The effectiveness of contact fungicides mancozeb in controlling potato leaf blight disease (*Phytophthora infestans* (Mont) de Barry) in Karo District in the wet month and in the laboratory

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Abstract. The increase of potato harvest area in North Sumatra was not accompanied by the production is caused by *Phytophthora infestans*, especially in the wet months. The most control method used in farming is using synthetic fungicides with mancozeb ingredients. To achieve efficiency, the effectiveness of management, and safety products, accuracy is needed in the use of concentration and application intervals. This research was conducted from December 2018 to December 2019 at the Laboratory of Plant Diseases, Faculty of Agriculture, Universitas Sumatera Utara and in an experimental field in Berastagi, Karo Regency. Laboratory experiment used a completely randomized design with fungicides concentrations 160 ppm, 240 ppm, 320 ppm and without fungicides. The field experiment was arranged in a Factorial Randomized Block Design with 1st factor was: concentrations of contact fungicide mancozeb 2 gr fungicide/L, 3 gr fungicide/L, 4 gr fungicide/L and without fungicides. The 2nd factor was: fungicide application interval 4 days, 8 days and 12 days respectively. The fungicide concentration could inhibit the growth of *P. infestans* in vitro. Consequently, the fungicides concentration and application intervals as well as their interactions were not effective in decreasing the severity of potato leaf blight in the field experiment during the wet months.

1. Introduction

The high number of imported potatoes caused by decreased interest of farmers to cultivate the potatoes, so that the increase in potato harvest area in North Sumatra Province in 2017 is insufficient compared to harvest in 2016 for potato commodity need. Compared to 2016, there was an increase in potato harvested area in North Sumatra during 2017 to 13.06%, however, the increase in harvested area was not as high as the increase in potato productivity in North Sumatra which only reached 6.01% in the last year. This needs attention because it is suspected that pest infestation causes an increase in potato productivity which is not done optimally [1].

Potato leaf blight by *Phytophthora infestans* has long been a problem for potato farmers and this disease is the most serious disease of potato crops in Indonesia. The pathogens infestation can reduce potato production by up to 90% of total potato production [2]. In general, potatoes are grown in the highlands with a significant rainfall. Therefore, the use of pesticides in potato farming, especially to control late blight *P. infestans* is very high [3].

Application with fungicides often cannot be done by one-time application during the growing season. Repeat application is needed to decrease disease progression. The application time interval is
adjusted to the incubation period, sporulation period and harvest period. This calculation is very necessary to achieve efficiency, management effectiveness, and safety of agricultural products [4]. Mancozeb is a contact fungicide with a narrow spectrum and a fungicide that acts as a curative control. Contact fungicides are suitable for controlling fungi that appear on the surface of plants, rust or leaf spot symptoms [5].

Based on the above problems, it is necessary to study the concentration and application interval of Mancozeb fungicide to control potato leaf blight caused by *P. infestans*.

### 2. Materials and methods

#### 2.1. Location and materials

This research was conducted from December 2018 to December 2019 at the Laboratory of Plant Diseases, Faculty of Agriculture, Universitas Sumatera Utara and in an experimental field in Berastagi, Karo Regency with an altitude of +1380 masl.

The materials used in this study were Granola 2 potato tuber seeds from Tongko Village, contact fungicide Mancozeb 80WP, water, distilled water, agar, 70% alcohol, V8 juice, CaCO₃, instant PDA, cling wrap, aluminum foil, cotton, chloramphenicol, labels, tissue, plastic, envelopes, plastic gloves, masks, wood, paperboard, measuring cups, plastic straps and burlap sacks.

#### 2.2. Experiment in the laboratory

2.2.1. Media preparation. The media used were V8 agar as a medium for pure culture providers and PDA (potato dextrose agar) media as the media used during observation. Making 1L of V8 media is done by boiling a mixture of 200 mL of V8 juice, 800 mL of distilled water, CaCO₃ 2 g and agar 15 g. To make PDA media, it is done by heating 1L of distilled water mixed with 39 g of PDA. After each medium has finished heating, the media is put into the Erlenmeyer, and then the media is sterilized using an autoclave.

