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Research Article
Yield of Local Varieties of Paddy (*Oryza sativa* L.) with Different Plant Spacing in Rainy Season

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Abstract

Background and Objective: Paddy *(Oryza sativa* L.) is one of the most important crops for Indonesian society and it is the main commodity for staple food of Indonesians. The growth and quality of the paddy depends on the interaction between environmental and plant genetic factors. Efforts to increase rice productivity by using only superior varieties will not be effective without being followed by site-specific cultivation techniques, especially optimize plant spacing. This study was conducted to determine the optimum spacing used in planting local varieties. **Materials and Methods:** This study was conducted from February, 2017 until May, 2017 in Tekung Village, sub-district of Tekung, Lumajang, East Java province. The factorial experiments were using split plot design with varieties (Ciherang, Mentik and Genjah Arum varieties) as main plots and plant spacing as sub plots. The parameters included were observation of productive tillers percentage, 100-grain weight, total grain per panicle, grain weight per clump and number of panicle per culmp. Data obtained were subjected to two-way analysis of variance (ANOVA) at 5 and 1% levels, if the significance difference will be continued by fisher's Least Significant Differences (LSD) test at the 0.05 probability level. **Results:** The results showed that the responses of each variety at various plant spacing had a significant interaction between varieties and plant spacing on the weight of grain weight per clump and number of panicle per clump. Whereas in parameter productive tillers percentage, 100-grain weight and total grain per panicle only influenced by varieties. **Conclusion:** The treatment of V1J40 (Ciherang variety with plant spacing 40 cm × 15 cm), had the highest grain yield compared to other treatments.

Key words: Grain weight, local variety, plant spacing, *Oryza sativa* L., superior variety

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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

Paddy is one of the most important crops for Indonesian society. Therefore, there are so many paddy cultivations in various regions, especially those that having a good watering systems. Plant growth and quality depends on the interaction between environmental and plant genetic factors. The genetic factor is related to the plant characteristics. Zaini *et al.*[1], stated that excessive weather conditions during the rainy season is considered a serious limiting factor on paddy production in Indonesia. Under the normal conditions, the rainy season in Indonesia occurs from October-April, but for nowadays, there is a fluctuate season because of the climate change[2].

The rainy season is characterized by the decreasing daily air temperature, lower solar radiation, cloudy and high rainfall. The dry season is characterized by increasing daily air temperatures, high solar radiation and the humidity is decreasing. These factors are clearly reflected on the growing season, thus the same variety that were planted in the same location with different seasons will have different yield. This as an indicator yield higher paddy in dry season than in rainy season[2,3].

The high solar radiation during the dry season along with the grain ripening stage contribute greatly to the optimum yield. Moreover, it is caused by different planting pattern system of each region, so that the radiation that received by the plant varies. Leaf morphology could affect the efficiency of solar radiation, vertical leaf type (vertical) will make a lot of sunlight passed by the surface of the soil, while the type of curved (horizontal) could make the land surface closure faster so that solar radiation will be more efficient[4]. Setting of plant spacing is important for plants because it can affect sunlight capture for photosynthesis, the effectiveness of nutrient uptake by roots, water requirements, air circulation, microclimate (temperature and humidity) and weed and pest populations[2]. This research was conducted to obtain the best treatment of plant spacing to improve paddy yield on local varieties which was planted in rainy season.

MATERIALS AND METHODS

The research was conducted from February, 2010 until May, 2017 and located in Tekung village, sub-district Tekung, Lumajang district, East Java on a lowland with 25-50 m above sea level and the air temperature between 24-32°C. The rainfall ranges from 1,500-2,500 mL. Lumajang geographically is in position 112°53'-113°23' East longitude and 7°54'-8°23 South latitude. The factorial experiments arranged in the split plot design with three times repetitions. The main plot was varieties (V), while the sub plot was plant spacing. Below are the details of the experiments as follows:

The main plot consists of 3 varieties:

- V1 = Ciherang (superior variety)
- V2 = Mentik (variety of local 1)
- V3 = Genjah Arum (variety of local 2)

The sub plot was plant spacing (JT) which consists of 4 types, such as:

- JT25 = Plant spacing 25×25 cm
- JT30 = Plant spacing 30×20 cm
- JT40 = Plant spacing 40×15 cm
- JT50 = Plant spacing 50×12 cm

The plant spacing was widened from East to West (distance between rows) and distance in rows or narrow distance from North to South. The experiments were replicated for 12 plots of treatment with 3 times repetitions, so that there were 36 units of experimental plots, with each plot contained 166 plants.

