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Application of bio-silicic acid to improve yield and fertilizer efficiency of paddy on tidal swamp land

Aplikasi bio-asam silika untuk meningkatkan produksi dan efisiensi pemupukan padi pada lahan rawa pasang surut

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Abstrak

Tanah di lahan rawa pasang surut sebagai daerah pengembangan baru untuk padi di Indonesia memiliki silika (Si) tersedia yang cukup rendah karena kondisi asam dan tidak ada pemupukan Si. Oleh karena itu, untuk meningkatkan produktivitas padi sebagai tanaman akumulator Si, di lahan rawa pasang surut membutuhkan pemupukan silika. Penelitian ini menyajikan pengaruh aplikasi silika dalam bentuk asam silika (H_4SiO_4) yang diperkaya dengan fungi pelarut silika (BioSilAc), dan diformulasikan dalam bentuk pupuk Si tablet 4-gram, di tanah lahan rawa pasang surut untuk meningkatkan hasil dan mengurangi dosis pupuk kimia pada padi. Percobaan lapangan dilakukan di Kecamatan Ketapang, Lampung Selatan menggunakan rancangan acak kelompok (RAK) dengan enam perlakuan dan empat ulangan, dengan masing-masing ukuran petak seluas 200 m^2. Perlakuan terdiri dari (ha^{-1} $musim^{-1}$): 100% NPK dosis rekomendasi (P1); 100% NPK + 80 tablet BioSilAc (P2); 75% NPK + 80 tablet BioSilAc (P3); 75% NPK + 100 tablet BioSilAc (P4); 50% NPK + 120 tablet BioSilAc (P5); dan kontrol (P6). Hasil penelitian menunjukkan bahwa perlakuan P2 meningkatkan hasil berupa gabah kering panen tertinggi sebesar 7,6% atau setara dengan 500 kg ha^{-1} dibandingkan dengan perlakuan P1. Efisiensi pemupukan tertinggi dicapai pada perlakuan P4 yang berarti dosis pupuk NPK rekomendasi dapat dikurangi 25% dengan menambahkan 100 tablet BioSilAc ha^{-1} $musim^{-1}$ yang ditunjukkan oleh produktivitas yang tidak berbeda secara signifikan dengan perlakuan P1. Nilai Revenue/Cost *(R/C) menunjukkan perlakuan P2 layak secara ekonomi untuk pemupukan tanaman padi.*

[Kata kunci: pupuk silika, fungi pelarut silika, silika larut air]

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Abstract

The soils in tidal swamp land as new development area for rice in Indonesia have a considerably low available silica (Si) because very acid condition and no Si fertilization. Therefore, increasing the productivity of rice as Si accumulator plant, in tidal swamp land requires silica fertilizer. This research presented the effect of applications of silicon in the form of ortho-silicic acid (H_4SiO_4) enriched with selected Si-solubilizing fungi, formulated as 4-gram tableted Si fertilizer (BioSilAc) on tidal swamp land soil to improve yield and reduce chemical fertilizer dosage for rice. Field experiment was conducted in Ketapang subdistrict, South Lampung by using a Randomized Block Design (RBD) with six treatments and four replicates. The treatments consisted of (ha^{-1} $season^{-1}$): 100% NPK recommended dosage (P1); 100% NPK + 80 BioSilAc tablets (P2); 75% NPK + 80 BioSilAc tablets (P3); 75% NPK + 100 BioSilAc tablets (P4); 50% NPK + 120 BioSilAc tablets (P5); and control (P6). The results showed that P2 treatment increased the highest rice yield in dried harvested grain by 7.6% or equivalent to 500 kg ha^{-1} compared to P1 treatment. The highest fertilization efficiency can be achieved in P4 treatment which means the NPK recommended dosage can be reduced 25% by adding 100 BioSilAc tablets ha^{-1} $season^{-1}$ indicated by insignificantly different productivity compared to that of P1. The Revenue/Cost (R/C) values showed that P2 treatment was economically feasible fertilization practices.

