



Silica Fertilizer (Si) Enhances Sugarcane Resistance to The Sugarcane Top Borer *Scirpophaga excerptalis* Walker

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ABSTRACT

Sugarcane is an essential industrial that produce sugar in the world. *Scirpophaga excerptalis* attacks can reduce the productivity of sugarcane up to 34%. To enhance the resistance to multiple stresses, Silicon is one of the elements for its role. This research aimed to determine the effect of the provision of silica fertilizer as part of the Integrated Pest Management strategy. This research was conducted in the Plant Protection Department, Indonesian Sugar Research Institute. The compost given as treatment in this research was straw, cane, and corn composts. Organic silica fertilizer (compost) provides the same effect as inorganic silica fertilizer in increasing the induction of sugarcane resistance to sugarcane top borer (*S. excerptalis*). Rice straw compost was a compost fertilizer that provides the best sugarcane resistance to sugarcane top borer compared to sugarcane plants that treated with sugarcane and corn leave to compost.

INTRODUCTION

As the important industrial crop, sugarcane (*Saccharum officinarum* L.) is cultivated on 20 million ha and that produce sugar in the world (Smiullah, Khan, Ijaz, & Abdullah, 2013). This plant accounts for 70% of world sugar production (Butterfield, D'Hont, & Berding, 2001). As a plantation commodity, sugar cane is widely cultivated in the territory of Indonesia. Sugarcane is a producer of vegetable oil which is renewable an important industrial raw material such as plywood, paper, industrial enzymes, and animal feed (Diederichs, Ali Mandegari, Farzad, & Görgens, 2016). The main problems in sugarcane are pests and diseases, more than 100 pests and 80 diseases can attack sugarcane. In Indonesia, sugarcane top borer *Scirpophaga excerptalis* (Lepidoptera: Crambidae) is the main pest of sugar cane (Goebel, Achadian, & McGuire, 2014). *Scirpophaga excerptalis* has been reported as one of the most destructive insects of

sugarcane in most parts of the world (Srivastava & Rai, 2012). The larvae usually penetrate along the midrib of the leaf into the heart of the plant and the top shoot becomes withered and stunted, whereas the internodes beneath may produce new leaves (Shobharani, Rachappa, Sidramappa, & Sunilkumar, 2018). *Scirpophaga excerptalis* attacks can reduce the productivity of sugarcane up to 34% (Goebel, Achadian, Kristini, Sochib, & Adi, 2011; Sushil et al., 2020). Some controls have been carried out such as the release of parasitoids, planting resistant varieties, use pheromone traps, and increasing soil nutrients, especially silicate (Si).

In the soil, Silicon (Si) is one of the most abundant nutrient for crop. The application of silicate fertilizer to sugarcane can increase land productivity (de Camargo, Rodrigues Gomes Júnior, Wyler, & Korndörfer, 2010; Meyer & Keeping, 2000; Nikpay, Nejadian, Goldasteh, & Farazmand, 2017). Silica is not only useful for increasing crop productivity but also increases resistance. It is also part of biological

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control by attracting predators and parasitoids from insect pests (Alhousari & Greger, 2018; de Oliveira et al., 2020). The resistance of plants to various stresses can be stimulated by increasing the hardness of the cell walls through deposition of Silicon in plant tissue. Silicate is known as a nutrient associated with induction of resistance to biotic and abiotic stresses (Massey, Ennos, & Hartley, 2006; Meyer & Keeping, 2000; Savant, Korndörfer, Datnoff, & Snyder, 1999). In addition, One of the nutrient that have role to enhance the resistance to various stresses (abiotic and biotic) is Silicon (Han, Lei, Wen, & Hou, 2015). There is positive relationship between the protective effect of silica to plants against insect herbivores and its accumulation in-plant tissues. This research aimed to determine the effect of the provision of silica fertilizer as part of the Integrated Pest Management strategy.

MATERIALS AND METHODS

Compost Production and Analysis of Si Content

This research was conducted in the Plant Protection Department, Indonesian Sugar Research Institute, Pasuruan from June 2019 to March 2020. The compost given as treatment in this research was straw, cane, and corn composts. The decomposition process was carried out by giving the BioCom plus decomposer and water to the material that has been chopped and dried. Si content in compost was analyzed by taking 100 g of each compost.

