Bulgarian Journal of Agricultural Science, 25 (No 3) 2019, 499–505

Utilization of rice husk silicate extract to improve the productivity of paddy Ciherang cultivar

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Abstract

Frasetya, B., Harisman, K., Sudrajat, D. & Subandi, M. (2019). Utilization of rice husk silicate extract to improve the productivity of paddy Ciherang cultivar. *Bulgarian Journal of Agricultural Science*, *25*(3), 499–505

Rice is staple food of Indonesian and most of Asian people. Various researches were conducted to increase rice production. The practice of rice cultivation by farmers to restore rice straw and rice husks in the form of compost to agricultural land is rarely done. This practice causes the reduction of the silica availability in the soil. The element of silica in rice plants is a functional micro element in improving the quality of paddy grains. One of the efforts to overcome the lack of Si element, and increase the productivity of paddy in the field is to give the silica from rice husk extraction and planted with using Jajar Legowo (planting arrangement). The experimental method using split plot design consists of two factors with three replications. The first factor was Jajar Legowo (J), (j_1) and (j_2). The second factor is concentration of silica rice husk extract (S), ie 20 ml L^{-1} (s_1), 25 ml L^{-1} (s_2) and 30 ml L^{-1} (s_3). The observed data were analyzed with the analysis of variance at 5% significant level. Duncan's multiple range test was performed at 5% significant level. The results showed that jajar legowo (j_1) and 20 ml L^{-1} silica rice husk extracts with the best treatment yielded 1000 grains of 40.5 g, productivity per plot of 842.45 g m^{-2} or 8.42 t ha^{-1}, yield of paddy per hill 54.09 g, plant height 107,91 cm, percentage of unfilled grain 4.3 % and number of tillers 15.62.

Keywords: functional; micro element; jajar legowo; silica availability; paddy grain

Introduction

Paddy is a national strategic food crop for Indonesian. Various researches and projects have been done to increase paddy production. Productivity of wetland paddy in West Java in 2015 was 6.209 t ha^{-1} and it was higher than the national productivity, which was 5.508 t ha^{-1}. The high productivity of wetland rice in West Java (6,209 t ha^{-1}) has not been distributed widely. Based on data from Central Bureau of Statistic of West Java Province (2015) Bekasi district was the lowest productivity of rice compared with other districts in West Java, which is 5.130 t ha^{-1}.

Efforts of increasing rice productivity in West Java have been done by the government through the National Rice Production Enhancement Program (P2BN). It is possible to increase the productivity of wetland rice based on the consideration of the difference between the potential yield and the actual productivity. The increment of rice production can be gained through amendment of cultivation technology and improvement of farmer institution (Friyatno, 2013). The application of improved cultivation among other is the addition of silica fertilizer and planting space (plant density) arrangement using the so called jajar legowo system (Directorate General Food Crops Ministry of Agriculture, 2016).

Planting space arrangement will affect rice productivity because it affects sunlight caption of the plant, nutrient and water (Hermawati, 2012). According to (Hai-xin et al., 2012), planting space significantly affected the growth and yield of rice crops. In addition, planting space arrangement is very important for the plants to get sunlight and reduce the nutrient competition (Ikhwani et al., 2013). Pratiwi (2016) reported that *Jajar Legowo* gave the best response to grain weight per plot or weight of grain per hectare. Practice of planting space based on dry season or rainy season has not been done. In the dry season the spacing is used more spacing and rainy season is used spacing is more tenuous, it is based on the consideration in the dry season maximum intensity of solar radiation while in the rainy the radiation intensity is lower, so it needs wider spacing (Hermawati, 2012). The research results of Santosa & Suryanto (2015) showed that the weight of grain during the dry season was 1.464 g m^{-2} while planted in the rainy season only 746.8 g m^{-2}.

The continuous pattern of paddy planting impacts on the decline of soil fertility and soil quality (Supriyadi et al., 2017) Indonesia term 2019s government has been promoting a program namely Merauke Integrated Food and Energy Estate (MIFEE.The silica element in paddy plants has been identified as a functional micro element that has an important role in improving the quality of paddy grains (Lavinsky et al., 2016). The total amount of silica (Si) in nature is abundant but the availability of Si in tropical soils is very low due to the desiccation process (Husnain et al., 2012). Farming practices of farmers to restore paddy straw and rice husks to land in the form of compost or bokashi are still less popular than to burn so that in the long term it will have an impact on the decreasing availability of Si in the soil (Kasno et al., 2017). Loss of Si in every planting period when straw and husk are not returned to the soil is 31.6%. Nguyen et al. (2016) reported that the leaching of Si occurred on flooded soil.

