Diversity of cassava-infecting diseases in district of Ponjong, regency of Gunungkidul, special region of Yogyakarta

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Abstract. The regency of Gunungkidul is the largest cassava (Manihot esculenta Crantz) production centers in Special Region of Yogyakarta. However, proper reference about cassava diseases was insufficiently available, thus local farmers were unable to distinguish disease symptoms found in the field. This study was aimed to identify various cassava-infecting diseases found in District of Ponjong, Regency of Gunungkidul. Disease survey was conducted using purposive sampling method at 4 months-aged plant. A survey was performed in three villages (Karangasem, Kenteng and Bedoyo) and each village was represented by three field plots. Disease incidence and severity were evaluated every two weeks. Data were analyzed statistically using a one-way analysis of variance and the difference between survey locations was assessed using DNMRT with a p<0.05. The highest disease incidence was recorded in Bedoyo village. Results showed the presence of six diseases infecting cassava in District of Ponjong in different level of incidence. Of those six diseases, three diseases were found in all locations with a high incidence up to 100%, namely brown leaf spot, diffuse leaf spot and anthracnose. These data were potential to be a reference in developing a proper disease control strategy to minimize the cassava-infecting diseases in District of Ponjong.

1. Introduction

Cassava (Manihot esculenta Crantz) belongs to the world’s five major food crops [1]. It has become one of the main staple foods for million of people in tropical regions, such as Africa, Latin America and Asia [2]. [1] reported that cassava had been consumed by reached approximately 800 million people. It is also considered as one of the most reliable crops to maintain the global food security due to its biochemical attributes. Besides, the utilization of cassava had been widely used for feeds and industrial products (starch and bioethanol) [3, 4]. Cultivation of this crop in Southeast Asia had been performed mostly by smallholder farmers (ca. 8 million) with area used had reached about 4 million hectares [1, 5]. [6] mentioned that the lands used for global cassava cultivation were recorded around 19 million hectares, including less productive and highly arid lands.

Cassava is the second most widely cultivated crop after rice in Special Region of Yogyakarta [7]. This crop exhibits a remarkably high tolerance against unfavorable condition, thus its cultivation can be performed even in a marginal yet infertile land. Therefore, most of smallholder farmers in Southeast Asia preferred to cultivate this crop, particularly for those who faced several serious geographical limitations [4, 8, 9]. Regency of Gunungkidul is one of the cassava production centers in Yogyakarta known to be highly arid area. Local farmers cultivated cassava using intercropping system.
as the alternative crop to be produced during the dry season. Due to its highly adaptive characteristic, cassava cultivation in Gunungkidul was mainly practiced without any proper input and treatment unlike other crops would get. This tendency led to a higher risk of disease infection.

Recently, cassava diseases have been at a high priority for most phytopathologists in Southeast Asia as it threatened the global food security [5]. Causal agent of cassava bacterial blight (CBB), Xanthomonas axonopodis pv. manihotis (Xam) belongs to the top 6 among the list of world’s most economically important bacterial pathogens [10]. In addition, African cassava mosaic virus (ACMV) placed the top 7 out of 10 world’s most destructive plant viruses [11]. However, the infection of cassava mosaic diseases (CMD) was recorded to be highly dominant in several regions of Southeast Asia [12, 13]. Other commonly found disease, brown leaf spot (BLS) caused by Cercosporidium henningsii, was reported to be a main leaf disease in cassava [14].

The majority of cassava farmers in Gunungkidul cultivated local cultivars. Lack of input and treatment applied during the cassava cultivation resulted in a lack of farmers’ knowledge regarding the plant growth condition, particularly once the plant infected by the diseases. Additionally, reference of cassava diseases infecting cassava production centers in Indonesia (including Gunungkidul) had not sufficiently represented the condition in most areas. Therefore, this present study was aimed to identify the disease diversity infecting several cassava plantations in District of Ponjong. This information might contribute as a cultivation reference for local farmers in Gunungkidul, particularly regarding the disease management.

2. Materials and Methods

Data was collected in three cassava fields located in three villages (Bedoyo, Karangasem, and Kenteng), District of Ponjong, Regency of Gunungkidul, Special Region of Yogyakarta. The location of sample collection was determined through purposive sampling. The cultivation pattern applied in each selected village was identified through the interview with the farmers. Several related information was collected, including cropping system, adjacent crops, crop age, field size, planting season, planting material, cultivated variety, harvest age, productivity and applied pest management.

