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ACTIVITY OF COCONUT-SHELL LIQUID-SMOKE AS AN INSECTICIDE ON THE RICE BROWN PLANTHOPPER (*Nilaparvata lugens*)

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ABSTRACT

Laboratory trial proved that the genuine of coconut-shell liquid-smoke grade II was very toxic against the rice brown planthopper (*Nilaparvata lugens*) and phytotoxic to the rice plants. The genuine liquid smoke is very acid (pH 1.2). It could be neutralized (pH 6, 46) by adding it with calcium oxide at rate of 7 grams per 100 ml. LC_{50} of the neutral coconut-shell liquid-smoke grade II against *N. lugens* at 24, 48, and 72 hours after treatment were 12.89, 11, and 9.94%, respectively. The concentration rate of 12.5% was feasible to be developed into application dosage at which this concentration rate of neutral liquid smoke was not toxic to the plant.

Keywords: rice, *Nilaparvata lugens,* coconut-shell liquid-smoke.

INTRODUCTION

Coconut shell is part of the coconut fruit at which having biological function to protect fruit core and is located on the inner side of the fiber with a thickness ranging from 3-6 mm. Coconut shell is classified as hardwood, mainly composed of lignin, cellulose, and hemicellulose, with water content of approximately 6-9 % (Tilman, 1981). Smoke is defined as a suspension of solid and liquid particles in a gas medium. The smoke is produced by the pyrolysis process by means of incomplete combustion at which involving reaction of constituent polymers decomposition into organic compounds with low molecular weight due to the effects of heat include oxidation reaction, decomposition, polymerization, and condensation (Girard, 1992). Liquid smoke is a solution of the result of condensation of vapor of wood smoke which is burned with limited air at high temperatures (Yulistiani, 1997). Wood components comprised of 40-60 % cellulose, 20-30 % hemicellulose, and 20-30% lignin. Liquid smoke contains many compounds that are formed due to the pyrolysis of three components of wood, namely cellulose, hemicellulose and lignin. Pyrolysis is the process of heating a substance in the absence of oxygen resulting in the decomposition of the constituent components of hardwood or may be said as an irregular decomposition of organic materials that was caused by heating without contact with the outside air. Coconut shell pyrolysis process produces three fractions, namely fraction of solid in the form of charcoal, the weight fraction of tar, and the light fraction of gas (Lawrie, 1983). More than 400 chemical compounds in the smoke have been successfully identified. These components are found in varying amounts depending on the type of wood, age of the plant of wood sources, and wood growing conditions such as climate and soil. These components include acid, carbonyl, and phenol. Acids affect the taste, pH, and storage duration of smoked products. Carbonyl reacts with proteins to form brown staining. Phenol is a major framer of aroma and showed antioxidant activity (Astuti, 2000).

Smoke of coconut shell charcoal making process is a pollutant. In the villages the smoke of burning wood in the kitchen is used for preventing the attack of corn pests. Hereafter, the coconut shell liquid smoke is abbreviated with CSLS. The CSLS has been widely used for various purposes including a wood preservative to prevent termite attack. Meanwhile, development of the CSLS to control crop pests is still limited.

The rice brown planthopper (*Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae)) - hereafter it is abbreviated with RBPH - is preferred as the test insect. The pest insect frequently outbreaks and becomes a significant constraint to national food security in Indonesia (Directorate General of Food Crops, 2010). The RBPH is the most serious pest of rice across the world, especially in tropical climates. Climate warming in tropical regions and occasional extreme high temperature events are likely to become important limiting factors affecting the survival and distribution of the pest (Piyaphongkul, *et al*., 2012). The pest control with chemical insecticides is risky to food health because of the high levels of residue and damaging the environment, hence, it is important to the development of environmentally friendly insecticides.

MATERIALS AND METHODS

Colonies of RBPH were obtained from Research Center for Management of Biological Resources, Gadjah Mada University. The RBPH was maintained on rice seedlings. Forth instars and adults of the RBPH were used in this experiment. Meanwhile, the CSLS grade II was obtained from Laboratory of Process Engineering of Food and Estate Product Processing, Gadjah Mada University. The CSLS grade II is the result of condensation of the first pyrolysis supposedly it still contains various compounds that are toxic to insect. The genuine CSLS is very acid (pH 1.20) and it was neutralized (pH 6.46) by adding it with calcium oxide at rate of 7 grams per 100 ml.

