Integrated trash management in acidic soil effect soil microbe population and increase sugarcane yields

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ABSTRACT

Production of sugarcane *(Saccharum officinarum L.)* can be improved through manipulating sugarcane trash management. Sugarcane litter as the main residual product of sugarcane plantation can be used as a source of nutrients to improve soil chemical and biological properties. Cellulolytic microbes are able to degrade sugarcane litter which need to be optimized under the combination of various organic or an organic inputs of soil amendment. However, various soil and environment condition are influenced cellulolytic microbe such as pH, nutrients, water availability, and availability of organic substrate along with their interaction with other microbes. Urea, Dolomite ($CaMg(CO_3)_2$) and manure is intended to optimize cellulolytic microbial growth. The research was conducted at Sugarcane Research Centre PTPN X, Djengkol, Kediri from January to December 2019. Materials on experiment used are cellulolytic bacterial isolates, *Trichoderma* sp., urea, dolomite, cow manure, molasses and sugarcane litter. The research method used combination of Randomized Complete Block Design (RCBD). The treatments were S_1 (Molasses + sugarcane litter) ; S_1S (Molasses + sugarane litter + Cellulolytic bacteria) ; S_1SU (Molasses + sugarcane litter + Cellulolytic bacteria + Urea) ; S_1SUD (Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Dolomite) ; S_1SUP (Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Cow manure), S_1T (Molasses + sugarcane litter + *Trichoderma* sp., S_1TU: Molasses + sugarcane litter + *Trichoderma* sp. + Urea), S1TUD (Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Dolomite), S1TUP (Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Cow Manure). The results showed that the greatest cellulolytic microbe were detected under S1SUD treatments, litter provide the best condition for soil microbe to grow, giving the total population of soil bacteria and cellulolytic bekteri population to reach 6.09×10^6 cfu g^{-1} and 3.45×10^6 cfu g^{-1} at 4 WAP (week after planting). However, under the addition of sugarcane litter, urea and cow manure (S1SUP) provided the best sugarcane growth and cane yield at about (90.32 ton ha^{-1}), as cow manure is more able to provide and fulfilled nutrients requirement for sugarcane, followed by (S1TUD) whereas cow manure did not exist, yielded at 84.48 ton ha^{-1}.

Keywords: soil microbe, nutrients balance, litter, manure, land management

I.INTRODUCTION

Sugar cane (*Saccharum officinarum* L.) is the main sweetener source in the world, almost 70% of the source of sweetener comes from sugarcane commodities (Lubis et al., 2015) or ethanol production (Franco *et al*., 2013; Carvalho *et al*., 2017a ; Carvalho et al., 2017b). Sugar cane become of the main commodities in Indonesia, which is then the sugarcane stem being harvested and processed to be made into crystalline sugar (Lubis et al., 2015). However, the sugarcane were cultivated under the system which allowing leaves as the major residual product of the upper part of sugarcane in the form of litter is being left in soil surface following harvest (Franco *et al*., 2015). Commonly, this biomass was collected in windrow system before burning, whereas most of soil organic matter and important nutrients were lost (Suma and Savitha, 2015). Incorrect soil management and cultivation towards sugarcane residues will affect soil properties. The average of this sugarcane residue can reach to about 10-15% of total aboveground sugarcane biomass. This biomass can be amended Nitrogen to soil up to 120 kg ha^{-1} annually (Nurhidayati, 2018), which may contribute a biomass residue at the amount of 10 to 30 t ha^{-1} $year^{-1}$ (Fortes et al., 2012). The advantages of burning sugarcane biomass was increasing on soil pH, unfortunately it will raise the risk on environmental pollution, greenhouse gases emission and soil erosion (Suma and Savitha, 2015)

In Indonesia most of soil pH under sugarcane plantation has been positioned in acid condition. This is due to the intensive uses of inorganic fertilizers such as urea (or ZA), and soil had

low organic matter content. The application of in-organic fertilizer in the form of Urea (or ZA) which was reach up to 700 – 1000 kg ha^{-1}, exceeded to lowering soil pH quickly. For example, most of the Sugar Research Center area of PT. Perkebunan Nusantara X at Kediri regency has a soil pH to slightly acidic condition (Harista, 2017), reach to about 5.95 to 6.2 (Agustin, 2018), with low to moderate organic matter content, whereas the application of in-organic fertilizer need to be evaluated and being monitored. The impact of low soil pH and high rates application of fertilizer can disrupt soil environment. At present, the Indonesian sugarcane sector has been required to inform how much sugarcane biomass left in soil surface as apart of land management. For anticipating this problem, an alternative solution is being offered, since high cellulose and lignocellulose content in sugar cane litter prolonged the time of decomposition by combining organic and in-organic inputs to exaggerate sugar cane trash decomposition.

