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Research Article
Effect of Flooding Time Length Before Rice Planting in System of Rice Intensification Method

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Abstract
Background and Objectives: System of rice intensification (SRI) is a method of rice cultivation which has proven to increase the rice yield in comparison with the conventional method. One of main problem in SRI cultivation is weeds. Hence, this research was aimed to study the influence of several land flooding time on weeds, growth and yield component of rice. **Materials and Methods:** The research design was randomized block design in split-plot. The main plot was the land flooding time before planting in 7, 14, 21 and 28 days. The subplot was the three rice varieties, Pandan Wangi, PB 42 and Kuranji 012. Each treatment consisted of 3 blocks. The study was carried out in rice field in Koto Tangah, Padang, west Sumatera, Indonesia and Laboratory of Agronomy, Faculty of Agriculture, Andalas University, Indonesia from April-October, 2018. **Results:** The result showed 14 weeds species from 10 families found in the field. Based on Summed Dominance Ratio (SDR), *Portulaca oleracea* was the dominant species (37.10%). The productivity of Pandan Wangi variety was 11.18 t ha^{-1}, PB-42 variety 10.23 t ha^{-1} and Kuranji 012 7.90 t ha^{-1}. **Conclusion:** The land flooding time influenced the plant height, length of panicle and total grain/panicle. For yield components, the land flooding influenced the average of weight of 1000 grains, production per plot and productivity.

Key words: Rice intensification, land flooding, Pandan Wangi, summed dominance ratio, *Portulaca oleracea*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice (*Oryza sativa* L.) is main staple food and more than half of global population consume it especially in Asia[1]. In developing countries, rice provides 27% of dietary energy and 20% of dietary protein for people's daily life[2]. Indonesia is one of country where rice is main staple food for its majority population[3].

The problem faced by Indonesia is that it has to import rice from other countries such as Thailand and Vietnam up till now. However, this issue can be solved by using System of Rice Intensification Method (SRI)[4]. System of rice intensification (SRI) is a rice cultivation method that was developed in Madagascar which increased rice productivity with reducing external input like fertilizer and herbicide[5]. This method could provide higher yields with fewer inputs than conventional methods including irrigation water[6]. This method could increase yield up to two times or more because of land and water management, with wider spacing (25×25 cm), seedlings planted one point per planting point, seedling age is shorter (7-15 days) and the soil is moist until hair cracks during the vegetative phase. Several studies reported that SRI method can provide yields of dry grain up to 10 t ha^{-1}, while rice production in west Sumatra only reached[7] 4.6 t ha^{-1}.

West Sumatera is one of region in Indonesia which is the rice producer in Sumatera Island[8]. This condition makes the demand of rice from other regions in this island increases every year. The SRI method has been adopted by west Sumatera farmers[9] since 2005. One of main problem in SRI cultivation is weeds[10]. Moist land is suitable condition for weed growth. This condition causes the farmers reluctant to control the weeds and the cost is expensive. Due to these problems, the SRI method is not adopted widely by farmers. There are many ways conducted by farmers to control weeds such as mechanical, biological pesticide even synthetic pesticides, but these ways are still not effective to control the weeds. For overcoming this problem, an alternative way is required such as sludging. Sludging is breakdown of soil aggregate into smaller pieces in standing water[11]. This condition causes the weed seeds die as the seed weeds can't absorb oxygen in standing water[12,13]. The previous report has not reported the effect of length of land flooding to vegetation of weed and growth and yield of rice especially in System of Rice Intensification method yet. Hence, this study aimed to analyze the effect of several flooding time to vegetation of weed, growth and yield components of rice in SRI method.

MATERIALS AND METHODS

Experimental sites: The study was carried out in rice field in Koto Tangah, Padang, west Sumatera, Indonesia and Laboratory of Agronomy, Faculty of Agriculture, Andalas University, Indonesia (April-October, 2018). The materials were used seeds of Pandan Wangi, PB 42 and 012 Kuranji. Rice seeds were obtained from the collection of Department of Agronomy, Faculty of Agriculture, Andalas University.

