# APPLICATION OF AGRICULTURAL WASTE TO REDUCE INORGANIC FERTILIZER AND IMPROVE SUGARCANE PLANT RESISTANCE TO STEM BORER ATTACK

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## ABSTRACT

Stem borer attack is one of the limiting factors in the production of sugar cane. Proper management of plant nutrients to improve soil productivity could also improve plant resistance to borer attack and increase the yield of sugar cane. The aim of this research is to study the effect of fertilizer and boiler ash application in improving sugar cane plant resistance to stem borer attack. A Split-Split-Plot field experiment was arranged in a Randomized Completely Block Design with three replicates. The main plot was inorganic N, P, K fertilizer (standard dose, 2/3 standard dose, 1/3 standard dose). The sub plot was boiler ash application (80 tons/ha boiler ash and without boiler ash). The sub-sub plot was type of Liquid Organic Fertilizer (LOF) (LOF "Bacteria", LOF "Double" and LOF "Plus", no LOF application). Field observation was conducted on 4 months old plant to examine the percentage of stalk attacked and percentage of internodes damaged by stem borer. Artificial infestation in laboratory was conducted to examine biological performance of *Chilo auricilius* on treated plants. The application of low dose of inorganic N, P, K resulted in significantly lower incidence of sugar cane infested by stem borer. Application of boiler ash could increase sugar cane resistance by reducing first instar larvae survival and reducing third instar larval growth. The application of LOF "Plus" could increase the resistance of sugar cane against stem borer attack by reducing third instar larval growth and decreasing the damage on treated plant.

KEYWORDS: STEM BORER, SUGAR CANE, RESISTANCE

## INTRODUCTION

Stem borer *Chilo auricilius* Dudg. is one of key pests of sugar cane in Indonesia (Sallam *et al*., 2010). Year round cane cultivation in PT. Gunung Madu Plantation causes this pest always present in the field (Saefudin & Sunaryo, 2010). Crop yields and sucrose content in sugar cane could decrease significantly because of borer infestation. Observation on 11 months old cane in Gunung Madu Plantation, Lampung showed that stem borer infestation of 16-20% and 46-50% reduced sugar content by 0.91% and 2.26%, respectively. However, borer infestation up to 50% did not significantly reduce weight, length and % cane juice (Saefudin, 2012). Borer's infestation on two months old cane could reduce sugar content by up to 97% (Mardiyani, 2012).

There are various control methods can be applied to reduce borer's infestation in sugar cane, including the use of resistant varieties. However, some resistant varieties have lower sugar content than the susceptible ones that are not favored by growers. Therefore, there is a need to improve the resistance of high yielding susceptible varieties against borer's infestation. Plant resistance to pest attack can be improved by providing appropriate nutrients. Silicon (Si) has been identified to increase plant resistance to pests and diseases (Savant *et al*., 1999; Datnoff *et al*., 2005; Laing & Adandonon, 2005; Meyer & Keeping, 2005). In plant, Si is deposited in cell wall served as physical and mechanical barrier. It is also involve in developing plants resistance against multiple stresses through metabolic and/or physiological activities (Liang *et al*., 2007).

Several studies have shown that application of Si rich materials increase sugar cane resistance to borer attack. Application of bagasse furnace ash and silica slag significantly reduced the incidence of borer damaged in sugar cane treated plots than untreated control plot (Pan *et al*., 1979). Other studies showed that application of different sources of Si increased sugar cane resistance to the stem borer *Diatraea saccharalis* F. (Anderson and Sosa, 2001), *Eldana saccharina* Walker (Keeping and Meyer, 2003; Meyer and Keeping, 2005; Kvedaras & Keeping, 2007; Kvedaras *et al*., 2007) and to shoot borer *Scirpophaga nivella intacta* Snellen (Saefudin & Sunaryo, 2010).

Boiler ash is an agricultural waste from the combustion of bagasse generated in the sugar production process. Boilers ash contains 71 % $SiO_2$, 2.4 % P2O5, 9 % K2O, 4 % CaO and several micro nutrients (2.3 % Na2O, 3.1 % Al2O3, 3.7 % Fe2O3 dan 3.2 % MgO) (Disbunjatim, 2011). Boiler ash from Gunung Madu Plantation contains silicon 7.97 ± 0.58% (Saefudin & Sunaryo, 2010). Application of boiler ash can increase the nutrient content of the soil when applied together with manure or compost, besides the high content of silicon can increase plant resistance to pests and diseases. In addition, applying boiler ash to the field will reduce the amount of sugar factory waste disposal.

