

INTERMITTENT IRRIGATION AND CUTTING HEIGHT ON GROWTH AND YIELD RATOON RICE (*Oryza sativa* L.)

Adi Setiawan^{*)}, Setyono Yudo Tyasmoro and Agung Nugroho

Faculty of Agriculture University of Brawijaya
Jl. Veteran Malang 65145, East Java, Indonesia

^{*)} Corresponding author Phone: +62-81334888689 E-mail: adisetiawan@ub.ac.id

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ABSTRACT

The purpose of this study was to examine the methods of intermittent irrigation and cutting height on growth and yield of ratoon rice (*Oryza sativa* L.). The research was conducted on Alluvial soil in Malang, ca. 507 m above sea level (asl), by using split plot design. The main plot was without flooding interval of rice field i.e. 0 (full flooding), 2, 4 and 6 days. The sub plot was ratoon height i.e. 0-5 cm, 10-15 cm and 20-25 cm. The result showed that there was no significant interaction between without flooding intervals and cutting height. The result of grinded dry spikelet weight of the first crop was 5.78 t ha⁻¹. The result of second crop showed that the treatment of 0 day (full flooding) gave the highest yield (3.12 t ha⁻¹), decreased of 46% from the first crop. The rice crop which was ratooned of 0-5 cm in height resulted the highest yield (2.95 t ha⁻¹), decreased of 49% from the first crop.

Keywords: intermittent irrigation, rice (*Oryza sativa* L.), ratoon, flooding

INTRODUCTION

Rice is the most essential crop of food commodity in Indonesia. The Indonesian people consume it for about 139 kg per capita annually (Central Bureau of Statistics, 2011a). Based on the forecasting number (ARAM) III, the rice yield in 2011 was 65.39 million ton of Grilled Dry Spikelet (GDS). This number decreased 1.08 million t (1.63%) compared to 2010 for about 66.47 million t GDS. (Central Bureau of Statistics, 2011b). Therefore, increasing production through technology needs to be applied. The role of superior variety and fertilizer, as well as sufficient water in order to increase productivity has reached

75% (Las, 2002). Higher productivity is achieved by making certain changes in the management of rice plants and the resources upon which these depend—soil nutrients, air, water, soil biota, and solar energy (Ceesay *et al.*, 2007; Xian-qing *et al.*, 2009; Zhao *et al.*, 2009; Thakur *et al.*, 2010). Technology, which is expected to be able to reduce the use of production means, is ratoon cropping by intermittent irrigation system.

Effective and efficient use of water in accordance with the crop need has become the essential factor and determines the crop production (Noggle and Fritz, 1983; Mubiyanto, 1997). Supply and good arrangement will be able to increase the yield significantly. Water is the basic requirement for plants to grow, develop, and produce better yields, which requires 1300-1900 mm during land preparation until planting time and starting the filling phase to spikelet filling. (De Datta, 1983; Bouman *et al.*, 2005; Kalsim *et al.*, 2007).

The intensified technology of ratoon cropping to the treatment stage of intermittent irrigation system has been developed in order to use the limited water efficiently. This research emphasized on height of ratooning treatment in which it will determine numbers of there mained internode (Quddus, 1981; Bardhan and Mondal, 1982). In general, yields of the ratoon crops have been influenced by some factors, such as height of crop, leaf area, leaf canopy, which are affected by genetic factor of the plant (Quddus, 1981, Krishnamurthy, 1988; Oad, 2002). Low yields of the ratoon crops are due to improper land cultivation, low quality of the soil, difficulty in controlling weeds, lack of water availability, low potential ratoon cropping, competition among shoots and disturbance (Arsana *et al.*, 1997). In order to gain more productive yields of ratoon cropping, an intensive maintenance should be applied, such as land cultivation,

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irrigation, weeding, applying fertilizer and controlling pests, diseases, or weeds (Arsana *et al.*, 1997). The research showed that yields of ratoon cropping decreased by 25.1 6% (Begum *et al.*, 2002), however, other research showed that the reduction reached 42-61 % from the first crops (Reddy *et al.*,1988). The purpose of this study was to examine the methods of intermittent irrigation and cutting height on growth and yield of ratoon rice (*Oryza sativa* L.).

