Journal of Smart Science and Technology
PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA
2023 March Volume 3 Issue 1
eISSN: 2785-924X

Effects of *Cellulolytic* Fungi and Biofertilizer Doses on the Growth and Yield of Tomato (*Solanum lycopersicum* L.) in Alluvial Soil

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Received: 29-09-2022
Revised: 02-12-2022
Accepted: 13-12-2022
Published: 30-03-2023

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DOI: https://doi.org/10.24191/jsst.v3i1.36

Abstract

The production and harvest areas of tomatoes in West Kalimantan tend to decrease. One of the cultivation techniques that is expected to increase the yield and quality of the plant is by using organic fertilizers. The study objective was to determine the effects of interactions between cellulolytic fungi and biofertilizer doses on the growth and yield of tomato (Solanum lycopersicum L.) in alluvial soils. A completely randomized design (CRD) with factorial patterns was applied in the research. The first factor which was cellulolytic fungi in biofertilizers (J) included: J0 (organic fertilizer without decomposer), J1 (organic fertilizer with Aspergillus sp.), J2 (organic fertilizer with Trichoderma spp.), and J3 (organic fertilizer with Aspergillus sp. and Trichoderma spp.). The second factor that was of biofertilizer doses (D) consisted of: D1 (25 g/polybag), D2 (50 g/polybag), D3 (75 g/polybag), and D4 (100 g/polybag). The results showed no significant difference between the cellulolytic fungi and biofertilizer doses on all observation variables (p>0.05). There was no significant main effect of cellulolytic fungus type on all observation variables, while the treatment of biofertilizer doses had a significant effect on plant height, total leaf number per plant, fruit number per plant, and fruit weight per plant. The J3D4 treatment gave the best results on the plant height (97.67 cm) and the leaf number (18.17 strands), while the J2D4 treatment gave the best results on the fruit number per plant (3.31 fruits), and the fruit weight per plant (13.32 g). The addition of cellulolytic fungi to biofertilizers at a dose of 100g/polybag can increase growth and yield on tomatoes in alluvial soil.

Keywords
Aspergillus sp.; Trichoderma sp.; Cellulolytic fungi; Biofertilizer; Solanum lycopersicum L.

Citation: Suyanto, A., Irianti, A. T. P., & Setiawan. (2023). Effects of c*ellulolytic* fungi and biofertilizer doses on the growth and yield of tomato (*Solanum lycopersicum* L.) in alluvial soil. *Journal of Smart Science and Technology*, *3*(1), 37-43.

1 Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most sought-after horticultural commodities, and it is needed in various places in Indonesia as tomato is consumed as vegetable and fruit. However, both production and harvest areas of the plant in West Kalimantan tend to decrease. The tomato yields of the province from 2016 to

2018 were 3,766 tons of 426 ha, 1,805 tons of 369 ha, and 1,128 tons of 374 ha[1]. The decline was led by the increasing pest pressure and intensified chemical treatments. It was also due to the reduced soil fertility especially its organic matter and phosphorus which are the major constraints that limit crop production. The high pressure on agricultural land also reduced the availability of soil nutrients and caused a significant reduction in soil fertility and crop yields[2,3].

To increase tomato productivity, there are many things which can be performed from improving cultivation techniques to postharvest treatment. To improve the cultivation techniques, one of the most important things to focus on is the availability of sufficient nutrients, as nutrition for the plant growth and development will then affect the quality and quantity of yielded tomatoes. One of the cultivation techniques that is expected to increase the yield and quality of the plant is by using organic fertilizers. The use of biofertilizers along with inorganic fertilizers could be the right answer since biofertilizers were eco-friendly and more economic, and it played an important role in reducing the dependence on chemical fertilizers[4]. Rice straw is one of the materials which can be used as organic fertilizer.

Rice straw is a crop waste that is generated in vast amount during harvest time. Rice straw was a part of a rice plant that includes stems, leaves, and tillers[5]. Composting rice straws would provide a method to avoid air pollution that comes from residual burning while also preventing the loss of nutrients in organic materials. The waste is a local material that can potentially be turned into organic fertilizer. Rice straws were abundantly available during harvest, yet they have not been fully utilized[6]. Recycling plant waste by composting is important for maintaining soil fertility in tropical regions. Global production of rice straws is estimated to be around 650-975 million tonnes annually. There is about 1-1.5 kg of rice straws from each kilogram of shifted rice produced. Various studies found that rice straws contain nutrients: N, P, K, and C-organic, which are needed by soil and plants. Rice straw contains around 0.6% N, 1.5% K, 5% Si, 40% C, and 0.10% of each P and S. The utilization of crop waste as compost would not only provide plants with important nutrients but also increase soil fertility, and it can be a method to protect the environment through waste management[5].

