Research article

On the Number of Seedlings for the System of Rice Intensification: Experiment Results from Lombok Island, Indonesia

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Received 4 October 2023 Accepted 28 December 2023 (*Corresponding Author)

Abstract The System of Rice Intensification (SRI) is an environmentally friendly and sustainable rice farming practice developed in the 1980s in Madagascar. It has spread to many countries in the early years of the 21st century, with Indonesia becoming one of the early adopters of SRI practices. The authors conducted experiments on SRI plots on Lombok Island, Indonesia, measuring water consumption, rice growth, GHG emissions and other variables. The focus of the current study was on accessing the appropriate number of seedlings under different irrigation regimes. This experiment prepared 30 small plots and set 2 types of irrigation: intermittent and continuous; 3 types of seedlings by nursery age: 0, 7, and 21 days; and 3 types of seedling groups: 1, 2, and 4 seedlings. At the harvest stage, the number of tillers, number of panicles, grain weight, filled grain weight, and root weight of 5 samples were measured from each plot. In terms of the irrigation method, intermittent irrigation achieved a higher yield than continuous irrigation. 2 seedlings achieved the best yield under intermittent irrigation, regardless of nursery age, while 4 seedlings achieved the best yield under continuous irrigation for both 7 day- and 21 day-old seedling types. In Indonesia, SRI promoters including local government and NPO staff recommend farmers to transplant one 7-day seedling. However, the experiment conducted in this study demonstrated that two day-old seedlings achieved better results. The two-seedlings method costs twice as much as the one-seedling method, but is only about half the cost of the traditional method. Moreover, the two-seedlings method gives farmers peace of mind at the transplant stage. The two-seedling method can thus be considered more reasonable than the one-seedling method.

Keywords system of rice intensification, number of seedlings, intermittent irrigation, yield

INTRODUCTION

The System of Rice Intensification (SRI) is an environmentally friendly and sustainable rice farming practice developed in the 1980s in Madagascar. This practice can reduce resources, such as irrigation water, chemical fertilizer, number of seedlings by keeping and sometimes increasing the yield of rice. It has spread to many countries in the early years of the 21st century. Indonesia is one of the early diffused countries and many farmers adopted this practice (Sato, 2006; Sato, 2007).

In Indonesia, SRI promoters of local government and NPO recommend farmers to transplant One 7-day seedlings. However, farmers are very afraid of less growth, and they often transplant two seedlings although they were taught to transplant one.

Previous research has shown that the adoption of intermittent irrigation reduced water use but not yield (Shimizu et al., 2007). However, a deeper consideration of the appropriate number of seedlings was needed. So, the authors made an SRI Experimental station at Puyung village, Lombok Island of Indonesia, and executed an experiment to identify an appropriate number of seedlings, measuring water consumption, rice growth, GHG emissions and other variables.

OBJECTIVE

The authors set the objective to identify which number of seedlings would be appropriate in conventional rice growing and in the System of Rice Intensification.

METHODOLOGY

The experiment involved setting up 30 small plots of size 5.0 m x 2.5 m (Fig. 1) and applying a number of different experimental treatments, including 2 types of irrigation: intermittent and continuous; 3 types of seedlings by nursery age: 0, 7, and 21 days, and 3 types of seedling groups: 1, 2, and 4 seedlings. The most popular rice variety in the area around the experiment station, Ciherang rice, was planted. The spacing of each seedling was 25 cm by 25 cm and irrigated each plot as an irrigation schedule (Table 1). At the growing stage, the number of tillers and height of 5 samples from each plot are precisely measured every week. At the harvest time, the number of panicles, grain weight, filled grain weight, and root weight of 5 samples from each plot. Also, grain weight with moisture content is measured in each plot. Grain weight was converted to yield (t/ha) at 14% moisture.

Fig. 1 View of experimental plots

Table 1 Setup of the experiment

Treatment		D1	D2	D4	S1	S2	S4	T1	T2	T4	N1	N2	N4	C1	C2	C4
Nursery	Direct seeding	○	○	○												
	7 days				○	○	○				○	○	○			
	21 days							○	○	○				○	○	○
Irrigation	Continuous										○	○	○	○	○	○
	Intermittent	○	○	○	○	○	○	○	○	○						
Number of Seedlings	1	○			○			○			○			○		
	2		○			○			○			○			○	
	4			○			○			○			○			○
Repetition	2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Table 2 Variety characteristics of Chiherang

Growing period	116 ~ 125 days
Average 1000-grain weight	28 g
Average number of tillers	14 ~ 17 tillers
Average plant height	107 ~ 115 cm
Average yield	6.0 t / ha
Yield potential	8.5 t / ha

Note: Data from Suprihartno et al., 2006

Seedlings for all plots were transplanted on May 17th, 2007. Rice variety is a local high-yield variety called Chiherang, which is widely cultivated on Lombok Island. Characteristics of Chiherang

are summarized in Table 2.

