The effect of trichoderma harzianum dose and shallot population (*Allium cepa* L.) on chili production (*Capsicum annuum* L.) by intercropping system

D Novianti, B Basyah, E Kesumawati*  
Magister of Agroecotechnology, Agriculture Faculty, Syiah Kuala University Darussalam, Banda Aceh, Indonesia.

*Email: ellykesumawati@unsyiah.ac.id

**Abstract.** *Trichoderma harzianum* is a soil fungus that plays a role in decomposing soil organic matter, and contains several components of substances such as N, P, S and Mg and nutrients needed by plants for their growth. Intercropping is one way to increase the efficiency of land use by planting several types of plants on the same land and at the same time. Meanwhile, to increase land use efficiency and reduce the risk of chili farming failure, it can be achieved by implementing an intercropping system of chili with shallots. The research aimed to determine the interaction between the *T. harzianum* dosage and the shallots population (*Allium cepa* L.). The interaction between these on the chili production (*Capsicum annuum* L.) by intercropping system. The experimental design used was Randomized Block Design 4 x 3 factorial with three replications. There were interactions between *T. harzianum* dosage and shallots population on fruits number per plant, fruit weight per plant and fruit length per plant. The best result were found at 20 g per plant *T. harzianum* dosage and two shallots population on fruits number per plant (153.33 fruit), fruit weight per plant (121.55 g) and fruit length per plant (126.41 cm).

1. Introduction

*Trichoderma* is an antagonistic fungus that is used to control soil-borne pathogens. It is also used as plant growth stimulation and an organism that decomposes organic material [1,2,3,4,5]. The use of soil microorganisms such as the fungus *Trichoderma harzianum* is an alternative in increasing the biological activity of soil microorganisms. *T. harzianum* can survive and well control the growing space. It also has a high level of competition when grown with pathogens [6]. Then, the use of *T. harzianum* on the shallot population can increase the planned productivity. Growing the shallots gives good results without facing competition between plants. It also reduces the possibility of disease attacks, especially in the rainy season.

Shallots (*Allium cepa* L.) are seasonal plants that grow in clumps, and the tubers are formed from layers of enlarged and united leaves. Shallots are a horticultural commodity included in the spice family and used as a food flavor [7]. The increase of the shallot's need is equal with the increase of population and purchasing...
power. Shallot production in Indonesia in 2020 reached 1.82 million tons, while shallot production in Aceh was 11,246 tons [8]. The shallot intercropping system between red chilies and shallot is an alternative method that can be developed. Intercropping is one way to increase land-use efficiency by planting several types of plants on the same land/field and at the same time. The planting method arranged in rows will optimize those two plants in the intercropping method. In addition, intercropping planting method can provide higher crop yields than the monoculture pattern [9].

Chili (Capsicum annuum L.) is one of the important vegetables in Indonesia. Chili has high nutritional value and economic value, both a domestically consumed commodity and an export commodity [10]. Indonesia's big chili production in 2020 is 1.26 million tons, while big chili production in Aceh has only reached 73,444 tons [8]. The increasing the big chilies production can be done in various ways. One of them is the use of soil microorganisms such as the as 15 g of T. harzianum per plant can control the Fusarium oxysporum f.sp capsici attack, which causes wilt disease in red chili plants [11].

The use of 20 g per plant T. harzianum can reduce the percentage of fusarium wilt. It impacts the vegetative and generative growth of tomato plants. The increase in Trichoderma spp dose can reduce the number of leaves affected by Fusarium wilt disease so that the results of photosynthesis in the leaves will increase the number of fruits and fruit weight [12]. The treating of Trichoderma spp affects plant height. Then, the treating of Trichoderma spp. 15 g per plant showed a better plant height than without Trichoderma spp [13]. Treatment with a dose of T. harzianum 20 g per plant gave the best results on root length. So, it could well absorb nutrients and dry space weight of chili plants [14]. The intercropping system is an alternative technology that can increase yields and land-use efficiency. Shallots can be planted together with other plants, such as between rows of red chili plants. However, it is necessary to regulate the number of shallot populations among chili plants to have no high competition. Indeed, this study was conducted to describe the effect of the T. harzianum dose on the shallot population. Then, it is also the interaction with them on chili production.

