The Growth and productivity enhancement of rice by jajar legowo (double row) planting method in freshwater swampland

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Abstract. One of the technological innovations to increase rice productivity is the Jajar Legowo (double row) planting method. The research aimed to examine the technology of planting Jajar Legowo rice in two ways: manual and transplanter machines in freshwater rice fields. The research was conducted on 6 ha of freshwater rice fields in Martapura Barat, Banjar Regency and involved six cooperator farmers. The superior varieties used were Inpari-30 and Inpari-32. The results show that the average grain yield was higher with transplanter (8.10 t ha$^{-1}$ GKP), compared to manual planting (6.90 t ha$^{-1}$). Grain yields planted with transplanter + manure increased grain yields by 1.2 t ha$^{-1}$ (increased by 17.4%). The transplanter treatment provided an income of IDR20,401,500.- and R C$^{-1}$ = 2.70 higher than manual row planting (income IDR16,959,500.- R C$^{-1}$ = 2.59). Transplanter also reduce labour costs for planting (IDR750,000.- per hectare), and reduce planting times.

1. Introduction
Rice is the staple food of the Indonesian people. The need for rice is increasing, along with population growth. Increased production can be done by increasing productivity and increasing the planted area. The increase in planting area leads to sub-optimal land (such as freshwater swamps), due to the narrowing of arable land. Freshwater swamps in Indonesia, covering an area of around 25.21 million ha (73.9% of the total swampland of 34.12 million ha), are scattered in Sumatra, Papua, Kalimantan, Sulawesi and Maluku, which have the potential as an alternative source of rice production [1]. Even though freshwater land has the potential for rice development, it has several limiting factors that can affect rice productivity.

The limiting factor for freshwater swamps is the fluctuation of the water regime which is quite high, namely floods in the rainy season and drought in the dry season, especially in shallow freshwater swamps, and the physicochemical characteristics and soil fertility and micro-hydro topography of the land, which are diverse and generally not well ordered [2, 3]. If the freshwater land can be engineered with the application of appropriate cultivation technology innovation, balanced development and management following the characteristics and behaviour of the swampland, it can make the swampland a productive, sustainable and environmentally friendly agricultural land [3, 4, 5]. Increasing rice productivity can be done by applying the Jajar legowo technology innovation. It is an integrated lowland rice crop management based on Jajar Legowo 2:1. The important parts are 1) New Superior Varieties (VUB) with high yield potential; 2) Biodecomposers, given during soil processing; 3) Bio-fertilizers as seed treatment and balanced fertilization based on the Rice Field Test Kit (PUTS); 4) Pest and disease control with vegetable pesticides (if possible); and 5) Agricultural tools and machinery, such as planting
tools (Jarwo transplanters) and harvesters (combine harvester). In rainfed and irrigated rice fields, the Jajar Legowo planting system can increase productivity and income [6, 7, 8].

The research aimed to examine the technology of Jajar Legowo rice cultivation both manually and using transplanters in freshwater swamps.

2. Methodology

Research activities were carried out in Hambuku village, West Martapura District, Banjar Regency during the 2018 dry season (March to October 2018). The research was designed in a split-plot design, planting system as the main plot and varieties as subplots. There were two treatments for the planting system (main plot), namely 1) Using a planting tool/transplanter (Jajar Legowo system 2: 1), 2) manual planting (Jajar Legowo 2: 1 system). There were two varieties planted (subplots), namely Inpari-30 and Inpari-32. Each treatment was repeated six times, the farmer as a replication, and the total research area was 6 ha.

After being ploughed once, the land was given 400 kg ha⁻¹ of lime and chicken manure at a dose of 2 t ha⁻¹, and at least seven days before planting the soil was sprayed with Biodecomposer (M-deck) at a dose of 2 kg ha⁻¹. Seedlings for planting with Transplanter were carried out on trays using loose seedling media. A nursery for manual planting is prepared on the ground. Treatment of seeds before sowing was given ten packs of Agrimeth (@ 40 g) for 1 ha of seed needs. Rice was planted when the seedlings were about 14-25 days after sowing.

