Responses of rice new superior varieties to the application of biofertilizers and plant system in Jayapura

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Abstract. Jajar Legowo (Jarwo) Super is an improved technological innovation used to increase the productivity of lowland rice varieties. Related to the introduction of the technology, it is necessary to conduct in-depth research on some components of Jarwo Super including new Superior varieties, application of Agrimeth biofertilizer and planting system on growth and yield. The research was aimed to investigate the response of the new Superior variety to biofertilizers and different planting systems. The study was conducted in Koya Barat, District Muara Tami, Jayapura, from June to September 2018. The treatments were arranged in a split-split plot design with three replications. The main plot was biofertilizers consist of Agrimeth and without Agrimeth. As subplot was planting methods Jarwo, consist of Jarwo 2:1 (25 cm x 12.5 cm x 50 cm) and Jarwo 4:1 (25 cm x 12.5 cm x 50 cm). As sub-sub plots were new superior variety (NSV): Inpari 33 and Inpari 43, respectively. The results showed that the combination of treatment of Agrimeth and without Agrimeth with planting system Jarwo 4:1 on Inpari 33 gave the higher grain yield compared to other treatments of 7.44 t/ha and 7.33 t/ha. The application of Agrimeth biofertilizers does not have a significant influence in increasing the yield of rice grain. Jarwo system 4:1 gives a dry grain yield of 6.30 t/ha which is higher 0.53 t/ha compared to Jarwo 2:1 (5.77 t/ha).

1. Introduction
Increasing the production of food crops, especially rice has become the government's priority in agricultural development considering its importance as a staple food for most of Indonesia's population. On the other hand, agricultural land has been decreasing yearly both in quantity and quality. In terms of quantity, agricultural land is reduced due to land conversion to residential, industrial and other areas. The conversion rate of paddy fields reaches 100 thousand hectares per year, while the government's ability in printing new paddy fields is limited in recent years with the ability of 40 thousand hectares per year [1]. Quality related to the reduction of the fertility of agricultural land. The excessive use of inorganic chemical fertilizers causes solidification of the soil structure and decreasing on carrying capacity of the soil for plant growth leads to the requirement on the using of biotechnology, such as biological fertilizers and pesticides that contain environmentally friendly microbes. Another factor that also affects the increase in rice production is the uncertain climate
phenomenon due to the influence of global warming resulting increases on the difficulty level of efforts to maximize production.

Extensification of the field might be a solution for increasing cultivated area. However, it is difficult for such a region like Papua. Therefore, innovation in agricultural practices is needed in order to escalate crop production. One of the innovations introduced by the Indonesia Agency for Agricultural Research and Development (IAARD) is Jajar Legowo (Jarwo). Super rice cultivation technology. *Jarwo* Super technology is a technology of rice cultivation based on *Jajar Legowo* planting system. The *Jarwo* system can produce optimal production, however, aspects of fertilization, superior varieties, pest control and integrated use of agricultural equipment and machinery will improve rice cultivation. So that the *Jarwo* Super technology is proposed to combine various other technologies to produce optimum production and productivity [2]. The *Jarwo* Super technology recommendations consist of: 1) Use of New Superior Varieties (*Varietas Unggul Baru/VUB*), high yield potential, 2) Biodecomposers when processing soil, 3) Biofertilizer as seed treatment and balanced fertilization based on soil nutrient status, 4) Pest control with plant-based pesticides and inorganic pesticides based on threshold control and 5) Use of agricultural equipment and machinery (transplanters and combine harvesters) [3].

The results of [4] show that *Jarwo* Super technology using Inpari 30 *VUB* can increase productivity by 15%. *Jarwo* Super technology has been tested on 50 ha of land in Indramayu Regency. The varieties planted were Inpari-30 Ciherang Sub-1, Inpari 32 HDB and Inpari 33 giving yields above 10 tons of MPD/ha compared to Ciherang in farmers’ fields outside the demplot area producing only 6 tons of MPD/ha. The technology package tested in addition to the planting system *Legowo 2:1* and *VUB* is fertilizing with urea 200 kg/ha and NPK Phonska 300 kg/ha combined with 2 t/ha compost (manure or straw), the use of M-Dec decomposers of 1 kg/tons of straw. This package is equipped with seed treatment with *Agrimeth* biofertilizer at a dose of 400 g/25kg of seed [3].

