Journal of **BIOLOGICAL RESEARCHES**
Berkala Penelitian Hayati
ISSN: 08526834 | E-ISSN:2337-389X
Volume 22 | No. 1 | December | 2016

Original Article

Effect of organic matter and Si liquid fertilizer on growth and yield of sugar cane

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Abstract

Sugarcane is known to absorb more Si than any other nutrient from the soil; therefore continuous cropping of the plant at the same soil would bring consequences of more Si and organic matter depletion. Silicon (Si) is considered as a beneficial nutrient for sugarcane production while organic matter is well known as soil amendment. Field study was carried out to know the effect of organic and Si liquid fertilizer on growth, Si and N uptake, and yield of cane variety of PSBM 901. The study field was located at Kempleng village, Purwoasri, East Java and the study was done from May 2013 up to September 2014. Split plot design with three replicates was employed to arrange treatments. Organic matter types (no organic matter, *Crotalaria juncea* and manure) were set as main plots while Si liquid fertilizer concentration (0, 15% Si and 30% S) were arranged as sub plots. *C juncea* was planted at 15 days before planting of sugar cane, and after 35 days the *C juncea* were chopped and mixed into the soil. Manure was added one week before sugar cane was planted. Si liquid fertilizer was sprayed to the whole part of sugar cane plant at 30 and 50 days after sugar cane was planted. All treatments received basal fertilizer of 800 kg ZA/ha, 200 kg SP 36/ha and 300 kg KCl/ha. Results showed that interaction between organic matter and Si liquid fertilizer significantly affected on Si and N absorption, length of stem, yield and rendement of sugar cane. Addition of manure and followed by spraying of 30% Si liquid fertilizer gave the highest value of S and N absorption (869 g SiO_2/plant and 720 g N/plant), cane yield (155.74 tons/ha) and rendement (8.15%).

Key words: cane yield, organic matter, Si fertilizer

Received: 30 June 2016 Revised: 12 January 2017 Published: 14 February 2017

Introduction

In Indonesia, average productivity of sugarcane tends to decrease. For the last 15 years (1998-2013) the average of cane productivity was only 1.49 tons cane/ha or 0.33% of its cane productivity during period of 1969-1979 which noted as much 4.44 tons cane/ha (Pusat Data dan Informasi Pertanian, 2014). Decreasing of sugarcane productivity might be as a result of declining soil nutrients contents, especially soil Si and C organic contents.

As sugarcane is known as Si accumulator plant, depletion of soil Si might decrease sugarcane yield. Husnain *et al.* (2008) reported that soil Si content at irrigated soil and in irrigation water in Java was low. Declining Si in sugarcane field is caused by continuous absorption in sugarcane ratoon without replacing with Si fertilizer (Savant *et al*., 1999). The consequence of soil depletion of Si is reducing Si absorption and decreasing sugarcane yield. Many studies in sugarcane production central area reported that addition of Si increased sugar cane yield (de Camargo *et al*., 2010; Keeping *et al.*, 2010; Matichenkov *et al.*, 2002), and increased the resistance of sugarcane against pest and disease attacks (Matichenkov dan Calvert, 2002). This current research was conducted to know the effect of liquid Si fertilizer on growth and yield of sugarcane.

Generally Si is applied in the form of granule or powder fertilizer. The fertilizer rate of granule or powder Si fertilizer is higher than the rate of liquid form. dos Santos *et al.* (2011) reported that the rate of Si powder to increase rice yield was 6 tons/ha and in the form of granule was 600 kg/ha, but when it was applied in the form of Si liquid the rate was only 2.5 l/ha to obtain the same amount of rice yield. Also, using liquid Si fertilizer might be more practical and efficient because it does not need large storage and easier to be delivered than the powder or the granular form. Moreover, solubility and availability of Si for plants are influenced by soil texture (Priyono dan Gilkes, 2004), soil pH (Priyono dan Gilkes, 2004), and organic matter (Oliva *et al*., 1999). In this study, liquid Si fertilizer was sprayed together with organic matter adittion. The objective was to know the effect of si liquid rate and organic matter types on growth and yield of sugarcane.

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Methods

The research was conducted at Kempleng Village, District of Purwoasari, Regency of Kediri from March 2013 up to December 2014. The location was chosen because in this area, sugarcane is planted on the same land continuously for more than 10 years. Consequently, organic matter and Si contents were very low (Table 1).

The research used Split plot Design with three replicates to arrange main plot and sub plot treatments. As a main plot was addition of organic materials: (1) *Crotalaria juncea*, (2) manure, (3) no organic matter (as a control). As sub plot was the concentration of Si liquid fertilizer: (1) 0 %, (2) 15 %, and 30% (v/v).

