Distribution of black shank disease on Temanggung tobacco and environmental factors affecting disease development

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Abstract. Temanggung tobacco recognized for its aromatic character and high-nicotine content is a main component of clove cigarette. Currently, it only fulfils 30% of market requests. A major issue is low productivity caused by land fertility degradation and pathogens invasion such as Phytophthora nicotianae, the causal agent of black shank disease. This research aimed to determine the incidence level and distribution of the disease within tobacco plantation in Temanggung. A survey was conducted on 53 locations determined by a land system method. The incidence of black shank was recorded for each location as well as soil samples were also taken to identify soil nutrient contents. The results revealed that black shank was found at various incidence levels in several sampling points, especially in the paddy land. In dry land, none of black shank was found. In contrast, in paddy land black shank incidence reached up to 44%. It indicated that environmental condition influenced development of black shank. C-organic has a negative correlation with black shank incidence. High black shank incidence took place in low C-organic areas. C-organic has an important effect on the improvement of physical and chemical structure of soil characters as well as the equilibrium of soil microbes.

1. Introduction
Temanggung tobacco is a type of dried sliced tobacco which is used for a main component of clove cigarette. As a major compound it occupies for 14-26% of clove cigarette components [1]. Temanggung tobacco has a special characteristic on its aroma and high nicotine content ranging from 3 to 8% [2]. These properties make Temanggung tobacco in great demand by cigarette factories which result in high price of tobacco.

In line with an increasing need for clove cigarette production, the requirement of Temanggung tobacco also increases. Study conducted by Djumali [3] revealed that the need of Temanggung tobacco could reach up to 31.200 ton per year. On the other hand, Bappeda-Temanggung [4] reported that Temanggung tobacco production was 6,922 ton per year, which meant it only meet about 22% of the need. This amount is still less to meet market demand.

Low production of Temanggung tobacco is due to various factors including accumulation of soilborne pathogens within tobacco land and intensive tobacco planting even in the land with more than 40% elevation. Consequently, it could become a major factor for land erosion and loosing of topsoil which could cause land fertility degradation [2, 5]. Possibly, intensive tobacco growing both in the land normally used for tobacco and new land becomes a factor causing soilborne pathogen accumulation [5].

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The land, which is accumulated by soilborne pathogens including *Ralstonia solanacearum*, *Phytophthora nicotianae* and *Meloidogyne* spp. was generally known as *lincat* land and the disease occurred at that land was called by *lincat* disease [5]. Due to the *lincat* disease, tobacco production was decreased from 1 ton/ha to 0.4 ton/ha with total production could only reach 16.821 ton in 2016 [6, 7]. Although black shank disease is one of most important diseases on Temanggung tobacco, there was limited information on the distribution of that disease across Temanggung tobacco plantation. It can cause difficulties in determining proper control methods for the disease.

Mapping distribution of black shank disease is very important, as it relates to determination of proper control method for soilborne disease and specific location. The control method should concern on the management of environmental factors affecting disease development, such as soil nutrient content and organic matter. As it was generally known that organic matter highly influences on soil-inhabitant microbial composition with various functions. The diversity of soil microbes also affects the existence of soilborne pathogens. Previous research reported that organic matter within tobacco land in Temanggung was very low [8]. Therefore, this research aimed to map distribution of black shank disease on tobacco plantation in Temanggung and identify factors affecting disease development in the field.

2. Materials and methods

This research was conducted by a survey on 53 sampling points in Temanggung District determined by land system method. It spread on 13 sub-districts and 43 villages, with various elevation ranged from 500-1400 m above sea level (asl). On those 53 sampling points, the observation of black shank disease was carried out at two-months tobacco. For each sampling point, the observation was conducted on 25 tobacco plant then the incidence of black shank was recorded. Afterward, the black shank incidence was classified as follow: very low (<10%), low (11–20%), moderate (21–30%), high (31–40%) and very high (>40%) [9].

In addition, the soil samples were also taken to determine soil nutrient contents and organic matter. Soil sampling was conducted as a composite, which meant for every sampling point determined three points diagonally then the soil samples were taken from those three points and collected into one sample.

To achieve more comprehensive understanding about the land’s history and farmer’s cultivation methods, an interview with prepared questionnaires was also conducted towards tobacco farmers who work on 53 sampling points.

Based on the data of black shank incidence, then the map of its distribution across tobacco plantation in Temanggung was created according to Kriging method using ArcGIS 10.6 program.

