The use of organic plus materials on the growth of sugarcane "Bulu Lawang" variety

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Abstract. Sugarcane is one of the biggest sugar-producing commodities in Indonesia and has been established by the government in a national sugar self-sufficiency program. Increasing sugar productivity is one of the keys to achieving sugar self-sufficiency. The use of organic material mixed with \textit{Trichoderma} sp. believed to be able to increase the productivity of sugarcane, especially those planted in the marginal fields with low fertility. The aim of this study was to evaluate the growth response of Bulu Lawang (BL) sugarcane variety to the application of organic plus material. The design of the experiment used a split plot design. The main plot was inorganic fertilizer with 4 levels while organic matter was added as a subplot with 3 levels. Based on the results of the study, there was no interaction between the main plot and the experimental subplot. Independently, the application of inorganic fertilizer 100% of the recommendations triggers a better sugarcane stem length. The application of organic rice straw plus endophytic and non-endophytic \textit{T. asperellum} encourages better leaf number, stem height, segment length and sugarcane stem diameter

1. Introduction

Sugarcane (\textit{Saccharum officinarum} L.) is used as the main raw material in making sugar [1, 2]. The increasing sugar demand cannot yet be matched by domestic sugar production. Domestic sugar production only reached 2.5 million tons in 2013 and always declined to reach 2.1 million tons in 2017 [3]. As a result, sugar imports are carried out to meet domestic sugar needs. According to Adhiem [4] import quotas were set at 111,000 tons of raw sugar, 3.6 million tons of refined sugar and 1.1 million tons of white crystal sugar.

The Ministry of Agriculture has tried to carry out a program of intensification, revitalization and expansion of sugarcane plantations including the construction of new sugarcane mills. Southeast Sulawesi has become one of the new locus of sugarcane factory development in Indonesia. According to [5] that efforts to increase sustainable sugar production can be pursued using multidisciplinary strategies including physiology, breeding, biotechnology and agronomy. Based on this description, the
handling of sugarcane cultivation is important to be done, including the management of the main pest or disease which can always threaten sugar productivity. The low sugar productivity is caused by low inorganic fertilizer inputs or land with low fertility. Additional inorganic and organic materials are needed [6]. The availability of balanced nutrients is needed so that it can be absorbed by plants, this is a factor that determines plant growth and production [7]. The high content of organic matter can maintain the physical quality of the soil to assist the development of plant roots and the smooth movement of soil water through soil pore formation and soil aggregate stability [8].

Making organic fertilizer from rice straw requires decomposers to accelerate the composting process. Decomposers that can be used are fungi *Trichoderma* sp. [9]. *Trichoderma* sp. besides being a decomposing organism, it can also function as a biological agent. *Trichoderma* sp. as an antagonistic agent has specific antagonistic mechanisms such as space competition, toxins or parasitic [10, 11]. The ability of parasitic pathogens to complement other functions as a decomposer. The purpose of this study was to evaluate the results of the application of organic plus materials on the growth of Bulu Lawang varieties in sugarcane fields.

2. Research method

2.1. Research location and time
The study was conducted at the Laboratory of Agrotechnology Education Unit, Faculty of Agriculture, University of Halu Oleo and Jhonlin Batu Mandiri gardens in Watu-Watu Village, Bombana Regency.

2.2. Rejuvenation and propagation of *Trichoderma* sp.
*Trichoderma asperellum* sp. isolate A [12] was re-grown using potato dextrose agar (PDA) with the following composition: 200g potatoes, 15g agar powder and 20g dextrose. Furthermore, *T. asperellum* was suspended with $1 \times 10^8$ CFU spore density to be propagated on rice media. Isolate B uses *T. asperellum*, which has been formulated by Mr. Ade Rosmana from Universitas Hasanuddin, in the form of powder ready for use.

2.3. Making organic plus fertilizer
Rice straw was chopped using a chopper machine then mixed with cow manure and *T. asperellum* (non endophytic) with a ratio of 1ton straw + 150 kg manure and 5 kg of rice media containing *T. asperellum*. As much as 5 kg of bran was added to the mixture of straw and manure. The mixture was stirred and fermented for 4 weeks.

2.4. Land processing and application of organic fertilizer.
Land management was carried out 3 times, then made planting holes or making "juringan" with a distance between 1.5 m with a depth of 30 cm. Application of organic plus fertilizer (rice straw compost plus *T. asperellum*) was done by sprinkling 35 kg of organic plus matter per plot or equivalent to 3,500 kg per ha, then covered with a layer of soil. Planting was done by means of sugarcane seeds/mules placed on each “juringan” using end to end planting methods and buds facing to the side, then sugarcane mule covered with a layer of soil using a hoe.