Green manure of *C. juncea* was planted 15 days previously before sugar cane was planted. Planting was done by placing the *C. juncea* seeds along side of sugar

http://dx.doi.org/10.23869/bphjbr.22.1.20165
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cane row. After 35 days, the C *juncea* were cut into pieces at about 10 cm sizes and mixed them into the soil at the time of elevating the ridge row.

Sugar cane PSBM 901 variety was planted at 15 days after planting of *C. juncea*. Seven months old of seedling sugar cane stem with 7 buds was planted in each meter of row. Manure was added at 5 tons/ha or equivalent to 60 kg/plot at three days before sugar cane was planted. Si liquid fertilizer was sprayed twice, at 30 and 50 days after sugarcane was planted. Initially, Si liquid fertilizer (29 % Si) was dissolved into water according to the rate of treatment. The solution was then sprayed on the whole plant of sugarcane.

Table 1. Soil characteristics of experimental site

Characteristics	Content	Category
C organic (%)	0.19	Very low
N (%)	0.09	Very low
P Bray1 (mg/kg)	15.16	Low
K NH_4OAc 1 N pH7 (me/100 g)	0.28	Medium
Si total (%)	22.40	Low
Si dissolved in water (ppm)	0.10	Low
Si dissolved in acid (ppm)	0.16	Low
Sand	79.00	-
Silt	13.00	-
Clay	8.00	-
Texture	-	Loamy sand

As basal fertilizer, rates of 800 kg ZA/ha + 200 kg SP 36/ha + 300 kg KCl/ha were added. ZA and KCL fertilizers were applied twice, half doses were applied at 7 days after planting and the rest were applied at 30 DAP. SP 36 fertilizer as a source of P_2O_5 was applied at the same time of planting.

Observations were done on parameters of Si and N absorption, length and diameter of stem, yield, and rendement. Length of stem was measured using roll meter, while diameter stem was determined using caliper and both parameters were measured one month before harvesting. In each treatment, 10 sample plants were chosen to be measured their diameters and their lengths. Stem diameter was measured at the middle of stem. Length of stem was measured after the stem was cut exactly from the base until the last nodes of stem. Harvesting of sugar cane was done at 14 months after planting. Yield of sugar cane was measured directly at the field by weighing all sugar cane stems collected from each plot treatment. Rendement of sugarcane was analyzed at Laboratory of Ngadirejo sugar factory, Kediri. Two samples in each treatment for analyzing Si and N absorption were cut at harvesting time and spent for about one week at room temperature. Analyzing of Si was done using chloride acid (HCl) as extractant (Association of Official Chemist, 2002). Prior to analyzes, the samples was heated at 550 – 600 ^oCuntil they change to ash. Then the ash was put on beaker glass and added with deionized water and 3 ml HCl. The solution was heated until the solid forms of samples were evaporated. The evaporation process was repeated twice, and it followed by addition of 1 ml HCl and 20 ml of deionized water. The solution then heated for 5 minutes and filtered using Whatman paper and cleansing using deionied water for four times. Whatman paper containing silicate was weighing prior it was heated at 300 ^oC for 30 minutes and at 300 ^oC for 3 hours until it changed to white SiO_2 form. The white SiO_2 was then put in desiccators until it was ready for weighing. SiO2 content in the sample was calculated using formula:

SiO2 (%) = (weight of SiO2/weight of sampel) x 100 x constanta

Results

Si and N Absorption

Statistical analysis shows that absorption of Si and nitrogen by sugarcane was influenced by interaction between addition of organic matter and Si fertilizer (table 2). Compare to control (no organic matter added to the soil), addition of organic matter (either in the form of green manure *C. juncea* or manure) and followed by increasing concentration of Si affected on elevating of the absorption of Si and nitrogen by sugarcane. The highest absorption of Si and N was found in the treatment of manure and 30% Si liquid fertilizer, 869 of kg SiO_2/plant and 720 kg N/ha respectively. However, the treatment of *C. juncea* and 15% or *C. juncea* and 30% Si were not significantly different with the treatment of manure and 30% Si in their effects on Si absorption. Compare to control (no organic matter and no Si liquid fertilizer), addition of *C. juncea* and 15% Si increased Si absorption from 471 g/plant up to 809 g/plant or 72%. On the influence of N absorption, addition of organic matter in the form of manure plus 30% Si increased N absorption from 228 up to 720 g/plant or 216%. The significant effect of addition organic matter (either in the form of manure or *C. juncea*) and spraying of Si liquid fertilizer may be due to low content of soil organic C and Si (Figure 1).

