Effect of Trichoderma and tofu waste based organic fertilizer on fruit development of chili (Capsicum annuum L.)

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Submission date: 13-Jul-2022 08:44AM (UTC+0700)
Submission ID: 1869869001
File name: ntja_2020_IOP_Conf._Ser.__Earth_Environ._Sci._486_012116.pdf (439.16K)
Word count: 3552
Character count: 18153

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To cite this article: K Mantja *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **486** 012116

Effect of Trichoderma and tofu waste based organic fertilizer on the fruit development of chili (*Capsicum annuum* L.)

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Abstract. The study aimed to determine the effect of the application of Trichoderma and liquid organic fertilizer from tofu wastes on the growth and production of large chilli plants (*Capsicum annuum* L.). The study was conducted at the Faculty of Agriculture Experimental Farm, Universitas Hasanuddin, Makassar, from April to August 2017. This study used a factorial two-factor randomized block design with three replications. The first factor of Trichoderma dose consisted of four levels (control, 10 g plant^{-1}, 15 g plant^{-1}, and 20 g plant^{-1}). The second factor was the concentration of liquid organic fertilizer consisted of four levels (control, 10 ml L^{-1}, 15 ml L^{-1}, and 20 ml L^{-1}). The results show that the interaction between Trichoderma treatment with a dose of 10 g plant^{-1} and liquid organic fertilizer 15 ml L^{-1} gave a higher number of fruits per plant. Trichoderma treatment with a dose of 20 g plant^{-1} gave the heaviest fruit weight and fruit weight per plant. There is no one concentration of liquid organic fertilizer which gives better growth and production of chili.

1. Introduction

One type of vegetable that is quite important in Indonesia is red chili (*Capsicum annuum* L.) both as a commodity consumed domestically and as an export commodity. The red chili has a fairly high economic value apart from the nutritional value. Indonesian people are among the biggest fans of chili in the world, so that chili is one of the important products in Indonesian food, it can even affect the rate of inflation. With a population of 237.6 million, Indonesia needs 118,800 tons of chili per year [1]. Despite the demand, increased chili production can have an impact on the environment due to the use of chemical fertilizers. The use of artificial chemical fertilizers without being accompanied by the provision of organic material can cause the soil to become barren and decrease productivity and pest disruption [2,3].

Organic fertilizers play an essential role in increasing the chemical, physical, and biological content in the soil as well as being a good source of plant nutrition [4]. The use of organic fertilizer which is more effective and efficient is in the form of liquid fertilizer. Liquid organic fertilizer is more easily absorbed by plants because the elements in it have been decomposed. Plants not only absorb nutrients through the roots but can also through the leaves of the plants. The use of liquid fertilizer is easier to work and its use, in one application liquid organic fertilizer performs three kinds of processes at once, namely fertilizing plants, watering plants and treating plants [5]. In the making of liquid organic fertilizer, there are several organic materials that can be used as alternative nutrients including cow

manure, tofu waste, coconut water and rice washing water. Cow manure is manure derived from cow dung which is good for improving fertility, physical, chemical and biological soil properties, increasing macro and micro nutrients, increasing water holding capacity and increasing cation exchange capacity [6]. Besides cow manure, industrial wastes such as tofu waste from tofu factory can be used. With a protein content of 30.2% (wet) and 34.9% (dry) [7], tofu waste contains enough nutrients needed for plant growth [8]. In addition, rice washing water which is commonly known by the term *leri* in Indonesia, still contains carbohydrates, protein and vitamin B which is mostly contained in vitamin B1 or thiamine [9]. Other compounds found in coconut water are protein, fat, minerals, carbohydrates, even complete with vitamin C and B complex. Proteins and carbohydrates needed by plants as food reserves, fats needed by plants as energy reserves, minerals as constituents of the body's plants, and vitamins C and B complex play a role in the metabolic process. Thus, coconut water can be used to spur growth in both shoots and roots in various types of plants [10].