Disease monitoring was performed using 25 plants sampled from two diagonals in each field and village [15]. Disease symptoms were observed visually from 4-5 months-aged cassava every two weeks. Disease severity per field was scored using a 4-category scale ranged from 0 (no symptom) to 4 (>75% of plant area infected). Index of disease severity was calculated using this following equation:

\[
\text{Disease Severity Index} (\%) = \frac{\sum_{i=0}^{n} (n_i \times v_i)}{N \times V} \times 100
\]

where \( n_i \) is the number of infected plants in each degree, \( v_i \) is scoring degree, \( N \) is the total number of plants observed and \( V \) is the highest scoring degree [16]. The incidence of each disease was calculated by the percentage of infected plants among all plants observed in each field.

Statistical analysis was performed using SPSS version 23.0. Data were analyzed using one-way analysis of variance (ANOVA) and significance among villages was further evaluated using Duncan’s New Multiple Range Test (DNMRT) with a \( p<0.05 \). Data were presented as mean values supported by standard error and statistical notation (if any).

3. Results and Discussion

3.1. Cultivation Patterns of Cassava in District of Ponjong

Pattern of cassava cultivation in all selected fields showed several similarities, particularly the application of intercropping, the planting period at the beginning of the rainy season and the planting material used (Table 1). All cassava fields observed in each village of Ponjong District applied mixed intercropping system where more than one crop is grown simultaneously in the same field with a random placement. This system provided an alternative production resulted from other crops while
waiting for the harvest period of cassava commonly took 10-11 months after planting. Despite applying the same cropping system, each field combined different number and variety of crops to be intercropped with cassava. Generally, the adjacent crops used were cereals and legumes (Table 2). However, chili was also found to be part of this intercropping in some fields in Kenteng and Karangasem (Table 2).

### Table 1. Patterns of cassava cultivation applied in three villages of District of Ponjong.

| Variables               | Field Locations               |
|-------------------------|------------------------------|
| Field size (m²)         | Bedoyo           | Karangasem  | Kenteng  |
|                         | ± 3,250           | ± 2,500     | ± 2,000  |
| Crop age (DAP*)         | ± 120             | ± 120       | ± 134    |
| Cropping systems        | Mixed intercropping  |
| Planting season         | At the beginning of rainy season |
| Planting material       | Stem cutting (stake) from previous planting period |
| Cultivars used          | Gambyong, Gatotkaca, Karet, Kirek |
|                        | Kirek             |
|                        | Gatotkaca and Kirek |
| Pest management         | None              |
| Fertilizers applied     | None              |
| Harvest age (DAP)       | 300               | 300 – 330   | 330      |
| Productivity (tonne/ha) | 5.0 – 6.6         | 4.0         | 2.8      |

* DAP: Days after planting

Cassava cultivation in Regency of Gunungkidul, including Ponjong District is mostly practiced by small scale farmers possessing limited resources, both land and capital. The majority of local farmers considered cassava as a secondary crop cultivated due to its high tolerance against environmental stress that matched with this region dry climate. This condition restricted the farmer’s choice of cultivated crop as it was lack of water. Therefore, cassava farming in Ponjong District is generally practiced through the intercropping with cereals and legumes.

The rainy season was chosen by local farmers in Ponjong District as the planting period of cassava (Table 1). It was aimed to anticipate the water availability problem as the region is known to have a dry climate with relatively low annual rainfall. The order of each crop planting is arranged based on the water status during the growing season. As the water was in abundance, cassava was intercropped with rice, which required to be mostly irrigated during its vegetative phase. Several more drought-tolerant crops (maize and legumes) were grown subsequently after rice harvesting as the water had depleted significantly. Once maize and legumes were ready for harvest, farmers then waited for the harvesting of cassava only. Regarding the planting material, local farmers utilized the stake (stem cutting) from the previous season (Table 1) to be grown in the upcoming growing season. Unlike other crops, local farmers in Ponjong District tended to consider the cassava as a secondary crop, hence no proper crop management was given specifically for cassava during the growing season (Table 1).

The combination of intercrops is supposed to be arranged based on the complementary of growth requirements favored by each crop, particularly in term of type and rooting ability, height, canopy structure and nutrients necessity [17]. For small-scale farmers, intercropping could ensure the stability of crop yield and minimize the risk of significant loss due to certain crop failure [17-19]. This system also showed a remarkable contribution in maintaining the socio-economic stability of rural farmers [20]. Additionally, it also improved the productivity per land area unit, conserved the soil productivity, promoted more efficient utilization of environmental resources, suppressed the weed growth, reduced the occurrence of pests and diseases as well as optimized the biodiversity in the ecosystem [19, 21-27].
Considering the long period to reach its harvest age (Table 1), cassava in Ponjong District was generally intercropped with shorter-aged crops, such as cereals and legumes. This mixed cropping potentially created an efficient cycle of energy utilization among the intercrops. In addition, a contrast difference in the harvest age of each crop enabled a highly efficient utilization of growing seasons and lands. As this region is known to have an extremely different intensity of rainfall, the placement of early-maturing yet drought tolerance crops is highly recommended to be planted during the dry season [17].