Sugarcane is a crop that requires a lot of fertilizer to produce high yield with high sugar content. Inorganic fertilizer may supply the needs of macro nutrients, such as nitrogen, phosphate and potassium. However, the use of excessive dose of inorganic fertilizer could lower the soil quality. Consequently, plants do not respond to fertilization, despite increased doses of inorganic fertilizers, and increasing crop productivity is not comparable to the addition of fertilizer intake (Adiningsih, 2006; Padmini, 2010). On the other hand, organic fertilizer provides macro and micro nutrient only in a modest level, but has less negative impact to the environment. Therefore, there is a need to balance the use of inorganic and organic fertilizer.

To improve soil productivity, improve efficiency of inorganic fertilizer use, as well as increase sugarcane production and yield, environmentally friendly cultivation technology can be applied by improving soil biology system and utilizing agricultural waste. Agricultural waste can be processed into liquid organic fertilizer and then used to add nutrients and plant hormones. Proper fertilization can accelerate and strengthen the growth and development of plants, increase resistance to certain pests and diseases, and thus improve plant production (Thompson and Troeh, 1978). This research aims to study the effect of inorganic and liquid organic fertilizer and boiler ash application on sugar cane resistance to stem borer attack.

## MATERIALS AND METHODS

A Split-Split-Plot field experiment was arranged in a Randomized Completely Block Design with three replicates. The Main plot was inorganic N, P, K fertilizer consisted of 3 levels, i.e., standard dose (N: 300kg/ha, P: 200 kg/ha, K: 300kg/ha), 2/3 standard dose (N: 200kg/ha, P: 200 kg/ha, K: 133 kg/ha), 1/3 standard dose (N: 100kg/ha, P: 67 kg/ha, K: 100kg/ha). The Sub plot was boiler ash application consisted of 2 levels, i.e., 80 tons/ha boiler ash and without boiler ash. The sub-sub plot was type of Liquid Organic Fertilizer (LOF) consisted of 4 levels, i.e., no LOF application, LOF Bacteria, LOF "Double" and LOF "Plus". The LOF was applied once a month at concentration 20 mL/L until the plant was 4 months after planting.

Field observation was conducted on 4 months old plant to examine the percentage of stalk attacked by stem borer and percentage of internodes damaged by stem borer. For each plot, six sampling points was selected randomly. Number of total plants and number of infested stalks were counted in 1 m of selected rows. Two infested stalks from each sampling points were split longitudinally to count the number total internodes/stalk and number of internodes damaged.

In addition, cane stalk of each treatment was cut for artificial infestation in the laboratory. The spindle (rolled leaf) was cut 8 cm long and infested with 20 first instar larvae (L1) of stem borer (*C. auricilius*) then kept in a glass tube. The upper part of stalk (the $4^{th}$ fully open leaf from top) was cut 6 cm long. The top and the bottom part of the upper stalk cut were covered with aluminum foil to prevent the larvae to bore into the open cut. Two third instar (L3) stem borer larvae were introduced in the leaf insertion (throat), and then kept in a plastic tube. The middle part of stalk was cut 6 cm long and bored longitudinally in the middle of stalk. Two third instar (L3) stem borer were infested through the hole, then kept in a plastic tube. The infested stalk cuts were incubated (t: 30±2 °C) for four days. The number of larvae (L1 and L3) died, number of leaf layer bored, weight of frass produced by L3, the length of bored stem and weight gain by L3 infested on stalk.

Collected data were analyzed using SAS® Software. Percentage data were transformed into Arcsin $\sqrt{x+1}$ before being analyzed. The data were subjected to Generalized Linear Model (GLM) procedure followed by Duncan Multiple Range Test.

## RESULTS AND DISCUSSION

### Field Observation

Field observation showed that application of different dose of N, P, K fertilizer (inorganic), ash and different types of liquid organic fertilizer (LOF) did not significantly affect percentage of damaged internodes. However, percentage of stalk attacked by stem borer was significantly higher on cane treated with standard dose of N, P, K than that treated with 1/3 of standard dose, but was not significantly different from that treated with 2/3 of standard dose. The application of ash and different types of LOF did not significantly affect percentage of stalk attacked.

These results indicates that by lowered the input of inorganic fertilizer (N, P, K) could reduced the percentage of stalk attacked by stem borer. High dose of inorganic fertilizer, especially nitrogen fertilizer, could boost vegetative growth of plant but resulted in succulent tissue. This condition makes plant vulnerable to pest attacked. Previous study

showed that fiber content of the cane reduced as the N application rate increased and thus increased the number of stalks and internodes damaged by *E. saccharina* (Coulibaly, 1990). Other study showed that *E. saccharina* larval survival, percentage internodes bored and percentage stalk length bored increased significantly with increasing levels of N (Keeping *et al*., 2011).

However, percentage of stalk attacked and internodes damaged did not affected significantly by application of boiler ash that rich in Si and different types LOF (Table 1). It could be that Si deposition in young cane (4 month after planting) has not been able to suppress stem borer infestation. Previous study showed that Si content in stalk was lower than leaves that resulted in no significant effect of silicate applied on stalk borer damage (Camargo *et al*., 2011).

