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RICE RATOON YIELD RESPONSE TO MAIN CROPS CUTTING HEIGHT IN TIDAL SWAMP USING DIRECT SEEDING SYSTEM

Evriani Mareza[1*], Zainal Ridho Djafar[2], Rujito Agus Suwignyo[2] and Andi Wijaya[2]

[1] Department of Agronomy, Faculty of Agriculture, IBA University
Jl. Mayor Ruslan, Palembang, 30113, South Sumatera, Indonesia
[2] Department of Agronomy, Faculty of Agriculture, Sriwijaya University
km. 32 Inderalaya, Palembang, 30662, South Sumatera, Indonesia
[*] Corresponding author E-mail: evriani_mareza@yahoo.co.id

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ABSTRACT

This study was aimed to evaluate the effect of main crops harvest cutting height on the yield of rice ratoon in the tidal swamp by using direct seeding system. The experiment was conducted in Telang Sari village, District of Tanjung Lago, Banyuasin, South Sumatra Province from November 2013 to April 2014. It measured plots 4 x 5 m through a randomized block design with 5 replications. The treatment was main crops harvest cutting height of 10, 20, 30, 40 and 50 cm above the soil surface. The results showed that the effect of cutting height on rice ratoon yield depends on the condition of photosynthetic and the amount of remaining nodes on the main crops stubble as an emergence ratoon shoots. The main crops cutting height of 20-40 cm above the soil surface increased the number of productive tillers, grain weight per hill, yield per plot, ratoon ability to grow per plot, and the rice ratoon/main crops yield ratio in tidal land by using direct seeding system.

Keywords: direct seeding system; rice ratoon; the main crops cutting height; tidal swamp; yield

INTRODUCTION

Indonesian target for food needs is to ensure the production of rice until 2025. It is required the increasing of the rice cultivation area of 1.4 million ha approximately. However, most of available land is suboptimal while the fertile lands have been converted to non-agricultural purposes. Suboptimal land area in Indonesia reaches 123.1 million ha of dry land and 34.1 million ha of swamp land where 11 million ha of swamp land is the tidal swamp (Haryono, 2013). In South Sumatra, suboptimal land area covers approximately 1.9 million ha (Sulistiyani, 2013). Approximately 60% of rice production in South Sumatra comes from tidal swamp. Nevertheless, the productivity of tidal swamp area is low at 3.5 t ha^{-1}. Therefore, intensification by developing and optimizing the tidal swamp will be good alternative to increase the productivity.

Rice production can be increased by improving the productivity and cropping index, including intensification of ratoon system, i.e. stubble of rice plants that grow back after harvest and produce new tillers and grain which can be harvested (Islam *et al.*, 2008). Ratooning rice is able to provide additional rice yield per season, and reduces the cost and labor, as well as the tillage time (Nakano and Morita, 2007). Normally, the farmers in tidal swamp area apply direct seeding system due to shortage of labor and limited planting time. According to Pane (2003), direct seeding system can be an alternative for farmers to reduce costs and labor and also pursuit the simultaneous growing season with relatively low cost.

One of the critical success factors of ratoon is the main crops cutting height (Daliri *et al.*, 2009; Harrel *et al*., 2009; Huossainzade *et al.*, 2011). The main crops cutting height deal with the status of reserve photosynthetic and the remaining segment, and node in the main crops stubble after harvesting. From the nodes appears lateral shoots that will produce ratoon shoots. Cutting can stimulate dormant shoots on the main crops to grow, so it will affect the number of tillers, plant growth period and yield (Harrell *et al.,* 2009).

