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Effect of three fungi species application and concentration on production and pest attack on shallot (*Allium ascalonicum* L.)

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Abstract. This study aims to determine the influence of three types of beneficial fungi with various concentration of application on shallot production and pest attacks. This research was carried out at the Plant Disease Laboratory and Teaching Farm, Faculty of Agriculture, Hasanuddin University, from September to November 2022. This research was arranged in a split plot design. The main plots are three types of fungi, namely *Trichoderma asperellum*, *Beauveria bassiana* and *Metarhizium anisopliae*, while the plot consists of concentration consisting of 0, 7, and 14 g/L. Results showed that there was no interaction that had an influence on production, bulb moisture content, production per hectare and the percentage of *Spodoptera exigua* attacks. The highest production per hectare was recorded in the *Beauveria bassiana* treatment of 15.97 tons. The application of the fungus at a concentration of 14 g/L producing the lowest weight loss of bulb 3.17%, production per hectare of 17.27 t and the lowest percentage of *Spodoptera exigua* attacks was 6.19%.

1. Introduction

Shallot is one of the leading horticultural commodities with good prospects for meeting national consumption, a source of income for farmers, and foreign exchange [1]. Shallots have many uses as a consumption ingredient to add flavor to dishes and are used as traditional medicines because shallots contain nutrient and active chemical compounds (sulfur compounds) [2]. As well as containing antioxidants to improve heart health and prevent cancer, and diabetes, anti-inflammatories can help fight obesity and prevent or treat allergies [3].

Shallot production in Indonesia will reach 2 million tons in 2024. This number has increased by 10.42% from 2020, which amounted to 1.82 million tons. In 2021, the highest shallot production will occur in August, reaching 218.74 thousand tonnes with a harvested area of 18.07 thousand hectares.



4 Meanwhile, the lowest production occurred in February, namely 126.7 thousand tons. An increase in shallot production has been seen every year since 2017 when Indonesia only produced 1.47 million tonnes. The number continues to increase, with an average increase of 8% annually [4]. Based on the production data, it is strongly influenced by very volatile prices, so it significantly contributes to inflation. There is a relatively significant price disparity between producers and consumers, so the shallot business is a source of income for farmers. Therefore, the need for shallots is essential [5].

In the business of cultivating shallots, one of the obstacles that 11 often encountered is pest attacks. One of the crucial pests on shallot plants is *Spodoptera exigua* which can cause a decrease in shallot production or yield loss of up to 32 - 42% [6]. Furthermore, in heavy pest attacks, the leaves dry out and fall prematurely, decreasing the quality and quantity of shallots [7]. Generally, the control farmers often carry out is using insecticides, which 1 can harm the ecosystem [8].

One effort that can be made in the use of *Trichoderma asperellum*, *Beauveria bassiana*, and *Metarhizium anisopliae*, which have the potential to promote growth and control pests. Research conducted by [9] found that when inoculated with *Trichoderma asperellum* under dry stress conditions, sugarcane plants had better photosynthetic rates, stomatal conductance, and water use efficiency compared to plants without inoculation. Furthermore, applying *Beauveria bassiana* can reduce the intensity of *Spodoptera exigua* attacks on local Palu shallot plants with the lowest attack intensity (2.02%) [10]. Then, apart 7 from biological control agents in pest control, *Beauveria bassiana* and *Metarhizium anisopliae* also trigger physiological mechanisms that promote nutrient 6 sorption and plant growth and increase tolerance to abiotic stresses 8 and drought [11,12]. Therefore, this study aims to see the effect of applying these three types of fungi on the growth and production of shallots.

2. Materials and method

6.1 Research Location

The research was conducted at the Plant Disease Laboratory, Departmen 2 of Plant Pests and Diseases, Faculty of Agriculture, Hasanuddin University. In addition, field research was conducted at the Teaching Farm, Faculty of Agriculture, Hasanuddin University, Makassar. This research was carried out from September to November 2022.

2.2 Fungus Propagation

The isolates of the fungi *Trichoderma asperellum*, *Beauveria bassiana*, and 12 *tarhizium anisopliae* were propagated according to the instr 1 ions [13]. The isolates were cultured on potato dextrose agar (PDA) media in a Petri dish. After 14 days after inoculation (DAI), the f 1 gal isolates were propagated on rice media to produce optimal amounts of conidia. Rice, as a growing media, 1 is previously washed using water. After cleaning, it was then soaked in water for two hours. Next, the 1 rice medium was sterilized in an autoclave at 121°C for 30 minutes and then cooled. Each plastic bag containing the rice medium was inoculated with a fungus suspension on 100 g of the media.

