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Response of rice (*Oryza sativa* L.) on seedling age and number of seedlings per planting hole

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Abstract. The objectives of this research were to investigate the growth and yield response of paddy rice on transplanting seedling ages and number of seedlings per planting hole. This research was conducted in October 2016 until January 2017 in Petuaran Hulu Village, Pegajahan Subdistrict, Serdang Bedagai Regency, North Sumatera Province. The experimental design used was a Randomized Block Design with two factors and three replications. The first factor was the age of transplanting seedlings with four levels (12, 16, 20, and 24 days). The second factor was the number of seedlings per planting hole with four levels (1, 2, 3, and 4 seedlings per planting hole). Analysis of Variance was conducted in order to see the effect of the treatments. The treatments that showed significant effect was tested with Duncan to compare among treatments effect. The results showed that transplanting seedling age and number of seedlings per planting hole had significant effect on plant height, number of tillers, but no significant effect on stem diameter, number of productive tillers, panicle length, and productivity. The effect of interaction of the two treatments had no significant effect on all observed parameters. Transplanting seedling age of 12 days and one seedling per planting hole was suggested to be applied for rice cultivation.

1.Introduction

Indonesia ranks third in rice production in the world after China and India. Rice is the staple food of Indonesian, more than 90% of Indonesia population consumes rice, as a source of more than 70% of the national caloric needs. Rice farming in Indonesia is dominated by small farmers who contribute about 90% of total rice production in Indonesia[1]. Paddy farming is the main source of income for more than 60% of the Indonesian population, so rice is considered a strategic commodity [1]. Based on data from [2] that national rice production from 2015 of 75,397,841 tons increased 13% compared with national rice production in 2010 which amounted to 66,755,904 tons. Nevertheless, Indonesia in 2016 still imports 1.1 million tons of rice [2]. Therefore, the government has sought to develop technologies that can increase rice productivity in meeting national rice needs. The current rice farming system applied by farmers is based on four important pillars namely water supply through irrigation system, optimal use of chemical fertilizer, pesticide application in accordance with pest attack rate, and use of superior varieties called green revoltion or conventional system.

With conventional rice cultivation system, where paddy field continues to be flooded, planting 5 to 7 seedlings per planting hole, with 21-27 days old seedlings, plant spacing of 20 cm x 20 cm and provide high external input, such as fertilizers and chemical pesticides. Through this system, the increase in rice yields doubles compared with traditional rice cultivation. With green revolution system, Indonesia has succeeded as a self-sufficiency country for rice from 1984 – 1989.

However, with the growing awareness of the importance of environmental sustainability, the green revolution system needs to be evaluated as the productivity of rice paddy fields tends to decline and the potential for environmental damage resulted, such as biodiversity decline, the continued use of fertilizer causes dependence on fertilizer, and the use of pesticides unstable causes the emergence of new strains of resistant pests [3] and [4].

Many efforts to improve productivity, sustainability, and efficiency of paddy field farming have been largely undertaken by governments and non-governmental organizations to meet food availability and increase farmer incomes. Integrated crop management approach to paddy rice is one of the approaches developed by the agricultural research and development agency in order to achieve rice self-sufficiency [5] and [6].The basic principles of integrated crop management development are realized in the form of integration of production technology components such as creating high yielding varieties with high production potential and appropriate cultivation techniques. One rice cultivation system with an integrated crop management approach known as System of Rice Intencification (SRI). This system was originally developed in Madagascar between 1983-1984 [7]. SRI practice is mainly based on six components: (1) planting of young seedlings, (2) single seedling per planting hole, (3) wide spacing, (4) aerobic soil moisture, (5) only apply organic fertilizer, and (6) weeding. The concept of SRI Indonesia has been also tested and practiced in several districts in Java, Sumatra, Bali, West Nusa Tenggara, Kalimantan, Sulawesi and Papua [8]. According to [9] the system of young and single seedlings per planting hole has an advantage over the conventional system, the young seedling system can shorten the stagnation period after transplanting, so that the seeds grow quickly and have a good vigor. Single planting per planting hole is expected to be efficient, in this way the seed requirement is only 8 -10 kg/ha, whereas common cropping system applied by farmer need seed more about 80kg seed/ha.Various introductions to the innovation of paddy field cultivation may not immediately be accepted for application by farmers and may even take a long time for innovation to be adopted and become part of the farmer's need as a user with various obstacles. Similarly with system of rice intensification (SRI) that is 100% pure organic farming system, it becomes difficult to be applied by farmers, including farmers in the research area, because the availability of organic fertilizers and organic pesticides to meet the needs of paddy rice is not economically to be implemented.