[Keywords: Si fertilizer, Si-solubilizing fungi, water-soluble Si]

Introduction

Rice is known as silica (Si) accumulator plant (Alvarez & Datnoff, 2001). The potential of Si in improving crop yield has been presented by many researchers, especially under abiotic and biotic stresses (Keeping & Reynold, 2009; Meena *et al*., 2014; Farooq & Dietz, 2015). Moreover, Si has been shown as a key nutrient to improve and stabilize rice yield (Ma & Takahashi, 2002; Ahmad *et al*., 2013; Rao *et al.*, 2017), and to control soil-borne pathogen (Botta *et al*., 2014) and leaf blast (Fillipi *et al*., 2014). Goenadi *et al.* (2018) also found that application of Si on wetland rice improved yield and reduced NPK fertilizer dosage. These evidences taken place almost all over the world indicating the important role of Si as a functional nutrient for crops.

The development of tidal swamp land is to be considered as one of the efforts in responding to the challenges for increasing agricultural production in a sustainable way, which becomes increasingly complex. Sustainable land management in tidal swamp area is an important effort to get optimum and economic returns. Tidal swamp land has good prospects to be developed into productive agricultural land with proper management through the application of appropriate technological innovations. The main limiting factors for the development of tidal swamp land are low soil fertility; acid soil reactions; the presence of pyrite (FeS); high levels of Al, Fe, Mn, and organic acids; P deficiency; and poor bases content of Ca, K and Mg; as well as inhibition microbial activity (Lestari *et al*., 2019; Arsyad *et al.,* 2014). In tidal swamp land, the soils have a low available Si due to a very low soil pH and the fact that Si fertilization is not a common practice yet (Siregar & Yusuf, 2020). These conditions will consequently result in the depletion of soil Si over prolong time which leads to the decreasing crop yield, especially for rice as a Si accumulator crop. Therefore, Si fertilization is necessary to resolve the problem particularly with a fertilizer technology which adapts to tidal swamp land characteristics.

Many Si fertilizer products have started to be available in the market during the last few years with various quality as most of them are somewhat misleadingly based on total SiO_2 content as quality indicator which actually unavailable to plants instead of soluble Si. It has been reported that plants absorb Si in the form of silicic acid (H_4SiO_4) only (Botta *et al.,* 2014; Sahebi *et al*., 2015). Currently, there is a new Si fertilizer formulated by the Indonesian Research Institute for Biotechnology and Bioindustry (IRIBB), i.e. bio silicic acid so-called BioSilAc, which combines the microbial and nanotechnological approaches (Santi & Goenadi, 2017). The formula has been shown improving performances of oil palm, sugarcane, and soybean against drought stress (Goenadi *et al*., 2019; Amanah *et al*., 2019; Santi *et al*., 2019; Santi *et al*., 2018). However, the impact of using BioSilAc to rice grown on soils in tidal swamp area has not been reported yet. Therefore, this research was aimed to evaluate the effect of BioSilAc application to improve yield and fertilizer efficiency of paddy on tidal swamp land.

Material and Methods

Location and design of experiment

This research was carried out in tidal swamp land, Ketapang Subdistrict, South Lampung starting from August to October 2019 (dry season) on a highly weathered soil belong to Kanhapludults subgroups (Wiryawan *et al.*, 2001). Chemical characteristics of the tidal swamp land for the experimental plot were as follow: pH 4.4, C-organic 2.05%, total-N 0.221%, total-P 0.023%, total-K 0.033%, CEC 20.99 cmol kg^{-1}, and available Si (H_2SiO_4) 21.0 ppm. A randomized block design (RBD) was used to examine six fertilization treatments with four replicates and each plot size of 200 m^2. The treatment consisted of (ha^{-1} $season^{-1}$): (i) 100% NPK recommended dosage (P1); (ii) 100% NPK + 80 BioSilAc tablets (P2); (iii) 75% NPK + 80 BioSilAc tablets (P3); (iv) 75% NPK + 100 BioSilAc tablets (P4); (v) 50% NPK + 120 BioSilAc tablets (P5); and (vi) control (P6). The recommended dosage of NPK fertilizers in this location were as follows; 300 kg Urea + 300 kg NPK (15-15-15) ha^{-1} $season^{-1}$. Rice var. Cilamaya Muncul was germinated until 21 days. Seedling with 21 days old was planted on the experimental plots with planting distance of 20 x 20 cm and two seedlings per hole.

