|--------------------------------------------------|
| 1  | Hipa 18   | 40          | ICRR licensed to Petrokimia Gresik               |
| 2  | Mapan P05 | 43          | Primasid Andalan Utama                           |
| 3  | SL 8.8S   | 20          | Syang Hyang Seri                                 |
| 4  | Sembada 188 | 37     | Biogene Plantation                               |
| 5  | Rejo      | 40          | Agri Makmur Pertiwi                              |
| 6  | Brang Biji | 40          | Padi Hibrida Nusantara                           |
| 7  | Intani-602 | 3          | BISI                                             |

2.2. Farmers preference of hybrid rice varieties
The preference test was conducted on the field, each panelist was positioned separately. A Hundred Balinese farmers from Subak Tajen were involved as a trained panelist. The panelists were allowed into the testing area in a smaller group (10-20 panelists) and had unlimited time to complete the test. They were asked to evaluate each hybrid rice variety based on its plant height, number of productive tillers, panicle performance, performance acceptability (PAcp), and overall performance of grain and plant.

2.3. Study of Small Farmers, Large Field scheme
The study of the was involved 100 farmers from irrigation society (Subak) Tajen in Penebel Sub-district, Tabanan District. They have planted 7 hybrid rice varieties in a total 50-hectare area. The technology applied was Jarwo Super which consists of several components including: cropping systems Jajar Legowo 2:1 and 4:1 ratio, hybrid rice varieties, decomposers, biological fertilizer as seed treatment and balanced fertilization based on Paddy Soil Test Kits (PUTS), monitoring of pest and disease using both biological and chemical application. There was used agricultural machinery and equipment, especially for planting (transplanters) and harvesting (combine harvester). Transfers information to the farmers were conducted by inviting 50 participants consisting of farmers, extension workers, and other stakeholders to field visit and got knowledge from the scientist and breeder from ICRR.

3. Result and Discussion

3.1. The location of demonstrasi area and culture of the farmers
Desa Tajen, which is the location of the Small Farmers, Large Field scheme, is located in Penebel sub-district, Tabanan district (picture 1). The population in 2016 was 2,921 and the population density was 744 persons / km². The area of the village is 300 ha used for SFLF is 50 ha. The majority of the people in Tajen Village work as farmers, both growers or smallholders. Subak Tajen (traditional agriculture association) is divided into 3 group farmers i.e. Dauh Yeh (1710 acre rice field), Lantang (2771 acre), and Ancut (1815 acre). The range ownership of rice fields is 6-90 acres from 340 farmers.

Balinese agriculture is a combination of science and art. The science, accumulated from hundreds of years of practical experience, the art from the attention to detail, and the value which the Balinese farmer places on the beauty of his fields. The organization community in Bali consisted of The subak (the irrigation society) and the banjar (the village). common features, e.g. leaders are elected from amongst the membership, the roles of these social institutions, vis-à-vis agriculture, are very different. The major role of the subak is to ensure an adequate and equitable supply of water for each farmer's rice crop; the role of the banjar is to provide labor for the cultivation of the rice crop. The rice farmers are members of both institutions, whilst hired labor and harvesting teams are members of the banjar only.
3.2. Farmers preference for performance of hybrid rice varieties

The farmers were asked to state the important traits of rice which have a bearing on the adoption of rice variety by the farmers. Several traits identified and were categorized in the nursery stage and plant growth stage, grain and eating quality. The traits having high significance for the adoption potential of rice variety were the crop duration, profitability, organoleptic traits. The traits having the least importance were disease vulnerability, threshing and germination vigor at the nursery stage.

The preference of the farmers to plant height and number of productive tillers (Table 2) showed that Rejo were most preferred by farmers. Other varieties that also got a higher percentage of liking were Mapan P05 and Sembada 188. Most farmers disliked of performance Brang Biji compared than hybrid rice varieties tested. The farmers like plants that have medium height. Plants that are too high are very vulnerable to lodging. The number of productive tillers is an important trait and related to grain yield. The farmers also like a hybrid rice varieties Rejo, Mapan P05, and Sembada 188 based on their quality of panicle and phenotypic acceptability. But most of the farmers dislike Hipa 18 and Brang Biji based on the above traits. It’s the challenge for ICRR to improve their hybrid rice variety especially its performance in the field to compete with hybrids from the private sector.

