The agronomic performance and feasibility study of new high yield rice varieties in Tegal district

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Abstract. Variety is one of innovations that could contribute to the increase of rice production. The objectives of this study were to compare the agronomic performance of rice varieties and its feasibility of new high yield varieties namely Inpari 30, Inpari 32 and Inpari 33) with the existing variety (Mekongga). Research was conducted in Banjaranyar Village, Balapulang Subdistrict, Tegal Regency. The agronomic performance observed were the height of plants, number of productive tillers, length of panicles, number of grain/panicles, and yield or milled dry grain production. Meanwhile the feasibility study was calculated in term of Revenue Cost Ratio (R/C) analysis. Result showed the significant different in observed performance among varieties. The productivity of Inpari 30, Inpari 32 and Inpari 33 were 5.45, 5.97, and 5.89 tons/ha of milled dry grain (GKG) respectively. All new high yield varieties showed better production performance compared to Mekongga (4.96 ton/ha GKG). The feasibility study showed R/C value of Inpari 30, Inpari 32, Inpari 33 and Mekongga were 1.28, 1.41, 1.39 and 1.14, respectively. Among these varieties, Inpari 32 has the highest feasibility study value.

1. Introduction
Food crops, especially paddy/rice, are strategic commodities. Demand for food crops continues to increase along with the increasing population in Indonesia. In 2020, the demand of rice is 25.9 million tonnes with population of 261.6 million people, and rice consumption is 99.1 kg/capita/year [1, 2]. The national rice production in 2017 was 56.97 million tons, while in 2018 it was 56.53 million tons or decreased by 0.78% [3]. The decrease of rice production is predicted to be continued in the following years since there are many complex farming problems which need to be overcomed by the farmer. Those farming problems are the decreasing of farm land area, decreasing quality of paddy fields, climate changes, and low application of agricultural technology innovations [4–6].

Efforts to increase rice production have been done either through increasing the area of rice fields (extensification) or increasing the application of agricultural technology innovation (intensification). Rice productivity could be increased by applying agricultural technology innovation such as the utilization of new high yielding quality seeds, improving technical culture including site-specific fertilization and controlling Plant Pest Organisms (OPT) [7]. The increase of productivity can be done through the utilization of new high yielding and high-quality varieties such as hybrid rice seeds [8].

Contribution of new high yielding varieties to improve national productivity is around 56% [9, 10]. Additionally, new high yielding varieties are more resistant to biotic and abiotic stress, early maturity age, use low inputs, improve the quality of grain and rice and increase the competitiveness of
commodities, as well as guarantee the successful of plant cultivation [11–13]. Currently, farmers are searching variety which early mature and high yielding of rice resulted, thus they could increase the frequency of harvest and the cropping index [14].

The potential of new improved rice varieties would be optimal if the varieties were combined with other technologies to increase plant population and grain yields. The utilization of new high yielding varieties combined with “legowo” row planting model could increase the production of grain [15]. Earlier study Indonesian Agency of Agricultural Research and Development [16], shows the application of new improved seed varieties such as Inpari 30 Citherang Sub-1 combined with super “legowo” rows could produce 13.9 tons/ha, Inpari 32 Variety HDB 14.4 tons/ha and Inpari 33 12.4 tons/ha. Another research by Aryawati et al. [17] stated the utilization of new high yielding varieties and the integrated plant management (PTT) technology could increase production by 15-22%. Therefore, the objective of this study is to analyze the agronomic performance and financial feasibility of new high yielding varieties which compared to the existing one.

2. Methodology

The research was conducted in Banjaranyar Village, Balapulang Subdistrict, Tegal Regency in the second planting season of year 2017, using 10 hectares of paddy field owned by 9 farmers. This study was on Farm Adaptive Research Approach. The new improved rice varieties was Inpari 30, Inpari 32 and Inpari 33. Mekongga as an existing variety was selected as control for comparison. The components of cultivation technology applied were similar for all variety in this study, namely: (1) the utilization of biodecomposers to improve the organic material using M-Dec; (2) the utilization of biological fertilizer as seed treatment using Agrimeth; (3) fertilization is given based on the results of PUTS, namely organic fertilizer 2 tons/ha, urea 200 kg/ha and Phonska 300 kg/ha; (4) the application of bioprotector which scheduled as an effort to prevent plant pest organisms (OPT); and (5) the utilization of agricultural machinery for cultivation, planting and harvesting; and (6) 2:1 row system plantation named “legowo” with spacing (40 × 20 × 15 cm).

