 Effects of Water Table, Population Density and Transplanting Time on Vegetative Growth of Black Sticky Rice at Floating Seedbed Method

Pengaruh Tinggi Muka Air, Kerapatan Populasi dan Waktu Transplanting terhadap Pertumbuhan Vegetatif Ketan Hitam dengan Metode Persemaian Terapung

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Abstrak

Pengembangan budidaya beras ketan hitam di Sumatera Selatan masih jarang dilakukan oleh petani. Penelitian bertujuan untuk mengetahui pengaruh kejenuhan media dan kerapatan populasi terhadap pertumbuhan bibit selama pembibitan menggunakan persemaian terapung, serta pengaruh waktu transplanting terhadap pertumbuhan beras ketan hitam varietas toraja pada fase vegetatif. Penelitian dimulai pada bulan Mei 2018 di Palembang. Beras ketan hitam yang digunakan pada penelitian ini adalah varietas toraja. Rakit yang digunakan dibuat dari botol plastik 1,5 L yang dirangkai mencapai ukuran 2x1 meter. Penelitian dilakukan dengan 2 fase, fase pertama melihat efek kejenuhan media dan kerapatan populasi pada pertumbuhan bibit, fase kedua melihat efek waktu transplanting terhadap pertumbuhan selama fase vegetatif. Secara statika, hasil menunjukan bahwa kejenuhan media dan kerapatan populasi bibit berpengaruh secara signifikan terhadap panjang akar bibit sedangkan waktu transplanting 14 HSS memberikan efek terhadap panjang daun, lebar daun dan luas daun.

Kata kunci: beras ketan hitam, metode terapung, kejenuhan media, kerapatan populasi, persemaian, waktu transplanting

ABSTRACT

Study on black sticky rice cultivation in South Sumatera is seldom carry out. The objective of this study was to evaluate the effect of water table and population density on the growth of rice during seedling preparation at floating seedbed; furthermore, this study aimed to evaluate the effect of transplanting time on vegetative growth of black sticky rice. The research was started in May 2018 in Palembang. Black sticky variety used in this research was Toraja variety. The raft used is made from 1,5 l plastic bottles which are arranged to reach 2x1 meters in size. This study was conducted by two stages. The first stage was for water table and population density treatments laid on split plot design. The second stage was for transplanting time utilizing completely randomized factorial design. Statistically, results showed water table and population density significantly influeneced...
INTRODUCTION

Study on black sticky rice cultivation in South Sumatera is seldom carried out. Morphology and anatomy of black sticky rice are similar to black rice in general. High plant crown, long harvesting age, and low productivity are inhibiting factors for black rice development. The height of black rice reaches 160 cm with a harvesting age of up to 157 days for producing 7.5 ton/ha (Azmi et al., 2017) and susceptible to environmental change had caused a little interest for farmers to cultivate it. However, black rice contains high amylose (9.05%) (Febriana et al., 2014). Black rice has a sticky structure (Adhi et al., 2017).

Sumatera Selatan is dominated with riparian wetland ecosystem. Yet, unpredictable flooding occurrence unable the farmers to utilize the paddy field for more than once plant cultivation per year (Guwat et al., 2015). High water level submerges rice seeds and decrease the ability of rice to grow optimally (Siaga et al., 2016). In addition, unpredictable water level increase the risk of waterlogging and submergence stress during vegetative stage of rice (Siaga et al., 2016). Seedling preparation on floating seedbed is an alternative solution to avoid high risk of submergence. Floating system allows farmers to utilize flooding period for early seedling preparation and accelerate planting time.

Floating system conducts on a raft with decomposed aquatic weeds biomass as growing media (Lindiana et al., 2016). Seedling growth usually affect by population density especially on competition for absorbing nutrients from growing media (Pithaloka et al., 2015). Higher density indicates higher plant population. Competition on absorbing sunlight, water, and nutrient happened when density is too high. In contrary, low density indicates low population with lower intensity of competition as well (Fatchullah, 2017). The precise transplanting time is necessary to anticipate the reduction of root development which is usually stop growing at 42 DAS (Kuniasari et al., 2018).

