

Study of rice varieties, fertilizer application and planting system on rice production in irrigated rice

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Abstract. Increasing rice production to achieve food security is a priority in Indonesia. Finding the right and efficient technology is still being carried out to achieve maximum rice production. The objective of this research was to observe the effect of the application of rice varieties, fertilizer application, and row planting system to rice production. The activities was conducted from April 2021 to January 2022 for two planting times (PT), located in Pulau Gambar village, Serba Jadi district, Serdang Bedagai regency. Technology component were applied to PT.I including : varieties of Inpari 30, 32 and Mekongga, legowo row planting system (2:1), (4:1) and tegel, application of granulate organic fertilizer (GOF) at 400 kg ha⁻¹, natural organic fertilizer (guano) at 100 kg ha⁻¹, NPK fertilizer (15-15-15) at 300 kg ha⁻¹ and Urea at 200 kg ha⁻¹ and PT.II used varieties of Inpari 16, 32, 43 and Mekongga, legowo row planting system (4:1), NPK fertilizer (15-15-15) at 300 kg ha⁻¹ and Urea at 200 kg ha⁻¹. The result showed that using of Inpari 32 varieties with application of combined organic and inorganic fertilizer and raw planting system of legowo 2:1 was the best treatment for irrigated rice in North Sumatera.

Keywords : Rice, varieties, fertilizer, production

1. Introduction

Government efforts to improve the farmer welfare carried out through various development programs, one of which is the introduction of agricultural technology innovations. The introduction activity is followed by a dissemination step to accelerate the increase in adoption which will ultimately lead to an increase in the welfare of farmers [1]. Many innovations in agricultural technology for rice cultivation to increase farmers' yields and income have been produced and this technology continues to develop according to the needs of the user community. For example, Integrated Crop Management (PTT) technology for lowland rice has been developing since 2008 [2] and in 2016 PTT technology was refined to become *jajar legowo super* (*Jarwo Super*) technology based on the *jajar legowo* planting system [3].

The *jarwo super* technology is an irrigated rice cultivation technology based on the *jajar legowo* (2:1) cropping system. This innovation applies several technological components, including: using new superior varieties of rice with high yields such as Inpari 30, 32 and 33 varieties, application of bio-decomposers before tillage to accelerate the weathering process of straw, using biofertilizers based on non-pathogenic microbes that are enzymatic for

stimulate plant growth, application of artificial fertilizers based on PUTS soil test equipment, application of organic fertilizer or manure, pest control with pesticides or biopesticides, using Jarwo Transplanter and Combine harvester equipment for planting and harvesting.

The successful application of the jajar legowo super technology is determined by the components of the technology package and the cultivation techniques used [4]. Several research results conducted in various regions in Indonesia reported that through the application of the Jarwo Super technology package, rice yields increased compared to the farmer method. Musfal [5] reported that the application of the jarwo super technology package was followed by the addition of cow manure as much as 1 t/ha, giving yields for the Inpari 30 variety as much as 8.50 t/ha, the Inpari 32 variety as much as 9.25 t/ha and Inpari 33 was 10.50 t/ha, while according to the farmer's method, only 6.50 t/ha.

2. Methodology

The study was conducted from April 2021 to January 2022 for two growing seasons, on irrigated rice fields belonging to the Margo Mulyo farmer group, located in Pulau Gambar Village, Serba Jadi District, Serdang Bedagai Regency, North Sumatra Province.

The technological components applied in the May 2021 Planting Season (PT. I) are: (1) using rice varieties Inpari 30, Inpari 32 and Mekongga, (2) jajar legowo (2:1), (4:1) and Tegel planting systems. The treatments were arranged according to a three-replicate randomized block design with an area of 0.25 ha for each plot. The treatment was given Urea fertilizer as much as 200 kg/ha, 300 kg/ha NPK (15-15-15), 100 kg/ha organic guano fertilizer and as 400 kg/ha Granular Organic Fertilizer (GOF). While in PT.II (October) 2021: (1) using rice varieties Inpari 16, Inpari 32, Inpari 43 and Mekongga, (2) jajar legowo planting system (4:1). Each variety was planted on a plot of 0.50 ha with three replications and was given Urea fertilizer as much as 200 kg/ha, and 300 kg/ha NPK (15-15-15) (without the addition of organic fertilizer).