2.2.2. Preparation of inoculum Phytophthora infestans. Isolation is done by technique direct plating[6] by placing potato leaf slices that showing symptoms of *P. infestans* infection on V8 agar medium which has been added with chloramphenicol in a sterile petri dish, then incubated at 16-18°C for 2-5 days. The growing colonies were identified using a fungal identification book to confirm the presence of *P. infestans*.

2.2.3. Testing by poisoned food technique. Make a stock solution of 100 mL of PDA, which containing Mancozeb fungicide with a concentration of 160 ppm, 240 ppm, and 320 ppm. The toxicity test was carried out with the Poisoned Food Technique as follows: A total of 10 ml of each concentration was poured into a petri dish, PDA media without fungicides were used as a control. The pure culture of the pathogen was cut using a cock borer right in the middle of the petri dish. Observations of the mycelium growth of fungal colonies were carried out until the colony mycelium filled the petri dish [7].

#### 2.3. Experiment in the field

2.3.1. Planting in the field. The land was processed by forming beds 60 cm wide by 18 m long and made as many as 3 beds with an area of 18 m x 3 m. Then after the beds are formed, give some plank every 1.5 m (for one mound) on the bed. Granola 2 (G2) seeds that sprout the buds are ready to be planted in the field. Potato seeds that are ready for planting in the field are planted with 30 cm spacing between plants and 30 cm between beds.
2.3.2. Application of fungicides. Applying a contact fungicide Mancozeb with concentration 2 g of fungicide/L, 3 g of fungicide/L and 4 g of fungicide/L on ±3 weeks after planting aged potato plants. The first application of the fungicide was carried out throughout the plant according to the concentration of the treatment, then the next application was carried out according to the treatment concentration and the application day interval, namely every 4 days, 8 days and 12 days with the number of applications 12 times at 4 day intervals, 6 times at 8 day intervals and 4 times at intervals of 12 days.

2.4. Observed variables

2.4.1. Observation parameters in the laboratory. Observations in the Laboratory of Plant Diseases, Faculty of Agriculture, Universitas Sumatera Utara were carried out every 3 days after the inoculation of P. infestans on each medium that had been mixed with a fungicide with the active ingredient Mancozeb. Observations made by the media were filled with P. infestans colonies. The observation variables include the percentage of fungicide inhibition (%). Inhibition of fungicides on the diameter of growth of fungal colonies in each treatment was determined using the formula:

\[ DH = \left( \frac{a-b}{a} \right) \times 100\% \] (1)

In which:
\( DH \) = fungicide inhibition against fungal colony diameter
\( a \) = diameter of the fungal colony in the control
\( b \) = diameter of fungal colonies in the treatment of fungicide formulations

2.4.2. Observation parameters in the field. Observation in the experimental field was carried out in all experimental units every eight days after the first application. The observation variables include:

2.4.2.1. Disease incidence. Disease observation potato leaf blight starting at 3 weeks after planting aged potato plants and every 4 days after the first fungicide application. Observations were made until all plants showed signs of being infected with P. infestans. The percentage of the incidence of late blight (P. infestans) in potato is calculated using the formula:

\[ \text{Disease incidence} = \frac{\text{Number of withered plants}}{\text{Total number of plants}} \times 100\% \] (2)

2.4.2.2. Disease severity. Observation of leaf blight was carried out by the scoring method starting at 8 days after the first application and carried out every 8 days for 6 observations. The intensity of leaf blight P. infestans in potato plants is calculated by the formula [8]:

\[ P = \frac{\sum (n \times v)}{N \times Z} \times 100\% \] (3)

