The effectiveness of essential oils as a biofungicide and potassium fertilizers in control of rubber leaf fall disease (*Corynespora* sp.)

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Abstract. *Corynespora* causes leaf fall disease in rubber plants. Control can be done with bio fungicides and potassium fertilizer. This study aims to determine the effectiveness of essential oils and potassium fertilizer in controlling rubber leaf fall disease. The research was conducted from January to December 2018 in Landak Regency, West Kalimantan. The study used a randomized block design with 13 treatments repeated 3 times. The treatment is without biofungicide and KCl, citronella oil + (KCl 250 g, 312.5 g, and KCl 375 g), clove oil + (KCl 250 g, 312.5 g, and 375 g), liquid smoke + (KCl 250 g, 312.5 g, and 375 g), chemical fungicides (*mancozeb)* + (KCl 250 g, 312.5 g, and 375 g). The results showed that citronella oil, clove oil, and liquid smoke had the same inhibitory power as chemical fungicides. The combination of citronella oil with fertilizer KCl 312.5 g/plant/year and clove oil with KCl 375 g/plant/year can reduce the intensity of *Corynospora* attack up to 7.33% with inhibition of rubber leaf fall disease reaching 90.09% and can maintain yield of 28.1-28.3 g/tapping (94.33%). KCl fertilizer increased the lignin content of rubber leaves by 22.63%.

1 Introduction

Leaf fall is one of the main diseases that attack rubber plants. Characteristics of the attack in the form of necrotic lesions, blackening of the vessels, and leaf bones that look pinnate like 'fish bones'. Attacks in all leaf phases and young leaves are most susceptible [1,2]. This can cause massive defoliation, delayed plant growth, decreased yield, and death [1,3,4]. Rubber leaf fall disease is caused by several fungi namely, *Corynespora cassicola*, *Oidium hevea*, and *Colletotrichum gloeospoiroides* [5]. The fungus spreads through sporangium carried by water, wind, and insects.

Several experts have conducted research to find inexpensive alternatives to control pests and diseases with low toxicity. The use of essential oils and plant extracts has the potential to control several phytopathogens. Essential oils are natural complex compounds as a result of secondary metabolites from aromatic plants, which play a role in plant protection against pathogens [6]. The main constituents of citronella oil are Citronellal (27.5%), geraniol (20.4%), citronellol (13.4%) [7]. Lemongrass oil is used as an antispasmodic, rubefacient,

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stimulant, insect repellent, carminative, and diaphoretic [8]. It is also possible to use smoke solutions to control some plant diseases. Liquid smoke contains phenolic, carbonyl, and acidic compounds that have antimicrobial and antioxidant properties [9]. Clove extract has the potential to be applied as a biofungicide because of its active component as anti-fungal [10].

The results showed that the essential oils inhibited the germination of urediniospores *H. Vastatrix* [11], had antifungal activity against *Penicillium* [12], the effectiveness of clove oil (*Syzygium aromaticum*) against *Venturia inaequalisstrains* [13], eugenol oil nanoemulsion protects cotton seeds from *Fusarium* wilt [14], inhibits the germination of *Aspergillus flavus* spores in rubberwood [7].

Increasing plant resistance can be done by using potassium fertilizer. It is known that nutrient K impacts several physiological, metabolic, and hormonal processes that may be important for plant susceptibility and susceptibility to pathogens and insects [15]. In addition, K fertilization on rubber plants can help increase the yield of latex [16].

Based on the description above, the application of bio fungicides in the form of essential oils and KCl fertilizer is thought to be effective in reducing the rate of development of leaf fall disease. This study aims to determine the effectiveness of several types of bio fungicides and the right dose of K fertilizer to control rubber leaf fall disease.

2 Materials and methods

2.1 Location and time

The research was carried out in Mandor District, Landak Regency, West Kalimantan Province (00015'- 00020' North Latitude and 109018'-109023'BT). The study was conducted from January to December 2017.

2.2 Materials and tools

The materials are community rubber plant (PB 260) aged 10 years, citronella oil, clove oil, liquid smoke, chemical fungicide (*mancozeb*), KCl fertilizer, urea fertilizer, and SP36 fertilizer. Tools such as hoes, hand sprayers, machetes, sickle tapping, bowls, and buckets.

2.3 Research design

The study used a randomized block design with 13 treatments repeated 3 times. The treatment is; (fo) without bio fungicides and KCl fertilizer, (f1) citronella oil + KCl 250 g/plants/year, (f2) citronella oil + KCl 312.5 g/plants/year, (f3) citronella oil + KCl 375 g/plants/year, (f4) clove oil + KCl 250 g/plants/year, (f5) clove oil + KCl 312.5 g/plants/year, (f6) clove oil + KCl 375 g/plants/year, (f7) liquid smoke + KCl 250 g/plants/year, (f8) liquid smoke + KCl 312.5 g/plants/year, (f9) liquid smoke + KCl 375 g/plants/year, (f10) chemical fungicide (*mancozeb*) + KCl 250 g/plants/year, (f11) chemical fungicide + KCl 312.5 g/plants/year, (f12) chemical fungicide + KCl 375 g/plants/year. The number of plants/plot was 18 plants, bringing the total to 648 plants.