Cellulolytic bacteria have been known to have an ability to decompose organic materials containing cellulose so that it can accelerate the decomposition process by releasing cellulolytic enzymes were being employed. However, under acidic condition cellulolytic bacteria could not grow under optimum conditions. This microbe helps to decompose lignocellulose material incorporation with others such as fungus. *Trichoderma sp* as one type of fungus which has ability for degrading cellulolytic is hypothesed to be complementary technique when they were being used to decompose sugarcane litter along with the application of Cellulolytic bacteria. According to Reddy et al. (2014) cellulolytic microbial growth is influenced by the level of carbon, nitrogen, pH and temperature for producing cellulases and they will compete with other microbe such as fungus. On the other hand, sugarcane litter contain low in nitrogen content while decomposition processes will be faster when litter has low C/N ratio. The addition of urea to sugarcane litter has been detected to reduce soil pH to acidic condition, for anticipating this, the use of dolomite ($CaMg(CO_3)_2$) is required.. This study was aimed to examine the effect of various combination of inputs of different sugarcane trash management system to the dynamics of soil microbe and soil properties and their relationship to sugarcane growth, since the information of this phenomenon is scanty. If any, Suma and Savitha, (2015) have been tried to implement a treatment of the application of 500 kg of farm yard manure (FYM), enriched with 25 kg microbial culture (*Trichoderma viridea*), however they did not realize that the initial soil condition was in slightly acidic soil which may disturb the effectiveness of those application, eventhough they found that this methods were effective for enhanching soil health and . Previous findings related to the impact of sugarcane management only focused on characterization of microbial group particularly the changes on fungal communities (Rachid *et al.*, 2012, Navarrete *et al*., 2015, Pitombo *et al.*, 2016), but not for bacterial communities. Hence, this present study was taken up to show the effect of different input of organic and in-organic input to the changes of cellulolytic bacteria which may then have an impact on sugarcane productivity in acidic soils. Member of cellulolytic bacteria has been recognized to be effectively used to monitor biological depletion of soil quality in sugarcane plantations.

II.MATERIALS AND METHODS

This research was conducted in January-December 2019, located in the Soil & Fertilizer Testing Laboratory, Microbiology Laboratory, and the experimental land of the Sugar Research Center of PT. Perkebunan Nusantara X, Djengkol, Kediri, East Java. The materials used are sugarcane seedlings (NX-02) for indicator crop growth, sugar cane litter (20 tons ha^{-1}), molasses (15 liters ha^{-1}), cellulolytic bacterial isolates (40 liters ton^{-1} sugarcane litter), fungal isolates *Trichoderma sp*. (1 liter ton sugarcane litter), Urea (75 kg ha^{-1}), cow manure (500 kg ha^{-1}) and dolomite (1 ton ha^{-1}). The design of this study used a randomized complete block design (RCBD) with 9 treatments and 4 replications, resulted in 36 treatment totally as follows (Table 1).

Table 1. A list of treatment and detail description

Code		Description
S1	:	Molasses + sugarcane litter
S1S	:	Molasses + sugarcane litter + Cellulolytic Bacteria
S1SU	:	Molasses + sugarcane litter + Cellulolytic Bacteria + Urea
S1SUD	:	Molasses + sugarcane litter + Cellulolytic Bacteria + Urea + Dolomite
S1SUP	:	Molasses + sugarcane litter + Cellulolytic Bacteria + Urea + Cow Manure
S1T	:	Molasses + sugarcane litter + *Trichoderma sp*.
S1TU	:	Molasses + sugarcane litter + *Trichoderma sp*. + Urea
S1TUD	:	Molasses + sugarcane litter + *Trichoderma sp*. + Urea + Dolomite
S1TUP	:	Molasses + sugarcane litter + *Trichoderma sp*. + Urea + Cow Manure

Sugar cane litter were buried in the soil two weeks before planting and an initial analysis of the soil chemical properties were carried out. Observations were made at 12 WAP (weeks after planting) to examine pH value, C-organic content, total N-content, total soil bacterial population, plant bacterial population, plant height, number of leaves, plant diameter, number of tillers and sugarcane biomass.

The research data obtained will be tabulated with Microsoft Office Excel 2016 and Analysis of Variance (ANOVA) is used using a F-level test of 5% with the Genstat ver 18 application along with regression analysis as suggested by Prayogo *et al.*

(2020) under additional assessment using multivariate CVA(Canonical Variate Analysis) (Setianingsih *et al.*, 2021; Prayogo et al., 2019; Prayogo et al., 2020)). Further tests will be carried out using a LSD test with a level of 5% to determine the difference between treatments.

