Akta Agrosia

Modeling of Fresh Fruit Bunches (FFB) Productivity Patterns Based on the Application of Biological Agents Against Pests in Oil Palm Plantations

Salmiyati*[1], Budi Kuncahyo[2]
[1]Agrotechnology, Institut Teknologi Perkebunan Pelalawan Indonesia
[2]Faculty of Forestry, Bogor Agricultural University

Doi: 10.31186/aa.25.2.45-51

ARTICLE INFO

Keywords:
biological agent,
FFB productivity,
modeling,
oil palm

Article history:
Received: Sept 28, 2022
Accepted: Jan 23, 2023
Published: Feb 05, 2023

**Corresponding author:*
E-mail:
salmiyati76@gmail.com

ABSTRACT

Pests are controlled in oil palm plantations by using biological agents to achieve higher productivity of fresh fruit bunches (FFB) of oil palm (*Elaeis guineensis* Jacq.). This study aims to create a modeling pattern for oil palm FFB productivity based on application data of biological agents at several levels of planting age. The research was conducted in Pelalawan, Riau, namely on young plants, juvenile plants, mature plants and old plants on mineral soil. The data used are the application data of the biological agents *Tyto alba*, *Antigonon leptosus* and *Turnera subulata*. Data were analyzed using Cobb Douglas multiple linear regression and correlation analysis. The results of the regression analysis are used to build a model for predicting FFB productivity patterns using *Stella Software*. The results of the model regression analysis showed that the coefficient of determination was obtained at 0.265, meaning that together the variables *Antigonon leptosus, Tyto alba* and *Turnera subulata* affected FFB productivity by 26.5%. The results of the regression analysis showed that the effect of each *Antigonon leptosus, Tyto alba*, and *Turnera subulata* increased by 1%, so FFB productivity increased by 0.018, 0.024, and 0.028%, respectively. The modeling pattern for the development of biological agents shows that FFB productivity will increase and start to decrease at the ages of 14 - 30 years in young, juvenile, mature, and old plants. The total rate of increase from the application of biological agents is 0.047%.

INTRODUCTION

Pest control in managing plantations greatly affects the productivity of oil palm (*Elaeis guineensis* Jacq.). Pest problems that threaten production continue to be overcome with environmentally friendly measures. Based on research by Muliani et al. (2017), there are 3 types of pests that threaten the FFB production of oil palm, including rats, caterpillars, and horn beetles. Pest management in oil palm plantations is very effectively controlled with a biological agent system (Peng and Christian, 2005). Pest control with a biological agents will only kill plant pests as programmed, such as controlling rats by keeping owls (*Tyto alba*) (Seprido and Mashadi, 2019). Planting *Turnera subulata* and *Antigonon leptosus*, nectar-producing plants that have been developed as food sources for parasitoid insects that are

ISSN: 1410-3354 / e-ISSN:2615-7136

Cited this as: Salmiyati and B. Kuncahyo. 2022. Modeling of fresh fruit bunches (FFB) productivity patterns based on the application of biological agents against pests in oil palm plantations. Akta Agrosia 25(2):45–51. doi: 10.31186/aa.25.2.45-51

natural enemies of coconut pests and oil palm, can control a variety of leaf caterpillars, including fire caterpillars, armyworms, and bagworms (Libing et al., 2017). Conservation of natural enemies as biological agents by planting flowering plants is one of the effective preventive measures (Pradana et al., 2020).

Oil palm plantations that are attacked by rats have a very large negative impact on the production of EFB. Rat pests not only attack oil palm seedlings, both immature and mature plants, and eat oil pollinating insects, but they also frequently damage oil palm flowers, both male and female flowers. As a result, the oil palm plants could not produce fruit, causing huge losses. Some rats also attacked the oil palm bunches. Rat pest control by keeping owls is highly developed. An owl is able to protect 25 square hectares of oil palm plantations from rats. The control method with biological agents is more environmentally friendly; the use of this owl can reduce the use of pesticides to 100% (*zero pesticides*) and suppress rat pest attacks to 0% (Sipayung et al., 2018).