The activity begins with clearing the land from existing weeds, then processing the soil by plowing with a tillage depth of 20-30 cm using a tractor. After two weeks of inundation the land is rotated to destroy lumps of soil to form mud and then the land is ready for planting.

The nursery preparation was carried out using the dapog system for jajar legowo planting system and the usual nursery method for *tegel* planting system. The method of dapog nursery is start by soaking the rice seeds for one night, then drain and let stand for one night, then the rice seeds are sown in the 18x56 cm dapog box which is lined with sheet plastic and filled with a mixture of mud and organic fertilizer (3:1), seeds sown about 100-125 g/dapog box. At the age of 14-17 days after seedlings or plants have grown to a height of 10-15 cm and already have 2-3 leaves, it can be planted with the jarwo transplanter equipment. While the usual nursery is carried out according to the farmer's method, namely by soaking the seeds for one night, then draining and letting it sit for one night, the next day sowing evenly on the nursery, at the age of 21 days after sowing the seeds are transferred to the field.

One day before planting, the land is cleaned of gold snail pests by spraying with snail poison and for controlling soil caterpillar pests. It is done by administering the insecticide Curater 3G according to the recommended dose. Then at the time of planting, granule organic fertilizer and guano organic fertilizer were applied according to the recommended dose by sowing evenly on the experimental land. After one week of planting, plants that do not grow are inserted so that the plant population can be maintained as optimally as possible.

Inorganic fertilizers according to the recommended dose are given twice, namely at 7-10 days after planting (DAP) given 2/3 doses of NPK (15-15-15) and 1/3 dose of Urea fertilizer. Then at 25-30 DAP, the rest (1/3 dose) of NPK fertilizer (15-15-15) and Urea fertilizer (2/3 dose) was given again. Weed control was carried out at 21 and 42 DAP or according to the level of weed growth in the field, by spraying using selective herbicides, for weeds that did not die, weeding was done manually by hand. For the prevention of pests and diseases, plants are

sprayed with pesticides according to the recommended dose periodically every week or adjusted to the level of pest and disease attacks in the field.

Harvest is adjusted to the description of the age of the variety or at physiological maturity which is characterized by more than 90% yellowing of the grain and the hardened or solid grain content with an estimated grain moisture content between 15-25%. Harvesting using a combine harvester in order to reduce the level of yield loss. The harvest of tiles according to the treatment was carried out according to the planting system (4 rows of plants) with a row length of 5 m and a tile method with a size of 4x5 m².

Observations were made for each activity plot with three repetitions, including: soil chemical properties before treatment, plant population, number of productive tillers, plant growth and grain yield. Observational data were analyzed according to statistics with Duncan Multiple Range Test (DMRT) advanced test at 5% significance level and Microsoft Excel program.

3. Result and Discussion

Soil Chemical Properties Before Treatment

The chemical properties of the soil before treatment showed that the value of soil organic matter and nitrogen content was classified as low (Table 1). The low value of soil organic matter indicates that the experimental land used is rarely or relatively never given organic matter by farmers. The value of the existing organic matter may come from the weathering of straw biomass from the remaining harvest in the previous season.

According to Salam et al. [6], organic fertilizer increased rice yield significantly and support less requirement of inorganic fertilizer. Meanwhile, according to Adiningsih [7], organic matter plays an important role in improving the physical and chemical properties of the soil. The average paddy soil in Indonesia contains low organic matter or below the critical limit of <2% [8]. To make efficient use of artificial fertilizers, it is necessary to add organic fertilizers either from manure or compost. The results of research by Musfal [9] reported that the application of inorganic fertilizer according to the PUTS soil test and followed by the addition of cow manure as much as 2 t/ha significantly increased rice yields by 2.35 t/ha compared to without application of manure and compared to the method of farmers without using fertilizer. organic matter and soil test yields significantly increased by 4.55 t/ha DGH (Dry Grain Harvest).

