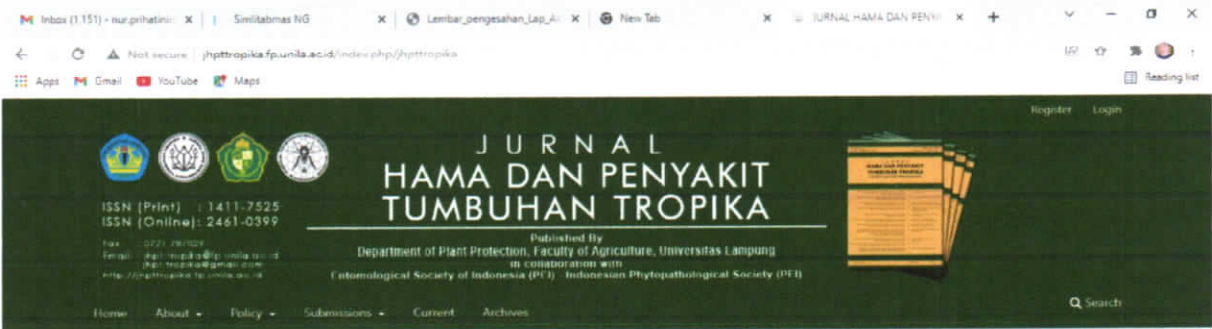


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CONGONGRASS ROOT EXTRACT FROM FIVE DIFFERENT SOILS TYPES FOR SUPPRESSING PURPLE BLOTCH AND INCREASING GROWTH AND YIELD OF SHALLOTS

ABSTRACT

The aim of this study was to examine the efficacy of cogongrass root extracts from five different soil types in suppressing purple blotch and increasing growth and yield of shallots. Split plot design was used with 13 treatments repeated three times, and 18 plants plot⁻¹. The treatment consisted of control, fungicide propineb applied before and after inoculation, and five types of cogongrass root extract 50, 60, and 70% concentration applied before and after inoculation. Results showed that cogongrass root extract of *Pachic Hapludolls* applied before inoculation had significant effect on the highest pathosystem component indicated by delaying the incubation period, suppressing the intensity of the disease, slowing down the infection rate, and decreasing values of AUDPC as 41.85, 69.87, 75.13, and 67.63%, respectively, compared to control. The cogongrass root extract from *Pachic Hapludolls* applied before inoculation could increase plant fresh and dry weight plant⁻¹, tuber weight plant⁻¹, plant fresh and dry weight plot⁻¹, and tuber dry weight plot⁻¹ as 42,7, 49,6, 51,92, 66,75, 72,29, and 73,53%, respectively, compared to control.

Keywords: Shallot, Purple blotch, cogongrass roots extract, growth and yield

INTRODUCTION

Purple blotch caused by *Alternaria porri* (Ellis) Cif is a disease in shallots that is very damaging and causes significant yield loss (Dar et al. 2020). Purple blotch is reported to cause a decrease in shallot production by up to 97% in onion fields worldwide (Kareem et al. 2012).

Efforts to control the disease are still emphasized on the use of synthetic chemical fungicides, in that their continuous use has a negative impact on the environment, the emergence of new strains and also damages human health (Idris and Nurmansyah 2015, Sari et al. 2016). Therefore, it is necessary to reduce the use of the chemical fungicides. One of them is the use of bothanical fungicides that are safe and environmentally friendly.

Many plants can be used as bothanical fungicides including cogongrass (*Imperata cylindrica*) (Gusmarini et al. 2014). Cogongrass contains alkaloids, flavonoids, steroids, terpenoids, and tannins which have antimicrobial effects and are a form of plant defense mechanism against pathogenic microbes (Seniwaty et al. 2009, Gurjar et al. 2012). Cogongrass can be found in a variety of habitats and a variety of soil types from natural areas that are relatively undisturbed and tolerant of a variety of growing conditions including shade, drought, and poor soil quality (Bryson et al. 2010). The role of chemical compounds produced by cogongrass depends on the soil-plant system (Malik 2000).

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COGONGRASS ROOT EXTRACT FROM FIVE DIFFERENT SOILS TYPES FOR SUPPRESSING PURPLE BLOTCH AND INCREASING GROWTH AND YIELD OF SHALLOTS

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ABSTRACT

Cogongrass root extract from five different soils types for suppressing purple blotch and increasing growth and yield of shallots. The aim of this study was to examine the efficacy of cogongrass (*Imperata cylindrica* (L.) Beauv.) root extracts from five different soil types (Typic Udipsamments, Aeris Endoaqualfs (=Gleisal Eutrik), Typic Quartzipsamments (=Regosol Eutrik), Aquertic Chromic Hapludalfs, and Pachic Hapludolls) in suppressing purple blotch and increasing growth and yield of shallots. Split plot design was used with 13 treatments repeated three times, and 18 plants plot⁻¹. The treatments consisted of control, fungicide propineb applied before and after inoculation, and five types of cogongrass root extract 50, 60, and 70% concentration applied before and after inoculation. Results showed that cogongrass root extract collected from Pachic Hapludolls which was applied before inoculation had significant effect on the highest pathosystem component indicated by delaying the incubation period, suppressing the intensity of the disease, slowing down the infection rate, and decreasing values of AUDPC as 41.85, 69.87, 75.13, and 67.63%, respectively, compared to control. The cogongrass root extract from Pachic Hapludolls applied before inoculation could increase plant fresh and dry weight plant⁻¹, tuber weight plant⁻¹, plant fresh and dry weight plot⁻¹, and tuber dry weight plot⁻¹ as 42.7, 49.6, 51.92, 66.75, 72.29, and 73.53%, respectively, compared to control.