The planting system using either the Transplanter or manual planting was Jajar Legowo 2:1. Chemical fertilization was carried out at the age of 7-14 days using Phonska fertilizer (dose 300 kg ha⁻¹) after planting and at the age of 30 after planting with Urea (dose 100-150 kg ha⁻¹). Pest control was carried out following the recommended pesticides. Observation of pests and diseases showed that the main pest attacking was green leafhoppers which caused tungro disease. The Inpari 32 variety was more resistant to tungro than the Inpari-30 variety. Apart from green leafhoppers, there were also fake white pests and rice stem borer.

Observations were made on plant growth (height, number of tillers), rice yield components (number of panicles hills⁻¹, number of filled grains panicles⁻¹, number of empty grains panicles⁻¹, panicle length), grains yield. The use of production inputs and labour during rice cultivation activities was carried out to calculate the economic feasibility analysis (R C⁻¹ ratio).

3. Results and discussion

3.1. Soil characteristics

The research location was a freshwater swampland. Freshwater swampland is a land that is submerged for more than or the same as three months, in the form of a basin with the characteristics of the rainy season being completely inundated by water. In the dry season, the water gradually dries up or even becomes completely dry in a relatively short period (1-2 months) [9]. Technically, freshwater swamps experience quite high-water regime fluctuations, namely floods in the rainy season and drought in the dry season, especially in shallow freshwater swamps [2]. Based on its topography, freshwater swamps are divided into three categories, namely shallow freshwater swamp, middle freshwater swamp and deep freshwater swamp. Inundation height in the shallow freshwater swamp is less than 50 cm, the middle freshwater swamp is 50-100 cm, and the deep freshwater swamp is more than 100 cm [10, 11].

Assessment of soil fertility is limited to the root area of overlay plants (0-20 cm). Based on the results of laboratory analysis, soil characteristics tested were texture, soil acidity (pH), Organic C, Total N, C / N ratio, available P, exchanged K, CEC, and cations (Ca, Mg, K, and Na) and several microelements in each freshwater swamp soil typology (table 1).
Table 1. Physical and chemical properties of the soil in the research location.

| Soil Characteristics | Value | Criteria | Soil Characteristics | Value | Criteria |
|----------------------|-------|----------|----------------------|-------|----------|
| pH (H₂O)             | 4.62  | M        | Exchange bases (me/100g): |
| pH (KCl)             | 3.88  | -        | Ca                   | 9.79  | S        |
| C. Organik (%)       | 2.28  | S        | Mg                   | 4.04  | S        |
| N total (%)          | 0.29  | S        | K                    | 0.57  | T        |
| P Bray I (ppm P₂O₅)  | 11.89 | S        | Na                   | 0.11  | R        |
| P total (mg/100g P₂O₅) | 15.17 | S       | Texture (%): |
| K total (mg/100 g K₂O) | 23.41 | T       | Clay                 | 35.51 |
| KTK (me/100 g)       | 22.26 | S        | Dust                 | 38.04 |
| Al-dd (me/100 g)     | 0.45  | -        | Sand                 | 26.45 |
| Fe dissolved (ppm)   | 16.46 | -        |                      |       |

Description: M=Masam (acid); S=Sedang (medium); T=tinggi (high); R=rendah (low).

The soil reaction was acidic with a pH of 4.62, which is still within the limits that rice plants can tolerate. The soil is quite fertile. It can be seen from the macronutrient content, which ranges from medium to high and C-organic 2.28% [12].