Preliminary experiment

The extent to which the activity of CSLS as an insecticide, it was evidenced by preliminary experiment. Mortality of RBPH due to the treatment of direct and indirect exposure to genuine CSLS grade II (100%) was compared to chemical insecticide with active ingredient of imidacloprid and distilled water. The number of RBPH was as many as 20 individuals per treatment with three replicates each.

Experiment on activity of the CSLS on the RBPH

Concentration rate of the CSLS was made to be seven levels i.e. 1.5625, 3.125, 6.25, 12.5, 25, 50, and 100% and 0% as control. CRD experimental design was applied in this experiment. Each concentration rate required 20 individuals of RBPH and it was repeated three times.

The RBPH as many as 20 individuals were kept in a glass tube with a height of 20 cm and a diameter of 3 cm and they fed with four rice seedlings. Single rice seedling had three leaves. A wet cotton swab was used to wrap the roots of rice seedlings as well as to cover the tube mouth. The acid and neutral CSLS were exposed directly and indirectly to the test insects. Direct exposure was done by spraying CSLS - according to a series of concentration - at RBPH colonies. The exposed colonies were then cultured in the glass tubes containing fresh rice seedlings for 3 days. Indirect exposure was done by spraying CSLS - according to a series of concentration - on the rice seedlings immediately before they were put into a glass tube. The RBPH as many as 20 individuals were then infested into the tube containing treated rice seedlings and cultured for 3 days. The RBPH were kept alive by sucking the rice seedlings.

Observations of RBPH mortality were done at 24, 48, and 72 hours after CSLS exposures. In addition to mortality of RBPH, the rice plant phytotoxicity symptoms were also observed. The phytotoxicity symptoms were scored. Symptom scores of the rice seedling phytotoxicity were categories such as follows. Healthy seedlings with normal green in color of leaves were Score 0. Seedlings with yellowish in color of small part of leaves were Score 1. Seedlings with yellowish in color of all leaves were Score 2. Seedlings with yellowish in color and light wilt of all leaves were Score 3. Seedlings with yellowish in color and moderate wilt of all leaves were Score 4. Seedlings with brownish in color and heavy wilt of all leaves were Score 5. Seedlings with brownish in color and very heavy wilt of all leaves were Score 6. Seedlings with dead and dry leaves were Score 7.

Anova and DMRT at α 0.05 were applied to determine significant difference of the RBPH mortality amongst treatments. Probit analysis was performed to determine the LC_{50} values.

RESULTS AND DISSCUSSIONS

The CSLS was promising to be developed into insecticide. The trials proved that it was very toxic against the RBPH; however it was also phytotoxic to the rice plants.

Activity of the genuine CSLS as an insecticide

The preliminary experiment showed that the CSLS was more poisonous than imidacloprid insecticide. Mortality of the RBPH due to genuine CSLS treatment was significantly higher than on treatment of the chemical insecticide (Table-1). Therefore, study on activity of the CSLS as an insecticide was feasible to be continued. Because of the genuine CSLS is also very toxic to the rice seedling, hence, it is important to cope the problem.

Table-1. The RBPH mortality on treatments of genuine CSLS, imidacloprid, and aquadest.

Treatments	**Mortality (%) of RBPH due to exposure**					
	Direct at hours			**Indirect at hours**		
	24	48	72	24	48	72
CSLS	100a	100a	100a	100a	100a	100a
Imidacloprid	77b	78b	78b	12b	22b	27b
Aquadest	0c	5c	5c	0c	0c	5c

Remarks

Numbers followed by the same letters in columns indicate mortality of RBPH amongst treatments was not significantly different by DMRT at α 0.05.

Phytotoxicity of CSLS on rice seedlings

The rice seedling was sensitive against the genuine CSLS. The genuine CSLS at 100% concentration rate killed rice seedlings within 24 hours, the seedlings getting dry. Brownish in color and heavy wilt of the rice seedlings were due to exposures of the genuine CSLS at 25-50% concentration rates. Even, it was at 3.125% concentration rate of the genuine CSLS made the seedlings getting yellowish in color. The seedlings showed as normal green in color as control when they were exposed with 1.5625% concentration rate (Table-2).