BioSilAc (Patent pending) was prepared by using method reported earlier. BioSilAc application was split two times, half at 30, and half at 45-55 days after planting (DAP). BioSilAc formulated in a tablet form containing 9% H_4SiO_4 enriched with selected Si-solubilizing fungus, i.e. *Trichoderma polysporum* (Figure 1) (Santi & Goenadi, 2017; Santi *et al.*, 2017). BioSilAc was applied by spraying into plant and plant root zone after diluting 100 tablets in 500 L fresh water. Standard crop maintenance was performed including weed, pest, and disease control during the experiment period.

Observation and data analysis

a. Plant growth and soil chemical analyses

Plant growth (plant height, number of leaves, and number of tillers) analyses and yield (dried harvested grains) waere observed between P1-P6 treatments at field experiment. Parameter of soil chemical analysis is available Si using standard methods (Wisconsin State Lab of Hygiene, 1992). This method used ammonium molybdate in acidic conditions can react with silica as well as orthophosphate which produces heteropoly acid. The resulting molybdo-silicate acid was then reduced by ascorbic acid resulting in a complex compound that has a blue-violet absorption that was measured by Spectrophotometer UV-Vis with wavelength of 660 nm (Wisconsin State Lab of Hygiene, 1992). The observed data of each treatment was analyzed statistically with ANOVA and Duncan's Multiple Range Test (Steel & Torrie, 1980).

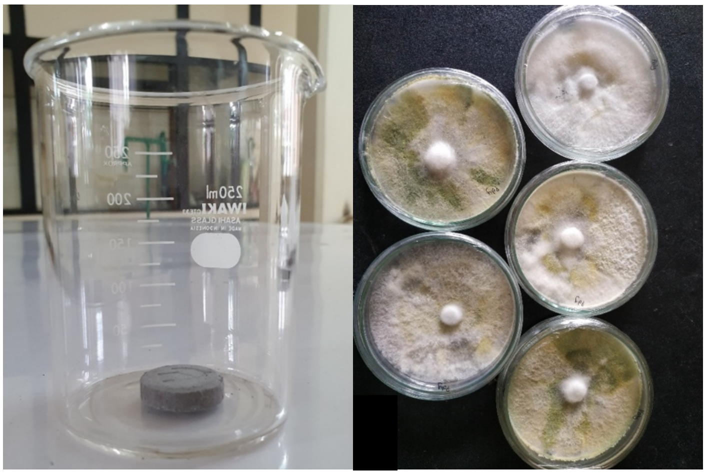


Figure 1. A 4-gram BioSilAc tablet (left) and the growth of *Trichoderma polysporum* in silicon (Si) -containing medium (right)

Gambar 1. Tablet BioSilAc 4-gram (kiri) dan pertumbuhan Trichoderma polysporum *pada media mengandung silikon (Si) (kanan)*

b. Total leaves chlorophyll analysis

Chlorophyll content was determined by the extraction of pigment and pigment content analysis. The measurement of chlorophyll content of the leaves begins with extraction using a 80% acetone solvent (Wellburn, 1994). The pigment extract in acetone solvent was 80% measured by UV-VIS spectrophotometers at a wavelength of 663 nm for chlorophyll a and 646 nm for chlorophyll b. Concentrations of chlorophyll a and b as well as total chlorophyll were calculated using the following formula (Wellburn, 1994):

$$\text{Total chlorophyll (mg g}^{-1}\text{)} = (17.30{*}A_{646}) + (7.18{*}A_{663})$$

