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Effectiveness of Rice Husk Liquid Smoke and Ameliorants in Controlling Bacterial Leaf Blight in Rice (*Oryza sativa* L.)

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Abstract

Wet rice farming is a crucial sector for global food security; however, it is frequently affected by bacterial leaf blight, a disease that can reduce yields by as much as 50%. Traditional chemical-based control methods pose environmental risks, highlighting the need for eco-friendly alternatives such as husk liquid smoke and soil ameliorants. This study aims to optimize the combination of liquid chaff smoke, agricultural lime, and organic materials to combat bacterial leaf blight and enhance rice productivity. The research was conducted in rain-fed paddy fields in Kotabaru Village, Lahat District, Lahat Regency, South Sumatra Province. The experimental design employed a Split Plot arrangement with 12 treatment combinations and three replications. The main plots included a control group, soaking seeds in liquid smoke, watering the base of the stem and roots with liquid smoke, and spraying liquid smoke on the stems and leaves. The subplots incorporated agricultural lime, organic matter, and a combination. The observed variables included disease severity, incidence, growth, and productivity. The low disease severity and incidence demonstrated plant resistance to bacterial leaf blight. This resistance was observed in the combination of liquid smoke treatments applied to the stems and leaves, along with agricultural lime and organic materials. This resulted in increased resistance of 47.63% and 20.01%, respectively. Meanwhile, the highest productivity was achieved by applying liquid smoke at the base of the stem and roots, combined with agricultural lime and organic matter, yielding 8.69 tons per hectare, representing a productivity increase of 10.01%.

Keywords: *Ameliorant, Liquid Smoke, Organic Bactericide, Rice, Sustainable Agriculture*

1. Introduction

Lowland rice farming plays a crucial role in addressing global food demands; however, its productivity is frequently jeopardized by bacterial leaf blight disease caused by the pathogen Xanthomonas oryzae pv. oryzae (Xoo). This disease inflicts damage on rice leaves and stems, posing a significant threat to global crop yields and food security. Control measures that still depend on chemical treatments can harm the environment (Yuliani et al., 2015). According to Nellawati et al. (2016), bacterial leaf blight disease in rice can lead to a reduction in crop yield of up to 10-12% under mild conditions and potentially as much as 50% under more severe conditions. Initial symptoms include yellowish to brownish stripes on the leaves, which can impair photosynthesis and panicle and seed formation.

Environmental factors such as high humidity and warm temperatures accelerate the spread of bacterial leaf blight disease in rice, so practical and sustainable control methods are needed. (Ardianto et al ., 2020) . So far, control of this disease still relies on synthetic chemicals such as copper-based bactericides, which, although effective in the short term, are at risk of polluting the environment, disrupting the balance of soil microbes, and encouraging pathogen resistance. Therefore, environmentally friendly alternative solutions are increasingly needed. Liquid smoke from rice husks increases plant resistance to pathogen attacks and supports the growth and yield of rice production.

According to Ariyani et al., 2015 in their research, it was revealed that liquid smoke from rice husks contains active compounds such as phenol, acetic acid, and carbonyl, which are antimicrobial. These compounds can also stimulate the plant's defense system and increase nutrient absorption efficiency by improving the soil's chemical properties (Istiqomah & Eka Kusumawati, 2019). Research conducted by Istiqomah and Kusumawati (2019)

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showed that applying liquid smoke from rice husks with a concentration of 2% significantly increased the growth and yield of rice plants. This increase was seen in plant height, number of tillers, number of grains per panicle, and weight of 1000 grains. In addition, Rusli et al. (2017) also reported that the combination of 2% liquid smoke from rice husks with 4 mL of liquid organic fertilizer (POC) was able to increase plant resistance to bacterial leaf blight attacks by 20.84%, which was indicated by a decrease in the intensity of disease attacks. These research results indicate that liquid smoke from rice husks can play a dual role, both as a growth stimulant and as a plant disease control agent.

In addition to liquid smoke from rice husks, agricultural lime and organic materials ameliorants also increase soil pH and provide additional nutrients to support plant growth and resilience. Low soil pH can harm plant productivity. Through its organic compounds, organic materials can stimulate plant growth and support microbial activity. In addition to loosening the surface layer of the soil, organic materials also increase the soil's ability to absorb and store water so that soil fertility can be significantly increased (Marlina et al., 2015).

