Agronomy Performance and Increasing of Rice Income by Integrated Crops Management (ICM) Assistance to Support Sustainable Agriculture in Bali Province

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Abstract. Research aimed to understand the agronomy performance, rice productivity, financial feasibility and increasing of farmer’s income through program of Integrated Crops Management (ICM) assistance. Research was conducted at Tabanan Regency in 2016. Research utilized Inpari 40, Inpari 30, Inpari 16, Inpari 20, Inpari 24, Inpari 28 and Ciheran g as superior rice varieties and involved 38 of farmers respondent in participating. Data of agronomy component was observed and analyzed by ANOVA. Economic feasibility of rice field farming was analyzed by using the analysis of income and R/C Ratio. Result showed that the agronomy performance of superior rice varieties cultivated with ICM technology were tend to equal to each other. Utilization of superior rice varieties with ICM technology implementation can increase rice productivity up to 1.80 ton/ha compared to farmer’s habits mainly the habit of Ciherang uses. Generally, rice field farming by ICM applications has financial feasibility supported by increasing of income average was IDR 5.640.831/ha and R/C ratio became 2.43. Implementation of ICM technology able to increase rice productivity and farmer’s income to support sustainable agriculture in Bali Province. ICM technology requires to disseminate to the farmers through assistance programs by government related that can be adopted well by farmers.

1. Introduction
Rice is the most important commodity in the world and also plays role as a major food staple for the most population in Indonesia, more than 90%, representing the largest nutritional caloric intake besides corn, cassava, soybean and sweet potato are important supplementary foods [1]. Rice also holds an important role as source of income for the most rural population in Indonesia. Effort to enhance rice productivity is required following the increasing of Indonesia’s population up to 1.3 % per year with 139 kg/head/year of rice consumption [2]. Rice consumption by Bali’s citizen reach up to 116 kg/capita/year, particularly it can reach up to 130 kg/capita/year for Tabanan Regency. Particular attention is paid to Bali Province due to the utilization of agricultural commodities such as rice, vegetables, fruits and others for religious ceremonies in Balinese society [3]. And also, Bali Province having a unique culture that ensures adequate irrigation for rice cultivation namely Subak [4-5]. In Bali, the amount of land available for rice production is less than that in other regions. The increasing of land use changes in Bali Province caused agricultural land became reduced in every year [6]. The expansion of the agricultural land is not easy to do because of geographical conditions that are less supportive, uncertain climate conditions that affect the productivity of land, land conversion, and others. Rice productivity is influenced by many factors such as land quality and availability of superior rice varieties. Agricultural land and plant varieties are production factor should be managed well to improve sustainable productivity. Impact of climate change on rainfall pattern affects agriculture production particularly rice and horticulture commodity. In additional, poor level of knowledge and low level of agriculture technology adoption can reduce the rice production run by the farmer.
Many efforts have been done by the government to solve the issues of rice fulfillments requirement even rice import has been undertaken. To ensure food security in Indonesia, the government always put a lot of effort to enhance rice productivity such as introduction of agriculture modern technology such as Integrated Crop Management and utilization of superior rice varieties with high productivity. Integrated Crop Management (ICM) is a farming method that balances the requirements of running a profitable business with environmentally sustainable responsibility includes waste management practices, enhance energy efficiency and minimize pollution. The ICM technology linked to best management practices such as integrated pest management includes soil fertility, the timing of planting and harvesting, varieties selection, tillage, crop rotations and other crop production factors [7]. All crop production management decisions were created by considering the balance of labor availability, soil, machinery resources and environmental concern. ICM combines the traditional farming methods with appropriate modern technology also good environmental management [8-10]. The ICM implementation is emphasizing on farmer active participation to choose and evaluate appropriate technology for their biophysical environment, social-cultural, and economic aspect. The implementation of ICM is not only solely purposed to maximizing yields but also environmentally sustainable while increasing production efficiency and profitability [11].