2. Method and Material

2.1 Data analysis

The experimental design used in this study was 4 x 3 Factorial Randomized Block Design with three replications. The factors studied were the dose of Trichoderma fertilizer and the shallot population among chili plants. The dose of T. harzianum (T) fertilizer consisted of 4 levels, namely T0 = without T. harzianum, T1 = 10 g T. harzianum per plant, T2 = 20 g T. harzianum per plant, T3 = 30 g T. harzianum per plant. The shallot population consisted of 3 levels, namely C1 = chili without shallots, C2 = two shallot bulbs among chili, and C3 = three shallot bulbs among chili. Data were analyzed using SPSS version 20 (SPSS Inc., Chicago, IL). HSD Test was used to ascertain the significance of differences between mean values. The level P < 0.05 was considered as the cutoff value or significance.

2.2 Producing Trichoderma harzianum

The materials used for making pellets of T. harzianum were bran (31.0 g), tofu dregs (10.5 g), molasses (15.0 ml), and sterile water (42.0 ml). All ingredients were weighed according to the predetermined composition. Then, 15 ml of molasses and 52 ml of sterile water were added to the mixture of the basic ingredients. Then, it stirred until homogeneous, then put into heat-resistant plastic and sterilized by autoclave. A total of 10 ml suspension of 5 days old T. harzianum fungi with a density of 1.3 × 10^7 CFU was added to the sterilized base material. Then, it stirs until it becomes a homogeneous mixture. The basic material dough is put into a mold in the form of a plastic straw, and it has a diameter of 1 cm and a length of 0.5 cm, sterilized. The pellets in the mold are put in the sterilized opaque paper, then incubated in an incubator at a temperature of 30°C for 48 hours until the dough is dry. After that, the T. harzianum pellets
were removed from the opaque paper and put into a plastic bag. Making these pellets is carried out aseptically in a laminar airflow cabin [15].

2.3 Planting and giving *Trichoderma harzianum*

Moving chili seedlings from the nursery to the field is carried out after the seedlings are 30 days after the nursery. At that age, the seedlings already have 3-4 leaves and 8-10 cm high. Before planting, the research area was watered to reduce stress on plants during planting.

According to the treatment dose, *T. harzianum* was given at the time of transplanting by sowing it around the chili seeds in the planting hole. The spacing of chilies used is 40 cm × 70 cm. The planting of red chili seeds is planted simultaneously with planting the shallot bulbs in the afternoon. Shallot bulbs are planted with 2/3 of the clove inserted into the soil and 1/3 on the soil's surface. The spacing between the two shallots used is 20 cm × 25 cm.

2.4 Treatment

The replanting of dead chili plants can be done seven days after transplanting. Replanting is done when the plant dies or does not grow. Then, watering is done 1-2 times a day using a sprinkling can. Each row is watered with a five sprinkling can. Each treatment requires sufficient water that the plant absorbs. Watering is carried out in the morning and evening or adjusted to weather conditions. If it rains, watering is not needed.

Weeding is done by clearing weeds around the plantations or adjusted to the field conditions. The reattach bamboo is 120 cm long, which helps support plants so that they do not fall. Irrigation was carried out at the age of 15 days after transplanting. Bamboo reattachment is only used on chili plants. Disposal of water shoots in chili plants is done by cutting with a sharp knife at the age of 15-30 DAT to stimulate the growth of chili plants to grow fertile and healthy.

Pest control was carried out by spraying insecticide with the active ingredient diafenthiuron with 4 ml per L of water concentration. Spraying is carried out on the entire surface of the plant using a sprayer. Spraying of insecticides on chili plants was carried out four times a week. Prevention of diseases that attack chili plants in the field, such as anthracnose fruit rot (*Collecrotichum gloeosporioides*), is carried out by removing plants and chilies affected by the disease.

2.5 Observed Parameters

2.5.1 Fruit weight (g). The weight of the fruit weight was carried out after the chilies were harvested, namely by weighing the chilies using a digital scale. Measurements were carried out for 15 harvests on 4 sample plants with an interval once in 5 days.

2.5.2 Total number of fruit per plant (fruit). The total number of fruits per plant was calculated by calculating the number of fruits per plant at each harvest from the 4 sample plants and then adding up from the first harvest to the 15th harvest Fruit length (cm). Measuring the fruit length was carried out after harvesting, namely by randomly taking five pieces of each sample. Measurements were made from the base of the fruit to the tip of the fruit.