Increased production and productivity strived by the application of innovative technology. One effort that can be done is the use of biofertilizers (utilization of soil microbes and natural fertilizers). One of the functional microorganisms known as biofungicides is the trichoderma fungus. Trichoderma as a decomposing organism, can also function as a biological agent of plant growth stimulators [11]. Trichoderma is able to increase plant growth and development, especially on the growth of roots that are more numerous and stronger because besides living on the root surface, the colonies can enter the epidermal layer of the root even deeper which then produces or releases various substances that can stimulate the formation of the body's defense system in in plants it is clear that this fungus is not pathogenic or parasitic to its host plant. Trichoderma isolates are found under the mahogany stand in Takalar District [12]. The results showed that plants containing Trichoderma colonies on the root surface only needed less than 40% nitrogen fertilizer compared to roots without colonies [13]. Giving Trichoderma as much as 15 g/plant gives the best production of growth in tomato plants [14]. *Trichoderma harzianum* functions as a biological agent, improves plant roots and stimulates lateral root formation [15]. While *T. asperellum* produces trichodermaerin antibiotics and several enzymes capable of lysis of cell walls such as lipase, NAGase, B-1.3-glucanase, B-glucosidase, and protease [16,17]. In addition, *T. asperellum* can stimulate plant resilience, growth and development resulting in increased crop production [18].

2. Methodology

This research was carried out in the Experimental Farm of the Faculty of Agriculture, Universitas Hasanuddin, Makassar, from April to August 2017 located about 16 meters above sea level (m asl). The research was conducted in the form of a two-factor factorial experiment based on the Randomized Blocked Design pattern. The first factor was the dose of Trichoderma (T) which consisted of four levels, namely: t0 = control, t1 = 10 g plant^{-1}, t2 = 15 g plant^{-1}, and t3 = 20 g plant^{-1}. While the second factor was the concentration of liquid organic fertilizer (P) consisting of four levels, namely: p0 = control, p1 = 10 ml L^{-1}, p2 = 15 ml L^{-1}, and p3 = 20 ml L^{-1}. The chili seeds used in this research was variety of Pillar F1 produced by PT East West Seed Indonesia, while the Trichoderma used was *Trichoderma asperellum* inoculants.

Preparation of 20 liters of the liquid organic fertilizer with tofu waste based was carried out using volume per volume method with a composition of 15% tofu waste (3 liters), 50% cow manure (10 liters), 25% old coconut water (5 liters), and 10% rice washing water (2 liters). Solid material (cow manure and tofu wastes) was mixed then put into a sack with pores. Then the liquid ingredients (coconut water and rice washing water) were put into a container with crushed brown sugar (1 liter) and 12 liters of water added. After that the solid material was put into the container that has been filled with liquid material and fermented for about four weeks. Every two days the solution was stirred and the sack containing solid material was dipped so that the fermentation takes place evenly.

The growing media consists of a mixture of soil and compost in a ratio of 2:1 the filled into 30 x 40 cm polybag. Application of the Trichoderma was carried at planting by placed it at the planting hole in

the seedlings rhizospher. The liquid organic fertilizer treatment was conducted started at 14 days after planting (DAP) and carried out in the morning by pouring it into the polybag every two weeks

Data collected and processed using analysis of variance (ANOVA) to test the effect of the treatment given. If there is a significant influence then proceed with further tests using the Tukey's Honestly Significant Difference (HSD) test at α 0.05 level.