III.RESULTS AND DISCUSSION

Soil chemical properties

Preliminary soil chemical analysis is carried out at the beginning before the soil is treated, to determine changes in soil conditions after the treatment. The results of initial soil analysis showed that soil pH, total soil N and soil C-Organic were to about 5.68 ; 0.24 ; 1.90 respectively. ANOVA was indicated that the treatment gave significant impact ($p<0.01$) to soil soil C, total soil N, and C/N ratio at 12 WAP (week after planting) (Table 2). The treatments increase soil pH at about 20% from those initial value in the average, where S1SUD produce the highest soil pH to about 6.45, which was significantly different ($p<0.05$) to all other treatments except with S1TUD treatments to about 6.37. SISUD treatments was also produce the greatest soil C which is not significantly ($p<0.05$) to S1; S1SU; and S1T. A similar pattern was observed to the soil Nitrogen status. In term of soil C/N ratio the lowest value has been detected at S1SUP treatments which is significantly ($p<0.05$) to other treatments and the highest was at S1T treatments.

Table 2. Soil chemical properties at 12 WAP (week after planting)

No.	Code	Soil pH	Soil C (%)	Soil N (%)	C/N ratio
1	S1	6.15 a	2.52 bc	0.33 de	7.64 b
2	S1S	6.06 a	2.26 b	0.31 cd	7.07 b
3	S1SU	6.14 a	2.52 bc	0.33 de	7.63 b
4	S1SUD	6.45 b	2.55 c	0.36 f	7.07 b
5	S1SUP	6.15 a	1.79 a	0.30 ab	5.91 a
6	S1T	6.08 a	2.29 bc	0.33 e	6.86 b
7	S1TU	6.14 a	2.24 b	0.31 bcd	7.08 b
8	S1TUD	6.37 b	2,39 b	0.31 abc	7.70 b
9	S1TUP	6.04 a	2.24 b	0.29 a	7.56 b

Note: The same letter in each column shows that there is no significant difference in the LSD test of 5%. S_1: Molasses + sugarcane litter, S_1S: Molasses + sugarcane litter + Cellulolytic bacteria, S_1SU: Molasses + sugarcane litter + Cellulolytic bacteria + Urea, S_1SUD: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Dolomite, S_1SUP: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Cow manure, S_1T: Molasses + sugarcane litter + *Trichoderma* sp., S_1TU: Molasses + sugarcane litter + *Trichoderma* sp. + Urea, S1TUD: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Dolomite, S1TUP: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Cow Manure.

The great changes on soil pH is difficult to detect since only one treatment (S1TUD) which was indicated that this treatment was significantly different to other treatment, however there was much clear indication on the changes of soil carbon and nitrogen amongst treatment. The changes on soil C content was correlated with the time elapsed after the changes on soil management (Rachid *et al.*, 2012). There was also indication that the deposit of organic matter in soil created a suitable niche for soil microbe to grow which affect to speed up the rate of soil organic matter decomposition. This was indicated from the soil organic matter content under S1SUD which was reach the greatest soil organic C reach to about 2.55% which was increased to about 84% from those initial value. Similarly, Suma and Savitha, (2015) which applying organic manure enriched with *Trichoderma viridae* had a positive increment on soil carbon by 11%. Previous study showed that the addition of sugarcane trash at different level (0%, 50%, 100%) slightly increased organic matter to about 34.6 g kg^{-1} ; 39.70 g kg^{-1} ; and 38.95 g kg^{-1} respectively (Rashid *et al.*, 2016), but in contrast under different management of trash application (Single trash load (SL) ; Double trash load (DL) and trash removal (TL), there was no evidence that those practices successfully increase soil organic matter, ranged between 2.91% to 3.36% (Miunoz -Arbodela, 2009). This may due the time for experiment was relatively short (10 years). Moreover, in this study, the application of *Trichoderma viridae* improved soil N from 0.24 % to 0.33 % under S1T treatment. The availability of soil N was influenced by nitrogen supply, crop removal and organic matter content of the soil (Suma and Savitha, 2015).

Soil biological properties

a. Total soil bacterial population

The treatment did not give significant effect to total population of soil microbe ($p> 0.05$) at 2, 4, 8 and 12 WAP (weeks after planting) (Table 3). There was an indication that the total population of soil bacteria under S1SUD treatment higher amongst all treatments. It can be seen from Table 2, that the total population of soil bacteria was slightly reduced during the period of observation. It was also clearly indicated that the addition of *Trichoderma sp*. (S1T;S1TU;S1TUD;S1TUP) suppressed the total population of bacteria which was lower compare to the treatments with no exist of *Trichoderma sp* (Figure 1). Generally, the highest bacterial population has been detected at 4 WAP (week after planting).