Table-2. Phytotoxicity scores of exposed rice-seedlings on acid and neutral CSLS.

Concentration rates (%) **of CSLS**	**Phytotoxicity scores of CSLS**					
	Acid (pH 1.20) **at hours**			**Neutral** (pH 6.46) **at hours**		
	24	48	72	24	48	72
0	0	0	0	0	0	0
1.56	0	0	0	0	0	0
3.125	0	0.33	0.33	0	0	0
6.25	1	1.33	1.33	0	0	0
12.5	2	3	3	0	0	0
25	4	5	5	2	3	4
50	5	6	6	3	4	4
100	6	7	7	4	4	5

The genuine CSLS is exactly very acid, it has pH 1.20. This phytotoxitiy is expected to be related with the very low pH. The genuine CSLS was successfully neutralized by adding calcium oxide and resulting pH 6.46. Addition of calcium oxide in genuine CSLS grade II did not influenced significantly on the RBPH mortality. Results of $t_{\alpha 0,\ 05}$ tests showed the mortality rates between acid and neutral CSLS were relatively similar. The testing resulted values of P by direct exposure at 24, 48, and 72 hours after application were P = 0.2756, 0.6271, and 0.5618, while by indirect exposure were P = 0.8664, 0.5014, and 0.1979, respectively. It implies that calcium oxide has an advantage in improving the CSLS insecticidal activity.

Insecticide activity of CSLS on the RBPH

The activity of CSLS as insecticide on the RBPH is seen by analyzing mortality and determining LC_{50} values.

The RBPH mortality

Either of acid or neutral CSLS showed significant effect on the RBPH mortality. It is indicated by significant higher mortality on treatments as compared with control using aquadest (Tables 1 and 3). It is approximately at concentration rate of 25%, the CSLS gives an signifiant advantage as an insecticide.

Table-3. The RBPH mortality on concentration series of Acid and neutral CSLS.

CSLS (%)	Mortality on direct exposure at hours			Mortality on indirect exposure at hours		
	24	**48**	**72**	**24**	**48**	**72**
Acid CSLS, pH 1.20						
0	10 d	13 e	15 e	2 d	7 c	8 d
15,625	13 d	20 de	43 e	3 d	10 c	17 cd
3,125	12 d	25 de	42cd	5 d	15 c	20 cd
6,25	22 cd	40 de	58cd	2 d	5 c	5 d
12,5	28bcd	42 cd	53cd	5 d	13 c	30 c
25	27 bc	43 bc	57 c	33 c	50 b	58 b
50	37 b	52 ab	67ab	72 b	90 a	98 a
100	100 a	100 a	100a	100a	100a	100 a
Neutral CSLS, pH 6.46						
0	2 c	3 c	3 c	5 b	8 b	10 b
15,625	5 c	7 c	10 c	7 b	13 b	15 b
3,125	10 c	13 c	13 c	5 b	8 b	15 b
6,25	8 c	12 c	20 c	8 b	17 b	18 b
12,5	45 b	52 b	57 b	8 b	13 b	18 b
25	87 a	88 a	88 a	17 b	35 b	38 b
50	93 a	100 a	100a	78 a	85 a	87 a
100	98 a	100 a	100a	90 a	95 a	95 a

Remarks

Numbers followed by the same letters in columns indicate mortality of RBPH amongst treatments was not significantly different by DMRT at α 0.05.

Direct and indirect exposures of the CSLS were considered to be done in these experiments, because it was inspired by experiences in the field application of insecticides. When we are spraying an insecticide on the plantation, parts of the drifts may directly contact to the target pest. Hence, we called it as direct exposure to the test insect. Another part of the drifts may land on the plant surface as a residue. A pest may come to the plants that already exposed with an insecticide; the pest will contact with the insecticide residues and will be affected. Hence, we called it as indirect exposure to the test insect. This exposure technique did not influence the activity of the CSLS as an insecticide against the RBPH. Results of $t_{\alpha 0.05}$ tests showed that the mortality rates between direct and indirect exposures of CSLS were relatively similar. The testing resulted values of P on acid CSLS at 24, 48, and 72 hours after application were P = 0.6156, 0.5022, and 0.2000, while on neutral CSLS were P = 0.1122, 0.1500, and 0.3239, respectively. This phenomenon indicates that the CSLS is advantage and promising to be developed as an insecticide against crop pests.