Parameters of observations: The parameters of observations included observation of productive tillers percentage, 100-grain weight, total grain per panicle, grain weight per clump and number of panicles per culmp.

Statistical analysis: The results of this experiment were analyzed using two way analysis of variance (ANOVA) with F-test at 5 and 1% levels. If there was a significantly different results, it will be continued with LSD test at 5% level[5].

RESULTS AND DISCUSSION

The observations of paddy yields were included observation of productive tillers percentage, 100-grain weight and total grain per panicle, there is no interaction between varieties and spacing but on parameter grain weight per clump and number of panicle per culmp, there is interaction between varieties and spacing.

Table 1 shows that productive tillers V1 (Ciherang) with value 50.08% were not significantly different with V2 (Mentik) value 46.33%. On the observation of 100-grain weight, V3 (Genjah Arum) with value 1.99 g were highest 27.87% than V1 and V2 with value 1.90-1.92 g. The 100-grain weight of V3 were higher 1.99 g than V2 and V1 with estimated differences

Table 1: Productive tillers percentage, harvest periods, 100-grain weight and number of grain per panicle

	Parameters of observations		
Varieties	Productive tillers (%)	100-grain weight (g)	Total grain per panicle
V_1	50.08[b]	1.92[a]	173.86[b]
V_2	46.33[b]	1.90[a]	82.24[a]
V_3	27.87[a]	1.99[b]	152.81[b]
LSD 5%	15.41	0.04	22.58
Plant spacing			
J_{25}	38.66	1.93	140.90
J_{30}	41.94	1.92	135.05
J_{40}	44.21	1.97	130.41
J_{50}	40.90	1.92	138.85
LSD 5%	ns	ns	ns

Means followed by the same letter on the column showed no significant difference based on LSD test at level 5%. ns: Non-significant

Table 2: Interaction between varieties and plant spacing to the number of panicle per clump

	Number of panicle per clump			
	Plant spacing			
Varieties	J_{25}	J_{30}	J_{40}	J_{50}
V_1	10.33[cd]	12.33[e]	15.08[f]	12.33[e]
V_2	8.33[b]	9.08[bc]	11.00[de]	9.33[bcd]
V_3	2.58[a]	2.92[a]	3.42[a]	3.25[a]
LSD 5%	1.69			

Means followed by the same letter on the column showed no significant difference based on LSD test at level 5%

Table 3: Interaction between varieties and plant spacing to the grain weight per clump

	Grain weight per clump (g)			
	Plant spacing			
Varieties	J_{25}	J_{30}	J_{40}	J_{50}
V_1	43.70[bc]	42.79[bc]	58.35[d]	48.81[c]
V_2	36.20[b]	35.17[b]	35.65[b]	36.42[b]
V_3	21.40[a]	22.26[a]	25.84[a]	24.78[a]
LSD 5%	8.62			

Means followed by the same letter on the column showed no significant difference based on LSD test at level 5%

0.07-0.09 g. Total grains per panicle of V2 were lower 82.24 compared to V3 with value 152.81 grains per panicle and V1 with value 173.86 grains per panicle.

Variety of ciherang (V1) were having number of panicle per clump between 10.33 up to 15.08 (Table 2), plant spacing J25 had the lowest number of tillers compared to J30, J40 and J50, whereas J30 and J50 had the number of panicles that were not significantly different. J40 had a greater number of panicles than other plant spacing of 15.08 panicle. Varieties of Mentik (V2) had a number of panicles with a range of 8.33 up to 11.00 panicles per clump. Variety of Genjah Arum (V3) had a total of panicle per clump 2.58 up to 3.42. The results indicated that V3 with wider plant spacing between rows not showed any difference in the number of panicle per clump. When compared to each treatment of plant spacing between rows of J25, J30, J40 and J50, indicated that V1 was the variety that had the highest number of panicles.

Data on Table 3 show that V1 (Ciherang) on various plant spacing J25, J30 and J50 were not significantly different on grain weight per clump, 43.70, 42.79 and 48.81 g, respectively. J40 having the highest grain weight per clump (58.35 g) than J25, J30 and J50. While on variety of Mentik (V2) and variety of Genjah Arum (V3), the difference between plant spacing row was not significantly different on grain weight per clump. The result of grain weight per clump on plant spacing J25 with V3 (21.40 g) showed lower than V1 and V2 (43.70 and 36.20 g). The result of J30 with V3 was 22.26 to 42.79 g, whereas in J40 and J50 shows that the three varieties had different results, which from the table shows V3 had the lowest yield and V1 had the highest yield.