Rice straws are a potential source of soil organic matter (SOM). However, the high C/N ratio contained is the main obstacle if it is directly applied to soil as SOM. In addition to reducing the volume of material to facilitate application, composting rice straw is required to avoid negative effects on plants. Composting process was regulated by the fundamental environmental factors such as temperature, moisture content, pH, aeration and some characteristics such as C/N ratio, particle size and nutrients of organic wastes[7]. The higher the C/N ratio, the longer the rate of decomposition, and vice versa. The availability of decomposers is one of factors which also determines the composting rate, so it is necessary to find effective decomposers to reduce the C/N ratio of crop waste to be used as compost.

Decomposer is a biological activator used to accelerate composting process and to improve compost quality. The number and type of microorganisms also determine the success of the composting process[8]. In ecosystems, decomposing microorganisms play a critical role because the remains of dead organisms will be broken down into elements in the form of nutrients: N, P, K, Ca, and Mg to be returned to soil and/or in the form of gases: CH or CO to be released into the atmosphere. The use of decomposers which are in accordance with organic substrates and soil conditions is an effective alternative used for decomposition acceleration and fertilization supplementation[9]. Organic decomposers consist of a group of fungi and bacteria. Cellulolytic fungi as organic decomposer generally have a better ability than bacteria in decomposing plant remains (hemicellulose, cellulose, and lignin). *Aspergillus* sp. and *Trichoderma* spp. are fungi that can be used as biofertilizers because they are able to decompose and inhibit the growth of fungal plant pathogens.

In accordance to this, it is important to conduct a study to obtain fungal isolates which have a high ability in degrading organic matter so as to optimize the utilization of rice straws as organic fertilizer which can be biological agents for plant protection. This study aimed to determine the effects of interactions between cellulolytic fungi and biofertilizer doses on the growth and yield of tomato (*Solanum lycopersicum* L.) in alluvial soils.

2 Materials and Method

The research was conducted at the Green House of Faculty of Agriculture, Panca Bhakti University, Pontianak, for a duration of four months, from May 2020 to August 2020. The materials included tomato seeds of Tymoti F1 variety, *Trichoderma spp.*, *Aspergillus sp.*, alluvial soils, polybags, biofertilizers, rice straw compost and inorganic fertilizers (urea, SP-36, and KCL), and dolomite lime (CaMg (CO3)2). The tools used consisted of hoes, machetes, shovels, ordinary scales, analytical scales, thermometers, hygrometers, meters, soil sieves, cameras, stationery, and other supporting tools.

A completely randomized design (CRD) with factorial patterns was applied in the research. The first factor that includes decomposer types in organic fertilizers (J) consisted of four treatment levels, while the second factor that was organic fertilizer doses (D) consisted of four treatment levels. Each treatment was repeated three times and each repetition involved three plants; therefore, there were 144 plants used altogether. The treatment details were as follows.

a. The first factor: cellulolytic fungi in biofertilizers (J), namely:

   J0: organic fertilizer without decomposer
   J1: organic fertilizer with *Aspergillus* sp.
   J2: organic fertilizer with *Trichoderma* spp.
   J3: organic fertilizer with *Aspergillus* sp. and *Trichoderma* spp.

b. The second factor: biofertilizer doses (D), namely:

   D1: 25 g/polybag
   D2: 50 g/polybag
   D3: 75 g/polybag
   D4: 100 g/polybag

The treatment combinations were: J_0D_1, J_0D_2, J_0D_3, J_0D_4, J_1D_1, J_1D_2, J_1D_3, J_1D_4, J_2D_1, J_2D_2, J_2D_3, J_2D_4, J_3D_1, J_3D_2, J_3D_3, and J_3D_4.

2.1 Research Implementation

2.1.1 Preparation of Compost Materials

This process took a month. Rice straws, manure, bran, and other additives were used for the treatment of compost materials.

2.1.2 Preparation of Planting Media

The planting media used were alluvial soil taken from a depth of ± 20 cm. The soils were washed, dried, and sieved before being placed in a 10 kg polybag.