Key words: cogongrass roots extract, growth and yield, purple blotch, shallot

INTRODUCTION

Purple blotch caused by *Alternaria porri* (Ellis) Cif. is a disease in shallots that is very damaging and causes significant yield loss (Dar *et al.*, 2020). Purple blotch was reported to cause a decrease in shallot production by up to 97% in onion fields worldwide (Kareem *et al.*, 2012).

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Many plants can be used as botanical fungicides including cogongrass (*Imperata cylindrica*) (Gusmarini *et al.*, 2014). Cogongrass contains alkaloids, flavonoids,

steroids, terpenoids, and tannins which have antimicrobial effects and are a form of plant defense mechanism against pathogenic microbes (Seniwaty *et al.*, 2009; Gurjar *et al.*, 2012). Cogongrass can be found in a variety of habitats and a variety of soil types from natural areas that are relatively undisturbed and tolerant of a variety of growing conditions including shade, drought, and poor soil quality (Bryson *et al.*, 2010). The role of chemical compounds produced by cogongrass depends on the soil-plant system (Mallik, 2000). This study aimed to test the efficacy of cogongrass root extract from five different soil types to suppress purple blotch, increase growth and yield of shallots.

MATERIALS AND METHODS

Research Site. This research was carried out at the Laboratory of Plant Protection, Faculty of Agriculture, and Integrated Laboratory, Jenderal Soedirman

University, and Agricultural Clinic of the Agriculture and Food Security Service at Tegal Regency and on the land of Sidapurna Village, Dukuhturi, Tegal (-6053'32", 10905'36", 24 m above sea level, with soil type Aeris Endoaqualfs (=Gleisal Eutrik), from August 2018 to June 2019.

Experimental Design. The in vitro experiment used a completely randomized design with 18 treatments and 3 replicates, consisted of a comparative fungicide (propineb) and cogongrass root extract treatment from five types of soil, namely Typic Udipsamments, Aeris Endoaqualfs, Typic Quartzipsamments (=Regosol Eutrik), Aquertic Chromic Hapludalfs, and Pachic Hapludolls. The in vivo experiment used a split plot design consisted of 13 treatments, 3 replicates, and 18 plants per plot. The main plot was the application time, namely before and after inoculation. Subplot was the treatment of cogongrass root extract from five types of soil. Cogongrass sampling technique was cluster random sampling (Taherdoost, 2016).

Preparation of Cogongrass Root Extract. The development of cogongrass extract began with preparing simplicia according to the method of Ahmad *et al.* (2014), followed by extraction with the 96% ethanol maceration method (Zhang *et al.*, 2018). Furthermore, the filtrate was concentrated with a rotary evaporator at a temperature of 30–40 °C (Muchtaromah *et al.*, 2018), resulting in a concentrated total extract. Determination of flavonoid levels was carried out by comparing quercetin (Chandra *et al.*, 2014).

Preparation of the Pathogen Suspension. Pathogenic fungus *A. porri* was propagated using sterile potato dextrose broth (PDB) aseptically. The culture was shaken with a shaking machine (VRN-200) for 10 days at medium speed at room temperature and ready for use (Abdel-Hafez *et al.*, 2013). Meanwhile, suspension of *A. porri* was prepared by adding 900 mL of distilled water to the erlenmeyer containing 100 mL of pure culture).

Preparation of Shallot Seeds. The shallot seeds used were certified onion seeds of the Bima Brebes variety from Pokar Suka Tani, Sidapurna Village, Dukuhturi District, Tegal Regency. The seed tubers used were medium sized tubers (5–10 g). The appearance of seed tubers must be healthy, well-pithy (dense, not wrinkled), and bright in color (not dull), the shelf life of seeds was 3 months (Sumarni *et al.*, 2012).

Preparation of Land. The soil was processed until it was loose, then the beds were made with a length of 13 m, 1.20 m wide, 0.5 m gutter width with 0.6 m gutter depth. The plot size of each treatment was 70 × 30 cm (adjusting the land condition). Basic fertilizer was given before the last hoeing (7 days before planting), namely using NPK Mutiara fertilizer (16: 16: 16) 500 kg ha⁻¹, SP-36 100 kg ha⁻¹, KCl 60 kg ha⁻¹ by spreading over the beds then stirring land (according to farmer's habits).

Planting and Fertilization. Seed tubers were planted at a spacing of 15 × 15 cm with a stick, the holes were made as deep as the average tuber. The shallot bulb was inserted into the hole in the plant using a screw-like motion, so that the tip of the bulb appears flat with the soil surface. The seeds were not planted too deep. After planting, the entire land was watered with a fine grain. The first follow-up fertilization in the form of N and K fertilizers was carried out at the age of 10 days after planting (DAP) and the second at the age of 30 DAP, 0.5 doses each. The dose of N fertilizer was 200 kg ha⁻¹ and the dose of K fertilizer was 100 kg ha⁻¹ (Sumarni *et al.*, 2012).

Fungal Pathogen Inoculation. Shallot plants were inoculated by spraying *A. porri* conidia suspension with a density of 1 × 10⁶ conidia mL⁻¹ of water when the shallot plants were 3 weeks after planting (WAP) (Marlitasari *et al.*, 2016). Each plant was sprayed with 5 mL of the suspension (Rai & Singh, 1980). Spraying the suspension was carried out at 05.30 PM. Furthermore, it was closed with a polyethylene lid for 48 hours to maintain high humidity, after 48 hours the lid was opened and the plants were left in normal conditions (Marlitasari *et al.*, 2016).

Plant Maintenance. Watering was carried out to rinse the leaves of the plant, namely to reduce the soil splash that sticks to the shallots. Maintenance of shallot plants was also carried out by controlling weeds by manually weeding. Meanwhile, to control pests, a bioinsecticide was used, namely Bio B10 with the active ingredient *Beauveria bassiana* secondary metabolites. The concentration used was 10 mL L⁻¹ at intervals of 3 days (based on farmer habits).