Until now, no study has comprehensively examined the optimal combination of rice husk liquid smoke with ameliorants in the form of agricultural lime and organic materials. Therefore, this study aims to develop a combination formulation of rice husk liquid smoke and ameliorants in an integrated farming system. The evaluation will focus on increasing plant resistance to bacterial leaf blight and the potential for increasing rice productivity. The results of this study are expected to provide practical guidance for farmers to implement this technology effectively while ensuring that its implementation does not harm the environment.

2. Material and Methods

The research was conducted in rainfed rice fields in Kotabaru Village, Lahat District, Lahat Regency, South Sumatra Province, at coordinates -3.780152,103.538592 at an altitude of 115 MDPL, from January to June 2024. The experimental design used was a Split Plot with 4 Main Plots and 3 subplots, resulting in 12 treatment combinations with 3 replications, a total of 36 plots. Each plot is 2x2 meters in size.

The main plot treatments included first control using chemical bactericide sprayed on rice leaves and stems at a dose of 1 g/l, second seeds soaked in liquid smoke at a dose of 2% for a day and night before sowing, third liquid smoke was sprinkled on the base of the stem and roots at a dose of 2%, and fourth liquid smoke was sprayed on the leaves and stems at a dose of 2%. All treatments in the main plot were carried out 14 days after planting, with 7-day intervals during the growth period, except for seeds soaked in liquid smoke. Sub-plot treatments involved first application of agricultural lime at a dose of 1 ton/ha, second organic matter at 2 tons/ha, and third a combination of agrarian lime at 1 ton/ha + organic matter at 2 tons/ha applied 1 week before planting in each of the designated plots.

2.1. Research Implementation

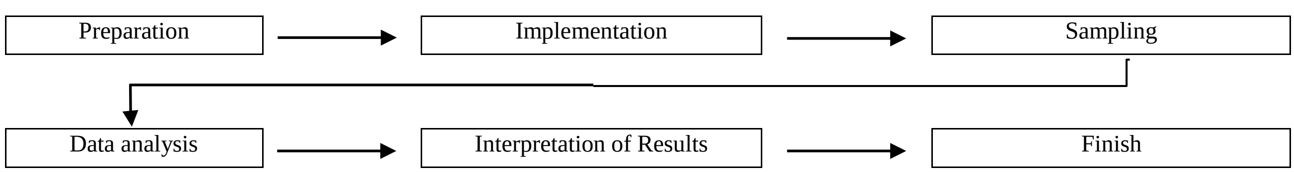

Figure 1. Research Flow Diagram

2.2. Data analysis

Data analysis was done using the Statistical Package for the Social Sciences (SPSS) version 26.0 application, namely the ANOVA test. Then, the Least Significant Difference (LSD) test was conducted at a real level of 5% and Standard Error. Observations on the day of onset, severity of the disease, and incidence of the disease Severity of the disease is calculated using the formula, namely:

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

KP = disease severity, n = number of clumps attacked in each attack category, v = attack category score, N = number of clumps observed, Z = highest category score used.

Scoring is determined based on the rice plant characteristic and evaluation system guidelines (translated from the Standard Evaluation System (SES) for Rice 4th edition, 1996), namely 0 for no attack (very resistant); 1 for 1-5% attack (resistant); 3 for 6-12% attack (slightly resistant); 5 for 13-25% attack (moderate); 7 for 26-50% attack (slightly susceptible); and 9 for 51-100% attack (very susceptible). The incidence of disease is calculated using the formula, namely:

$$KJP = \frac{n}{N} \times 100\%$$

KJP = disease incidence, n = number of clumps attacked, N = number of clumps observed. Furthermore, observations were made on plant height, number of tillers, number of productive tillers, root volume, total number of grains per panicle, percentage of empty grains, weight of 1000 full grains, and productivity.

3. Results and Discussion

The study's results indicated that liquid smoke derived from rice husks had a highly significant impact on the disease's severity and incidence. Additionally, it significantly influenced plant height, the number of tillers, and the number of productive tillers. However, it did not significantly affect the onset of the disease, root volume, total grain count per panicle, percentage of empty grains, weight of 1,000 complete grains, or overall productivity. Ameliorants significantly affected the number of offspring, the number of productive offspring, and overall productivity.