2.3 Field Experiment

Conducting research in the field included sowing the seeds of the Maserati variety of shallots, making beds with a size of 100 cm × 100 cm, planting shallots after 40 days after sowing (DAS) in each hole 1 the bed filled with one plant with a spacing of 15 cm × 10 cm. , application of the fungi *Trichode 15 a asperellum*, *Beauveria bassiana* and *Metarhizium anisopliae* by spraying on the plants after 14 days after planting with a vulnerability of spraying seven days and spraying stops one week before harvest. Then plant maintenance includes watering, replanting, sugar control, fertilizing, harvesting, and drying.

2.4 Experimental design

2 This research was carried out in the form of a Split Plot Design, which consisted of the main plots, namely the type of fungus (C): *Trichoderma asperellum* (c1), *Beauveria bassiana* (c2), *Metarhizium anisopliae* (c3). In addition, subplots were concentration treatment (K): control (k0), 7 gr/L (k1), 14 gr/L (k2) with 3 replications to obtain 27 experimental units.

2.5 Data analysis

The data obtained was then subjected to analysis of variance. If the variance analysis results are significant, then a Tukey test (HSD) with α 0.05 is performed. All data analysis processes were carried out using Microsoft Excel software. The parameters observed in this study were bulb weight loss (%), bulb moisture content (%), bulb production per hectare (t), and the percentage of attack by *Spodoptera exigua* with the formula according to [14], as follows:

$$P = \frac{a}{b} \times 100\%$$

Notes:

- P = Percentage of attack (%)
 a = Number of Attacked Plant
 b = Number of Plant Population

1

3. Results and Discussion

3.1 Results

Applying the three types of fungi did not affect shallot bulb losses, but the concentration of spray had a statistically significant effect on shallot bulb losses (Table 1). The lowest tuber shrinkage was in the treatment with a concentration of 14 g/L, which was 3.17%, the same as the treatment with a concentration of 7 g/L (4.57%) and significantly different from the treatment with a control (7.52%).

Table 1. Bulb Weight Loss (%)

Fungi	Concentration		
	0 g/L	7 g/L	14 g/L
<i>Trichoderma asperellum</i>	8.31	5.36	2.35
<i>Beauveria bassiana</i>	6.50	3.85	2.25
<i>Metarhizium anisopliae</i>	7.74	4.50	4.92
Mean	7.52a	4.57b	3.17b
2 LSD	1.87		

Note: Means followed by the same letter are not significantly different for $p \leq 0.05$ according to Tukey multiple comparison test.

The application of three types of fungi and the concentration of spraying did not have a statistical effect on the moisture content of shallot bulbs (Figure 1). The highest tuber water content was in the *Beauveria bassiana* treatment (80.35%) and a concentration of 14 g/L (80.40%), while the lowest tuber water content was in the *Metarhizium anisopliae* treatment (79.89%) and a concentration of 0 g/L (79.67%).

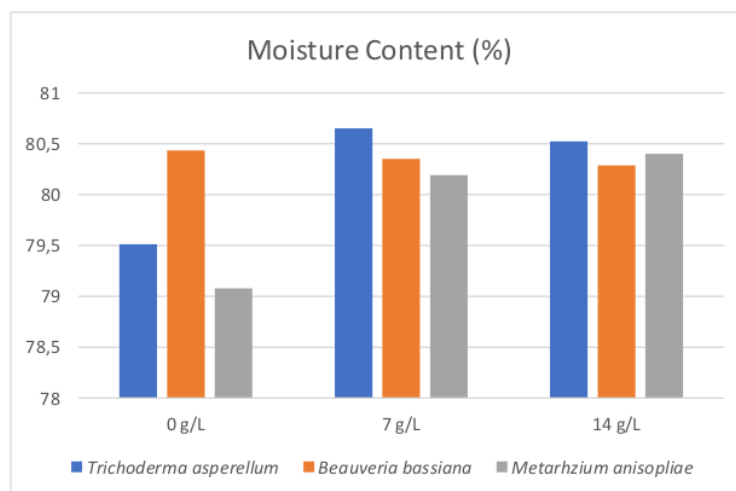


Figure 1. Average Moisture Content

The treatment of the three types of fungi and the spraying concentration significantly affected the production per hectare of shallot plants (Table 2). The *Beauveria bassiana* treatment produced the highest production (15.97 t), which was the same as the *Metarhizium anisopliae* treatment (15.86 t) and significantly different from the *Trichoderma asperellum* treatment (14.12 t). The treatment with a concentration of 14 g/L produced the highest production (17.27 t), which was not significantly different with a concentration of 7 g/L (15.43 t) and significantly different with a concentration of 0 g/L (13.25 t).