Rice husk is a byproduct of rice milling that is very rarely returned to the soil in the form of compost or bokashi because it spends extra time to do. The high economic value of rice husk used for poultry, brick industry fuel, planting medium, and others also affect the enthusiasm of farmers to make compost or bokashi rice husk. According to Luh (1991), the content of Si of husk is (18.8% – 22.3%) and Si content on rice straw is 9.30% (Chairunnisa & Hanum, 2013).

The loss of silica of rice husk is very high amounting – 18.8% to 22.3%. It is necessary for silica of rice husk to be processed for fertilization with faster process and easy to be distributed compared to composting or bokashi process. Plants absorb silica in amorphous form, whereas silica in the form of crystals cannot be utilized by plants. The research results of Huntanuwatr et al. (1976) cited by Luh (1991) showed that rice husk silica can be extracted with a strong base of NaOH or KOH. Utilization of KOH as an extracting material is greater potential, because K^+ ion is needed in large quantities of plants (macro elements) whereas large amounts of Na^+ can cause salinity that inhibits plant growth. The availability of rice husks in some rice production center areas are abundant due to transportation access problem resulting in high transportation costs.

Materials and Methods

The research was conducted in the period September 2016 – January 2017 at Bekasi district at the elevation of 13 m above sea level (asl) with average daily temperature 30^{o} C (Fig. 1).

The research method used was experimental method using split plot design consisting of two factors with three replications. The first factor Jajar Legowo (row space) (J),