The information of the main crops cutting height that effectively increase the rice ratoon yield is still inconsistent, ranging from a low cutting height near the soil surface to below the

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panicle neck (Dunand and Dilly, 2005; Setiawan *et al.*, 2014). Previous studies indicate that the main crops cutting height that effectively increase the yield of rice ratoon were strongly influenced by location, season, varieties and cultivation of rice. The application of cutting height of 0-15 cm above the soil surface gave higher ratoon yield and harvest index on rice ratoon (Nakano *et al.,* 2009; Petroudi *et al.,* 2011; Setiawan *et al.,* 2014). Medium cutting height of 20-30 cm above the soil surface can optimize ratoon yield per panicle (Harrel *et al.,* 2009; Huossainzade *et al.,* 2011; Susilawati *et al.,* 2011; Beuzelin *et al.,* 2012). The cutting height ≥ 40 cm gave high ratoon result (Dunand and Dilly, 2005; Daliri *et al.,* 2009; Nassiri *et al.,* 2011). However, those researches were applied in the optimal land with transplanting system. Researches on suboptimal land such as tidal swamp area with direct seeding system have not been applied. Therefore, this research was aimed to evaluating the main crops cutting height that effectively increase the yield of rice ratoon in tidal swamp planted with direct seeding system.

MATERIALS AND METHODS

The experiment was conducted on tidal swamp (overflow type B) in the Telang Sari village,Tanjung Lago, Banyuasin District, South Sumatra Province from November 2013 to April 2014.

This research used Ciherang rice varieties planted by using direct seeding system on plots of 4x5 m and the distance between the plots of 1 m. Maximum tillage was applied prior to disseminating the seed. Fertilizer rate was in accordance with the recommendation of farmers in the study area. For the main crops, Urea 300 kg ha^{-1}, Super Phosphate-36 (SP-36) 100 kg $ha^{-1}$and Kalium Chlorida (KCl) 150 kg ha^{-1} were used. Half dose of Urea and all of SP-36 and KCl were given on the 14^{th} day after planting (DAP) while the remaining half dose of Urea was given on the 40^{th} DAP. For rice ratoon, it was given a half of the main crops fertilizer rate, which was given once on the 3^{rd} day after harvesting (DAH) the main crops. Main crops were harvested at 80% grains in panicle that had ripened. Tiller which emerged from the main crops stubble was considered as ratoon tiller when it had 2 blooming leaves without considering their size. Throughout the study, the flooding was done until harvesting. Crops were protected from pests, diseases and weeds by using the pesticide.

This research used a randomized block design (RBD). The treatment was the main crops cutting height on harvest consisted of 10, 20, 30, 40 and 50 cm above the soil surface with 5 replications. Parameters observed during harvesting involved ratoon yield and yield component. The data were analyzed by using ANOVA with F-test. Significant level was defined as $P < 5\%$.

RESULTS AND DISCUSSION

The cutting height of main crop was related to the number of nodes and inter nodes. The number of remaining nodes on the main crops stubble that was on the above soil surface varies from 0 up to 4 nodes, depending on the main crops cutting height. A total of 86.67% of the main crops was cut on 10 cm above the soil surface, left 1 node on stubble. In cutting of 20 and 30 cm, respectively 70.28 and 79.44% left 2 nodes on the main crops stubble. While the main crops cutting of 40 cm (91.67%) and 50 cm (82.78%) average left 3 nodes (Table 1). The higher the cutting height, the more remaining nodes and internodes will be. The number of nodes is important for productivity because the nodes will emerge lateral bud which will be ratoon tiller. The number of nodes will affect the number of ratoon tiller (Daliri *et al.,* 2009; Harrel *et al.,* 2009; Nassiri *et al.,* 2011). The more nodes, the more possibility of ratoon tillers emerge, which led to competition between tillers. Thus, it will affect the tiller production per hill.

Number of Productive Tillers

The higher cutting of the main crops on harvest up to 50 cm above the soil surface increases the number of productive tillers of ratoon. At the cutting height of 40 and 50 cm above the soil surface, the number of productive tillers ratoon was more than those were cut at 10 cm (Table 2).