Pests that eat oil palm leaves include fireworms, armyworms, and bagworms. Caterpillar attacks will reduce oil palm productivity. Natural enemies have been developed to control these caterpillars. Predatory attacks will suck the liquid into the fire caterpillar, so the fire caterpillar will die. There are several types of attacks that can be classified as natural enemies of leaf sheath-eating caterpillars. *Sycanus dichotomus* is a fairly active predator for fireworms and bagworms. *Eucanthecona* sp. is the main predator of fire caterpillars, sucking the liquid from the caterpillars. These two predatory insects were developed by providing a place to live (hosts) in the form of plants, namely *Turnera subulata* and *Antigonon leptopus* (Susanto et al., 2020). Jamian (2017) stated that *Turnera subulata* and *Antigonon leptosus* have the potential to reduce pests in the oil palm industry.

One of the factors influencing pest attack power on oil palm plantations is oil palm planting age. Based on data from Susanto (2011), an important problem in oil palm plantations is the attack of leaf-eating caterpillars that attack both immature and mature plants. The decrease in the amount of oil palm production due to these pests reached 40%, or around 6.4 tons per hectare. The attack rate of bagworms is higher in immature plants compared to mature plants (Sembiring et al., 2013). The intensity of pest attacks on average in 2015 was 3.49%, and in 2016 it was 8.71%, while the average production of oil palm in 2015 was 116.18 tons, and in 2016 it was 197.95 tons. The results of the 5% level statistical test showed a significantly different interaction between 2015 and 2016 (Alfianor et al., 2017). According to Lubis and Lontoh (2016), the composition of plant age consists of young plants (4–8 years), juvenile plants (9–13 years), mature plants (14–20 years), and old plants (>20 years).

Riau Province is one of the provinces in Indonesia that has developed oil palm plantations. The area of plantations in Riau Province increased over time. In 2019, the area of oil palm plantations increased to 2.80 million hectares. The increasing area of oil palm plantations affects oil palm production. Palm oil production in 2016 was 7,668.081 tons/ha; in 2017, it reached 8,113.852 tons/ha. Furthermore, in 2018, it was 8,586.379 tons/ha, and in 2019, it increased to 8 864.883 tons/ha (Directorate General of Plantations, 2020). This strongly indicates the need for a model that describes the effect of appropriate pest management on the production of FFB and can support government policies on oil palm development. Globally, all CPO-producing countries are currently looking for and developing a sustainable oil palm plantation management model, referring to the Roundtable on Sustainable Palm Oil (RSPO) concept. This concept consists of eight principles and 39 criteria for sustainable oil palm plantations that are able to meet biophysical, economic, and social aspects (Dja'far et al., 2005). Considering these problems, it is important to design an oil palm plantation management model that is able to describe the relationship between pest management and FFB production in oil palm plantations.

MATERIALS AND METHODS

Research has been carried out on oil palm plantations of four age groups, young plants (4 –8 years), juvenile plants (9–13 years), mature plants (14–20 years), and old plants (>20 years) from 14 blocks of mineral land in one of the oil palm plantation companies in Pelalawan Regency (Salmiyati et al., 2016).

The study was conducted using the survey method through observation (Uwin et al., 2017). The duration of the study was three months, starting from April to July 2021. The data used included monthly productivity (kg/ ha) from 2019 to 2021. The data collected in the area of application of *Antigonon leptosus* (bridal tear flowers), *Tito alba* (owl), and *Turnera subulata* (flower at eight o'clock). Data on pest attack intensity was tabulated using MS. Excel, SPSS Statistics 18, and Stella 9.0.2 *software.* The stages of analysis were:

1. *Correlation analysis on lagged*. A correlation analysis was carried out using Paswstatistik 18, which previously carried out a linearity test of the data. If the data has a significance value > 0.05, it means that the data has a linear correlation, whereas otherwise, the data has a non-linear correlation.
2. *Simple Linear Regression Analysis*. Simple linear regression was used to predict the extent to which the value of the independent variable changes for the dependent variable. Regression analysis is not only used to measure the strength of the relationship between two variables; it also shows the direction of the relationship between the independent variable and the dependent variable.
3. *Multiple Linear Regression Analysis*. The Cobb-Douglas function was used to determine the influence of the independent variable on the dependent variable.
4. *Productivity distribution model*. The productivity distribution model was carried out using the Stella software. The distribution model is based on the pattern of linkages between the application of biological agents and the productivity of FFB.