However, it had no significant effect on the day of disease onset, disease severity, disease incidence, plant height, root volume, total number of grains per panicle, percentage of empty grains, and weight of 1,000 full grains. The interaction between treating liquid smoke from rice husks and ameliorants had no significant effect on all observed variables. The results of the analysis of variance in the treatment of liquid smoke from rice husks, ameliorant treatments, and the interaction of both on the observed variables can be seen in Table 1.

3.1. Rice Husk Liquid Smoke

Rice husk liquid smoke had a very significant effect on disease severity and disease incidence. Rice husk liquid smoke sprayed on stems and leaves resulted in the lowest disease severity and incidence of 26.91% and 38.55%, respectively. This was significantly different from the treatment of seeds soaked in liquid smoke before sowing, resulting in the highest disease severity and incidence of 42.22% and 46.48%, respectively (Table 2). According to, bioactive compounds in liquid smoke, such as phenols and organic acids, effectively suppress the growth of the pathogen Xanthomonas oryzae pv. Oryzae. (Istiqomah & Eka Kusumawati, 2019) Also, the spraying method is considered more optimal because it allows the active compounds to be evenly distributed on the stems and leaf surfaces.

Table 1. Results of analysis of the variety of rice husk liquid smoke treatments, ameliorant treatment, and the interaction of both on the observed variables.

No	Observed Variables	Treatment			Diversity Coefficient (%)
		Rice Husk Liquid Smoke (C)	Ameliorant (A)	Interaction (C+A)	
1	Day of Starting to Get Sick	tn	tn	tn	1.59
2	Severity of Disease	**	tn	tn	17.15
3	Disease Occurrence	**	tn	tn	7.83
4	Plant Height	*	tn	tn	3.40
5	Number of Offspring	*	*	tn	2.88
6	Number of Productive Offspring	*	*	tn	2.47
7	Root Volume	tn	tn	tn	8.75
8	Total Number of Grains Per Panicle	tn	tn	tn	1.39
9	Empty Grain Percentage	tn	tn	tn	4.15
10	Weight of 1000 Grains of Grainy Rice	tn	tn	tn	3.36
11	Productivity	tn	*	tn	4.34

Description: tn: no real effect, *: real effect, **: very real effect

Research by Rusli et al. (2017) showed that the combination of 2% rice husk liquid smoke with 4 mL of liquid organic fertilizer (POC) was able to increase plant resistance to bacterial leaf blight attacks by 20.84%, which was indicated by a decrease in the intensity of disease attacks. Meanwhile, this study showed higher resistance to bacterial leaf blight disease, namely 47.63% against disease severity and 20.01% against disease incidence (table 3). This achievement demonstrates the effectiveness of the treatment used in this study in increasing plant resistance and strengthening previous findings regarding the role of rice husk liquid smoke in controlling bacterial leaf blight disease.

Rice husk liquid smoke significantly affected plant height, number of tillers, and number of productive tillers. The treatment of rice husk liquid smoke sprinkled on the base of the stem and roots produced the highest plant height, number of tillers, and productive tillers, respectively 101.09 cm, 32.89, and 26.87. Significantly different from the control treatment using chemical bactericides, which produced the lowest plant height, number of tillers, and number of productive tillers, respectively 95.31 cm, 31.87, and 26.02 (Table 2).

This shows that liquid smoke can stimulate plant growth. Liquid smoke contains compounds that are phytohormones, such as acetic acid. According to Istiqomah & Eka Kusumawati (2019), the content of active compounds in liquid smoke, such as acetic acid, is a stimulant for plant growth hormones, especially auxin. This hormone encourages cell division and elongation, especially during the vegetative phase of the plant. Furthermore, Dhaifulloh et al . (2024) revealed that using chemical bactericides can damage soil microorganisms that support soil fertility and disrupt the biological balance of the soil, which can slow plant growth. Liquid smoke has the potential to replace chemical bactericides, although its effectiveness is highly dependent on the application method. As a more environmentally friendly solution, liquid smoke can help reduce chemical dependence in agriculture.