In Vivo Test. Cogongrass root extract was treated twice, namely before inoculation (S1) and after inoculation (S2). The extract application before inoculation was carried out 3 times, namely when the plants were 10, 15, and 20 DAP. The first application

after inoculation was carried out 24 hours after inoculation and an interval of 5 days after the first application (Jhala *et al.*, 2017), namely 22, 27, 32 DAP. The dose used was 5 mL plant⁻¹ (Tombe *et al.*, 2012).

Observed Variables. The inhibitory ability test was carried out by the disc diffusion method (Liu *et al.*, 2016). The disc method was carried out using disc paper with a diameter of 6 mm. The antifungal activity was determined by the formula (Suryanto *et al.*, 2011):

$$I = \frac{r_1 - r_2}{r_1} \times 100\%$$

I = the level of cogongrass root extract inhibition,

r₁ = trace pathogenic colonies to the Petri dish,

r₂ = trace pathogenic colonies leading to disc paper.

The level of inhibition was calculated by the equation of Bekker *et al.* (2006), namely:

$$r = y - x$$

r = inhibition zone,

x = fungal colony radius which has stunted growth (mm),

y = radius of fungal colony with normal growth (mm).

The method of measuring the dry colony weight of *A. porri* was by preparing pathogenic fungi from the 6 days inhibitory test results, adding 10 mL of 1% HCl to each Petri dish and heating it in a water bath until it melts, pouring it on filter paper with known weight, spraying it with sterile water, and the remaining colonies on filter paper were dried in an incubator at 30 °C for 24 hours, then weighed twice (Supriyanto *et al.*, 2020).

Observation of the incubation period was carried out every day from the time the plants were inoculated until the time symptoms appeared. Disease intensity was recorded 10 day after inoculation (DAI) (Jhala *et al.*, 2017), namely when the plants were 33, 36, 39, 42, 45, and 48 DAP and calculated by the formula:

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

DI = disease intensity (%),

n = number of plant parts affected (strands),

v = damage scale value,

N = number of leaves observed,

Z = the highest scale. The value of the damage scale according to Abdel-Hafez *et al.* (2013) were 0 (no symptoms), 1 (1–25% infected leaves), 2 (26–50% infected leaves), 3 (51–75% infected leaves), and 4 (76–100 infected leaves).

Area Under Disease Progress Curve (AUDPC) was calculated by a formula of Ling *et al.* (2017) as followed:

$$AUDPC = \sum_i^{n-1} \left(\frac{y_i + y_{i+1}}{2} \right) (t_{i+1} - t_i)$$

y_i = disease severity on the i th date;

t_i = i th day;

n = number of dates on which purple Blotch was recorded

The infection rate was calculated using epidemiological formula of Van Der Plank (1963):

$$r = \frac{2.3}{t} \left(\log \frac{x_t}{1 - x_t} - \log \frac{x_o}{1 - x_o} \right)$$

r = infection rate,

t = interval of observation time,

x_t = proportion of sick leaves at time t,

x_o = proportion of sick leaves at the beginning of observation. The units used were units per day.

Observations of plant height, number of leaves, number of tillers were carried out on 10 sample plants per experimental plot which were determined systematically with a U pattern (Setiawati *et al.*, 2011), and starting at 7, 14, 21, 28, and 35 DAP. Leaf chlorophyll was measured using SPAD at the end of the vegetative phase of the plant, while yield component observations were measured after harvest. Leaf area measurements were carried out when the plants were 35 DAP with the cylinder method (Maftuchah & Idiyah, 1995).

$$LD = (2 \cdot \pi \cdot r_1 \cdot h_1) + \left(\frac{1}{3} \cdot 2 \cdot \pi \cdot r_2 \cdot h_2 \right)$$

r₁ = radius of tube,

h₁ = height of tube,

r₂ = radius of cone,

h₂ = cone height.

The total phenol content of leeks was measured by the Folin-Ciocalteu method from Blainski *et al.* (2013) modified.

Data Analysis. Data analysis of variance was carried out, if there was a significant difference in treatment, the DMRT test was carried out at the 5% level.

RESULTS AND DISCUSSION

Based on the results of the analysis, the treatment of cogongrass root extract from five types of soil gave differences to the growth of *A. porri* (Table 1). Treatment of root extract 60% collected from Pachic Hapludolls gave the better results compared to Aerice Endoaqualfs cogongrass root extract and was not significantly different from other treatments, including the comparator propineb fungicide, in inhibiting the development of *A. porri* colonies, with an inhibition of 55.80%.

This showed that almost all extracts had the same potential to suppress the growth of *A. porri* in in vitro tests. The chemical compounds produced by cogongrass roots were thought to be different in each type of soil, so that they had a different effect on microbes. Soil allelopathy is influenced by soil conditions, growing conditions of giver and recipient plants, and climatic conditions. Soil factors that influence are soil texture, organic and inorganic materials, moisture and organisms that affect phytotoxin activity in the soil (Kobayashi, 2004).

The lowest percentage of inhibition was found in the treatment of Aerice Endoaqualfs cogongrass root extract 60% and it was not significantly different from all treatments, apart from the treatment of Pachic Hapludolls cogongrass root extract at 50 and 60% of concentration and Typic Quartzipsamments all concentrations. Propineb fungicide treatment at all concentrations was not different from almost all cogongrass root extract treatments. Based on the results of the analysis above, it appeared that the two observed variables were interrelated. The large inhibition zone value and inhibition percentage tended to cause the small dry weight of *A. porri* colonies on PDA, the smaller the inhibition zone and the percentage of inhibition, the colony dry weight tended to be greater. This showed that the cogongrass root extract could replace the role of propineb function.