Furthermore, the results of the estimation of the productivity distribution pattern will be compared with the real monthly productivity achievement. The Stella model compiled can be seen in Figure 1. The resulting simulation data is the result of multiple linear regression with the Cobb-Douglas production function. Model Testing, To test the modeling that has been done is the chi Square test

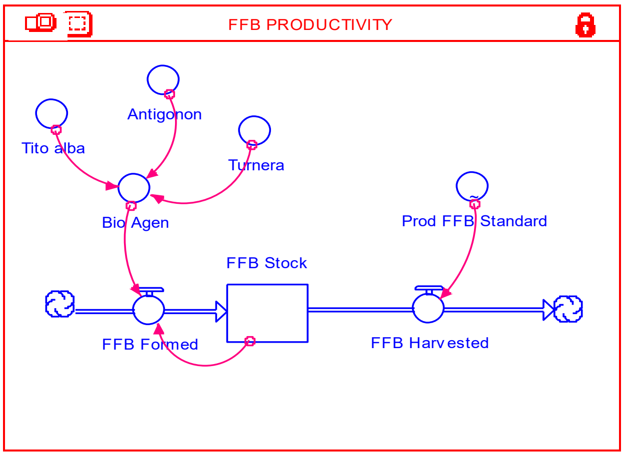

Figure 1. Sub-model of Oil Palm Plantation Biological Agents

RESULTS AND DISCUSSION

Correlation analysis and Simple linear regression

The initial stage of statistical analysis in this study was testing the hypothesis of each observed biological agent factor on FFB production. Correlation analysis shows the correlation of each biological agent affecting FFB productivity (Table 1).

Table 1. Correlation of biological agents that affecting FFB productivity

Variable	Pearson Corr.	Sig. (2 tails)
Antigonone leptosus	0.253**	0.01
Tyto alba	0.395**	0.00
Turnera subulata	0.121*	0.00

Biological agents and FFB productivity have a low correlation of 0.121–0.253 and a positive value indicated by *Tyto alba*, *Antigonon leptosus* and *Turnera subulata.* The result of the direction of the relationship is positive because the value of (r) is positive. This means that the higher the value of the biological agent factor, the higher the productivity of FFB (Rosenfield, 2015). Based on the correlation results, the analysis was carried out with a simple linear regression test to determine the magnitude of the relationship between variables, as well as the shape of the relationship function of each biological agent factor with FFB productivity, as well as the variable at a constant level as an increasing or decreasing value, as shown in Table 2.

Biological agents that are widely used in oil palm plantations to control caterpillar pests are beneficial plants, namely *Turnera subulata* and *Antigonon leptopus*. Meanwhile, to control rat pests, use natural predators like *Tyto alba* (Seprido and Mashadi, 2019). The analysis revealed that Tyto alba had the greatest increase in FFB productivity when compared to Turnera subulata and Antigonon leptopus. The simple linear regression equation was constant for the variable Tyto alba at 18.310, while *Tyto alba* was 2.799, meaning that every one percent increase in *Tyto alba* will increase the productivity of FFB by 2.799 (279.9%). While a *Tyto alba* significance of 0.00 or less than 0.05 indicated that there was a significant effect on FFB productivity. Based on the R squared of 0.156, there are 15.6% influencing factors between *Tyto alba* and FFB productivity. Application of biological agents in oil palm plantations to control weeds, pests, and diseases can minimize costs and increase FFB productivity (Helmi et al., 2015).

Multiple linear regression analysis

Biological agents are one factor that affects the productivity of FFB. The results of statistical analysis using Cob Douglas' model are shown in Table 3. A regression model between the variables of biological agents and the FFB variables is shown in the following equation:

Ln Biological Agent = 2.996 + 0.018 ln AP + 0.024 ln TA + 0.028 ln T

A coefficient of determination (R2) of 0.265, means that together the variables *Antigonon leptosus*, Tyto *alba,* and *Turnera subulata* affect the productivity of FFB by 26.5%, while the rest is influenced by other factors that have not been included in the model. The results of the F test analysis had a significance level of 0.00. This means that a 0.000 significance level shows that all

Table 2. Analysis results and simple linear regression function between biological agents and FFB productivity

Model	R^2 –	Standard Error	F	Sig.	Regression equation
Antigonone leptosus	0.064	4.6351	10.778	.001a	Y = 22.974 + 0.257
Tyto alba	0.156	2.0805	24.066	.000a	Y = 18.310 + 2,799
Turnera subulata	0.015	6.7517	4.48	.035a	Y = 23.759 + 0.336

Table 3. Cob Douglas Regression Model on Biological Agents on FFB Productivity

Dependent Variable	Cooffecient	t statistic	Sig.	VIF
Constant	2.996	62.525	0.00	
LnAntigonon	0.018	2.97	0.00	1.00
LnTyto	0.024	4.00	0.00	1.04
LnTurnera	0.028	3.05	0.00	1.04
Adjusted R Square	0.265			
F Statistics of Sig.	0.000a			
Sig. 0f Heteroscedasticity test	0.727a			
Kolomogororov-Smirnov Test	0.465			
Durbin Watson	1.652			

independent variables (*Antigonon leptosus*, *Tyto alba,* and *Turnera subulata*) jointly affect the dependent variable (FFB productivity). The probability result (0.000) is much less than 0.05, so the regression model can be used to predict the productivity of FFB.

