**INTRODUCTION**

Chrysanthemum (Dendranthema grandiflora Tzvelev syn. Chrysanthemum morifolium [Ramat.] Kitam) is one of the most important ornamental crops in the world. It is typically used as cut flowers or potted plants. It exhibits various colors such as white, yellow, red, purple and pink, but lack of bright red and blue flowers (He, Ke, Keting, Qiaoyan, & Silan, 2013). In international market, this commodity is positioned as the first occupying more than 35% of the world’s marketed cut flowers and the second is rose. Several European and American countries like Netherlands, Italy, Columbia, Spain, Germany and USA have been known to be the main chrysanthemum producers which supplied more than 60% of the world market request (Plasmeijer & Yanai, 2012). In Indonesia, chrysanthemum is also positioned as the top marketed ornamentals in domestic market. The production increased from 305.9 million in 2011 to 442.7 million stalks in 2015 as a result from the increase of harvested area from 881.2 ha in 2011 to 1,087.2 ha in 2015 (Ministry of Agriculture Republic of Indonesia, 2016).

The production process however, is still constrained by several factors, particularly in traditional famers. Disease attacks especially white rust is known to be the most prominent problem to make chrysanthemum production become more efficient and profitable. The disease is caused by an obligate parasitic fungus Puccinia horiana P. Henn (Basidiomycetes). These pathogenic fungus have been known to infect 12 species including chrysanthemum, Nipponanthemum and Leucanthemella (Alaei et al., 2009). The production lost due to these fungus might reach 80% as reported in Turkey and India during the outbreak seasons (Dheepa, Renukadevi, Vinod Kumar, & Nakkeeran, 2015; Göre, 2008). The disease intensity and severity depended on genotype resistances and environmental conditions. High humidity coupled with warmer temperature might induce a conducive...
circumstance for the pathogen to develop rapidly in susceptible cultivars (Boné et al., 2015; Rahardjo, Budiarto, & Marwoto, 2019).

Growers still relied on chemicals, though several tolerance or resistant cultivars have been widely released and become the alternative way out in reducing the economic losses due to the disease attacks. Several synthetic fungicides with the active ingredient of oxycarboxin, triforine, benodanile, triadimefon, diclobutrazol, bitertanol dan propiconazol are commonly employed to control the disease. In several countries like Indonesia however, no synthetic fungicide has been registered specifically for white rust control (Yusuf, Djatnika, & Suhardi, 2014). To cope up this situation, growers then tend to use various kinds of fungicide with inappropriate dosages expecting the reduction of damages. In long and frequent applications, these practices would induce pathogen resistance and make the chemicals no longer effective (Torres et al., 2017). The chemicals were often employed even in the absent of the symptoms and intensity of the diseases to assure the marketable flower quality. These practices might spend 13 - 32% of the total production cost (Suhardi, 2009) and made the business more uncompetitive.

The use of natural enemies like mycoparasite is considered to be an alternative way to reduce the economic impact of disease attacks. Cladosporium Link is one of the most common genera of fungi occurring on various substrates and diverse lifestyle including mycoparasite (Abdel-Rahim & Abo-Elyouser, 2018; Siegel-Hertz et al., 2018; Yusuf, Nuryani, & Hanudin, 2016). These fungi might compete to control the nutrient source or other environmental factors and are capable to exhibit as saprophytic fungi to exploit dead substrates or even are able to act as pathogenic fungi to penetrate their fungal hosts (Herrera, Hirooka, & Chaverri, 2016; Traquair, Meloche, Jarvis, & Baker, 1984). Some of the most common examples came from the relationship between Cladosporium sp. and rust pathogen were C. uredinicola parasitizing Puccinia violae, P. puta and Cronartium fusiforme (Barros, Oliveira, Bastos, & Maia, 1999; Morgan-Jones, & McKenny, 1990; Traquair, Meloche, Jarvis, & Baker, 1984), Cladosporium sp. on Melampsora sp. and Exobasidium camelliae and Hemileia vastatrix (Busby, Peay, & Newcombe, 2016; James, Marino, Perfecto, & Vandermeer, 2016; Mims & Richardson, 2006), C. tenuissimum parasitizing Uromyces appediculatus, Cronartium flaccidum and Peridermium pini (Assante et al., 2004; Moricca, Ragazzi, & Assante, 2005; Moricca, Ragazzi, Mitchelson, & Assante, 2001). C. cladosporoides parasitizing Ventura inequalis, Puccinia striiformis f.sp. tritici and Coleosporium plumeriae (Baiswar, Chandra, & Kumar, 2008; Köhl, Molhoek, Groenenboom-De Haas, & Goossen-Van De Geijn, 2009; Zhan et al., 2014). On Puccinia horiana only C. uredinicola, C. sphaerospermum and C. cladosporoides have been previously reported (García-Velasco et al., 2005; Srivastava, Défago, & Kern, 1985; Torres et al., 2017) that inhibited the disease development up to 30 - 80% (Torres et al., 2017; Yusuf, Nuryani, & Hanudin, 2016).