The chemical properties of P, Ca, Na and Mn according to the criteria of Cottenie [10] were classified as moderate and the chemical properties of K, Mg were classified as high and Fe were classified as very high. Ponnampereuma [11] stated that the increase in P availability in flooded soils was caused by several things, including the reduction of ferric phosphate, the release of P from Ca, Al, and Fe bonds, and an increase in pH in the soil. sour soil. P in soil is generally found in the form of Al-P, Fe-P in acid soils and Ca-P in alkaline soils. The increase in pH due to flooding encourages the solubility of Al-P and Fe-P, while the decrease in pH increases the solubility of Ca-P. The increase in Ca in flooded soil (reduction condition) was caused by the exchange of Ca⁺⁺ by Fe⁺⁺, then the high content of Fe is reviewed because in flooded soil Fe⁺⁺ will dominate the exchange complex. The very high Fe content in the soil is also reflected by the reaction of the soil which is classified as acidic with a soil pH value of 5.03. This effect is thought to be because the land is often flooded. As a result of continuous inundation, there is a reduction of Fe so that the level of Fe⁺⁺ in the soil will increase [12]. Soil reaction will also determine the availability of other nutrients in the soil, the more acidic the soil reaction, the lower the availability of nutrients [13]. (Islam et al, 1980).

Table 1. Soil chemical properties before treatment, Pulau Gambar Village, PT.I (Mei 2021)

Parameters of analysis	Value	Criteria
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Organic Carbon (%)	1.27	Low
Total N (%)	0.17	Low
Available P (ppm)	13.5	Moderate
Exc. K (me/100g)	0.63	High
Exc. Ca (me/100g)	4.04	Moderate
Exc. Mg (me/100g)	1.28	High
Exc. Na (me/100g)	0.47	Moderate
CEC (me/100g)	9.53	Low
Cu (ppm)	2.0	Low
Zn (ppm)	6.0	Low
Mn (ppm)	69.0	Moderate
Fe (ppm)	769	Very high
pH (H ₂ O)	5.03	Acid

To reduce the impact of Fe on the experimental field, it is necessary to carry out special handling such as the use of rice varieties that are resistant to the influence of Fe and the application of balanced fertilizers. According to Adiningsih [7] balanced fertilizer application is one way to avoid nutrient imbalances in the soil. Unbalanced nutrient elements will cause the soil reaction to become acidic and plant growth to be imperfect.

In addition to some of the treatments given, intermittent irrigation (dry-wet) was also carried out. According to Zaini et al. [2] intermittent water supply will change the oxidation and reduction reactions in paddy fields so that the increase in Fe levels in the soil can be controlled. According to Suseno [14] high levels of Fe in the soil and if the absorption by plants exceeds 200 ppm it can cause rice plants to be poisoned to death.

Observation of plant growth and production on dry season (PT.I May-August)

Plant population

The plant population in PT.I (May 2021) seems to be affected by the cropping system. The row legowo planting system (2:1) gave the highest plant population, followed by the row legowo planting system (4:1) and the lowest plant population was according to the *Tegel* planting system (Table 2).

The number of plant populations per unit area according to Ikhwan et al. [15] that the spacing of rice plants will determine the quality and quantity of plants. Things that must be considered in the application of plant spacing include: the availability of labor, the availability of seeds, the ease of application in the field (there is an alley or not), the condition of the area whether there is sufficient water and whether the area is endemic to the golden snail pest. Furthermore, it was suggested by Rauf et al [16] that not all rice varieties are suitable for planting according to the *jajar legowo* planting method, certain varieties will increase the levels of phenolic acid (alelopathy) from 260 to 777 ppm, with increasing levels of phenolic acid it will interfere with surrounding plant growth. Meanwhile, rice varieties suitable for close planting (*jajar legowo*) are rice varieties that are drought-resistant and grow well in infertile land conditions.

Table 2. Plant population according to different planting system in Pulau Gambar Village, PT.I (May 2021)

No	Sistem Tanam	Jarak Tanam	Populasi/m ²	Populasi/ha
1	Jarwo (2:1)	14x20x40 cm	28	233,333
2	Jarwo (4:1)	20x25x25 cm	20	200,000
3	Tegel	25x25 cm	16	160,000

The rice planting system as a component of cultivation will affect the yield, according to

Makarim et al. [17] there are several processes that influence it, including: capture of solar radiation by plants for photosynthesis, absorption of nutrients by plants, plant water requirements, circulation of CO₂ and O₂, the results of photosynthesis, the availability of space that determines the weed population, and the microclimate under the canopy that affects the development of plant-disturbing organisms.