Based on the regression analysis of the Cobb Douglas' function, the effect of *Antigonon leptosus* increased by 1%, so the productivity of FFB increased by 0.018%. The effect *of Tyto alba* increased productivity by 1%, so FFB productivity increased by 0.024%. The effect *of Turnera subulata* increased productivity by 1%, so FFB productivity increased by 0.028%. The results of the analysis showed that the application of *Tyto alba*, *Turnera subulata,* and *Antigonon leptosus* as biological agents in oil palm plantations was able to increase FFB productivity (Wardati et al., 2013).

Modeling FFB Productivity

Figure 2 depicts a simulation model for estimating FFB productivity of each age group to the plant's 30-year productive age. Analysis of data applied *by Antigonon leptosus* , *Tyto alba,* and *Turnera subulata* was carried out in 4 age groups, namely young plants (4–8 years), juvenile plants (9–13 years), mature plants (14 –20 years), and old plants (> 20 years). Figure 2 shows the results of FFB productivity in 4 age groups applied with biological agents at the ages of 5 years, 10 years, 14 years, and 22 years. The development of biological agents in the young and juvenile plants will increase the productivity of FFB, but it will slowly decrease from the ages of 14 to 30 years (A and B). They can be productive in mature and old plants (C and D) until the age of 30 years. The total rate of increase from the application of *Antigonon leptosus, Tyto alba,* and *Turnera subulata* was 0.047%.

Model testing is done by comparing the results of FFB productivity based on the projected simulation with FFB productivity in reality. The test in Table 4, which was carried out using the chi square test, indicated that H0 was accepted. This condition illustrates that the simulation model can be used as a reference to