The collection and isolation of potential antagonist for chrysanthemum white rust in the last few years at several chrysanthemum production centres in Bandung and Cianjur cities of West Java, Indonesia have identified at least 20 mycoparasites that showed blackish brown colloidal colonies in isolated culture, thus putatively referred to Cladosporium (Yusuf, Djatnika, & Suhardi, 2014). The effectiveness of these Cladosporium isolates have not been tested yet thus, these experiment was conducted to evaluate the isolates in controlling white rust in chrysanthemum under in vivo conditions with the comparison of synthetic pesticide application commonly used by growers at present. The study was also carried out to observe the parasitic mechanism of Cladosporium on the targeted pathogenic fungus Puccinia horiana.

MATERIALS AND METHODS

The research was conducted from January to December 2015 covering laboratory and green house studies. Field work for in vivo test of Cladosporium isolates was conducted at the Indonesian Ornamental Crops Research Institute (IOCRI), while laboratory studies on parasitic mechanism Cladosporium were carried out in Laboratory of Biology, Indonesian Institute of Science, Cibinong, Bogor, Indonesia. The procedure of the experiment was described in the following details.

Preparation of Cladosporium Isolates

The isolates used were those which had high effectiveness to P. horiana based from Yusuf, Djatnika, & Suhardi (2014) and coded as SGC, HNC, DEC, YEC, L1C, SG1C, Y4C, UC, DC and EC. All the isolates were aseptically cultured in liquid PDA
medium for 10 days incubation. Each isolate culture solution was then diluted in sterile water until the concentration reached $10^7$ spore cells/ml.

**Preparation of the Experimental Sites, Planting and Plant Maintenance**

The area inside the plastic houses was hoed to clean the planting sites from weeds and other substances. The soil was then properly mixed with 30 t/ha manure and 300 kg/ha NPK (15:15:15) fertilizers. The planting sites were then organized into 1 x 2 m beds and the distance between beds was 1 m. The planting beds were then poured with water to facilitate humidity before planting. Rooted cuttings of cv. White Fiji (standard flower type) gathered from the commercial nursery were planted in beds with the density of 100 plants/m². All the plants were maintained in long day conditions using 100 lux artificial lighting for 4 h every night until 30 days after planting. For insect pest prevention, the plants were sprayed using Abamectin (Syngenta Co. Ltd, Indonesia) once a week at the recommended dosage.

**Application of Treatments**

The treatments consisted of 10 *Cladosporium* isolates as coded above, commonly used synthetic fungicides by growers at present, namely Propineb dan Azoxystrobin as positive control and without *Cladosporium* and synthetic fungicide applications (sprayed with sterile water spray) as negative control. The treatments were arranged in a completely randomized block experiment with 4 replications. After the rooted cuttings were planted, the young plants were then sprayed with treatment solutions. For *Cladosporium* isolates, each isolate solution with the concentration of $10^7$ cfu/ml and volume of 300 - 400 ml/m² was sprayed to the plant with interval of 7 days starting from 2 days after planting (DAP) until harvesting periods. While the synthetic fungicide treatments (positive control) were sprayed with the concentration of 2 g/l. The positive and negative control treatments were employed with the same frequencies and volumes as those of *Cladosporium* treatments.

**Data Gathering and Analysis**

The observation of white rust intensity was conducted at 10% plant samples at 21, 35, 49, 63 and 77 DAP. The disease intensity was measured using the following formula:

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

Where:
- $I$ = Intensity of white rust infection (%)
- $v$ = Scale of the observed damage
- $n$ = number of infected plants categorized in the respected damage scale
- $Z$ = highest scale of the observed damage
- $N$ = total number of observed plant samples

The disease development was determined using Suhardi’s criteria (Suhardi, 2009) as presented in Table 1.