RESULTS AND DISCUSSION

Weather and Irrigation

In this experiment, the sowing and harvesting dates were aligned. Sowing took place on 5 December 2007. Direct sowing was fielded on that day, 7-day seedlings were transplanted to the main field after 7 days in the nursery, as were 21-day seedlings. The harvest date was 8 April 2008 in every plot.

It was the rainy season and there was occasional precipitation. The total precipitation for the 118 days until harvest was 1,286 mm. During the experiment, the average temperature was 30.1 degrees, and the relative humidity was 60.2%.

Intermittent irrigation is applied until the end of the vegetative growth stage, about 60 days after transplanted, and after this water depth is also kept shallow (1-2 cm water depth) until stopping water to harvest, while conventional irrigation uses continuous flooding with deep water (4-5 cm water depth) (Fig. 2).

Treatments are two irrigation patterns, three seedlings, and three transplanting methods, a total of 15 treatments l duplicated two times, are prepared. A control plot was also prepared.

For all plots, seedling age, spacing, weeding method, fertilizer amount, and variety of rice are selected to match for local rice cultivation method. Fertilizers are chemical fertilizers standing on the position SRI technology does not include the application of compost. Weeding for 15 treatment plots was done 3 or 4 times depending on weed condition.

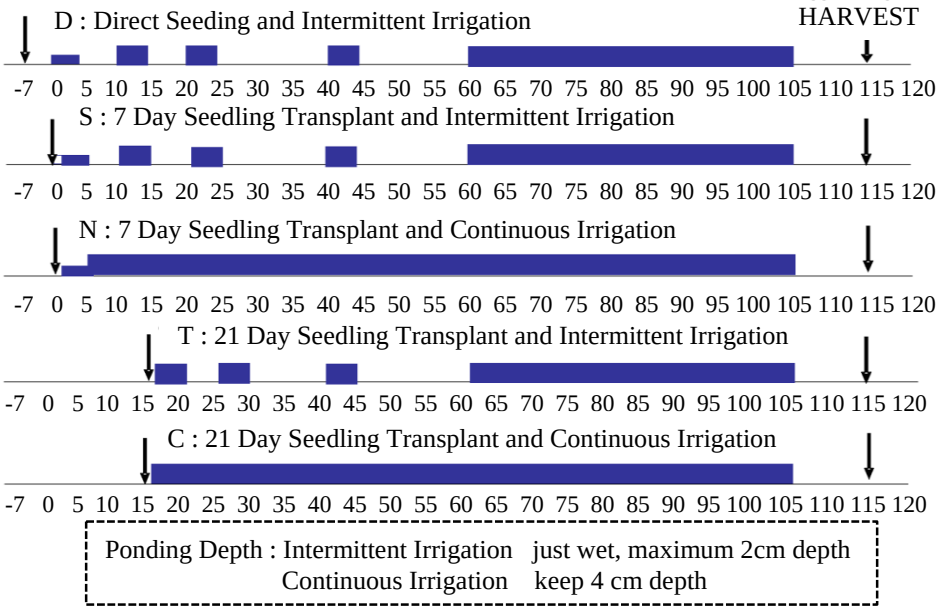

Fig. 2 Irrigation schedule (2007/2008 rainy season)

Growth

Rice seedlings were planted in each plot at 200 rice plant hills. Measurements of height and stem number were taken weekly on five plant hills in the middle of the plot. After the earing stage, the number of tillers is also counted. Changes in the number of tillers are shown in Fig. 3. One seedling set (D1, S1, N1, T1, C1) starts with one seedling, two seedlings set (D2, S2, N2, T2, C2) with two seedlings and four seedlings set (D4, S4, N4, T4, C4) with four seedlings. The seedlings then grow and divide by earing. The number of tillers declines after the maximum tillering period. The number of tillers at harvest time was almost all between 15 and 20.