MATERIALS AND METHODS

This research was conducted in Tunjung Sekar village, Lowokwaru District, Malang, at the altitude of ± 507 m above sea level (asl), on 7°55'34.04" S and 112°37'27.71" E in Alluvial soil, from November 2011 to May 2012. The experiment used Ciherang paddy Variety. The research carried out in two stages. The first stage begins with the use of planting new seeds. The first study conducted as a preliminary study to determine the outcome of grilled dry spikelet.

The second experiment applied Split Plot Design (SPD), in which the Main Plot was interval full days flooding, without flooding the rice field in 2 days, 4 days, 6 days, and the Sub Plot was Height ratoon cropping ranging in 0-5 cm, 10-15 cm, 20-25 cm (Figure 1).

The observation was conducted on growth and yield components by taking 4 samples of crop for each combination of treatment at the age of 14, 28, 42, 56, 70 and 84

days after ratooning, and the last sample was taken during the harvest time. This parameter includes non-destructive and destructive growth components. The observed components of non-destructive growth include Height of crop (cm), by measuring the height of crop from soil surface to the highest canopy. The number of tillers is observed by calculating the number of the resulted stems after subtracted by the number of seedlings per planting hole. The destructive growth component includes Leaf area (cm²), dry weight of crop (g), crop growth rate (CGR), and leaf area index (LAI).

This observation includes (1) number of panicles/clusters calculated during harvest time (2) the number of spikelets/panicles was calculated based on the entire spikelets in each panicle, both the filled spikelets and empty ones (3) percentage of the filled spikelet (4) percentage of the empty spikelet (5) dry weight of 1000 kernels (g), by weighing 1000 dry kernels of each treatment (6) yield of grilled dry spikelet (GDS), by weighing the yield of harvested spikelets taken from the area of 1 m² and sun dried for ± 2 days till the water content reached 13%. The weight of the grilled dry spikelets was used to calculate the harvest yield/planting area (t ha⁻¹). The obtained data were tested using analysis of variance (F-test) with significance level (P. 0.05). However, in order to investigate difference among treatments, a comparative test was applied using LSD5%.