The research begin with an assessment of potential locations through coordination with the Office for Agriculture and Food in Tegal Regency and Balapulang Office for Agricultural Extension (BPP). The socialization of the research activities and implementation was carried out in the following stages: (1) preparing a nursery in the form of a bed (120 cm wide, 10 cm high and according to the size of the plot) as a means to grow seedlings; (2) preparing the soil until it is ready to plant. The soil preparation includes: land clearing from previous crop residues or weed remnants, the first plowing (soil reversal), 7-15 days of inundation, and the second plowing (ripping, silting and leveling); (3) cultivating the seed using 2:1 “legowo” row plantation system (40 × 20 × 15 cm) with 1 to 3 seeds per hole, and then muddying the field for 5-7 days; (4) preserving the plants through: irrigation, fertilization, weeding and plant pest organisms control; (5) harvesting the yield when the plants are physiologically riped or when 90% of the grain has turned to yellow [18].

The data collected were the data on agronomic performances such as: height, number of tillers, length of panicles, number of grains per panicle, and yield/production (milled dry grain/ha). Data on farming input – output was also collected for calculating the financial feasibility of farming. The agronomic performance data was analysed using the analysis of variance (ANOVA). If there are a significant effect, then the analysis will be proceed using least square methods (LSD) at 5% level. A correlation analysis was conducted afterwards to identify the relationships among the agronomic component variables [19]. Meanwhile, the input - output data of rice farming were analyzed using the formula according to the previous study Soekartawi et al. [20], as follows:

\[ \pi = TR - TC \]
\[ \pi = Ypy - \sum_{i=1}^{n} X_i Pxi - TFC \]
3. Results and discussion

3.1. Agronomic performances

Table 1 showed the results of the agronomic performances of rice varieties used in the current study. There were significant differences among varieties in the height of plants, number of productive tillers, length of panicles, number of grain/panicles, and yield or milled dry grain production (GKG).

| Varieties planted | The height of the plants (cm) | The number of tillers | The length of panicles | The number of grain/panicles | Production (tonnes/ha) |
|-------------------|-------------------------------|-----------------------|-----------------------|-------------------------------|-----------------------|
| Mekongga          | 94.7 \( ^{a} \)              | 12.4 \( ^{a} \)       | 19.7 \( ^{a} \)       | 102.9 \( ^{a} \)              | 4.96 \( ^{a} \)       |
| Inpari 30         | 98.7 \( ^{b} \)              | 12.1 \( ^{a} \)       | 21.1 \( ^{a} \)       | 103.0 \( ^{a} \)              | 5.45 \( ^{b} \)       |
| Inpari 32         | 102.7 \( ^{c} \)             | 17.1 \( ^{c} \)       | 22.5 \( ^{c} \)       | 119.9 \( ^{b} \)              | 5.97 \( ^{c} \)       |
| Inpari 33         | 93.3 \( ^{a} \)              | 15.3 \( ^{b} \)       | 21.9 \( ^{b} \)       | 115.9 \( ^{b} \)              | 5.89 \( ^{c} \)       |

Note: The numbers followed by the same letter in the same column are not significantly different based on the 5% significant level using least square methods

3.2. The number of productive tiller and plants’ height

Differences in the height of plants and the number of productive tillers in each variety were thought to be as the result of internal and external factors such as: genetic factors and growing environment (temperature, water conditions, light intensity and soil fertility). Inpari 32 had the highest number of productive tillers namely 17.1 stems while Inpari 30 had the lowest one, which was around 12.1 stems. Productive tillers will produce panicles on rice plants. The higher the number of productive tillers produced, the higher the grain production would be. The number of tillers is very much influenced by the number of seeds planted. If there are too many seeds planted, there will be a competition for nutrition and other growth factors among seeds [21]. The differences in the number of productive tillers produced between varieties in this study were caused by the differences in ability to adapt with the growing environment. Previous study Maintang et al. [22] stated that the new high yielding varieties usually
produced 20-25 tillers. The first tillers tended to produce a higher number of grain than the second tillers and substantially for the third, forth, and others. In this study, there were 11-22 tillers produced. Among those tillers produced, the last grown tillers produced could not be harvested because they were too late to ripen.