The results of the rice spacing study reported by Pratiwi et al [18] concluded that wide spacing gives an opportunity for certain plant varieties to develop or grow well, in dense plant population, gave the fewer of tillers and panicles in the cluster. In a small population (wide spacing) the performance rice clumps is large, but the yield and yield components are lower than the denser spacing (*jajar legowo*).

Number of productive tillers

The average of productive tillers in PT.I (May 2021) was influenced by the planting system, the row planting system (2:1) and (4:1) on average gave a higher number of productive tillers than the *Tegel* planting method (Fig. 1).

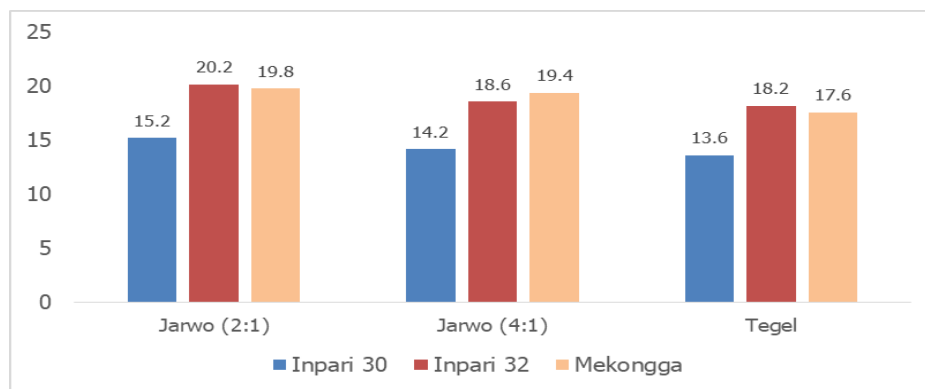


Figure 1. The number of productive tillers of several rice varieties on the application of different planting system in Pulau Gambar Village at PT.I (May 2021)

In the jajar legowo (2:1) planting system, the highest number of productive tillers was given by the Inpari 32 variety with 20.2 panicles/clump, followed by the Mekongga variety with 19.8 panicles/clump and the lowest by the Inpari 30 variety with 15, 2 panicles/clump. While in the row legowo planting system (4:1) the highest number of productive tillers was given by the Mekongga variety, then by the Inpari 32 variety and the lowest by the Inpari 30 variety. In the *Tegel* planting system the highest number of productive tillers was given by the Inpari 32 variety, followed by Mekongga and Inpari 30 varieties. Inpari 30 varieties on average gave the lowest number of productive tillers for the three planting systems tested.

Ikhwani et al [15] suggested that in principle the rowing legowo planting system is to increase the population by adjusting the spacing. This planting system also manipulates the layout of the plants, so that the clumps of plants are mostly side plants. Rice plants on the side position get more sunlight and better absorption of nutrients, resulting in higher panicles and grain numbers with better quality. Furthermore, it was stated by Pratiwi et al. [18] that wide spacing provides an opportunity for plant varieties to express their growth potential, so that the clumps of plants appear to be larger but produce fewer yield and yield components. The denser plant population will provides the fewer number of tillers per clump, but in a certain area unit it provides more yield and yield components than the wide spacing.

Grain yield

The results of the PT.I activity (May 2021) showed that the jajar legowo planting system (2:1) on average gave the highest grain yield for the three varieties tested, then it was not significantly different from the row legowo planting system (4:1). The *Tegel* method gave significantly lower yields than the jajar legowo planting system (Table 3). The highest average yield was given by the Inpari 32 variety, followed by the Mekongga variety and the lowest by the Inpari 30 variety.