The real effect of cogongrass root extract was possible because of the presence of flavonoid compounds. The cogongrass root extract of Pachic Hapludolls contains flavonoids 420.861 mg L⁻¹ followed by cogongrass root extract of Aquertic Chromic Hapludalfs (369.846 mg L⁻¹), of Typic

Table 1. Effect of soil type where it was grown and when the cogongrass root extract was applied to the growth of *A. porri* colonies in vitro

Types of soil where cogongrass grow	Concentration (%)	Inhibition zone (cm)	Colony dry weight (mg)	Inhibition (%)
Comparison (propineb)	50	1.97 abc	26.33 ab	54.28 c
	60	1.70 abc	18.33 a	46.09 abc
	70	1.97 abc	18.67 a	54.11 c
Typic Udipsamments	50	1.93 abc	25.00 ab	48.67 bc
	60	2.07 abc	20.00 a	52.12 c
	70	2.07 abc	25.00 ab	51.56 c
Aerice Endoaqualfs	50	1.00 a	25.67 ab	34.13 ab
	60	0.93 a	19.33 a	30.53 a
	70	1.00 a	25.00 ab	33.68 ab
Typic Quartzipsamments	50	2.03 bc	33.33 b	54.83 c
	60	1.92 bc	19.00 a	51.82 c
	70	1.98 bc	21.67 a	53.72 c
Aquertic Chromic Hapludalfs	50	1.43 abc	23.33 a	46.63 abc
	60	1.43 abc	21.67 a	46.30 abc
	70	1.43 abc	18.33 a	46.09 abc
Pachic Hapludolls	50	1.83 bc	20.33 a	48.27 bc
	60	2.10 c	19.33 a	55.80 c
	70	1.97 abc	20.00 a	52.07 c

The numbers followed by the same letter in the same column are not significantly different according to the DMRT level of 5%.

Quartzipsamments (333.845 mg L⁻¹), of Aeric Endoaqualfs (290.461 mg L⁻¹), and the lowest was the root extract of Typic Udipsamments (217.907 mg L⁻¹). Flavonoids are a group of polyphenolic compounds in plants commonly found in vegetables, fruit, flowers, seeds, honey and propolis (Ahmad *et al.*, 2015). Flavonoids are formed through the shikimat route and have antimicrobial and antioxidant properties.

The ability of flavonoid compounds as a secondary metabolite had been proven by several researchers. Arie *et al.* (2015) reported that cogongrass extract had an effect in suppressing the growth and sporing of *Colletotrichum musae*. According to Gusmarini *et al.* (2014), reeds extract could suppress the growth of *C. musae*, because cogongrass contains alkaloids, flavonoids, mannitol, malic acid, citric acid, coixol, arundoin, cylindrine, fernerol, simiarenol, anemone, esin, alkaline, saponins, tannins, and polyphenols.

Meanwhile, Kumar & Pandey (2013) and Kalogianni *et al.* (2020) said that flavonoid compounds entered fungal cells through holes in the cell membrane that were formed because phenolic compounds have denatured cell membrane lipids. These protein compounds will be denatured by flavonoids through their hydrogen bonds. The ability of flavonoids to bind to proteins causes inhibition of cell wall formation, so that hyphal growth is also inhibited because the required cell wall composition is not fulfilled. Apart from being a

structural component, protein also functions as a functional component, namely an enzyme. All metabolic reactions in cells are catalyzed by enzymes which are proteins. These metabolic reactions include important biosynthetic reactions and reactions that produce energy that result in cells being deprived of energy for growth (Maslanka *et al.*, 2020). This results in inhibited hyphal elongation, so the growth of mycelium colonies will be smaller.

In Vivo Test. Based on the results of analysis of variance, there are significant differences in the variables of incubation period and disease intensity, infection rate, and AUDPC (Table 2).

Pathosystem Components. Symptoms of purple blotch began to appear at the 4th week after planting. The fastest incubation period was found in the control but it was not significantly different from that of the cogongrass root extracts in Typic Udipsamments and Aeric Endoaqualfs, while the treatment of cogongrass root extracts of other soil types and fungicides was longer, and the longest was the cogongrass root extract of Aquertic Chromic Hapludalfs by 41.85% followed by Pachic Hapludolls at 40.25% compared to control (Table 2). Meanwhile, the incubation period for other soil types was not significantly different from the comparator propineb fungicide, and the application

Table 2. Effect of soil type where it was grown and the time of application of cogongrass root extracts on the development of onion purple blotch

Types of soil where cogongrass grow	Application at inoculation	Incubation period (DAI)	Disease intensity (%)	Infection rate (unit per day)	AUDPC (% day)
Control		7.17 a	61.30 h	0.1528 c	437.75 c
Comparator (Propineb)	Before	11.00 cde	28.05 def	0.0583 ab	203.28 ab
	After	9.67 cde	20.65 abc	0.0462 ab	169.44 ab
Typic Udipsamments	Before	8.33 abc	34.68 efg	0.0719 b	229.64 b
	After	9.00 abc	35.45 efg	0.0711 b	233.81 b
Aeric Endoaqualfs	Before	7.33 ab	32.05 def	0.0691 ab	227.09 b
	After	9.00 ab	32.51 def	0.0689 ab	227.14 b
Typic Quartzipsamments	Before	9.00 bcd	29.59 def	0.0619 ab	212.51 ab
	After	11.00 bcd	26.93 def	0.0572 ab	211.22 ab
Aquertic Chromic Hapludalfs	Before	11.67 e	23.64 bcd	0.0517 ab	185.44 ab
	After	12.33 e	24.30 cde	0.0528 ab	189.63 ab
Pachic Hapludolls	Before	12.00 de	18.47 a	0.0380 a	141.70 a
	After	10.33 de	19.32 ab	0.0401 a	150.26 a

The numbers followed by the same letter in the same column are not significantly different according to the DMRT level of 5%. The data was transformed to $\sqrt{(x + 0.5)}$. dai = days after inoculation.

before and after inoculation was not significantly different. This was because the chemical compound content of cogongrass root extract from each soil type was not the same. The results of the flavonoid content analysis showed that the roots of the cogongrass in Typic Udipsamments and Aeric Endoaqualfs were the lowest compared to other soil types. This was in accordance with the opinion of Kobayashi (2004) and Yang *et al.* (2018), that soil factors affected the production of plant secondary metabolite compounds.