2.5. Application of inorganic fertilizers
Application of NPK inorganic fertilizer 15:15:15 was done by sprinkling on each row according to the experimental plots and covered with a layer of soil. The dosage of fertilizer used was 250 kg per ha given 2 times, before planting and 2 months after planting.

2.6. Research design
The research design used was a Randomized Block Design (RCBD) in the Split Plot Design (SPD) pattern. The main plot was the application of inorganic fertilizers consisting of 4 levels, which were:
no fertilizer (P0); 50% fertilization as recommended or equal to 1.25 kg per plot (P1); 75% as recommended or equal to 1.9 kg per plot (P2); and fertilizing 100% as recommended or equivalent to 2.5 kg per plot (P3). Plots were applied with organic material with 3 levels, which were: without organic matter (V0); *T. asperllum* isolate A (non-endophytic rhizosphere) + straw or equivalent to 35 kg per plot (V1); and *Trichoderma* sp. isolate B (*T. asperellum* endophytic) + Straw or equivalent to 35 kg per plot (V2), which was repeated as many as 3 treatments to obtain 12-unit experiments with 3 replications, so that the total experimental plot was 36 units. Plots measuring 10 x 10 m square in each plot were made as many as 1 x 1m square sub plots of three diagonally. Observations and data collection were carried out in the sub-plot.

2.7. Observation variables
Observation started when the plant was 2 months after planting (MAP). The variables observed were number of leaves (strands), stem height (cm), length of internodes (cm), and stem diameter (cm). The data obtained were analyzed using analysis of variance (F test). If the treatment has a significant effect, then proceed with the Honestly Significance Difference (HSD) test at a 95% confidence level.

3. Results and discussion
The results of the analysis showed that there was no interaction between the main plot and the sub-plot tested, therefore the data displayed was the test results independently of the main plot and sub-plot.

3.1. Number of leaves
There was no statistical difference in the number of leaves of sugarcane, but the average 100% inorganic fertilizing according to recommendations treatment (P3) gave the response of the highest number of leaves at each observation time, at the age of 2 months after planting up to 5 months after planting (Table 1).

| Fertilizer                          | Average Number of Leaves (strands) |
|------------------------------------|-----------------------------------|
| Without inorganic fertilizer (P0)  | 6.11 13.23 17.71 21.73            |
| Inorganic 50% as recommended (P1)  | 6.41 13.46 17.80 21.93            |
| Inorganic 75% as recommended (P2)  | 6.59 13.61 18.31 22.04            |
| Inorganic 100% as recommended (P3) | 7.11 14.26 18.70 22.70            |

Note: MAP = Month after planting.

Whereas on the independent effect of organic matter plus, especially at the age of 5 months after planting, treatment V2 namely straw + *T. asperellum* endophytes responded to the highest number of leaves which was 22.86 strands (Table 2).

| Organic Materials                    | Average Number of Leaves (strands) |
|--------------------------------------|-----------------------------------|
| Without organic materials (V0)       | 6.19c 12.33c 16.54b 20.85b         |
| Organic rice straw + *T. asperellum* non-endophytic (V1) | 6.25b 13.31b 18.69a 22.59a |
| Organic rice straw + *T. asperellum* endophytic (V2)    | 7.22a 15.28a 19.16a 22.86a |
| HSD<sub>0.05</sub>                    | 0.31 0.64 0.73 0.59               |

Note: MAP = months after planting, and the numbers followed by letters show differences based on the HSD test at a 95% confidence level.

3.2. Stem height
The statistical difference was only seen at the age of 3 months after planting with the best height of sugarcane stem which was in the treatment of 100% fertilization (P3) 75.17cm which was significantly
different from the control (P0) 68.24cm (Table 3). The same response was shown in plants with age of 5 months after planting, the P3 treatment produced a plant height of 182.40cm compared to the control (P0) which produced a plant height of 145.18cm even though it had no statistically significant effect.