The parameter of productive tillers percentage, 100-grain weight and total grain per panicle only influenced by varieties. This result is in accordance with the research of Rahimi *et al.*[6], where the spacing is not so influential on the parameters where the parameters are strongly influenced by the genetic nature of the plant itself. Yield components in this study such as the grain weight per clump and number of panicle per culmp indicated that there were interaction between varieties and plant spacing. Putranto[7] said that the components of paddy yields were significantly influenced by plant spacing, especially the number of grains and panicle length. The research of Husana and Ardian[8] found that paddy yields not only determined by the type of varieties, but also determined the population on plant spacing, the plant spacing is to regulate the neatness of plants and also in use as the growth of paddy tillers (clump). In this study, the result of observations of the productive tillers percentage, 100-grains weight and the number of grain per clump were influenced by the type of plant varieties. Varieties is one of the determinants of crop yields, each variety has its own characteristics. Syamsudin *et al.*[9] suggested that different yield components of paddy are generally influenced by the types of varieties. Muyassir[10] showed grain yield greatly influenced by plant spacing.

The results showed that varieties and plant spacing determine the yield of rice crops. Each variety has a different response at each plant spacing. Paddy yields indicated that there were some influences from various varieties and plant spacing. Crop yields could be increased by increasing the total dry weight produced or by increasing the proportion yield of economic. The yield helps to illustrate the level of ratio/

profitability gained from the land inputs. In the practice, the results were often converted into economic value (selling value) per unit area to calculate the profit economically[3]. The differences of total yields were affected by yield loss, that were affecting the optimum yields per hectare of paddy. Loss of yield during the harvest may be affected by several factors, such as harvest periods, moisture content, tools and how to harvest. In addition, overcrowding paddy crops with low moisture content could cause grain easily to fall off during harvest[11].

The concept of plant spacing is giving the possibility to the plants for optimum growth without experiencing too much competition, such as water absorbtion, nutrients and sunlight. The right spacing is important, so the plant could has the optimum sunlight utilization for photosynthesis and the plant will have a balance growing space. Sohel *et al.*[12], stated that the optimum plant spacing could make the vegetative organs and roots in the optimum growth, so that it could utilize more sunlight and nutrients. Otherwise, if plant spacing was too close, the plants will having intense competition on sunlight, water and nutrients. As the result, plant growth is inhibited and the yield is low. The study of plant spacing in Indonesia reported by Pratiwi[13], concluded that wider plant spacing given the opportunity of plant varieties to express their growth potential.

In low populations (wide plant spacing), the performance of clumps of paddy were high, but the yield component is lower than the closer plant spacing. Hatta[14] stated that the wide plant spacing will increase the reception of solar radiation by plant canopy, thus it will increasing plant growth such as; number of productive tillers, volume and root length, plant dry weight and grain weight per clump, but it was not affecting the yield per unit area. Setting spacing is one factor that plants need to boost production[15]. Mobasser *et al.*[16], stated that in the dense plant spacing, the number of panicles per clump were decreased, but the number of panicles per m^2 were significantly increase. Existing plant spacing will increase the capture of solar radiation by the plant canopy, so increase plant growth such as amount of productive tiller, total volume and root length, increase the dry weight of the plant and the weight of grain per hill, not biased against yield unit area[17]. Conversely, at the spacing of the meeting amount panicle per hill decreases, but the number of panicles per m^2 real increases[18]. The results showed different spacing gave different responses to each variety. V1 with J40 has the best result, whereas on V2 and V3 the difference in spacing does not affect on the yield. The closer of plant population, the fewer number of tillers and the number of panicles per clump.

CONCLUSION

The response of each variety in the spacing arrangement will be different in the three varieties of paddy that planted in the rainy season. Plant spacing of 40 cm × 15 cm (J40) in the national superior variety of Ciherang had the highest grain weight per clump compared to the others plant spacing. Meanwhile, the result of various plant spacing on the local varieties of Mentik and Genjah Arum were not significantly different on the grain weight per clump.

SIGNIFICANCE STATEMENT

This research is expected to give recommendations on how to plant rice and selection of rice varieties to be planted in the rainy season. In general, the people of East Java, Indonesia plant rice in the rainy season, but there are some problems that occur such as the production of rice plants are not optimum caused by the lack of solar radiation. The results of this study will provide information on varieties and spacing is best used in the rainy season.

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