Optimum time for rice transplanting is 15 DAS (Napisah, 2014). Younger seedling age is more adaptable to environment and deeper root system that higher resistance to fall and drought stress, and might absorb nutrient effectively (Anggraini, 2013). Thus, this study aimed to understand the effect of water table, population density, and precise transplanting time for black sticky rice vegetative growth.

MATERIALS AND METHODS

Seedling preparation

Seedling was prepared on 3 rafts (2x1 meter) constructed from 1.5 L size mineral water bottles. Each raft represented different water table (mainplot) and was divided into 3 parts per each for population density treatments (sub-plot). This study was arranged base on split plot design with 2 factor and 3 treatments per each. The first factor (mainplot) were: R1 = 0.0 mm (in contact with water surface); R2 = 7.5 mm (partial saturated); R3 = 15 mm (fully saturated). The second factor (sub-plot) were D1 = 0.25 kg/m²; D2 = 0.50 kg/m²; D3 = 0.75 kg/m².

Transplanting

Seedlings were transplanted at 14 DAS, 21 DAS, and 28 DAS.

DataAnalysis

Statistical analysis for evaluating treatment’s effect on measured variables were carried out using the Analysis of Variance (ANOVA). Differences between
means were tested using the Least Significant Difference (LSD) at p < 0.05.

RESULTS AND DISCUSSION

Seedling Preparation
Seedling Height and Leaf Variables
The result of analysis of variance showed that water table and population density were not significantly affected the seedling height but it was increasing every week (Figure 1 a). The highest seedling showed by R1D3 treatment and the lowest height found in R2D2. The longest leaf length obtained by R2D1, while the shortest was R2D2 (Figure 1 b). For leaf width, the highest average found in R1D1 and lowest in R1D2 (Figure 1 c). The highest leaf area showed by R1D1 and smallest at R2D2 (Figure 1 d). Significant effect of water table found in number of leaves. The highest number of leaves obtained by seedlings treated with R3 (Figure 1 e).

Seedling Root Length
Based on analysis of variance, water table and population density were significantly affected root length. The longest root length average showed by R1D1 treatment and the shortest at R1D3 treatment (Figure 1 f).

Seedling Density, Fresh Weight, and Dry Weight
Based on analysis of variance, population density significantly affected seedling density, and its fresh and dry weight. For those three variables, treatment density 0.75 kg/m² was significantly different with 0.25 kg/m² and 0.50 kg/m². Water table was significantly affected seedling fresh weight (Table 1).

Plant Height and Leaf Area after Transplanting
The average of plant height was affected by transplanting time (Table 3). 14 DAS showed highest value on leaf area at 7 WAT until 10 WAT (Table 2).

Number of Leaves and Number of Tillers after Transplanting
The result of analysis of variance showed that the interaction of water table and population density showed R1D3 was significantly different with R2D2, R2D3, and R3D2. Result also indicated that number of tillers effect by transplanting time showed significant difference of W1 compared to W2 and W3 (Table 5).

Leaf SPAD
Leaf SPAD was measured using chlorophyll meter (Konica Minolta SPAD-502 Plus). Result of analysis of variance showed that transplanting time was significantly affected leaf SPAD. At 5 weeks after transplanting 5 WAT, treatment 14 DAS significantly different with 21 DAS and 28 DAS but at 8 WAT, 28 DAS was significantly different with 14 DAS and 21 DAS (Table 6). Figure 1 a-1 f explained that the highest number of seedling height, leaf length, leaf width, leaf area, and number of leaves dominantly obtained by R1 treatment. It was reasonable since R1, media was not saturated by water and oxygen was still available. This condition allowed rice root to grow and absorb nutrient well and support the better growth. D1 treated with low density resulted lower intensity of competition.