2.1.3 Seed Preparation and Seeding

Polybags with alluvial soil and rice husk charcoal 2 : 1 were used. Alluvial soils used in the study belong to the classification of the order Inceptisol. The physical properties of alluvial soils are steep and shapeless, with slow permeability. The chemical properties of alluvial soils are low organic matter content and low soil pH. Before seeding, rice seeds were selected and immersed in water for 15 minutes; the floating seeds were discarded and the sunk seeds were used and seeded.

2.1.4 Liming

Liming was done three weeks before planting, and it aimed to increase the soil pH to 6.0 using dolomite lime at a dose of 9.6 grams/polybag.

2.1.5 Fertilization

a. The fertilizers used in this research consisted of biofertilizers, rice straw compost, urea, SP-36, and KCL.
b. The biofertilizers were made from rice straw compost that had been treated for one month with decomposers *Trichoderma* spp. and *Aspergillus* sp. Fertilizer was applied seven days before planting. The decomposer

types and biofertilizer doses were acceptable for the treatments.

c. Inorganic fertilizers were administered at the following rates: 0.7 g/polybag urea, 1.25 g/polybag SP-36, and 1 g/polybag KCL. Fertilizer was applied during planting.

2.1.6 Transplanting of Tomato Seedlings into Polybags

The seedlings were transplanted into the polybags after 21-23 days of seeding. Thinning was only carried out when there were unhealthy or dead plants, no later than two weeks after planting.

2.1.7 Staking

To keep the plants upright, bamboo or wooden stakes were installed when the plants were 21 days after planting. The stakes were installed at a distance of 5 cm from the tomato plants with a minimum depth of 10 cm.

2.1.8 Maintenance

a. Watering

It was carried out twice a day, in the morning and the afternoon, taking into account the moisture of the media.

b. Weed control

The weeds surrounding the plants in the polybags were pulled out mechanically.

2.1.9 Harvesting

The tomatoes were harvested after 66 days of being transplanted (DAT) into the polybags. They were harvested after ripening with physiological characteristics: the change of fruit skin from light green to pink or to dark red. Tomatoes were harvested as many as six times in the morning.

2.2 Research Observations

The parameters observed were :

a. Plant height (cm)

It was measured at the end of the research from the base of the trunk to the highest leaf tip.

b. Leaf number per plant (strand)

The number of leaves was calculated for those that had been completely formed at the end of the research.

c. Fruit number per plant (unit)

It was calculated by summing the total fruit produced from each treatment that was carried out six times during harvesting.

d. Fruit weight per plant (gram)

The weight was calculated with scales by calculating the total weight of fruit produced from each treatment that was carried out six times during harvesting.

2.3 Data Analysis

The *F*-test at the 5% level of significance was performed to determine the effects of all treatments. If there was a significant effect on the observed parameters, each treatment would be compared using honestly significant difference (HSD) test at 5%.

3 Results and Discussion

Based on the statistical analysis, the interaction of cellulolytic fungi and biofertilizer doses did not have a significant effect on all observation variables. The treatment of single cellulolytic fungus type also did not show any significant effect on all observation variables, while the treatment of biofertilizer doses had a significant effect on plant height and a highly significant effect on leaf number per plant, fruit number per plant, and fruit weight per plant. The J3D4 treatment gave the best results on the plant height (97.67 ± 3.54 cm) and the leaf number (18.17 ± 1.15 strands), while the J2D4 treatment gave the best results on the fruit number per plant (3.31 ± 0.17 fruits), and the fruit weight per plant (13.32 ± 1.36 g) (Table 1).

The application of bio-fertilizers which were the compost enriched with *Trichoderma* spp. and *Aspergillus* sp. was suspected to be able to maintain the neutrality of soil pH and to contribute to the increase of the total soil C, N, P, and K, and the tomato yields. The incorporation of biofetilizers in soil plays a major role in improving soil fertility, yield attributing characters and final yield. Biofertilizers were certainly known to enhance the nutrient availability for crop plants and to impart better health to plants and soils, thus enhancing crop yields as they are modernized forms of organic fertilizers into which beneficial microorganisms have been incorporated[10]. The best plant growth was through the application of organic fertilizers, which provide an additional source of nutrients and improve the efficiency of mineral fertilizers by making nutrients more available for plant growth[11].

Table 1. Results of the average effects of *Cellulolytic* fungi and biofertilizer doses on growth and yield of tomato (*Solanum lycopersicum L.*) in alluvial soil.