The micronutrient content of Iron (Fe) is 16.46 ppm, which is still low. The availability of Fe microelement is influenced by waterlogging conditions, ion balance, organic matter and soil pH. If the nutrient availability is at a low concentration of Fe²⁺ 30 ppm, it is capable of poisoning plants. According to Hanafiah [13], the range of Fe in leaves is 10-100 ppm with a sufficiency level of only 50-75 ppm; however, according to Jones et al. [14], the range for iron adequacy for rice is 70-200 mg kg⁻¹ in young leaves.

Dusty clay texture is classified as a suitable soil texture for food crops. The soil cation exchange capacity (CEC), which is classified as medium indicates that the soil can hold nutrients so that plants can absorb it.

3.2. Rice growth and yield
Observations on rice plant growth showed that Inpari-30 plant height ranged from 101.88-110.88 with the number of tillers per hill 13.63-18.00, and the plant height Inpari-32 ranged from 74.50-103.38 cm. The number of tillers 18-22. Statistical tests on plant height and number of tillers showed an interaction between planting method and variety on plant height. The use of transplanters increased plant height in the Inpari-32 variety, but there was no difference in the Inpari-30 variety. Cultivation methods and varieties increased the number of tillers (table 2).

Table 2. The effect of planting method on plant height and number of tillers of Inpari 30 and Inpari 32 varieties.

| Planting method | Plant Height | Average | Number of tillers | Average |
|-----------------|--------------|---------|-------------------|---------|
|                 | Inpari-30    | Inpari-32|                   |         |
| Transplanter    | 101.88 a     | 103.38 a| 102.63            | 18.00   |
| Manual          | 102.88 a     | 80.13 b | 91.51             | 13.63   |
| Average         | 102.38       | 91.78   | 15.81 b           | 19.57 a |

The treatment of planting methods and varieties affected the number of panicles per hill and panicle length (table 3). The number of panicles is also influenced by the number of tillers. The use of a transplanter increases the number and length of panicles. There are more panicles in Inpari 32 than Inpari 30, but Inpari-30 had longer panicle.
Table 3. The effect of planting method on the number and length of panicles of Inpari 30 and Inpari 32 varieties.

| Planting method | Number of panicles/hills | Average | Panicle length (cm) | Average |
|-----------------|--------------------------|---------|---------------------|---------|
|                 | Inpari-30 | Inpari-32 | Inpari-30 | Inpari-32 | Inpari-30 | Inpari-32 |
| Transplanter    | 13.5      | 15.8     | **14.7 a** | 24.6     | 22.3     | **23.5 a** |
| Manual          | 12.1      | 12.7     | **12.4 b** | 24.4     | 20.6     | **22.5 b** |
| **Average**     | **12.8 b**| **14.3 a**| **24.5 a**| **21.5 b**|          |           |

The method of planting using a transplanter increased the number of fill per panicles compared to planting manually, but the varieties showed no difference. There was no effect of planting method or variety on the amount of empty grain (table 4).

Table 4. The effect of planting method on the number of filled and empty grains per panicle of Inpari-30 and Inpari-32 varieties.

| Planting method | The number of filled grains/panicles | Average | The number of empty grain/panicles | Average |
|-----------------|-------------------------------------|---------|-----------------------------------|---------|
|                 | Inpari-30 | Inpari-32 | Inpari-30 | Inpari-32 | Inpari-30 | Inpari-32 | Inpari-30 | Inpari-32 |
| Transplanter    | 124.7     | 115.6     | **120.15 a** | 15.3     | 11.8     | **13.55 a** |
| Manual          | 110.1     | 98.5      | **104.30 b** | 12.2     | 14.5     | **13.35 a** |
| **Average**     | **117.4 a**| **107.05 a**| **13.75 a**| **13.15 a**|          |           |

Table 5. The effect of planting methods on the yield of harvested dry grain (t ha \(^{-1}\)) Inpari-30 and Inpari-32 varieties.

| Planting methods | Varieties | Average |
|------------------|-----------|---------|
|                  | Inpari-30 | Inpari-32 |         |
| Transplanter     | 7.92      | 8.28     | **8.10 a** |
| Manual           | 7.18      | 6.63     | **6.90 b** |
| **Average**      | **7.55 a**| **7.45 a**|         |