In line with the fast incubation period, the highest disease intensity was found in shallots without treatment, which was significantly different from all treatments including comparator (Table 2). The smallest emphasis on purple blotch intensity was found in the cogongrass root extract of Pachic Hapludolls before inoculation of 69.87% compared to control. All treatments of cogongrass root extract did not differ from fungicide treatment, this meant that cogongrass root extract could replace the role of fungicides in overcoming onion purple blotch, with a suppression range between 42.17–69.87% compared to control.

This was consistent with the results of the *in vitro* test on the growth of fungal colonies, and was supported by the higher flavonoid content in the cogongrass root extract, especially from the Pachic Hapludolls soil type, which was 420.861 mg L⁻¹. The high content of flavonoids contributes to the correlation and may have a role in reducing plant susceptibility by impacting resistance to disease-causing infections (McLay *et al.*, 2020; Shah & Smith, 2020). Furthermore, McLay *et al.* (2020) explained that UV-B-induced flavonoids could partially mediate the reduction in the phenotype of disease severity, which was negatively correlated with the amount of *Bremia lactucae* conidia in lettuce plants.

The incubation period data showed no significant difference in all treatments of cogongrass root extract, while the disease intensity data were significantly different. This was presumably due to the insufficient dose of cogongrass root extract or the slow mechanism of flavonoids in overcoming symptoms. Meanwhile, when these compounds begin to be absorbed by plants, activity in the face of pathogen attacks begins to appear. This condition was in accordance with the statement of Shah & Smith (2020), that flavonoids were secondary metabolites and biostimulants; which played a key role in plant growth by impacting resistance to certain biotic and abiotic stresses.

Time of treatment application had no significant effect between before and after inoculation. In almost all treatments, the application time before inoculation

tended to be higher than that applied after inoculation (Table 2). It was suspected that the treatment applied before the inoculation of plant pathogens could serve as a preventive measure. This was in accordance with the opinion of Khalid *et al.* (2019), that the application of flavonoids, in particular, was related to the protection of plants from pathogen attack and had a very important role in plant resistance to pathogens.

Meanwhile, the intensity of the disease tended to increase in line with the increasing age of the shallot plants (Figure 1). However, the incidence of disease progression was much higher in the untreated compared to treated plants. This was in accordance with the statement of Mierziak *et al.* (2014) stated that flavonoid compounds were transported to the site of infection and cause hypersensitivity reactions, thus inhibiting disease progression.

The highest infection rate was found in the control and the lowest in the root extract of cogongrass Pachic Hapludolls application before inoculation (Table 4). The development of the infection rate during five observations could be seen in Figure 2. The cogongrass root extract was able to compensate for propineb in suppressing the rate of infection. The application of Pachic Hapludolls cogongrass root extract before inoculation was able to slow down the infection rate by 75.13% compared to control. However, overall, the mean infection rate was less than 0.5 per unit per day. According to Van Der Plank (1963), the infection rate value could be defined as whether the pathogen was aggressive, the variety was susceptible or resistant, and whether the environment was favorable or not for the development of the disease. Furthermore, it said that if the value of *r* was greater than 0.5 units per day, it meant that the pathogen was aggressive, the varieties were susceptible and the weather was favorable.

The slow growth rate of infection in the treatment based on the results of the 5% DMRT did not significantly differ between the propineb fungicide and all cogongrass root extracts. There was no significant difference between the applications before and after inoculation. This condition was in line with the incubation period and the intensity of the disease above. This was supported by the important role of flavonoids contained in cogongrass root extracts, which play a role in protecting plants against the attack of biotic and abiotic pathogens (McLay *et al.*, 2020; Shah & Smith, 2020).

Meanwhile, the control treatment had a higher AUDPC value than the treatment, which was in line with the incubation period, disease intensity, and infection rate (Table 2). The treatment of cogongrass Pachic