2.5.3 Fruit length (cm). Measuring the fruit length was carried out after harvesting, namely by randomly taking five pieces of each sample. Measurements were made from the base of the fruit to the tip of the fruit.
3. Results and discussion
3.1 Fruit weight Per Plant
The analysis of variance showed a significant interaction between the dose of *T. harzianum* and the shallot population on fruit weight per plant. The average fruit weight per plant due to the interaction between *T. harzianum* dose and shallot population after being tested with HSD (0.05) is presented in Table 1.

| Dosage T. harzianum (g per plant) | Shallot population | HSD 0.05 |
|-----------------------------------|-------------------|-----------|
| Without T. harzianum              | Without Shallot   | Without Shallot |
|                                   | 50.01 Aa          | 73.14 ABa  |
| 10 g per plant                   | 81.15 Aa          | 71.42 Aa   | 90.37 Bb   |
| 20 g per plant                   | 81.79 Aa          | 121.55 Bb  | 88.80 ABab |
| 30 g per plant                   | 79.21 Aa          | 72.90 Aa   | 53.50 Aa   |

Note: Numbers followed by the same letter (capital letters viewed horizontally and lowercase letters viewed vertically) are not significantly different at the 5% level (HSD Test 0.05)

As presented in Table 1, the fruit weight per plant in the treatment without *T. harzianum* was heavier in the population of three shallots, which was significantly different from the population without shallots, but was not significantly different from the population of two shallots. At a dose of *T. harzianum* 10 g per plant, there was no significant difference in fruit weight per plant between the three shallot bulb populations. While at a dose of *T. harzianum* 20 g per plant, the weight of fruit per plant was heavier in the population of two shallot bulbs. It was significantly different from the population without shallot bulbs but not significantly different from the population treatment of three shallots. At a dose of *T. harzianum* 30 g per plant, there was no significant difference between the three shallot bulb populations. The best fruit weight per chili plant was found in the combination treatment with *T. Harzianum* 20 g per plant and shallot bulb populations.

Weight per plant fruit is a character that has a great influence on fruit weight per plant, the more fruit weight is formed, the higher the fruit weight per plant will be [16]. In intercropping, overall crop yields are higher than in monocultures if the combination of intercropping plant species is selected correctly. Intercropping can increase yields up to 62%. The success of intercropping is largely determined by the combination of the constituent plant species. The combination of two types of plants of unequal age, the maximum need for sunlight, *CO₂*, water, and nutrients for each type of plant occurs at different times if the two types of plants are planted at the same time, thus competition between plant species can be minimized or eliminated, so that the total yield of the constituent plants is high. It is suspected that the onion population used does not get enough sunlight and nutrients between plants which causes some shallot production to tend to be low. This is supported by statement. that, plant growth is largely determined by the intensity, quality, and duration of irradiation. Planting distances that are too close or high population density levels can result in competition between plants for growth factors such as water, nutrients, light and space to grow, so that it will affect the growth and yield of shallots [17].

3.2 Number of fruits per plant
The variance analysis results showed a significant interaction between the dose of *T. harzianum* and the shallot population on the number of fruits per plant. The average number of fruits due to the interaction between the dose of *T. harzianum* and the shallot bulb population after being tested with BNJ (0.05) is presented in Table 2.
Table 2. The interaction between the dose of T. harzianum and the shallot population on the number of fruits per plant

| Dosage T. harzianum (g per plant) | Without shallot | Two shallots | Three shallots | HSD 0.05 |
|----------------------------------|-----------------|--------------|----------------|----------|
| Without T. harzianum             | 21.67 Aa        | 35.95 Ba     | 38.92 Bb       |          |
| 10 g per plant                   | 33.93 Aa        | 30.50 Aa     | 38.50 Ab       | 13.71    |
| 20 g per plant                   | 33.58 Aa        | 153.33 Bb    | 36.92 Aab      |          |
| 30 g per plant                   | 29.67 Aa        | 32.00 Aa     | 24.00 Aa       |          |

Note: Numbers followed by the same letter (capital letters viewed horizontally and lowercase letters viewed vertically) are not significantly different at the 5% level (HSDTest 0.05).

Table 2 shows that the number of fruits in the treatment without T. harzianum. It shows the best result in a population of three shallots, which was significantly different from the treatment without shallots but not significantly different from the population of two shallots. At a dose of 10 g of T. harzianum per plant, the number of chilies did not differ between the treatment populations of three shallots. Meanwhile, at a dose of T. harzianum 20 g per plant, the best number of chilies was found in the treatment of populations of two shallots, which were significantly different from those without shallots and populations of three shallots. At a dose of T. harzianum 30 g per plant, there was no significant difference between the three shallot bulb populations. The best number of chilies was found in the combination treatment with a dose of T. harzianum 20 g per plant and a population of two shallots.