**Table 1.** Scale and damage criteria of white rust (*Puccinia horiana* Henn) infection on chrysanthemum (Suhardi, 2009)

| Scale | Damage Criteria |
|-------|-----------------|
| 0     | Not infected (symptomless) |
| 1     | Very low, infection was detected only on lower plant leaves and the intensity was not exceeding 5% of the total leaf area. |
| 2     | Low, infection was detected on lower plant leaves and the intensity ranges between 5 - 10% from total leaf area. |
| 3     | Medium damage, infection was detected on middle and lower plant leaves and the intensity ranges between 10 - 20% from the total leaf area. |
| 4     | Heavy damage, infection was detected on upper, middle and lower plant leaves and the intensity ranges between 20 - 40% from the total leaf area. |
| 5     | Very heavy damage, infection detected on upper, middle and lower plant leaves and the intensity was more then 40% from the total leaf area. |
The intensity of parasitism was measured based on the percentage of infected rust pustules by *Cladosporium* hypha. The infected pustule was characterized by the existence of growing whitish grey *Cladosporium* hypha covering the pustule dome. Five leaves per plant of the lower portion from 10% plant samples were taken and the infected pustules were counted. The percentage of parasitism intensity was calculated using the following formula:

\[
\text{Intensity of parasitism} = \frac{\text{Number of infected pustules}}{\text{Total observed pustules}} \times 100\%.
\]

The population dynamic of the mycoparasite was determined by the number of the growing mycoparasite on the leaves as represented by the number of growing conidia colonies in artificial medium. The observations were carried out at 30, 60 and 90 days after treatment applications. Three leaves from the lower parts from the sample plants were taken and gently rinsed with 10 ml sterile water. For about 1 ml rinsed water was inoculated into 10 ml PDA medium. The growing colonies were then observed using colony counter.

Flower quality was determined from stalk length, flower diameter and vase life. Stalk length was categorized based on the standard grading system. The vase life was observed from the number of days of the fresh flower withstand under room conditions.

Scanning Electron Microscope of the infected pustule was carried out by gathering the leaves with infected pustules by *Cladosporium*. The leaves were gently poured with water to remove the debris and then air-dried. All preparations of leaf specimen were conducted under 4°C room with the following processes. The leaf samples were immersed in cacodylate buffer for 2 h and agitated using ultrasonic cleaner. The leaf samples were then soaked in 2.5% glutaraldehyde solution for 2 h and air dried. The leaves were immersed in 2% tannic acid solution for 6 h and air dried. These steps were repeated after 2 days. After tannic acid immersion, the leaf samples were washed with cacodylate buffer for 4 times. The leaf samples were subsequently immersed in 50% ethanol for 5 minutes, 70% ethanol for 20 minutes, 85% ethanol for 20 minutes, 95% ethanol for 20 minutes and at absolute alcohol for 10 minutes. The leaves were then soaked in tert-buthanol for 10 minutes and refrigerated until they were frozen. The frozen leaves were then dried using frozen dryer and put into specimen stub cemented with colloidal Ag pasta covered with Au. The specimens were then observed under SEM (type JEOL model JSM-5310LV).

**RESULTS AND DISCUSSION**

**White Rust Incidence**

In all treatments, the incidence of white rust was visually absent until 14 DAP. The symptom is detected at 35 DAP on most plots though the incidence is not evenly spread in all plant within the plot (Table 2). The disperse incidence of rust was related to the former disease incidence as the source of inoculum, the production of inoculum and the dispersal from the source of inoculum to newly targeted hosts (Zeng et al., 2013). Data on Table 1 also indicated that the rust intensities varied among the treatments on 35, 49, 63 and 77 DAP. The negative control treatment showed the highest infections, while the synthetic fungicides (Propineb dan Azoxystrobin) were the lowest until 77 DAP.

Among *Cladosporium* treatments, the rust intensity varied representing different effectiveness of the *Cladosporium* isolates in inhibiting the development of the rust diseases. At 5 DAP, the disease intensity at DEC and UC plots is the lowest with insignificant differences with the positive control (Table 2). This situation was predicted due to the uneven disease spread in the early infection stages. At further plant growth stages (63 and 77 DAP), the percentage of disease intensity was diverted. *Cladosporium* isolates HNC and UC were found to have the lowest at 63 and 77 DAP and the values were not significantly different with synthetic fungicide application. Among the *Cladosporium* treatments, isolates EC and Y4C were found less effective. The rust incidence on these two isolate plot treatments were found higher than those of other fungicide treatments.