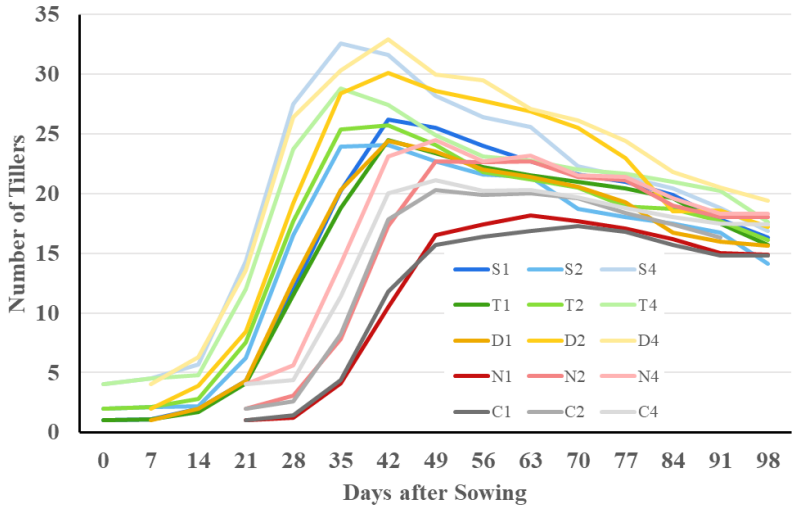

Fig. 3 Number of tillers

The plant height is shown in Fig. 4. Although plant height was low in the nursery due to dense cover, growth was vigorous after transplanting, with almost all reaching 130-140 cm at harvest time.

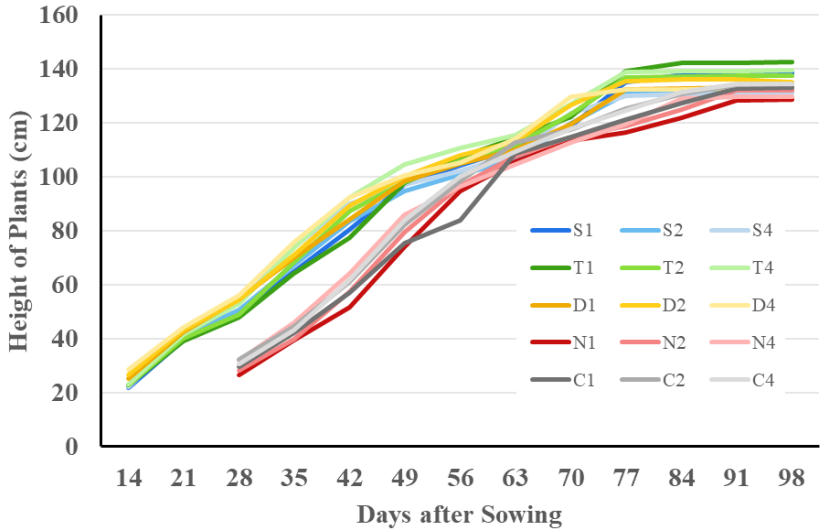

Fig. 4 Height of rice plant

Yield and Components

At the harvest, the number of tillers, number of panicles, grain weight, filled grain weight, and root weight of 5 plant hills from each plot are measured. One plant hill produces 43-73 grams of grains, meaning 1500-2600 grains. To identify 1000 grains' weight, sampled grains are well mixed, and 20-30% of grains are used for counting. By this method, 1000 grains weight from each plot was calculated.

From this measurement, the following was revealed. The intermitted irrigation group (D, S, T) had a few fewer panicles but greater grain weight, which was attributed to the fact that each grain was larger and heavier. It was revealed that the roots of the intermitted irrigation group were very heavy. Especially, the root weight of treatment D4 were several times heavier than in continuous irrigation. This suggests that many roots grow deeper under intermittent irrigation, which is presumed to be the reason for the higher growth. The comparison between seedling numbers did not show a clear difference.

Table 3 Details of rice plant at the harvest time

Treatment	Number of tillers	Number of panicles	Grain weight (gr)	Filled grain weight (gr)	Root weight (gr)	Sample grains			
						Weight (gr)	Number	Moisture (%)	Weight of 1000 grains (gr)
D1	16.3	15.2	63.1	61.8	24.4	16.4	561.3	23.4	29.2
D2	17.9	17.4	64.5	62.5	20.3	15.8	517.7	22.9	30.5
D4	20.6	19.4	73.5	72.3	43.0	15.9	523.9	22.8	30.3
S1	15.7	14.8	50.9	48.9	16.4	20.0	784.3	23.4	25.4
S2	12.9	12.7	53.8	52.8	19.1	19.3	583.5	23.3	33.1
S4	15.0	14.7	50.8	48.2	23.2	20.5	731.5	23.3	28.1
T1	16.8	15.8	53.8	50.8	19.9	20.9	824.4	23.6	25.3
T2	19.6	15.9	52.9	51.1	23.7	18.2	658.6	23.5	27.6
T4	18.5	17.4	59.2	57.4	21.0	21.4	751.0	23.1	28.6
N1	14.7	14.6	45.8	43.9	8.7	12.4	512.7	22.7	24.2
N2	18.0	17.3	50.6	48.3	10.5	10.8	445.0	23.5	24.2
N4	18.9	17.6	60.4	58.8	10.7	14.3	595.7	21.5	24.0
C1	14.8	14.3	43.5	42.1	7.9	13.6	558.7	23.2	24.4
C2	16.4	16.2	49.4	47.0	10.1	16.9	705.4	22.5	23.9
C4	18.0	17.4	43.7	42.0	7.4	11.4	485.4	21.7	23.4
D, S, T	17.0	15.9	58.1	56.2	23.4	18.7	659.6	23.2	28.7
N, C	16.8	16.2	48.9	47.0	9.3	13.2	550.5	22.5	24.0
1	15.7	14.9	51.4	49.5	15.5	16.6	648.3	23.3	25.7
2	17.0	15.9	54.2	52.3	16.8	16.2	582.0	23.1	27.9
4	18.2	17.3	57.5	55.7	21.0	16.7	617.5	22.5	26.9