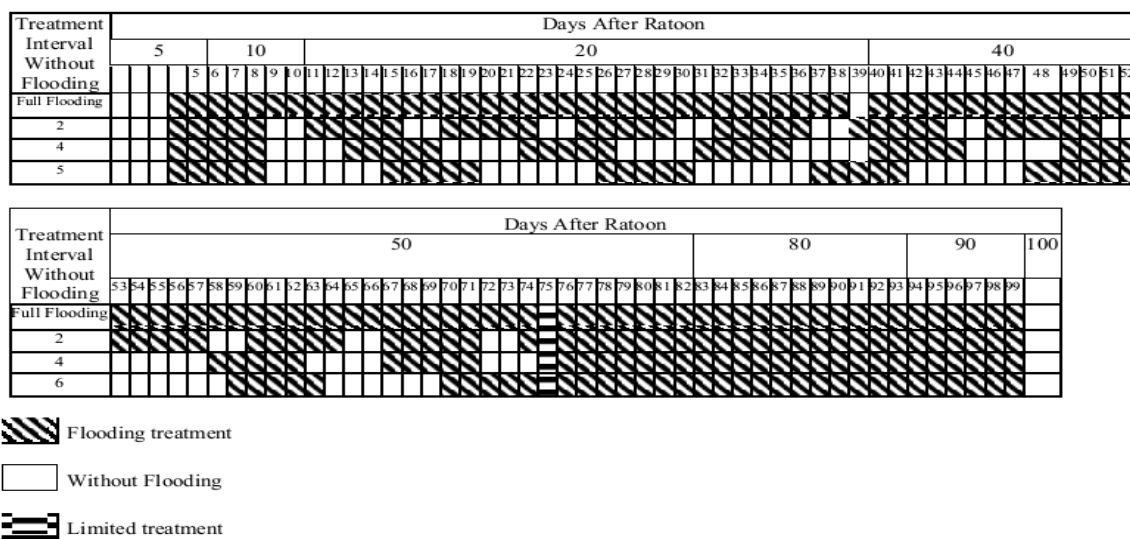


Figure 1. Scheme of intermittent irrigation treatment

RESULTS AND DISCUSSION

Growth Responses

The results showed ratoon crop shoots emerging from the base of the stem grows well in comparison to at the top of the stem. The cutting height affected the seed aging and maturation, shown by the quality of new rooting system, which emerged from the stem base and resulted in a number of better productive tillers. Cutting height of 20-25 cm showed that tillers at the stem base was disturbed due to the remained joints of the previous harvest. Cutting height of 10-15 cm was the ideal rice rationing after the first harvest, in which the growth of the remaining joints was not disturbed by the previous remaining harvest. On the contrary, Mochizuki *et al.* (2001), Daliri *et al.* (2009) and Huossainzade *et al.* (2011) believed that cutting height of 30 cm resulted the best yields, but not in this research due to different varieties used; therefore, Dustin *et al.* (2009) stated that the right cutting height on rice become to positive effect on ratoon yield. The height of the main crop as well as different varieties determines the ideal cutting height. The result of plant height indicated that cutting height 0-5 cm with combined interval without flooding the rice field in 0 day showed that the treatment was better than another one (Table 1).

Table 1. Plant height (cm) as a result of interval treatment without flooding and cutting height

Treatment	Plant height (cm)	
	70 DAR	84 DAR
Interval without flooding (Days):		
Full flooding	84.80 c	81.23 c
2	82.42 b	81.77 c
4	81.54 b	79.19 b
6	79.02 a	77.01 a
LSD 5 %	1.00	0.89
Cutting height (cm):		
0-5	84.52 b	82.44 b
10-15	82.94 b	79.34 ab
20-25	78.38 a	77.61 a
LSD 5%	3.51	3.25

Remarks: Numbers followed by the same letters show insignificant difference on the LSD 5%. DAR : Day After Ratooning

In this research, response of the crop by cutting height of 0-5 cm showed more shoots or tillers and leaf area index (Table 2 and 3) because cutting the tip part could inhibit the growth of apical domination. Such a tip cutting would trigger the growth of lateral shoots, for the auxin, which accelerates the plant growth (Hopkins, 1995), was produced in the apical shoot.

Table 2. Number of tillers as a result of interval treatment without flooding and cutting height

Treatment	Number of tillers	
	70 DAR	84 DAR
Interval without flooding (Days):		
Full flooding	20.86 c	20.08 c
2	20.31 bc	18.06 b
4	18.89 ab	17.39 ab
6	18.08 a	16.69 a
LSD 5 %	1.81	0.81
Cutting height (cm):		
0-5	20.48 b	19.17 b
10-15	19.40 ab	18.13 ab
20-25	18.73 a	16.88 a
LSD 5%	1.16	1.47

Remarks: Numbers followed by the same letters show insignificant difference according to the LSD 5%. DAR : Day After Ratooning

Table 3. Leaf area index as a result of interval treatment without flooding and cutting height

Treatment	Leaf area index	
	70 DAR	84 DAR
Interval without flooding (Days):		
Full flooding	2.44 c	2.40 b
2	2.18 b	2.55 c
4	1.92 a	2.15 ab
6	1.95 a	1.94 a
LSD 5 %	0.19	0.33
Cutting height (cm):		
0-5	2.51 b	2.43 b
10-15	2.05 a	2.44 b
20-25	1.81 a	1.91 a
LSD 5%	0.26	0.38

Remarks: Numbers followed by the same letters show insignificant difference according to the LSD 5%. DAR : Day After Ratooning