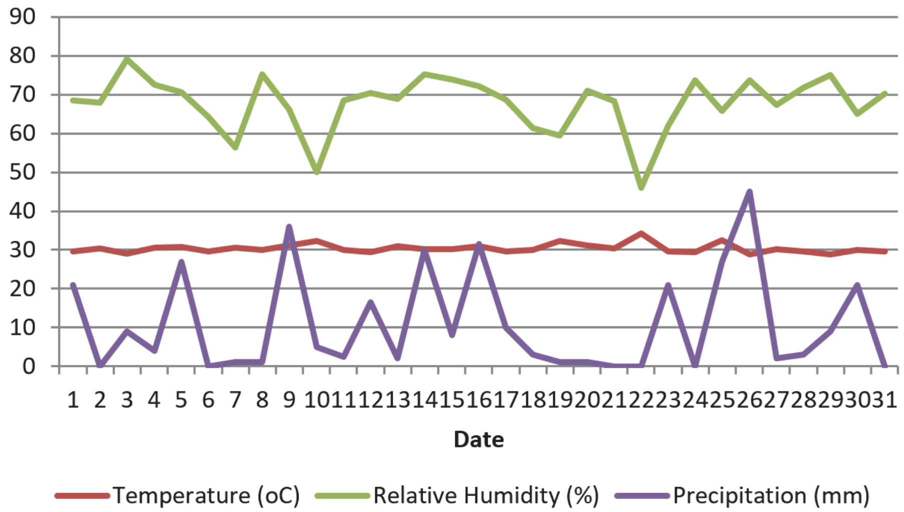


Fig. 1. Meteorological factors during the study

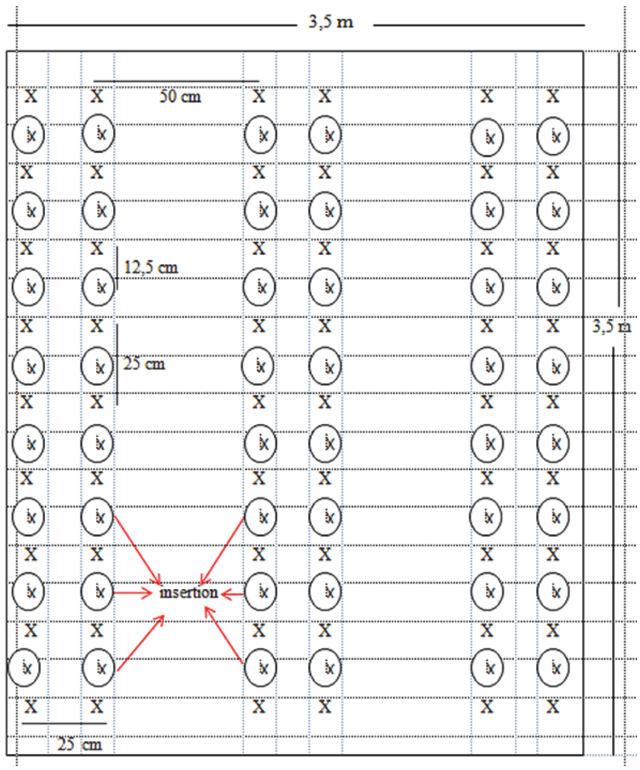


Fig. 2. Jajar Legowo A Layout

Remarks: X = main plant; ⓧ = insertion plant

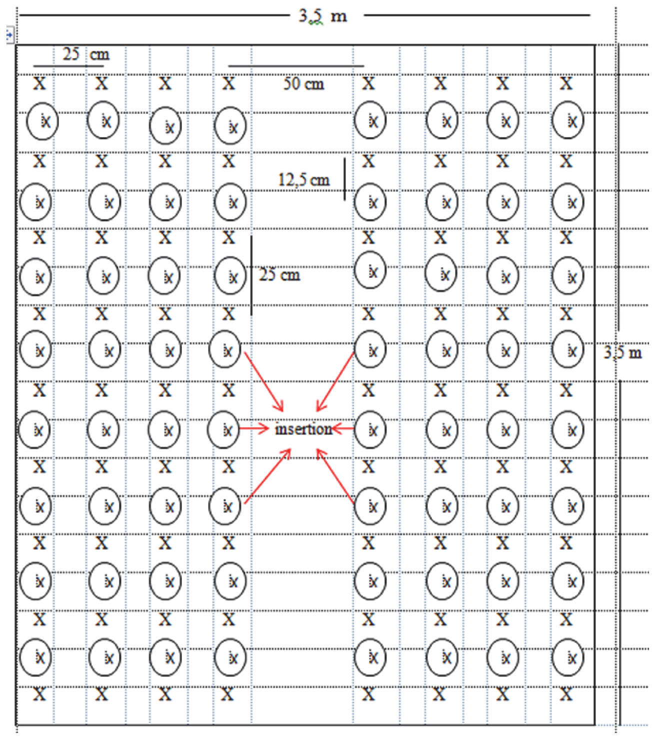


Fig. 3. Jajar Legowo B Layout

Remarks: X = main plant; ⓧ = insertion plant

respectively legowo A (type 2: 1) (j_1) is the arrangement of planting space at which there are 2 rows of plants was intermitted with a row of no plant (Fig. 2) and legowo B (type 4: 1) (j_2) is the arrangement of planting space at which there are 4 rows of plants was intermitted with a row of no plant (Fig. 3). The second factor was the concentration of silica husk extract (S), ie 20 ml L^{-1} (s_1), 25 ml L^{-1} (s_2) and 30 ml L^{-1} (s_3).

Research steps begin with soil tillage, namely the capsizing and ground leveling, the next step then preparing a plot size 3.5 m x 3.5 m. The paddy cultivar used was Ciherang cultivar. Two kilograms of seed then soaked and let the paddy was dumped. The soaking was done for 2 days after it is incubated until it grows its roots for 2 days, then the seedlings are spread in the plot that has been given bulkhead around them. During the research the paddy plants were fertilized with urea at the rate 200 kg ha^{-1}, SP36 75 kg ha^{-1} and KCl 50 kg ha^{-1} were applicated in three stages, ie 14 HST (urea 66.66 kg ha^{-1}, SP36 75 kg ha^{-1}, KCl 25 kg ha^{-1}); 28 HST (urea 66.66 kg ha^{-1}) and 45 HST (urea 66.66 kg ha^{-1},KCl 25 kg ha^{-1}) (Santosa & Suryanto, 2015).

The process of preparing rice husk silica extract (Fig. 4) begins with cleaning the husk from the impurities and then the husk is mashed with a crusher chaff milling machine. Extraction process is done by taking 50 g of husk that has been mashed and then put into a pan and added KOH 1.5% 100 ml then added with water as much as 500 ml then heated to boiling. To make a large amount of silicates extracts can be done by multiplying the basic needs of the material according to the desired target (Suka et al., 2008). The boiled chaff solution is then cooled and filtered. Screening is done to separate the fine husk with the silicate extract solution of rice husk. The extracted husk has a softer texture than the texture of the chaff before it is extracted (roughly). The change in husk texture becomes softer; the silicate indicator on the husk has been extracted. The filtered solution was used in accordance with the treatment level of the concentration of rice husk silica extract. The giving of silica extract was given three times with 10 day interval starting on 28 DAP (day after plant). The application of rice husk silicate extract was done by spraying to the leaves of the rice plant with the rate 1 ml per plant.