Plants whose roots submerged has shorter roots because water inhibits root growth. Seeds with high population density make it difficult for roots to grow. Seeds with high population density make it difficult for roots to grow.
Table 1. The effects of water table and population density on seedling density, fresh weight, and dry weight of black sticky rice seedling prepared on floating seedbed

| Density (kg/m²) | Seedling Density (g/cm²) | Average | Fresh Weight (g) | Dry Weight (g) |
|----------------|--------------------------|---------|------------------|---------------|
| 0.25 kg/m²     | 99.33 a                  | 0.182 a | 0.039 a          |               |
| 0.50 kg/m²     | 184.00 b                 | 0.386 b | 0.069 b          |               |
| 0.75 kg/m²     | 237.33 c                 | 0.569 c | 0.116 c          |               |
| LSD 5%         | 29.70                    | 10.74   | 2.35             |               |

Water Table (mm)

| Water Table (mm) | Seedling Density (g/cm²) | Fresh Weight (g) | Dry Weight (g) |
|------------------|--------------------------|------------------|---------------|
| 15 mm            | 181.47                   | 0.392 b          | 0.072         |
| 7.5 mm           | 175.13                   | 0.323 a          | 0.074         |
| 0.0 mm           | 164.07                   | 0.422 a          | 0.080         |
| LSD 5%           | 4.28                     |                  |               |

Means followed with the same letters within rows are not significantly different based on the LSD at p < 0.05

Table 2. The effect of transplanting time on leaf area of black sticky rice's leaf

| Transplanting Time | Leaf Area (cm²) |
|--------------------|-----------------|
|                    | 7 WAT | 8 WAT | 9 WAT | 10 WAT | 11 WAT |
| 14 DAS             | 50.16 c | 53.91 b | 60.80 | 71.19 b | 70.62 |
| 21 DAS             | 43.38 b | 52.21 b | 59.61 | 64.58 a | 68.05 |
| 28 DAS             | 36.10 a | 48.50 a | 58.84 | 71.19 a | 71.37 |
| LSD 5%             | 3.24 | 3.00 | 3.33 |

Means followed with the same letters within rows are not significantly different based on the LSD at p < 0.05

Table 3. Significantly different of height of black sticky rice after transplanting time

| Treatment | Height (cm²) |
|-----------|--------------|
|           | 6 WAT | 7 WAT | 8 WAT | 9 WAT | 10 WAT | 11 WAT |
| 14 DAS    | 65.65 c | 74.85 c | 83.32 c | 89.21 c | 98.55 b | 104.03 c |
| 21 DAS    | 52.28 b | 67.35 b | 77.68 b | 86.68 b | 92.29 a | 98.29 b |
| 28 DAS    | 37.32 a | 53.37 a | 68.37 a | 83.48 a | 91.11 a | 96.09 a |
| BNT 5%    | 1.82 | 1.79 | 2.31 | 1.93 | 1.89 | 2.09 |

Means followed with the same letters within rows are not significantly different based on the LSD at p < 0.05

Table 4. Significantly different of number of leaves after transplanting time

| Treatment | Number of Leaves |
|-----------|-----------------|
|           | 6 WAT | 7 WAT | 8 WAT | 9 WAT | 10 WAT | 11 WAT |
| 14 DAS    | 102.92 c | 126.78 c | 126.18 c | 126.85 c | 127.70 c | 97.00 |
| 21 DAS    | 55.33 b | 90.00 b | 101.93 b | 104.28 b | 120.22 b | 94.55 |
| 28 DAS    | 27.56 a | 48.44 a | 58.49 a | 89.15 a | 102.33 a | 93.11 |
| BNT 5%    | 4.9 | 6.7 | 6.68 | 6.06 | 4.53 |

Means followed with the same letters within rows are not significantly different based on the LSD at p < 0.05

Table 5. Number of tillers after transplanting time from 6 WAT until 11 WAT

| Treatment | Number of Tillers |
|-----------|-----------------|
|           | 6 WAT | 7 WAT | 8 WAT | 9 WAT | 10 WAT | 11 WAT |
| 14 DAS    | 34.37 c | 43.33 c | 42.18 c | 42.51 c | 43.62 c | 32.14 |
| 21 DAS    | 18.44 b | 30.04 b | 34.49 b | 35.48 b | 39.96 b | 31.88 |
| 28 DAS    | 9.19 a | 16.37 a | 27.30 a | 30.37 a | 34.37 a | 32.25 |
| BNT 5%    | 1.7 | 2.15 | 2.39 | 2.12 | 1.65 |