Table 2. Mean ± Standard Error of the Effect of Rice Husk Liquid Smoke and Ameliorant Treatment on Observed Variables

Treatment	Observation Variables					
	Severity of Disease	**Disease Occurrence**	**Plant Height**	**Number of Offspring**	**Number of Productive Offspring**	**Productivity**
Rice husk liquid smoke (C)						
Chemical Control / Bactericide	30.37±2.095 a	40.82±1.226a b	95.31±1.077a	31.87 ±0.279a	26.02 ±0.214a	8.05 ±0.092
Seeds are soaked in liquid smoke before sowing	42.22±1.814 b	46.48±0.743c	98.91±1.089a b	32.31 ±0.403ab	26.18 ±0.250ab	8.20 ±0.102
Liquid smoke is poured onto the base of the stem and roots	30.37±1.814 b	44.44±1.393b c	101.09±1.121 b	32.89 ±0.226b	26.87 ±0.183b	8.42 ±0.142
Liquid Smoke is sprayed on the Leaves and Stems	26.91±1.675 a	38.55±0.717a	100.49±0.868 b	32.76 ±0.258b	26.69 ±0.177b	8.29 ±0.160
BNT 0.05	6.16	3.84	4.1	0.64	0.56	
Ameliorant (A)						
Agricultural chalk	34.07 ±1.959	42.18 ±1.337	98.97 ±0.968	32.45 ±0.255ab	26.53 ±0.166ab	8.32 ±0.093b
Organic materials	33.70 ±2.706	42.86 ±1.231	98.03 ±1.249	31.90 ±0.207a	26.02 ±0.221a	7.96 ±0.084a
Agricultural lime and organic materials	29.63 ±2.107	42.69 ±1.316	99.85 ±1.052	33.02 ±0.273b	26.77 ±0.157b	8.44 ±0.114b
BNT 0.05				0.81	0.56	0.34

Chemical Bactericides | Seeds are soaked in liquid smoke before sowing | Liquid smoke is poured onto the base of the stem and roots | Liquid Smoke is sprayed on the Leaves and Stems

Figure 2. Research Documentation on Liquid Smoke Treatment

3.2. Ameliorant

Ameliorants significantly affect the number of tillers, the number of productive tillers, and the productivity of each treatment. The provision of agricultural lime and organic materials carried out simultaneously provided the highest number of tillers, productive tillers, and productivity of 33.02, 26.77, and 9.46 tons/ha, respectively. This significantly differed from the provision of organic materials carried out independently, resulting in the lowest number of tillers, productive tillers, and productivity of 31.90, 26.02, and 8.95 tons/ha, respectively. (Table 3).

Agricultural Chalk | Organic Materials | Agricultural Lime and Organic Materials

Figure 3. Research Documentation on Ameliorant Treatment

Combining agricultural lime and organic matter is essential in improving soil quality, supporting plant growth, and increasing yields. Agricultural lime functions to raise the pH of acidic soil to be more neutral, which is very important to increase the availability of nutrients such as phosphorus, calcium, and magnesium, which plants at optimal soil pH more easily absorb. In addition, agricultural lime can also reduce the toxicity of excess nutrients such as aluminum, which can damage plant roots at very low soil pH (Wildani & Bowo, 2019). On the other hand, organic matter improves soil structure, increases cation exchange capacity (CEC), and reduces erosion. Organic matter also provides nutrients such as nitrogen, phosphorus, and potassium, which can be released slowly through decomposition. Microorganisms contained in organic matter support soil health and increase water absorption.

Meanwhile, providing organic materials independently without a mixture of agricultural lime offers less than optimal effects, allegedly because organic materials require a long time to be absorbed and utilized optimally by plants. The decomposition process of organic materials takes place slowly and is influenced by soil conditions and the activity of microorganisms. According to Parna et al. (2025), organic materials provide maximum benefits to plants after the complete decomposition process, which can take several months to years, depending on the type of organic material and soil conditions. Therefore, the absorption of organic materials given at the beginning of the planting season can be hampered, especially during periods of high rainfall, which reduces their effectiveness.

3.3. Percentage Increase in Plant Resistance and Productivity

The interaction between the treatment of liquid smoke from rice husks and ameliorants showed no significant effect on all observed variables. Overall, although the differences between treatments did not show any statistically significant impact, the combination of treatment between liquid smoke sprayed on the stems and leaves with agricultural lime and organic matter provided the best percentage increase in plant resistance from bacterial leaf blight disease attacks. This can be seen in the percentage increase in plant resistance from the disease severity variable of 47.63% and disease incidence of 20.01% (Table 3).

Table 3. Mean ± Standard Error of the Effect of Treatment Combinations on Increasing (%) Plant Resistance to Bacterial Leaf Blight Attacks and Productivity.

