Response of *Trichoderma* sp and shallot varieties towards plant growth and disease incidence

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Abstract. The main diseases that commonly attack shallots include purple blotch disease (*Alternaria porri*), anthracnose (*Colletotrichum gloeosporioides*), wilt (*Fusarium oxysporum*) and *Stemphylium vesicarium*. Purple blotch disease can cause yield losses of 3-57% . The research is aimed to measure the response of *Trichoderma* sp and other varieties to the growth and development of shallot disease. The study was conducted at IP2TP Margahayu Indonesian Vegetable Research Institute (IVEGRI), in August - November 2019. The research used a randomized block design (RBD) with 12 treatments and 3 replications. The treatments consisted of three varieties which are Batu Ijo, Sumenep, Trisula, Violeta 1, Maja Cipanas, and Ambasador in combination with Trichoderma and without Trichoderma. Results for the parameters of plant height and number of leaves showed that varieties that have been Trichoderma applied have reached higher height than those without Trichoderma. Ambasador showed the highest plant height (46.27 cm) and the highest number of leaves (44.16 cm). The intensity of the purple blotch disease attacks *A. porri* (0.67-8.00%) and *S. vesicarium* (6.67-23.33%) on all varieties treated with Trichoderma lower than without Trichoderma. For the number of tillers, it is almost the same as an average of 6-7 tillers, except for Sumenep that has only 3-4 seedlings. For wet weight and dry weight per clump in the varieties applied to Trichoderma, the weight per clump is higher than those without Trichoderma, and yet wet weight and dry weight for Batu Ijo without Trichoderma application are relatively similar.

1. Introduction

Shallot is the vegetable commodity that is often used for daily uses as a complement to cooking spices. In the industrial sector, it is required to produce fried onions or pasta, so the availability should be sustainable. Apart from having high economic value, it also has the opportunity to become a promising export commodity. Under these conditions shallots become a very strategic vegetable, where the price often fluctuates which can affect the inflation rate. According to BPS [1] about inflation rate of 0.51%, shallots contribute around 0.9%. Based on the distribution of production every year (2012-2014) which is taken from the average per month, generally high production occurs in January, but decreases until March and then increases again in June – August. Production will decline again in November- December and will rise again in January and so on. This situation is related to climatic conditions at the time of production, such as planting in the dry season (April - September) which is often hampered by pest attacks, which if not handled from the start and not controlled will cause yield losses [2] Meanwhile, when planting in the rainy season (October - March) there are often disease attacks due to humid climatic conditions. The main diseases that commonly attack shallots include purple blotch disease (*Alternaria porri*), anthracnose (*Colletotrichum gloeosporioides*), wilt (*Fusarium oxysporum*) and *Stemphylium vesicarium*. Purple blotch disease can cause yield losses of 3-57% depending on the growing season [3].
So far, plant disease control still relies on fungicides and unfortunately encourages farmers to overuse fungicides. According to [2] excessive use of fungicides can be reduced by 87.50% if a control threshold is applied. However, it is difficult to apply because farmers generally choose the practical one in controlling without considering the symptoms appear. Fungicides that have been tried to control *A. porri* include those with active ingredients Mancozeb, Carbendazim, Metalaxyl + Mancozeb, Ipodione and Propiconazole [4]. In addition, farmers also uses fungicides with active ingredients tebuconazole and azoxystrobins [5] In addition to using fungicides as a control method, to support the availability of a supply of shallots in the rainy season, varieties that can be planted and widely adapted are needed. Ivecri as a technology fabricator has released many shallots varieties including Trisula, Violeta, Ambasador and Maja Cipanas [6]. But in these varieties are still often found their main disease, due status in the description is still susceptible to moderately resistant, therefore it is necessary to try an easy way to control performed in application by Trichoderma.