If SRI is applied 100%, then the cost of production will be much higher than the conventional system applied by farmers. Therefore, wetland rice cultivation system by adopting some SRIprinciples such as seedling age and number of seedlings per planting hole have been studied extensively and specifically location, such as [10] reported that the combination of seedlings 15 days after seeding with spacing of 20 cm x 20 cm gave the highest grain yield of 7.59 t / ha in the rainy season and 8.35 t / ha in the dry season. In addition, the application of 1 seed per planting hole gave a higher yield than 3 seeds per planting hole. The number of seedlings per planting hole did not affect the productivity of the four rice varieties [11]. Research conducted by [9] showed that the number of seedlings and the age of transplanting seedlings did not affect rice yield. According to [12] that spacing affected the length of panicle, the number of seeds per panicle and the yield. Spacing with 35cm x 35 cm of IR-64 rice varietygave the highest yield compared with plant spacing of 25 cm x 25 cm, 30 cm x 30 cm and 40 cm x 40 cm. Planting of 12-day-old seedlings yielded the highest grain yield, grain protein content and NPK absorption compared to 8, 16, 20 days old seedlings and 25 cm x 25 cm planting patterns recorded higher grain yields, protein content and NPK uptake compared with 20 cm x 20 cm, 30 cm x 30 cm and 35 cm x 35 cm. while the lowest parameter value was at plant spacing of 35 cm x 35 cm [13].

From the interviews with farmers and site observations in the village of Petuaran Hulu, Pegajahan Subdistrict, Serdang Bedagai Regency generally farmers sow seeds of approximately 50 kg / ha. Usually farmers plant rice with 5 to 7 seeds per planting hole, this is very high when compared with the recommended 25 to 30kg / ha. Therefore, one effort to minimize the cost of rice cultivation can be by saving the use of seeds. The purpose of this study was to investigate the response of paddy rice on transplanting seedlings age and number of seedlings per planting hole in oder to obtain the effective and efficient of rice cultivation.

2. Materials and method

2.1.Place and time of research

The study was conducted from October 2016 to January 2017, in the wetland rice field, Petuaran Hulu Village, Pegajahan Subdistrict, Serdang Bedagai District, North Sumatra, with elevation 25 m above sealevel, soil pH 6.5.

2.2.Materials and tools

Ciherang rice varieties was used that was obtained from Seed center, Jln. Tanjung Morawa, Lubuk Pakam, Deliserdang, North Sumatra; urea fertilizer, SP-36, and KCl, dolomite, EM-4, insecticides, kakterisida, fungisida and moluskisida (Besnoit). The tools used were a roller meter, screw length, scales, and pH meters.

2.3. Experimental design

The experimental design used was Factorial Randomized Block Design (RCBD), with two factors each with four levels with three replications. The first factor was the age of transplanting seedling with four levels (12, 16, 20, and 24 days). The second factor was the number of seedling seedlings per planting hole with 4 levels (1, 2, 3, 4 seedlings per planting hole). Analysis of Variance was applied in order to see the treatment effect and interaction treatments effect. The treatments that showed significant effect was proceeded with Duncan test with alpha 0.05 and 0.01. Linear regression analysis was used to see the correlation between treatments and parameters.

2.4. Parameters observed

The parameters observed were plant height, stem diameter, number of tillers, number of productive tillers, panicle length, number of grains per panicle, weight of 1000 harvest dry grain, and yield.

2.5. Research process

Land preparation, the soil was first plowed twice. During plowing the dolomite and EM-4 were applied. While the soil was flattened molluscicide, bensoit was applied. Made a plot of 2.5m x 2.5m, the distance between plots 0.5m, the distance between replicates 1m, the number of plots 48 with spacing 35cm x 35cm. Furrow ws created around the experimental field and between replicates.