Growth parameters and yield observed were plant height (cm), number of tillers, weight of grain per clump (g), weight of 1000 grains (g), percentage of unfilled grain, and productivity per plot (kg m^{-2}). Data were then analyzed with F test at the 5%

Fig. 4. (*A*) The addition of KOH to Rice Husk; (*B*) The process of boiling rice husk that has been mixed KOH and Water; (*C*) Cooling process of solution (*D*) Filtering process of Silicate Extract results

level, if the F test results are significantly different then proceed with Duncan multiple range test at 5% significant level.

Results and Discussions

Result of Soil Analysis and Analysis of Rice Husk Silica Extract

The result of soil sample analysis used in this study is presented in Table 1. The C-organic value as an indicator of the availability of soil organic matter (SOM) is low. The low content of C-organic soil can be used as an indicator of the low level of the practice of giving organic material in the form of straw compost or manure on paddy fields by farmers. The result of silica husk rice extract analysis was done at Research Institute for Vegetable Crops (Balitsa) of silica extraction containing 99.20% water and 0.38% silica (Si). The silica extraction methods performed still need to be improved given the silica potential of rice husk + 18%. The average rainfall during the study was 172 mm with an average temperature of 30.40° C (Fig. 1).

Table 1. Soil Sample Analysis

No.	Soil Parameter	Value	Criteria*
1	pH H_20	6.0	Moderate Acid
2	pH KCl	4.9	–
3	C-organik (%)	1.86	Low
4	N-Total (%)	0.16	Low
5	C/N rasio	12	Moderate
6	P_2O_5 – Total (mg 100 g^{-1})	26.74	Moderate
7	K_2O – Total (mg 100 g^{-1})	31.52	Moderate

Notes: *Staff of Soil Research Center (1983) in Hardjowigeno (2010)

Pests and Diseases

During the research pests attack paddy plants, were brown stem borer (*Nilaparvata lugens Stal*), white pests (*Nhympula depunctalis*) and rat (Rattus rattus). The attack of disease was not found during the research as a result of applying silicate increased the resistance of rice plants to disease attacks. Element Si is an element capable of improving the negative impact of biotic stress (caused by pathogens and insects) (Lavinsky et al., 2016; Nguyen et al., 2016).

Plant Height

Table 2 shows plant height is 107.91 cm at 68 DAP. Ciherang cultivar based on descriptions 107-115 cm (Suprihatno et al., 2009). The application of silica extract and jajar legowo did not give interaction nor independent on effects plant height. The results of the study (Amrullah et al., 2014) on the high parameters of silicate cultivation were able to increase the height of the plants compared to the controls without the addition of silicate fertilizers while the addition of nanosilika as much as 20 ppm and 30 ppm was not significantly different to the increase of paddy plant height (Fig. 5 B).

In this study the arrangement of planting space of jajar legowo A and legowo B supported the plant height growth. The treatments affected the height is indicated with the fact that plant height is not below 107 cm or above 115 cm. The growth below 107 cm or exceed 115 cm is an indicator of the competition of nutrients, water and sunlight. Symptoms of lack of sunlight are characterized by excessively high growth (etiolation)

Fig. 5. (*A*) Aplication Rice Husk Silica Extract; (*B*) Plant Height Measurement; (*C*) Observation Panicle of rice; (*D*) Harvest of rice crops

due to too dense plant spacing. The research results of Lavinsky et al. (2016), whether or not Si applied at each growth phase has no effect on plant height. The research results of (Hermawati, 2012) plant spacing interact with paddy cultivar grown. This means that setting the spacing on different varieties will affect the expression of the plant.

Number of Tillers

Analysis result of tillers number (Table 2) showed no interaction between applications of silica husk extract with row legowo. Extract of silica did not give effect on number of tillers but the spacing arrangement with jajar legowo A and B have significant effect. Jajar legowo A (j_1) yielded number of tillers of 15.62. The number of tillers produced was lower than that of (Santosa & Suryanto, 2015) on the Ciherang cultivar (cultivated variety) of 23.6 pieces with the application of 100 kg ha^{-1} N, 50 kg ha^{-1} P_2O_5 and 75 kg ha^{-1} K_2O fertilizers. In this research, application is of 200 kg ha^{-1} Urea (92 kg ha^{-1} N), 75 kg ha^{-1} SP 36 and 50 kg ha^{-1} K_2O. Nitrogen fertilizer (N) is necessary for plant vegetative (root growth, leaf number, number of seedlings and flowering phase) (Rusdiansyah & Saleh, 2017).