Research methodology

Vegetation of weed: The purposive random sampling was used to take weed from the field. Five plots sized 1×1 m were chosen randomly as samplings. The collected weeds were then carried to Laboratory of Agronomy, Faculty of Agriculture Andalas University, Indonesia for identification.

Analysis of effect of land flooding length to growth and yield components of rice: Randomized block design in split-plot was used for this assay[14]. The main plot was the flooding time before planting in 7, 14, 21 and 28 days. The sub-plot was rice varieties (Pandan Wangi, PB 42 and 012 Kuranji). Each treatment consisted of 3 blocks. Rice plant which planted in field sized 2×1 m used as plot to measure the yield in this assay.

Procedures: The seeds of three rice varieties were grown in sowing field (sized 3×3 m). The seeds were grown until 12 days after planting (DAP). After 12 DAP (days after planting), the seedlings were moved to main plot to plant. The field sized 20×20 m was used in this assay. Four plots for 28, 21, 14 and 7 days flooding time sized 10×10 m were prepared. The water was flooded for 28 days plot. After 7 days, the water was flooded for 21 days plot. After 7 days, the water was flooded for 14 days plot and finally after 7 days later, the water was flooded for 7 days plot. The rice seedlings were planted in same time for all plots. The rice seedlings were planted in space 25×25 cm. Urea fertilizer (0.42 g/plant) was applied 3 times, on planting time, 32 DAP and 49 DAP. The TSP and KCl fertilizer (0.625 g/plant) were only applied in planting time. The rice was seedlings were observed every day until the yield of rice were obtained. The weeds grew in sampling plot were carried to the Laboratory of Agronomy to identify. The weight of weed also was measured.

Parameters observed: The parameters were observed vegetation, dry weight, Summed dominance ratio (SDR) of weed, growth and yield of components of rice. The SDR was calculated by calculating the absolute density, relative density, absolute frequency and important value index. The formulas follow[15]:

Absolute density (AD): Number of individual of certain species on sample plots:

$$\text{Relative density (RD)} = \frac{\text{Absolute density}}{\text{Sum absolute density}} \times 100\%$$

Absolute frequency (AF): Number of sample plots containing certain species:

$$\text{Relative frequency} = \frac{\text{Relative frequency of certain species}}{\text{Sum relative frequency of all species}} \times 100\%$$

$$\text{Important value index (IVI)} = \text{Relative density (RD)} + \text{Relative frequency (RF)}$$

$$\text{Summed dominance ratio (SDR)} = \frac{\text{Relatived density (RD)} + \text{Relative frequency (RF)}}{2}$$

The growth components of rice that were measured the plant height (cm), length of panicle (cm) and total of grain/panicle. For yield components, the parameters that were measured the weight of 1000 grains (g), production per plot (kg/2 m^2) and productivity (t ha^{-1}).

Statistical analysis: The statistical analysis was conducted by using two-way ANOVA Statistic 8 Program. A significance difference among the treatment then followed by Duncan Multiple Range Test (DNMRT) at 5% level of probability.

RESULTS

Weed vegetation: The result showed that 14 weed species from 10 families was found in the field (Table 1). The weed composition were *Ageratum conyzoides*, *Borreria laevis*, *Cyperu iria*, *Cyperus kyllingia*, *Dactyloctenium aegyptium*, *Echinocloa crussgalii*, *Eleocharis acicularis*, *Ipomea aquatica*, *Marsilea crenata*, *Mimosa pudica*, *Monochoria vaginalis*, *Paspalum distichum*, *Portulaca oleracea dan Sida acuta*. *Portulaca oleracea* was dominant species than others (37.10%). This species almost found entire area of field. The second dominant species was *Monochoria vaginalis* (18.24%).