2.6. Seed nursery

Before seeds put into seedbed, firstly, seeds were tested for the seed germination rate, then seeds were put into fertilizer sack and soaked in water for 48 hours. This immersion aimed to accelerate germination. The soaked seeds were then removed and put into a porous sack or container in order to allow air to enter the rice seed, and then stored in a humid place. Seed nursery was prepared in the research site, in accordance with what is usually done by local farmers. The nursery time was arranged so that the time to transplant seedlings could coincide according to the level of treatments, transplanting seedlings age.

2.7. Transplanting seedlings

Before planting, the planting spacing was determined by 35cm x 35cm. Each point which wasa long and widening enclosure was a place for planting rice seedlings. Planting was done simultaneously according to each treatment level with a depth of 1 - 2 cm.

2.8. Fertilization.

The fertilizer used was urea 250 kg / ha, SP-36 150 kg / ha, and KCl 150 kg / ha. The urea fertilizer was applied 3 times with each 1/3 dose at age 10, 21 and 40 days after transpalanting.

2.9. Irrigation

The provision of irrigation water, intermittently with the water level from the surface of the soil in the maximum 2 cm paddy field.

2.10. Pest and disease control

Control of pests and diseases was done depending on the monitoring in the field.Parameter Observation. For parameters observation, three clumps of each plot were used.

2.11.Plant height

Plant height was measured from the base of the stem exactly on the soil surface to the highest leaf by enforcing the leaves. Plant height was measured from 3 plants of each sample clump. Measurements were performed at ages 10, 20, 30, 40, 50 and 60 days after transplanting . Plant height is measured by meter rolls.

2.12.Number of tillers

The observation of the number of tillers was calculated from 3 sample clumps from each plot, which was performed on 30, 40, 50 and 60 days after transplanting.

2.13.Stem diameter

Stem diameter measurements were performed at 90 days after transplanting, using a sliding range. Determination from 3 sample plants from each sample clump for measuring stem diameter. The diameter was measured on the second segment of each stem of the sample plant.

2.14.Number of productive tillers

The number of productive tillers was counted from three sample clumps of each plot. Counting was performed on 90 days after transplanting, by counting the number of tillers that produced panicles.

2.15. Panicle length

Measurement of panicle length was done at harvest, 110 days after transplanting. The length of panicle was measured from the base of panicle to the tip of panicle using a ruler. Observations were made on three plants from each of the 3 sample clumps.

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2.16. Number of grains per panicle

Counting the number of grains per panicle was done at harvest time by counting all grains included the empty grains. Counting the number of grains was done on three plants from 3 each sample clump.

2.17.Yield

Harvesting was done at the time after the physiological matured grain, which was marked by yellowing the grain evenly, and the grain was not watery when bitten. Yield was calculated by harvesting 1m2 of each plot, then converted into yield per ha.

2.18.Weight of 1000 grains of harvested dry grain

The weigh of 1000 grains of dry grain harvest was done at harvest time. The 1000 rice grains were then selected randomly and manually, then were weighed with an analytical scale.

3. Results and discussion

The results of observation of the effect of planting seedlings age and the number of seedlings per planting hole were presented in table 1 and 2; Fig. 1,2,3 and 4. The results showed that the observed parameters were more or less the same as the description of potential Ciherang rice varieties, even higher than the description of its potential such as the number of productive tillers in the description of the potential number of productive tillers 14-17 stems, while in this study 26 -29 stems, the yield per hectare according to the potential description of 6 tons per hectare, in this study even reached the potential of the description that was in the range of 8 tons per hectare.

3.1.Effect of Transplanting seedlings age

Based on analysis of variance indicated that the age of transplanting seedlings had significant effect on plant height and number of tillers, but had no significant effect on stem diameter, number of productive tillers, panicle length, number of grains per panicle, weight of one thousand harvested dried grain and yield (table 1). This result was in accordance with the results of [9], [13]. However, this result differed from the results of research by [10] and [14] who reported that the age of seedlings had a significant effect on rice yield. The differences in the results of this study may be due to differences in rice varieties used and research sites. The highest plant height wasresulted by planting age of 20 days with an average height of 101.15 cm. The correlationequation between transplanting seedling age with plant height was $y = 46{,}71 + 6{,}087x - 0{,}342X^2$ with r = 0,974 * indicated that 97,4% of variation of plant height caused by treatment of transplanting seedlings ageand 18 days of seedling age resulted the optimum height of rice (Fig.1). Transplanting seedling age had significantly affected the number of tillers (table 1). The correlation equation between transplanting seedling age with number of tillers was $y = -9{,}895 + 5{,}665X - 0{,}168X^2$ with r = 0,985 * indicated that 98,5% variation of number of tiller was due to treatment of transplanting seedlings age and 17 days of transplanting seedling age resulted maximum number of tillers (Fig. 2).

