Combination of Exercise Treatment and Planting Spacing in Improving Growth and Productivity of Welshaw Rice (*Oryza Sativa L*)

Sulardi, M.Sidik.Tarigan, Ocdy Amelia

Abstract

This study aimed to determine the effect of soil tillage systems and planting spacing, as well as their interaction, on the growth and productivity of lowland rice (Oryza sativa L.) variety IR64. The research was conducted in paddy fields using a factorial randomized block design (RBD) with two factors. The first factor was the soil tillage system consisting of three levels: plowing (P1), tractor tillage (P2), and hoeing (P3). The second factor was planting spacing consisting of three levels: 30×20 cm (J1), 30×30 cm (J2), and 30×40 cm (J3). The observed parameters included plant height, number of tillers, leaf area, grain weight per clump, grain weight per plot, and grain yield per hectare. The results showed that the interaction between soil tillage systems and planting spacing had a significant effect on the number of tillers, grain weight per clump, grain weight per plot, and grain yield per hectare, but had no significant effect on plant height and leaf area. The best treatment was obtained from the combination of P2J2 (tractor tillage and 30×30 cm spacing) which produced the highest grain yield, reaching 600 g per 1 m² plot, equivalent to 6 tons per hectare. Thus, the tractor tillage system combined with moderate planting spacing effectively improved growth efficiency and grain yield of lowland rice (IR64 variety)

Keywords: Fertilizer, Plant Spacing, Growth, Yield, Rice

Sulardi[1]
[1]Bachelor of Agribusiness, Universitas Pembangunan Panca Budi, Indonesia
e-mail: sulardi@dosen.pancabudi.ac.id`

M.Sidik.Tarigan[2], Ocdy Amelia[3]
e-mail: msidiktarigan@dosen.pancabudi.ac.id[2], ocdyamelia@dosen.pancabudi.ac.id[3]
2nd International Conference on Islamic Community Studies (ICICS)
Theme: History of Malay Civilization and Islamic Human Capacity and Halal Hub in the Globalization Era

Introduction

Lowland rice is a type of rice plant that requires abundant water and is cultivated in wetland or paddy fields, which differs from upland rice that is suited to dry land conditions. The cultivation of lowland rice involves soil preparation under flooded conditions, starting from removing crop residues to puddling the soil to make it easier for planting. Lowland rice serves as an important source of carbohydrates and energy for the Indonesian population and represents the main livelihood for millions of smallholder farmers across the country.

Rice (Oryza sativa L.) is the main food commodity in Indonesia and plays a strategic role in national food security. Efforts to increase rice productivity are carried out through improvements in cultivation technology, one of which is through appropriate tillage systems and optimal plant spacing.

Tillage serves to improve soil structure, enhance aeration, and reduce weed competition. The commonly used tillage systems include traditional plowing, tractor tillage, and hoeing. Meanwhile, plant spacing plays an important role in influencing plant population density, the number of tillers, and the efficiency of light and nutrient utilization.

Literature Review

Food security is a global strategic issue encompassing the availability, access, utilization, and stability of food for all. In Indonesia, rice plays a crucial role as a staple food for over 95% of the population. Therefore, sustainable rice production is a key foundation for maintaining national food security. This article examines the concept of food security, the factors influencing rice production, and strategies for increasing the productivity and efficiency of rice farming. The discussion is based on an academic approach that connects social, economic, and environmental aspects within a sustainable agricultural system.

Rice-Based Food Security Strengthening Strategy

a. To strengthen national rice-based food security, an integrated strategy is required:
b. Production intensification: through increasing land productivity and input efficiency.
c. Land extensification: utilizing suboptimal land such as swamps and drylands.
d. Food diversification: reducing dependence on rice by developing other carbohydrate sources.

Technological innovation and agricultural digitalization: implementing smart farming and spatial data for planting and harvest planning. Farmer empowerment and village economic institutions: strengthening farmer groups, cooperatives, and market access.

The IR64 variety was selected because it is a high-yielding variety with a preferred taste, early maturity (approximately 115 days), and high yield potential. Therefore, this study aims to examine the interaction between tillage systems and plant spacing on the growth and yield of lowland rice (Oryza sativa L.) variety IR64.

Environmental Pollution: The excessive use of pesticides and fertilizers can contaminate water and soil; therefore, wise and environmentally friendly management practices are necessary.

Tillage affects plant growth because it is closely related to oxygen availability, soil moisture, and weed control. According to Hardjowigeno (2015), proper tillage can improve soil structure, allowing roots to develop more easily.

Tillage is a crucial initial step to ensure that maize plants can grow optimally and produce abundant yields. This process aims to create ideal soil conditions—such as a loose structure, good drainage, and sufficient nutrient availability for the plants.