Table 1. Number of the remaining nodes in the main crops stubble above the soil surface

The main crops cutting height	Number of the remaining nodes in the main crops stubble above the soil surface (%)				
	0 node	1 node	2 nodes	3 nodes	4 nodes
10 cm	4.44	86.67	8.89	-	-
20 cm	-	27.64	70.28	2.08	-
30 cm	-	-	79.44	20.56	-
40 cm	-	-	-	91.67	8.33
50 cm	-	-	-	82.78	17.22

Table 2. The effect of main crops cutting height on harvest to number of productive tillers, days to flowering, days to harvest, panicle length, number of grains per panicle and the percentage of empty grains per panicle rice ratoon

The main crops cutting height	Number of productive tillers	Days to flowering (DAH)	Days to harvest (DAH)	Panicle length (cm)	Number of grains per panicle	The percentage of empty grains per panicle (%)
10 cm	2.00 a	40.60 b	69.60 d	14.93 b	47.05 b	18.60 a
20 cm	4.75 ab	23.80 a	61.80 d	14.33 ab	41.23 ab	24.57 ab
30 cm	5.40 ab	20.20 a	54.80 b	13.36 ab	39.48 ab	32.59 bc
40 cm	6.55 b	17.80 a	48.00 a	14.31 ab	40.07 ab	35.32 c
50 cm	5.65 b	17.00 a	47.20 a	12.54 a	32.66 a	48.21 d
HSD	1.92	7.08	1.99	2.32	12.07	8.85

Remarks: DAH = days after the main crops harvest. Figures in the same column followed by the same letter are not significantly different means to HSD 5% test

This condition was caused by the differences in the amount of photosynthetic as food reserves remaining at the main crops stubble. Cutting height was also associated with the remaining segment and nodes in the main crops stubble. The results showed that there was more number of productive tillers on the 20-50 cm cutting height with 2-3 nodes of leaves on main crops stubble. Based on Susilawati (2011), cutting height with 2-3 segment leaves on the main crops stubble is the optimum cutting that can increase the ratoon vigor. The nodes appearing in the lateral shoots will produce ratoon shoots that can affect the number of tiller. The higher main crops cutting, the higher number of productive tillers would be (Daliri *et al.,* 2009; Harrell *et al.,* 2009; Nassiri *et al.,* 2011; Mareza *et al.,* 2014). In addition, the fewer supply of photosynthetic and remaining nodes, the lower the cutting at 5-10 cm above the soil surface would be. It could cause the main crops suffering decay as it was too closed to the flooded water and easily trampled at harvest (Pane, 2003; Susilawati, 2011).

Days of Flowering (DAH)

Ratoon days to flower ranged from 17.00-40.60 DAH. Days of flowering were faster in the higher cutting above the soil surface. The average days of flowering did not differ among cutting height at 20-50 cm (Table 2). It was faster because ratoon shoots of higher node grew faster than the shoots produced by the lower node. Ratoon days of flowering was faster due to the ratoon experienced a very short vegetative phase even sometimes they did not experience the vegetative phase, where the emergence of ratoon tillers often followed or in conjunction with the panicles released or flower. Makarim and Suhartatik (2006) stated that rice ratoon directly went to reproductive phase without the vegetative phase in the range of 35 days, followed by the ripening phase about 30 days.

Days to Harvest (DAH)

Table 2 showed that the average of rice ratoon harvest ranged from 47.20 to 69.90 DAH. The fastest days to harvest were obtained at the main harvest cutting height of 50 cm (47.20 DAH) which is not differrent from 40 cm cutting height (48.00 DAH), and differ significantly with the 30 cm cutting height (54.80 DAH), 20 cm (61.80 DAH) and the 10 cm (69.60 DAH). Similar to the days of flowering, ratoon days of harvest were faster on the higher cutting above the soil surface because of a very short time vegetative phase.