Intercropping between cassava and legumes had been widely reported as a highly compatible mixed crops [28-30]. Cassava utilized a high amount of potassium (particularly during storage root development) and required nitrogen for its leaf development stage [31, 32]. In contrast, legumes played an important role as a nitrogen provider through its association with nitrogen-fixing bacteria, while these crops favored high P uptake [33]. [25] mentioned that the involvement of legumes within the intercropping system could minimize the competition of soil N uptake among the intercrops. Another study also reported more effective suppression of weed growth that might be attributed to the typical pattern of legume growth, which covered the soil surface [34]. Nonetheless, intercropping between cassava and cereals had been reported previously as the crop interaction improved the content of soil organic matter [30]. However, quantitative data on the effect of this intercropping system applied in Ponjong District toward the yield of cassava had not been measured yet, thus the efficacy of these crop combinations was still questioned.

3.2. Diversity of Cassava-Infecting Diseases

Generally, cassava cultivation in Bedoyo exhibited the highest dynamic of disease development compared to the other two villages (Fig. 1). Considering the cropping system used, cassava cultivation in Bedoyo combined the least variety of crops compared to Karangasem and Kenteng (Table 2). However, farmers in Bedoyo cultivated 2-3 different cassava cultivars altogether at the same growing period (Table 1). It might increase the disease spread, especially if there was susceptible cultivar among all cultivars grown. Moreover, the disease occurred in the adjacent crops could infect the cassava as a secondary host. Figure 1 also showed a significant increase in disease severity during the late canopy establishment stage (148-176 DAP) found in field 1 of Bedoyo.

Regarding the disease severity, nearly all observed cassava fields in Ponjong District revealed the disease severity index less than 60%, except in field 1 (Bedoyo) (Figure 1). It proved that the practice of intercropping in cassava cultivation suppressed the disease development significantly. The diversity shaped from the combination of intercrops was assumed to reduce the density of host [35] as the result of microclimate modification that become less favorable for the pathogen development. In line with this statement, [17] mentioned that significant change in microclimate affected the pathogen distribution, thus delayed the onset of certain disease. Previous studies reported the decrease of Ascochyta blight (Mycosphaerella pinodes) severity resulted in the intercropping of cereals and legumes [36]. The difference of canopy types among the intercrops might alter the microclimate, then stimulated a shorter period of leaf wetness, thus affected the development of this disease indirectly. The combination of legumes and cereals could improve the resistance of susceptible cultivar against certain disease [37]. As the majority of cassava fields in Ponjong District applied the intercropping, the field practicing monoculture one was pretty scarce to be found. This lack of information provide no equal comparison regarding the disease severity recorded, both in monoculture and intercropping system.

Disease types infecting cassava cultivation in Ponjong District were relatively similar in all villages observed, except the leaf rust that infected one cassava field in Kenteng only (Table 2). Of six diseases recorded, diseases found in all selected cassava fields in Ponjong District were dominated with brown spot, diffuse spot, antrachnose and bacterial blight (Table 2; Fig. 2). Three diseases (brown spot, diffuse spot, antrachnose) exhibited extremely high incidence since the beginning of the monitoring indicating that the infection might had occurred at the early stage of cassava growth (Fig. 2a-c). Lack of proper crop management and pest-free planting materials supported by the unfavorable climate for
plant growth might be several contributing factors that weakened the plant resistance, thus resulting in a more severe infection. Unlike these most severe diseases, infection of bacterial blight was also found in all fields with lower incidence ca. 25-56%. Nevertheless, the occurrence of leaf rust and sooty mold was pretty invisible suggesting that both diseases might not the main disease of cassava (data not shown).

