Chemical characters of disease suppressive and conducive soil of Moler on shallot in Brebes Central Java

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Abstract. In the latest years, a disease epidemic of Moler caused by Fusarium oxysporum f.sp. cepae have just occurred in Brebes Central Java. The disease intensity, however, varies between the shallot production lands. Some lands show suppressive with disease intensity lower than 5%, and others are conducive to disease intensity over 50%. It is interesting that in Brebes occur suppressive and conducive soil to moler disease. The suppressiveness may be determined by environmental conditions, including chemical soil characters. This paper reports the chemical character of suppressive and conducive soil to moler disease in Brebes. The evidence shows that the suppressive soil is more fertile than that conducive one. The suppressive soil is chemically characterized by significantly higher organic mineral, C-organic, P-available, K-exchangeable, and Cation Exchange Capacity than that conducive one.

1. Introduction

Shallots are the leading commodity of lowland farmers in Brebes, Central Java, contributing the most prominent (30%) of shallot production in Indonesia [1]. In recent years, moler disease (twisting disease) caused by Fusarium oxysporum f.sp. cepae (Hanzawa) Snyder & Hansen (FOCe) has become an epidemic in the region [2]. Cultivation practice factors play an important role in the epidemic [3]. Lack of organic fertilizers and lack of crop rotation by farmers, on the one hand, are responsible for decreasing soil fertility, and on the other hand, potentially increasing moler disease intensity [4,5]. However, the intensity of moler disease varies widely between fields, ranging from very low (less than 5%) to very high (more than 50%) [3]. There are both suppressive and conducive soils to the disease [6–8]. This paper reports the phenomenon of variations in the intensity of moler disease in 30 shallot fields in Brebes, Central Java. Analysis of soil chemical character in this area supports the relationship between soil suppressive and soil conducive to moler disease intensity.

2. Materials and methods

2.1. Place and time

This survey research was conducted in April–May 2021. A total of 30 samples of shallot fields were determined from seven of the 17 sub-districts in Brebes Regency, which have the largest shallot fields. They are Larangan, Tanjung, Bulakamba, Wanasari, Songgom, Jatibarang, and Brebes. For each sub-district, 4–5 lands were selected to be sampled.
2.2. Disease intensity measurement
The research fields are determined by purposive sampling. Fields, with an area of at least 100 m$^2$, with plants aged 50–60 days after planting, were selected. Ten shallot beds from each field were sampled, and their disease intensity was measured by the scoring method and calculated by the following formula:

$$DI = \frac{\sum (n \times v)}{N \times Z} \times 100\%$$

Where $DI$ = Disease Intensity; $n$ = number of plants in category; $v$ = category value; $N$ = total number of plants, $Z$ = The highest category value used. The category values are: 0 = beds with no moler; 1 = beds with 1–25% moler; 2 = beds with 26–50% moler; 3 = beds with 51–75% moler; and 4 = beds with 76–100% moler.

2.3. Suppressive and conducive field designation
Shallot field with disease intensity equal to or less than 5% is designated as a suppressive field, while shallot field with an intensity equal to or more than 50% is defined as a conducive field.

2.4. Soil sampling
Three of each represented suppressive and conducive field were randomly selected. About 100 g of soil samples were randomly taken from every 10 locations, and then the soil was composited. Soil chemical analysis was carried out at the Soil Chemistry Laboratory, Faculty of Agriculture, Universitas Sebelas Maret (UNS). The observed variables were pH, organic matter, C-organic, N-total, C/N ratio, P-available, K-switched, Cation Exchange Capacity (TK).

2.5. Data analysis
The average difference of each value of soil chemical properties on suppressive and conducive was tested in pairs with T-Test. The significance value of the $T$-test is 5%. The relationship between disease intensity and yield and the percentage of yield loss was figured as a regression correlation.

3. Results and discussion
The moler disease intensity caused by FOCe in 30 shallot fields in Brebes, Central Java, varied widely, from zero to 75% (Figure 1), with an average value of 20.64% and a standard deviation 20.94%. Nine of 30 fields have 50% or more disease intensity, showing as conducive soils, while three of 30 fields have 5% or less disease intensity, showing as suppressive soils. Almost all of the chemical properties measured that of taken from disease suppressive were significantly different that of taken from conducive soils. Only N Total (‰) and Cation Exchange Capacity (me ‰) are not significantly different (Table 1). The variations in the intensity of moler disease in Brebes, Central Java (Figure1) and significant differences in almost all soil chemical characteristics between suppressive and conducive soils (Table 1) indicate a direct or indirect relationship between the two.