In 2016, Assessment Institute for Agricultural Technology (*Balai Pengkajian Teknologi Pertanian/BPTP*) Papua implemented the *Jarwo* Super rice planting system in Merauke Regency to produce 8.5 tons/ha of GKP [5], then in 2017 it was Jayapura City's which practices the *Jarwo* Super planting system activities in Demonstration Plots producing 9.38 t/ha [6] and in 2018 the application of *Jarwo* Super is further expanded in the form of Demfarm. Considering the all mention fact, it is important to examine the effect of every component on crop yield. Our research purpose was to found out the response of a new superior variety to biofertilizers and different planting system.

### 2. Materials and Methods

The study was conducted in Koya Barat, District Muara Tami, Jayapura Municipality in the second planting season start from June to September 2018. The site was selected deliberately with the consideration that the district was the location of *Jarwo* Super rice cultivation activities. The treatments were arranged in a split-split plot design with three replications. The main plot was biofertilizers consists of (P1) using *Agrimeth* biofertilizers and (P2) without using *Agrimeth* biofertilizers. As subplot was *Legowo* planting methods, consist of *Jarwo* (J1) 2:1 (25 cm x 12.5 cm x 50 cm) and *Jarwo* (J2) 4:1 (25 cm x 12.5 cm x 50 cm). As sub-sub plots were *VUB*, (V1) Inpari 33 and (V2) Inpari 43, respectively. *Agrimeth* biofertilizer has applied only once, at the sowing stage and control of pests and diseases were adjusted to the principal of Integrated Pest Management.

Agronomic observations include the number of tillers and plant height in the vegetative phase, grain yield, number of panicles/clumps, panicle length, number of filled grains per panicle, number of unfilled grains per panicle, and weight of 1000 grains. Soil fertility was analysed using POTS and grain yields are determined based on the harvesting of tiles in 3 m x 4 m plots for 2:1 *Jarwo* planting systems and 3.75m x 3m for 4:1 *Jarwo* planting systems. Result of tiles then converted to t/ha.

Statistical analysis of all variables observed using the program DSAASTAT 1.101. If there are significant differences, the analysis continues with the DMRT test at 5% level. Linear model as follows:
\[ Y_{ijkl} = \mu + K_l + P_l + Y_{il} + (PJ)_{ij} + (PV)_{ik} + (JV)_{jk} + (PVJ)_{ijk} + \varepsilon_{ijkl} \]
where: \( i = 1,2; j = 1,2; k = 1,2,3,4,5; l = 1,2,3 \) \( (1) \)

\[ Y_{ijkl} = \] observations on a unit of experiment on the 1st repeat that obtained by combination of treatment level \( i \) of factor \( P \), level \( j \) of factor \( J \) and level \( k \) of factor \( V \)

\[ \mu = \] actual average value (mean population)

\[ K_l = \] additive effect of the 1st group

\[ P_l = \] additive influence of the \( i \)-level factor \( P \)

\[ Y_{il} = \] the random effect of the main plot, which appears at the \( i \)-level of factor \( A \) in group 1 is often called the main plot error or error a. \( Y_{il} \sim N(0, \sigma_{Y}^2) \).

\[ J_j = \] additive influence of the \( j \)-level factor \( J \)

\[ (PJ)_{ij} = \] additive influence of \( 1^{st} \) level of factor \( P \) and level \( j \) of \( J \) factor

\[ \delta_{ijl} = \] random effect from the \( 1 \)st trial unit which obtained a combination of treatments \( ij \). Often called subordinate errors or errors b. \( \delta_{ijl} \sim N(0, \sigma^2) \).

\[ V_k = \] additive influence of level \( k \) on factor \( V \)

\[ (PV)_{ik} = \] additive influence of level \( I \) on factor \( P \) and level \( k \) on factor \( V \)

\[ (JV)_{jk} = \] additive influence of level \( j \) on factor \( J \) and level \( k \) on factor \( V \)

\[ \varepsilon_{ijkl} = \] random effect from the \( k \)-experimental unit that obtained a combination of \( ijk \) treatment. Often called squatter plot error or error c. \( \varepsilon_{ijkl} \sim N(0, \sigma_{e}^2) \).