Research Methodology

A Factorial Randomized Block Design (RBD) was used with two factors:

Factor I: Tillage System (P)

P1 = Plowing

P2 = Tractor

P3 = Hoeing

Factor II: Plant Spacing (J)

J1 = 30 × 20 cm

J2 = 30 × 30 cm

J3 = 30 × 40 cm

Observed Variables

1. Plant height (cm)
2. Number of tillers per clump
3. Leaf area (cm²)
4. Grain weight per clump (g)
5. Grain weight per plot (g)
6. Yield per hectare (ton/ha)

Data Analysis

Data were analyzed using Analysis of Variance (ANOVA) at a 5% significance level. When significant effects were found, the analysis was followed by the Least Significant Difference (LSD) test at the 5% level.

Results

5.1 Plant Height (cm)

The results showed that plant height and leaf area did not differ significantly between treatments. This aligns with the findings of Setyawan (2016), who stated that plant height is more influenced by genetic factors than by cultivation factors.

The average plant height at 8 weeks after planting due to the treatment of soil tillage and plant spacing, after being tested using the Duncan's Distance Test, is shown in Table 1.

Table 1. Interaction of Soil Processing System and Planting Spacing in Increasing the Growth and Productivity of Lowland Rice Plants (Oryza sativa L.) Plant Height 8 Weeks After Planting

Treatment	Plant Height (cm)	Notasi
P1J1	89,05	a
P1J2	90,03	a
P1J3	89,68	a
P2J1	89.59	a
P2J2	89.66	a
P2J3	90,02	a
P3J1	90,20	a
P3J2	89,70	a
P3J3	90,04	a

Numbers followed by the same letter in the same column indicate no significant difference at the 5% level (lowercase) based on the Duncan Distance Test (DMRT).

5.2 Number of offspring per clump

The number of tillers differed significantly between treatments. The combination of tillage using a tractor with wide spacing (30 × 30 cm and 30 × 40 cm) resulted in more tillers. This indicates that optimal spacing provides more growing space and reduces competition between plants (Suryanto, 2018).

Number of tillers per clump the significant differences are soil tillage treatment and rice plant spacing in the field. The number of tillers per clump due to soil processing and planting distance treatments, after being tested using the Duncan Distance Test, is shown in Tablel. 2

Table 2. Interaction of Soil Processing System and Planting Spacing in Increasing the Growth and Productivity of Lowland Rice Plants (Oryza sativa L.) Number of Tillers 8 Weeks After Planting

Treatment	Number of offspring	Notasi
P1J1	12.1	a
P1J2	13.2	ab
P1J3	13.4	ab
P2J1	14.5	bc
P2J2	15.6	c
P2J3	15.2	c
P3J1	12.3	a
P3J2	13.8	ab
P3J3	14.2	b

Numbers followed by the same letter in the same column indicate no significant difference at the 5% level (lowercase) based on the Duncan Distance Test (DMRT).

5.3 Leaf area (cm²)

Leaf area parameters showed insignificant differences, namely soil cultivation treatment and rice planting distance in the field. The number of tillers per clump resulting from soil cultivation treatment and planting distance, after being tested using the Duncan Distance Test, is shown in Table 3.

Table 3. Interaction of Soil Processing System and Planting Spacing in Increasing the Growth and Productivity of Lowland Rice Plants (Oryza sativa L.) Leaf Area 8 Weeks After Planting

Treatment	Leaf Area	Notasi
P1J1	384,2	a
P1J2	384,5	a
P1J3	384,2	a
P2J1	384,6	a
P2J2	384,3	a
P2J3	384,2	a
P3J1	384,6	a
P3J2	384,4	a
P3J3	384,4	a

Numbers followed by the same letter in the same column indicate no significant difference at the 5% level (lowercase) based on the Duncan Distance Test (DMRT).

5.4 Grain weight per clump (g)

The parameters of grain weight per hill showed no significant differences, namely the treatment of soil processing and rice planting distance in the field. The number of tillers per hill produced from the treatment of soil processing and planting distance, after being tested using the Duncan Distance Test, is shown in Table 4.

Table 4. Interaction of Soil Processing System and Planting Spacing in Increasing the Growth and Productivity of Lowland Rice Plants (Oryza sativa L.) on Grain Weight per Clump

Treatment	Grain weight per clump (g)	Notasi
P1J1	21.3	a
P1J2	23.5	ab
P1J3	24.2	ab

P2J1	25.5	bc
P2J2	28.8	d
P2J3	27.6	cd
P3J1	22.0	a
P3J2	24.6	bc
P3J3	25.8	bc

Numbers followed by the same letter in the same column indicate no significant difference at the 5% level (lowercase) based on the Duncan Distance Test (DMRT).