Figure 1. Moler disease intensity of Bima varieties Shallots in thirty shallot fields in Brebes, Central Java.
The relatively high molar disease intensity may be related to overall soil chemical properties. The number (%) of C-organic and N-total are low. Even the C/N ratio is very low. Currently, farmers in Brebes rarely use organic fertilizers in shallot cultivation [3]. However, the organic matter content in the suppressive soil was higher than in the conducive soil. Organic matter provides not only essential nutrients but also a complex of micronutrients, improves soil structure, and increases the activity of functional microorganisms. They can play a role in suppressing diseases caused by weak pathogens such as Fusarium.

Table 1. Chemical properties of disease suppressive and conducive soil at Brebes, Central Java

| Chemical Properties | Soil Character | Replication of Soil Samples | Composite | Average | Criteria\(^1\) | T-Test Significance |
|---------------------|----------------|----------------------------|-----------|---------|----------------|--------------------|
| pH-H\(_2\)O         | Suppressive    | 6.38 6.42 6.36             | 6.39      | Rather acid | Neutral        | 0.017*             |
|                     | Conducive      | 6.68 6.65 6.51             | 6.61      | Neutral | Neatral        | 0.0117*            |
| Organic Metter      | Suppressive    | 2.08 2.13 2.06             | 2.09      | Low     | Low            | 0.002*             |
|                     | Conducive      | 1.80 1.89 1.90             | 1.86      | Low     | Low            | 0.004**            |
| C-organic (%)       | Suppressive    | 1.24 1.19 1.22             | 1.22      | Low     | Low            | 0.002*             |
|                     | Conducive      | 1.04 1.10 1.04             | 1.04      | Low     | Low            | 0.003*             |
| N Total (%)         | Suppressive    | 0.26 0.26 0.25             | 0.26      | Low     | Low            | 0.094**            |
|                     | Conducive      | 0.25 0.25 0.25             | 0.25      | Low     | Low            | 0.0017*            |
| C/N Ratio           | Suppressive    | 4.77 4.58 4.88             | 4.74      | Very Low | Very Low       | 0.047*             |
|                     | Conducive      | 4.16 4.40 4.16             | 4.24      | Very Low | Very Low       | 0.0117*            |
| P-available (ppm)   | Suppressive    | 16.95 14.62 16.02          | 15.86     | Medium  | Medium         | 0.044*             |
|                     | Conducive      | 13.07 13.38 13.84          | 13.43     | Medium  | Medium         | 0.006**            |
| K-Exchangeable (me %)| Suppressive    | 0.39 0.41 0.46             | 0.42      | Medium  | Medium         | 0.017*             |
|                     | Conducive      | 0.33 0.34 0.35             | 0.34      | Low     | Low            | 0.005*             |
| Cation Exchange Capacity (me %) | Suppressive | 25.85 25.44 25.80 | 25.70 | High | High | 0.171** |
|                     | Conducive      | 20.76 20.60 20.64          | 20.67     | Medium  | Medium         | 0.171**            |

\(^1\) Criteria by Balai Penelitian Tanah in 2009
* = significantly different
** = non significant

The P-availability and K-exchangeable in this study may be the most influential factor in the intensity of molar disease in suppressive and conducive soils. The P-available and K-exchangeable in the suppressive soil were significantly higher than in the conducive soil (Table 1). K (potassium) and P (phosphate) are essential nutrients that play an important role in various physiological and structural processes of plants in responding and protecting themselves against biotic and biotic environmental stresses [9]. Phosphate-solubilizing-fungi increasing P-available have been shown to suppress the development of molar disease [10]. The application of 100 kg.ha\(^{-1}\) of KCl fertilizer on sandy soil can extend the disease's incubation period and suppress molar disease on shallots with a very good effectiveness value (89.23%) [11]. On the other hand, phosphorus and potassium deficiency in garlic has been reported to increase the molar intensity of garlic [4].

In this study, although the soil acidity (pH) in the suppressive soil (6.39) was significantly lower than the conducive soil (6.61), the difference was not much, only 0.22. Thus, the pH factor does not seem to play a role in the difference in molar disease intensity between suppressive and conducive soils. To be noted, *Fusarium* can grow well in acidic media [12,13]. Media acidity (pH) affects the production of degradative enzymes involved in the pathogenesis of *Fusarium*. Using lime reduces pathogen persistence by increasing soil pH to a neutral range (6.5–7.0) [14,15].

The study shows that the suppressive soil is more fertile than that conducive one. The suppressive soil is chemically characterized by significantly higher organic mineral, C-organic, P-available, K-exchangeable, and Kation Exchange Capacity than that conducive one.
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