Yield and Rendement

Yield and rendement (sucrose content) of sugar cane were increased when soil with low vorganic C and Si was added with *C. juncea* or manure and sugar cane plant was sprayed with Si liquid fertilizer. The highest yield and rendement of sugar cane was found in the treatment of manure addition and 30% Si liquid fertilizer, 155.74 tons/ha and 8.15 % respectively (Figure 3).

The importance addition of organic matter and Si liquid fertilizer on soil with low content of organic C and Si had been identified. Addition of organic matter to the soil combined with spraying of Si liquid fertilizer increased absorption of Si and N, length of stem, cane yield and rendement. Addition of manure and spraying of

30% Si liquid fertilizer gave the highest cane yield and rendement, 155.74 tons/ha and 8.15 % respectively.

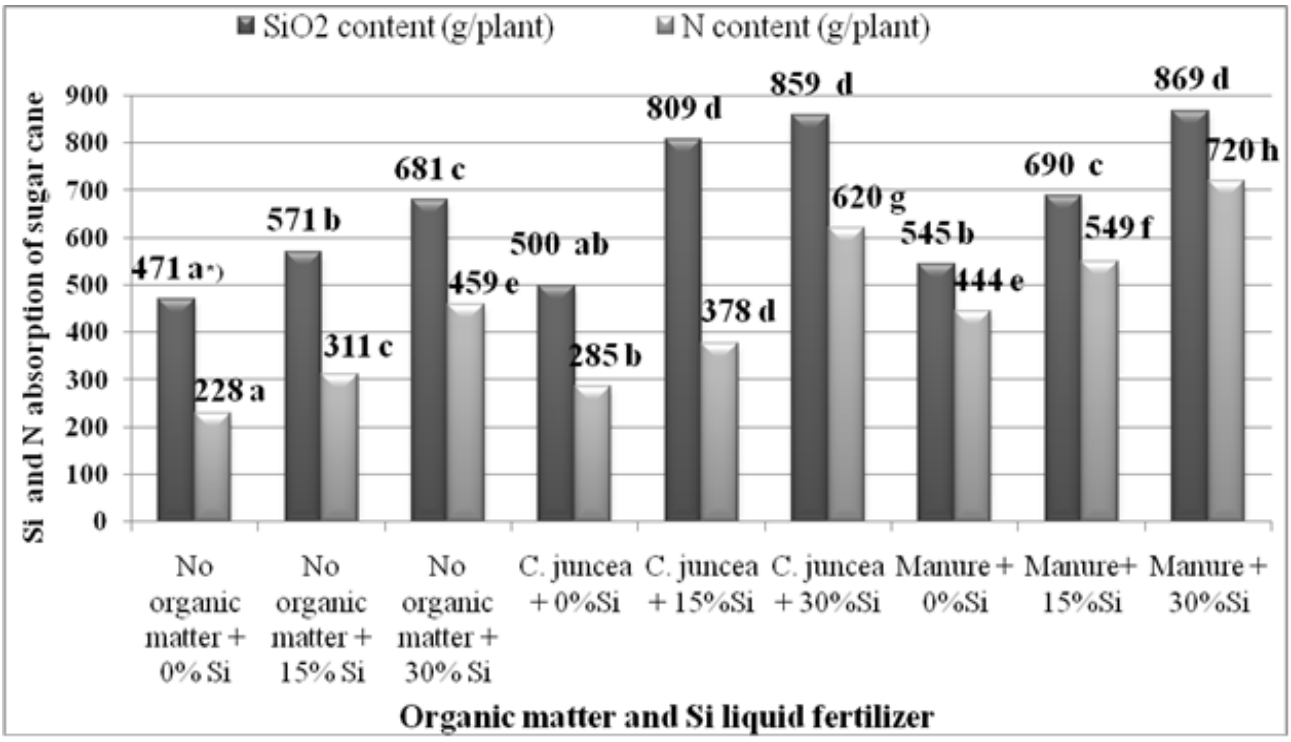

Figure 1. Effect of organic matter and Si liquid fertilizer on Si and N absorption of sugar cane. *Numbers in the same bar followed by the same letters are not significantly diferrent at p<0.05.