The assessment of Integrated Crop Management implementation in many regions mainly at the center of rice production represented that ICM technology capable to enhance rice productivity up to 30-50% [12]. Nevertheless, the information on ICM technology is has not disseminated widely to small farmers mainly in Bali Province. Based on that, The Bali Assessment Institute for Agriculture Technology built cooperation with the government related to introduce the ICM technology for rice cultivation in Bali through the program of Integrated Crops Management (ICM) assistance. This study was conducted to understand the agronomic performance, financial feasibility and increasing of farmer’s income through program of Integrated Crops Management (ICM) assistance in order to enhance rice production in Bali Province.

2. Materials and Methods
Research was conducted in Tabanan Regency mainly at Subak Saih and Subak Jaka, Kukuh Village, Marga District, Tabanan Regency by using 2 ha of land in Subak Saih and 3 ha in Subak Jaka. Subak Jaka was chosen as location for exhibition of superior rice varieties cultivation.

Rice crops were cultivated by implementation of The Integrated Crop Management (ICM) technology. ICM technology components applicated in this research consists of a) utilization of superior rice varieties officially certified namely Inpari 14, Inpari 16, Inpari 20, Inpari 24, Inpari 28 and Ciherang cultivated in Subak Saih, b) <20 of seedling age, c) number of seed per hole was 2-3 seed, d) implemented jajar legowo 2:1 cropping system (25 cm x 12.5 cm x 50 cm), e) balanced fertilization by application N, P, K and organic fertilizer (cow manure), f) intermittent irrigation, g) pest, plant disease and weeds were controlled by using The Integrated Pest Management (IPM) principal. NPK fertilizer was applied at 5-7 Days After Planting (DAP) with 200kg/ha dosage. Nitrogen fertilizer with dosage of 110 kg/ha was given at 3 and 7 Weeks After Planting (WAP) followed by 50 kg/ha of KCl fertilizer. Biosilica (organic) fertilizer was applicated to rice crops at 20-25 days after planting (DAP) and 40-45 DAP by adding 100 liters of water into 1 liter of biosilica fertilizer then it was sprayed to rice crops in the morning and evening, following by addition the cow manure fertilizer. This research was built by using Randomized Block Design and replicated 3 times. The treatments were utilization of superior rice varieties cultivated with the ICM technology application.

Agronomic data observed were growth performance and yield parameters namely plant height, number of productive tillers, panicle length, number of filled grain, 1000 grain weight, empty grain and yield. Data were analyzed by using variance analysis (ANOVA) and advance test by using Duncan Multiple Range Test at 5% significance level (5% DMRT) if P value >0.005. Selection of plant samples were done according to Figure 1 and with ignorant the border plant.
The success of ICM implementation assistance was determined based on enhancing indicator of production and income by farmers. Increasing of production was done by counting the difference of production after ICM implementation assistance reduced with production before ICM implementation assistance, following one of this equation:

$$\Delta Y = Y_1 - Y_0$$

$$\Delta Y(\%) = \left[ \frac{Y_1}{Y_0} - 1 \right] \times 100\%$$

$$\Delta Y(%) = \frac{\Delta Y}{Y_0} \times 100\%$$

Note:
Y0: production before ICM implementation assistance
Y1: production after ICM implementation assistance
Y: production total

The average of input-output farming system analysis was obtained from direct interview with farmers correspondent related (38 farmers) representing before and after ICM implementation assistance. Then, data were analyzed by using analysis of income, financial feasible analysis and R/C ratio. Income of rice farming system was calculated by following this equation:

$$TI = Y \times Py - \sum X_i \times P_i$$

Note:
TI: income of rice farming system (IDR)
Y: rice production (kg)
Py: rice price (IDR/kg)
Xi: use of the i\(^{th}\) factor
Pi: price of the i\(^{th}\) factor

Then, revenue cost (R/C) ratio was analyzed by following this equation:

$$\text{Revenue cost ratio} = \frac{\text{Income total (IDR)}}{\text{Total of production cost (IDR)}}$$
If R/C ratio > 1, it can be said that farming system related is feasible to be developed and if R/C ratio < 1, it is not benefited to be developed. Then, if R/C ratio = 1, farming system related is on break event point.