A_{663} : wavelength chlorophyll a (663 nm)
A_{646} : wavelength chlorophyll b (646 nm)

c. Scanning Electron Microscopy

The deposition of Si in leaves and stem in each treatment were observed using the Scanning Electron Microscopy (SEM). Preparation was consisted of 3 stages. First was the fixation stage, the sample soaked in the solution cacodylate buffer (sodium caccodylate trihydrate, HCl and H_2O with pH 7.4). The immersion process was done for ± 2 hours, then soaked in glutaraldehyde solution 2.5% for 2 hours and after that in a 2% tannic acid solution during overnight. Second was the dehydration stage, i.e. the sample soaked sequentially with alcohol 50% for 4 x 5 minutes, alcohol 70% for 20 minutes, and alcohol 85% for 20 minutes at a temperature of 40°C. Further, the sample was marinated in alcohol 95% for 20 minutes, an absolute alcohol 2 x 10 minutes and T-Butanol for 2 x 10 minutes at room temperature. Third was the gluing stage, i.e. a sample with a size of 1 x 1 cm glued to a sterile metal cylinder placed into the ion coating for vacuum, then coated with a metal Pt-Au using an ion coating. The observations with SEM were photographed at a magnification of 350x and 1500x (Talbot & Rosemary, 2013).

d. Economic analysis for fertilizer application

Economic analysis for fertilizer application based on calculating the feasibility of fertilizer application. Revenue to cost ratio (R/C ratio) is one indicator of the feasibility of agriculture investment. Treatments with higher yield was evaluated its feasibility by using R/C ratio value. If the ratio of R/C > 1 then it means the treatment is considered feasible. The R/C ratio was calculated using the following formula (Suratiyah *et al.*, 2003):

$$\text{R/C Ratio} = \frac{Revenue}{Cost}$$

Results and Discussion

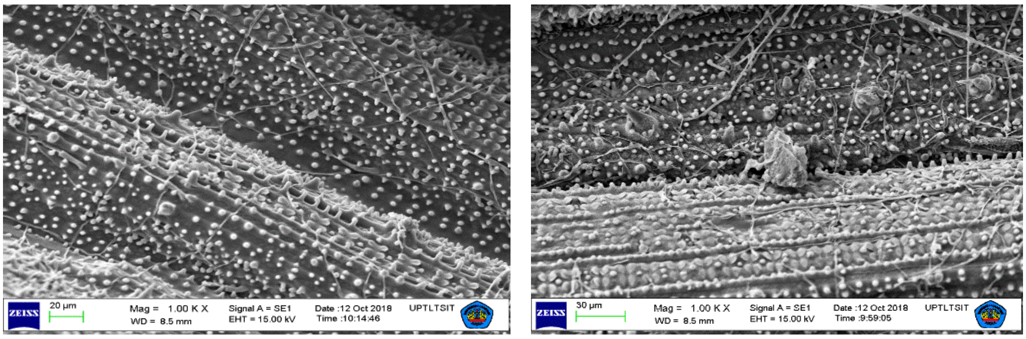
Vegetative growth of rice var. Cilamaya Muncul

The vegetative growth, i.e. plant height, number of leaves and number of tillers at 50 DAP of Rice var. Cilamaya Muncul, was presented in Table 1. The data showed that the application of BioSilAc (P2-P5) tends to improve vegetative growth of the plant compared to P1 (100% NPK recommendation), and especially to P2 (100% NPK + 80 BioSilAc tablets) but it was not significant. Plant height was slightly increased by the application of BioSilAc and there was no significant difference among treatments, except P6. This phenomenon was different with number of leaves and number of tillers, by which NPK treatments and the additions of BioSilAc tend to increased them significantly and there were differences among treatments. Our findings were similar to that reported by Gerami *et al* .(2012) and Pati *et al.* (2016). In general, the application of BioSilAc tends to improved vegetative growth of

Table 1. Vegetative growth of rice var. Cilamaya Muncul at 50 DAP
Tabel 1. Pertumbuhan vegetatif padi var. Cilamaya Muncul umur 50 HST

Treatments *Perlakuan*	Plant height (cm) *Tinggi tanaman (cm)*	Number of leaves (strand) *Jumlah daun (helai)*	Number of tillers (hill) *Jumlah anakan (rumpun)*
100% NPK recommendation dosage (P1)	117.5 a*)	141.4 a	29.6 a
100% NPK + 80 BioSilAc tablets ha^{-1} (P2)	118.2 a	154.4 a	30.4 a
75% NPK + 80 BioSilAc tablets ha^{-1} (P3)	113.7 a	106.0 b	20.2 b
75% NPK + 100 BioSilAc tablets ha^{-1} (P4)	118.7 a	116.4 b	22.4 b
50% NPK + 120 BioSilAc tablets ha^{-1} (P5)	116.5 a	108.6 b	16.0 c
Control (P6)	102.0 b	67.6 c	11.8 d
CV (%)	6.1	9.0	9.7