5.5 Grain weight per plot (g)

Table 5. Interaction of Soil Processing System and Planting Spacing in Increasing the Growth and Productivity of Lowland Rice Plants (Oryza sativa L.) on Grain Weight Per Plot

Treatment	Grain weight per plot	Notasi
P1J1	**520.0**	**a**
P1J2	**545.0**	**ab**
P1J3	**555.0**	**ab**
P2J1	**570.0**	**bc**
P2J2	**600.0**	**d**
P2J3	**590.0**	**cd**
P3J1	**530.0**	**a**
P3J2	**555.0**	**ab**
P3J3	**565.0**	**bc**

Numbers followed by the same letter in the same column indicate no significant difference at the 5% level (lowercase) based on the Duncan Distance Test (DMRT).

5.6 Yield per hectare (ton/ha)

The grain weight per hectare parameter showed significant differences, particularly among tillage treatments and rice spacing in the paddy fields. The number of tillers per hill produced by the tillage and spacing treatments, after being tested using the Duncan Distance Test, is shown in Table 6.

Table 6. Interaction of Soil Processing System and Planting Spacing in Increasing the Growth and Productivity of Lowland Rice Plants (Oryza sativa L.) in Grain Weight per Hectare

Treatment	Produk (ton/ha)	Notasi
P1J1	5.6	a
P1J2	6.0	ab
P1J3	6.2	ab
P2J1	6.5	bc
P2J2	7.5	d
P2J3	7.2	cd
P3J1	5.8	a
P3J2	6.3	bc
P3J3	6.6	bc

Numbers followed by the same letter in the same column indicate no significant difference at the 5% level (lowercase) based on the Duncan Distance Test (DMRT).

Discussion Result

6.1 Plant Height

The results indicated that plant height was not significantly affected by different soil tillage systems or planting spacings. This suggests that these factors did not directly influence the vertical vegetative growth of rice plants. Plant height is largely determined by the genetic potential of the IR64 variety and its physiological condition during the early growth phase. According to Sutoro et al. (2018), the height of rice plants is a relatively stable trait, mainly influenced by genetic factors rather than environmental conditions, unless extreme stress such as drought or nutrient deficiency occurs.

Furthermore, different tillage systems did not result in notable variations in soil aeration or water availability in the root zone, leading to a relatively uniform nutrient distribution that supports stem elongation (Arifin et al., 2020). Therefore, ploughing, tractor tillage, and hoeing provided comparable soil conditions for the vegetative growth of IR64 rice.

6.2 Number of Tillers

Significant differences were observed in the number of tillers due to variations in soil tillage systems and planting spacing. The combination of P2J2 (tractor tillage and 30×30 cm spacing) produced the highest number of tillers. Tractor tillage improved soil structure by enhancing aeration, water-holding capacity, and root proliferation, resulting in better tiller formation (Slamet et al., 2019).

A 30×30 cm spacing also proved to be optimal, providing sufficient space for light interception and reducing intra-plant competition. Sembiring and Sumarni (2021) noted that excessively narrow spacing increases competition for nutrients and light, whereas excessively wide spacing reduces the number of plants per unit area. Consequently, the combination of tractor tillage and moderate spacing created a balance between plant density and growth efficiency, leading to a higher number of productive tillers.

6.3 Leaf Area

Leaf area was not significantly affected by either soil tillage or planting spacing. This indicates that the photosynthetic capacity per plant remained relatively stable across treatments. Leaf area development depends mainly on nitrogen availability and light interception rather than spacing or tillage method (Fagi et al., 2017).

Additionally, the IR64 variety is known for having a moderate and stable leaf area index under various environmental conditions (Ismunadji & Suhartatik, 2019). Hence, despite differences in tillage systems and spacing arrangements, leaf area expansion remained statistically unchanged, suggesting that plants were able to maintain similar photosynthetic surfaces across treatments.

6.4 Grain Weight per Clump

Grain weight per clump was significantly affected by the interaction of tillage and spacing. The highest value was observed in treatment P2J2 (tractor tillage and 30×30 cm spacing). This result indicates that improved soil physical properties, achieved through tractor tillage, enhanced nutrient and water uptake efficiency during grain filling. According to Rahmawati et al. (2020), improved soil structure increases phosphorus (P) and potassium (K) absorption, both of which are essential for grain formation and filling.

Moreover, moderate spacing ensures optimal solar radiation distribution and reduces shading, leading to efficient photosynthesis and assimilate translocation to the panicles. Therefore, the significant increase in grain weight per clump under the P2J2 treatment reflects improved physiological efficiency supported by favourable soil and canopy conditions.

6.5 Grain Weight per Plot (1 m²)

Grain weight per plot showed a similar trend, with P2J2 producing the highest value (600 g/plot). This increase corresponds to higher productive tiller numbers and greater grain weight per clump. Hatta and Kadir (2021) stated that tractor tillage enhances soil porosity and reduces water loss, promoting root development and nutrient uptake.