3. Results and Discussion
Agronomic performance of superior rice varieties used in this study could be seen in Table 1. The highest plant height was found in Inpari 28 (118.20 cm) and was higher than superior rice varieties description by Reference [13] namely ±97 cm. All of superior rice varieties cultivated in Subak Saih (Table 1) capable of growth well according to their plant height were 90-110 cm, the number of productive tillers was 10-20/panicle, the number of filled grains were 150-300/panicle, the upright leaves following by dark green color [14-16]. The difference of superior rice varieties were not affect significantly to the number of productive tillers (Table 1). Factors influencing tillering in rice was divided into three major groups namely multiple genes contained, environmental factors and biotic factor which functionally contributed to hormonal, genetic control, growth and developmental [15-18].

The panicle length could be used as indicator to represent the probability of grains amount produced. Equal to previous parameter, the panicle length of all varieties were same. Inpari 20 produced the panicle with the length was 25.10 cm and suitable with the statement by Reference [19] was 25.33 cm. All of panicle length observed in this study could be categorized as medium namely 20-30 cm [20].

Table 1 showed that the number of filled grains produced by all superior rice varieties used were not significantly different to each other. In contrast, the significantly effect could be found on the number of empty grains namely Inpari 16 to others. Inpari 16 produced the highest of empty grains than others, in the same line with the lowest of filled grains amount. Number of filled grains formed in panicle highly relied on plant photosynthesis during growing period and gene character of varieties cultivated [21]. Empty grains could be occurred because of the ripening of seeds not simultaneously due to seeds come out separately therefore there were seeds not filled completely when it harvested and then it became empty grain.

The 1000 grains weight and yield by all superior rice varieties were tend to equal to each other. The yield by Inpari 20 was higher than result by Reference [19] was 5.11 ton/ha. In contrast, it was lower than description by Reference [22].

Table 1. Agronomic performance of superior rice varieties cultivated in Subak Saih

| Variety  | Plant height (cm) | Number of productive tillers | Panicle length (cm) | Number of filled grains | Number of empty grains | 1000 grains weight (gram) | Productivity (ton/ha) |
|----------|------------------|------------------------------|---------------------|------------------------|------------------------|--------------------------|----------------------|
| Inpari 14 | 101.40 a         | 20.40 a                      | 24.20 a             | 146.60 a               | 12.30 b                | 23.68 a                  | 7.22 a               |
| Inpari 16 | 109.60 bc        | 18.40 a                      | 24.00 a             | 115.10 a               | 35.50 a                | 25.04 a                  | 7.11 a               |
| Inpari 20 | 100.80 a         | 20.60 a                      | 25.10 a             | 116.00 a               | 14.80 b                | 25.18 a                  | 7.50 a               |
| Inpari 24 | 111.00 c         | 19.60 a                      | 24.30 a             | 122.80 a               | 13.20 b                | 24.17 a                  | 6.20 a               |
| Inpari 28 | 118.20 d         | 14.40 a                      | 25.10 a             | 119.40 a               | 13.20 b                | 25.60 a                  | 6.86 a               |
| Ciberang  | 103.80 ab        | 21.20 a                      | 22.90 a             | 125.50 a               | 14.80 b                | 23.90 a                  | 6.53 a               |

Noted: Numbers followed by the same letters in same coloumn were not significantly different at DMRT 5%.

