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Research Article

Improving Rice Productivity and Farmers' Incomes in South Sumatra Province with Superior Varieties and Jarwo 2:1

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Abstract.
Rice has become the government's focus to sustainably increase productivity. The applicable technological innovation to intensively increase rice productivity and farmers' income is using superior varieties and the jarwo spacing system. This study determines the productivity of some rice superior varieties by applying a jarwo 2:1 in irrigated paddy fields. The research lasted from April to August 2021 on a farmer's paddy field in Musi Rawas Regency, South Sumatra. The oversite design research involved 5 replications. The applied tested factors were: 1) superior variety implementation (Inpari 22, 32, and IR Nutri Zinc) and 2) the planted spacing (tiles 25 x 25 cm^2, and jarwo 2:1). The results showed an increment in the superior varieties of rice productivity using the jarwo 2:1 with a percentage of 38.8% for Inpari IR Nutri Zinc, a percentage of 31.5% for Inpari 32, and a percentage of 32.8% for Inpari 22. The jarwo 2:1 was more profitable than tiles, observable on 3.2 R/C ratio value and 3.5 MBCR value. Therefore, the jarwo 2:1 is very feasible to be widely developed in irrigated paddy fields.

Keywords: productivity, cultivation, IR nutri zinc, Jarwo

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1. Introduction

The National Rice Production Increase Movement (NRPIM) launched by the government, specifically the Ministry of Agriculture, aims to increase the national rice production and to fulfil the basic food necessity (rice) of the Indonesian people based on the increasing population growth. The general objective of national development is to achieve the welfare of the Indonesian people (farmers). Farmers' welfare goes along with the production level achievement and farmer income increment. Suparwoto and Waluyo [1] explain one of the efforts to increase rice production capacity is implementing superior rice cultivation technology.

Various research results on rice bring rice cultivation technology with the ultimate goal of increasing rice productivity and farmers' income. High productivity contributes to rice production increment, reaching to 56.1% [2,3]. The applicable efficient and effective technologies by farmers are – new superior variety seed and adaptive-specific location [4].

Appropriate cultivation technology supports the new superior rice variety and can increase the yields by 12.26-32.03% [5], 21-54% [6]. Inpari IR Nutri Zinc is a new superior special variety, while Inpari 22 and 32 are location-specific varieties produced by the Agricultural Research and Development Agency, Ministry of Agriculture. Inpari IR Nutri Zinc has a higher zinc content than other varieties that influence the growth and development; fight infections and minimize stunting [7]. Zinc content in the Inpari IR Nutri Zinc variety reaches 34.51 ppm [8]. Most farmers widely cultivate Inpari 22 and 32.

The application of jajar legowo (jarwo) spacing in rice cultivation could increase rice productivity. The principle of jarwo is to increase the plant population per unit area with the exact portion, 33.31%, by adjusting the spacing and manipulating the layout of plants. This procedure allows the clumps of plants become peripheral plants, a looser space to get sunlight, and better air circulation to facilitate weeding and fertilization [8-10].

The application of jarwo based on local environmental conditions increases rice productivity [11] and farmers' income [12,13]. Jarwo 2:1 (two rows, one aisle) with a spacing of 20 cm x 10 cm x 40 cm can increase rice productivity by 560-1,550 kg ha^{-1} compared to tile (20 cm x 20 cm) [14]. This method also increases harvest dry grains (HDG) by 1.32 t ha^{-1} compared to tile planting system [15]. The jarwo super rice technology package application can increase rice productivity by 84 percent [16].

Jarwo spacing technology is being intensively disseminated to farmers for further massive and wide adoption as observable on the Inpari IR Nutri Zinc variety. Therefore, this research aimed to increase the productivity of superior rice varieties through the application of jarwo 2:1 and assess the feasibility of the farming business.

2. Methodology

The research site was on 0.75 ha of irrigated rice fields in Ketuan Jaya Village, Muara Beliti District, Musi Rawas Regency, South Sumatra Province. The research was carried out at dry season I, namely in April to August (DS I) 2021. This is intended so that rice

plants still have a supply of water from rainfall at the end of the rainy season. Modelling results from Asfew and Bedemo [17] show that rainfall has a significant and positive impact on cereal crop production in both the long and short term, while temperature has a negative impact in the long term.

This Oversite research design used 2 factors and 5 replications. The tested factors were: 1) three rice varieties, such as Inpari IR Nutri Zinc (special variety), Inpari 22 and Inpari 32 (location specific variety), and 2) distance planting manipulation, such as, tile (25 cm x 25cm), and jarwo 2:1 (50 cm x 25 cm x 12.5 cm). In jarwo 2:1, 50 cm was the aisle distance; 25 cm was the inter-row distance; and 12.5 cm was the in-row distance. The number of clumps in the tile system was about 160,000 clumps per ha, while the number of clumps in jarwo 2:1 was about 213,300 clumps per ha.