Panicle Length (cm)

Panicle length was diminished on the higher main crops cutting on harvest (Table 2). The higher main crops cutting on harvest, the shorter panicle length would be. The length was not different among treatments, except for the 50 cm cutting height (12.54 cm) which was different from 10 cm cutting height with panicle length 14.93 cm.

Number of Grains per Panicle (grains)

The most number of grains per panicle was obtained in the main crops cutting height 10 cm above the soil surface (47.05 grains), which was different from the higher cutting up to 40 cm, but different from the 50 cm cutting height which produced 32.66 grains per panicle (Table 2). The ability of the crop to produce grain was determined by photosynthate produced which acts as a source of feeding. It was determined by the growth during the vegetative phase before entering the reproductive phase. Moreover, it was determined by the photosynthate translocated from the source to the sink during the ratoon reproductive phase (Makarim and Suhartatik, 2006). In 10 cm cutting height, more number of grains per panicle produced because ratoon had a longer vegetative phase before flowering. According to Nakano and Morita (2007), a crop that has a longer vegetative phase can produce more grain because of the longer time to produce photosynthate which will affect the sink of grain filling.

The percentage of empty grains per panicle (%)

The higher main crops cutting on harvest, the more percentage of empty grains per panicle would be. The highest percentage of empty grains per panicle was obtained at 50 cm main crops cutting height above the soil surface which was different from the other treatments (Table 2). This is presumably due to the condition of limited sources. As ratoon had a very short vegetative phase, the ability of crops to provide photosynthate was limited. Rice panicle that supported grain was the sink that needed to be filled with photosynthate from crop sources (Makarim and Suhartatik, 2006).

Grain Weight per Hill (g)

Most grain weight per hill obtained in the main crops cutting height at 40 cm above the soil surface (6.87 g) was not different from the 20 cm cutting height (5.53 g) and 30 cm (5.29 g), but in contrast with the 10 and 50 cm cutting height produced 3.77 g and 4.65 g grain weight per hill (Table 3). Components that contributed to the weight of grain per hill were the number of productive tillers, grains per panicle and the percentage of empty grains per panicle. The grain weight per hill will be higher on the crops that have more productive tillers, panicle length, number of grains per panicle and a low percentage of empty grains (Oad and Cruz, 2002; Oad *et al.*, 2002; Susilawati *et al.*, 2010). According to Susilawati (2011), a cutting height with leaves of 2-3 segments is the optimum cutting that can increase the ratoon vigor and optimize the yield of ratoon panicle. At the main crops cutting height under panicle neck (50 cm above the soil surface), the number of grains per panicle and grain weight per hill were decreased. Petroudi *et al.* (2011), Susilawati (2011) and Setiawan *et al.* (2014) reported that the main crops cutting height does not always correlate with the success of rice ratoon grain filling. The high cutting below the panicle neck generates many productive tillers and has a high percentage of empty grains (Wijaya and Soehendi, 2012).

The high main crops cutting can inhibit the growth of ratoon shoots and reduce the amount of ratoon grain produced. In this case, the remaining photosynthate on the main crops stubble was not used for the growth of buds and ratoon grain filling, but used by the remaining leaves in unproductive main crops stubble.

Table 3. Effect of the main crops cutting height on harvest for grain weight per hill, ratoon ability to grow per plot, yield per plot and rice ratoon/main crops yield ratio per plot

The main crops cutting height	Grain weight per hill (g)	Ratoon ability to grow per plot (%)	Yield per plot (kg)		Rice ratoon/main crops yield ratio per plot
			MC	R	
10 cm	3.77 a	40.00 a	7.02	0.42 a	6.21 a
20 cm	5.29 ab	78.00 b	7.30	1.19 b	16.98 b
30 cm	5.53 ab	80.00 b	7.56	1.25 bc	17.37 b
40 cm	6.87 b	86.00 b	7.29	1.70 c	23.67 b
50 cm	4.65 a	84.00 b	6.53	1.03 b	15.78 a
HSD	2.16	16.94	-	0.47	10.44