| No. | Hybrid rice varieties | Plant Height | Number of productive tillers |
|-----|-----------------------|--------------|-------------------------------|
|     |                       | Like         | Moderate | Dislike | Like | Moderate | Dislike |
| 1   | Mapan 05              | 52.5         | 47.5     | 0.0     | 45.8 | 54.2     | 0.0     |
| 2   | Hipa 18               | 22.0         | 54.2     | 23.7    | 20.3 | 66.1     | 13.6    |
| 3   | Rejo                  | 72.9         | 27.1     | 0.0     | 62.7 | 37.3     | 0.0     |
| 4   | SL-8                  | 27.1         | 69.5     | 3.4     | 13.6 | 69.5     | 17.0    |
| 5   | Intani-605            | 15.3         | 69.5     | 13.6    | 27.1 | 61.0     | 11.9    |
| 6   | Brang Biji            | 11.9         | 55.9     | 32.2    | 11.9 | 59.3     | 28.8    |
| 7   | Sembada 188           | 62.7         | 37.3     | 0.0     | 54.2 | 45.8     | 0.0     |
Tabel 3. Preference of farmers to panicle quality and PAcp of hybrid rice varieties.

| No. | Hybrid rice varieties | Panicle quality (%) | Phenotypic Acceptability (PAcp) (%) |
|-----|-----------------------|---------------------|-------------------------------------|
|     |                       | Like | Moderate | Dislike | Like | Moderate | Dislike |
| 1   | Mapan 05              | 49.2 | 50.9 | 0.0      | 35.6 | 64.4 | 0.0       |
| 2   | Hipa 18               | 6.8  | 52.5 | 40.7     | 8.5  | 59.3 | 32.2      |
| 3   | Rejo                  | 61.0 | 39.0 | 0.0      | 54.2 | 45.8 | 0.0       |
| 4   | SL-8                  | 18.6 | 62.7 | 18.6     | 15.3 | 74.6 | 10.2      |
| 5   | Intani-605            | 10.2 | 55.9 | 33.9     | 11.9 | 66.1 | 22.0      |
| 6   | Brang Biji            | 3.4  | 25.4 | 71.2     | 5.1  | 59.3 | 35.6      |
| 7   | Sembada 188           | 57.6 | 40.7 | 1.7      | 52.5 | 47.5 | 0.0       |

The relative yield performances of the hybrid rice varieties are presented in Table 4. Overall, rice hybrid performed excellently with an average yield of 10.50 ton ha\(^{-1}\). However, Sembada 188 a hybrid rice variety from Biogene Plantation showed highest grain yield than others (13.5 ton ha\(^{-1}\)), whereas Hipa 18 from ICRR showed lowest grain yield (7.5 ton ha\(^{-1}\)). The result of grain yield the same as the level preference farmers for the overall performance of the plant. Most of the farmers (50.9%) were prefer Sembada 188 as their favorite varieties (Table 4).

Tabel 4. Preference of farmers to overall hybrid rice varieties and its grain yield.

| No. | Hybrid rice varieties | Overall plant (%) | Grain yield (t ha\(^{-1}\)) |
|-----|-----------------------|-------------------|----------------------------|
|     |                       | Like | Moderate | Dislike |     |                       | Like | Moderate | Dislike |     |
| 1   | HIPA 18               | 5.08 | 49.15    | 45.76   | 7.5 |                       | 5.08 | 49.15    | 45.76   | 7.5 |
| 2   | SL 8 SHS              | 15.3 | 67.8     | 16.95   | 8.7 |                       | 15.3 | 67.8     | 16.95   | 8.7 |
| 3   | MAPAN P.05            | 35.6 | 62.71    | 1.69    | 12.4|                       | 35.6 | 62.71    | 1.69    | 12.4|
| 4   | Sembada 188           | 50.9 | 47.46    | 1.69    | 13.5|                       | 50.9 | 47.46    | 1.69    | 13.5|
| 5   | Rejo                  | 49.2 | 49.15    | 1.69    | 12.1|                       | 49.2 | 49.15    | 1.69    | 12.1|
| 6   | BRANG BIJI            | 3.39 | 54.24    | 42.37   | 8.2 |                       | 3.39 | 54.24    | 42.37   | 8.2 |
| 7   | Intani-602            | 6.78 | 72.88    | 20.34   | 11.0|                       | 6.78 | 72.88    | 20.34   | 11.0|

[11] reported that most farmers prefer Sembada, Hipa 18, Mapan P 05, Intani 602 based on its cooked rice had moist and tender texture while Hipa 19 cooked rice had a dry and hard texture. Grain physical and milling quality determined farmers’ preference. [12] also had shown in their study that technology-specific variables (e.g. yield potential and acceptability) are significant for explaining adoption behavior, implying that it is important to take farmers’ preferences to varietal characteristics into consideration in the design of a research and development program.

3.3. The studi of Small Farmers, Large Field scheme

The development of hybrid rice, public-private partnership is very important to improve the adoption level in the farmers. The government should be facilitating public-private partnership for sustainable hybrid rice growth and development. The activities i.e. encouraging farmers to join the field production experiment, organize farmers participation in the hybrid rice production model, establish high-yield cultivation model, organize a field visit and product evaluation for the farmers, develop training on seed production technique, cultivation techniques, and new varieties selection transfer for farmers.