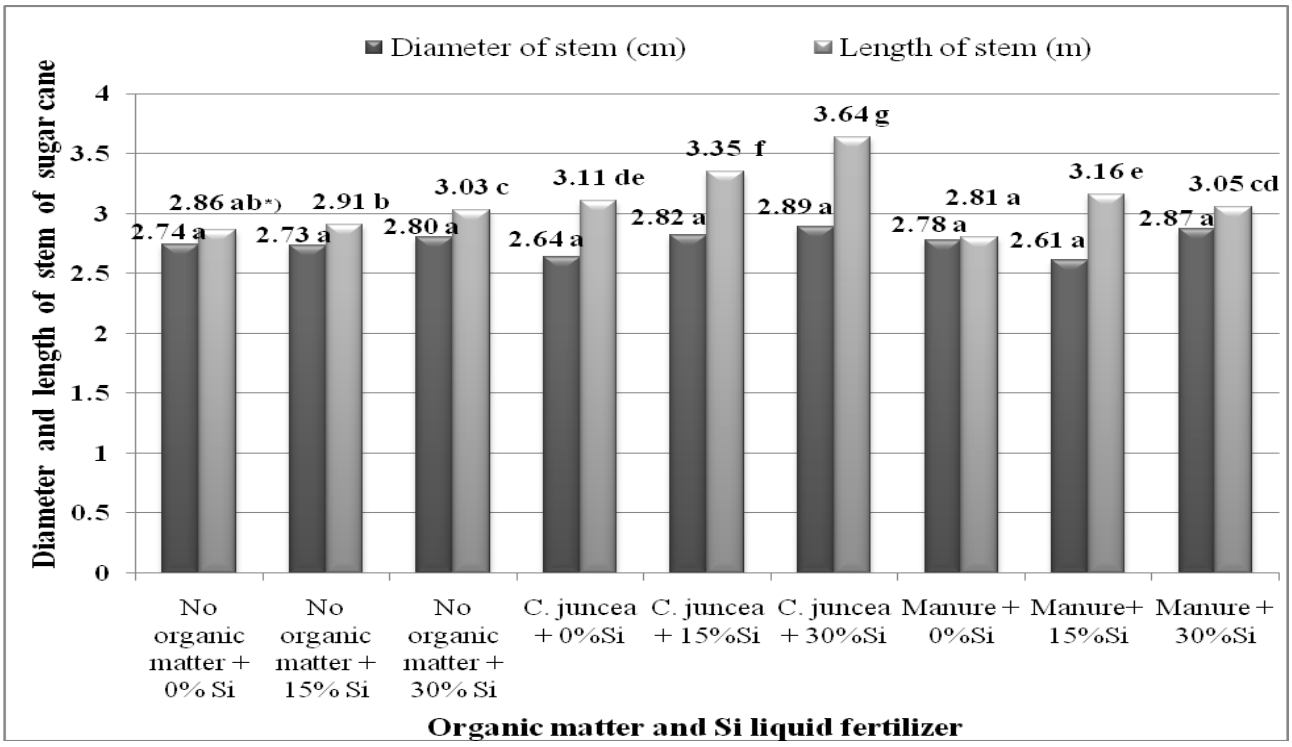

Figure 2. Effect of organic matter and Si liquid fertilizer on diameter and length of stem of sugar cane. * Numbers in the same bar followed by the same letters are not significantly diferrent at p<0.05