3. Results

3.1. Number of fruit per plant

Number of fruit per plant of chilli plant was significantly ($p \leq 0.05$) affected by the interaction of Trichoderma and tofu waste based liquid organic fertilizer treatments. Average number of fruit per plant as affect by both treatment are shown in table 1. The Tukey's ($\alpha = 0.05$) test results in Table 1 show that chilli plants applied with Trichoderma 10 g plant^{-1} with a concentration of liquid organic fertilizer 15 ml L^{-1} produces the highest value of 10.67 fruit plant^{-1} which is no different significantly with the treatment application of Trichoderma 20 g plant^{-1} and the concentration of liquid organic fertilizer 10 ml L^{-1}, the application of Trichoderma 0 g plant^{-1} (control) with the concentration of liquid organic fertilizer 15 ml L^{-1}, the application of Trichoderma 10 g plant^{-1} with concentration of liquid organic fertilizer 10 ml L^{-1}, and application of Trichoderma 10 g plant^{-1} with concentration of liquid organic fertilizer 0 ml L^{-1} (control). The treatment application of Trichoderma dose of 10 g plant^{-1} and the concentration of liquid organic fertilizer 20 ml L^{-1} gave the lowest yield of 6.00 fruits that were not significantly different from the treatment application of Trichoderma 20 g plant^{-1} and the concentration of liquid organic fertilizer 20 ml L^{-1}.

Table 1. Average number of fruit per plant (fruits plant-1) of chilli (Capsicum annuum L.) on different dose of Trichoderma and concentration of liquid organic fertilizer.

Dose of Trichoderma	Concentration of liquid organic fertilizer				Tukey's HSD $_{0.05}$
	0 ml L^{-1}	10 ml L^{-1}	15 ml L^{-1}	20 ml L^{-1}	
0 g plant^{-1}	7.33 b	8.00 b	7.33 b	9.67 a	1.81
10 g plant^{-1}	6.67 c	6.33 c	10.67 a	6.00 c	
15 g plant^{-1}	10.00 a	8.67 b	6.33 c	7.67 b	
20 g plant^{-1}	7.33 b	8.00 b	7.33 b	9.67 a	

Numbers followed by different letters (a, b, c) are significantly different at Tukey's test (α=0.05).

3.2. Fruit length

Analysis of variance on the fruit length observation data show that there was no significant effect of all treatment on the fruit length of chilli plants. Figure 1 shows that the average fruit length in the Trichoderma application treatment dose of 20 g plant^{-1} and the concentration of liquid organic fertilizer 20 ml L^{-1} tended to give the highest yield of 13.23 cm and the treatment application of Trichoderma dose of 15 g plant^{-1} and the concentration 0 ml L^{-1} liquid organic fertilizer gives the lowest yield of 9.80 cm.

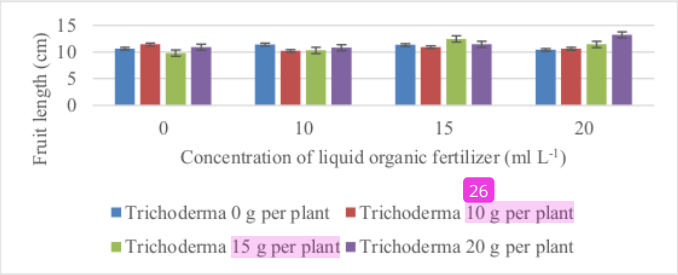

Figure 1. Average fruit length (cm) of chilli (*Capsicum annuum* L.) on different dose of Trichoderma and concentration of liquid organic fertilizer.

3.3. Weight per fruit

Analysis of variance on the observed weight per fruit parameter shows that the Trichoderma dose treatment significantly affected the weight of the fruit. Table 2 shows that weight per fruit of the chilli plant varied with the dose of Trichoderma applied. The average weight per fruit in the Trichoderma control application treatment (0 g plant^{-1}) resulted in the heaviest fruit (25.77 g) followed by the application of 20 g per plant Trichoderma. The application of Trichoderma application dose of 10 g plant-1 showed the lowest weight per fruit (22.01 g).

Table 2. Average weight per fruit (g) of chilli (*Capsicum annuum* L.) on different dose of Trichoderma and concentration of liquid organic fertilizer.

