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# EXTRACT OF OIL PALM EMPTY FRUIT BUNCHES WASTE AS AN POTENTIAL INSECTICIDE FOR CONTROLLING *Spodoptera frugiperda* J. E. SMITH

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## ABSTRACT

The percentage of attacks by *Spodoptera frugiperda* in Indonesia has reached 94% and is still increasing due to the use of chemical pesticides, which might have led some *S. frugiperda* to develop resistance. This problem must be addressed immediately in order to prevent continued losses for farmers. Moreover, an alternative method to control pests is by using natural materials that can potentially serve as insecticide, namely the liquid smoke of the empty oil palm fruit bunches (OPEFB). In this study, there were four treatments and four replications were conducted. The treatment was carried out in the field and in the laboratory. The treatments for the application of liquid smoke as vegetable pesticide in the laboratory were J1: control, J2: 10.0 ml/l, J3: 15.0 ml/l, and J4: 20.0 ml/l. Meanwhile, the treatments for the application of liquid smoke as vegetable pesticide in the field used a non-factorial randomized block design with the following treatments: H1: farmer application, H2: 10.0 ml/l, H3: 15.0 ml/l, and H4: 20.0 ml/l. The results showed that the J2, J3, and J4 treatments carried out in the laboratory had the highest proportion of mortality, with an average mortality percentage of 100% on day 6. Meanwhile, the intensity of *S. frugiperda* attacks indicated the highest attack on H1, which was the treatment carried out by farmers, with a value of 32.0% damage. In addition, the lowest attack by *S. frugiperda* was observed in the H4 treatment, which was 11%. This study provides important data to aid in the understanding of the secondary compounds contained in OPEFB liquid smoke and recommended concentrations in the application of liquid smoke against *S. frugiperda* on maize plant.

**Keywords**: Attack intensity, maize plant, *Spodoptera frugiperda*

## ABSTRAK

Serangan *Spodoptera frugiperda* di Indonesia setakat ini telah mencapai 94% dan terus meningkat akibat penggunaan racun perosak kimia yang mungkin telah menyebabkan kerintangan ke atas *S. frugiperda.* Masalah ini perlu diselesaikan segera agar petani tidak mengalami kerugian berterusan. Salah satu kaedah alternatif kawalan serangga ialah penggunaan bahan semula jadi yang berpotensi sebagai racun serangga iaitu asap cair dalam tandan buah kepala sawit kosong (OPEFB). Kajian ini menggunakan empat rawatan dan empat replikasi. Rawatan racun perosak dijalankan di lapangan dan di makmal. Rawatan penggunaan racun serangga sayuran asap cecair di makmal ialah J1: Kawalan, J2: 10.0 ml/l, J3: 15.0 ml/l, J4: 20.0 ml/l. Penggunaan racun serangga sayuran asap cecair di lapangan menggunakan Reka Bentuk Blok Rawak bukan faktor dengan rawatan H1: Aplikasi petani, H2: 10.0 ml/l, H3: 15.0 ml/l, H4: 20.0 ml/l. Hasil kajian menunjukkan peratusan kematian tertinggi dari makmal adalah pada rawatan J2, J3, J4 dengan purata peratusan kematian sebanyak 100% pada hari ke enam. Manakala intensiti serangan *S. frugiperda* menunjukkan serangan tertinggi terhadap H1 iaitu rawatan yang dijalankan oleh petani dengan nilai 32% kerosakan. Di samping itu, serangan paling rendah oleh *S. frugiperda* diperhatikan dalam rawatan H4, iaitu 11%. Data kajian ini membantu dalam pemahaman tentang sebatian sekunder yang terkandung dalam asap cecair dan kepekatan yang disyorkan dalam penggunaan asap cecair TKKS terhadap *S. frugiperda* pada tanaman jagung.