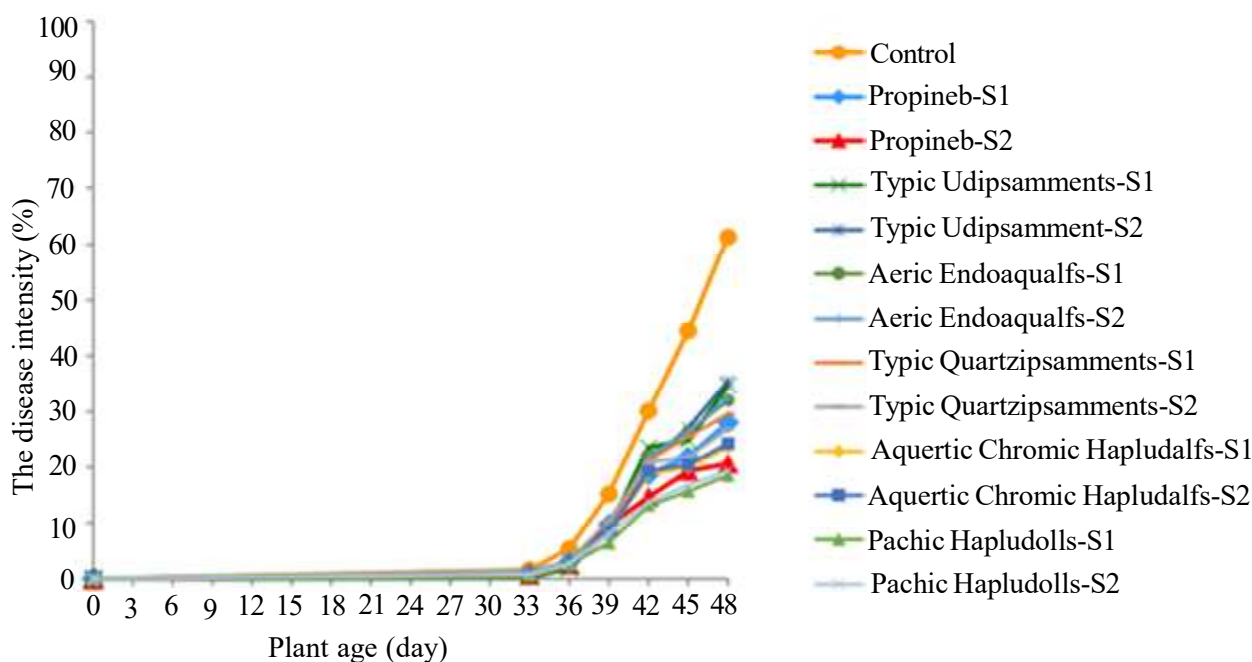


Figure 1. Development of purple blotch due to cogongrass root extract treatment from types of soil. Information: S1= before inoculation and S2= after inoculation.

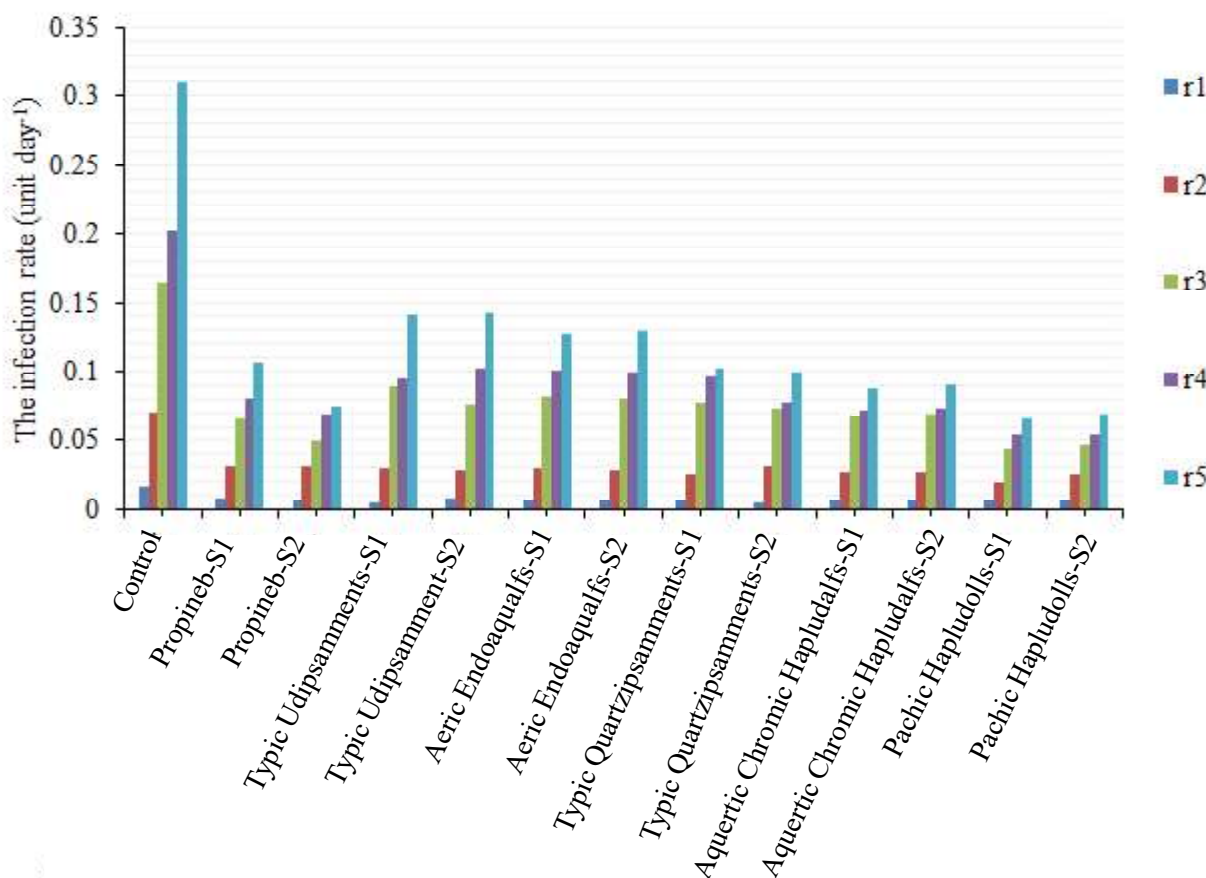


Figure 2. Development of purple blotch infection rate due to ogongrass root extract treatment from types of soil. Information: S1= before inoculation; S2= after inoculation; r= infection rate; 1, 2, 3, 4, 5= observation times.

Haludolls root extract before inoculation showed the highest AUDPC suppressor value of 67.63% compared to control. This was consistent with the suppression of disease intensity and infection rate. The AUDPC value in the cogongrass root extract was not significantly different from the propineb, even the AUDPC value in the propineb fungicide treatment tended to be higher when compared to the treatment of cogongrass root extract Pachic Hapludolls and Aquertic Chromic Hapludalfs.

The application of propineb before inoculation caused shallot plants to be relatively more susceptible to pathogens. This was thought to be the nature of the contact propineb fungicide, so that when applied before inoculation it can wash off or evaporate. In accordance with the statement of Majeed *et al.* (2014) stated that systemic fungicides were more effective at controlling disease severity and disease progression than contact fungicides. This was because of the non-absorption capacity into host tissue, contact fungicides were only effective when applied at shorter intervals (Carmona *et al.*, 2020). AUDPC chart was shown in Figure 3.