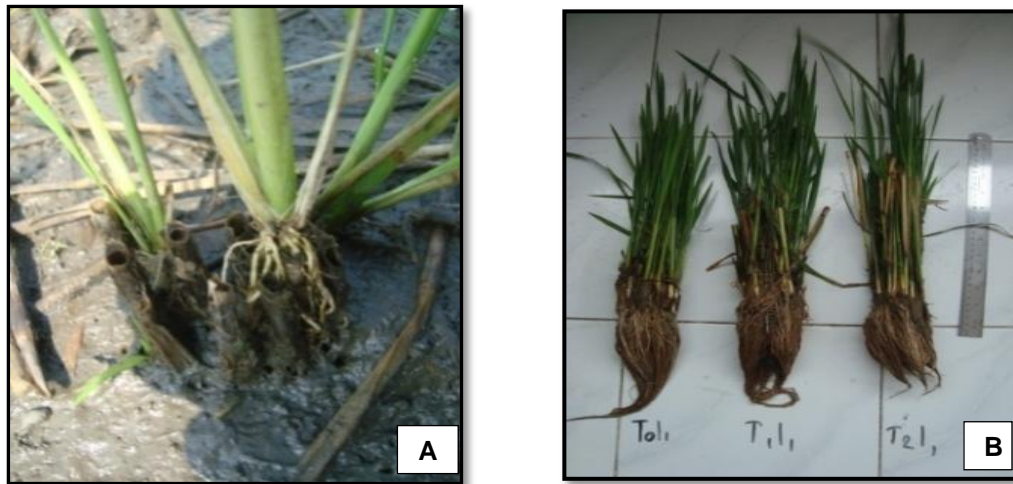


Figure 2. Budding condition in ratoon rice in (a) Rice growth at various cutting heights (b)

Table 4. Growth rate ($\text{g m}^{-2} \text{day}^{-1}$) as a result of interval treatment without flooding and cutting height

Treatment	Growth rate ($\text{g m}^{-2} \text{day}^{-1}$)				
	14-28 DAR	28-42 DAR	42-56 DAR	56-70 DAR	70-84 DAR
Interval without flooding (Days):					
Full flooding	5.21 ab	19.60	32.38 c	58.59	19.30 b
2	6.33 b	21.15	33.67 c	53.11	14.60 a
4	6.37 b	18.20	23.10 b	50.74	15.53 ab
6	3.77 a	19.15	11.68 a	49.92	12.83 a
LSD 5 %	1.65	ns	7.60	ns	4.62
Cutting height (cm):					
0-5	3.14 a	20.83 b	35.17 b	57.95	15.30
10-15	6.21 b	23.37 b	18.78 a	54.14	16.45
20-25	6.91 b	14.37 a	21.67 a	47.18	14.94
LSD 5%	1.78	3.21	6.90	ns	ns

Remarks: Numbers followed by the same letters show insignificant difference according to the Least Significance Difference (LSD) Test at 5% level, ns : non significance (Day After Ratooning)

Seedling emergence in ratoon rice was the same as that of the first rice. Ratoon rice seedlings emerged from the bud the main stem. The next root began to develop. If not balanced with stagnant water conditions, it was difficult to infiltrate roots in the soil (Figure 2). For the first rice plant, the growth throughout the stages was in accordance with the growth phase. Gardner *et al.* (1991) stated that in the narrow sense, growth refers to irreversible size change, which reflects the increasing number of protoplasm due to enlarging size of cell as well as increasing number of cells. However, development means differentiation, a change in

higher level that relates to specification and organization, both anatomically and physiologically. The development phase was observed based on the growth rate and age of ratoon rice harvested within 97 DAR (days after ratooning). The periods of ratoon rice occurred as follows: vegetative phase in 50 days, reproductive in 25 days, maturity in 22 days (Figure 3 and Table 4) differed from the first rice plant. According to Yoshida (1981), where the vegetative phase lasted 55-60 days, reproductive phase lasted 30 days, and maturity phase lasted 30 days. The rice required different volume of water in each phase of its growth.

Therefore, water management technique should be developed specifically in accordance with rice production system and the planting pattern.