2.4 Research implementation

The recommended dose of KCl fertilization is 250 g KCl/plant/year. The dosage of essential oil used is 5 ml/liter of water, while the liquid smoke is at the dosage of 40 ml/liter of water. Spraying volume 250 ml/plant. Chemical fungicide with the active ingredient *mancozeb* 80%

with a concentration of 0.1%. The spraying interval is once every three months. Application of KCl fertilizer was two times/year, half the dose at the beginning and end of the rainy season with Urea and SP36 fertilizers at 300 g/plant and 200 g/plant, respectively. Fertilization is carried out by making an array around the plant canopy (1 m from the base of the stem). The cleaning of the plant canopy and weeding using herbicides at a dose of 4 liters/ha every three months.

2.5 Observation

Parameters observed were attack intensity, lignin content in leaves, latex flow time, and latex production/leads. The intensity of the disease attack was observed by counting the number of healthy leaves and pain in each plant in the North, South, West, and East directions. Symptoms of damage to leaves due to disease are determined based on a 0-4 scale value as shown in Table 1.

Table 1. Scale values with the level of leaf damage due to disease.

Scale value	Leaf damage rate (%)
0	0
1	1 – 25
2	26 – 50
3	51 – 75
4	76 – 100

Source: [17]

The intensity of the disease attack is calculated using the formula :

$$I = \frac{\sum(ni \; x \; vi)x \; 100\%}{n \; x \; Z} \quad (1)$$

Information :
I = intensity of disease attack
ni = number of leaves on the-i attack scale (v)
vi = scale value of each attack category
Z = scale value of the highest attack category
N = number of leaves observed

Observation of lignin content was carried out by taking leaves that grew new after treatment and had fully grown on all four sides of the plant with three leaves each. Observation of lignin content conducted in the laboratory. Production and duration of latex flow were observed every three months, namely March, June, September, and December. The duration of latex flow was observed based on the length of time the latex flowed from the first drop until it stopped dripping, while the production of latex/lead was the weight of latex, in the form of a frozen lump after the latex stopped dripping (g/lead). Statistical analysis to distinguish between treatments using a DMRT test with a level of 5%.

3 Results and discussion

3.1 The intensity of attack and disease inhibition

The results showed that the use of essential oils and the dose of KCl fertilization affected the intensity of leaf fall disease on rubber plants (Table 2). The lowest attack intensity (7.33%) or the highest disease inhibition (90.09%) was obtained with the use of citronella oil with a

KCl fertilizer dosage of 312.5 g/plant, which was not significantly different from the clove oil treatment and a KCl fertilizer dosage of 375 g/plant, the use of liquid smoke, and *mancozeb* at all tested doses of KCl fertilizer. Clove oil will be effective if it is accompanied by the application of KCl fertilizer at a dose of 312.5 and 375 g/plant. If the dose of KCl fertilizer was according to the recommendation of 250 g/plant, the intensity of the attack would be high, but significantly lower than without fungicide and KCl fertilizer (Table 1).

Citronella oil, clove oil, and liquid smoke, each contain citronella, eugenol, and phenol compounds, which can kill disease-causing fungi. Li et al. [18], stated that citronella oil can destroy hypha cell walls and then act on the sporoplasm to kill conidia. The same thing is suspected to have happened to the fungus *Corynespora* which causes rubber leaf fall disease so that it can inhibit the development of the disease. The combination of the use of essential oils and the application of KCl fertilizer, not only kills the fungus that causes leaf fall disease, but also makes it difficult for the fungus to infiltrate the mycelium into the leaves. So that it can inhibit the attack of leaf fall disease until 90.09%.

Nutrients Potassium functions in regulating turgor pressure which affects the size of the pores in the leaves (stomata). The small pores prevent the mycelium from infiltrating. Stomata can function properly when there is sufficient K, thereby preventing pathogen invasion by rapid stomata closure [19]. Narrow stomata, thick epidermis, and strong cuticle cells will increase plant resistance by making it difficult for disease-causing fungi to thrive. Plants with high K nutrient status had better resistance to *Corynespora* leaf fall disease.

Table 2. The intensity of attack and disease inhibition of several types of bio fungicides and potassium fertilizers.