Grain Weight per clump

The result of analysis (Fig. 5 D) of grain weight (Table 2) per hill by applying silicate extract and row of legowo did not have an interaction effect but jajar legowo B (j_2) effect independently on yield of grain per hump of 54.09 g. The treatment of various concentrations of rice husk silica extract did not significantly affect grain weight per clump. The arrangement of planting space with jajar legowo allows there some space in the planting area. This has a positive impact on increasing the intensity of light until the leaves more density, especially on the edge of the hall thus increasing the efficiency of photosynthesis and filling of grain (Hai-xin et al., 2012).

Grain Weight of 1,000 Grains

Grain weight of 1,000 grains observations were measured when the paddy was harvested (Fig. 5 D). The result of variance analysis (Table 3) showed the application of silicate extract (S) and jajar legowo (J) affected interactionally. The treatment of (j_1s_1) on the weight of 1000 grains (g) gave the highest yield of 40.5 g on the jajar legowo A with applicated of 20 ml L^{-1} rice husk silica extract. In the legowo A (j_1) row treatment of each concentration of rice husk extract (20 ml L^{-1}, 25 ml L^{-1} and 30 ml L^{-1}) there was a decrease in weight of 1000 grains to (40.5 g, 39 g, and 38.5 g) while in jajar legowo B (j_2) each increase of concentration of rice husk silica extract (20 ml L^{-1}, 25 ml L^{-1} and 30 ml L^{-1}) weight of 1000 grains (33.75 g, 36.5 g and 35.5 g). In jajar legowo A the plant population is less than jajar legowo B but on the jajar legowo A more space causing plants get more sunlight. In the B jajar legowo plants that get less sunlight on the edges, the application of silica extracts allows plants to improve the photosynthesis process. According to (Lavinsky et al., 2016) silicate elements can improve the ability of plants to withstand abiotic stress.

Lavinsky et al. (2016) stated that Si application has a direct and positive effect on increasing rice production. The analysis result of weight 1.000 grains in this study was higher compared with the results of the research conducted by Santosa & Suryanto (2015) with the application of 100 kg ha^{-1} urea, 50 kg ha^{-1}

Table 2. Effect of silicate extract of rice husk and jajar legowo on parameters of plant height, number of tillers and weight of grain per hill

Treatments	Plant Height Average (cm)		Number of Tillers		Grain Weight per clump (g)	Unfilled grain (%)
	54 DAP	68 DAP	54 DAP	68 DAP		
Jajar Legowo (J)						
j_1	83.92	107.39	15.03 b	15.62 b	54.09 b	4.41
j_2	86.47	107.80	11.43 a	11.65 a	43.27 a	4.25
Rice Husk Silicate Extract (S)						
s_1	85.14	107.40	13.05	13.41	47.57	4.28
s_2	85.36	107.91	13.51	13.92	48.78	4.41
s_3	85.05	107.49	13.14	13.57	49.70	4.31

Notes: 1. The average number in each of the same labeled columns is not significantly different according to Duncan Multiple Range Test at 5% level; 2. DAP: Day after plant

Table 3. Results of observations of 1000 grain weight (g)

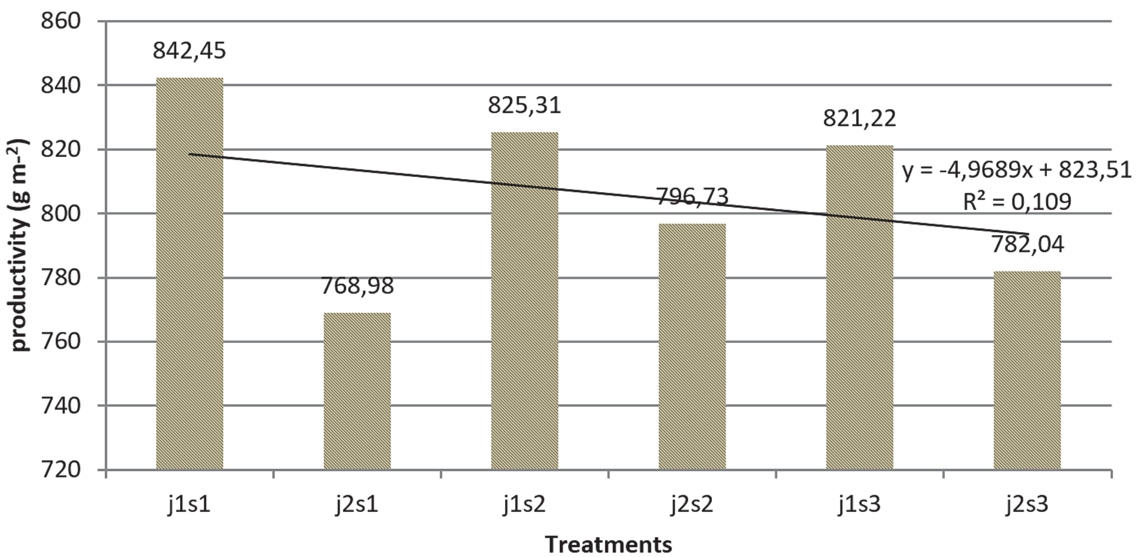
Treatments	Silica rice husk extract (S)		
Jajar legowo (J)	s_1	s_2	s_3
j_1	40.5 a B	39 a B	38.5 a B
j_2	33.75 a A	36.5 b A	35.5 ab A