3. Results and discussion

According to the observation of black shank incidence, we found that the disease incidence ranged from 0-44% that could be classified as very low to very high (Table 1). However, not all locations were found to have this disease (Figure 1). This may relate to environmental conditions when the survey was taken place. There was not rain for three months until we did survey, as a result, it was very dried and not favourable for development of black shank disease. However, we got an interesting finding, in which most of infected field was paddy land which has high soil moisture rather than dry land.

| Sampling point | Village      | Sub-district | Black shank incidence (%) | Geographical coordinates          |
|----------------|--------------|--------------|---------------------------|-----------------------------------|
| 1              | Kemloko      | Tembarak     | 0.00                      | 7°22'21.012"S 110°7'42.904"E     |
| 2              | Ngadiirto    | Selopampang  | 0.00                      | 7°22'28.969"S 110°8'22.844"E     |
| 3              | Kemloko      | Tembarak     | 0.00                      | 7°22'16.225"S 110°7'59.352"E     |
| 4              | Pagersari    | Tlogomulyo   | 0.00                      | 7°20'54.016"S 110°7'18.365"E     |
| 5              | Tawangsari   | Tembarak     | 0.00                      | 7°21'58.785"S 110°8'56.986"E     |
| 6              | Legoksari    | Tlogomulyo   | 0.00                      | 7°21'34.011"S 110°6'56.914"E     |
| No. | Village       | Town              | Latitude          | Longitude         |
|-----|---------------|-------------------|-------------------|-------------------|
| 7   | Gandu         | Tembarak          | 7°20'29.755"S     | 110°8'47.485"E   |
| 8   | Jetis         | Selopampang       | 0.00              | 0.00              |
| 9   | Losari        | Tlogomulyo        | 0.50              | 0.00              |
| 10  | Krajan        | Tembarak          | 0.00              | 0.00              |
| 11  | Losari        | Tlogomulyo        | 0.00              | 0.00              |
| 12  | Pagergunung   | Bulu              | 0.00              | 0.00              |
| 13  | Losari        | Tlogomulyo        | 0.00              | 0.00              |
| 14  | Losari        | Tlogomulyo        | 0.00              | 0.00              |
| 15  | Tlogomulyo    | Tlogomulyo        | 0.00              | 0.00              |
| 16  | Wonotirto     | Bulu              | 24.00             | 0.00              |
| 17  | Wonosari      | Bulu              | 0.00              | 0.00              |
| 18  | Pandemulyo    | Bulu              | 0.00              | 0.00              |
| 19  | Tlahap        | Kledung           | 4.00              | 0.00              |
| 20  | Wonotirto     | Bulu              | 4.00              | 0.00              |
| 21  | Candisari     | Tlogomulyo        | 0.00              | 0.00              |
| 22  | Wonosari      | Bulu              | 0.00              | 0.00              |
| 23  | tegalurung    | Bulu              | 32.00             | 0.00              |
| 24  | Gandurejo     | Bulu              | 0.00              | 0.00              |
| 25  | Glapansari    | Parakan           | 0.00              | 0.00              |
| 26  | Pagergunung   | Bulu              | 0.00              | 0.00              |
| 27  | Gilingsari    | Temanggung        | 0.00              | 0.00              |
| 28  | Wonotirto     | Bulu              | 0.00              | 0.00              |
| 29  | Tuksari       | Kledung           | 0.00              | 0.00              |
| 30  | Pakurejo      | Bulu              | 0.00              | 0.00              |
| 31  | Jeketro       | Kledung           | 0.00              | 0.00              |
| 32  | Pagergunung   | Bulu              | 0.00              | 0.00              |
| 33  | Balesari      | Bansari           | 8.00              | 0.00              |
| 34  | Canggal       | Kledung           | 0.00              | 0.00              |
| 35  | Tlahap        | Kledung           | 0.00              | 0.00              |
| 36  | Katekan       | Ngadirejo         | 0.00              | 0.00              |
| 37  | Mranggen Tengah | Bansari       | 0.00              | 0.00              |
| 38  | Gondosuli     | Bulu              | 0.00              | 0.00              |
| 39  | Campursari    | Bulu              | 44.00             | 0.00              |
| 40  | Bansari       | Bansari           | 0.00              | 0.00              |
| 41  | Purboerejo    | Bansari           | 0.00              | 0.00              |
| 42  | Candisari     | Bansari           | 0.00              | 0.00              |
| 43  | Giripurno     | Ngadirejo         | 0.00              | 0.00              |
| 44  | Kentengsari   | Candiroto         | 0.00              | 0.00              |
| 45  | Purbosari     | Ngadirejo         | 0.00              | 0.00              |
| 46  | Mangunsari    | Ngadirejo         | 0.00              | 0.00              |
| 47  | Purwosari     | Wonoboyo          | 0.00              | 0.00              |
| 48  | Campurejo     | Tretip            | 0.00              | 0.00              |
| 49  | Cemoro        | Wonoboyo          | 0.00              | 0.00              |
| 50  | Tawangsari    | Wonoboyo          | 28.00             | 0.00              |
The highest incidence of black shank disease was 44% which occurred at sampling point 39 situated in Village of Campursari, Sub-district of Kedu. The type of this land is a paddy land with high soil moisture. This condition is favourable for the development of *P. nicotianae*, the causal agent of black shank disease. Gallup et al [10] revealed that the incidence of black shank disease commonly associated with wet soil. In our agricultural ecosystem, wet soil is represented by paddy land. Moreover, Gallup et al [10] stated that the release of zoospores from sporangia which roles as primary infective propagules is encouraged by saturated soil. In that condition, make it possible to zoospores to move into greater distance to reach the host plants.