The applied materials were 250 kg urea ha^{-1}, 200 kg NPK Ponska ha^{-1}, rice seeds (each variety 25 kg seeds ha^{-1}), insecticides, herbicides, sacks, and plastic sheeting. The applied tools, such as two-wheeled tractors, machetes, sickles, hoes, scales, and meters. The applied varieties were from the Sukamandi Rice Research Centre, Agricultural Research and Development Agency.

The researchers cultivated the soil with a two-wheel tractor until for planting. The researchers planted the seedlings at the age of 20 days after sowing; the spacing was tile (25 cm x 25 cm) and jarwo 2:1 (50 cm x 25 cm x 12.5 cm); and the number of seedlings was 3 stems per hole. The researchers administered the fertilizer twice. The first fertilizer administration was at the age of 7 days after planting (DAP), at the rate of 75 kg Urea ha^{-1} and 100 kg NPK Ponska ha^{-1}. The second fertilizer administration was at 30 DAP, at the rate of 75 kg Urea ha^{-1} and 100 kg NPK Ponska ha^{-1}. The researchers weeded for 2 to 3 times based on weed conditions in the field. The applied pest and plant disease control were chemical pesticides.

The observed parameters were plant height, number of productive tillers, panicle length, number of grains per panicles, number of pithy grains per panicle, and productivity. The researchers measured the productivity with a ubinan method. The size of the seedling for the tile system was 2.5 cm x 2.5 cm, and 3 cm x 4 cm for the jarwo 2:1 system. The productivity was then converted to t ha^{-1}.

The data analysis was the F-test at 5% level and DMRT test at 5% level. The financial feasibility analysis test used the calculation of Total Revenue (TR) and Net Revenue (NR). The calculation of TR and NR calculated the value of the R/C ratio and MBCR (Marginal Benefit Cost Ratio).

Here is the cost and revenue analysis formula:

NR = TR-TC (1)

TR = Tp x P (2)

TC = FC + VC (3)

description:

NR = Net Revenue

P = Price

TR = Total Revenue

FC = Fixed Cost

TC = Total Cost

VC = Variable Cost

Tp = Total Product

$$R/C = \frac{TR}{TC}$$

the criteria for the R/C ratio value are:

R/C >1, the farming business is economically profitable

R/C = 1, the farming business is economically at break-even point (BEP)

R/C < 1, the farming business is economically unprofitable (loss)

The following is the MBCR formula:

$$MBCR = \frac{TR\ of\ jarwo\ -\ TR\ of\ tile}{TC\ of\ jarwo\ -TC\ of\ tile}$$

criteria:

MBCR >1 = The application of technology introduction pattern is feasible

MBCR <1 = The application of technology introduction pattern is not feasible

Results and Discussion

The results of the analysis of variance found the jarwo 2:1 implementation significantly influenced the panicle length, while using superior varieties had a significant effect on panicle length and the number of pithy grains per panicle. The combination of the application of jarwo 2:1 and superior varieties provided an actual interaction on plant height, number of productive tillers, and HDG (Table 1). The result indicates that factors

of rice variety does not only influence HDG but also surrounding environmental factors, such as spacing techniques, influence the HDG. This is in line with the research results of Lestari et al. [18] that there is an interaction between the use of new superior varieties, the application of biological fertilizer and the planting system to increase rice yields.

The rice varieties, such as Inpari 22, 32, and IR Nutri Zinc, have a moderate plant posture (Table 2). The moderate posture of rice plants has a plant height of about 90-125 cm [19]. The Inpari IR Nutri Zinc variety that applies jarwo 2:1 has the highest plant posture compared to other varieties both planted using jarwo 2:1 and tile. However, the Inpari 32 variety has the same plant height whether it is planted in jarwo 2:1 or tile (Table 2). Therefore, the spacing arrangement has high influence on the growth plant (Table 1).

The jarwo 2:1 spacing has higher plant height than the tile (Table 2) due to the narrower spacing between rows. Narrow spacing causes competition for sunlight. Plants that lack light will elongate their stems and leaves. This situation leads to a higher plant posture than plants with full light [12,20]. The high posture of rice plants makes the plants to be susceptible to lodging and reduces rice productivity [21]. Therefore, a tall rice plant stem does not guarantee high productivity [22]. Short and stiff plant posture is one of the criteria in developing of superior varieties, to avoid plant lodging [4].

2.1. Variety of yield components

The Inpari 22, 32, and IR Nutri Zinc varieties grown with jarwo 2:1 and tile have panicle lengths in the range of 22.90-26.66 (Table 2). Farmers want rice that has long panicles because of the capability of producing a greater number of grains per panicle. Varieties strongly influenced panicle length and yield. Genetics factors strongly influenced the panicle length [23,24] and adaptability to the environment [25].