Summed dominance ratio (SDR) of weed: The experimental field was dominated by *Portulaca oleracea* (Number 13, SDR: 37.10%) (Fig. 1). The dominant species were

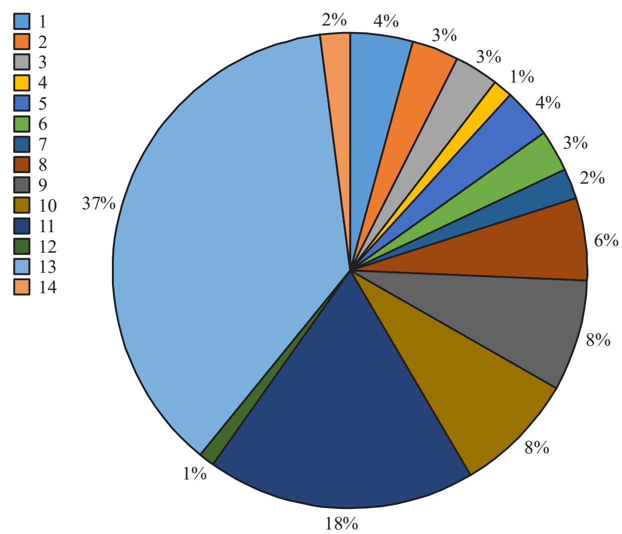

Fig. 1: Comparison of summed dominance ratio of weeds in field. 1: *Ageratum conyzoides*, 2: *Borreria laevis*, 3: *Cyperus iria*, 4: *Cyperus kyllingia*, 5: *Dactyloctenium aegyptium*, 6: *Echinocloa crussgalii*, 7: *Eleocharis acicularis*, 8: *Ipomea aquatica*, 9: *Marsilea crenata*, 10: *Mimosa pudica*, 11: *Monochoria vaginalis*, 12: *Paspalum distichum*, 13: *Portulaca oleracea*, 14: *Sida acuta*

Table 1: Vegetation, Summed dominance ratio (SDR) and dry weight of weed

Number	Species	Families	Local names	Summed dominance ratio (%)	Dry weight (kg)
1	*Ageratum conyzoides*	Asteraceae	Babandotan	4.24	0.31
2	*Borreria laevis*	Passifloraceae	Kancing ungu	3.21	0.90
3	*Cyperus iria*	Cyperaceae	Jekeng	2.97	0.20
4	*Cyperus kyllingia*	Cyperaceae	Wedulan	1.32	0.22
5	*Dactyloctenium aegyptium*	Poaceae	Tapak Jalak	3.42	0.31
6	*Echinocloa crussgalii*	Poaceae	Jajagoan	2.85	0.31
7	*Eleocharis acicularis*	Cyperaceae	Rumput kecil	2.01	0.34
8	*Ipomea aquatica*	Convolvulaceae	Kangkung	5.65	1.42
9	*Marsilea crenata*	Marsilaseae	Semanggi Air	7.56	0.96
10	*Mimosa pudica*	Fabaceae	Putri malu	8.34	1.02
11	*Monochoria vaginalis*	Pontederiaceae	Eceng padi	18.24	1.84
12	*Paspalum distichum*	Poaceae	Asinan	1.04	0.54
13	*Portulaca oleracea*	Portulacaceae	Kerokot gelang	37.10	3.12
14	*Sida acuta*	Malvaceae	Siduri	2.05	0.63
Total				100.00	