3. Results and Discussion

3.1. Soil fertility

Soil status measurement using Paddy Soil Test Kit (PSTK). The study site has relatively high soil pH (7-8), relatively low soil structure, medium P content and high content of N and K. Recommendations for single and compound fertilizers on soil test status of samples based on the Land Use Device Version 1.1 with yield potential > 7 t/ha DMG are Phonska NPK 350 kg/ha and Urea single fertilizer supplement (200kg/ha), SP36 (75 kg/ha) and KCL (50 kg/ha) [8] According to the result of research [9] the use of PSTK as a reference for fertilization can increase rice production. The use of biofertilizers aims to increase fertilization efficiency, fertility and soil health however in this study, the application of biofertilizer Agrimeth did not have a significant effect in increasing the yield of DMG (Table 1) as well as the yield and growth components (Table 3 and Table 5). It is assumed that the land used has sufficient nutrients based on the PUTS so that it does not respond to the application of biological fertilizers. According to [10] fertile soil does not respond to fertilization so it does not improve plant growth and yield.

3.2. Yield

Crops were harvested at 88–95 days after planting and the analysis of various varieties of milled grain (DMG) is presented in Table 1. There is an interaction between biofertilizer, planting methods and varieties in increasing yield.

The combination of Agrimeth and without Agrimeth with Legowo 4:1 using Inpari 33 yielded the highest yield compared to the other treatments, which were 7.44 t/ha and 7.33 t/ha, respectively (Table 2). From the analysis, it is seen that the yield of rice paddy remained high even without the use of Agrimeth biofertilizer as long as the cultivated distance used Legowo 4:1 and the varieties used Inpari 33. Lowest yield on combination of Agrimeth and without Agrimeth biofertilizer with Legowo. 2:1 and using Inpari varieties 43. The yield on legowo 4:1 was higher compared to Legowo 2:1 In this study, the biofertilizer treatment on the spacing and varieties factors gave the same effect in increasing rice yield. In line with the research conducted by [11] there was no significant difference between giving Agrimeth and without Agrimeth on rice production.
Table 1. Analysis of variance of paddy yield in West Koya Village, Muara Tami District, Jayapura City in 2018.

| Treatment                        | Middle square |
|----------------------------------|---------------|
| Biofertilizer (P)                | 0.0067 ns     |
| Planting method (J)              | 1.7108 *      |
| Varietas (V)                     | 15,4294**     |
| P x J                            | 0.3539 ns     |
| P x V                            | 0.12566 ns    |
| J x V                            | 1.8984**      |
| P x J x V                        | 0.0115*       |

* not significant
** very significant at 0.05 and 0.01 probability levels by the F test, respectively

Table 2. The yield on the trial of biofertilizers, planting method, and varieties in West Koya Village, Tami Muara District, Jayapura City in 2018.

| Treatments | Yield (t/ha) DMG | Average | Legowo 2:1 | Legowo 4:1 | Average |
|------------|------------------|---------|------------|------------|---------|
|            | Agrimeth         | Without Agrimeth |
| Inpari 33  | 6.41 b           | 6.92    | 6.17 b     | 7.33a      | 6.75    |
| Inpari 43  | 4.92 d           | 5.18    | 5.58 c     | 5.00 d     | 5.29    |
| Mean       | 5.67             | 6.44    | 5.88       | 6.17       | 6.02    |

Note: The numbers followed by the same letter in the column and row were not significantly different according to DMRT α 0.05

The planting method plays an important role in the process of capturing solar radiation by plants for photosynthesis, root absorption by plants, water demand, circulation of CO₂ and O₂ by photosynthesis, availability of space that determines weed populations and microclimate under canopy [12]. In principle, the Legowo planting method is to increase the population by regulating the planting distance. Different planting distances will result in different yields due to different plant populations [13], [14]. Regulation of the planting method greatly determines the quantity and quality of crop yields so that the proper implementation can ensure improved crop productivity and profitability of farmers. In the proper planting method, the plant will have a balanced growth space [16]. The planting method Legowo 4:1 has higher production compared to the 2:1 crop in the varieties Inpari 3. This is also supported by the [15], [16], [17]. Although the population of Legowo 2:1 is greater than Legowo 4:1, it’s yield is less than Legowo 4:1. This is related to the density of plants in the Legowo planting system. The wider the planting distance the higher the tendency for grain yield [13], as well as the high fertility rate of the soil at the research site so that Legowo 4:1 is more suitable to be applied at this location.