The LC_{50} values

LC_{50} value is used as one of the insecticidal activity criteria to the CSLS. The lower the LC_{50} value the more poisonous of an insecticide. Increasing mortality within 3 days (Table-3) resulting decreasing values of the LC_{50} (Table-4). It would be better if we consider the LC_{50} values of the neutral CSLS are chosen for determining the appropriate concentration

Table-4. LC_{50} of acid and neutral CSLS that were directly and indirectly exposed to the RBPH at 24, 48, and 72 hours after exposure.

Exposure:	LC_{50} (%) at hours after exposure		
	24	**48**	**72**
Acid CSLS, pH 1.20			
Direct	100.08	42.97	12.87
Indirect	32.75	22.55	9.91
Neutral CSLS, pH 6.46			
Direct	12.89	11.00	9.94
Indirect	36.36	28.06	26.15

rate to be developed into an application dosage. Referring to Table-2, the neutral CSLS at 12.5% concentration rate did not affect phytotoxicity of the rice seedling. Meanwhile, the LC_{50} values at 24 - 72 hours after exposure approximately range from 12.89 - 9.94. Meaning that concentration rate of 12.5% is the best basic value for further developing application dosage.

Coconut shell smoke as a fumigant is effective to control the rice grain borer *Rhyzopertha dominica* F. (Aryawan *et al*., 2013). Empirical experiences in application of CSLS have been conducted on paddy plantation. One part of CSLS plus 15 parts of water was sprayed on 1 month old paddy. It could reduce attack of

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the RBPH and the rice field that was previously attacked by RBPH still produced good yield (Masyhudi, 2009 cit. Sumarno, 2010). It implies that results of this experiment support previous findings and the CSLS is promising as insecticide against pests of crops and stored products.

CONCLUSIONS

The CSLS was an effective insecticide against the RBPH. LC_{50} of the neutral CSLS at 12.5% concentration rate was the appropriate to be developed into application dosage. The CSLS was phytotoxic against the rice seedlings at 6.25% for the genuine CSLS (pH 1:20) and at 25% for the neutral CSLS (pH 6.46).

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REFERENCES

Aryawan A. K., B. T. Rahardjo and L. P. Astuti. 2013. Potency of the coconut smoke in pest control of *Rhyzopertha dominica* F. (Coleoptera: Bostrichidae) on rice grain in the storage. Journal of HPT. 1(1): 6-15.

Astuti. 2000. Utilization of fiber and shell of coconut and oil palm shell for producing liquid smoke as natural food preservatives.
http://alcoconut.multiply.com/journal/item/6.

Directorate General of Food Crops. 2010. Control and anticipation of impact of pest attack brown planthopper (BPH). http://www.deptan.go.id/ news/ detail.php?id=760.

Girard J P. 1992. Technology of Meat and Meat Products. Ellis Horwood, New York, USA.

Lawrie R.A. 1983. Meat Science. Pargamon Press, London.

Piyaphongkul J, Pritchard J and Bale J. 2012. Can Tropical Insects Stand the Heat? A Case Study with the Brown Planthopper Nilaparvata lugens *(Stål).* PLoS ONE 7(1): e29409. doi:10.1371/journal.pone.0029409.

Sumarno. 2010. Liquid smoke plus; the coconut shell liquid smoke (distillate I) for protection and hormones. http://www.majalah-gempur.com/2010/10/asap-cair-plus-asap-cair-tempurung.html.

Tilman D. 1981. Wood Combustion: Principles, Processes and Economics. Academics Press Inc., New York, USA.

Yulistiani. 1997. The inhibition ability of liquid smoke against growth of bacterial pathogens and blight on cow tongue. Master Thesis. Study Program of Food Science and Technology. University of Gadjah Mada.