Table 2: Growth components of 3 rice varieties in several flooding time

Flooding time (days)	Plant height (cm)			Length of panicle (cm)			Total of grain/panicle		
	Pandan Wangi	PB 042	Kuranji 012	Pandan Wangi	PB 042	Kuranji 012	Pandan Wangi	PB 042	Kuranji 012
7	99.17^{Aa}	71.17^{Ca}	79.67^{Ba}	27.13^{Aa}	26.73^{Aa}	28.93^{Aa}	143.75^{Ab}	137.25^{Aa}	156.00^{Aa}
14	91.00^{Ab}	71.00^{Ca}	81.80^{Ba}	29.50^{Aa}	15.15^{Cd}	22.33^{Bb}	124.25^{Ac}	65.25^{Bc}	71.75^{Bc}
21	112.80^{Aa}	68.90^{Ca}	87.50^{Ba}	29.50^{Aa}	19.08^{Bc}	20.88^{Bb}	156.00^{Aa}	61.50^{Bc}	74.75^{Bc}
28	110.20^{Aa}	73.90^{Ca}	83.80^{Ba}	28.95^{Aa}	21.98^{Bb}	21.50^{Bb}	131.50^{Ac}	77.25^{Abb}	86.75^{Ab}
	KK A = 3.25%			KK A = 5.74%			KK A = 5.26%		
	KK B = 8.13%			KK B = 8.77%			KK B = 36.93%		

Different letters indicate a significant difference (p>0.05) (uppercase was compared in row, lowercase was compared in column)

Table 3: Yield components of 3 rice varieties in several flooding time

Flooding time (days)	Weight of 1000 grains (g)				Production per plot (kg/2 m^2)				Productivity (t ha^{-1})			
	Pandan Wangi	PB 042	Kuranji 012	Average	Pandan Wangi	PB 042	Kuranji 012	Average	Pandan Wangi	PB 042	Kuranji 012	Average
7	26.81	21.86	19.54	22.73^{a}	2.31	2.09	1.68	2.02^{a}	11.55	10.45	8.40	10.13^{a}
14	25.65	20.33	19.99	21.99^{a}	2.42	2.02	1.56	2.00^{a}	12.10	10.10	7.80	10.00^{a}
21	26.12	22.68	20.01	22.93^{a}	2.01	1.98	1.63	1.87^{a}	10.05	9.90	8.15	9.37^{a}
28	26.31	21.97	19.87	22.71^{a}	2.21	2.10	1.45	1.92^{a}	11.05	10.50	7.25	9.60^{a}
Average	26.22^{A}	21.71^{A}	19.85^{B}		2.23^{A}	2.04^{B}	1.58^{B}		11.18^{A}	10.23^{A}	7.90^{B}	
	KK A = 8.46%				KK A = 7.18%				KK A = 10.53%			
	KK B = 13.47%				KK B = 10.30%				KK B = 13.78%			

Different letters indicate a significant difference (p>0.05) (uppercase was compared in row, lowercase was compared in column)

followed by *Monochoria vaginalis* (Number 11, SDR: 18.24%). 3 weeds species, *Mimosa pudica* (Number 10, SDR: 8.34%), *Marsilea cranata* (Number 9, SDR: 7.56%) and *Ipomea aquatica* (Number 8, SDR: 5.65%) were more dominant instead of 9 another weed.

Growth components: The growth components of rice generally were influenced by flooding time before planting. The result showed height of plant was influenced by flooding time. Pandan Wangi variety was the best variety instead of 2 other varieties. For in same variety, generally, plant height was not significantly affected by flooding time (Table 2).

Length of panicle of 3 varieties tested was influenced by flooding time. Pandan Wangi was the best variety in this case. In same variety, the flooding time also influenced the length of panicle. For total of grain/panicle, it was influenced by flooding time. For PB 042 variety, 7 days flooding was the best treatment. For Kuranji 012 variety, 7 and 28 days flooding time were the best varieties for total grains/panicle (Table 2).

Yield components: Generally, weight of 1000 grains, production per plot and production/hectare were not influenced by flooding time (Table 3). The difference occurred in average of result. Pandan Wangi and PB 042 were the best variety than Kuranji 012. The difference also occurred in average of each variety in production per plot. Pandan Wangi variety was the best variety instead of PB 042 and Kuranji 012 varieties. Productivity of yield was influenced by the production per plot.