Dose of Trichoderma	Concentration of liquid organic fertilizer				Mean	Tukey's HSD $_{0.05}$
	0 ml L^{-1}	10 ml L^{-1}	15 ml L^{-1}	20 ml L^{-1}		
0 g plant^{-1}	23.07	30.87	24.63	24.50	25.77 a	3.07
10 g plant^{-1}	21.07	21.80	22.17	23.00	22.01 b	
15 g plant^{-1}	21.82	23.93	22.86	27.08	23.92 ab	
20 g plant^{-1}	25.97	24.47	25.90	25.05	25.35 a	

Numbers followed by different letters (a, b, c) are significantly different at Tukey's test (α=0.05).

3.4. Fruit weight per plant

Data on fruit weight per large chili plant and its variance indicate that the treatment dose of Trichoderma application had a significant effect while the application of liquid organic fertilizer and its interaction with other treatment had no significant effect. The average fruit weight per plant are shown in table 3. The average fruit weight per plant applied with 20 g plant^{-1} Trichoderma resulted in the highest yield of 223.55 g and was not significantly different from the Trichoderma dose of 15 g plant^{-1}. Trichoderma application treatment dose of 10 g plant^{-1} gave the lowest results ie 154.11 g.

Table 3. Average fruit weight per plant (g) of chilli (*Capsicum annuum* L.) on different dose of Trichoderma and concentration of liquid organic fertilizer.

Dose of Trichoderma	Concentration of liquid organic fertilizer				Mean	Tukey's HSD $_{0.05}$
	0 ml L^{-1}	10 ml L^{-1}	15 ml L^{-1}	20 ml L^{-1}		
0 g plant^{-1}	169.47	254.20	181.77	226.67	208.03 a	57.02
10 g plant^{-1}	133.33	133.80	218.63	130.67	154.11 b	
15 g plant^{-1}	211.08	203.48	144.47	205.75	191.20 a	
20 g plant^{-1}	235.83	247.37	244.10	166.91	223.55 a	

Numbers followed by different letters (a, b, c) are significantly different at Tukey's test (α=0.05).

4. Discussion

In the recent study, it is shown that the interaction between Trichoderma and liquid organic fertilizer significantly affected the parameters of the number of fruit per plant. The results indicate that the application of Trichoderma and liquid organic fertilizer package has a significant effect. The package of Trichoderma and liquid organic fertilizer provides the best effect on plant growth factors due to the availability of N nutrients used by the roots of chili plants. This is in line with the opinion of Harman and Uphoff [19] that soil microbes will gather near the roots of plants that produce root exudates and root cap pieces as a source of food for soil microbes. If the microbial population around the plant roots is dominated by beneficial microbes, the plants will get the most benefit from the presence of these microbes. Under normal crop conditions, nitrogen administration will result in a normal growth pattern. Other research show results present that bacteria inoculated from roots and roots area of chili pepper are potential as Plant Growth Promoting Bacteria [20].

The availability of nutrients for plants is sufficiently available and the natural balance or environmental conditions are sufficient for *Trichoderma* sp to multiply. Microorganisms contained in organic fertilizers especially *Trichoderma* sp have the ability to compete with soil-borne pathogens mainly to get nitrogen and carbon [21]. Trichoderma sp response at the beginning of plant growth requires time to multiply in organic fertilizer, as well as acting as a decomposer of organic matter in providing nutrients for plants. On the other side, the microbes that interact with plants are divided into phyllosphere and epiphyte [22]. The more microorganisms present in organic fertilizer can help metabolism in the soil so that the soil is more able to provide nutrients needed by plants [23].

5. Conclusions

Based on the results of research that has been done, it can be concluded as follows:

a) Interaction of Trichoderma dose of 10 g plant^{-1} and liquid organic fertilizer 15 ml L^{-1} gives a higher number of fruits per plant.
b) Trichoderma application with a dose of 20 g plant^{-1} gives the heaviest weight per fruit and fruit weight per plant.
c) There is no one concentration of liquid organic fertilizer which provides better growth and production of chili.

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