The number of grains per panicle was 147.73-178.90, and the number of pithy grains per panicle was 112.70-142.30 (Table 3). The highest number of productive tillers was observable on the Inpari 32 variety planted with tile spacing at 24.40 and the lowest by the Inpari 22 variety with tile spacing (Table 4).

The HDG of superior varieties with the jarwo 2:1 method had higher yields than tile. A previous study also found the same result [26]. The HDG increments of each variety planted with jarwo 2:1 was 31.5%, 38.8%, and 32.8% compared to tile (Table 4). The jarwo cropping system can increase productivity by 16.4% in Inpari 30 and Inpari 15

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TABLE 1: Anova table comparing plant height, number of productive tillers, panicle length, number of grains per panicle, number of pithy grains per panicle, and harvest dry grains under different varieties and plant spacing conditions.

Dependent variables	Plant height (cm)		Number of productive tillers		Panicle length (cm)		Number of grains per panicle		Number of pithy grains per panicle		Harvest dry grains	
	MS	F value	MS	F value	MS	F value	MS	F value	MS	F value	MS	F value
Varieties (V)	15,950	1.85^{ns}	63,033	30.44**	20,977	5.37*	2515,300	1.92^{ns}	2205,1	4.34*	8,457	3,964.32**
Plant spacing (S)	252,880	29.29**	9,63	4.65^{ns}	18,723	4.80*	5280,133	4.03^{ns}	2150,533	4.23^{ns}	21,386	10,024.6**
V x S	106,610	12.35**	24,633	11.90**	4,656	1.19^{ns}	1030,033	0.79^{ns}	929,433	1.83^{ns}	0,056	26.16**

*, ** Indicate significant difference at 0.05 and 0.01 probability levels, respectively; ns: nonsignificant results.

Table 2: Effect of several varieties and plant spacing on plant height and panicle length.

Variables	plant height (cm)		panicle length (cm)		
Factors	tile	jarwo	tile	jarwo	mean
Inpari 22	105.40 c	111.80 b	23.02	25.00	24.01 a
Inpari 32	110.60 b	109.60 b	22.90	25.60	24.25 a
Inpari IR Nutri Zinc	105.10 c	117.12 a	26.60	26.66	26.63 a
mean			24.17 a	25.75 a	(-)

Means followed by different letters are significantly different (DMRT, α = 0.05)

Table 3: Number of grains and number of pithy grains per panicle of several varieties and plant spacing.

Factors	Number of grains per panicle	number of pithy grains per panicle
Varieties:		
Inpari 22	155.40 a	112.70 a
Inpari 32	148.70 a	129.60 a
Inpari IR Nutri Zinc	178.90 a	142.30 a
Plant spacing:		
Tile	147.73 a	119.73 a
Jarwo	174.27 a	136.67 a

Means followed by different letters are significantly different (DMRT, α = 0.05)

varieties [27], and 23.18% in Inpari 6 [28]. Jarwo planting distance of 2:1 could not only increase the number of populations per hectare but also the circulation of sunlight and air. This situation influences the increasing yield of assimilates from the photosynthesis process [29].

Grain production is mostly influenced by the yield potential of the rice varieties [30]. Potential HDG from the highest to the lowest are from the Inpari IR Nutri Zinc, 22 and 32 varieties respectively at 9.9, 8.42, and 7.9 t ha^{-1} planted with the tile system [8]. Meanwhile, the results showed that the highest HDG was observable on the Inpari 32 variety, Inpari 22, IR Nutri Zinc planted in the jarwo 2:1 method of 10, 8.50, and 7.46 t ha^{-1} (Table 4). The results show the significant influence of environmental conditions and cultivation techniques on the variety. Sutardi et al. [31] state that the massive use of new superior varieties is one of the important drivers of agricultural growth in the future, in addition to the use of agricultural machinery and land or institutional reform.

The results of the correlation analysis showed that only the parameter of the number of pithy grains per panicle was strongly and positively correlated to HDG yield, with a value of R=0.8359. While the parameters of plant height, panicle length, number of

Table 4: Effect of several varieties and plant spacing on the number of productive tillers and harvest dry grains.

Variables	Number of productive tillers		Harvest dry grains (t ha-1)	
Factors	tile	jarwo	tile	Jarwo
Inpari 22	16.40 c	18.80 bc	6.40 e	8.50 b
Inpari 32	24.40 a	20.80 b	7.60 c	10.00 a
Inpari IR Nutri Zinc	21.60 b	19.40 b	5.44 f	7.46 d

Means followed by different letters are significantly different (DMRT, α = 0.05)

productive tillers, and number of grains per panicle did not correlate with HDG (Table 5).