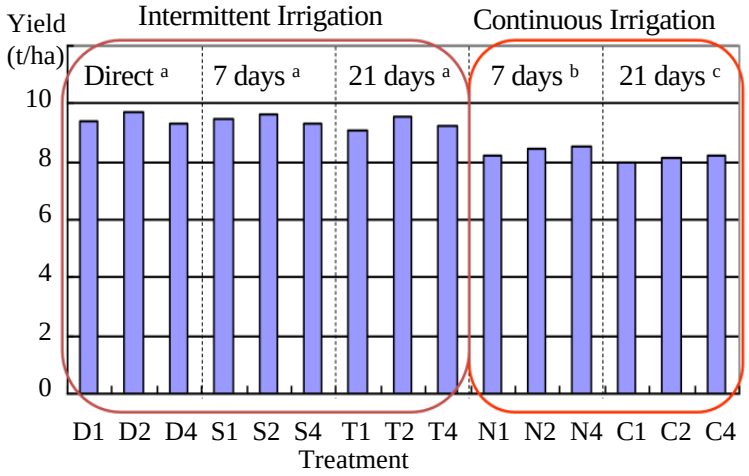

Fig.5 Yield of each treatment

After measuring five plant hills in detail, the rest 195 plant hills were harvested from the entire plot. There are 2 plots for each treatment and the average yield is shown in Fig. 5.

From these results, intermittent irrigation produces greater yields than continuous irrigation. On the number of seedlings, 2 seedlings achieved the best yield in intermittent irrigation and 4 seedlings achieved the best yield in continuous irrigation. Comparison between the five groups shows that 3 groups of intermittent irrigation achieved best, 7 days seedling in continuous irrigation was second-, and 21-days seedling in continuous irrigation was third. All comparisons are statistically significant at the risk of 5%.

CONCLUSION

The results of this experiment showed that in continuous irrigation, two seedlings were better than

one, and four seedlings were better than two in terms of yield. In traditional farming, the number of transplanted plants is 3-5. As a result, the correctness of the farmers' choice of number of seedlings in traditional farming methods was proved as rational.

In intermittent irrigation, the highest yield was obtained with two seedlings. The two-seedling method needs two times the cost of seedlings than one seedling method. However, this method costs about half the cost compared with the traditional method. Moreover, two seedlings method gives farmers peace of mind or a sense of security during the transplant stage. So, this method is to be said as more reasonable than one seedling method. We need to execute this experiment in every place where the SRI method is introduced.

ACKNOWLEDGEMENTS

The authors are deeply grateful for the support of the DISIMP team, Mr. Bagus Santika, and team members.

REFERENCES

Sato, S. 2006. An evaluation of the System of Rice Intensification (SRI) in Eastern Indonesia for its potential to save water while increasing productivity and profitability. International Dialogue on Rice and Water: Exploring Options for Food Security and Sustainable Environments, IRRI, Los Baños, Philippines, March 7-8, 2006, Retrieved from URL http://sri.ciifad.cornell.edu/countries/indonesia/wwfindosato06.pdf

Sato, S. 2007. 4 Years experience with SRI practice under DISIMP in Eastern Indonesia. Decentralized Irrigation System Improvement Project in Eastern Region of Indonesia Report.

Sato, S., Yamaji, E. and Kuroda, T. 2011. Strategies and engineering adaptions to disseminate SRI methods in large-scale irrigation systems in Eastern Indonesia. Paddy and Water Environment, 9, 79-88, Retrieved from DOI https://doi.org/10.1007/s10333-010-0242-2

Shimizu, K., Yamaji, E., Sato, S., Budiharto, P.S. and Mizoguchi, M. 2007. Sustainability of system of rice intensification, Benefits of SRI focusing on effects of intermittent irrigation on yield increase and water saving. Proceedings of the 6th International Conference on Sustainable Rural Development and Management, 25-37.

Suprihartno, B., Dradjat, A.A., Satoto., Baehaki, S.E., Widiarta, N., Setyono, A., Indrasari, S.D., Lesmana, O.S., Sembiring, H. 2006. Deskripsi varietas. Balai Besar Penelitian Tanaman Padi, 15. (in Indonesian)