Table 1. Average response of growth and yield on transplanting seedlings age.

Seedling age (day)	Plant height (cm)	Stem diameter (mm)	Number of tillers	Number of productive tillers	Panicle Length (cm)	Number grain per panicle	Weight of 1000 grains of harvested dry grain (g)	Yield (t/ha)
U1	95,41a	28.52 a	33.53 b	28.52 a	26,14 a	156,18 a	20,55 a	8,78 a
U2	99,45b	28.52 a	38,31c	27,68 a	26,30 a	153,75 a	20,67 a	8,34 a
U3	100,88b	28.52 a	35,14b	29,36 a	26,09 a	153,10 a	21,12 a	7,75 a
U4	93,97a	28.52 a	29,12a	27,83 a	26,21a	151,96 a	20,12 a	7,77 a

The numbers followed by the same letter in the same column are not significantly different at the 5% level based on the Duncan distance test.

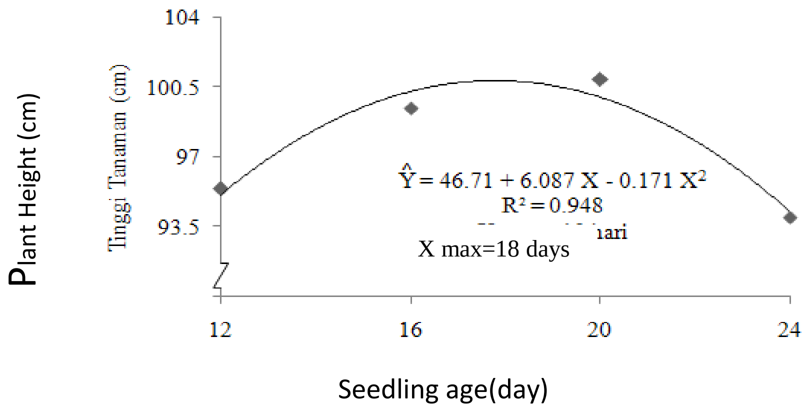

Figure 1. Correlation between transplanting seedlings age and plant height

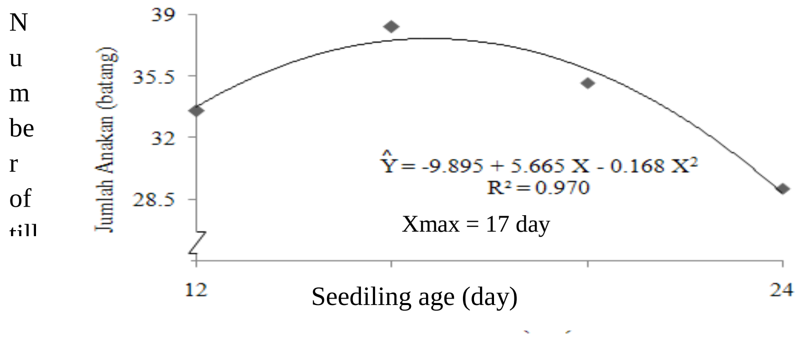

Figure 2. Correlation between transplanting seedlings age and number of tillers

3.2. Effect of number of seedlings per planting hole

The results of analysis of variance showed that the number of seedlings per planting hole had significant effect on plant height and number of tillers, but not significant on stem diameter, number of productive tillers, panicle length, number of grains per panicle, weight of one thousand harevested dry grain sand yield (table 2). This result was in accordance with the results of research [9] and [11] who reported that the number of seedlings per planting hole did not affect rice yield. The correlation equation between number of seedlings per planting hole and plant height was Y = 79,46 + 16,11X - 2,977X^2 * with r = 0,999 * indicated that variation of plant height 99,9% caused by number of seedlings per planting hole (Fig. 3). From correlation equation 3 seedlings per planting hole gave maximum plant height (Fig. 3). The correlation between number of seedlings per planting hole and number of tillers has the equation Y = 20,77 + 10,22X - 1,64X^2 * with r = 0,999 * indicated that the variation of the number of tillers 99.9% was due to number of seedlings per planting hole (Fig. 4). From the correlation equation of the number of seedlings per planting hole was found that 2 seedlings per palnting hole resulted maximum tillers (Fig. 4).