The Effect of Si Fertilizer on Sugarcane from Sugarcane Top Borer Attack

The analysis was carried out by planting sugarcane seeds variety PS 59 (sugarcane top borer sensitive) in 10-liter plastic pots. Each pot was filled with 2 seeds (*bagal*) sugarcane. The experimental design used was a randomized block design with 4 treatments. The treatments consisted of sugarcane plants fertilized with straw compost, sugarcane leaf compost, corn leaf compost, inorganic Si fertilizer, and control (without fertilizer). The treatment was repeated 3 times with each test consisting of 3 plastic pots. The dosage of each compost used was 5 t/ha while the dose of inorganic Si fertilizer was 250 kg/ha, fertilizing was given at the same time as planting. Three months after planting, sugarcane

plants were infested with one larvae (*S. excerptalis*) larva instar as much as two larvae for each plant.

The percentage of attacks on sugarcane due to sugarcane top borer were made every two weeks (14 days) once by observing the symptoms of attacks on each plant. In the 6th week, the plants were observed destructively to measure the length of the sugarcane top borer larvae. The analysis of Si content in sugarcane stems and hardness level of sugarcane shoots were extracted using 0.01 M CaCl₂ (Berthelsen et al., 2001). Si content in extracts was measured by a spectrophotometer as well as the molybdosilicic acid method (Galhardo & Masini, 2000).

Data Analysis

The data were analyzed using ANOVA (single factor). Further tests are carried out if there were significantly different treatment effects namely the DMRT (Duncan Multiple Random Test). All the data were analyzed using Microsoft Excel 2016.

RESULTS AND DISCUSSION

Silica Content (Si) of Composts

The result of the laboratory analysis of silica content (SiO₂) of rice straw, sugarcane leaves, and corn leaves was listed in Table 1. The analysis showed that compost from sugarcane leaves had the highest silica content, followed by rice straw and corn leaves. Savant, Korndörfer, Datnoff, & Snyder (1999) stated that sugarcane absorbs more Si than any other nutrient, ca. 380 kg/ha, in a 12-months old crop. Responses of sugarcane to silicon fertilization have been documented in some areas of the world based on growth and development. High silica content in leaves can increase the firmness of leaves and stems of plants (Laane, 2018; Meyer & Keeping, 2000). Physically, sugarcane and rice leaves are more rigid and sharp compared to corn leaves.

The C/N ratio of three composts was different, sugarcane leaves was a higher C/N ratio followed by corn leaves and rice straw were a lower C/N ratio. A high C/N ratio indicates that compost material was not completely decomposed, conversely if the C/N ratio was lower, it indicates that the material has been decomposed and nutrients can be available to plants.

Table 1. Silica content (SiO₂) and C/N ratio of sugarcane leaves, rice straw, and corn leaves compost

Compost	Silica (SiO ₂) (%)	C/N ratio
Sugarcane leaves	1.870	29.12
Rice straw	0.757	12.99
Corn leaves	0.696	27.12

Effect of Compost and Silica Fertilizer on the Resistance of Sugarcane Plant against Sugarcane Top Borer Attack

The percentage of symptoms of sugarcane top borer larvae in sugarcane plants that have been treated differently was presented in Table 2. The average percentage of attack symptoms ranged from 22.22–50%. There was no significant difference in the percentage of larvae attack symptoms between composts and inorganic silica fertilizer ($F = 1.83$; $df = 2.4$; $P = 0.18$). This result showed that the application of Si fertilizer from organic material (compost) had the same effect as the Si fertilizer from inorganic materials produced by the factory. Thus increasing the sugarcane's resistance to sugarcane top borer *S. excerptalis* can be done by adding Si fertilizer from organic matter (compost), particularly rice straw. Because compost of rice straw showed the lowest percentage of the symptom of larvae attack compared to other treatments. Han, Lei, Wen, & Hou (2015) stated that rice varieties resistant to the rice leaf folder are generally characterized by high silicon content. In this study, silicon amendment, at 0.16 and 0.32 g Si/kg soil, enhanced resistance of a susceptible rice variety to the rice leaf folder.

The addition of organic material from fallen leaves of plants or other agricultural wastes that have been neglected by farmers turned out to be able to have a positive impact. In addition to adding nutrients to the soil, the organic material also able to increase plant resistance to pests. Thus the use of synthetic fertilizers and pesticides can be reduced and replaced with compost in order to minimize costs as well as degradation of the surrounding environment in the long term. Based on Altieri, Ponti, & Nicholls (2012) shows that soil organic fertility can influence the ability of a crop plant to deal with pest attacks in many ways.