The 2 : 1 “jajar legowo” planting model could mainly be one of solution to optimize the number of productive tillers in a variety. The idea is supported by earlier study Arafah [23] that gave an illustration on how “jajar legowo” planting system could optimize the growing environment, light, water and nutrition for plants, and thus, it could increase the number of productive tillers.

The height of plants could be one of criteria that is considered by farmers before choosing a variety. Farmers are generally do not prefer high yielding varieties with high posture [24]. Apart from being easy to fall, plants with high posture could not guarantee that the productivity will also higher since the fallen plants could reduce grain yield. In this study, Inpari 32 was the variety with the highest plant height (102.70 cm) and Inpari 33 was the variety with the shortest plant at 93.34 cm. According to farmers who have already planted Inpari 32, the roots of Inpari 32 are easy to fall down, especially if the variety is planted in the rainy season. Aside from its higher posture compared to other varieties, the roots of Inpari 32 are also shallower. Plants with a relatively low height could avoid overcrowding caused by strong winds and prevent them for having a low production [25].

3.3. Length of panicles
The highest panicle length was produced by Inpari 32, 22.5 cm and the shortest was produced by Mekongga variety, 19.7 cm. The difference in panicle length performance is caused by genetic factors of each variety. In a very extreme conditions, such as super dense spacing, panicle length could be affected, and panicle length would significantly and positively correlate with grain weight per hill [26]. An increase in plant population will significantly increase the number of panicles per square meter (m²) with shorter panicle posture. The previous study Tian et al. [27] shows the density of the rice plant population has impact on the number of panicles per unit area and the number of grains per panicle, but this is not the case for grain filling and grain yield.

3.4. Production
In this study, the new high yielding varieties introduced were Inpari 30, Inpari 32 and Inpari 33. Those varieties could produce relatively higher grain yield than the existing variety (Mekongga with average yield was 4.96 tons/ha) with an average productivity level of 5.77 tons/ha. Among those varieties, Inpari 32 had highest production that is 5.97 tons/ha (Table 1). By using Inpari 32, farmers could increase the yield by 1.01 tons/ha of GKG, 0.93 tons/ha of GKG more by using Inpari 33 and 0.49 tons/ha of GKG more by using Inpari 30. The increasing production of the introduced varieties is supported by the previous study [28]. The application of new high yielding varieties together with other technologies could increase production by 21-54% of usual farmers’ yields. Additionally, Adijaya and Sudiarto [29] also found that the cultivation of Inpari varieties with 2 : 1 “legowo” row cropping system could increase the production up to 0.61 tons/ha compared to the production of ordinary farmers’ method of planting, and as the results, farmers could have higher profits.

Increased production of rice varieties is very much determined by many factors. Aside from genetic factors, the ability of plants to respond to technological inputs and adaptability to the growing environment could also be a determinant of increased production. New improved seed varieties are usually created or produced by the agronomists for different agroecosystems. Therefore, the new high yielding varieties are generally more adaptive to the growing environment, and this ability could affect the genetic potential of a variety, including the number of tillers, length of panicles, number of grains per panicle, and rice yields [14, 30]. Moreover, the new high yielding varieties for lowland ricefield with better adaptive ability to the local environment could produce optimum grain yields next to its potential yields [31].

The dense planting with the “legowo” row system was effective in increasing grain yields of hybrid rice varieties in the highlands and inbred rice varieties in the medium lands [32]. The average rice
production in the lowlands were 8.78 tons/ha GKG and in the highlands 8.09 tons/ha GKG. The interaction between altitude and planting method is a necessity for a variety, specifically to produce optimal numbers of tillers [32, 33].