Table 2. Production per Hectare (t)

Fungi	Concentration			Mean	LSD
	0 g/L	7 g/L	14 g/L		
<i>Trichoderma asperellum</i>	11.52	14.76	16.10	14.12a	1.17
<i>Beauveria bassiana</i>	14.69	15.49	17.72	15.97b	
<i>Metarhizium anisopliae</i>	13.55	16.05	17.98	15.86b	
Mean	13.25a	15.43ab	17.27b		
LSD	2.96				

Note: Means followed by the same letter are not significantly different for $p \leq 0.05$ according to Tukey multiple comparison test.

The application of three types of fungi did not affect the percentage of *Spodoptera exigua* attacks on shallot plants. However, the concentration of spraying had a statistically significant effect on the percentage of *Spodoptera exigua* attacks (Table 3). The lowest percentage of *Spodoptera exigua* attacks was recorded in the treatment with a concentration of 14 g/L, namely 6.19%, which was the same as the treatment with a concentration of 7 g/L (6.35%) and significantly different from the treatment with a concentration of 0 g/L (8.57%).

Table 3. *Spodoptera exigua* Attack Percentage (%)

Fungi	Concentration		
	0 g/L	7 g/L	14 g/L
<i>Trichoderma asperellum</i>	7.62	7.14	7.62
<i>Beauveria bassiana</i>	9.52	6.66	6.19
<i>Metarhizium anisopliae</i>	8.57	5.24	4.76
Mean	8.57a	6.35b	6.19b
LSD	1.55		

Note: Means followed by the same letter are not significantly different for $p \leq 0.05$ according to Tukey multiple comparison test.

3.2 Discussion

The application of the type of fungus did not have a statistical effect on the parameters of plant shrinkage, tuber moisture content, and the percentage of attack of *Spodoptera exigua*. However, applying *Beauveria bassiana* resulted in the lowest bulb weight losses and the highest water content and reduced the percentage of *Spodoptera exigua* attacks. The same result was produced [15], which found that *Allium schoenoprasum* L. plants inoculated with the fungus *Beauveria bassiana* had a growth that was not significantly different from the control plants. In addition, research [13] suggests that the success of *Beauveria bassiana* in infecting insect pests is influenced by several factors, one of which is environmental factors and spore viability.

Spraying with a concentration of 14 g/L affected the parameters of bulb weight loss, production per hectare, and the percentage of attack of *Spodoptera exigua*. So the higher the concentration, the lower the percentage of *Spodoptera exigua* attacks, so the production is higher. Shallot production was higher at high concentrations than the control due to the increasing effectiveness of the fungus in infecting the target insects. According to [16], pathogenic insect fungi's effectiveness in controlling target pests is strongly influenced by the number of spores applied. The more effective the fungus is in infecting *Spodoptera exigua*, the more it can affect production, as one of the causes of decreased shallot production is *Spodoptera exigua* attack. These pests attack shallot plants throughout the year, both dry and rainy seasons, which can result in decreased production and even yield loss [17].

Fungi which are commonly used as biocontrol agents can also stimulate plant growth. The ability of endophytic fungi to help transfer nutrients from the soil to plants helps stimulate growth [18]. For example, inoculation with *Beauveria bassiana* can increase wheat yield and P uptake [19]. The results of the study [20] found that the highest shallot production was produced by the mushrooms *Beauveria bassiana* and *Metarhizium anisopliae*. Further research conducted by [21] found that *Beauveria bassiana* was able to colonize melon and strawberry plants, which increased the number of flowers and fruits formed. The study also proved that the fungus *Beauveria bassiana* has two functions at once: an entomopathogen and a plant growth promoter. In addition, the study's results [22] found that the endophytic fungus *Beauveria bassiana*, as an endophytic fungus, can colonize chili plants, thereby increasing the germination and growth of chili plants derived from wheat.

4. Conclusion

The best application of the type of fungus is *Beauveria bassiana* which produces the highest shallot production. While applying, the best concentration was 14 g/L with the lowest bulb weight loss, namely 3.17%, the highest production per hectare was 17.27 t/ha, and the lowest percentage of attack by *Spodoptera exigua* was 6.19%. However, further research is still needed to evaluate the effectiveness of the application of this fungus on the growth and production of shallot plants

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