Aside from using varieties to support production in order to provide a year-round supply of shallots, biological agents can also be used as growth promoters as well as sources of control. Biological agents that have been widely used include *Trichoderma harzianum* [7-8], *Pseudomonas fluorescens* [9-11]. *Trichoderma* sp. is a fungi that live freely, very interactive in the environment of roots, soil, and leaves [12]. Besides, it is also a very popular fungus, as a plant growth promoting fungi (PGPF), and biological control agent. The ability of *Trichoderma* sp. in inhibiting the growth of plant pathogens directly indicates that these fungi can induce local and systemic resistance to various plant pathogens. Certain strains also have a substantial effect on plant growth and development [12-13]. This study aims to determine the response of several varieties of shallots and Trichoderma to the plants growth and disease development.

2. Materials and methods
The research was conducted from August to November 2019, in IP2TP Margahayu Lembang Indonesian Vegetable Research Institute at an altitude of 1250 m asl. The design used was a randomized block design (RBD) with twelve (12) treatments and repeated three (3) times, each treatment consisted of five (5) polybags. The treatments used in this study were: (1) Batu Ijo, (2) Sumenep, (3) Trisula, (4) Violeta 1, (5) Maja Cipanas, (6) Ambasador, (7) Batu Ijo + Trichoderma, (8) Sumenep + Trichoderma, (9) Trisula + Trichoderma, (10) Violeta 1 + Trichoderma, (11) Maja Cipanas + Trichoderma, (12) Ambasador + Trichoderma. *Trichoderma* sp. as a treatment was applied as Trichocompost which was previously incubated in compost media. Before becoming in the form of Trichocompost, *Trichoderma* isolates were reproduced in maize media and incubated for 7 days. After it was grown on maize media, it was mixed with compost with a ratio of 1: 6 and incubated for one week before ready for use.

The planting container used is a polybag 40 × 40 cm. The media used for planting is a mixture of husk charcoal, chicken manure and horse manure (1: 1: 1). The media mixed with 30 g of *Trichoderma* sp. for each poly bag one day before planting.

The variables observed included plant growth (plant height, number of tillers and number of leaves), disease attack and crop yields. Symptom of *A. porri* and *S. vesicarium* infection was observed by following a scale of 0-4 as follows (Table 1):

| Score | Spot area (%) |
|-------|---------------|
| 0     | No visible spot |
| 1     | 1 – 25         |
| 2     | 26 – 50        |
| 3     | 51 – 75        |
| 4     | > 75           |

Table 1. Scala and pathogenicity criteria of *A. porri* and *S. vesicarium*.
The disease intensity is calculated using the formula:

\[
IP \, (\%) = \frac{\sum (n \times v)}{N \times V} \times 100
\]

Where:
- \(IP\) = Disease intensity (%)
- \(v\) = scale for each symptom category
- \(n\) = number of infected leaves
- \(V\) = the highest scale
- \(N\) = number of leaves observed

3. Results and discussion

3.1. Plant growth

The results of statistical analysis on the height of shallots at each treatment 2 weeks after planting (WAP) showed no significant difference between the varieties given Trichoderma and without Trichoderma (Figure 1), but for Trisula and Ambasador with Trichoderma and without Trichoderma application showed significant differences with other treatments. In the 4 WAP observations, it appeared that the varieties applied by Trichoderma showed a higher plant height than those without Trichoderma. Likewise, at the age of 6 WAP observations on the treatment of varieties applied by Trichoderma, it appeared that the plant height was higher, except for Trisula whose height was almost the same whether with or without Trichoderma. In the 6 WAP observations, the highest number of shallot plants was shown by Ambasador which were not significantly different from the varieties of Batu Ijo and Trisula with the application of Trichoderma. Regarding the ability of Trichoderma as a growth promoter, it was also reported by [14] on wheat and beans [15]. In the observation at 4 WAP, the highest number of leaves was produced from the Ambasador which was not different from all varieties except Sumenep and Maja Cipanas without Trichoderma (Figure 2). In the observation at 6 WAP, the highest number of leaves was still produced by Ambasador which was not significantly different from Batu Ijo without Trichoderma, as well as Batu Ijo, and Trisula which were applied by Trichoderma.