Combination Treatment	Severity of Disease	P (%)	Disease Occurrence	P (%)	PDV	P (%)
Chemical Control/Bactericide + Agricultural Lime	33.33 ±2.566	28.58	40.82 ±1.178	14.28	8.16 ±0.152	4.17
Chemical Control/Bactericide + Organic Material	31.85 ±3.919	31.75	40.14 ±1.799	15.71	7.82 ±0.124	
Chemical Control/Bactericide + Agricultural Lime + Organic Matter	25.92 ±3.919	44.46	41.50 ±3.599	12.85	8.17 ±0.153	4.28
Seeds soaked in liquid smoke before sowing + agricultural lime	42.22 ±2.566	9.53	46.94 ±1.178	1.43	8.15 ±0.101	4.05
Seeds soaked in Liquid Smoke Before Sowing + Organic Materials	46.67 ±2.566		47.62 ±1.360		8.07 ±0.210	3.1
Seeds soaked in Liquid Smoke Before Sowing + Agricultural Lime + Organic Material	37.78 ±2.566	19.05	44.90 ±1.178	5.71	8.39 ±0.203	6.79
Liquid smoke is poured onto the base of the stem and roots + agricultural lime	31.85 ±3.919	31.75	42.18 ±4.138	11.42	8.55 ±0.088	8.54
Liquid smoke is poured onto the base of the stem and roots + organic materials	28.89 ±2.566	38.1	44.90 ±1.178	5.71	8.02 ±0.242	2.49
Liquid smoke is poured onto the base of the stem and roots + agricultural lime + organic materials	30.37 ±3.919	34.93	46.26 ±0.680	2.85	8.69 ±0.221	**10.01**
Liquid Smoke sprayed on Leaves and Stems + Agricultural Lime	28.89 ±2.566	38.1	38.77 ±1.178	18.58	8.41 ±0.303	7.01
Liquid Smoke is sprayed on Leaves and Stems + Organic Materials	27.41 ±3.919	41.27	38.77 ±1.178	18.58	7.92 ±0.132	1.26
Liquid Smoke is sprayed on Leaves and Stems + Agricultural Lime + Organic Materials	24.44 ±2.566	**47.63**	38.09 ±1.799	**20.01**	8.53 ±0.310	8.32

Note: PDV: productivity of each treatment, P (%): increase (%) .

This shows that spraying liquid smoke directly on plants is more effective, especially on the leaves, which are the central location of infection. Liquid smoke contains active compounds such as phenols and organic acids, which are antiseptic, can increase plant resistance, and can inhibit the development of pathogenic bacteria on the surface of leaves and stems. Liquid smoke also contains bioactive compounds that can increase soil microbial activity and improve plant metabolism, thus supporting grain filling and reducing the percentage of empty grains.

According to, agricultural lime effectively balances soil acidity, thus supporting the efficiency of nutrient uptake by plants. Combining agricultural lime and organic matter improves soil structure, cation exchange capacity, and soil microorganism activity, contributing to more optimal grain filling.

Meanwhile, the combination of liquid smoke treatment sprinkled on the base of the stem and roots with agricultural lime and organic materials gave the highest productivity of 8.69 tons/ha, with an increase of 10.01%. This finding shows a synergy between liquid smoke that stimulates plant growth and agricultural lime and organic materials that improve soil quality. This is supported by the research, which revealed that liquid smoke can potentially increase plant growth by increasing the availability of nutrients in the soil that support better plant growth. Research also shows that applying 2% concentrated liquid smoke increases root absorption of nutrients, supporting plant height growth and production yields.

Furthermore, using agricultural lime combined with organic materials can improve soil structure and quality and support optimal plant growth. Using agricultural lime can neutralize acidic soil pH and increase nutrient availability, while organic materials improve soil structure and increase soil microorganism activity, both supporting plant growth. This aligns with the findings, which show that combining agricultural lime and organic materials can increase agricultural yields.

4. Conclusion

The most effective control of bacterial leaf blight was observed by spraying liquid smoke on the stems and leaves, combined with agricultural lime and organic materials. This treatment resulted in a 47.63% increase in plant resistance, as indicated by the disease severity variable, and a 20.01% reduction in disease incidence. The highest productivity, measured at 8.69 tons per hectare, was achieved by applying liquid smoke at the base of the stem and roots, along with agricultural lime and organic materials, resulting in a 10.01% increase in yield.

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