The superior rice varieties cultivated in Subak Jaka namely Inpari 16, Inpari 30 and Ciberang were affected significantly only to plant height and number of empty grains (Table 2). Plant height of Inpari 30 was highest than Ciberang and Inpari 16. The difference of plant height could be caused by genetic factor of varieties and environment [15, 23]. Reference [24] stated that plant height could be categorized as growth variable however it cannot determine the productivity. Nevertheless, Reference [25] stated
that the plant height was positive correlate to the yield mainly in Inpari 7, Inpari 14 and Inpari 15. Plant height variable could not be used as indicator in terms of yield potential rice due to environmental factor effect was various in every location. The plant with more than 110 cm height was more susceptible to lodging therefore it able to reduce the yield [26]. Ciherang varieties tend to stable minimize the empty grains production cultivated both in Subak Saih (Table 1) and Subak Jaka (Table 2). Contrastly. Inpari 16 produced the highest empty grains than others (Table 2), equal to Table 1.

**Table 2.** Agronomic performance of superior rice varieties cultivated in Subak Jaka.

| Variety   | Plant height (cm) | Number of productive tillers | Number of filled grains | Number of empty grains | 1000 weight grains (gram) | Productivity (ton/ha) |
|-----------|-------------------|-------------------------------|-------------------------|------------------------|---------------------------|-----------------------|
| Inpari 30 | 106.33 a          | 13.53 a                       | 123.67 a                | 17.13 b                | 26.97 a                   | 7.88 a                |
| Inpari 16 | 117.80 b          | 15.53 a                       | 133.20 a                | 15.63 b                | 26.97 a                   | 7.17 a                |
| Ciherang  | 107.47 a          | 13.40 a                       | 126.20 a                | 12.13 a                | 24.57 a                   | 6.65 a                |

Noted: Numbers followed by the same letters in same column were not significantly different at DMRT 5%.

Table 3 and 4 showed the increasing of each superior rice variety productivity with ICM technology implementation compared to the use of Ciherang during before the implementation of ICM technology (farmer’s way). Ciherang varieties mentioned was cultivated following the farmer’s way then it was used as comparison before implementation of ICM technology. The highest rice productivity changes (32.31%) in Subak Saih occurred when ciherang was replaced with cultivation of Inpari 20 following ICM technology principal namely from 6.50 ton/ha to 8.6 ton/ha (Table 3). In Subak Jaka, substitution of Ciherang to Inpari 16 caused the rice productivity was increasing up to 39.08% from 6.5 ton/ha to 9.04 ton/ha with ICM technology application. followed by Inpari 30 (26.62%) and Ciherang (17.23%) cultivated in Subak Jaka (Table 4). For Ciherang itself, the implementation of ICM can enhance rice productivity was 15.23% from 6.50 ton/ha to 7.49 ton/ha cultivated in Subak Saih (Table 3) and 17.23% in Subak Jaka (Table 4).

**Table 3.** The increasing of rice productivity by ICM technology application in Subak Saih.

| Variety   | Rice productivity by ICM technology application (ton/ha) | Increasing value (ton/ha) | Percentage (%) |
|-----------|----------------------------------------------------------|---------------------------|----------------|
|           | After | Before (Ciherang) |                               |                |
| Inpari 14 | 8.28  | 6.50             | 1.78                         | 27.38          |
| Inpari 16 | 7.64  | 6.50             | 1.14                         | 17.54          |
| Inpari 20 | 8.6   | 6.50             | 2.1                          | 32.31          |
| Inpari 24 | 7.11  | 6.50             | 0.61                         | 9.38           |
| Inpari 28 | 7.87  | 6.50             | 1.37                         | 21.08          |
| Ciherang  | 7.49  | 6.50             | 0.99                         | 15.23          |
| Average   | 7.83  | 6.50             | 1.33                         | 20.49          |

The Integrated Crop Management (ICM) technology consists of good agronomic practices namely a) selection of superior varieties with high quality. b) good water and nutrition management. c) integrated pest management and d) good harvest and postharvest management. The utilization of superior rice varieties is one of ICM technology components which able to increase productivity significantly [27]. Besides high productivity, the growth of superior rice varieties tends to equal therefore it can be harvested simultaneously with better quality [28]. The role of superior rice varieties
in enhancing rice productivity could reach up to 75% when integrated with irrigation technology and fertilization [29]. The ICM technology does not only involve technology but also farmers' mindsets and habits, therefore even though ICM technology has been proven to be able to increase productivity, it does not always increase productivity if it is not supported by farmer adoption ability. Because of that, ICM technology require to disseminate to the farmers through assistance programs by government related in order to can be adopted well by farmers.