Treatment	The intensity of attack (%)	Inhibition of disease (%)
Without fungicide and KCl fertilizer	74.00 a	-
Citronella oil + KCl 250 g/plant/year	16.67 bc	77.47
Citronella oil + KCl 312.5 g/plant/year	7.33 c	90.09
Citronella oil + KCl 375 g/plant/year	19.56 bc	73.57
Clove oil + KCl 250 g/plant/year	23.67 b	68.01
Clove oil + KCl 312.5 g/plant/year	16.67 bc	77.47
Clove oil + KCl 375 g/plant/year	7.33 c	90.09
Liquid smoke + KCl 250 g/plant/year	19.67 bc	73.42
Liquid smoke + KCl 312.5 g/plant/year	17.33 bc	76.58
Liquid smoke + KCl 375 g/plant/year	17.67 bc	76.12
Chemical fungicide + KCl 250 g/plant/year	22.00 b	70.27
Chemical fungicide + KCl 312.5 g/plant/year	16.11 bc	78.28
Chemical fungicide + KCl 375 g/plant/year	11.56 bc	84.38

Note: Numbers in the same column followed by the same letter are not significantly different according to DMRT at a significant level of 5%

3.2 Lignin content in rubber leaves

Potassium fertilization affected the lignin content of rubber leaves (Table 3). Lignin or wood substance is one of the components that make up plant tissue that functions as a binding material or adhesive for other tissue components. The highest lignin content was obtained at a dose of K fertilizer of 375 g/plant, which was 22.63% which was not different from that of a fertilizer dose of 312.5 g/plant, except with a fertilizer dose of 250 g/plant and without K fertilization. Optimum K fertilizer increased the accumulation of lignin into vessels and sclerenchyma cells of plant cell walls [19]. Lignin, cellulose, and carbohydrates are the main constituents of cell walls that play a role in plant resistance [20].

Table 3. Effect of several doses of KCl fertilizer on lignin content in rubber leaves.

Dosage of KCl fertilizer (g/plant/year)	Lignin content (%)
No fertilizer	14.00 c
250.0	18.50 b
312.5	22.36 a
375.0	22.63 a

Note: Numbers in the same column followed by the same letter are not significantly different according to DMRT at a significant level of 5%.

3.3 Latex flow time and production

The results showed that the application of essential oils and potassium fertilizer affected the duration of latex flow and latex production (Table 4). The longest latex flow and the highest production of latex/tapping were found in the use of citronella oil with a dose of KCl 312.5 for 5.8 hours and 28.3 g/tapping which was not significantly different from the use of clove oil and a dose of KCL fertilizer of 375 g/plant, as well as other treatments except essential oils treatment with KCl 250 g/plant and without essential oil and KCl fertilizer treatment.

Table 4. Effect of treatment on flow time and latex production.

Treatment	Latex flow time (hour)	Latex production/tapping (g)
Without fungicide and KCl fertilizer	3.3 c	16.1 c
Citronella oil + KCl 250 g/plant/year	4.4 b	21.3 bc
Citronella oil + KCl 312.5 g/plant/year	5.8 a	28.3 a
Citronella oil + KCl 375 g/plant/year	5.5 ab	26.6 ab
Clove oil + KCl 250 g/plant/year	4.6 b	22.3 b
Clove oil + KCl 312.5 g/plant/year	5.6 a	27.3 ab
Clove oil + KCl 375 g/plant/year	5.8 a	28.1 a
Liquid smoke + KCl 250 g/plant/year	4.6 b	22.6 b
Liquid smoke + KCl 312.5 g/plant/year	5.4 ab	26.3 ab
Liquid smoke + KCl 375 g/plant/year	5.7 a	27.6 ab
Chemical fungicide + KCl 250 g/plant/year	4.8 b	22.3 b
Chemical fungicide + KCl 312.5 g/plant/year	5.4 ab	27.1 ab
Chemical fungicide + KCl 375 g/plant/year	5,7 a	27,9 ab

Note: Numbers in the same column followed by the same letter are not significantly different according to DMRT at a significant level of 5%.

Reducing the dose of KCl fertilizer to 250 g/plant significantly reduced the duration of latex flow and latex production. The use of citronella oil with a KCl fertilizer dose of 312.5 g/plant, and clove oil with a KCl fertilizer dose of 375 g/plant resulted in a low attack intensity of 7.33%, to maintain latex production of 28.1 – 28.3 g/tapping (93.67-94.33%). While the use of citronella oil or clove oil with a dose of KCl fertilizer was reduced to 250 g/plant, the intensity of attack would increase to 16.67% and 23.67%, respectively, and latex production decreased by about 21.3 – 22.3 g/tapping (down 25.67% - 29.00 %), but still higher than without fungicide and KCl fertilization.

Potassium nutrients can indirectly inhibit the development of leaf fall disease in rubber plants by increasing the lignin content in the leaves from 14% to 23.63%. According to [21], accumulation of lignin can restrain the spread and reduce pathogens into plant cell walls, thereby losing the ability of pathogens to infect the host.

4 Conclusion

Clove oil, citronella oil, and liquid smoke have the same inhibitory power as the chemical fungicide *mancozeb*. The combination of citronella oil with fertilizer KCl 312.5 g/plant/year and clove oil with KCl 375 g/plant/year can reduce the intensity of *Corynospora* attack up to 7.33% with inhibition of rubber leaf fall disease until 90.09% and can maintain production of 28.1-28.3 g/tapping (94.33%). KCl fertilizer can increase lignin content in rubber leaves by 22.63%. The higher the dose of K fertilizer, the higher the lignin content in the leaves.

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