Means followed with the same letters within rows are not significantly different based on the LSD at p < 0.05
Table 6. The effect of transplanting time on leaf SPAD

| Transplanting Time | 35 DAS     | 56 DAS     |
|--------------------|------------|------------|
| 14 DAS             | 40.14c     | 33.50a     |
| 21 DAS             | 36.51b     | 37.76b     |
| 28 DAS             | 22.89c     | 40.18c     |
| LSD 5%             | 2.00       | 1.00       |

Means followed with the same letters within rows are not significantly different based on the LSD at p < 0.05

Note: R is treatment of water table symbol; 15 mm (R1); 7.5 mm (R2), 0.0 mm (R3), D is treatment of density population symbol; 0.25 kg/m² (D1); 0.50 kg/m² (D2); 0.75 kg/m² (D3)

Figure 1. The effects of water table and population density on height (a), leaf length (b), leaf width (c), leaf area (d), number of leaves, and root length (f) of black sticky rice seedlings at floating seedbed 4 WAT
Spacing density between one seedling and another causes root damage during seedling during transplanting (Usman et al., 2014). The optimum seed density (not too dense) provides good growth because it utilizes more sunlight and nutrients (Ikhwan et al., 2013). D3 has a higher fresh weight due to having more seeds. Overall dry weight is affected by elongation of stems and carbohydrates. According to Gribaldi and Nurlaili (2016) immersion stress affected dry weight of plants per clump. Based on (Erungan et al., 2014), rice transplanted at 10 DAS show the highest plant height every week. Young seedling (<15 DAS) have better adaptation ability with new environment after transplanting and utilize nutrient well. Transplanting time at 14 DAS (W1) significantly affected the length, width and area of leaf. Arif et al. (2014) stated that the low leaf area due to late transplanting time affected by several factors, such as stress due to movement shocks when transplanting. Thus, transplanting at 15 DAS is best for providing the highest vegetative growth including length, width, and area of leaf, and producing higher yield compared to 20 days after seedling (Napisah, 2014).

Number of leaves and number of tillers (Table 4 and 5) in treatment W1 (14 DAS) was significantly different to other treatments since the age of seedlings affected the number of tillers per hill and number of leaves. Transplanting at 14 DAS resulted in more leaves and higher number of tillers due to a longer vegetative stage to increase number of leaves and number of tillers continuously until 7 WAS. According to the study of Jalil et al. (2015), it was proven that transplanting at 15 DAS affected the number of tillers and panicle length. Transplanting at 10 WAS, increment number of tillers because plant starts entering the generative stage. Khakim et al. (2015) revealed that the number of tillers will decrease in each plant family due to physiological death after the maximum number of tillers is reached. Tillers that are unable to compete in getting nutrients or other growth factors will also die. The number of leaves and number of tillers were also influenced by transplanting time. According to Kuniasari et al. (2018) rice seedling transplants at 12 DAS rice seedlings produces the highest number of tillers compared to those transplanted at 24 DAS. Rice transplants at the older age have less ability to form high number of tillers. The number of tillers is related to the period of phyllochron formation.

Strategy for achieving long phyllochron formation period is by transplanting the seedlings at a young age (Sumardi et al., 2003). The longer the age of the seedlings, the less the number of phyllochron produces. Leaf SPAD at 56 DAS of plants treated with W1 was significantly different (Table 6), it was in association with W1 leaf area (Table 2). Leaf area affects the amount of SPAD. According to Haryanti (2014) larger and thinner leaves with larger size of stomata, and too high light intensity can reduce the rate of photosynthesis due to the fast-acting chlorophyll photooxidation which damaging chlorophyll.

CONCLUSION

Water level 0.0 mm and 25 kg/ha density resulted the best seedling growth such as leaf width, leaf area and root length. After transplanting, plants transplanted at 14 DAS provided better vegetative growth and a higher number of tillers than 21 DAS and 28 DAS.

ACKNOWLEDGEMENT

The authors would like to express gratitude to editor and the anonymous reviewers for their constructive comments on this manuscript.

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