The number of fruit plants is a character that has a great influence on increasing the number of chilies per plant, the more the number of chilies, the more fruit will be produced. [16] Intercropping system is competition between cultivated plants for example for nutrients, water, nutrients, light and growing space which is higher than monoculture [4]. The competition occurs between plants of the same type and different species. Therefore, it is necessary to adjust the spacing so as to reduce the competition between these plants. This shows that there is no competition in utilizing the growing space, especially light, so that a closer spacing can produce relatively the same crop yields with a larger spacing. Based on this, it is suspected that the availability of nutrients needed by red chili is not disturbed by the presence of shallots in the root area [18].

The administration of trichoderma suppressed the development of fusarium wilt disease, so that the production achieved was still quite high. The existence of yield fluctuations as a result of fluctuations in environmental factors is related to the mechanism of plant appearance stability. The development of shallot plants is directed at the optimal suitability of environmental physical factors [19].

3.3 Fruit length
The variance analysis result showed a significant interaction between the dose of T. harzianum and the shallot population on fruit length. The average fruit length due to the interaction between the dose of T. harzianum and the shallot population after being tested with HSD (0.05) is presented in Table 3.
Table 3 shows that the fruit length in the treatment without *T. harzianum* was longer in the population of three shallots, which was significantly different from the treatment without the shallots, but not significantly different from the population of two shallots. At a dose of 10 g of *T. harzianum* per plant, there was no significant difference between the three shallot bulb populations. At a dose of *T. harzianum* 20 g per plant, longer fruit was found in the population of two shallot bulbs, which was significantly different from the treatment without shallot bulbs, but not significantly different from the population of three shallot bulbs. The dose of *T. harzianum* 30 g per plant, there was no significant difference between the three populations of shallot bulbs. The best length of chili fruit was found in the combination of treatment with a dose of *T. harzianum* 20 g per plant and a population of two shallots.

Fruit length of plants will produce high fruit weight per plant [20]. Fruit production will succeed perfectly if the nutrients for plants are sufficient [21]. Provision of the *T. harzianum* does not have a direct impact on production per plant, this is due to its role not as a direct provider of nutrition but through a disease control system and organic matter degradation [22, 23]. Chili fruit length is influenced by P nutrients. Trichocompost can increase the availability of P nutrients that easy to be absorbed by plants so that the length of chili fruit increases. Fruit formation is also influenced by nutrient K. Nutrient K functions for the transport of carbohydrates, as a catalyst in the formation of protein, increases the levels of carbohydrates and sugars in fruit, makes plant seeds fuller and denser, and improves fruit quality such as a better shape [5]. The vegetative phase is a phase that greatly determines plant productivity. In this phase, all growth energy is used for vegetative development including stems. If in this phase a large stem is formed, it can be ascertained that it will be able to achieve high productivity [17].

4. Conclusion

The variables observed were the number of fruit, fruit length and fruit weight. The interaction of *T. harzianum* dosage and the shallot population had a very significant effect on the was in the number of fruits per plant and fruit weight per plant. Overall, the best interaction was found at a dose of 20 g per plant in a population of two shallot bulbs.

References

[1] Made S A, Rosmini and Panggeso J 2015 Pengaruh Berbagai Dosis Cendawan Antagonis *Trichoderma* spp. untuk Mengendalikan Penyakit Layufsarium oxysporum pada Tanaman Tomat. Skripsi. Universitas Tadulako, Palu.

[2] Lugtenberg Ben J J, Malfanova N, Kamilova F and Berg G 2013 Molecular Microbial Ecology of the Rhizosphere: *Plant Gro. Promot.* by Microbes.
[3] Chang Y C, Baker R, Kleifeld and Chet 1986 Increased Growth of Plants in the presence of The Biological Control Agent Trichoderma harzianum. Plant Dis. 70 145-148.

[4] Mauizotussyarifah N, Aini and Herlina N 2018 Optimalisasi Pemanfaatan Lahan dengan Pola Tanam Tumpangsari pada Tanaman Buncis (Phaseolus vulgaris L.) dan Tanaman Pakcoy (Brassica rapachinensis L.). J. Prod. Tanaman 6 246-251.