Table 3 Total Soil Bacteria Population (cfu / gram)

No.	Treatment Code	2 WAP	4 WAP	8 WAP	12 WAP
1	S1	3.14×10^6	4.60×10^6	3.61×10^6	2.58×10^6
2	S1S	4.08×10^6	5.77×10^6	4.36×10^6	3.45×10^6
3	S1SU	3.39×10^6	5.07×10^6	4.08×10^6	3.37×10^6
4	S1SUD	4.11×10^6	6.08×10^6	4.86×10^6	3.89×10^6

5	S1SUP	3.03 × 10^6	5.19 × 10^6	3.84 × 10^6	3.03 × 10^6
6	S1T	2.59 × 10^6	4.33 × 10^6	2.91 × 10^6	2.66 × 10^6
7	S1TU	3.37 × 10^6	5.53 × 10^6	4.26 × 10^6	3.36 × 10^6
8	S1TUD	3.63 × 10^6	5.81 × 10^6	4.82 × 10^6	3.68 × 10^6
9	S1TUP	2.82 × 10^6	5.53 × 10^6	4.44 × 10^6	3.50 × 10^6

Note: The same letter in each column shows that there is no significant difference in the LSD test of 5%. S_1: Molasses + sugarcane litter, S_1S: Molasses + sugarane litter + Cellulolytic bacteria, S_1SU: Molasses + sugarcane litter + Cellulolytic bacteria + Urea, S_1SUD: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Dolomite, S_1SUP: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Cow manure, S_1T: Molasses + sugarcane litter + *Trichoderma* sp., S_1TU: Molasses + sugarcane litter + *Trichoderma* sp. + Urea, S1TUD: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Dolomite, S1TUP: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Cow Manure.

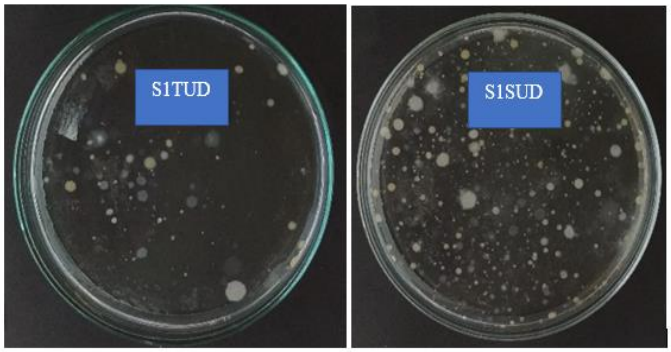

Figure 1. Soil Bacteria Population (NA) : comparing S1TUD and S1SUD treatments

Similarly, Rachid *et al.* (2016) who studied the effect of different levels of sugarcane trash in the top of soil surface to look after the changes on the structure of soil bacterial and fungal communities in two contrasting seasons, also found that there was no effect from the treatments during short term of experiment. However, there was an indication of changes on fungal communities, but it took after twelve months to be appeared. It was due to fungal communities use the sugarcane trash for source of their energy and growth. The clear changes on fungal communities has been observed greater in number in dry season rather than wet seasons (Rashid *et al.*, 2016). In this study the addition of urea and dolomite can change soil pH. The level of soil acidity affects the amount of bacterial growth in the soil. The graph in figure 2 shown the relationship between soil pH and soil bacterial populations.

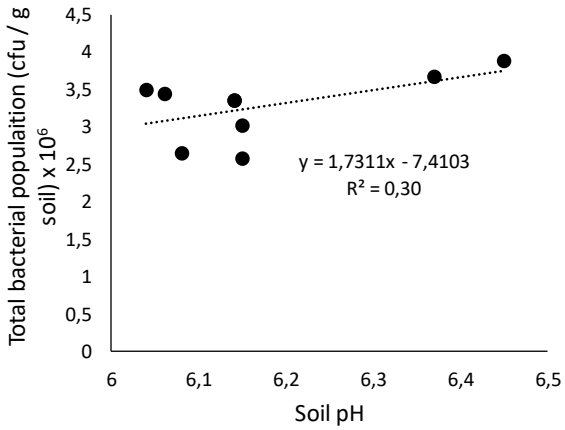

Figure 2. Relationship between soil pH and bacteria population

Based on the results of the correlation test, soil pH has a positive relationship with the population of bacteria in the soil (r = 0.55*) following linear equation of y = 1.7311x – 7.4103 (Figure 1), whereas x is the soil pH and y is the population of soil bacteria (R^2 = 0.30*). Tian and Shuli (2015) noted that a decrease in pH is in line with the addition of urea, the more urea added to the soil the more acidic soil will be achieved. Dolomite is required to increase and maintain soil pH so that it remains optimal soil condition for bacterial growth. Furthermore, Availability of the substrate as an energy source from the growth and propagation of bacteria is also needed, according to the opinion of Yulianti ***et al.*** (2012) organic materials are needed in increasing the activity of cellulolytic bacterial populations. The substrate can be seen from the C-organic content in the soil. After 12 WAP, the C-organic content increased from the low category (1, 9%) at the beginning became 4.45% which included in the high category at the end of the observation on a combination of treatments. Besides organic matter can increase soil fertility and increase the growth of sugarcane. Organic matter in the form of fertilizer and plant litter can be a soil enhancer by maintaining organic matter and soil CEC, and increasing pH and available P, neutral organic material accordingly applied to agricultural land which tends to be acidic, in addition organic matter is able to increase aggregate stability (Dariah, 2015).