**Figure 1.** Distribution of black shank disease in tobacco plantation across Temanggung District

Black shank is one of major diseases on tobacco plantation worldwide which can cause considerable yield losses up to million dollars annually [11–14]. The disease could infect all stages of tobacco including seedling stage and mature plant in the field. It could also affect all parts of tobacco such as root, stem, and leaves [11]. The infected plants show yellowing and wilting leaves, rot at the lower stem which then turn into black and finally plant death (Figure 2). When the infected stems were sliced, it would appear blackened pith with distinctive disks along necrotic stem (Figure 3).

The development of black shank disease highly depends on environmental conditions including temperature and moisture. The disease would be well developed in warm moist soil. Gallup et al [10] stated that initial disease on tobacco seedlings or within the field occurred when soil temperature increases more than 20°C. In addition, agroecosystem surrounding tobacco plant including soil chemistry such as pH and nutrient content especially C-organic might also influence the disease. Soil
pH more than 6.2 is favourable for black shank development. In contrast, the disease is suffered from low pH. Moreover, the fungal pathogen of black shank disease is also vulnerable to aluminium. In which the increase activity of aluminium, which normally occurs at low level of pH, is highly toxic to the fungus [10].

The content of C-organic within soil also plays an important role in the development of black shank disease. Our results revealed that C-organic content has a negative correlation with the incidence of black shank disease. This indicated that high disease incidence occurred in locations with low C-organic content. Our survey on 53 sampling points showed that C-organic and organic matter content of tobacco field ranged from 0.80 to 2.93% and 0.89 to 5.07% respectively, which could be categorized as very low to moderate (figure 4). The sampling point of 39 which was known to have the highest incidence of black shank disease only has 1.01% of C-organic.

C-organic content within soil might relate to the diversity and population of soil microbes, as the nutrient acts as source of nutrition for supporting microbial growth. In addition, the existence of soil microbes also associated with the development of soil suppressive. It is a condition where the soil has
an ability to inhibit pathogen development itself or minimalize the incidence of diseases caused by soilborne pathogen. In addition to the establishment of soil suppressive, C-organic content also plays on the improvement of physical and chemical structure of soil characters as well as the equilibrium of soil microbes.

4. Conclusion
Based on this survey, it can be summarized that the incidence black shank disease caused by a fungus *P. nicotianae* was varied, ranged from 0–44%. The highest incidence was found in the paddy land characterised with wet and high soil humidity. The environmental conditions have significant influence on development of the disease.

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References
[1] Basuki S, Rochman F and Yulaikah S 2000 *Monograf Tembakau Temanggung* 5 1–6
[2] Prasetiyo A, Djajadi and Sudarto 2016 *Jurnal Tanah dan Sumberdaya Lahan* 3 389–399
[3] Djamali 2008 Disertasi Doktor (Malang: Universitas Brawijaya)
[4] Bappeda-Temanggung 2015 *Statistik Kabupaten Temanggung 2015* (Temanggung: Bappeda)
[5] Yulianti T 2009 *Perspektif* 8 1–16
[6] Achmad D and Mukani 2004 *Prosiding Diskusi Panel Revitalisasi Sistem Agribisnis Tembakau Bahan Baku Rokok* (Bogor: Pusat Penelitian dan Pengembangan Perkebunan)18–20
[7] Temanggungkab.go.id/berita/detail/201702/3792/petani-diminta-waspada-hama-tembakau-
html

[8] Djajiadi and Murdiyati 2000 *Monograf Tembakau Temanggung* 5 32–39
[9] Abadi A L 2003 *Ilmu Penyakit Tumbuhan* III (Malang: Bayumedia) p 137
[10] Gallup C A, Sullivan M J and Shew H D 2006 *The Plant health Instructor*
[11] Gutierrez W A and Mila A L 2007 *Plant Disease* 91 985-989
[12] Gallup C A and Shew H D 2010 *Plant Disease* 94 557-562
[13] Mila A L and Radcliff J 2014 *Flue-Cured Tobacco Guide* (Raleigh: North Carolina State University) p 124–156
[14] Bittner R J, Sweigard J A and Mila A L 2017 *Crop Protection* 102 63–71