The growth is particularly determined by water and N, while the differentiation, such as thickening of the cell wall is due to the excessive photosynthetic yields. The differentiation process requires specific enzyme and temperature. According to Gardner *et al.* (1991), production or yield of qualified crops frequently requires a balance between growth and differentiation. Moreover, Gardner *et al.* (1991)

stated that growth through cell division and enlargement occurs in a specific tissue called meristem. The growth occurs at the lateral and at the tip part of the meristem. The growth at the tip part leads to prolongation, while lateral growth leads to enlargement. Prolongation of stem and leaf, particularly at the tip part of the meristem, requires the growth hormone having a number of cells and higher cell activity. Efforts to increase the crops production depend on meristem management and how to increase number of branches, flowering, and leaf area.

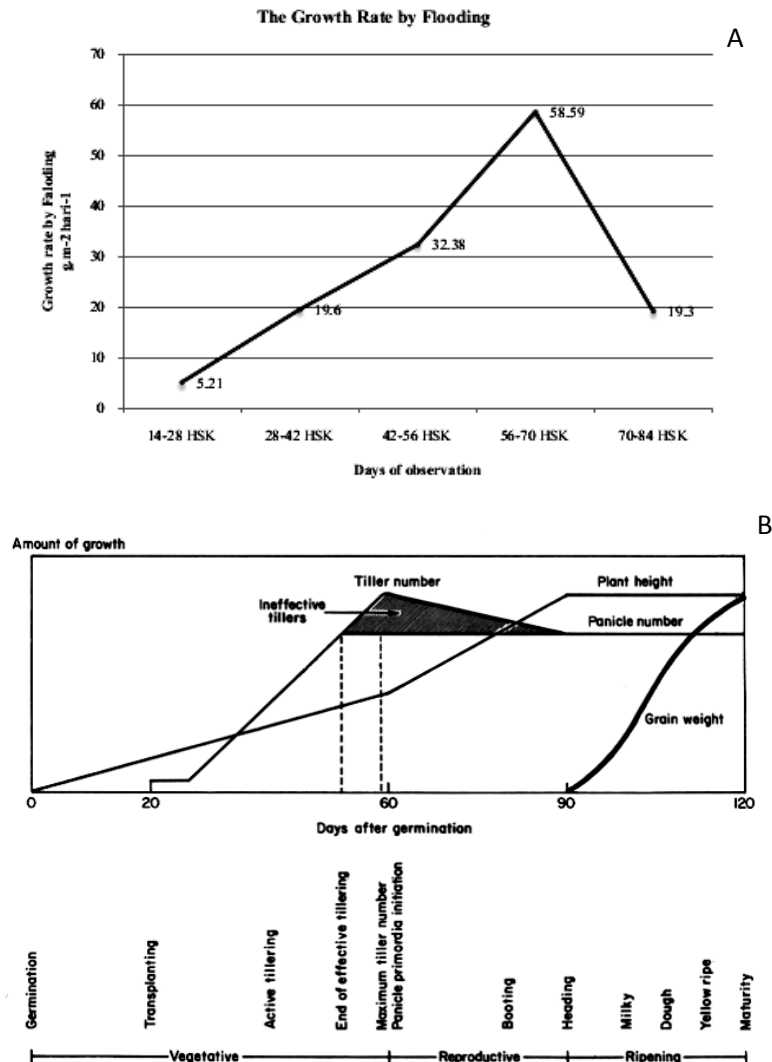


Figure 3. Comparison of the growth rate (a) ratoon rice under I_0 treatment and (b) first rice (Yoshida, 1981)

Table 5 shows dry weight of the crop as an indication of the growth quality. Dry matter is considered as manifestation of a process that occurs during the crop growth. Dry weight of the early crops at the ratooning in 14 and 28 days after ratooning (DAR) was still affected by the first remaining rice plant, so that more dry weight was significantly accumulated. Furthermore, when the rest of the first crop started to rot and decomposed, the cutting height of 0-5 cm showed better effect at the end of planting season at 70 and 84 DAR. The estimated it has been affected by the first remaining crops, which inhibited development of the tillers, therefore, the increasing number of tiller and its development were less optimal. At 70 DAR, interval without flooding 0 day showed better effect than another treatment by average dry weight of 111.62 g, which was significantly different from the treatment of 4 and 6 days for about 96.96 and 91.99 g.