*) Means in the same column followed by the same letter are not significantly different according to Duncan's multiple range test at $\alpha = 0.05$.
**) Angka dalam kolom yang sama diikuti oleh huruf yang sama berarti tidak berbeda nyata menurut uji jarak berganda Duncan pada α = 0,05.*



(a) (b)

Figure 2. Scanning Electron Microscopy showing deposition of Si on leaves of without BioSilAc-treated plants (a) and leaves of BioSilAc-treated plants (b)
Gambar 2. Scanning Elektron Mikroskopis yang menunjukkan deposisi Si pada daun tanaman yang tanpa BioSilAc (a) dan daun tanaman yang diberi BioSilAc (b).

rice var. Cilamaya Muncul because the deposition of Si in cell walls (Figure 2a - b) could increase rice plant height, resulting in a decrease of mutual shading caused by the high density of plant, thereby increasing the photosynthetic rate of the plant due to better light interception (Pati *et al.*, 2016).

Plant physiological of rice var. Cilamaya Muncul

The soil analysis after harvest (Table 2) indicated that available Si increased 0.7-6.7% compared to P1, and the highest content achieved by P2 treatment (144 ppm). In P6 treatment a significant increased in available Si content compared to P1 treatment was interesting but the data obtained from this study were not enough to explain this evidence. In the soil solution, Si is present as mono-silicic acid and poly-silicic acid (Rao *et al.*, 2017). Mono-silic acid and poly-silicic acid are referred to plant available silica (PAS) that is taken up by the plant and has a direct influence on crop growth (Rao & Susmitha, 2017). Ma *et al.* (2001) also reported mono-silicic acid is the predominant form of Si absorbed by roots via active uptake mechanism, where Si uptake is performed by lateral roots and not by root hairs.

In this research silica content in leaves (Table 2) was significantly different among treatments after harvest. Plants with treatment of 100% NPK + 80 BioSilAc tablets ha^{-1} had a significantly higher Si content as compared than those 100% NPK recommendation. Available form of Si in soil solution is H_4SiO_4 and it follows water into the plant root. Silica is translocated from the roots through the xylem until it is deposited under the cuticle and in intercellular spaces (Heckman, 2013). The absorbed water is lost through transpiration and the Si stays in the plant tissue then Si concentration increases in the plant (Mitani *et al.,* 2005). Observation via SEM analysis showed the evidence of Si on the leaves of plant without BioSilAc treatment (P1) (Figure 2a) and leaves of BioSilAc-treated plants (P2) (Figure 2b as well. These evidences were similar to those reported by Ning *et al* (2014), the results of SEM analysis showed that application of Si-fertilizer to more pronounced cell silicification in rice leaves, and more silica cells, compared to rice leaves without application of Si-fertilizer. As consequent of this evidence, Si deposition in leaf and stem tissues has been reported to make the plant more resilience to pest and disease attacks (Rao *et al.*, 2017; Alhousari & Greger, 2018). The presence of

Si in plant tissues has also been considered to be responsible in regulating stomatal openness upon drought stress resulting in reduced transpiration rate and at the end less water consumption (Santi *et al.*, 2018, 2019). Overall, these conducive effects of Si become the reason why this nutrient could support better growth of the crops.

The data (Figure 3) showed that the application of BioSilAc tend to improve chlorophyll in leaves among treatments, compared to P1 treatment. This finding was similar to Silva *et al*. (2012) and Santi *et al*. (2018), who also reported the application of silica fertilizer improved chlorophyll contents in leaves. The addition of Si could protect the photosynthetic pigments in leaves, alleviate the damage to chloroplast ultrastructure, and increase the expression genes associated with photosynthesis (Song *et al.*, 2014). Improvement of chlorophyll content will in turn promote efficient metabolism resulting in improved yield as well. The P6 treatment resulted in a higher chlorophyll content in leaves compared to that of P1 treatment. However, the reason for this evidence has been unclear yet, and therefore needs further studies.