The different capability among *Cladosporium* isolates against white rust infections was predicted due to the different characteristic of the isolates. The different characteristics might refer to different species of the fungi as also reported by Guimarães, Chambel, Melzoch, Pereira, & Tenreiro (2011) that found several *Cladosporium* species in the same phyloplane on several plant species.
The application of synthetic fungicide was found to give the highest suppression on the rust development, which demonstrated 45.8% from negative control (Table 2). HNC and UC showed higher, yet EC and Y4C isolates gave the lowest values of suppression among *Cladosporium* treatments. Some of the tested *Cladosporium* isolates were potential isolates and the application the isolates might reduce the use of synthetic fungicide when controlling the disease.

### Intensity of Parasitism

The degree of parasitism does not so vary among the *Cladosporium* isolates (Table 3). At 35 DAP, the degree of parasitism was mostly uniform in all tested *Cladosporium* isolates and slightly diverse at 49 DAP. The parasitism intensity increased after 63 and 77 DAP, though less variation was observed among tested isolates. At 77 DAP, the highest parasitism is found in *Cladosporium* isolates of Y4C, UC and DC and higher parasitism intensity in UC is in line with the higher degree of suppression as also presented in Table 2. The increase parasitism intensity of *Cladosporium* accordingly to the increase of plant age reflected the positive prevalence of the tested *Cladosporium* to white rust. As the intensity of parasitism increased, the white rust development was supressed. The growth suppression resulted in decrease of spore production, thus limited the spread of disease infection (Assante et al., 2004).

The existence of *Cladosporium* was also observed on the plants of negative control and synthetic fungicide treatments. The existence of *Cladosporium* at untreated plants (negative control) reflected the capability of the *Cladosporium* spore to transfer using air and water splash as the transmission media (Nikkels, Terstegge, & Spieksma, 1996). The intensity of parasitism was found to be the lowest at synthetic fungicide application. These conditions inferred to the application of synthetic fungicide and also gave negative effects on *Cladosporium* development. Further studies are needed to find the application method of combined *Cladosporium*-synthetic fungicide that give not only the lowest usage of synthetic fungicide but maximum suppression on rust infection and increase marketable flower as well.

### Table 2. White rust intensity and percentage of suppression among biofungicide and control treatments

| Treatments | Rust Intensity at … DAP ¹(%) | Percentage of Suppression |
|------------|------------------------------|---------------------------|
|            | 35  | 49  | 63  | 77  |                  |
| SGC        | 7.3 | 6.2 | 26.8| 44.8| 29.5             |
| HNC        | 2.1 | 2.1 | 25.0| 39.6| 35.8             |
| DEC        | 1.0 | 2.0 | 31.2| 48.0| 25.7             |
| YEC        | 6.2 | 6.2 | 25.0| 53.1| 19.5             |
| L1C        | 3.1 | 5.2 | 27.8| 46.9| 27.0             |
| SG1C       | 5.2 | 5.2 | 29.2| 43.7| 30.8             |
| Y4C        | 6.2 | 5.2 | 35.1| 62.5| 8.3              |
| UC         | 2.1 | 4.2 | 25.0| 41.7| 33.2             |
| DC         | 4.2 | 4.2 | 31.0| 46.9| 27.0             |
| EC         | 7.3 | 5.2 | 35.4| 59.4| 12.0             |
| Propineb   | 2.1 | 2.1 | 19.8| 31.2| 45.8             |
| Azoxystrobin| 0.0 | 0.0 | 15.6| 31.2| 45.8             |
| Negative control | 9.4 | 11.5| 50.0| 83.3| -                |

Remarks: ¹ Values followed by different letters in the same column differ significantly at LSD (α = 5%)
Effect of Cladosporium Treatments on Flower Quality