b. Total Cellulolytic bacteria

ANOVA test showed a significant effect ($p<0.05$) of treatment to the total cellulolytic bacteria. The total population of soil bacteria experienced an increase in population at 4 WAP observations and declined for the next following week (Table 4). LSD (least significant differences) test showed that S1SUD treatment was significantly different ($p<0.05$) to the other treatment. The total population of cellulolytic bacteria is strongly influenced by materials containing cellulose and environmental conditions. The availability of cellulose greatly influences the production of

cellulose enzymes. This shows that cellulolytic bacteria are able to utilize it as an energy source, especially as a carbon source. In general, total population of cellulolytic bacteria were 40 to 50% of total bacterial population in soil. The highest population of cellulolytic bacteria has been observed at 4 WAP (week after planting) before they were declining for the next following weeks. At 12 WAP (weeks after planting) the highest cellulolytic bacteria population was detected under S1SUD treatments to about 1.67 x 106 cfu/ g of soil, which was significantly different to other treatment, except with S1 ; S1S and S1SU (Table 4). Moreover, under the addition of *Thricoderma sp*, total population of cellulolytic bacteria were much lower (Figure 3).

Table 4. Cellulolytic Bacteria Population (cfu / g of soil)

No.	Code	2 WAP	4 WAP	8 WAP	12 WAP
1	S1	1.29 × 10^6 a	3.30 × 10^6 ab	2.32 × 10^6 a	1.36 × 10^6 bc
2	S1S	1.92 × 10^6 de	3.60 × 10^6 b	2.69 × 10^6 cd	1.44 × 10^6 c
3	S1SU	1.43 × 10^6 ab	3.50 × 10^6 ab	2.65 × 10^6 c	1.35 × 10^6 bc
4	S1SUD	2.20 × 10^6 e	3.97 × 10^6 b	2.96 × 10^6 d	1.67 × 10^6 c
5	S1SUP	1.64 × 10^6 bcd	3.45 × 10^6 ab	2.66 × 10^6 c	1.26 × 10^6 a
6	S1T	0.93 × 10^6 a	3.17 × 10^6 a	2.35 × 10^6 ab	0.96 × 10^6 a
7	S1TU	1.39 × 10^6 ab	3.47 × 10^6 ab	2.53 × 10^6 abc	1.29 × 10^6 ab
8	S1TUD	1.57 × 10^6 abc	3.32 × 10^6 ab	2.61 × 10^6 bc	1.15 × 10^6 a
9	S1TUP	1.89 × 10^6 cde	3.52 × 10^6 b	2.79 × 10^6 cd	1.25 × 10^6 a

Note: The same letter in each column shows that there is no significant difference in the LSD test of 5%. S_1: Molasses + sugarcane litter, S_1S: Molasses + sugarane litter + Cellulolytic bacteria, S_1SU: Molasses + sugarcane litter + Cellulolytic bacteria + Urea, S_1SUD: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Dolomite, S_1SUP: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Cow manure, S_1T: Molasses + sugarcane litter + *Trichoderma* sp., S_1TU: Molasses + sugarcane litter + *Trichoderma* sp. + Urea, S1TUD: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Dolomite, S1TUP: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Cow Manure.

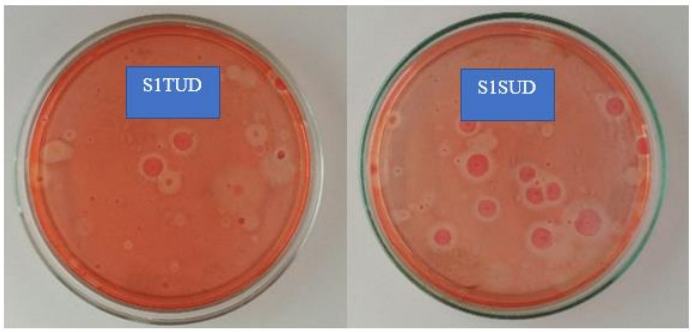

Figure 3 Cellulolytic Bacteria Population (cfu / g of soil) : comparing S1TUD (with *Trichoderma sp* and S1SUD (no *Trichoderma sp*)

For comparison, several studies have been reported the impact of different type of sugarcane litter (burning vs non burning sugarcane trash management) to total soil bacterial communities and the nitrifying and denitrifying gene diversity (Souza *et al.*, 2012). However those activities involving fire which then also include other factors such soil mechanization for soil cultivation and harvesting that affected the results. The biological properties it self were much more sensitive compare to the changes on soil chemical or physical properties (Rashid *et al.*, 2016)

Addition of urea can influence the rapid sugarcane litter decomposition and total soil N. The consequences of sugarcane litter decomposition is releasing nutrient to soil following mineralization processes. The graph of the effect of soil N availability to soil cellulolytic bacterial populations was illustrated in Figure 2. Based on the results of the correlation test, soil N has a positive relationship with the population of bacteria in the soil (r = 0.46*) following linear equation of y = 4.3089x – 0.0707 (Figure 2), whereas x is the soil N (%) and y is the population of soil cellulolytic bacteria (R^2 = 0.21*). The increasing on soil N will be followed by the raising of soil cellulolytic bacteria population.