Table 4. The increasing of rice productivity by ICM technology application in Subak Jaka.

| Variety  | Rice productivity by ICM technology application (ton/ha) | Increasing value (ton/ha) | Percentage (%) |
|----------|--------------------------------------------------------|---------------------------|----------------|
|          | After                                                  | Before (Ciherang)          |                |
| Inpari 16| 9.04                                                   | 6.50                      | 2.54           | 39.08          |
| Inpari 30| 8.23                                                   | 6.50                      | 1.73           | 26.62          |
| Ciherang | 7.62                                                   | 6.50                      | 1.12           | 17.23          |
| Average  | 8.30                                                   | 6.50                      | 1.80           | 27.64          |

The farmer’s income rate can be determined by calculating the income obtained from rice farming system and the cost total required for running rice farming system in once plant season (Table 5). The production cost total increase of 12.79% in same line with the increase of income obtained was 51.19% or IDR 5.640.831 per hectare due to the ICM implementation technology (Table 5). The increasing of production cost total can be found in fertilizer utilization used namely organic fertilizer and labor utilization. Jajar legowo planting system require more cost due to the increasing of plant number cultivated. Contrastly, the reducing of production cost total can be occurred because of the number of seed planted is 1-3 seeds per hole and also the reducing of the cost for chemical pesticide. Additionally, R/C ratio also increase 0.36% namely from 2.06 to 2.43 therefore it can be concluded that ICM technology implementation for rice cultivation was feasible to be adopted by farmers in the future.

Table 5. The changes of income and production cost total because of the ICM technology implementation

| Code | Component            | Price (IDR)    | Changes         | Percentage (%) |
|------|----------------------|----------------|-----------------|----------------|
|      |                      | Before         | After           |                |
| A    | Production requirements |                |                 |                |
|      | Seed                 | 265.093        | 250.000         | 15.093         | -5.69          |
|      | Fertilizer           | 1.481.101      | 2.242.500       | 761.399        | 51.41          |
|      | Chemical pesticide   | 992.475        | 856.660         | 135.815        | -13.68         |
|      | Labor                | 7.121.234      | 7.835.960       | 714.726        | 10.04          |
|      | Other cost           | 504.423        | 504.423         | 0              | 0.00           |
|      | Cost total           | 10.364.326     | 11.689.543      | 1.325.217      | 12.79          |
| B    | Income               | 21.384.615     | 28.350.664      | 6.966.049      | 32.58          |
| C    | Benefit value        | 11.020.289     | 16.661.120      | 5.640.831      | 51.19          |
| D    | R/C Ratio            | 2.06           | 2.43            | 0.36           | 17.55          |

4. Conclusion
The agronomic performance of superior rice varieties cultivated with ICM technology in this study were tend to equal to each other. Utilization of superior rice varieties with ICM technology implementation
can enhance the rice productivity compared to farmer’s habits mainly the habit of Ciherang uses. The increasing of income obtained was 51.19% or IDR 5,640,831 per hectare following by the increasing of R/C ratio up to 0.36% namely from 2.06 to 2.43 therefore it can be concluded that ICM technology implementation for rice cultivation was feasible to be adopted by farmers in the future. ICM technology require to disseminate to the farmers through assistance program by government related in order to can be adopted well by farmers.

5. Authors Contribution Statement
All authors contributed equally as the main contributor of this paper. Sagung Ayu Nyoman Aryawati and Anak Agung Bagus Ngurah Kamandalu contribute to observation and collection the data in field. Ida Bagus Kade Suastika contribute to conceptualization, methodology and validation the research outputs. Anella Retna Kumala Sari contribute to data analysis, writing draft manuscript (original, review and editing) and visualization data presentation.

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