AUDPC is a parameter to measure the progression of disease severity over a certain time (Apriyadi *et al.*, 2013). The higher the AUDPC value, the lower the resistance level or the percentage of inhibition in the treatment (Gunaeni, 2015). According to Nuryani *et al.* (2011), if the AUDPC number was lower, the treatment would be more effective in controlling the pathogen, and conversely, the higher the

AUDPC number, the treatment will have no effect on pathogen infection. Based on the data above (Table 2), it appeared that the treatment of cogongrass root extract was able to reduce the AUDPC value. Thus, there was a chance that cogongrass root extract could be used to control purple blotch on shallots.

Based on the results, it turned out that cogongrass root extract could compensate for the ability of the propineb fungicide in suppressing the development of purple blotch on shallots and impacting resistance of shallots. This was reinforced by the results of the analysis of the total phenol of shallots, namely propineb fungicide (12.97 mg g⁻¹), and the cogongrass root extract of Typic Udipsamments (11.51 mg g⁻¹), of Aeric Endoaqualfs (12.22 mg g⁻¹), of Typic Quartzipsamments (12.84 mg g⁻¹), of Aquertic Chromic Hapludalfs (11.66 mg g⁻¹), and of Pachic Hapluderts (13.84 mg g⁻¹).

Growth Components. The range of mean plant height, number of leaves, leaf area, chlorophyll content, and number of tillers showed no significant difference between treatment and control (Table 3).

Vegetative growth of plants is more influenced by the availability of nutrients, which function to maintain the survival of a plant. These nutrients include N, P, and K. The availability of nutrients needed by plants results in a better vegetative plant growth and will accelerate the generation of the plant's generative phase (Isda *et al.*, 2013).

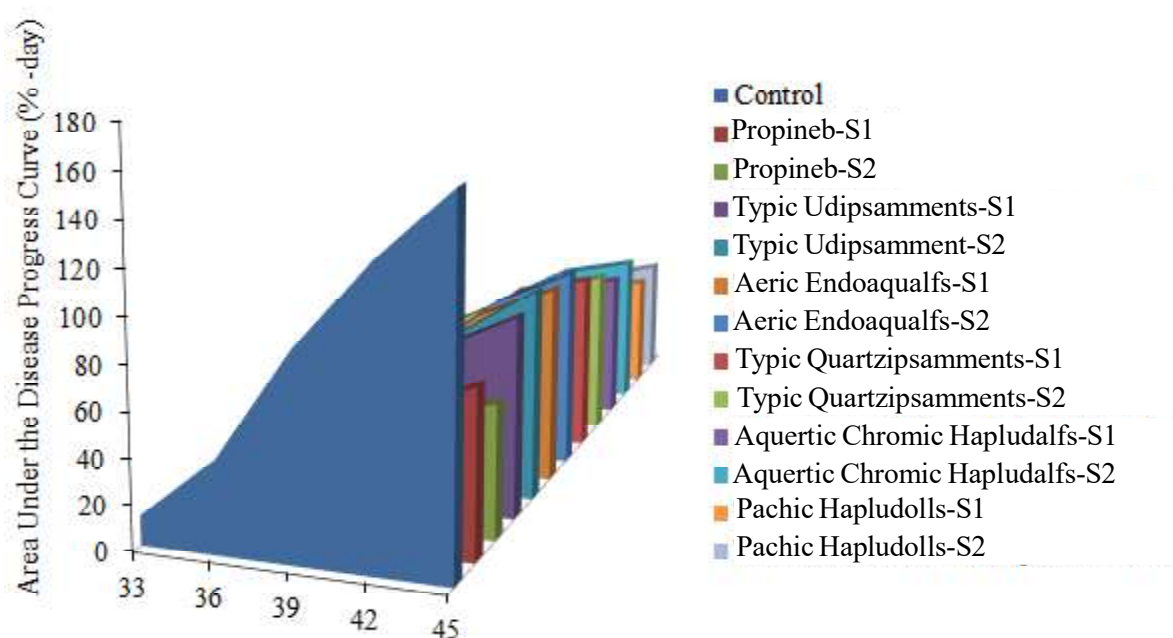


Figure 3. Differences in AUDPC values of onion purple blotch due to cogongrass root extract treatment from types of soil. Information: S1= before inoculation and S2= after inoculation.

Yield Components. All treatments had no significant effect on the number of tubers planted (Table 4). This was thought to be related to the growth component which was not significantly different. According to Sumarni *et al.* (2012), the number of tillers or the number of tubers was determined more by genetic factors than environmental factors including fertilization. This was also stated by Sekara *et al.* (2017), that the number of shallot tillers was a plant genetic trait that cannot be easily changed by external factors.

The treatment of cogongrass root extract Pachic Hapludolls before inoculation was able to increase the highest plant fresh weight per plant by 42.7% compared to the control (Table 4). In addition, the application of Pachic Hapludolls cogongrass root extract before inoculation increased the plant dry weight per plant and the highest tuber dry weight per plant by 49.6 and 51.92%, respectively, compared to the control. There was no significant difference between propineb fungicide treatment and all cogongrass root extract treatments. This was consistent with the data on the low pathosystem components (Table 2).

In line with Table 4, the treatment of cogongrass root extract Pachic Hapludolls before inoculation was able to increase the plant fresh weight per plot, plant dry weight per plot, and the highest tuber dry weight

per plot, respectively 66.75, 72.29, and 73.53% compared to control (Table 5). Propineb fungicide treatment was not significantly different from all treatments of cogongrass root extract. However, among the cogongrass root extract treatments, there were differences in tuber dry weight per plot. The cogongrass root extract of Pachic Hapludolls was different from that of Typic Quartzipsamments, Aeris Endoaqualfs, and Typic Udipsamments. When compared to the control, treatment of cogongrass root extract Pachic Hapludolls before inoculation can increase the yield of dry tubers per hectare as 73.53%.