Table.1: Stem borer infestation on 4 month plant cane

| Treatment | | Stalk attacked (%) | Damaged internodes (%) |
|---|---|---|---|
| N, P, K Dose | Standard dose* | 35.0±2.2 a | 21.4±0.8 a |
| | 2/3 dose | 32.8±1.4 ab | 20.0±0.6 a |
| | 1/3 dose | 29.4±2.3 b | 19.7±1.0 a |
| Boiler ash application | 80 tons/ha | 33.3±1.6 x | 20.6±0.6 x |
| | No application | 31.5±1.7 x | 20.1±0.7 x |
| Liquid Organic Fertilizer | "Bacteria" | 33.4±1.8 p | 21.7±1.0 p |
| | "Double" | 29.5±2.7 p | 20.0±1.0 p |
| | "Plus" | 33.7±3.0 p | 19.4±1.1 p |
| | No application | 33.1±1.9 p | 20.4±0.5 p |
| Interaction | | - | - |

Standard dose*: N: 300kg/ha, P: 200 kg/ha, K: 300kg/ha

Means within a column followed by the same letter are not significantly different from one another as determined by Duncan's multiple range tests.

## Laboratory Experiments

The mortality of L1 was significantly lower when they were infested on spindle (rolled leaf) of cane treated with 1/3 of standard dose of N, P, K than those infested on cane treated with higher dose. More L1 died when they were infested on spindle (rolled leaf) of cane treated with ash than those infested on cane without ash application. The mortality of L3 did not significantly affected by ash application or LOF application. However, the mortality of L3 was significantly higher when they were infested on upper part of cane stalk treated with 2/3 of standard dose of N, P, K than those infested on cane treated with full dose of N, P, K, but similar to those infested on cane with 1/3 of standard dose of N, P, K (Table 2).

Lower survival of newly hatched (L1) *C. auricilius* larvae occurred when they were infested on rolled leaves (spindle) from plant treated with higher dose of N, P, K fertilizer. This result is in contrary to the results of previous research that showed increasing levels of N significantly increased larval survival (Keeping *et al*., 2011). It

could be because in this research the application of higher dose of N was also followed with higher dose of P and K. Phosphorous (P) has a role in energy generation, nucleic acid synthesis, photosynthesis and other physiological processes in plant (Vance *et al*., 2003). Potassium (K) supports plant defence against abiotic and biotic stresses, including pest attack (Wang *et al*., 2013).

Higher mortality of first instar *C. auricilius* larvae infested on spindle of cane treated with ash could be because the rolled leaf contains Si that hampered the young larvae to chew the epidermis of leaf tissue. Previous study showed that epidermal tissue of leaf bud, internodes and root band of sugar cane treated with calcium silicate had increased silica than untreated plant (Keeping *et al*., 2008). Young larvae have fragile mandible, the presence of Si in epidermal tissue could damage the mandible (Savant *et al*., 1999).Other study showed that cell wall of tissue culture deposited in silicic acid was thicker, contains cellulose and hemicelluloses per cell-wall unit area was larger (Nissan *et al*., 2011). This Si content and cell wall structure served as mechanical barrier to young larvae to feed that lead to mortality.

However, this effect was less significant on larger larvae (L3). The mortality of L3 was similar whether they were infested on plant treated with ash or without ash. Dose of N, P, K and ash application did not significantly affect number of leaf sheath bored by L3. Number of leaf sheath bored by L3 infested on the upper part of stalk from cane without LOF application was not significantly higher than those treated with LOF “Double”, but it was significantly higher than those treated with LOF “Bacteria” or LOF “Plus” (Table 2). Liquid Organic Fertilizer "Bacteria" contains a variety of soil microbes beneficial for soil health. Microorganisms’ activity will generate residual and metabolic substances to form soil aggregates ideal for plant growth and ecosystem balance in the soil (Saraswati *et al*., 2006). Besides containing nutrients LOF "Plus" also contains botanical pesticide thus increasing plant resistance to pests.

Weight of frass (feces) produced by L3 infested on the upper part of stalk from cane treated with boiler ash was significantly higher than that produced by L3 infested on cane without ash application. Dose of N, P, K and LOF application did not significantly affect weight of frass produced by L3 (Table 2). Silicon mostly was accumulated in epidermal tissue of internodes, but less dense in the underlying tissue (Keeping *et al*., 2008). Therefore, once the larvae were able to penetrate they can consume the tissue.