**Kata kunci**: Intensiti serangan, tanaman jagung, *Spodoptera frugiperda*

## INTRODUCTION

Attacks by pests and diseases can decrease maize production (Hanif & Susanti 2017). *Spodoptera frugiperda* was initially discovered in West Pasaman Regency, West Sumatra, in 2019 (Sartiami et al. 2019), and it has since spread to several other provinces in Sumatra, Java, Kalimantan, Sulawesi (Girsang et al. 2020; Maharani et al. 2019), and Maluku. The high cruising range of this pest allows it to reach up to 100 km in one night (Westbrook et al. 2016). Due to its cruising ability, this pest can quickly spread to other areas of Indonesia. Moreover, *S. frugiperda* is a polyphagous insect species capable of feeding on 353 various types of plants from 76 families, especially Poaceae, Asteraceae, and Fabaceae. Larvae feed on the leaves, stems, and reproductive parts of various plants such as maize, rice, sorghum, sugarcane, vegetables, and cotton (Montezano et al. 2018). In addition, *S. frugiperda* remains a dangerous pest because its attack rates range from 15 to 73%, which is considered a high attack rate on many stable crops (Day et al. 2017).

*Spodoptera frugiperda* has so far resulted in yield losses of 94% in Indonesian maize plants (Meilin 2020). This problem must be addressed immediately to prevent continued losses for farmers. The high yield losses caused by the high attack of *S. frugiperda* on maize plants have resulted in farmers suffering economic losses. Moreover, the use of chemical pesticides for controlling farms is not suggested as a sustainable control since they cause pest resistant and damage to the environment. It is necessary to implement an environmentally friendly control method in order to maintain an environmental balance. In this research, empty oil palm fruit bunches (OPEFB) were processed into liquid smoke as a botanical pesticide to control *S. frugiperda* in corn plants. Previous studies on oil palm empty fruit bunches (OPEFB) liquid smoke have been proven to reduce the intensity of leaf-destroying pest attacks on mustard plants was reduced by 24.83% when liquid smoke was applied (Sari et al. 2018).

Farmers have carried out conventional control using chemical pesticides with constant, high-frequency spraying (Arif 2015). The environment will suffer from the continued use of chemical insecticides because they leave residues that are difficult to decompose both in the environment and on cultivated plants, making them dangerous if ingested by humans. In addition, one alternative method to control pests is the use of natural materials that have the potential to serve as insecticides, such as liquid smoke. According to the results of several previous studies, the liquid smoke from oil palm empty fruit bunches (OPEFB) contains secondary metabolites that have the potential to function as vegetable pesticides.

Currently, only 10% of OPEFB is converted and used as boiler fuel or compost, and the remaining 90% is still in the form of waste (Dewanti 2018). Utilization of OPEFB waste provides benefits as an environmentally friendly vegetable pesticide thereby reducing the use of chemical insecticides (Widihastuty et al. 2022). In addition, OPEFB liquid smoke must undergo laboratory and field testing for the control of *S. frugiperda* in order to obtain the appropriate concentration for application by farmers.

## MATERIALS AND METHODS

**Study Sites**
The study was conducted in Pematang Ganjang Village, Sei Rampah Sub-district, Serdang Bedagai Regency, North Sumatra, Indonesia. The study site in this study was a maize farm in Pematang Ganjang Village, Sei Rampah Sub-district, Serdang Bedagai Regency, North Sumatra (3.445147 N; 99.119093 E). Moreover, the analysis of secondary metabolite content was carried out in the Natural Organic Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Indonesia. Palm oil solid waste was obtained from the Adolina PTPN IV palm oil factory, Perbaungan Sub-district, Deli Serdang Regency. The pyrolysis process that has been completed is continued with the distillation process in the laboratory of the Faculty of Agriculture, Muhammadiyah University of North Sumatra. In addition, phytochemical analysis and metabolite analysis tests were carried out to determine the content of secondary metabolites in OPEFB which are toxic to the *S. frugiperda* pest.

**Treatments and Experimental Design**
This study used a non-factorial completely randomized design. Moreover, there were four treatments and four replications. The number of samples for observation in the laboratory is 16. In addition, samples for field research were taken from as much as 30% of 0.20 ha of a maize farm, which was used as the study site. Application time for days one and two for treatment in the laboratory and treatment in the field. The concentration of each treatment in the laboratory were J1: control, J2: 10.0 ml/l, J3: 15.0 ml/l, J4: 20.0 ml/l. Whereas, concentration of each treatment in the field were H1: farmer treatment, H2: 10.0 ml/l, H2: 10.0 ml/l, H3: 15.0 ml/l, and H4: 20.0 ml/l.