The effect of the application of cogongrass root extract on yield components because the cogongrass root extract contains nutrients needed by shallot plants. Hagan *et al.* (2013) and Isda *et al.* (2013) added that in addition to producing phenolic compounds, cogongrass also produces nutrients which can be used as growth promoters. Cogongrass roots contain heavy metal compounds such as iron (Paz-Alberto *et al.*, 2007; de la Fuente *et al.*, 2017). The function of iron (Fe) is to play a role in the formation of chlorophyll, Cu is a constituent of enzymes, the formation of chlorophyll, and the metabolism of carbohydrates and proteins (Printz *et al.*, 2016).

Table 3. Effect of soil type where cogongrass grows and application time on plant height, number of leaves, leaf area, leaf chlorophyll, and number of tillers

Types of soil where cogongrass grow	Application at inoculation	Plant height (cm)	Number of leaves	Leaf area (cm ²)	Leaf Chlorophyll (CCI)	Number of tillers
Control		34.42 a	20.57 a	8.05 a	4.98 a	5.33 a
Comparator (propineb)	Before	35.89 a	22.00 a	6.75 a	5.18 a	5.00 a
	After	36.05 a	23.67 a	7.18 a	4.93 a	5.33 a
Typic Udipsamments	Before	35.55 a	23.00 a	8.74 a	6.57 a	5.67 a
	After	37.85 a	22.67 a	9.08 a	3.77 a	5.67 a
Aeris Endoaqualfs	Before	38.23 a	23.33 a	7.68 a	5.28 a	4.67 a
	After	38.20 a	22.00 a	8.14 a	7.25 a	5.00 a
Typic Quartzipsamments	Before	38.77 a	22.67 a	8.90 a	5.27 a	5.00 a
	After	38.17 a	21.67 a	8.10 a	6.17 a	5.00 a
Aquertic Chromic Hapludalfs	Before	37.10 a	22.67 a	7.20 a	4.38 a	5.00 a
	After	36.35 a	21.00 a	8.10 a	3.53 a	4.67 a
Pachic Hapludolls	Before	38.27 a	22.67 a	8.32 a	6.16 a	5.00 a
	After	36.50 a	22.67 a	6.66 a	9.87 a	5.00 a

The numbers followed by the same letter in the same column are not significantly different according to the DMRT level of 5%. CCI = Chlorophyll Content Index.

Table 4. Effect of soil type where it is grown and application time to the number of tubers, plant fresh and dry weight, and tuber dry weight per plant

Types of soil where cogongrass grow	Aplication at inoculation	Number of tubers	Plant fresh weight plant ⁻¹ (g)	Plant dry weight plant ⁻¹ (g)	Tuber dry weight plant ⁻¹ (g)
Control		4.50 a	17.58 a	12.08 a	10.83 a
Comparator (propineb)	Before	5.67 a	25.27 bc	20.63 cd	17.67 bc
	After	5.67 a	29.90 bc	23.10 cd	21.70 bc
Typic Udipsamments	Before	5.33 a	26.06 bc	19.74 bc	18.04 b
	After	5.00 a	24.47 bc	16.80 bc	15.43 b
Aeric Endoaqualfs	Before	5.00 a	25.57 bc	19.42 bcd	18.23 bc
	After	5.33 a	29.83 bc	20.72 bcd	19.33 bc
Typic Quartzipsamments	Before	5.00 a	25.84 b	19.82 b	18.58 b
	After	5.67 a	21.30 b	14.14 b	12.60 b
Aquertic Chromic Hapludalfs	Before	4.67 a	27.93 bc	19.03 bc	17.90 b
	After	4.67 a	24.77 bc	18.47 bc	17.32 b
Pachic Hapludolls	Before	4.33 a	30.68 c	23.97 d	22.54 c
	After	5.67 a	28.73 c	24.13 d	23.07 c

The numbers followed by the same letter in the same column are not significantly different according to the DMRT level of 5%.

Table 5. Effect of soil type where it is grown and application time on plant fresh weight, plant dry weight, and tuber dry weight per plot

Types of soil where cogongrass grow	Application at inoculation	Plant fresh weight per plot (g)	Plant dry weight per plot (g)	Tuber dry weight per plot (g)
Control		224.33 a	147.33 a	130.75 a
Comparator (propineb)	Before	407.00 bc	323.33 bc	283.00 bc
	After	619.00 bc	489.00 bc	443.67 bc
Typic Udipsamments	Before	403.33 b	317.67 b	279.33 b
	After	414.00 b	328.00 b	294.00 b
Aeric Endoaqualfs	Before	446.33 b	334.67 b	305.67 b
	After	513.00 b	407.33 b	315.00 b
Typic Quartzipsamments	Before	422.33 b	333.67 b	305.00 b
	After	326.00 b	257.33 b	215.67 b
Aquertic Chromic Hapludalfs	Before	527.00 bc	416.33 bc	362.00 bc
	After	507.33 bc	396.33 bc	338.00 bc
Pachic Hapludolls	Before	674.67 c	531.67 c	494.00 c
	After	598.00 c	472.67 c	457.00 c

The numbers followed by the same letter in the same column are not significantly different according to the DMRT level of 5%.

CONCLUSION

Cogongrass root extract was able to inhibit the growth of *A. porri* fungi in vitro. The treatment of Pachic Hapludolls 60% cogongrass root extract was the best extract concentration in the in vitro test. The treatment of Pachic Hapludolls cogongrass root extract before inoculation had a significant effect on the highest pathosystem components by being able to delay the appearance of purple blotch by up to 41.85%, reducing disease intensity by 69.87%, slowing the infection rate by up to 75.13%, and reducing the AUDPC value up to 67.63% compared to control. The treatment of Pachic Hapludolls cogongrass root extract before inoculation increased plant fresh and dry weight per plant, tuber weight per plant, plant fresh weight per plot, plant dry weight per plot, and the highest tuber dry weight per plot, respectively, as 42.7, 49.6, 51.92, 66.75, 72.29, and 73.53% compared to control.

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