Table 2 showed that number of cassava-intercropped crops contributed to the diseases diversity occurred in a field. Cassava field with the least crop combination exhibited the least diverse diseases occurred, as seen in field 3 (Bedoyo) and field 2 (Kenteng) (Table 2). In contrast, the more diverse the crop combination grown in a field (as seen in field 1 - Kenteng), the more diverse the diseases triggered (Table 2). Additionally, the combination of cassava-intercropped crops were assumed to stimulate the occurrence of certain disease. The intercropping between cassava, rice, maize and peanut seemed to trigger the development of sooty mold (Table 2). Unlike this combination, sooty mold was not detected in cassava fields intercropped with rice and peanut (Table 2) suggesting that the occurrence of this disease might be triggered by the presence of maize. Interestingly, this sooty mold symptom was missing from the cassava intercropped with rice, maize, peanut and chili (Table 2) indicating the presence of chili possibly reduced the possibility of this disease development. Table 2 also conferred the occurrence of leaf rust in field 1 (Kenteng) due to the high crop density and the presence of cowpea. Other remarkable pattern found was the decrease of bacterial blight incidence.
possibly related to the presence of maize, except in field 1 (Kenteng) (Table 2). However, the main factor triggering this decrease remained unknown. Further analysis by monitoring the disease incidence of cassava adjacent crops might provide better understanding regarding this pattern.

Despite being considered as quite severe in most of cassava fields, the diseases variety occurred was high (Table 2) revealing high incidence in several diseases, such as brown spot, diffuse spot and antrachnose. According to its incidence value (Fig. 2), it was predicted that those three diseases had appeared since the early stage of cassava growth. It might be attributed to the utilization of stem cutting from the previous period as the planting material. Since most of cassava fields observed in this study did not practice any rotation, pathogen from the previous season might develop a survival structure inhabiting the plant parts or tissues, such as stem.

**Table 2.** Diversity of cassava-infecting diseases found in three selected fields of each village in Ponjong District.

| Location   | Field 1                                                                 | Field 2                                                                 | Field 3                                                                 |
|------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Bedoyo     | Cassava, rice, maize, peanut                                            | Cassava, rice, maize, peanut                                            | Cassava, rice, peanut                                                   |
| Karangasem | Cassava, rice, maize, peanut, chili                                     | Cassava, rice, maize, peanut, chili                                     | Cassava, rice, maize, peanut, chili                                     |
| Kenteng    | Cassava, rice, maize, peanut, chili, cowpea                             | Cassava, rice, peanut                                                   | Cassava, rice, maize, peanut, chili                                     |

Each field was composed of different mixed crops. Bar lengths were adjusted based on the mean value of each disease incidence (n=4).

Therefore, several studies recommended the use of pathogen-free planting material (stem cutting) to prevent the disease occurrence [38, 39]. However, most of the local farmers were unable to distinguish whether the planting materials had been infected or not [39], especially if no visible symptoms. Besides, the high incidence of several diseases found in this region was also triggered by the lack of proper crop management. This condition directly affected the cassava growth, resistance and production, especially if the climate was found to be less favorable. [40] proposed that cassava
was regarded as a crop with high yield potential. However, the gap between the actual yield in farmers’ lands and the maximum yield potential reached 8-folds due to the use of local cultivar and the cultivation in sub-optimal conditions without any proper input.