Table 3. Average grain yield (t ha⁻¹) of several rice varieties according to the different planting system in Pulau Gambar Village PT.I (May 2021)

Varieties	Planting system			Average
	Jarwo (2:1)	Jarwo (4:1)	Tegel	
Inpari 30	7.35 cd	7.25 de	6.55 e	7.05 B
Inpari 32	9.19 a	8.06 bc	7.40 cd	8.22 A
Mekongga	8.30 b	8.07 bc	7.03 de	7.80 A
Average	8.28 A	7.79 A	6.99 B	

Numbers followed by the same letter are not significantly different according to the DMRT test at a 5% significance level

The low average yield of rice with the *Tegel* planting system in this experiment assumed to the smaller number of plant populations compared to the jajar legowo planting method. According to Pratiwi et al [18] wide spacing with a small plant population will give a large clump performance but the yield and yield components given will be lower. On the other hand, it was reviewed that a large or dense plant population gave a small number of tillers but on the contrary gave a higher yield component and grain yield.

Of the three varieties tested, the Inpari 32 variety on average gave higher yields than the Mekongga and Inpari 30 varieties, both planted according to the row of legowo (2:1) or the *Tegel* method. While the method of planting system jajar legowo (4:1) the Mekongga variety gave the highest yield compared to the Inpari 32 and Inpari 30 varieties. The highest grain yield was 9.19 t ha⁻¹ given by the Inpari 32 variety, followed by the Mekongga variety at 8.30 t ha⁻¹. where these two varieties were grown according to the row legowo (2:1) cropping system, while the lowest yield of 6.55 t ha⁻¹ was given by the Inpari 30 variety which was grown according to the *Tegel* method.

The results of the same study were reported by Hamdani and Murtiani [19] that the jajar legowo (2:1) planting system gave higher rice yields than the tiled planting method. While [20] BB Padi (2011) reported that not all rice varieties gave high yields when planted with the jajar legowo system, certain varieties actually gave higher yields when planted with the *Tegel* planting system. Varieties that are suitable for the jajar legowo planting system are varieties that have shade resistance, disease resistance, have a small number of tillers, moderate to high soil fertility and suitable for the dry season where the average light intensity or irradiation is more.

The application of the spacing system is basically to give plants the possibility to grow well without experiencing a lot of competition in terms of taking water, nutrients, and sunlight. Proper spacing is important in optimal utilization of sunlight for photosynthesis. In the right spacing, plants will get a balanced growth space [21]. The row planting system (2:1) consists of two rows of plants and one hurdle, all of which are side plants. The high average yield through this planting system is possible because the effects of the edge plants will receive more lighting so that the photosynthesis process will run well. Lin et al [22] stated that wide margin spacing can improve the total light capture by plants and can increase grain yields. Wider spacing between rows can improve the total light radiation captured by plants and can increase yields. Therefore, the implementation of the jajar legowo planting system in accordance with local environmental conditions will almost certainly increase the productivity of rice plants and profits for farmers.

Observation of plant growth and production on wet season (PT.II Oct-Jan)

Plant height and number of tiller

The highest plant height in the MT.II (October 2021) activity was given by the Inpari 43 variety, which was 100 cm and the plant height was then followed by the Inpari 16, Mekongga and Inpari 32 varieties. While the highest number of tillers was 40.3 stems/clump given by the variety Inpari 43, the number of tillers was then given by Inpari 16, Mekongga and Inpari 32 varieties (Table 5).

The appearance of this plant growth is not only influenced by soil fertility factors but also due to the genetic characteristics of each variety tested. According to Dobermann and Fairthurs [23] the growth of rice plants during the maximum vegetative growth period (60 - 75 DAP) is strongly influenced by the level of nitrogen availability in the soil and the irradiation system by the sun or the ongoing photo synthesis process. The better photosynthesis process and the increased nitrogen content in the soil, provides the better plant growth.