Table 2: Biological performance of *Chilo auricilius* on upper part of stalk and spindle of 4 month plant cane

| Treatment | | Mortality of L1 (%) | Mortality of L3 (%) | Number of Leaf Sheath Bored | Frass Weight (g) |
|---|---|---|---|---|---|
| N,P,K Dose | Standard dose* | 51.8±3.4 a | 9.1±2.1 b | 3.1±0.4 a | 0.019±0.002 a |
| | 2/3 dose | 54.5±3.8 a | 14.2±2.9 a | 3.7±0.4 a | 0.016±0.001 a |
| | 1/3 dose | 43.4±2.0 b | 9.6±1.8 ab | 3.4±0.4 a | 0.016±0.001 a |
| Boiler ash application | 80 tons/ha | 54.5±3.1 x | 12.8±2.1 x | 3.1±0.3 x | 0.019±0.002 x |
| | No application | 46.1±2.0 y | 8.9±1.6 x | 3.7±0.4 x | 0.015±0.001 y |
| Liquid Organic Fertilizer | "Bacteria" | 49.0±3.4 p | 11.1±3.7 p | 3.0±0.4 q | 0.017± 0.001p |
| | "Double" | 50.5±4.3 p | 12.2±2.2 p | 3.3±0.5 pq | 0.015±0.001 p |
| | "Plus" | 52.3±4.2 p | 10.6±2.5 p | 3.0±0.6 q | 0.016±0.001 p |

| | | | | | |
|---|---|---|---|---|---|
| | No application | 49.3±3.5 p | 9.4±2.1 p | 4.1±0.4 p | 0.021±0.003 p |
| Interaction | | - | - | - | - |

Standard dose*: N: 300kg/ha, P: 200 kg/ha, K: 300kg/ha

Means within a column followed by the same letter are not significantly different from one another as determined by Duncan's multiple range tests.

The L3 gain less weight when infested on the middle part of stalk from cane treated with ash than that infested on cane without ash application. Silicon appears to contribute to the reduced larval growth. This result is similar to other research on *Eldana saccharina* Walker (Kvedaras & Keeping, 2007) and *Diatraea saccharalis* (F.) (Sidhu *et al*., 2013). Dose of N, P, K did not significantly affect larval weight gain (Table 3).

Table 3: Biological performance of *Chilo auricilius* on middle part of stalk of 4 month plant cane

| Treatment | | L3 Weight gain (g) | Length of Bored Stalk (mm) | Frass Weight (g) |
|---|---|---|---|---|
| N, P, K Dose | Standard dose* | 0.069±0.002 a | 42.2±1.2 a | 0.031±0.001 a |
| | 2/3 dose | 0.065±0.002 a | 42.5±1.3 a | 0.029±0.001 b |
| | 1/3 dose | 0.066±0.003 a | 44.4±1.0 a | 0.028±0.001 b |
| Boiler ash application | 80 tons/ha | 0.064±0.002 y | 43.1±0.9 x | 0.030±0.001 x |
| | No application | 0.069±0.002 x | 43.1±1.0 x | 0.029±0.001 x |
| Liquid Organic Fertilizer | "Bacteria" | 0.065±0.002 q | 43.0±1.4 p | 0.029±0.001 pq |
| | "Double" | 0.064±0.001 q | 42.8±0.8 p | 0.030±0.001 pq |
| | "Plus" | 0.064±0.002 q | 43.9±1.8 p | 0.028±0.001 q |
| | No application | 0.073±0.005 p | 42.5±1.3 p | 0.031±0.001 p |
| Interaction | | - | - | - |

Standard dose*: N: 300kg/ha, P: 200 kg/ha, K: 300kg/ha

Means within a column followed by the same letter are not significantly different from one another as determined by Duncan's multiple range tests.

The application of LOF seems to increase plant resistance to stem borer by reducing larval growth and feeding damage. The L3 gain more weight when infested on the middle part of stalk from cane without LOF application than that infested on cane treated with various types of LOF. L3 infested on the middle part of stalk from cane treated with LOF "Plus" produced significantly less frass than those infested on cane without LOF application, but it produced about similar weight of frass than that infested on cane treated with other types of LOF (Table 3).

Weight of frass (feces) produced by L3 infested on the middle part of stalk from cane treated with standard dose of N, P, K was significantly higher than that produced by L3 infested on cane treated with lower dose (Table 3). The fibre content of the cane decreased as the N application rate increased (Coulibaly, 1990). This made the larvae consumed more and produced more frass. However, this did not prolong the bored tunnel in internodes. Length of bored stalk did not affected significantly by N, P, K dose, ash application and LOF application. Ash application did not significantly affect frass produced by L3 (Table 3).

## CONCLUSION

The resistance of sugar cane to pest infestation and damage can be improved by plant nutrition management. The application of low dose of inorganic N, P, K in combination with boiler ash and LOF "Bacteria" or LOF "Plus" may increase the resistance of sugar cane toward stem borer attack. Application of boiler ash in combination with liquid organic fertilizer made of agricultural waste could support green agroindustry, by reducing and recycling the agroindustrial waste.

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