In which:
\( P \) = intensity of crop damage (%)
\( v \) = The value of plant damage based on the leaf area of all affected plants, namely:
0 = No damage at all
1 = Area of damage to crops > 1 - <10%
2 = Area of damage to crops > 11 - <20%
3 = Area of damage to crops > 21 - <40%
4 = Area of damage to crops > 41 - <60%
5 = Area of damage to crops > 61%
\( n \) = number of plants that have the same \( v \) value (crop damage)
Z = The highest score  
N = Number of plants observed

3. Results and discussion

3.1. Percentage of fungicide inhibition
Observation data on the percentage of inhibitory power of contact fungicides Mancozeb shows that the application of fungicides with a concentration of 160 ppm (D1), 240 ppm (D2) and 320 ppm (D3) has a very significant effect on each observation. The percentage of fungicide inhibition can be seen in table 1.

Table 1. Data on the percentage of inhibitory power of contact fungicides with active ingredient Mancozeb against P. infestans (%)

| Fungicide concentration (ppm) | Observation time (Day after inoculation) | Average |
|-------------------------------|------------------------------------------|---------|
|                               | 3  | 6  | 9  | 12 | 15 | 18 | 21 |       |
| D0 (Control)                 | 0.00b | 0.00b | 0.00b | 0.00c | 0.00c | 0.00c | 0.00c | 0.00c | 0.00c | 0.00c | 0.00c |
| D1 (160)                     | 67.32a | 72.11b | 69.03b | 68.56b | 63.56b | 60.11b | 54.29b | 65.00 |
| D2 (240)                     | 70.08a | 76.46ab | 75.01ab | 76.44a | 73.42a | 69.95a | 63.22a | 72.08 |
| D3 (320)                     | 70.08a | 81.04a | 80.80a | 79.35a | 79.14a | 75.23a | 69.13a | 76.40 |
| Average                      | 51.87 | 57.40 | 56.21 | 56.09 | 54.03 | 51.32 | 46.66 | 53.37 |

Note: The numbers followed by the same notation show no significant difference in Duncan's Multiple Distance Test at the level α = 5%.

Among all treatments, D3 was the treatment with the highest percentage of inhibitory power while D1 was the treatment with the lowest percentage of inhibitory power (table 1). The percentage of inhibition was above 50% for each observation (table 1). This proves that the fungicide with active ingredient Mancozeb can inhibit the growth of P. infestans well. The decrease in inhibition occurs due to the toxicity of the fungicide which disappears over time, this is consistent with the statement of Bohmont in Sumardiyono [9] which states that the weakness of fungistatic fungicides is their toxicity will disappear with time and weather conditions.

3.2. Disease incidence
The percentage of disease incidence in the treatment of contact fungicide concentration and fungicide application intervals can be seen in table 2.

Table 2. Observation data on the percentage of disease incidence in potato four days after the first application.

| Fungicide concentration (fungicide gr / L) | Disease incidence (%) | Fungicide application intervals | Average |
|------------------------------------------|-----------------------|---------------------------------|---------|
|                                          | D0 (0)                | D1 (4 days)                     | D2 (8 days) | D3 (12 days) |       |
|                                          | 88.89                 | 88.89                           | 66.66    | 81.48        |
|                                          | D1 (2)                | 77.77                           | 77.78    | 100.00       | 85.18  |
|                                          | D2 (3)                | 88.89                           | 88.89    | 66.66        | 81.48  |
|                                          | D3 (4)                | 66.66                           | 77.78    | 55.55        | 66.66  |
|                                          | Average               | 80.55                           | 83.33    | 72.22        |

Note: The numbers followed by the same notation show no significant difference in Duncan's Multiple Distance Test at the level α = 5%
Table 2 shows that D1 treatment had no significant effect on D2, D0, and D3. The highest percentage of disease occurred in treatment D1 of 85.18% and the lowest was treatment D3 of 66.66%. Treatment I2 did not significantly affect treatment I1 and I3. The highest average percentage of disease incidence was in treatment I2 which was 83.33%, while the lowest percentage was in treatment I3 at 72.22%.