Remarks: MC = main crops, R = ratoon. Figures in the same column followed by the same letter are not significantly different means to HSD 5% test

Ratoon Ability to Grow per Plot (%)

Ratoon ability to grow per plot in the tidal swamp with direct seeding ranged between 40.00-84.00% (Table 3). At the 10 cm main crops cutting height above the soil surface, only 40.00%of the stubble main crops population per plot was alive and grew to produce ratoon rice, in contrast with 20-50 cm cutting height where ratoon ability to grow per plot were 78.00-84.00%. In some genotypes, ratoon shoots are growing from the higher node, while shoots that grow from the low node or close to the soil many dead than survive (Harrel *et al.,* 2009). Ratoon ability to grow per plot was also affected by water management in the field. Flooding after harvest can result in death on ratoon shoots at lower cutting of 5-10 cm above the soil surface (Susilawati, 2011). Moreover, the irregular spacing of direct seeding caused farmers difficult to pass between the crops on harvesting without damaging the growing crops (Pane, 2003). Result showed that at moderate cutting height of 20-50 cm above the soil surface, only 78.00-84.00% of the stubble main crops population grew to produce ratoon successfully (Table 3).

Yield per Plot (kg)

The highest yield per plot was obtained in the main crops cutting height at 40 cm above the soil surface (1.70 kg), in contrast with other treatments (Table 3). Yield per plot was the lowest at 10 cm cutting height (0.42 kg). It was not different from the 20, 30 and 50 cm cutting height (1.19, 1.25 and 1.03 kg). Moreover, it related to the number of productive tillers, grain weight per panicle and population per plot associated with ratoon ability to grow per plot. It was also correlated to the right management of cultivation (Nakano and Morita, 2007). The result was very low on the low cutting 10 cm above the soil surface because it was influenced by low ratoon ability to grow in tidal swamp per plot with direct seeding system. Flooding after harvest on the lower stubble cutting could adversely affect ratoon death. Direct seeding system with iregular spacing also caused damage on main crops trampled during harvesting.

While at 50 cm cutting height, yield per plot decreased due to the cutting height below the panicle neck. Although generating many productive tillers, it had a high percentage of empty grains.

Rice Ratoon/Main Crops Yield Ratio per Plot

The main crops yield per plot ranged between 6.53-7.56 kg, while rice ratoon yield per plot ranged between 0.42-1.70 kg (Table 3). The low rice ratoon yield compared to main crops yield was lower in weight of grain per ratoon panicle becaused of the high percentage of empty grains per panicle (Table 2). The yield of ratoon was lower than the main crops because it had shorter vegetative phase. The unbalance of vegetative and generative phase will cause the photosyhthate production cannot support the maximum growth and development. This is in accordance to Makarim and Suhartatik (2006); and Wijaya and Soehendi (2012), the ability of crops to produce the grain depends on the level of photosynthate which plays as a source. It was produced during vegetative phase before entering reproductive phase.

Rice ratoon/main crops yield ratio per plot in tidal swamp with direct seeding was very low, it ranged between 6.21-23.67% (Table 3). A research by Susilawati (2011) who studied the ratoon at Kalimantan tidal swamp with transplanting system gave ratio 0f 38.1-56.6%. Direct seeding system with irregular spacing and dense will lead the competition among the crops, and cause damage on main crops due to the trampled during harvesting. In addition, it has high weed due to the water during the initial growth. As a result, the rice ratoon/main crops yield ratio in this study was lower than that of Susilawati (2011).

CONCLUSION

Rice ratoon yield responses to the main crops cutting height on harvest was varied, it depends on location, varieties and cultivation. The main crops cutting height on harvesting of 20-40 cm above the soil surface increases the number of productive tillers, grain weight per hill, yield per plot, ratoon ability to grow per plot, yield per plot and rice ratoon/main crops yield ratio per plot in tidal swamp by using direct seeding system.

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