Effect of Cladosporium and synthetic fungicide treatments on flower properties is presented in Table 4. The plants treated with various Cladosporium isolates and synthetic fungicides gave varied plant height (stalk length). The plant treated with Cladosporium isolate HNC, L1C, SG1C and synthetic fungicide azoxystrobin gave the highest value in term of stalk length, while isolate YEC was the shortest. The stalks length of all treated plants, however, was not significantly different in term of plant height. The average stalk length of all treated plants, however, was not significantly different in term of plant height. The average stalk length of all treatments fell under category of grade B (60 - 80 cm). These conditions inferred that the effect of rust infection decrement due to Cladosporium and synthetic fungicide applications could not be clearly seen on stalk length. The chrysanthemum vegetative growth mainly progressed until 30 DAP during long day forcing (Kjaer & Ottosen, 2011). The observation of rust infection on Table 2 indicated that the disease incidence up to 35 DAP was still low in all treatment and predictably had not affected the growth quality seriously. These situations might become the putative cause of the insignificant differences on stalk length of the treated plants.

The effect of fungicide application was merely detected on flower diameter. The plant treated by synthetic fungicide Propineb showed the lowest rust infection (Table 2) thus gave the biggest flower and was significantly different from the negative control (Table 3). Among the Cladosporium treatments, isolates HNC, DEC, UC and EC not only have insignificant flower size with those of Propineb treatment, yet negative control as well. The lowest flower size was observed on the plant treated by Cladosporium isolate DC. Flower diameter is one important market character for standard type chrysanthemum. Maintaining to produce a single flower in a plant had made the character was predictably less affected by rust infection when the infection was still in leaves part. In severe incidences, the pustule symptoms might reach the flower petal and made the flowers unsalable as reported by Hanudin, Budiarto, & Marwoto (2017).

Unlike flower diameter, chrysanthemum plants treated by Cladosporium isolates and synthetic fungicide show a significant longer fresh life under room temperature than the negative control (Table 4). All the bio- and synthetic fungicides treated plants had more than 10 days of shelf life, while the negative control had less than 9 days.
The low rust infection represented means the healthier photosynthetic organs is to support the plant growth and development including the flower development (Hanudin, Budiarto, & Marwoto, 2017). The optimum flower development process revealed premium flower quality including longer shelf life.

**Population Dynamic of Cladosporium**

The population of dynamic *Cladosporium* was represented by number of growing conidia colonies cultured in PDA medium (Table 5). Most of *Cladosporium* conidia taken from the *Cladosporium*-treated plants had double to quadric increased in number from 30 to 60 DAP. The numbers were somehow, flattened and diminished at 60 to 90 DAP. Unlike in *Cladosporium*-treated plants, the increase of number of conidia in synthetic fungicide-treated and negative control plants was less fluctuating during the first 60 days and also of the decrement until 90 DAP. The population trends of *Cladosporium* in *Cladosporium*-treated plants were mostly in line with the intensity of rust infection (Table 2). The sigmoidal increase of rust infection during the first 60 days provided abundant parasitized hosts for *Cladosporium* to develop. When the infection lowered down after at 77 DAP, the number of *Cladosporium* conidia also followed to a sloping decrease.

The *Cladosporium* population in synthetic fungicide-treated and negative control plants were the lowest at 30, 60 and 90 DAP. Since there was no initial introduction of *Cladosporium* and the existence of parasitized hosts were still low, the population of *Cladosporium* was limited in 30 DAP. The *Cladosporium* were seemed to be affected by the application synthetic fungicide as viewed from the lower population compared to negative control at 60 DAP. The trend were somehow slightly decrease at 90 DAP. Though the existence of parasitized hosts were merely connected with the *Cladosporium* mycoparasite, the population dynamic and the persistency of *Cladosporium* was also influenced by microclimatic conditions (temperature, humidity, precipitation, solar radiation and air-flow) and other properties, such as edaphic factors (Ciancio & Mukerji, 2008).