The Small Farmers, Large Field scheme in Bali was a program that supported by various institution i.e. government (IAARD-ICFORD, ICRR, Bali’s AIAT, local government), a private company, and international organization (IRRI). ICRR as coordinator this program was sharing the qualified seeds, technology for agriculture, and high-tech harvesting tools. That variety has been planted in Subak Tajen. Tajen headman, Gusti Putu Sumerta Yasa reported rice harvest previously only reaches to the
6-7 ton, but after planting a hybrid seed it increases to 9-10 ton of rice with planting seven seeds of hybrid as a model. It is certainly supporting because the income of the farmer is increasing. Besides that, farmer no longer burning straw, as usual, they make fertilizer with that straw and it is certainly useful for rice field. The comparison of income between using non-hybrid seed and hybrid seed is about Rp. 10 million per hectare, and of course it is a good opportunity for attracting society back to being farmer.

The SFLF schema on 50 ha of farmers' land has shown that Balinese farmers who have a characteristic of small land, when joined by farmer groups through joint management with one type of variety, the same cultivation system, integrated pest control in groups is very influential besides increasing togetherness and cooperation between farmers also increases their income. This approach is expected to be carried out in other regions, especially for the development of hybrid rice which has been considered slow in terms of development.

4. Conclusion

The SFLF schema outputs are generally comply most of the technology components and standard operational procedure (SOP) in the implementation of Best Management Practices (BMP) in large scale mechanized rice farming. Early warning system must be continuously exercised to avoid pest and diseases outbreak. Brown plant hopper and rat are two main pests that must be closely monitor and immediately controlled. In average, potential yield of Sembada 188 hybrid rice variety is highest compared with other hybrid rice varieties or about 13.5 ton/ha average.

The SFLF schema on 50 ha of farmers' land has shown that Balinese farmers who have a characteristic of small land, when joined by farmer groups through joint management with one type of variety, the same cultivation system, integrated pest control in groups is very influential besides increasing togetherness and cooperation between farmers also increases their income. This approach is expected to be carried out in other regions, especially for the development of hybrid rice which has been considered slow in terms of development.

5. References

[1] Satoto, Rumanti I A, and Widyastuti Y 2016a Yield stability of new hybrid rice across locations Agrivita Journal of Agricultural Science 38(1):33-39.
[2] Widyastuti Y, Satoto, and Rumanti I A 2015 Performance of promising hybrid rice in two different elevations of irrigated lowland in Indonesia Agrivita Journal of Agricultural Science 37(2):169-177.
[3] Kartina N, Wibowo B P, Widyastuti Y, Rumanti I A, and Satoto 2016 Korelasi dan sidik lintas karakter agronomi padi hibrida Jurnal Ilmu Pertanian Indonesia (Bahasa) 21(2):76-83.
[4] Ruskandar A 2010 Persepsi petani dan identifikasi faktor penentu pengembangan dan adopsi varietas padi hibrida Iptek Tanaman Pangan (Bahasas) 5(2):113-125.
[5] Sumarno, Wargiono J, Kartasasmita U G, Ismail I G, and Soejitno J 2008. Pemahaman dan kesiapan petani mengadopsi padi hibrida Iptek Tanaman Pangan (Bahasa) 3(2):167-183.
[6] Firohmatillah A R, Nurmalina R 2012 Pengembangan padi varietas unggul hibrida: pendekatan metode quality function development dan sensitivity price analysis. Jurnal Ekonomi Pembangunan (Bahasa) 13(1):29-45.
[7] Satoto, Widyastuti Y, Kartina N, and Wibowo B P 2016b Analisis adopsi pengembangan padi hibrida di Indonesia Iptek Tanaman Pangan (Bahasas) 12(1):1-8.
[8] Mottaleb K A, Mohanti S, and Nelson A 2014 Factors influencing hybrid rice adoption: a Bangladesh case Australian Journal of Agricultural and Resource Economics 59:258-274.
[9] Directorate General of Crops 2019 Petunjuk Pelaksanaan Kegiatan Perbenihan Tanaman Pangan Ministry of Agriculture.
[10] Rosellon E 2015 “Small farmers, large field” scheme gaining success in Vietnam http://news.irri.org/2015/05/small-farmers-large-field-scheme.html. Friday, May 15, 2015.
[11] Ardhiyanti S D, Aurum F S, Handoko D, Liyanan, Widyastuti Y, and Satoto 2018 Farmers' preferences for grain quality of hybrid rice: A study case in Bali Preprint.
[12] Ghimire R, Wen-Chi Huang, and Shrestha R B 2015 Factors Affecting Adoption of Improved Rice Varieties among Rural Farm Households in Central Nepal *Rice Science* 22(1):35-43.