**Table 3. Effect of fertilizer on the height of sugarcane stems**

| Fertilizer                                      | Average height of sugarcane (cm) |
|-------------------------------------------------|----------------------------------|
|                                                 | 2 MAP   | 3 MAP   | 4 MAP   | 5 MAP   |
| Without inorganic fertilizer (P0)               | 15.33   | 68.24b  | 107.83  | 145.18  |
| Inorganic 50% as recommended (P1)               | 16.88   | 69.36b  | 114.16  | 150.04  |
| Inorganic 75% as recommended (P2)               | 18.29   | 69.57b  | 114.46  | 150.60  |
| Inorganic 100% as recommended (P3)              | 20.16   | 75.17a  | 121.88  | 162.40  |

**HSD**<sub>0.05</sub> 3.04

Note: MAP = months after planting, and the numbers followed by letters show differences based on the HSD test at a 95% confidence level.

The application of organic plus material has a significant influence on the height of sugarcane stems at all observations. Observation at the age of 5 days after planting, treatment V2 gave the highest stem height response of 167.29cm which was significantly different from the control (V0) 14.16cm (Table 4).

**Table 4. Independent effects of organic plus material on the height of the sugarcane stem**

| Organic Materials                                      | Average stem height (cm) |
|--------------------------------------------------------|--------------------------|
|                                                        | 2 MAP   | 3 MAP   | 4 MAP   | 5 MAP   |
| Without organic materials (V0)                         | 14.00b  | 64.84b  | 104.27c | 144.16b |
| Organic rice straw + *T. asperellum* non-endophytic (V1)| 19.88a  | 73.87a  | 125.97a | 167.29a |
| Organic rice straw + *T. asperellum* endophytic (V2)   | 19.10a  | 73.05a  | 113.51b | 144.72b |

**HSD**<sub>0.05</sub> 2.00 3.81 8.23 7.80

Note: MAP = months after planting, and the numbers followed by letters show differences based on the HSD test at a 95% confidence level.

### 3.3. Length of stem segment

The effect of sugarcane stem segment length was seen in the treatment of inorganic fertilizer P3 (10.66 cm) which was significantly different from all treatments P2, P1 and P0 (control), especially at the age of 5 months after planting (Table 5).

**Table 5. Effect of independent fertilizer application on the length of the sugarcane stem segment**

| Fertilizer                                      | Average length of stem segments (cm) |
|-------------------------------------------------|-------------------------------------|
|                                                 | 3 MAP   | 4 MAP   | 5 MAP   |
| Without inorganic fertilizer (P0)               | 7.77c   | 8.13c   | 8.84d   |
| Inorganic 50% as recommended (P1)               | 8.06b   | 8.85b   | 9.51c   |
| Inorganic 75% as recommended (P2)               | 8.59ab  | 9.22ab  | 9.84b   |
| Inorganic 100% as recommended (P3)              | 9.35a   | 9.74a   | 10.66a  |

**HSD**<sub>0.05</sub> 0.73 0.57 0.45

Note: MAP = months after planting, and the numbers followed by letters show differences based on the HSD test at a 95% confidence level.

The application of organic plus materials V1 which gave the longest stem segment (25.27cm) and significantly different from V2 (9.53cm) and control (9.34cm) at the age of 5 months after planting (Table 6).
Table 6. Independent effects of organic plus materials on stem segment length

| Organic Materials                                      | Average length of stem segments (cm) |
|--------------------------------------------------------|--------------------------------------|
|                                                        | 3 MAP | 4 MAP | 5 MAP |
| Without organic matter (V0)                           | 7.97  | 8.44  | 9.34  |
| Organic rice straw + \textit{T. asperellum} non endophytic (V1) | 8.93  | 9.87  | 10.27 |
| Organic rice straw + \textit{T. asperellum} endophytic (V2) | 8.43  | 8.64  | 9.53  |

Note: MAP = months after planting, and the numbers followed by letters show differences based on the HSD test at a 95% confidence level, ns = not significant.

3.4. Stem diameter

There was no significant effect on the observations of sugarcane diameter for all observations, but the average fertilization rate of 100% (P3) was better than other treatments including controls (Table 7).

Table 7. Effect of independent fertilization on sugarcane diameter

| Fertilizer                                                   | Average stem diameter (cm) |
|-------------------------------------------------------------|----------------------------|
|                                                             | 3 MAP | 4 MAP | 5 MAP |
| Without inorganic fertilizer (P0)                          | 2.41  | 2.45  | 2.54  |
| Inorganic 50% as recommended (P1)                          | 2.45  | 2.47  | 2.63  |
| Inorganic 75% as recommended (P2)                          | 2.47  | 2.52  | 2.63  |
| Inorganic 100% as recommended (P3)                         | 2.55  | 2.58  | 2.68  |

Note: MAP = months after planting.