Table 5. Plant height and number of tillers at 60 DAP on different rice varieties in Pulau Gambar Village. PT.II (October 2021)

Varieties	Plant height (cm)	Number of tiller (stems/clump)
Mekongga	94.0 a	37.0 bc
Inpari 16	94.7 a	37.3 b
Inpari 32	81.5 b	35.0 c
Inpari 43	100.0 a	40.3 a
CV (%)	8.70	5.85

Numbers followed by the same letter are not significantly different according to the DMRT test at a 5% significance level

Rice plants require sufficient and balanced nutrients. Most of the needs, especially for nutrients N, P and K. Currently, paddy fields generally contain macronutrients N, P, K, Ca, Mg

and soil organic matter content that varies from low to moderate [23]. Nitrogen (N) deviation in rice plants is more common than P, K elements. However, the N nutrient test is difficult and less developed than the P and K test because of the rate of organic matter decomposition by microbes is highly dependent on temperature, humidity, aeration, type of organic matter, and pH. Then the form of inorganic N in the soil is the result of the process of washing, fixation, denitrification, and others. This condition makes it difficult to predict when and how much N will be available [25].

Grain yield

The grain yield in the MT.II activity (October 2021) showed that the highest yield was given by the Inpari 32 variety of 7.60 t ha⁻¹, the next yield by the Inpari 43 variety and the Mekongga variety of 7.36 t ha⁻¹ and the lowest yield was by the variety Inpari 16 of 6.88 t ha⁻¹ (Figure 7).

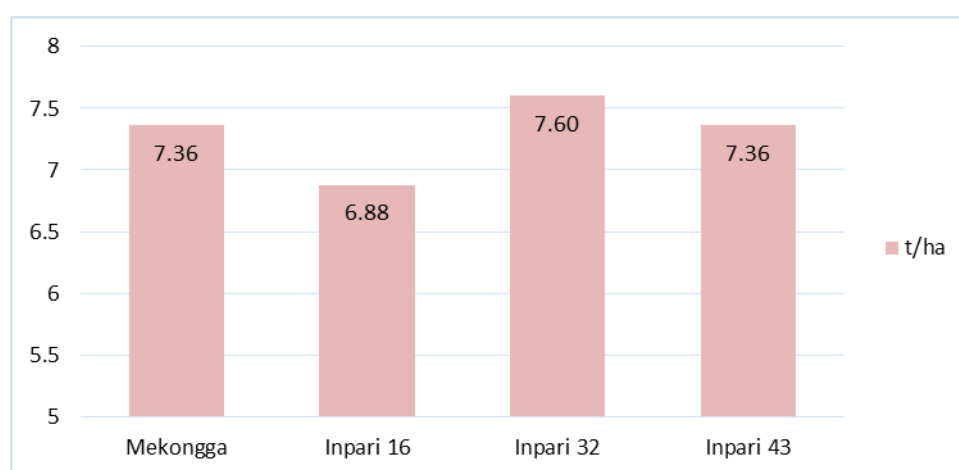


Figure 2. The yield of several rice varieties in Pulau Gambar Village, PT.II (October 2021)

When compared to MT.I (May) 2021 activities, the average results obtained in MT.II (October) 2021 activities tend to be lower. The low yield to MT.II assumed due to absence of granule organic fertilizer and guano organic fertilizers. As the previous discussion, organic fertilizers function is to increase the availability of nutrients and guano fertilizers (natural phosphates) function is to increase the availability of phosphates in the soil. With the increased availability of Phosphate nutrients in the soil, the results will also increase.

4. Conclusion

The row planting system (2:1) on average gave the highest grain yield and plant population, followed by the row legowo planting system (4:1) and the lowest according to the tile planting system. The results of the MT I study (May) 2021 applied the jajar legowo planting system (2:1), followed by the addition of organic and inorganic fertilizers, the grain yields for the Inpari 32 variety were 9.19 t ha⁻¹, Mekongga 8.30 t/ha. ha and Inpari 30 as much as 7.35 t ha⁻¹. The results of the MT.II (October) 2021 applying the jajar legowo planting system (4:1) followed by the application of inorganic fertilizers only (without the addition of organic fertilizers), Inpari 43 were 7.36 t ha⁻¹ and Inpari 16 were 6.88 t ha⁻¹. The Inpari 32 variety is quite suitable for the study location, on average it is able to give the highest yields in MT.I (May) and MT.II (October) 2021, further suitability by the Mekongga variety. The average grain yield for MT.II (October) 2021 tends to be lower than MT.I (May) 2021, the cause of the low yield is the implementation of the row legowo (4:1) cropping system with a lower plant population and without the addition of organic fertilizer.

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