Rice yield and fertilizer use efficiency

Data of rice var. Cilamaya Muncul yield (dried harvested) from each treatment were presented in Figure 4. Application of BioSilAc tend to increased the rice yield compared to P1, especially P2. The values range from 1.5 (P6) to 7.1 (P2) ton ha $^{-1}$ which is in the range of genetic potential yield of 6.0 to 7.0 ton ha $^{-1}$ (BPTP Kalsel, 2011). The highest yield was obtained from combined application of 100% NPK + 80 BioSilAc tablets ha^{-1} (P2), i.e. 7.1 ton ha $^{-1}$. The results showed that the application of P2 increased the rice yield in the form of dried harvested grain by 7.6% or equivalent to 500 kg ha $^{-1}$ compared to the conventional fertilizers recommended dosage (P1).

Table 2. Silica content in soil and leaves after harvest
Tabel 2. Kandungan silika pada tanah dan daun setelah panen

Treatment *Perlakuan*	Silica content in soil (ppm) *Kandungan silika pada tanah (ppm)*	Silica content in leaves (ppm) *Kandungan silika pada daun (ppm)*
100% NPK recommendation dosage (P1)	135 bc	319 c
100% NPK + 80 BioSilAc tablets ha^{-1} (P2)	144 a	439 a
75% NPK + 80 BioSilAc tablets ha^{-1} (P3)	138 bc	377 b
75% NPK + 100 BioSilAc tablets ha^{-1} (P4)	141 ab	392 b
50% NPK + 120 BioSilAc tablets ha^{-1} (P5)	136 bc	266 d
Control (P6)	131 d	231 d
CV (%)	1.4	4.2

*) Means in the column followed by the same letter(s) are not significantly different according to Duncan's multiple range test at $\alpha = 0.05$.
**) Angka dalam kolom yang sama diikuti oleh huruf yang sama berarti tidak berbeda nyata menurut uji jarak berganda Duncan pada α = 0,05.*