![Figure 1. Average plant height of several treatments in few weeks after planting (WAP).](image-url)
For the average number of tillers at the age of 2, 6, and 8 weeks after planting (WAP), it appeared that there was no significant difference between varieties except for the Sumenep (Figure 3). This variety produced the least number of tillers, which was only 3-4 tillers. Meanwhile, the other varieties had 6-7 tillers. In terms of number of tillers, it seemed there was no positive response for Trichoderma application and without application. It is possible that in this case the genetic role of the different varieties appeared. As reported by [16] stated that the number of shallot bulbs in Ampenan cultivar was moderate (21.05%). In this case, the heritability value means that the character of the number of shallot tubers is mostly influenced by genetic factors and is slightly influenced by the environment. The results of the study also explained that there was no difference in the number of tillers obtained from the five varieties tested in this study.

Figure 2. Average number of leaves from several treatments in few weeks after planting.

Figure 3. Average number of tillers from several treatments in few weeks after planting.
3.2. Disease progression

Plant diseases that arose during the activity were purple blotch disease (*Alternaria porri*) and *Stemphylium vesicarium*. Purple blotch disease has started to appear in shallot plants aged 3 WAP with the highest attack found in the Batu Ijo variety without Trichoderma with the intensity of 3.33%, Maja Cipanas (2.67%), and Ambassador (2.00%) (Figure 4). At the age of 4, 7, 8 DAP observations, all plants showed almost even disease attack and there was no significant difference. In the shallot, the vegetative phase conditions at the age 4, 7, 8 DAP were susceptible to disease. If the condition of the plant at that age the attack is light, the plant can survive until the generative phase, but if the attack is severe, the plant cannot produce tubers. It is assumed that the severity of the disease depends on the intensity of the attack based on the scoring and genetic conditions of each variety.

On the observations of the age of onion plants 7 and 8 DAP, it appeared that there had been differences in disease attacks between varieties without and with Trichoderma, in this case the lowest *A. porri* disease attack was shown in the Violeta that was applied Trichoderma with an attack intensity of 0.67%, where at that age (8 DAP) there was a decrease in disease attacks. The low intensity of attack on the Violeta variety was probably because the variety, based on the description, was somewhat resistant to *A. porri* [6] Based on the results of the overall observation of all treatments, it appeared that the varieties applied by Trichoderma showed lower disease attacks than those without Trichoderma. Regarding the ability of Trichoderma in suppressing plant diseases, it has been widely reported, such as the report by [17] that the attack of *Fusarium oxysporum* and *Alternaria alternate* diseases in legume plants can be reduced by the addition of Trichoderma applications, and *Phytophthora infestans* can be inhibited by up to 86% [18] besides that Trichoderma can also suppress major diseases in legumes such as *Rhizoctonia solani*, *Sclerotium rolfsii*, *Macrophomina phaeolina*, *Alternaria alternata*, *Fusarium solani* and *Colletotrichum capsici* with inhibition percentage values of 70%, 68.2%, 70.0%, 73.3%, 69.3% and 70.1% respectively [19].

![Figure 4](image-url) Figure 4. The effect of treatments to the intensity of the *Alternaria porri* in few weeks after planting (WAP).

In addition, other research states that if Trichoderma can be applied with *Pseudomonas fluorescens*, it will be more effective in suppressing *A. porri* [11] compared to individual applications [20]. The low intensity of *A. porri* attacks in this study was more due to weather conditions that did not support disease development. According to [3] high humidity is not enough to cause infection, especially at the time of this study the weather conditions were relatively dry. Application of *T. harzianum* Th-3013 in vivo under greenhouse conditions caused disease reduction up to 52.3 and 79.9% before and after 48 h of the pathogen inoculation, respectively [8].

Apart from *A. porri* disease, there are also attacks *Stemphylium vesicarium*. The attack of this disease is higher than *A. porri*. At the beginning of the observation when the shallot plants were 3 week after planting (WAP), the varieties that did not show symptoms of *S. vesicarium* attack were the
Sumenep and Violeta 1 without and with the application of Trichoderma, while the high intensity was shown by the Batu Ijo (Figure 5). At the age of 4 WAP, the highest attack symptom was found in the Trisula variety without Trichoderma and those without *S. vesicarium* symptoms at that age were the Sumenep. At the age of 5 to the age of 7 WAP the intensity of the disease attack was almost evenly distributed in all treatments with the percentage of attacks between 1 - 12%. At the age of 8 WAP, the attacks increased in line with the age of the plants, with the highest attack shown by Trisula without Trichoderma, reaching 33.33%, then Violeta 1 and Maja Cipanas.