This is because potato leaf blight can develop rapidly in the highlands where potato plants are cultivated, thus the spread of the disease occurs quickly and the initial symptoms of *P. infestans*. It can be seen that more than 60% of the potato plant population is still aged 3 WAP, this is by Semangun’s statement [10] which states that symptoms generally only appear in plants that are more than one month old, although sometimes they are seen in new plants 21 days old.

The development of potato leaf blight is also supported by weather conditions at the beginning of the planting period, namely with 92% humidity and 183 mm of rain (based on Indonesian Meteorology, Climatology and Geophysical Agency data from the Deli Serdang Climatology Station, the observation location of Kuta Gadung, Karo Regency) is a category included in the wet month according to Schmidt-Ferguson, this is following the climatic classification according to Schmidt-Ferguson in Kusriyanto & Sulistinah [11] which states that which is included in the wet month is a month that has the amount of rainfall > 100mm. Weather conditions that support the spread of *P. infestans* pathogens such as Adijaya [12] stated that the spread of *P. infestans* spores is triggered by relatively humid air conditions (above 80%) and according to Susetyo [13] epidemics of potato late blight usually occurs at temperatures of 16-24°C, in the highlands, late blight is particularly severe during the rainy season.

### 3.3. Disease severity

The percentage of disease severity in the treatment of contact fungicide Mancozeb and the application day interval in the wet month can be seen in the following table.

| Fungicide concentration (gr / L) | Disease severity (%) | Interval days | Average  |
|---------------------------------|----------------------|---------------|---------|
|                                 |                      | I1 (4 days)   | I2 (8 days) | I3 (12 days) |         |
| D0 (0)                          |                      | 100.00        | 100.00    | 100.00       | 100.00  |
| D1 (2)                          |                      | 86.82         | 94.18     | 99.11        | 93.37   |
| D2 (3)                          |                      | 86.84         | 89.30     | 98.65        | 91.60   |
| D3 (4)                          |                      | 87.11         | 95.59     | 100.00       | 94.23   |
| **Average**                     |                      | **90.19**     | **94.77** | **99.44**    |         |

Note: The numbers followed by the same notation show no significant difference in Duncan's Multiple Distance Test at the level α = 5%.

Based on observations made during the wet month with an average rainfall during the observation of 156 mm (based on data from BMKG at the Deli Serdang Climatology Station, the observation location of Kuta Gadung, Karo Regency), the treatment of the concentration of contact fungicide Mancozeb and the application interval was not effective in reducing the severity of potato leaf blight. Treatment I1 (4 days interval) showed the lowest average disease severity every observation. This is because the time interval for fungicide application is not too far away so that it can slightly cover the loss of fungicide deposits due to washing by rainwater, this is by Sumardiyoono's statement [14] which states that the application time interval is adjusted to the incubation period.

The concentration of contact fungicide Mancozeb that applied in wet months cannot reduce the percentage of disease severity caused by leaching of fungicide deposits due to high rainfall. This...
statement is consistent with the statement according to Crowdy in Sumardiyono [15] that leached deposits will affect the amount of fungicide exposure to other pathogens and phyloplanic organisms.

During epidemic times, conidia from *P. infestans* germinates as a zoospore in water droplets on the edges of potato leaves, so that fungicide applications carried out during wet months without the presence of additives (adjuvant) such as adhesives or a mixture of levelers and adhesives are deemed less effective because fungicide deposits can be reduced due to washing while the pathogen continues to grow because a suitable environment is available for its growth. Lukens [16] stated that during epidemics, *P. infestans* conidia germinated as a zoospore in water droplets on the margins of potato leaves could be prevented if the leaf margins were covered with a barrier.

4. Conclusion
The experiment in the laboratory showed that concentration could inhibit the growth of *P. infestans*. The results of the study in the wet months showed that the fungicides concentrate, application intervals and their interactions were not effective in reducing the severity of potato leaf blight.

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