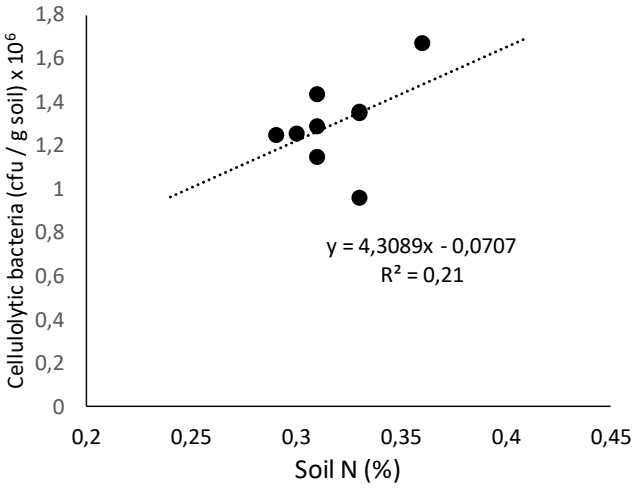

Figure 4. Relationship between soil N and cellulolytic bacteria population

Addition of urea can be a source of nitrogen in the soil. Nitrogen content in the soil can affect the number of cellulolytic bacteria in the soil. It can be seen, that after 12 WAP the total N-content in the soil increased from the initial observation of 0.24% to 0.36% at the end of the observation, on the addition of cellulolytic bacteria, urea and dolomite. Cellulolytic bacteria require nitrogen to produce and elongated cell formation. There

is a relationship that shows that the availability of nitrogen is related to the physiological function of bacteria as cellular resources (Berlemont ***et al.***, 2014). Urea is one source of nitrogen that is quickly available to plants and microorganisms. This is supported by the opinion of Yang et al. (2014) that the addition of Urea is a source of nitrogen, but not very good compared to organic fertilizer, for bacterial growth because of its nature which causes a decrease in pH (acidification). In addition, nitrogen also functions in increasing plant growth. Nitrogen is important in the formation of chlorophyll in plants to increase the absorption of sunlight, so that the process of photosynthesis can run smoothly, the resulting photosynthate will support the growth of sugar cane plants (Cahyani ***et al.,*** 2016).

It can be seen, that, there was almost 50% of total bacterial population in soil were consisted of cellulolytic bacterial. The increasing of total bacterial population was in the line with the raising of cellulolytic bacteria (r=0.52), following linear regression of y = 0.2313x + 0.5447 (Figure 2), whereas x is the total bacterial population (cfu / g soil) and y is the population of soil cellulolytic bacteria (cfu / g soil) (R^2 = 0.27). Those relationship was presented in Figure 3.

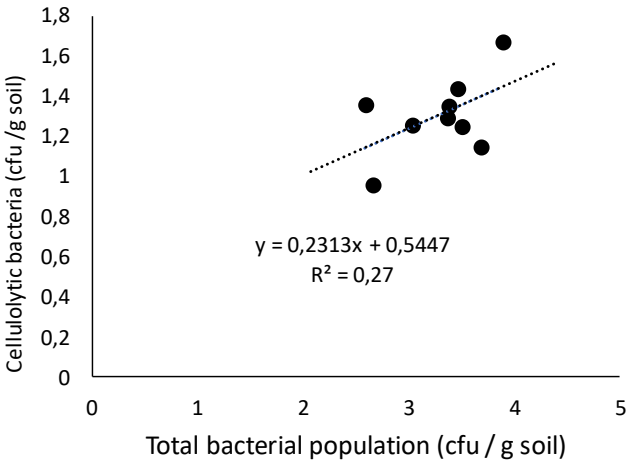

Figure 5. Relationship between total soil bacterial population and cellulolytic bacteria

Sugarcane growth

a. Crop height, stem diameter, no of leaves and no of tillers

Based on the ANOVA, the treatment showed a significant effect ($p<0.05$) to sugarcane height of sugarcane at 2, 4, 8 and 12 WAP (week after planting). At 12 WAP (week after planting), the highest population of cellulolytic bacteria was detected under S1SUP which almost 3 times higher compare to those initial value at 2 WAP (Table 5). This result was significantly different ($p<0.05$) to S1T and S1TUP treatments.