Among treatments, it appeared that the varieties without Trichoderma had a higher attack than when Trichoderma was applied. The increasing attack of *S. vesicarium* at the age of 8 WAP is also due to the symptoms of the disease attacking shallot plants more often before the generative. As reported by [21] that *S. vesicarium* conidia are scattered from brown symptomatic lesions that already exist in the vegetative phase which is a source of secondary inoculum as pseudothecia. Another source states that at the age of 54-69 day after planting (DAP) the dominant symptom that attacks shallots is *S. vesicarium* (42%), while *Alternaria porri* (6%) and a mixture of other diseases (52%) [22]. Another study states that *S. vesicarium* is often associated with *A. porri* with attack intensities of 39.8% and 2.6%, respectively, while a mixture of two pathogens reached 57.6% [23]. [24] stated that at the age of 61 DAP the damage by *S. vesicarium* reached 15-87%.

![Figure 5](image_url)

**Figure 5.** The effect of treatments to the intensity of the *Stemphylium vesicarium* in few weeks after planting (WAP)

### 3.3. Yields

Production components consisted of the number of tubers, the wet weight and the dry weight of the tubers. Effect of combination of varieties and *Trichoderma* sp to the highest number of tubers was resulted in the Violeta 1 applied by Trichoderma with the number of tillers reaching 8.72. This average was not significantly different from other treatments except for the Sumenep variety with and without Trichoderma, and the Batu Ijo variety. In terms of the average number of tillers, Sumenep produced the lowest number of tillers with an average of only 5 tubers, and Batu Ijo an average of 6. While other varieties produced 7 to 8 tillers (Figure 6). The highest wet weight was produced in the Batu Ijo treatment with Trichoderma application of 64. 56 g per clump which was not different from the treatment of all Trichoderma application varieties, except for Sumenep with and without Trichoderma,
Trisula, Maja Cipanas and Ambasador applications. Likewise, the highest dry weight of ascp was achieved by the Batu Ijo variety with Trichoderma application which reached 53.36 g per hill. The average dry weight was not different from the varieties that used the Trichoderma application, except for the Sumenep variety, although the Trichoderma application was not able to increase the tuber weight. In addition to small tubers, Sumenep only produced 3 - 4.5 g per tuber and has a small number of tillers (Table 6). The same results for the number of tubers, low wet weight and dry weight of the Sumenep were reported by [25]. However, the advantages of this variety is to have a high volatile content, so it is very suitable as raw material for the fried shallot industry, as reported by [26] that Sumenep onions are very dominant used for processing fried onions in Kuningan.

Overall, the dry weight of shallot bulb extract applied by Trichoderma was higher than that which was not applied by Trichoderma with an average of above 40 g per hill, except for Sumenep variety. From these data shown, Trichoderma sp. can increase the dry weight of the tubers. This was stated by [27] that some rhizosphere competent Trichoderma strains have a direct effect on plants, increase their growth potential and nutrient uptake, use efficiency of fertilizers, percentage and speed of seed germination, and stimulate plant resistance to biotic and abiotic damage. Apart from directly suppressing the development of plant pathogens, some Trichoderma isolates are known to affect the phytohormonal tissues of their host plants, which will result in improving plant growth and stress tolerance [28].

Figure 6. Number of tubers, wet weight and dry weight of shallot bulbs per hill.

4. Conclusion

The use of Trichoderma can reduce the attacks of Alternaria porri and Stemphylium vesicarium diseases. The Ambasador and Violeta 1 varieties that were applied by Trichoderma were a treatment with a low attack intensity percentage against both diseases with an attack percentage of 0.67-2.67% and 6.67-15.33%. To reduce disease attacks in shallot, it is recommended to use Trichoderma before planting.

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