Note: The numbers followed by the same letters (lowercase letters vertical and capital letters horizontally) indicate no significant difference according to Duncan Multiple Range Test at 5% level

SP36 and 75 kg ha^{-1} KCl of 26.6 g. The results of this study are also higher than the research conducted by Amrullah et al. (2014) reporting that colloidal nano silica (NSK) 20 ppm and 30 ppm was not significantly different from the average weight of 1000 ciherang cultivar of 32.74 g and 32.73 g, respectively.

Unfilled Grain Percentage (%)

The result of variance analysis (Table 2) showed there was no interaction between jajar legowo planting space with rice husk silicate extract concentration on the percentage of unfilled



Remarks:
j_1s_1 = Jajar Legowo 2: 1 & 20 ml l^{-1} rice husk silicate extract
j_2s_1 = Jajar Legowo 4: 1 & 20 ml l^{-1} rice husk silicate extract
j_1s_2 = Jajar Legowo 2: 1 & 25 ml l^{-1} rice husk silicate extract
j_2s_2 = Jajar Legowo 4: 1 & 25 ml l^{-1} rice husk silicate extract
j_1s_3 = Jajar Legowo 2: 1 & 30 ml l^{-1} rice husk silicate extract

Fig. 6. Ciherang cultivar yield productivity in two planting space and diffrent concentration of rice husk silicate extract

grain. The independent influence of each treatment also no effect on the percentage of unfilled grain. The research results of Amrullah et al. (2014) in Ciherang cultivar of unfilled grain percentage in the control treatment without silicates by 10.69% and the application of silicates into the soil as much as 300 kg ha^{-1} yielded 8.97% unfilled grain while the nano silica fertilizer provided through seeds and sprayed through leaves as much as 10 ppm, 20 ppm and 30 ppm respectively produce 3.54% unfilled grain; 2.92% and 2.95%. The results of this study on various concentrations of silicate extracts resulted in an average percentage of unfilled grains of 4.3%. The results were still lower when compared with nano silica 10 ppm, 20 ppm and 30 ppm, but still lower when compared with the treatment of silica fertilizer and without the application of silicate (control). The results of this study also revealed that the application of silicate in paddy plants can reduce the percentage of unfilled grain.

Productivity per plot

The application of silicate extract and jajar legowo affected the productivity per plot (kg m^2) of 842.45 g m^2 or 8.42 t ha^{-1} (Fig 6) in jajar legowo A with silicate extract concentration of rice husk 20 ml L^{-1} average yield of Ciherang cultivar 6 t ha^{-1} whereas the yield potential is 8.5 t ha^{-1}. The results of this study reaffirmed the results of previous studies on the role of Si fertilization and plant spacing arrangements to increase rice productivity.

Conclusions and Suggestions

The arrangements of planting space with jajar legowo system and application of rice husk silica extract affected on increasing yield of paddy, which was 1000 grains weight and productivity per plot. The growth parameter number of tillers is independently affected by the plant spacing of legowo system while the height of the plant was not affected by the plant spacing arrangement and the application of silica rice husk extract. The plant spacing arrangement with legowo system A and the application of 20 ml L^{-1} silica rice husk extract gave the best result to the weight of 1000 grains 40.5 g and the productivity of paddy 8.42 t ha^{-1}.

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Received: January, 8, 2018; *Accepted:* April, 5, 2018; *Published:* June, 30, 2019