A set of pyrolysis tools was used to make liquid smoke. Moreover, empty oil palm fruit bunches (TKKS) are cut or chopped into small pieces after being dried directly in the sun until dry. Liquid smoke was made by incorporating the raw material from OPEFB into the reactor, which was then tightly closed and connected to a series of condensers. After that, the heater (burner) was turned on. This process was carried out for ± six hours by maintaining the temperature in the reactor in the range of 150–250ºC. The smoke from the reactor was channeled through pipes to the condenser circuit, which condensed the smoke into condensation (liquid smoke). The condensation from the condenser was then accommodated in a holding container to be further filtered so that the remaining material could be cleaned.

**Data Analysis**
ANOVA testing with a 95% confidence level and Microsoft Excel were used for the quantitative data analysis, then a multiple comparison was performed using the DMRT (Duncan's Multiple Range Test) at the 95% confidence level.

**Laboratory Bioassay of OPEFB Liquid Smoke on *S. frugiperda* Larvae**

Larvae or eggs were reared until they reached the third instar, with the following characteristics: the body color became dark green-black, and a pattern of white stripes appeared along the sides of the body (Karlina et al. 2022). The larval stage used was 8 third instar larvae per treatment, applied using a 1 liter hand sprayer on the leaves and sprayed directly onto the larvae and corn leaves. The sprayed larvae were put into a plastic box measuring 15 x 7 cm with a cover covered with gauze and placed at room temperature (±28°C). Observations were made at 1, 2, 3, and 5 days after the OPEFB application Was carried out in the laboratory using below formula.

$$\frac{a}{a+b}\,100\%$$

Note:
a = dead larvae
b = live larvae


Figure 1. Laboratory Bioassay of OPEFB Liquid Smoke on *S. frugiperda* larvae: a,b, preparation of test insects; c, application of insecticides

**Field Evaluation of OPEFB Liquid Smoke**

The research was conducted on a maize farm in Pematang Ganjang Village, Sei Rampah Sub-district, Serdang Bedagai Regency, North Sumatra, using a non-factorial randomized block design with four treatments. Land processing or cultivation was carried out in accordance with what farmers usually do without any additional treatment, either fertilizers or pesticides (Figure 2). The treatment of the application of OPEFB liquid smoke vegetable pesticide in the field was at the same dose as the treatment in the laboratory. Two days following the application, observations were conducted.


Figure 2. Application of TKKS Liquid Smoke in the field; a, experimental plot; b, insecticide dose; c, application of insecticides

The parameters observed were the intensity of attacks in the field, using the formula as follows Hendrival et al. (2013):

$$IS = \frac{\sum V \times ni}{N \times Z} \, 100\%$$

Note:
IS = intensity of attack
V = score damage to the sample
ni = number of samples on the score damage
N = the total number of samples
Z = highest score of categories attack

Table 1. Score of leaf damage

| Score | Affected Leaf Area (%) |
|---|---|
| 0 | 0 area of affected leaves |
| 1 | < 25 area of affected leaves |
| 2 | 25 ≤ μ < 50 area of affected leaves |
| 3 | 50 < μ < 75 area of affected leaves |
| 4 | μ ≥ 75 area of affected leaves |

Note: μ = distribution of plant damages

## RESULTS

The application of OPEFB liquid smoke vegetable pesticide could be used to control *S. frugiperda,* on maize plants. This is demonstrated in Table 2, which shows the results of the application of OPEFB liquid smoke vegetable pesticide in the laboratory.

Table 2. Percentage of *S. frugiperda* larval mortality

| Treatment | Average Larval Mortality | | | | |
|---|---|---|---|---|---|
| | **Day 2** | **Day 3** | **Day 4** | **Day 5** | **Day 6** |
| J1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| J2 | 0.00 | 0.00 | 0.00 | 50.00 | 100.00 |
| J3 | 0.00 | 0.00 | 0.00 | 50.00 | 100.00 |
| J4 | 0.00 | 0.00 | 25.00 | 50.00 | 100.00 |

Table 2 shows that the J2, J3, and J4 treatments had the highest average mortality with a value of 100%, and the lowest was in the J1 treatment with a value of 0%.

Table 3. Percentage of *S. frugiperda* larval mortality

| Treatment | Total Mortality (%) |
|---|---|
| J1 | 0.00b |
| J2 | 100.00a |
| J3 | 100.00a |
| J4 | 100.00a |

Based on Table 3, treatments J2, J3, and J4 have an average larval death value of 100%. Meanwhile, the average death rate in treatment J1 was 0% or no larvae died. The percentage of larval death was not significantly different in treatments J2, J3 and J4 which were given different doses of liquid smoke, and was significantly different compared to J1.