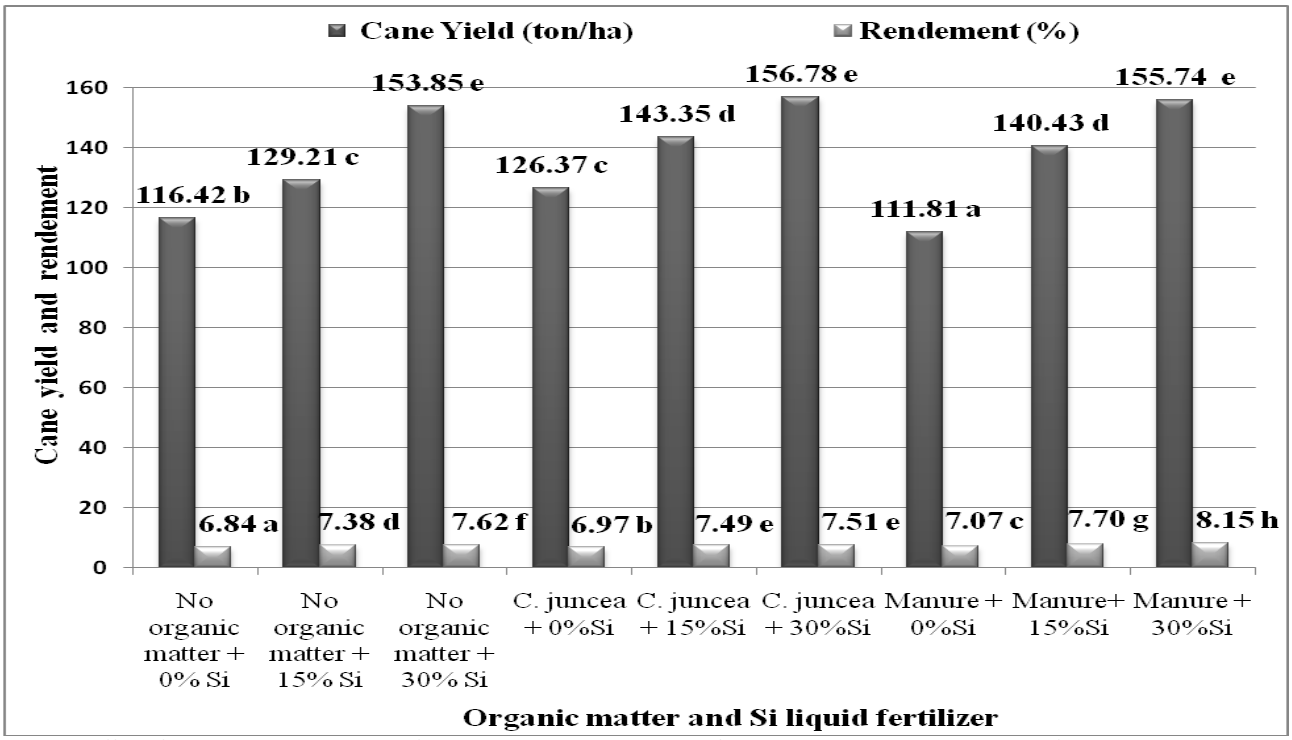

Figure 3. Effect of organic matter and Si liquid fertilizer on yield and remdement of sugarcane. *Numbers in the same bar followed by the same letters are not significantly diferrent at p<0.05

Discussion

The increasing absorption of Si and N by sugarcane might be related to the role of organic matter which can induce the growth of roots and buds of sugar cane. Shukla *et al*. (2013) reported that addition of organic matter enhanced new roots and buds to sprout of sugar cane under cold condition. This was attributed to favorable environment in root zone with lower bulk density and higher infiltration rate with organic matter added. As Si is absorbed by roots and buds of sugar cane (Ma and Yamaji, 2015), so that increasing concentration of Si liquid fertilizer will increase absorption of Si. This results agree with those of de Camargo *et al.* (2014) who reported that addition of Si fertilizer increased the Si concentrations in the soil and the leaves of the sugar cane at 8 month in tropical soils of Brazil. Role of *C. juncea* is also increasing N availability through their roots that fix air free Nitrogen and producing green biomass (Rutherford, 2009). Planting 60 kg seeds of *C. juncea* per hectare at the potato field could improve soil chemical characteristics by elevating soil total N and available P about 11 % and 36% respectively (Ossom *et al*., 2010).

Our results found that addition of organic matter together with Si increased the growth and yield of sugarcane. Previous study reported by Helall *et al*. (2012) identified that addition of organic matter and Si fertilizer increased plant height of wheat as consequence of increasing absorption of N and P. Silicon is absorbed by plant, and accumulated in leaves, increasing the photosynthetic activity due to the leaf being erect and thereby increasing light interception characteristics (Inanaga *et al.*, 1995). Furthermore increasing cane yield and rendement due to interaction between organic matter addition and Si liquid fertilizer might be as a result of increasing Si and N absorption and length of stem. As organic matter has a role to improve soil environment that favorable for root to grow, addition of Si was increased chlorophyll so that photosynthesis will increase (Shen *et al.*, 2010). As the photosynthesis increases, production of carbohydrate will be followed by increasing the cane yield and rendement.

Diameter and Length of Stem

Interaction between organic matter and Si liquid fertilizer had significant influence on length of stem, but it did not have significant effect on diameter stem of sugar cane (Figure 2). Compare to the stem of sugar cane planted in soil with no addition of organic matter and without spraying of Si liquid fertilizer, those with addition of organic matter (either *C. juncea* or manure) and Si liquid fertilizer had a longer stem. The longest stem (363.60 cm) was found in sugar cane which was planted in soil added with *C. juncea* and sprayed with 30% Si liquid fertilizer. Compare to control treatment, additioj of *C. juncea* to the soil and spaying of 30% Si to sugar cane increased length of stem up to 27%. The significant influence of organic matter and Si fertilizer on length stem of sugar cane may be related to increasing of N absorption. Helall *et al.* (2012) reported that addition of organic matter and Si fertilizer increased plant height of wheat as consequence of increasing absorption of N and P.

Acknowledgement

We thank Indonesian Agency for Research and Development for financial support to the research.

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