Tabel 5. Dry Weight (g) as a result of interval treatment without flooding and cutting height

Treatment	Mean of Dry Weight (g)	
	70 DAR	84 DAR
Interval without flooding (Days):		
Full flooding	111.62 c	124.67 c
2	106.85 bc	110.79 b
4	96.96 ab	106.01 b
6	91.99 a	92.12 a
LSD 5 %	12.10	9.22
Cutting height (cm):		
0-5	112.15 b	115.52 b
10-15	102.92 ab	111.30 b
20-25	90.49 a	98.38 a
LSD 5%	13.27	11.09

Remarks: Numbers followed by the same letters show insignificant difference according to the LSD 5%. DAR : Day After Ratooning

Yield

The results for analysis on yield components that include number of panicles per cluster, number of spikelets per panicle, percentage of filled-spikelet, percentage of empty spikelet, percentage of 1000 kernels and yield of grinded dry spikelet did not show significant interaction between interval without flooding and cutting height. The condition on yield variable of grinded dry spikelet was linear to indicator of another crop growth, whereas the

yield was accumulation based on the crop growth (Kasto, 2005).

Table 6. Number of panicles as a result of interval treatment without flooding and cutting height

Treatment Interval without flooding (Days)	Number of panicles per cluster
Full flooding	12.61 c
2	11.19 b
4	10.89 ab
6	9.72 a
LSD 5 %	1.18
Cutting height (cm)	
0-5	12.10 b
10-15	11.23 ab
20-25	9.98 a
LSD 5%	1.30

Remarks: Numbers followed by the same letters show insignificant difference according to the LSD 5%.

Following the first harvest, rice plant had characteristic to adapt to ratooning, therefore ratoon rice would grow from the first remaining rice plant. The shoot would grow better when cut shorter than that of higher cutting height. Table 2 represents mean for number of tiller due to different cutting height. Interval without flooding showed that 0 day treatment had greater in comparison with two-, four-, and six-day treatments. The Mean for number of panicles per cluster reached 12.61. Under cutting height treatment of 0-5 cm, number of panicles per cluster was 12.1, which was insignificantly different from cutting height of 10-15 cm, and was significantly different from cutting height of 20-25 cm, for about 9.98 (Table 6). Number of productive tillers for Ciherang variety was 14-17 in ratooning rice 9-12 decreased 30-50%. Tillers of the ratoon rice emerged from the former remaining unproductive tillers. These tillers emerge from both apical and lateral shoots. It means that more unproductive tillers of the first (former) rice crop would increase the number of the ratoon rice tillers. According to Bardhan and Mondal (1982), the ratooning height does not significantly affect the shoot's ability to grow on ratoon crops. The function of ratooning and cutting have different meaning, but both of them have identical meaning for the physiological response.

The first rice plants yielded 6.64 t ha⁻¹ for harvested dry spikelet or 5.78 t ha⁻¹ for grilled dry spikelets. Ratoon rice was harvested at 97 days (Table 7), which was earlier 26 days in comparison with common rice plants grown from seeds and harvested in 123 days. The mean mortality of ratoon crop (m²) was 1.8 (Table 7). Based on the data, yield of ratoon rice and grilled dry spikelet showed that interval treatment of 0 and 2 days had insignificant difference and better than other treatments of 4 and 6 days. Yield of the grilled dry spikelet under interval without flooding 0 day was about 3.12 t ha⁻¹ or decreased by 46% in comparison with the first one (Table 8). Under cutting height of 0-5 cm, the yield was 2.95 t ha⁻¹ or decreased by 49%, and 10-15 cm yielded 2.86 t ha⁻¹, and it was better than the treatment of 20-25 cm. Benefit Cost or B/C ratio show that based on farming operation analysis, some conclusions were drawn in accordance with B/C Ratio, which showed that the first rice plant was 3.32 and the highest yield of B/C Ratio for ratoon rice was 1.49.