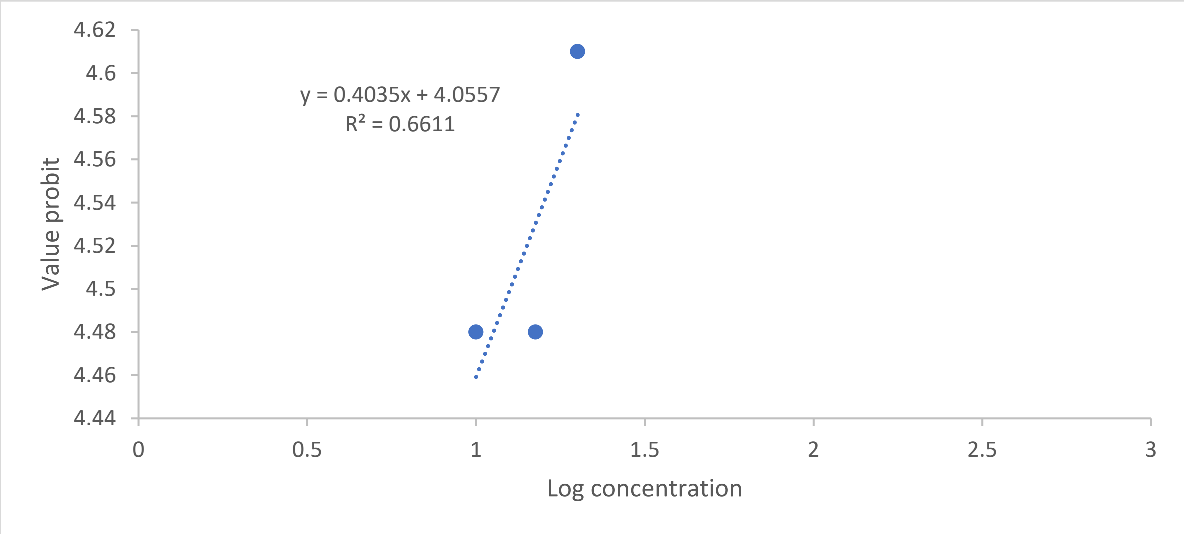


Figure 3. Regression results of the TKKS toxicity test against *S. frugiperda*

Figure 3 Probit analysis to determine $LC_{50}$ (Lethal Concentration 50), which is the concentration required to kill 50% of the test larvae. The $LC_{50}$ value for the OPEFB toxicity test on *S. frugiperda* larvae was 129.86 ppm.

Table 4. The attack intensity of *S. frugiperda* on 22–31 Days After Planting (DAP)

| Treatment | 22 | 25 | 28 | 31 | Total | Average |
|---|---|---|---|---|---|---|
| H1 | 16.67 | 20.00 | 25.00 | 32.00 | 96.00 | 32.00d |
| H2 | 15.00 | 18.33 | 20.00 | 26.50 | 53.00 | 26.50c |
| H3 | 10.00 | 10.67 | 11.00 | 12.50 | 25.00 | 12.50ab |
| H4 | 10.00 | 10.00 | 10.67 | 11.00 | 22.00 | 11.00a |

Based on Table 4, it can be seen that the highest percentage of *S. frugiperda* attack intensity was in treatment H1 with an average of 32.00%, and the lowest was in treatment H4 with an average of 11.00%. The percentage of larval death showed that there was no difference in mortality in treatments H3 and H4. Meanwhile, treatments in H2 and H1 showed high differences in mortality. Symptoms of attacks in the field due to S. litura attacks can be seen in Figure 4.

Figure 4. Symptoms of plant damage due to *S. litura* attacks

Table 5. Secondary metabolites types fromresults of OPEFB liquid smoke

| No | Types Of Secondary Metabolites Tests | Test Results |
|---|---|---|
| 1. | Flavonoid | Negative |
| 2. | Alkaloid | Negative |
| 3. | Terpenoid | Positive |
| 4. | Steroid | Positive |
| 5. | Tanin | Positive |
| 6. | Saponin | Positive |

The results of the Liquid Smoke OPEFB Secondary Metabolite Type Test gave positive results for alkaloids, steroids, tannins and saponins. This shows that the OPEFB liquid smoke used in the research contains these compounds. Meanwhile, flavonoids and alkaloids showed negative results. This indicates that the OPEFB liquid smoke used in the research does not contain these compounds.