Table 2. Response of growth and yield of rice on number of seedlings per planting hole.

Number of seedlings per planting hole	Plant height (cm)	Stem diameter (mm)	Number of tillers	Number of productive tillers	Panicle Length (cm)	Number grain per panicle	Weight of 1000 grains of harvested dry grain (g)	Yield (t/ha)
J_1	92,65a	26.99 a	29.58 a	26.99 a	26.05 a	154.05 a	20.35 a	8.23 a
J_2	99,66c	28.72 a	33.97 b	28.72 a	26.18 a	158.20 a	20.55 a	8.19 a
J_3	101,15c	28.17 a	37.36 c	28.17 a	26.26 a	152.51 a	20.90 a	8.27 a
J_4	96,25b	29.52 a	35.19 b	29.52 a	26.24 a	150.23 a	20.80 a	7.95 a

The numbers followed by the same letter in the same column are not significant at the 5% level based on the Duncan distance test.

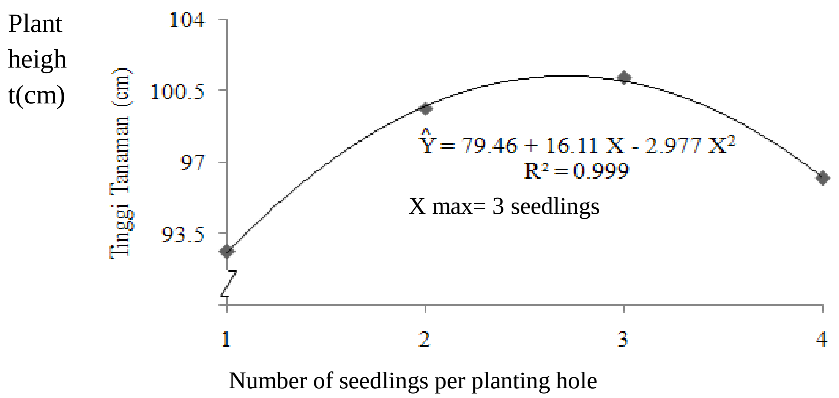

Figure 3. Relationship between number of seedlings per planting hole and plant height.

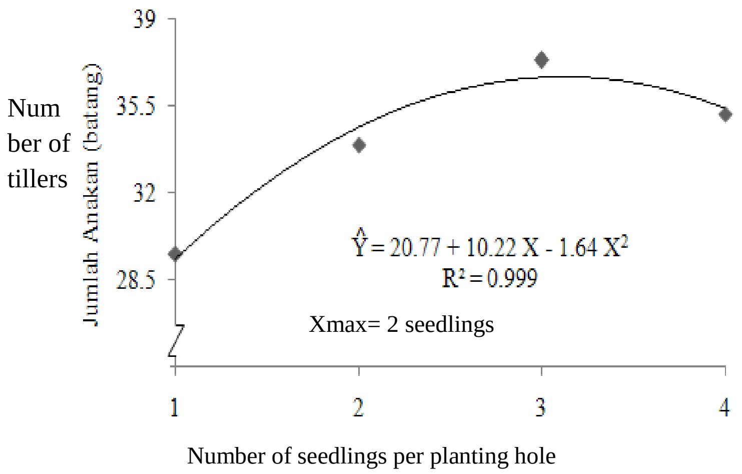

Figure 4. Correlation between number of seedlings per planting hole and number of tillers.

3.3. Interaction effect

Based on results of analysis of variance showed that interaction between transplanting seedling age and number of seedlings per planting hole did not significantly affect all observed parameters. These results were in accordance with the results [9]. This indicated that the main factor solely determined the response of all observed parameters.

4. Conclusion

1. Number of seedlings per planting hole and age of planting seedlings had significant effect on plant height, but not significantly effect stem diameter, number of productive tillers, panicle length, number of grains per panicle, weight of 1000 harvested drygrain yield.
2. Effect of interaction number of seedlings per planting hole and age of planting seedlings have no significant effect on growth and yield.
3. Transplanted seedlings age of 12 days and one seed per planting hole could be applied on rice cultivation.

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