Table 5. Sugarcane height (cm)

No.	TCode	2 WAP	4 WAP	8 WAP	12 WAP
1	S1	52.0 d	67.2 d	78.6 ab	97.3 bc
2	S1S	48.5 cd	64.5 cd	79.0 ab	98.2 bc
3	S1SU	45.3 bcd	59.7 abc	78.7 ab	96.7 bc
4	S1SUD	42.0 abc	56.2 a	75.2 ab	101.1 bc
5	S1SUP	43.8 abcd	62.7 bcd	82.3 b	105.7 c
6	S1T	46.5 bcd	57.8 ab	73.1 ab	92.5 ab
7	S1TU	46.0 bcd	62.7 bcd	80.5 ab	97.8 bc
8	S1TUD	39.2 ab	60.5 abc	77.7 ab	96.2 bc
9	S1TUP	35.0 a	56.5 a	69.3 a	84.2 a

Note: The same letter in each column shows that there is no significant difference in the LSD test of 5%. S_1: Molasses + sugarcane litter, S_1S: Molasses + sugarane litter + Cellulolytic bacteria, S_1SU: Molasses + sugarcane litter + Cellulolytic bacteria + Urea, S_1SUD: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Dolomite, S_1SUP: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Cow manure, S_1T: Molasses + sugarcane litter + *Trichoderma* sp., S_1TU: Molasses + sugarcane litter + *Trichoderma* sp. + Urea, S1TUD: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Dolomite, S1TUP: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Cow Manure.

Decomposition of organic matter by cellulolytic bacteria helps quickly decompose organic matter so that it becomes available to plants. With the decomposition of organic matter, plant nutrients can be met and support the growth of sugarcane plant height. Litter which was returned to agricultural land can increase soil fertility due to nutrient content Iqbal (2018), who informed that sugar cane litter in the Karanganyar-Solo contains 1.7% nitrogen, 1.7% phosphate, 1.91% potassium and 0.3% calcium, increased soil carbon content by 5% and nitrogen up to 21%. On the other hand, cow manure can also be given as additional organic material. The addition of cow manure at the level of 10 ton ha^{-1} along with inorganic fertilizer 120 kg ha^{-1} N, 60 kg ha^{-1} P_2O_5 and 90 kg ha^{-1} K_2O produced the best sugarcane growth followed by the highest sugarcane productivity (Gana, 2008).

Sugarcane biomass

There was a significant effect of the treatments ($p<0.01$) to the total dry weight of sugarcane biomass. S1SUP treatment has been significantly different to all other treatments ($p<0.05$) on biomass accumulation which can be divided into root, stem and leaves. Table 6 showed that S1SUP treatment has the highest total dry weight of sugarcane biomass to about 1.129 grams which was increasing 5 times greater compare to those initial value at 2 MST (week after planting). S1SU treatment had the lowest total dry weight of sugarcane biomass, accumulated only of 632 g at 12 weeks after planting.

Table 6 Sugarcane Dry Biomass Weight (g) at 12 weeks after planting at the population of 80.000 tiller ha^{-1}

No.	Code	Root (g plant^{-1})	Stem (g plant^{-1})	Leaf (g plant^{-1})	Total (g plant^{-1})	Yield (ton ha^{-1})
1	S1	157 d	602 g	154 a	913 d	73,04 d
2	S1S	196 e	462 c	323 f	982 e	78,56 e
3	S1SU	74 a	332 a	226 b	632 a	50,56 a
4	S1SUD	133 c	487 cd	214 b	833 c	66,64 c
5	S1SUP	230 f	636 h	263 cd	1.129 g	90,32 g
6	S1T	154 d	368 b	253 c	775 b	62,00 b
7	S1TU	99 b	512 de	304 e	914 d	73,12 d
8	S1TUD	240 f	569 fg	247 c	1.056 f	84,48 f
9	S1TUP	209 g	342 bc	278 d	879 c	70,32 c

Note: The same letter in each column shows that there is no significant difference in the LSD test of 5%. S_1: Molasses + sugarcane litter, S_1S: Molasses + sugarane litter + Cellulolytic bacteria, S_1SU: Molasses + sugarcane litter + Cellulolytic bacteria + Urea, S_1SUD: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Dolomite, S_1SUP: Molasses + sugarcane litter + Cellulolytic bacteria + Urea + Cow manure, S_1T: Molasses + sugarcane litter + *Trichoderma* sp., S_1TU: Molasses + sugarcane litter + *Trichoderma* sp. + Urea, S1TUD: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Dolomite, S1TUP: Molasses + sugarcane litter + *Trichoderma* sp. + Urea + Cow Manure.