4. Conclusion
This present study successfully displayed that the effect of cassava cropping system applied by local farmers contributed toward the diseases diversity and incidence. The combination of intercrops found in several fields could limit the development of certain diseases as long as the placement of each crop was managed proportionally based on the size of land area. It was required to maintain the crop density, so that the competition of niche among crops could be minimized. The utilization of local cultivars showed various patterns of disease development indicating the presence of disease-resistant local cultivar. However, the intercropping of more than one local cultivar in the same field should be considered carefully as each cultivar might require different growth requirements. In addition, local farmers were suggested to be introduced with the information about the cultivation reference of cassava local cultivars as well as procedure of planting material selection. The cultivation of disease-resistant cultivar, pathogen-free plant stocks and proper crop management could minimize the risk of disease infection yet optimize the cassava production in Ponjong District.
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References
[1] Howeler R, Lutaladio N, Thomas G 2013 (Rome: FAO) pp 87-97.
[2] McCallum E J, Anjanappa R B, Gruissem W 2017 Curr. Opin. Plant Biol. 38 50-8.
[3] Maziya-Dixon B, Dixon A G, Adebowale A R A 2007 Int. J. Food Sci. Tech. 42 969-76.
[4] Ceballos H, Ramirez J, Bellotti A C, Jarvis A, Alvarez E 2011 ed Yadav S S, Redden R J, Hatfield J L, Lotze-Campen H, Hall A Es (Oxford, United Kingdom: Blackwell Publishing) pp 411-25.
[5] Graziosi I, Minato N, Alvarez E, Ngo D T, Hoat T X, Aye T M, Pardo J M, Wongtiem P, Wyckhuys K A 2016 Pest Manag. Sci. 72 1071-89.
[6] Zhu W, Leesander T A, Örberg H, Wei M, Hedman B, Ren J, Xie G, Xiong S 2015 CGB Bioenergy 7 72-83.
[7] Statistics 2019 https://www.bps.go.id [Accessed 11 September 2019].
[8] Hershey C H, et al. 2012 ed Hershey C H, Neate Ps (Cali, Colombia: Centro Internacional de Agricultura Tropical (CIAT)).
[9] Jarvis A, Ramirez-Villegas J, Campo B V H, Navarro-Racines C 2012 Trop. Plant Biol. 5 9-29.
[10] Mansfield J, et al. 2012 Mol. Plant Pathol. 13 614-29.
[11] Scholthof K B G, et al. 2011 Mol. Plant Pathol. 12 938-54.
[12] Legg J, Owor B, Sseruwagi P, Ndunguru J 2006 Adv. Virus Res. 67 355-418.
[13] Legg J P, Fauquet C M 2004 Plant Mol. Biol. 56 585-99.
[14] Ayesu-Offei E, Antwi-Boasiako C 1996 Ann. Bot. 78 653-7.
[15] Sseruwagi P, Sserubombwe W, Legg J, Ndunguru J, Thresh J 2004 Virus Res. 100 129-42.
[16] Horsfall J G, Heuberger J W 1942 Phytopathol. 32 226-32.
[17] Lithourgidis A, Dordas C, Damalas C A, Vlachostergios D 2011 Aust. J. Crop Sci. 5 396.
[18] Eskandari H, Ghanbari A, Javanmard A 2009 Not. Sci. Biol. 1 07-13.
[19] Ali Z, Malik M A, Cheema M A 2000 Int. J. Agric. Biol. 2 42-4.
[20] Sadashiv B N, Nemogouda B 2004 Production potential of hybrid cotton (Gossypium hirsutum) based vegetable intercropping systems under irrigation M. Sc. (Dharwad, India: University of Agricultural Sciences)
[21] Ijoyah M, Dzer D 2012 ISRN Agron. 2012.
[22] Thrupp L A 2000 Int. Aff. 76 265-81.
[23] Scherr S J, McNeely J A 2007 Philos. Trans. R Soc Lond B: Biol. Sci. 363 477-94.
[24] Brintha I, Seran T 2009 J. Agric. Sci. 4 19-28.
[25] Dapaah H, Asafu-Agyei J, Ennin S, Yamoah C 2003 J. Agric. Sci. 140 73-82.
[26] Amanullah M M, Somasundaram E, Vaiyapuri K, Sathyamoorthi K 2007 Agric. Rev. 28 179-87.
[27] Zinsou V, Wydra K, Ahohuendo B, Hau B 2004 Plant Pathol. 53 585-95.
[28] Pypers P, Sanginga J-M, Kasereka B, Walangulu M, Vanlauwe B 2011 Field Crops Res. 120 76-85.
[29] Iijima M, Izumi Y, Yuliani E, Sunyoto S, Sabe Ardjaswa W 2004 Plant Prod. Sci. 7 347-55.
[30] Islami T, Guritno B, Utomo W H 2011 J. Trop. Agric. 49 31-9.
[31] Howeler R H 2002 ed Hillocks R, Thresh J, Bellotti As (Wallingford: CAB International) pp 115-47.
[32] Carsky R, Toukourou M 2005 Nutr. Cycl. Agroecosys. 71 151-62.
[33] Giller K E 2001 Nitrogen fixation in tropical cropping systems (Wallingford: CAB International)
[34] Chikoye D, Ekeleme F, Udensi U E 2001 *Weed Sci.* **49** 658-67.
[35] Ramkat R, Wangai A, Ouma J, Rapando P, Lelgut D 2008 *Ann. Appl. Biol.* **153** 373-80.
[36] Schoeny A, Jumel S, Rouault F, Lemarchand E, Tivoli B 2010 *Eur. J. Plant Pathol.* **126** 317-31.
[37] Vieira R F, Júnior P, Teixeira H, Vieira C 2009 *Ciênc. Agrotec.* **33** 1931-4.
[38] Hillocks R, Thresh J 2000 *Roots* **7** 1-8.
[39] Calvert L, Thresh J 2002 (Wallingford: CAB International) pp 237-60.
[40] Okogbenin E, Setter T L, Ferguson M, Mutegi R, Ceballos H, Olasanmi B, Fregene M 2013 *Front. Physiol.* **4** 93.