The method of planting using the Transplanter increased the yield (harvested dry grain), but the yield between varieties was not different (table 5). The yield of dry grain due to the use of transplanters is higher than manual planting. The two varieties of Inpari-30 and Inpari-32 gave the same grain yield. The difference in grain yield between manual planting and transplantation is thought to be due to the age of the seedlings and different populations. Planting with a transplanter requires that young seedlings are less than 18 days old, cannot use seeds that are more than 20 days old. At the age of young seedlings, the roots of the plants are still easy to separate with clamps on the Transplanter. When transplanting, young seedlings will experience less stress, resulting in more seedling growth. Manually planting using human labour (planting wages). The seeds used are 21 to 25 days old. Younger seedlings (10 to 15 DAS=day after sowing) will provide a higher number of tillers and panicles and productivity than older seedlings (more than 20 DAS). Transplanter planting made spacing more regular and row spacing of about 12.5 cm, the plant population was 213,333. Manual planting, spacing in irregular rows, averaging about 15 cm, plant population is 177,777. The results show that the Jajar Legowo planting method was an effort to increase the plant population per hectare so that productivity increased. In Jajar Legowo planting, all the hills become fringe plants. The effect of fringe plants is to get more sunlight and better air circulation, as well as to facilitate plant maintenance [15]. Several other research results also show that the 2: 1 Jajar Legowo planting system is profitable both in increasing productivity and farmers'
income. According to Erythrina and Zaini [16], the application of the Jajar Legowo 2:1 planting system technology can increase the plant population by 33.33%, and according to Ishaq [17], this technology increases production by 18.7% in irrigated land. According to Suratmini and Suryawan [18], this technology produces milled dry grain 19.7% higher than the tile planting system. The results of the study by Suratmini and Sukraeni [19] showed that the number of productive tillers was higher in Jajar Legowo than in the tile planting method (the farmer’s method) [20, 21].

The results of the Jajar Legowo super dem-area activity in Indramayu shows that the productivity of the Inpari-30 Cihergang Sub-1 variety was 13.9 t ha⁻¹; Inpari-32 HDB of 14.4 t ha⁻¹; and Inpari-33 amounted to 12.4 t ha⁻¹, while the average productivity of farmers outside the dem-area with the Cihergang variety was 7.0 t ha⁻¹ [22]. Planting the Jajar Legowo system can increase farmers’ income compared to non-Jajar Legowo planting. The magnitude of the difference in yield between the Jajar Legowo 2:1 planting system model with the non-Jajar Legowo system is 1,483 kg ha⁻¹, with the difference in profit from the non-Jajar Legowo system of IDR6,463,750.- ha⁻¹ [23].

3.3. Farming analysis
The use of a transplanter provides an income of IDR20,401,500.- with R C⁻¹ = 2.70 higher than manual planting, and an income of IDR16,959,500.-, R C⁻¹ = 2.59. A higher R C⁻¹ value indicates that the use of a transplanter is feasible, reducing labour costs for planting by IDR750,000.- per hectare, and the planting time is shorter (table 6).

The use of transplanters requires additional costs for seedling media because the media for seedlings in the tray requires loose media to facilitate the removal of young seedlings. The media for the seedling is a mixture of soil, manure and husk ash so that it is crumbled and loose.

| Table 6. Analysis of manual and Transplanter farming, Banjar Regency, 2018. |
|---|---|---|
| No | Description | Total (IDR) |
| | | Manual | Transplanter |
| A. | Expenditures / inputs | | |
| 1. | The seeds | 240,000 | 240,000 |
| 2. | Fertilizer | 2,048,500 | 4,156,500 |
| 3. | Pesticides | 1,427,000 | 1,427,000 |
| 4. | Labor | 6,925,000 | 6,175,000 |
| | The amount of costs | 10,640,500 | 11,998,500 |
| B. | Reception/output | | |
| - | GKP results 8.100 kg x Rp. 4,000, (Transplanter) | | 32,400,000 |
| - | GKP results 6.900 kg x Rp. 4,000, (Manual) | 27,600,000 | |
| C. | Income | 16,959,500 | 20,401,500 |
| D. | RC Ratio (B/A) | 2.59 | 2.70 |

Information : GKP = Harvested Dry Grain.