## DISCUSSION

Larval mortality increased with each treatment defined the treatment. Based on Table 2, there was a larval mortality rate of 25% on the fourth day after application of liquid smoke. Larvae died due to exposure to liquid smoke on the cuticle. On the sixth day of observation following the application, all larvae died, bringing the mortality rate to 100%. Meanwhile, due to the absence of liquid smoke application in the J1 treatment or control, there was no larval mortality until day six. This shows the real effect of spraying OPEFB, which stuck to the cuticles of the larvae or seeped into the leaf tissue, causing poisoning and damage to the larvae's body parts if ingested. Other research also shows that contact (direct) application of liquid smoke is better compared to administering it as bait or indirect application (Prabowo et al. 2016). Table 3 shows the highest percentage of mortality in the J2, J3, and J4 treatments with a value of 100% and the lowest mortality in the J1 treatment or control with a value of 0%. This shows that the application of OPEFB to the larvae was toxic and caused death.

Table 4 shows the highest intensity of damage on H1, which is the application of pesticides by farmers that they usually do, with a damage value of 32.00%. Moreover, damage has occurred since the first observation on day 22. The application carried out in the field when the plants were 20 days old caused *S. frugiperda* to attack the plants first, resulting in relatively high *S. frugiperda* attacks based on the initial observations on day 22. Meanwhile, in observations conducted on days 28 and 31, the attack rate decreased from previous observations, which shows that observations on days 28 and 31 have the same value or much fewer attacks. This is due to the fact that as the plant gets older, its parts become more difficult for larvae to ingest and digest. According to Trisyon et al. (2019), immature maize plants had a greater attack rate of *S. frugiperda*. Therefore, control measures carried out in the early phase could reduce the intensity of attacks and affect crop yields. The H4, H3, and H2 treatments were significantly different from the H1 treatment. Following the application, the attack by *S. frugiperda* showed a significant effect on reducing the intensity of damage to maize plants consistently for each observation. Based on the study by Sari et al. (2018), the percentage of plant damage could be reduced by administering liquid smoke. Furthermore, the OPEFB applied has a strong smokey aroma. According to Wijaya (2022), insects are able to communicate through smells thus, by spraying liquid smoke on cabbage plants, insects will stay away from them since they cannot communicate with each other through smells. The unpleasant smell of liquid smoke is an insect repellent and antifeedant for insect pests. Due to the fact that the damage intensity on H1 with a value of 32% was considered big damage, farmers need to carry out control measures using OPEFB.

The analysis of liquid smoke OPEFB contains secondary metabolites of terpenoids, steroids, tannins, and saponins. The secondary metabolite compounds contained in the liquid smoke of OPEFB decreased the larvae's hunger, resulting in their deaths. Saponins made the digestive tract corrosive due to a decrease in the surface tension of the mucous membrane of the digestive tract of the larvae, which decreased eating and digesting activity (Utami et al. 2016). In addition, the cuticle layer, which was affected by saponin compounds, was damaged as a result of the cuticle absorbing toxic substances that were then flowed by hemolymph into the larvae's bodies, resulting in damage to their internal organs (Wahyuni & Loren 2015). Again, steroids could interfere with the octopamine structure; if there were a disruption in the octopamine structure, there would be a disruption in larval activity, thereby increasing larval mortality (Prakoso et al. 2017).

## CONCLUSION

According to the study, OPEFB compounds are very toxic to *S. frugiperda* larvae and can be used as a biopesticide to control *S. frugiperda*. The $LC_{50}$ value for the OPEFB toxicity test on *S. frugiperda* was 129.86 ml/L. Moreover, OPEFB contains secondary metabolites and has an unpleasant odor that *S. frugiperda* larvae do not like. Again, the application period for the OPEFB is before 20 days after planting, and doses of 10.0 ml/l and 15.0 ml/l can be applied. Additionally, suggestions for future research are related to the period of the OPEFB application on maize plants.

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## CONFLICT OF INTEREST

**Conflict of Interest**
The authors declare that they have no conflict of interest.

**Ethics Declarations**
No ethical issue is required for this research

**Data Availability Statement**
This manuscript has no associated data

**Authors' Contributions**
Nurhajijah conceived this research, designed experiments, and interpretated the data. Nurhajijah wrote the paper and participated in its revisions. All authors read and approved the final manuscript.

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