3.3. Yield component

The analysis of the various yield components is presented in Table 3. Using Agrimeth did not have any significant effect on all rice yield components contrary to the planting method. Adjusting the distance had a significant effect on the amount of grain content of the crop. Variety has a very significant effect on the number of empty grains per panicle and the weight of 1,000 grains. The variety has a very real effect on the number of unfilled grain per panicle and weighs 1,000 grains. The interaction of
spawning treatment with varieties has a significant effect on the amount of grain content per millimeter and the weight of 1,000-grain grains. There is no interaction between biofertilizer, planting methods and varieties in enhancing rice yield components. The use of new varieties significantly affected unfilled grains per panicle and weight of 1,000 seeds, but it does not depend on the biofertilizer and planting method applied. Similarly, the planting method variable was significantly affected on filled grains per panicle but this is not affected by biofertilizer and varieties.

Table 3. Analysis of variance of paddy yield components in West Koya village, Muara Tami district, Jayapura city in 2018.

| Treatment          | Panicle length (cm) | Filled grains per panicle | Unfilled grains per panicle | Weight of 1,000 seed (g) |
|--------------------|---------------------|---------------------------|-----------------------------|--------------------------|
| Biofertilizer (P)  | ns                  | ns                        | ns                          | ns                       |
| Planting Method (J)| ns                  | ns                        | **                         | ns                       |
| Varieties (V)      | ns                  | *                         | ns                          | ns                       |
| P x J              | ns                  | ns                        | ns                          | ns                       |
| P x V              | ns                  | ns                        | ns                          | *                       |
| J x V              | ns                  | **                        | ns                          | **                      |
| P x J x V          | ns                  | ns                        | ns                          | ns                       |

ns not significant  
* significant  
** very significant at 0.05 and 0.01 probability levels by the F test, respectively

The interaction of the planting method with varieties has a significant effect on the number of grains per panicle and the weight of 1000 grains. (Table 3). The highest number of tillers per acre was found in the combination of 4:1 planting method with the use of Inpari 33 varieties (97.50 grains/penicle) and 43 varieties (85.11 grains/penicle). The weight of 1000 grains was highest in the combination of Legowo 2:1 with Inpari 33 varieties (31.14 g) and was not significantly different from Legowo 2:1 planting distance combination with Inpari 33 varieties (29.70 g). Inpari 33 has a weight of 1000 grain heavier than Inpari 43 either planted at the method 2:1 or 4:1 Cropping Grounds (Table 4). Large grain sizes and amounts of grain/panicle increase the weight of 1000 grains, and vice versa [18]. Grain weight is one of the parameters closely related to rice yield per unit area [19].

Table 4. Interaction between planting method and varieties on filled grains per panicle and weight of 1,000 grains (g) in West Koya village, Muara Tami district, Jayapura city in 2018.

| Yield Component       | Planting Method | Varieties      |
|-----------------------|-----------------|----------------|
|                       | Inpari 33       | Inpari 43      |
| Filled Grain per panicle | Legowo 2:1    | 52.94 c        | 75.50 b        |
|                       | Legowo 4:1     | 97.50 a        | 85.11 b        |
| Weight of 1000 seed (g) | Legowo 2:1   | 29.70 a        | 22.29 b        |
|                       | Legowo 4:1     | 31.14 a        | 20.57 b        |

Note: The numbers followed by the same letter in the column and row were not significantly different according to DMRT α 0.05

3.4. Components of plant growth
Application of biofertilizer, planting methods and varieties independently has no significant effect on plant height or number of tillers. There are interactions between the treatments increase the plant height and the number of tillers.