The 30×30 cm spacing also provided an optimal balance between plant density and resource availability. This combination ensured maximum yield per unit area by integrating efficient plant growth with effective land utilisation. The P2J2 treatment, therefore, demonstrated a synergistic relationship between soil physical improvement and optimal plant spacing, resulting in superior yield performance.

6.6 Grain Yield per Hectare

Grain yield per hectare followed the same pattern, where the P2J2 treatment achieved the highest yield of approximately 6 tons ha^{-1}. This outcome indicates that combining an efficient soil tillage system with a balanced planting density enhances the utilisation of growth resources and land productivity.

Subekti et al. (2018) emphasised that rice yield is determined by a complex interaction among agronomic factors affecting photosynthesis and grain formation, such as soil aeration, nutrient availability, and the number of productive tillers. Tractor tillage accelerates organic matter decomposition and improves soil fertility, while moderate spacing provides the optimal plant population for maximum yield.

Overall, the results suggest that tractor tillage combined with 30×30 cm spacing (P2J2) offers the best agronomic approach for improving growth efficiency and yield performance of lowland rice variety IR64, significantly outperforming other treatments.

References

[1] Arifin, M., et al. (2020). *Pengaruh Sistem Pengolahan Tanah terhadap Pertumbuhan dan Hasil Tanaman Padi Sawah*. Jurnal Ilmu Pertanian Indonesia, 25(3), 145–152.

[2] Desi. S.P.S.S, Ahmad.N (2024). Strategi Pengembangan tanaman Pangan, hortikultura dan Obat Sebagai Urban Farming Untuk mencegah Mitigasi Bencana Perubahan Iklim di Kecamatan Medan Timur

[3] Fagi, A. M., et al. (2017). *Fisiologi Tanaman Padi di Lahan Sawah dan Tadah Hujan*. Balai Besar Penelitian Tanaman Padi.

[4] Hatta, A., & Kadir, A. (2021). *Pengaruh Jarak Tanam terhadap Produktivitas Padi di Lahan Irigasi*. Jurnal Agroteknologi, 15(1), 25–33.

[5] Hanafiah, K.A. (2010). Dasar-dasar Ilmu Tanah. Jakarta: Raja Grafindo Persada.

[6] Ismunadji, M., & Suhartatik, E. (2019). *Karakter Fisiologis Varietas Unggul Padi Indonesia*. Puslitbangtan.

[7] Marahadi. S, Sulardi (2018) Budidaya Tanaman Padi. Penerbit FE.UNPAB

[8] Marahadi. S, Sulardi (2019) Agribisnis Budidaya Tanaman Padi. Penerbit FE.UNPAB.

[9] Wasito.M, Najla.L, Sulardi (2025) Penggunaan Kotoran Sapi dan Urin Kambing untuk Budidaya Kedelai. Penerbit PT. Tri Selaras Cendikia

[10] Rahmawati, T., et al. (2020). *Respons Fisiologi Padi terhadap Ketersediaan Unsur Hara dan Struktur Tanah*. Jurnal Agroekoteknologi, 8(2), 77–84.

[11] Sembiring, M., & Sumarni, T. (2021). *Optimasi Jarak Tanam terhadap Hasil Padi Sawah Varietas Unggul Baru*. Prosiding Seminar Nasional Pertanian.

[12] Slamet, A., et al. (2019). *Hubungan Kondisi Tanah dan Pembentukan Anakan Padi*. Jurnal Ilmiah Pertanian, 10(1), 1–8.

[13] Subekti, N., et al. (2018). *Strategi Peningkatan Produktivitas Padi Melalui Pengelolaan Tanah dan Populasi Tanaman*. Jurnal Pengkajian dan Pengembangan Teknologi Pertanian, 21(2), 123–130.

[14] Sulardi, Wasito.M, Agnes.R.S (2024) Pupuk Multifungsi. Penerbit PT. Tri Selaras Cendikia.

[15] Sutoro, M., et al. (2018). *Stabilitas Karakter Agronomi pada Beberapa Varietas Padi*. Jurnal Agronomi Indonesia, 46(1), 54–61.

[16] Suryana, A. (2015). Teknik Budidaya Padi Sawah. Bandung: Alfabeta.

[17] Susanto, A. (2018). Pengaruh pengolahan tanah dan jarak tanam terhadap hasil padi sawah. Jurnal Agronomi Indonesia, 46(2): 85–92.

[18] Yoshida, S. (1981). Fundamentals of Rice Crop Science. International Rice Research Institute.

[19] Tharmizi. H, Sulardi, Wasito.M (2023) Analysis of the Utilization of Agricultural Waste Fermentation in Increasing Shallot Production