4. Conclusion
Plant growth (height, number of tillers, number of panicles, panicle length, number of filled grains) using a transplanter is better than manual. The average yield of jajar legowo using a transplanter was higher (8.10 t ha⁻¹) than manually. Increase in yield of 17.4% (equal to 1.2 t ha⁻¹).

The advantages of transplanting are higher grain yield (8.10 t ha⁻¹ GKP) compared to manual planting (6.90 t ha⁻¹); providing more profit (IDR20,401,500.-) with R C⁻¹ = 2.70 than manual planting which is only IDR16,959,500.- with R C⁻¹ = 2.59; reducing labour costs for planting (IDR750,000.- per hectare), and shorter planting times.
References

[1] BBSDLP (Balai Besar Sumber Daya Lahan Pertanian) 2015 Sumber Daya Lahan Pertanian Indonesia: Luas, Penyebaran, dan Potensi Ketersediaan (Jakarta: Indonesian Agency for Agricultural Research and Development (IAARD) Press)

[2] Alihamsyah T 2005 Pengembangan Lahan Rawa Lebak untuk Usaha Pertanian (Jakarta: Balai Penelitian Pertanian Lahan Rawa, Badan Litbang Pertanian)

[3] Jumberi A and Las I 2006 Inovasi Teknologi Pengembangan Pertanian Lahan Rawa Lebak 16 p

[4] Widjaja-Adhi I P G, Nugroho K, Didi Ardi S and Karama A S 1992 Sumberdaya lahan rawa: Potensi, keterbatasan dan pemanfaatan Pengembangan Terpadu Pertanian Lahan Rawa Pasang Surut dan Lebak ed Partohardjono S and Syam M (Bogor: SWAMPS II-Puslitbangtan)

[5] Alihamsyah T and Noor I 2003 Lahan Rawa Pasang Surut: Pendukung Ketahanan pangan dan Sumber Pertumbuhan Agribisnis (Jakarta: Balai Penelitian Pertanian Lahan Rawa, Badan Litbang Pertanian)

[6] Hutapea Y, Waluyo and Sasmita P 2017 Persepsi Petani dan Prospek Budidaya Padi Jajar Legowo Super di Oku Timur Pros. Seminar Nasional Pengembangan Teknologi Pertanian Politeknik Negeri Lampung 07 September 2017 ISBN 978-602-70530-6-9 p 212-221 DOI: http://dx.doi.org/10.25181/prosemsnas.v0i0.726

[7] Slameto and Lasmono A 2018 Analisis usahatani padi sawah dengan penerapan teknologi jarwo super di Lampung Pros. Seminar Nasional Pengembangan Teknologi Pertanian Politeknik Negeri Lampung 08 Oktober 2018. ISBN 978-602-5730-68-9 p 25-32. http://journal.polinela.ac.id/index.php/PROSIDING

[8] Priatmojo B, Adnyana M O, Wardana I P and Sembiring H 2019 Kelayakan Finansial dan teknis cara tanam padi jajar legowo super di sentra produksi padi kawasan Sumatera Jurnal Penelitian Pertanian Tanaman Pangan 3 9-15. DOI: http://dx.doi.org/10.21082/jpptp.v3n1.2019 http://ejurnal.litbang.pertanian.go.id/index.php/jpptp/article/view/9583/8404

[9] Widjaja-Adh, Nugroho K, Suriadikarta D A, and Karama A S 1992 Sumber Daya Lahan Rawa:Potensi Keterbatasan dan pemanfaatan. Risalah Pernas Pengembangan Pertanian di Lahan Rawa Pasang Surut dan Lebak Cisarua 3 – 4 Maret 1992. a. 3 (2) 57 – 66. Jakarta.