Table 5: Correlation analysis between parameters observed.

Parameters	Number of productive tillers	Number of pithy grains per panicle
Number of grains per panicle	-0.3853	0.8359*
Harvest dry grains	0.0828	0.2096

2.2. Farming analysis

Production costs incurred in rice farming tile system is IDR 7,535,000 ha-1 season-1, higher than the production costs of rice farming by using technology jarwo 2:1 planting system is IDR 8,992,000 ha-1 season-1. The high production cost is due to the additional cost of production facilities and labor costs. The cost production increment of the jarwo 2:1 system, reached 30% compared to the seed requirement of the 25 kg ha-1 tile system, and the dose increment of fertilizer by 30%. The labor costs during planting and harvesting also increased. Harvest cost calculation applied a 7:1 bawon system, with 6 shares for the owner and 1 share for harvest labor.

The HDG obtained by farmers after deducting the bawon yield for Inpari 32, 22, and IR Nutri Zinc varieties were 8.35, 7.08, and 6.21 t HDG ha-1 season-1, respectively. The average of HDG grown in the jarwo 2:1 system was higher than the tile system at 7.22 and 5.54 t ha-1 season-1, respectively. The selling price of HDG was IDR 4,000 kg-1. The average revenue obtained with the jarwo 2:1 system was IDR 28,864,000 ha-1 season-1 and the average profit was IDR 19,872,000 ha-1 season-1. The profit reached 35.76% (IDR 5,234,000 ha-1 season-1) compared to the tile system (Table 6).

Rice cultivation using superior varieties (Inpari 22, 32, and IR Nutri Zinc) and jarwo 2:1 planting system has an R/C ratio value >1. The R/C ratio of rice cultivation of superior

TABLE 6: Farming costs of some varieties planted in tile and jarwo 2:1 system.

No	Description	Value	
		Tile	**Jarwo 2:!**
1	Saprodi cost (IDR)	2,775,000	3,092,000
2	Manpower cost (IDR)	4,760,000	5,900,000
3	Production cost (IDR)	7,535,000	8,992,000
	HDG (kg ha^{-1} $season^{-1}$)		
	Inpari IR Nutri Zinc	5,400	7,500
	Inpari 32	7,600	10,000
	Inpari 22	6,400	8,500
	mean	**6,466**	**8,666**
4	HDG (kg ha^{-1}) after deducting 7:1 *bawon*)		
	Inpari IR Nutri Zinc	4,629	6,214
	Inpari 32	6,515	8,350
	Inpari 22	5,486	7,084
	mean	**5,543**	**7,216**
5	Income (IDR)		
	Inpari IR Nutri Zinc	18,516,000	24,856,000
	Inpari 32	26,060,000	33,400,000
	Inpari 22	21,944,000	28,336,000
	mean	**22,173,000**	**28,864,000**
6	Profit (IDR)		
	Inpari IR Nutri Zinc	10,981,000	15,864,000
	Inpari 32	18,525,000	24,408,000
	Inpari 22	14,409,000	19,344,000
	mean	**14,638,000**	**19,872,000**
7	R/C		
	Inpari IR Nutri Zinc	2.4	2.7
	Inpari 32	3.4	3.7
	Inpari 22	2.9	3.1
	mean	**2.9**	**3.2**
8	MBCR		
	Inpari IR Nutri Zinc		3.3
	Inpari 32		4.0
	Inpari 22		3.4
	mean		**3.5**

HDG: harvest dry grains; price of HDG kg^{-1}: IDR 4,000

varieties with the tile system averaged 2.9 and the R/C ratio of jarwo 2:1 averaged 3.2 (Table 6). This shows that every cost expenditure of IDR 1.00 will get a revenue of IDR 3.20. The magnitude of the R/C value generated on the farm shows the amount of profit obtained by farmers [32]. The research results of Sumarno et al. [16] also show that the Jarwo Super technology package produces an R/C ratio of 3.99, which is higher than the existing rice farming with an R/C ratio value of 2.55. The average MBCR value generated reached 3.5. This shows that rice cultivation using superior varieties of Inpari 22, 32 and IR Nutri with the jarwo 2:1 system is feasible to be developed widely.

3. Conclusion

Rice cultivation of superior varieties using jarwo 2:1 spacing could increase the productivity of rice varieties Inpari 22, 32, and IR Nutri Zinc respectively for 32.8%; 31.5%, and 38.8% compared to the tile system. The application of jarwo 2:1 is more profitable than tile as seen in the R/C ratio value of 3.2 and MBCR value of 3.5. Therefore, jarwo 2:1 spacing is very feasible to be developed widely in irrigated rice fields.

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