Table 2. The average (mean $\pm$ SD) percentage of sugarcane top borer larvae attack

Treatment	Symptom of larvae attack (%) ^{ns}
Control	50.00 $\pm$ 8.34
Compost of rice straw	22.22 $\pm$ 4.81
Compost of sugarcane leaves	33.33 $\pm$ 8.33
Compost of corn leaves	50.00 $\pm$ 8.34
Inorganic silica fertilizer (Si)	50.00 $\pm$ 8.34

Remarks: ^{ns} Indicate not significant differences within column

Actually, the application of compost fertilizer can increase the resistance of sugarcane top borer larvae attack. However, the supply of silica from composts or organic matters requires a longer time and process to be absorbed by plants. To overcome this it can be done by adding a dose of compost and applying it before planting with some repetitions. It is expected to be able to meet the needs of the silica element by plants to inducing resistance against sugarcane top borer (*S. excerptalis*).

The application of compost also were not influence the bore length of the sugarcane top borer larvae in the sugarcane stem (Table 3). Bore length of larvae decreased during the third observation except on corn leaves to compost. Sugarcane plants that were treated with rice straw compost, the infested larvae died at the third observation (Table 4). This result showed that rice straw compost can induce sugarcane resistance to sugarcane top borer even better than inorganic silica fertilizer. Silica element can increase plant resistance to pests and diseases by thickening the cuticle layer and hardening the plant tissue. Thus pests or pathogens become difficult to penetrating plant tissues (Meyer & Keeping, 2000; Tubana, Babu, & Datnoff, 2016). Calatayud, Njuguna, & Juma (2016) stated that deposition of silica in plant epidermal cells provides a physical barrier against insect's probing and feeding or insect's penetration into plant tissues.

Table 3. The average (mean $\pm$ SD) bore length of larvae in the sugarcane stem

Treatment	Bore length of larvae (cm) at observation		
	First ^{ns}	Second ^{ns}	Third ^{ns}
Control	20.42 $\pm$ 1.65	27.50 $\pm$ 0.43	17.67 $\pm$ 7.75
Compost of rice straw	22.50 $\pm$ 2.22	9.67 $\pm$ 8.37	9.67 $\pm$ 8.37
Compost of sugarcane leaves	11.33 $\pm$ 4.93	27.00 $\pm$ 1.15	9.67 $\pm$ 8.37
Compost of corn leaves	19.17 $\pm$ 0.72	27.50 $\pm$ 0.75	31.00 $\pm$ 1.32
Inorganic silica fertilizer (Si)	21.17 $\pm$ 0.63	24.83 $\pm$ 1.18	18.67 $\pm$ 8.08
<i>F-value</i>	2.20	2.85	0.86
<i>Df</i>	2.40	2.40	2.40
<i>P-value</i>	0.12	0.06	0.51

Remarks: ^{ns} Indicate not significant differences within column

Table 4. The average (mean $\pm$ SD) length of sugarcane top borer larvae

Treatment	Larval length (mm) at observation		
	First	Second ^{ns}	Third ^{ns}
Control	18.00 $\pm$ 1.73 b	15.63 $\pm$ 1.49	0.00 $\pm$ 0.00
Compost of rice straw	21.67 $\pm$ 1.89 b	7.00 $\pm$ 6.06	0.00 $\pm$ 0.00
Compost of sugarcane leaves	8.33 $\pm$ 3.69 a	19.70 $\pm$ 2.02	0.00 $\pm$ 0.00
Compost of corn leaves	20.67 $\pm$ 2.52 b	15.77 $\pm$ 1.18	7.33 $\pm$ 6.35
Inorganic silica fertilizer (Si)	17.00 $\pm$ 0.50 ab	21.27 $\pm$ 3.38	0.00 $\pm$ 0.00
<i>F-value</i>	3.84	2.09	1.00
<i>Df</i>	2.40	2.40	2.40
<i>P-value</i>	0.03	0.13	0.44

Remarks: Means $\pm$ SD followed by the same letters indicate not significant differences within the column (DMRT test, $P < 0.05$). ^{ns} Indicate not significant differences within the column

CONCLUSION

Organic silica fertilizer (compost) provides the same effect as inorganic silica fertilizer in increasing the induction of sugarcane resistance to sugarcane top borer (*S. excerptalis*). Rice straw compost was a compost fertilizer that provides the best sugarcane resistance to sugarcane top borer compared to sugarcane plants that treated with sugarcane and corn leaves to compost.

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