Whereas organic plus material gave significantly different effect on sugarcane diameter at 3 MAP, 4 MAP and 5 MAP. The V1 treatment was able to encourage the increase in the diameter of sugarcane stems of 2.70cm which was significantly different from V2 and the control of 2.62 and 2.53cm (Table 8).

Table 8. Independent effects of organic plus materials on sugarcane diameter

| Organic Materials                                      | Average stem diameter (cm) |
|--------------------------------------------------------|----------------------------|
|                                                        | 3 MAP | 4 MAP | 5 MAP |
| Without organic matter (V0)                           | 2.30  | 2.32  | 2.53  |
| Organic rice straw + \textit{T. asperellum} non endophytic (V1) | 2.59  | 2.62  | 2.70  |
| Organic rice straw + \textit{T. asperellum} endophytic (V2) | 2.52  | 2.55  | 2.62  |

Note: MAP = months after planting, and the numbers followed by letters show differences based on the HSD test at a 95% confidence level.

4. Discussion

There was no interaction between inorganic fertilizer and organic fertilizer of rice straw and \textit{T. asperellum} endophytic and non-endophytic. Independently, organic fertilizer plus is able to trigger vegetative growth which is observed at every observation, 3, 4, and 5 months after planting. The use of organic material as soil amendment is an important key to increase the productivity of sugarcane, including establishing an environmentally friendly and sustainable sugarcane plantation. Some of the results of previous studies have reported that the addition of organic matter can soften the soil, increase water retention, increase the activity of beneficial microorganisms and fertilize the soil. It was
also reported that sugarcane plants like loose soil, crumb structure, and well drained [13] The results of this study prove that the addition of organic material from rice straw plus *T. asperellum* which is propagated to rice media at a dose of 35 kg per 10m² square or equivalent to 35 kg/ha can increase the growth of sugarcane in the experimental plot. This dosage differs from the recommendation of organic material by some previous research which is equal to 5-tons per hectare. The difference may be due to the organic material used.

The results of the research of sugarcane which were given organic plus material produced a higher stem height, length of stem segment and sugarcane diameter compared to control. It was reported that the addition of organic-biochar material into various types of soil provides various types of soil benefits such as increasing water content in clay pores, and in macropores and silica soil storage pits. In general, it significantly increases the capacity of available water [14].

The better growth of sugar cane on all observed variables might be due to the performance of organic plus material which is able to accelerate the decomposition process and have a positive effect on the antagonistic microbial colonization in the soil. The addition of *T. Asperellum* is thought to be able to reduce the C/N ratio so that it is easily absorbed by plant roots. Based on the notes that organic material that can be absorbed by plants including sugarcane with a C/N ratio close to 12-15% with temperatures almost the same as the ambient temperature. The fungus mixture significantly reduced the C/N ratio (16.3%) and reduced the mass of the material (38.0%), organic carbon content (17.5%) and increased the nitrogen content (1.07%) of organic material using sugarcane waste. [15] explained that *Trichoderma harzianum* and *T. viride* significantly increased sugarcane germination (6-14%), number of tillers (21-78%), number of sugarcane stems per unit area (5-30%), yields (6-38%) and yield or Commercial Cane Sugar (CCS) ton/ha (30-34%). In summary, productivity increases more economically, non-toxic, and good for soil health.

The interesting thing from this research is the significant diameter of sugarcane stem which was given organic material plus non-endophytic fungi, when sugarcane was 5 months after planting reaching 2.70cm, although the land used is marginal land (ultisol) with low fertility. The diameter of the stem is different from what has been reported by [16s] using the same method (single juring) with Alfisol soil type in Pati, Central Java, which is quite fertile compared to the land used in this study. It was reported that the diameter of sugarcane stems only reached 2.74cm after the age of 10 months after planting. This difference proves that although the land used is marginal land but if given organic plus material can increase the diameter of the stem. However, differences may be due to different sugarcane clones. Therefore, it can be reported that the use of organic matter enriched with *T. asperellum* both endophytic and non-endophytic has a significant effect on sugarcane growth in marginal land, at least until the age of 5 months after planting.

5. Conclusions

There is no interaction between the main factors of fertilization and biological agent subplots. Independently, the application of inorganic fertilizer 100% of the recommendations triggers a better sugarcane stem length. The application of organic rice straw plus endophytic and non-endophytic *T. asperellum* encourages better leaf count, stem height, segment length and sugarcane stem diameter.

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