[5] Shinta, Kristanti and Warisnu 2014 Pengaruh aplikasi pupuk hayati terhadap pertumbuhan dan produktivitas tanaman cabai rawit variasi bhaskara di PT Petrokimia Gresik. Jurnal Sains dan Seni POMITS, 2 2337-3520.

[6] BPS 2021 Produksi Tanaman Sayuran 2020 https://www.bps.go.id/indicator/55/61/1/produksi-tanaman-sayuran.html. Accesed at 26 june 2021.

[7] Lorito M, Woo S L, Harman G E and Monte E 2010 Translational Research on Trichoderma from omics to the Field Annu Rev. Phytopath. 48:395:417.

[8] Fitria E, Kesumawati E, Basyah B and Asis 2021 The Role of Trichoderma harzianum as a Producer of Growth Regulating Substances on the Growth and Productivity of Chili Varieties (Capsicum annuum L.) J. Agron. Indonesia, 49 45-52.

[9] Arma MJ, Fermin U and Sabaruddin L 2013 Pertumbuhan dan produksi jagung (Zea mays L.) dan kacang tanah (Arachis hypogaea) Harpenas A, and Dermawan R 2010 Budidaya Cabai Unggul. Penebar Swadaya. Jakarta.

[10] Ban G, Akanda S and Maino M 2013 Study on the Effectiveness of Trichoderma sp. on the Growth of Bean and Tomato Plants under Greenhouse Condition. Department of Agriculture, PNG University of Technology PMB. Papua.

[11] Srigiwati R, Chamzurni T and Kemalasari L 2014 Kemampuan Bertahan Hidup Trichoderma harzianum dan Trichoderma virens setelah ditumbuhkan bersama dengan jamur Patogen Tular Tanah secara In Vitro. J. Floratek. 9 14-21.

[12] Suriani N 2011 Bawang Bawa Untung Budidaya Bawang Merah dan Bawang Putih. Cahaya Atma Pustaka. Yogyakarta.

[13] Hardianti R A, Rahayu Y S and Asri M T 2014 Efektivitas Waktu Pemberian Trichoderma harzianum dalam Mengatasi Serangan Layu Fusarium Pada Tanaman Tomat Varietas Ratna. J. MaterBio. 3.

[14] Zikriah 2016 Potensi Daun Katuk Dan Lamtoro Sebagai Nutrisi Cendawan Trichoderma sp Pada Pelet Media Tumbuh Dalam Menekan Pertumbuhan Patogen Tular Tanah. Skripsi Universitas Syiah Kuala, Banda Aceh.

[15] Syukur M, S Sujiadi R Yuniti and K Nida 2010 Pendugaan Komponen Ragam, Herebilitasi dan Korelasi untuk Menentukan Kriteria Seleksi Cabai (Capsicum annuum L.) Populasi P5. J. Hort. Indo. 174-80.

[16] Wulandhari R, Suminarti NE, Sebayang HT 2016 Pengaruh jarak tanam dan frekuensi penyiangan gulma pada pertubuhan dan hasil tanaman bawang merah (Allium ascalonicum). J. Prod. Tanaman 4 547- 553.

[17] Surtinah N, Susi and S U Lestari 2016 Optimasi Lahan Dengan Sistem Tumpang Sari Jangkung Manis (Zea Mays Saccharata, Sturt) Dan Kangkung Sutra (Ipomea reptans) di Pekanbaru. Jurnal Ilmiah Pertanian, 12 62-72.

[18] Sudarjat, Kusumiyati, Hasanuddin and Munawar A A 2019 Rapid and non-destructive detection of insect infestations on intact mango by means of near infrared spectroscopy IOP Conference Series: Earth and Environmental Science vol 365 (Institute of Physics Publishing).

[19] Hermosa R, Chet and Monte E 2012 Plant Beneficial Effects of Trichoderma and o its Genes J. Microbiology 158 17-25.
[21] Ganefianti D W, Yulian A N and Suprapti 2006 Korelasi dan Sidik Lintas antara Pertumbuhan, Komponen Hasil dan Hasil dengan Gugur Buah pada Tanaman Cabai. J. Akta agroseia, 9 1-6.

[22] Jumin. H B 2005 Dasar-dasar Agronomi. Raja Grafindo Perseda. Jakarta. Cetakan kelima.

[23] Hermawan R, Maghfoer M D Wardiati T 2013 Aplikasi Trichoderma harzianum Terhadap Hasil Tiga Varietas Kentang di Dataran Medium Jurnal Produksi tanaman. 1 464-470.