Table 7. Mortality of ratoon crop and time harvest

Treatment	The mean mortality of ratoon crop (m ²)	Harvest time (days after ratoon)
I ₀ T ₀	1.92	98
I ₁ T ₀	2.17	98
I ₂ T ₀	2.58	96
I ₀ T ₁	1.75	98
I ₁ T ₁	1.33	96
I ₂ T ₁	1.58	96
I ₀ T ₂	1.50	96
I ₁ T ₂	1.75	94
I ₂ T ₂	1.58	94
Average	1.80	96.2

Table 8 shows that water had significant effect on the yield. Interval without flooding affected water availability for the crops. Ratoon rice by cutting height of 20-25 cm along with intermittent irrigation for 4 days did not affect the increasing growth and yields. The results conducted by the previous author showed that the yield increased when NPK fertilizer was proportionally applied for each increasing dosage of N, P, K (about 3 kg ha⁻¹), which will be able to increase the yield of grilled dry spikelets for about 0.01 t ha⁻¹. It shows such

increasing quality of soil by adding fertilizer and organic matters, which are highly required.

Table 8. Grilled dry spikelet (t ha⁻¹) as a result of interval treatment without flooding and cutting height

Treatment	Yield of grilled dry spikelet (t ha ⁻¹)		
	Main crop	Ratoon crop	Total yield
Interval without flooding (days):			
Full flooding	5.78	3.12 c	8.9
2	5.78	3.05 c	8.83
4	5.78	2.78 b	8.56
6	5.78	2.43 a	8.21
LSD 5 %	ns	0.16	ns
Cutting height (cm)			
0-5	5.78	2.95 b	8.73
10-15	5.78	2.86 b	8.64
20-25	5.78	2.73 a	8.51
LSD 5%	ns	0.10	ns

Remarks: Numbers followed by the same letters show insignificant difference according to the LSD 5%, ns : non significance

Intermittent water distribution given as the treatment would affect the depth of rooting system, in which the rooting depth highly affects the absorbed water. However, as shown by soil condition in the field, without soil cultivation on land where the remaining ratoon rice was grown, more energy for the root acceleration to penetrate the dried soil is required. Therefore, the photosynthate yields would not be optimal to be distributed to the entire part of the plant during reproductive phase. It will decrease quality of the ratoon rice lower than the first one. It includes the plant growth.

In general, any plant having better irrigation will bring about longer rooting system than plants grown in arid area. Lower content of water will reduce the root elongation, depth of penetration, and diameter of the roots. Water plays important role because water deficit will affect all the metabolic process in the related plant, which will inhibit the growth. Mullet and Whissit, (1996) statement that response of plant having drought stress includes some changes in cellular and molecular levels as changes in the plant growth, smaller volume of the cell, reduced leaf area, thicker leaf, the emergence of hairy leaf, and increasing ratio of root-canopy. Ratoon rice grown in uncultivated land requires

more intensive irrigation to soften the soil and adequate organic matter to improve physical, chemical, and biological features of the soil (Burke *et al.*, 1995).

CONCLUSION AND SUGGESTION

Ratooning the rice has become the alternative technology of cropping by considering other aspects that relate to availabilities of production means and water, as well as the balance between pests and diseases. Results in analysis of variance and the growth components showed insignificant interaction between interval without flooding and cutting height. The calculation result of the first grinded dry spikelet and yield of the ratoon rice, due to the effect of interval without flooding 0-6 days, decreased by 46-57% in comparison with the first rice. Meanwhile, the first grinded dry spikelets and yield of the ratoon rice reduced 49-53%, due to the effect of cutting height of 0-5 cm to 20-25 cm by B/C Ratio on ratoon rice was 1.49. The cutting height of 10-15 cm by considering the pests and diseases, as well as the death rate of the ratoon rice and interval without flooding for 2 days related to water efficient use as the recommended treatment for ratoon rice cropping.

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