The use of organic fertilizer on agricultural land in addition to aiming at maintaining soil fertility, at the same time organic fertilizer is also able to increase crop productivity in a sustainable manner and reduce the rate of soil degradation (Roidah, 2013 ; Arfarita *et al.*, 2019 ; Prayogo & Ihsan, 2018). According to Kresnatita *et al.* (2013), the use of cow manure must be accompanied with other soil amendment to optimize those effects. According to Kresnatita *et al.* (2013), the use of slow release cow manure cannot be put to good use by short-lived plants. Thus the use of organic fertilizer on sugarcane can be used properly.The weight of plant biomass shows the results of photosynthesis that can be stored by plants. The results of plant photosynthesis are used in the formation of sugarcane biomass in the form of tillers and crown canopy development (Mutaqqin *et al.*, 2016). The higher the plant biomass, the higher the productivity value of sugarcane. The high weight of sugarcane biomass that is supported by plant growth such as height, diameter circumference, number of leaves and root development can support high productivity and yield value (Erlina, 2017).

Sugar cane production in this study were within ranges of 50-56 ton ha-1 to 90.32 ton ha-1 which were comparable to those of sugarcane production in India, with an average yield at 93 to ha^{-1} in demo field and 88.3 ton ha-1 in control plot (Dhanushkodi *et al.*, 2019). On the other in Tiruchirapalli district of Tamil Nadu the average production could reached 100 ton ha^{-1}.

Though the principal components analysis is important to determine the relationship between parameter and understanding their magnitude and direction, PCA Biplot was adopted (Figure 6). It was verified that the first principal component analysis axis (PC1) responded to 81,75% of the total observed parameter (total soil bacteria, cellulolytic bacteria, soil pH, C-org total N, C/N ratio, stem biomass, root biomass, leaves biomass, total biomass, cane height and yields), while the second principal components analysis axis (PC2) was compounded by 14,12% of the total variance, the joint of both PCA1 and PCA2 resulted in 100% of the total variance. PC1 was accounted mostly for the above parameters

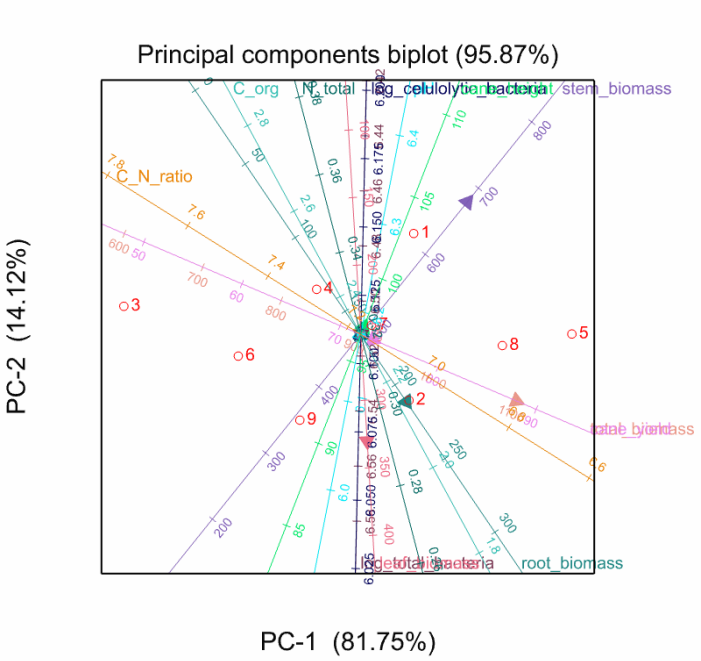

Figure 6. Principle Component Biplot of selected parameter (total soil bacteria, cellulolytic bacteria, soil pH, C-org total N, C/N ratio, stem biomass, root biomass, leaves biomass, total biomass, cane height and) influenced sugarcane production

Total cellulolytic bacteria had similar direction and magnitude with C-org, total N and cane height (upper position). The soil bacteria and root biomass were in the other direction and magnitude (bottom position) (Figure 6).

IV.CONCLUSION

The addition of combination treatment of sugarcane litter, urea and dolomite (S1SUD) provide the best condition for soil microbe to grow, giving the total population of soil bacteria and cellulolytic bekteri population to reach 6.09 × 10^6 cfu g^{-1} and 3.45 × 10^6 cfu g^{-1} at 4 WAP (week after planting). Bacterial growth is strongly influenced by the availability of organic

matter, pH and nitrogen content in the soil. An increase in bacterial population occurs at the beginning of the incubation period and decreases with the decrease in the amount of organic matter. However, the greater total bacteria and cellulolytic bacteria did not guarantee it will produce the best sugarcane cane yields under with or without the addition *of Trichoderma sp*. Under the addition of sugarcane litter, urea and cow manure (S1SUP) provided the best sugarcane growth and yield at about (90.32 ton ha^{-1}), as cow manure is more able to provide and fulfilled nutrients requirement for sugarcane, followed by (S1TUD) whereas cow manure did not exist, yielded at 84.48 ton ha^{-1}. The existing of *Thicoderma sp* may compete with the addition of cellulolytic bacteria since both sharing a similar energy source for grow need to be evaluated and monitored for future research activities.

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