Observations on plant height indicate that the combination of Agrimeth and without Agrimeth biofertilizer using planting method Jarwo 4:1 and Inpari 43 had the highest plant height compared to
other treatment combinations (Table 6). The high potency of different crops besides the expression of genetic factors may also be due to different levels of entrepreneurial management [20]. Relatively low vegetation can avoid debris caused by strong winds. Falling crops can reduce yield [21].

Table 5. Analysis of variance of plant growth, West Koya village, Muara Tami district, Jayapura city in 2018

| Treatment | Plant height (cm) | Number of tillers |
|-----------|------------------|------------------|
| Biofertilizer (P) | ns | ns |
| Planting Method (J) | ns | ns |
| Varieties (V) | ns | ns |
| P x J | ns | ns |
| P x V | ** | ns |
| J x V | * | ns |
| P x J x V | * | * |

* ns not significant
** very significant at 0.05 and 0.01 probability levels by the F test, respectively

Table 6. Interaction between biofertilizer, planting methods, and varieties on plant height in West Koya village, Muara Tami district, Jayapura city in 2018

| Treatment | Plant Height (cm) | Mean |
|-----------|------------------|------|
| Agrimeth | Without Agrimeth | |
| Legowo 2:1 | Legowo 4:1 | Mean | Legowo 2:1 | Legowo 4:1 | Mean |
| Inpari 33 | 61,67 abc | 60,33 abc | 61,00 | 63 ab | 56 bc | 59,5 | 60,75 |
| Inpari 43 | 61,67 abc | 64,67 a | 63,17 | 54 c | 66 a | 60 | 61,58 |
| Mean | 61,67 | 62,50 | 62,08 | 58,5 | 61 | 59,75 |

Note: The numbers followed by the same letter in the column and row were not significantly different according to DMRT α 0.05

The highest number of tillers was 35 belong to the combination without Agrimeth with Jarwo 4:1 using Inpari 43, while the least productive variety was 19,33 on treatment combination without Agrimeth application with Jarwo 4:1 planting system and using Inpari 33 varieties (Table 7).

The research result by [22] reported that the addition of biofertilizer can increase the number of tillers, but this experiment was the first time application and fertilizer treatment did not affect significantly soil properties. It is suitable with the result by [23] which the addition of organic fertilizer needs to be done regularly. Then, the application of organic fertilizer for 4-6 season can significantly increase soil C-organic, nutrient availability, soil and plant health [24]. In the long term, organic fertilizer can improve soil pH and increase crop yield on acid soil [25].

Table 7. Interaction between biofertilizer, planting method, and varieties on number of tillers in West Koya village, Muara Tami district, Jayapura city on 2018.

| Treatment | Tiller | Mean |
|-----------|--------|------|
| Agrimeth | Without Agrimeth | |
| Legowo 2:1 | Legowo 4:1 | Mean | Legowo 2:1 | Legowo 4:1 | Mean |
| Inpari 33 | 26,67ab | 26,67 ab | 26,67 | 25,66 ab | 17,66 b | 21,67 | 24,17 |
| Inpari 43 | 29,33 ab | 28,67 ab | 29 | 19,33 b | 35 a | 27,17 | 28,09 |
| Mean | 28 | 27,67 | 27,83 | 22,5 | 26,33 | 26,12 |

Note: The numbers followed by the same letter in the column and row were not significantly different according to DMRT α 0.05
4. Conclusions
The components of Jarwo Super technology, namely new superior varieties, agrimeth biofertilizer and planting method respond to the growth and yield of rice plants. There is an interaction between the use of new superior varieties, the application of biofertilizers and the planting system in increasing rice yields. The Inpari 33 varieties produced the highest yields with or without Agrimeth biofertilizer and used planting method Legowo 4:1 with a yield of about 7.44 t/ha and 7.33 t/ha, respectively. The provision of biofertilizer has no effect on improving rice yield. The method of planting affects rice yield. Planting method Jarwo 4:1 resulting in higher yields than Jarwo 2:1.

The highest number of filled grains per panicle was found in the combination of Legowo 4:1 with the use of Inpari 33 varieties (97.50 grains/panicle), while the highest weight of 1,000 grains was in the combination of 4:1 Legowo with Inpari 33 varieties. Inpari 33 varieties planted with 4:1 Jarwo give higher yields, so it can be recommended to be developed in this Jayapura city.

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