No.	Treatments	Plant height ± SD (cm)	Leaf number/Plant ± SD (strand)	Fruit number/Plant* ± SD (unit)	Fruit weight/Plant* ± SD (gram)
1	J0D1	78.67 ± 4.64	13.83 ± 0.76	2.73 ± 0.19	11.13 ± 0.41
2	J0D2	85.06 ± 3.99	16.39 ± 0.91	3.04 ± 0.15	12.37 ± 0.17
3	J0D3	87.11 ± 16.51	16.11 ± 1.57	3.35 ± 0.53	13.59 ± 1.27
4	J0D4	95.56 ± 11.23	18.56 ± 4.24	3.33 ± 0.24	14.13 ± 1.26
5	J1D1	83.33 ± 5.77	13.00 ± 1.73	1.32 ± 1.41	3.94 ± 5.95
6	J1D2	81.61 ± 7.05	15.11 ± 1.01	2.79 ± 0.32	11.70 ± 1.60
7	J1D3	91.17 ± 14.91	16.50 ± 1.50	3.16 ± 0.38	11.94 ± 1.20
8	J1D4	94.00 ± 12.00	16.06 ± 1.41	3.04 ± 0.25	12.79 ± 1.28
9	J2D1	82.56 ± 16.22	14.44 ± 1.26	2.06 ± 1.35	7.59 ± 6.14
10	J2D2	85.56 ± 4.85	16.22 ± 1.34	2.81 ± 0.29	12.14 ± 0.67
11	J2D3	83.00 ± 4.72	15.22 ± 2.03	2.75 ± 0.49	12.48 ± 0.22
12	J2D4	90.78 ± 18.37	17.83 ± 1.04	3.31 ± 0.17	13.32 ± 1.36
13	J3D1	84.94 ± 7.87	15.56 ± 1.38	2.57 ± 0.58	9.67 ± 2.29
14	J3D2	87.22 ± 3.34	15.00 ± 1.45	3.20 ± 0.22	13.02 ± 1.59
15	J3D3	80.83 ± 9.25	15.56 ± 2.34	3.22 ± 0.18	12.73 ± 0.69
16	J3D4	97.67 ± 3.54	18.17 ± 1.15	2.91 ± 0.05	12.00 ± 0.26

Note: * = Transformation Yield Data, $\sqrt{x} + 0.5$; SD = Standard deviation; n = 48

Symbiotic relationships between fungi and a variety of plants can occur, and this can produce colonies on the outside part of a root system. This condition could increase the uptake of water and nutrients by the plant roots[12]. The result could be linked to the presence of *Trichoderma* spp. and *Aspergillus* sp. in the compost. *Trichoderma* spp. certainly can grow into the soil and exert spatial and nutrient competition. *Trichoderma* spp. had the ability to release bioactive molecules and facilitate the supply of nutrients[13]. Sawadogo et al.[14] tested the effect of compost enriched with *Trichoderma harzianum* on tomato plants and showed that the high content of total N, P and K in biofertilizers could be due to the fungus that has the capacity to colonize the environment in which it was found to promote the mineralization of organic matter.

Aspergillus sp. is known to be able to absorb phosphorus for its own nutritional requirements, and this promotes the availability of the soluble form of phosphorus for easy absorption by plant roots. In the solubilization of phosphorus for nutrient plants, *Aspergillus* sp. was identified as an active biological agent to promote the availability of soluble phosphorus in the soil[15]. *Aspergillus* sp. was also known to produce plant growth promoting substances such as indole-3-acetic acid (IAA) and gibberellic acid (GA) that affect plant growth parameters and nutrient uptake[16].

4 Conclusion

In accordance with the research results, the interaction of cellulolytic fungi and biofertilizer doses did not have a significant effect on all observation variables. The treatment of single cellulolytic fungus type also did not show any significant effect on all observation variables, while the treatment of biofertilizer doses had a significant effect on plant height and a highly significant effect on leaf number per plant, fruit number per plant, and fruit weight per plant. The J3D4 treatment gave the best results on the plant height (97.67 cm) and the leaf number (18.17 strands), while the J2D4 treatment gave the best results on the fruit number per plant (3.31 fruits), and the fruit weight per plant (13.32 g).

Conflict of Interest

The authors reported that there was no conflict of interest in this work.

Acknowledgment

The authors are grateful to the Agriculture Faculty, Universitas Panca Bhakti, Pontianak for the support and assistance.

Funding

This research was funded by the authors themselves.

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Formal analysis: Setiawan
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Validation: Suyanto, A., Irianti, A.T.P., & Setiawan
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Funding acquisition: Irianti, A.T.P.
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