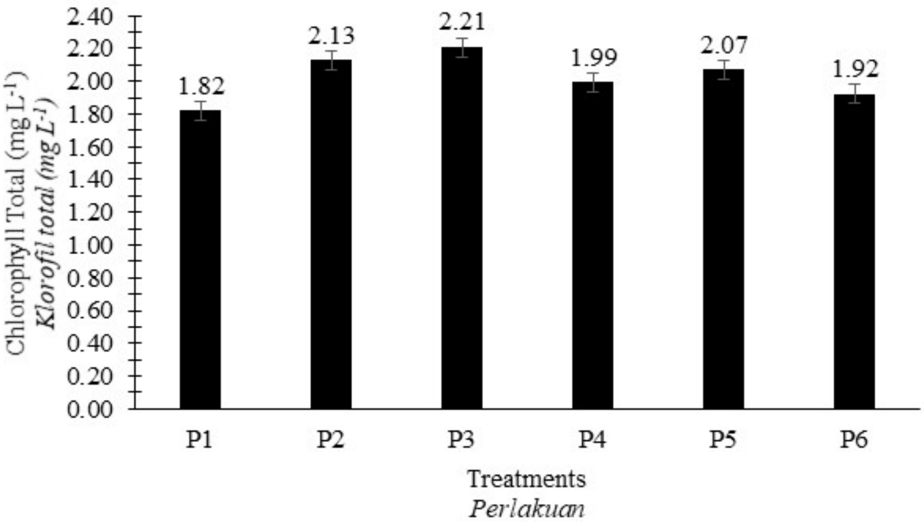


Figure 3. Total leaves chlorophyll of rice var. Cilamaya Muncul under combination treatments of NPK and BioSilAc fertilization after harvest. Treatments (ha^{-1} season^{-1}): 100% NPK recommended dosage (P1); 100% NPK + 80 BioSilAc tablets (P2); 75% NPK + 80 BioSilAc tablets (P3); 75% NPK + 100 BioSilAc tablets (P4); 50% NPK + 120 BioSilAc tablets (P5); and control (P6)
Gambar 3. Klorofil total daun padi var. Cilamaya Muncul dengan kombinasi perlakuan pemupukan NPK dan BioSilAc. Perlakuan : 100% NPK dosis rekomendasi (ha^{-1} musim^{-1}) (P1); 100% NPK + 80 tablet BioSilAc (P2); 75% NPK + 80 tablet BioSilAc (P3); 75% NPK + 100 tablet BioSilAc (P4); 50% NPK + 120 tablet BioSilAc (P5); dan kontrol (P6)

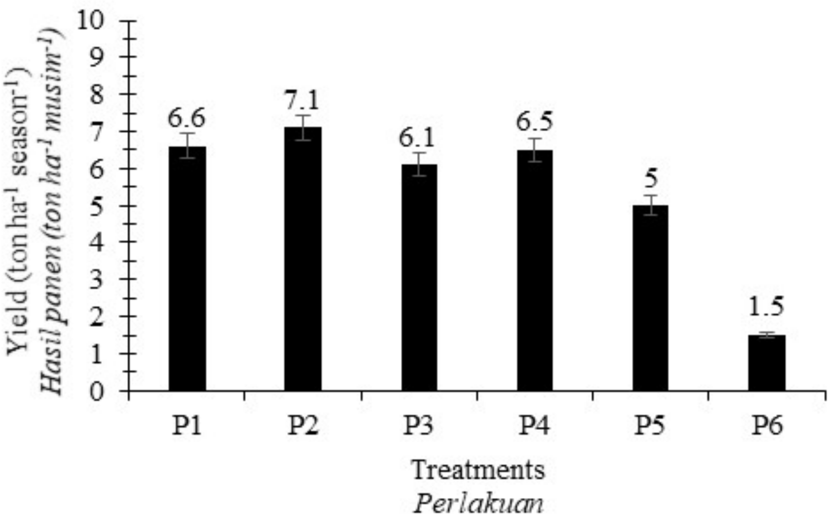


Figure 4. Yield of rice var. Cilamaya Muncul under combination treatments of NPK and BioSilAc fertilization. Treatments: 100% NPK recommended dosage (ha^{-1} $season^{-1}$) (P1); 100% NPK + 80 BioSilAc tablets (P2); 75% NPK + 80 BioSilAc tablets (P3); 75% NPK + 100 BioSilAc tablets (P4); 50% NPK + 120 BioSilAc tablets (P5); and control (P6)

Gambar 4. Hasil panen padi var. Cilamaya Muncul dengan kombinasi perlakuan pemupukan NPK dan BioSilAc setelah panen. Perlakuan : 100% NPK dosis rekomendasi (ha^{-1} $musim^{-1}$) (P1); 100% NPK + 80 tablet BioSilAc (P2); 75% NPK + 80 tablet BioSilAc (P3); 75% NPK + 100 tablet BioSilAc (P4); 50% NPK + 120 tablet BioSilAc (P5); dan kontrol (P6)

Fertilization efficiency can be achieved by reducing the fertilizer dosage to 75% NPK + 100 BioSilAc tablets ha^{-1} (P4) as indicated by the yield obtained at the P4 treatment in which it was not significantly different to that of the conventional fertilizers recommended dosage (P1), i.e. 6.5 tons ha^{-1} (P4) and 6.6 tons ha^{-1} (P1). The results also showed that the addition of BioSilAc was able to save chemical fertilizer up to 25%. In this research, a positive response of grain yield to application of Si fertilizer was observed as also reported earlier by Pati *et al.* (2016) showing a significant increase in grain yield of rice with increasing Si level. The increase of grain yield might be because the positive effect of Si to increase growth and yield characteristics (Prakash *et al.*, 2011; Pati *et al.*, 2016), enhance photosynthetic activity (Detmann *et al.*, 2012), reduce abiotic and biotic stresses, improve structural support and biomass (Meharg & Meharg, 2015), and improve nutrient uptake (Pati *et al.*, 2016; Crooks & Prentice, 2017). Positive response of plant to Si application to some extent could also be attributed to the very low Si content in soil (i.e. 21 ppm), which was far below the sufficiency level of soluble Si in soils (i.e. 157 ppm) as guided in Japan and South Korea (J. H. Kim, personal communication, 2019).