### Table 4. Flower characteristics of chrysanthemum cv. White Fiji on various biofungicide and control treatments

| Treatments | Stalk length (cm) | Diameter (cm) | Vase life (days) |
|------------|------------------|---------------|------------------|
| SGC        | 68.3 abc         | 8.7 bc        | 10.3 cd          |
| HNC        | 78.2 a           | 9.6 ab        | 13.0 abc         |
| DEC        | 73.8 abc         | 9.5 ab        | 10.8 cd          |
| YEC        | 63.7 c           | 8.8 bc        | 12.3 abcd        |
| L1C        | 78.4 a           | 8.9 bc        | 12.8 abc         |
| SG1C       | 77.6 a           | 8.9 bc        | 13.0 abc         |
| Y4C        | 72.1 abc         | 8.7 bc        | 11.3 bcd         |
| UC         | 74.7 ab          | 9.6 ab        | 11.8 abcd        |
| DC         | 64.7 bc          | 8.1 c         | 10.5 cd          |
| EC         | 74.6 ab          | 9.2 ab        | 12.5 abc         |
| Propineb   | 73.9 abc         | 10.1 a        | 15.0 a           |
| Azoxystrobin | 76.6 a        | 9.4 ab        | 14.5 ab          |
| Negative control | 68.6 abc | 8.9 bc | 8.8 d |

Remarks: * Values followed by different letters in the same column differ significantly at LSD (α = 5%)
Parasitic Mechanism of Cladosporium

The SEM photomicrographs of the rust infected leaves from the Cladosporium treated plants were presented in Fig. 1. The Cladosporium hypha filaments grow and attach to the rust teliospores (Fig. 1A). At further process, the hypha stealthy enveloped the teliospores and colonized the sporogenous cells (Fig. 1B). The evidence of direct penetration of Cladosporium to P. horiana teliospores could not be verified, since SEM was only able to capture the outer side of teliospores. According to Torres et al. (2017) the parasitic mechanism of Cladosporium to P. horiana was not through a direct penetration to the rust teliospores, though certain Cladosporium species excreted glutacanases enzyme when parasitizing U. appendiculatus. The possible Cladosporium - P. horiana relationships was by antibiotic mechanism.

Table 5. Number of Cladosporium conidia colonies derived from chrysanthemum leaves at various growth periods

| Treatments | Number of Cladosporium conidia after ... DAP\(^{1}\) (10^6 cells/ml) |
|------------|---------------------------------------------------------------|
|            | 30          | 60          | 90          |
| SGC        | 0.4 b       | 1.68 ab     | 1.67 abc    |
| HNC        | 0.7 b       | 1.87 ab     | 1.85 abc    |
| DEC        | 0.6 b       | 3.18 a      | 2.54 ab     |
| YEC        | 0.5 b       | 1.47 bc     | 1.55 bc     |
| L1C        | 0.5 b       | 2.22 ab     | 1.63 bc     |
| SG1C       | 0.8 a       | 3.07 a      | 2.67 a      |
| Y4C        | 0.6 b       | 1.73 ab     | 1.56 bc     |
| UC         | 0.6 b       | 2.16 ab     | 1.9 abc     |
| DC         | 0.5 b       | 1.29 bc     | 1.21 c      |
| EC         | 0.5 b       | 1.73 ab     | 1.33 c      |
| Propineb   | 0.0 c       | 0.09 d      | 0.05 d      |
| Azoxyystrobin | 0.01 c   | 0.10 d      | 0.09 d      |
| Negative control | 0.0 c | 0.68 cd | 0.40 d |

Remarks: \(^{1}\) Values followed by different letters in the same column differ significantly at LSD (\(\alpha = 5\%\))

Fig. 1. The SEM photomicrographs of the rust infected leaves from the Cladosporium treated plants showed (A) Cladosporium hypha grew toward and attached on the surface of P. horiana teliospores, (B) the hypha enveloped the teliospores and colonized the sporogenous cells and (C) the constricted rust teliospores due to Cladosporium parasitism.
that affecting teliospores morphology. These constricted teliospores (Fig. 1C) predictably resulted in loss of viability.

**CONCLUSION**

*Cladosporium* isolates gave various effectiveness in controlling white rust on chrysanthemum. Some isolates decreased rust intensity with the same affectivity as synthetic fungicide. Isolates HNC, DC, SGC and UC had higher percentage of suppression and parasitism intensity to white rust. The degree of suppression ranged from 8.3 to 35.8%. Flower stalk and diameter were less affected by the application of *Cladosporium* and synthetic fungicides, while longer vase life was produced from the less infected plants. In *Cladosporium*-treated plants, the population of *Cladosporium* increased in response to the increment of rust infection and subsequently decreased when the infections were diminished. The population dynamic were not fluctuating in synthetic fungicide-treated and negative control infected plants. In *Cladosporium*-infected plants, the parasitizing mechanism of *Cladosporium* to *P. horiana* was through teliospores envelopment resulted in the changes of teliospores morphology.

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