3.5. **Financial feasibility of rice farming**

In this study, the input-output analysis was conducted to determine the difference between using the new improved varieties introduced and the existing varieties commonly grown by farmers from an economic perspective. All production costs incurred both for the new high yielding varieties and existing variety in the form of production costs, labor and other costs are calculated. The description of farm input - output could be seen in Table 2. According to Table 2, there are differences in costs and revenues between using new high yielding varieties and existing variety.

| Structure                  | Inpari 30   | Inpari 32   | Inpari 33   | Mekongga   |
|----------------------------|-------------|-------------|-------------|------------|
| Fixed Cost (IDR)           | 10,800,000  | 10,800,000  | 10,800,000  | 10,800,000 |
| Variable Cost (IDR)        | 12,135,000  | 12,135,000  | 12,135,000  | 12,135,000 |
| Production Inputs (IDR)    | 3,635,000   | 3,635,000   | 3,635,000   | 3,455,000  |
| Labor (IDR)                | 8,500,000   | 8,500,000   | 8,500,000   | 9,300,000  |
| Total Cost (IDR)           | 22,935,000  | 22,935,000  | 22,935,000  | 23,555,000 |
| Revenue (IDR)              | 31,795,200  | 32,270,400  | 29,435,400  | 26,800,200 |
| Production/Yield (Kg)      | 5,888       | 5,976       | 5,451       | 4,963      |
| Output Price (IDR/kg)      | 5,400       | 5,400       | 5,400       | 5,400      |
| Income (IDR)               | 8,860,200   | 9,335,400   | 6,500,400   | 3,245,200  |
| (Total Revenue - Total Cost) | 1.39       | 1.41       | 1.28       | 1.14      |
| COGS (IDR)                 | 3,895       | 3,838       | 4,207       | 4,746      |

Table 2 shows that by using farmers’ methods, farmers have to spend labor cost IDR 620,000,- higher but IDR 180,000,- lower for production inputs compared to the methods used in the application of introduced varieties. According to farmers, the higher labor cost in the farmers’ methods was because farmers were used to spray pesticide 2 times higher than that of the introduced varieties. The higher utilization of pesticide was an indication that Mekongga varieties commonly planted by farmers were more susceptible to plant-disturbing organisms than the introduced varieties.

The cost of production inputs for the introduced varieties is higher due to additional costs for seed treatment and buying hay rot biodecomposer. In general, farmers in Banjaranyar Village have to spend more than 50% of the total production costs for labor from land preparation to harvest. Therefore, farmers could increase their income, if they reduce the cost of labor. One of solution for reducing the labor cost is by using the agricultural mechanization. The utilization of agricultural mechanization could increase the efficiency of labor by 0.72 or from 1.28 before using agricultural mechanization to 1.99 after using the mechanization [34]. In the other words, the daily labor volume with mechanization was lower compared to that without mechanization.

Although Inpari 32 is easy to fall, but the production of Inpari 32 is still higher compared to the other rice varieties introduced. Therefore, the income obtained from using Inpari 32 variety is the highest compared to the other varieties which is around IDR 9,335,400/ha. Inpari 33 is the second higher or IDR 8,860,200/ha and Inpari 30 is the third with IDR 6,500,400/ha. As for the existing variety (Mekongga), it has the smallest income obtained which is IDR 3,245,200/ha. The higher income in the introduced varieties is due to an increase in the production compared to the use of existing varieties. According to RCR or the Revenue Cost Ratio, all rice varieties (either the introduced varieties or the existing variety) are financially feasible. However, among those varieties, Inpari 32 gives the highest value of RCR or
1.41 and Mekongga (existing variety) gives the lowest value of RCR or 1.14. Therefore, Inpari 32 is more financially feasible compared to the other varieties.

4. Conclusion and Recommendation

4.1. Conclusion
The utilization of new high yielding varieties of paddy could increase the productivity between 0.49 and 1.01 tonnes/ha GKG compared to that of the existing variety. The introduction of new varieties gives better efficiency in, 7.2% more, compared to that of the existing variety, thus it could increase the farmer income. All the varieties introduced were economically feasible.

4.2. Recommendation
a. Farmers have to consider the utilization of agricultural mechanization if farmers would like to increase their income and reduce the labor cost.
b. Inpari 32 could be used as an alternative choice to replace the varieties commonly planted by farmers, especially in Banjaranyar Village, and generally in Balapulang Subdistrict and Tegal District.
c. To anticipate the increasing demand of Inpari 32, it is recommended for the government, both the Ministry of Agriculture and the Regional Government, to train farmers in producing Inpari 32 seeds to maintain the availability of the seed stock at any time.

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