[10] Direktorat Rawa. 1992. Kebijaksanaan Departemen Pekerjaan Umum dalam Rangka Pengembangan Daerah rawa.

[11] Noor M 2007 Rawa Lebak: Ekologi, Pemanfaatan, dan Pengembangannya

[12] Peraturan Menteri Pertanian Nomor 79/Permentan/OT.140/8/2013 tentang Pedoman Kesesuaian Lahan pada Komoditas Tanaman Pangan

[13] Hanafiah K A 2005 Dasar-dasar Ilmu Tanah (Jakarta: Raja Grafindo Persada)

[14] Jones J B, and Eck H V 1973 Plants analysys as an aid in fertilizing corn and grain sorgum Soil Testing and Plant Analysis ed L.M. Wals and J.D Beaton (Madison Wisconsin USA: Amer Inc.)

[15] Muisishono R and Santosa T 2001 Sistem budidaya teknologi tanam benih langsung (TABELA) dan Tanam jajar legowo (TAJARWO) Makalah Seminar Perekayasaan Sistem Produksi Komoditas Padi dan Palawija (Yogyakarta: Diperta Prop. DIY)

[16] Erythrina and Zaini Z 2014 Budidaya padi sawah sistem tanam jajar legowo : tinjauan metodologi untuk mendapatkan hasil optimal Jurnal Litbang Pertanian 3 79-86

[17] Ishaq I 2012 Jajar legowo (Jarwo) komponen teknologi penciri PTT penunjang peningkatan hasil padi sawah Sinar Tani Edisi 19-25, No. 3487 Tahun XLIII, http://www.litbang.pertanian.go.id/download/one/299/file/TAJARLEGOWO-JARWO-.pdf

[18] Suratmimi P and Suryawan I B G 2017 Pengaruh sistem tanam terhadap pertumbuhan dan produksi Impari 20 dan Inoari 23 di Dubak Gantalan II, Karang asem Bali Pros. Seminar Nasional 2016. Balai Besar Penelitian tanaman padi, Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian Sukamandi p 181
[19] Suratmini P and Sukraeni K K 2015 Pertumbuhan dan produksi tiga varietas unggul baru (VUB) padi sawah pada dua sistem tanam berbeda Pros. Seminar Nasional 2014 Inovasi Teknologi Padi Mendukung Pertanian Bioindustri Balai Besar Penelitian tanaman padi, Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian. Sukamandi

[20] Ningsih, Rina D, Yasin M and Noor A 2020 Rice productivity on tidal swampland in the agricultural assistance area program in Barito Kuala Regency South Kalimantan. IOP Conference Series: Earth and Environmental Science 484 012123. doi: 10.1088/1755-1315/484/1/012123

[21] Witjaksono J 2018 Kajian sistem tanam jajar legowo untuk peningkatan produktivitas tanaman padi sawah di Sulawesi Tenggara Jurnal PANGAN 27 (1) 1-8 doi: 10.33964/jp.v27i1.400

[22] Badan Litbang Pertanian 2016 Teknologi Jajar Legowo Super untuk Mendongkrak Produktivitas Padi. http://www.litbang.pertanian.go.id/berita/one/2574/. [Accessed 10 October 2018]

[23] Sutardi 2017 Pengaruh model sistem tanam jarwo terhadap pertumbuhan dan hasil padi pada pola tanam padi+padi+kedelai Pros. Seminar Nasional 2016 buku 2 Balai Besar Penelitian tanaman padi, Badan Penelitian dan Pengembangan Pertanian Kementerian Pertanian. Sukamandi.