Economic analysis for fertilizer application

Economic analysis of rice var. Cilamaya Muncul grown under different treatments, i.e. P1, P2, and P4 (Table 3), yields different R/C (revenue/cost) values as follow: 2.08 (P1), 2.19 (P2), and 2.14 (P4). These values showed that P2 treatment could result in economically feasible fertilization practices. The R/C values of treatments P2 was attributed to the addition BioSilAc as supplementary fertilizer (without reduced NPK fertilizer dosage). BioSilAc as supplementary fertilizer can increase profit IDR 2.650.000 per ha. However, further study is needed to confirm these findings especially under different locations and wider area.

Table 3. Economic analysis of rice var. Cilamaya Muncul yield under combination treatments of NPK and BioSilAc fertilization
Tabel 3. Analisis ekonomi produksi padi var. Cilamaya Muncul dengan kombinasi perlakuan pemupukan NPK dan BioSilAc

Description *Deskripsi*	Unit *Satuan*	Amount *Jumlah*	Price (IDR) *Harga (Rp)*	P1 *P1*	P2 *P2*	P4 *P4*
A. Land Compensation	ha	1	2,500,000	2,500,000	2,500,000	2,500,000
B. Labor Costs						
1. Soil Tillage	m^2	10,000	650	6,500,000	6,500,000	6,500,000
2. Planting	Workday	15	55,000	825,000	825,000	825,000
3. Crop maintenances						
a. Spraying	Workday	6	55,000	330,000	330,000	330,000
b. Fertilization	Workday	5	55,000	275,000	385,000	385,000
c. Weeding	Workday	10	55,000	550,000	550,000	550,000
4. Harvesting	Workday	10	55,000	550,000	550,000	550,000
C. Material and Tools						
1.Paddy seeds	kg	20	15,000	300,000	300,000	300,000
2.Fertilizers						
a. Urea	50 kg	6	295,000	1,770,000	1,770,000	1,327,500
b. NPK 15-15-15	50 kg	6	500,000	3,000,000	3,000,000	2,250,000
c. BioSilAc	Tablet	80	3,000	-	240,000	300,000
3.Pesticides	ha	1	250,000	250,000	250,000	250,000
Total Cost				16,850,000	17,200,000	16,067,500
Production	Kg ha^{-1}			6,600	7,100	6,500
Cost of goods	IDR kg^{-1}			2,553	2,423	2,472
Income	IDR			34,980,000	37,630,000	34,450,000
R/C ratio				2.08	2.19	2.14

*) 100% NPK recommended dosage (P1); 100% NPK + 80 BioSilAc tablets (P2); 75% NPK + 80 BioSilAc tablets (P3); 75% NPK + 100 BioSilAc tablets (P4); 50% NPK + 120 BioSilAc tablets (P5); and control (P6); 100% NPK recommended dosage : 300 kg Urea + 300 kg NPK (15-15-15) ha^{-1} $season^{-1}$

*) *100% NPK dosis rekomendasi (P1); 100% NPK + 80 tablet BioSilAc (P2); 75% NPK + 80 tablet BioSilAc (P3); 75% NPK + 100 tablet BioSilAc (P4); 50% NPK + 120 tablet BioSilAc (P5); dan kontrol (P6); 100% dosis rekomendasi NPK* : 300 kg Urea + 300 kg NPK (15-15-15) ha^{-1} $musim^{-1}$

Conclusion

The application of Si fertilizer in the form of BioSilAc on tidal swamp land soil promoted better growth and yield of rice var. Cilamaya Muncul. The highest yield was obtained by combining BioSilAc (80 tablets ha^{-1} $season^{-1}$) and NPK recommended dosage. However, at a 100 tablets ha^{-1} $season^{-1}$ dosage, BioSilAc was able to save NPK fertilizer dosages by 25%. Further study is needed to confirm these results, especially under different locations and a wider application.

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