DISCUSSION

The result of this study showed the number of weed in the field was different to several previous research. Kurniadie *et al.*[16] reported 9 weed were found in the field in conventional method and 7 weed were found in the organic method. Other result reported that 16 weed species were found in the rice field[17]. Different results were due to several factors which affected weed diversity such as the type and degree of soil fertility, temperature, altitude, cultivation method, seeding method, water management, soil treatment and weed control technique[16,18]. Weed distributors were carried out with the help of wind, water, animal and human[19].

Flooding time influenced the rice plant height. Pandan Wangi became a best variety in plant height. Previous report reported that plant height of Pandan Wangi variety[20] was 118.78 cm. The different results was influenced by genetic factor of rice. Genetic factor played a important role to plant height[21]. The plant height variation occurred due to each variety had different genetic characteristic. It was caused by the certain genes controlled that character. A gene, called *OsMPH1* was reported to controlled the plant height of rice[22]. The different genetic structure was a factor that caused the plant height varied. Manjunatha *et al.*[23] also stated that the length of panicle was not influenced by seed, but it was influenced by genetic factor of rice variety.

Length of panicle of Pandan Wangi in previous report was recorded[20,24] 24.33 cm and 22.67 cm. First result was not significantly different but the second result was different to this study result (29.50 cm). Length of panicle in SRI method was better than conventional method. In SRI method, one plant per hole increased the length of panicle. It is due to there was no competition to get sunlight among the plants[25]. Length of panicle was influenced by many genes that controlled the genetic characteristic of rice plant. One of gene that reported was OsGRF4[26].

Growth components influenced the yield components of rice. Yield components is decisive thing for analyzing the character of a rice species. The result showed the weight of 1000 grains was not significantly different. The different occurred in average. Pandan Wangi variety was the best variety for weight of 1000 grains. Other report recorded that the weight of 1000 of Pandan Wangi Variety[27,20] was 26.81 g and 27.5 g. The different of grain weight was caused by genetic factor. Each variety had certain characteristic that caused the grain weight. The grain weight depended on *palea* and *lemma* size. It indicated the stability of an variety and it was determined by *palea* and *lemma* size. These size were regulated by a gene called OsMADS34[28].

Weight of grain influenced the production of rice. Pandan Wangi was the best variety for production per plot (2.23 kg/2 m^2) or 11.15 t ha^{-1}. This result was different from the yield when 2 seedlings were planted in one hole (5.11 t ha^{-1})[20] and when organic matter was applied (4.54 t ha^{-1})[27]. The different yield was due to planting one seedling per hole caused the space of growth wider and the plant phyllochron was performed optimally[29]. The different yield was caused internal factor such as; genetic factor or derivative characteristic such as; age of plant, plant morphology, yield potency, storage capacity, food reserve and resistance to pest and disease[30]. To solve the problem of weed control and avoiding the synthetic pesticide, Pandan Wangi and PB 042 varieties in 21 days flooding time before planting are recommended to use in SRI method to increase the yield of rice.

CONCLUSION

Fourteen species of 10 families of weed were found in the field before land flooding. They were *Ageratum conyzoides*, *Borreria laevis*, *Cyperu iria*, *Cyperus kyllingia*, *Dactyloctenium aegyptium*, *Echinocloa crussgalii*, *Eleocharis acicularis*, *Ipomea aquatica*, *Marsilea crenata*, *Mimosa pudica*, *Monochoria vaginalis*, *Paspalum distichum* and *Portulaca oleracea dan Sida acuta*. *Portulaca oleracea* was the most dominant species than others (SDR: 37.10%). Generally, the growth components of rice were influenced by several time flooding. For the yield of rice, Pandan Wangi and PB 042 were the best variety for productivity of rice.

SIGNIFICANCE STATEMENT

The study aimed to identify the weed species in rice field and influence of several time flooding to growth and yield of components of rice. The study is needed to obtain the best treatment for solving the weed in System of Rice Intensification method. The result of this research will help the researchers and local farmers to use the technical culture for supporting sustainable agriculture.

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