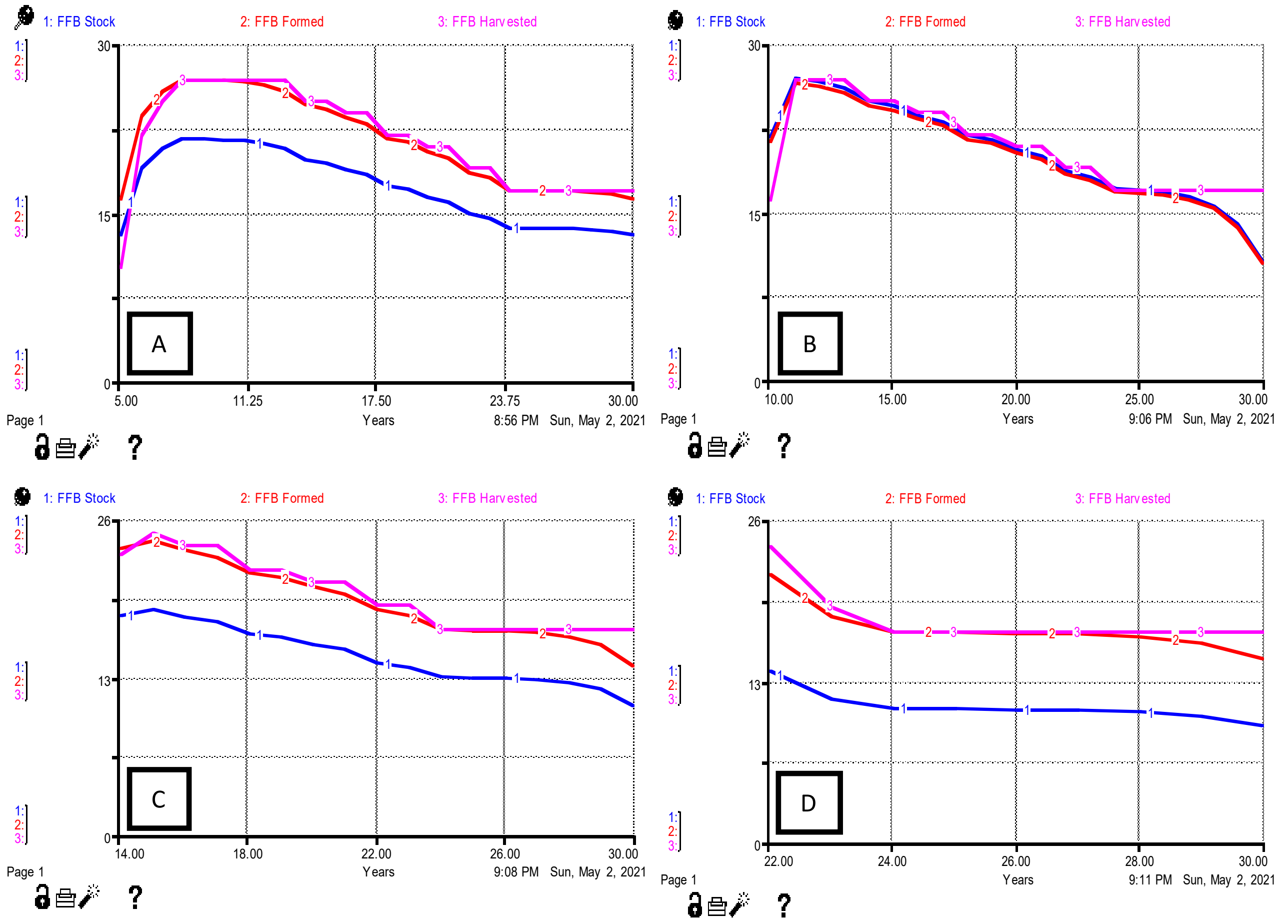

Figure 2. Results of Modeling Applications of Biological Agents (*Antigonon leptosus, Tyto alba* and *Turnera subulata)* on FFB Productivity, A). young plants; B). juvenile plants; C). mature plants; D).old plant

Table 4. The results of the chi-square test analysis comparing the productivity of FFB simulation results with actual conditions in the field

Year	FFB productivity (ton/ha)		X^2	Criteria
	current	Model	Asymp.sig.	
2018	18.8	19.1	0.258	Accepted Ho
2019	20.1	22.5	0.073	Accepted Ho
2020	22.3	22.9	0.241	Accepted Ho
2021	21.1	23.0	0.15	Accepted Ho

predict the productivity of FFB applied by Antigonon leptosus, Tyto alba, and Turnera subulata, and the results are very logical. Management of oil palm plantations both in terms of nutritional needs and controlling pests and diseases can increase FFB productivity (Salmiyati et al., 2016) . Based on the significance of Asym.Sig FFB productivity every year, > 0.05 means H0 is accepted. So it can be concluded that there is no significant difference between the simulation results and the actual productivity of oil palm plantations. The simulation modeling carried out by Gromikora and Yahya (2014) stated that the simulation model built at several stages of shoots was able to predict 75% of the average bunch weight and oil palm production with different numbers of midribs. The simulation model is considered valid for estimating oil palm production at various stages of maturity at the research location. FFB productivity is strongly influenced by the management carried out in oil palm plantations (Salmiyati et al., 2014).

The modeling was carried out with the criteria of phenology, allocation, and yield of oil palm, which resulted in a simulation that was able to predict the average leaf growth and FFB productivity of oil palm (Fan et al., 2015). Research by Pradiko et al. (2017) stated that the results of correlation analysis were used to build a model for estimating monthly productivity patterns.

CONCLUSION

The highest percentage that increased FFB productivity was for *Tyto alba* compared with *Turnera subulata*, and *Antigonon leptopus*. The coefficient of determination (R2) was 0.265, which means that the variables *Antigonon leptosus, Tyto alba,* and *Turnera subulata* affect the productivity of FFB by 26.5%. Regression analysis using the Cobb Douglas function showed that each of *Antigonon leptosus, Tyto alba*, and *Turnera subulata* increased FFB productivity by 0.018, 0.024, and 0.028%, respectively. The modeling pattern for biological agents shows that FFB productivity will increase and then start to decrease at the ages of 14–30 years in the stages of young, juvenile, mature, and old plants. The results of this study can be used as a reference for predicting the productivity of FFB after being applied *by Antigonon leptosus, Tyto alba,* and *Turnera subulata.*

REFERENCES

Alfianor, S. Wahyudiono, and S. Tarmaja. 2017. Study of pest attacks in amara gardens using GIS (Geographical Information System). Journal of Agromast 2(2):1:13.

Directorate General of Plantation. 2020. Palm oil area by province in Indonesia 2013-2020. Oil Palm Area 1.

Dja'far, N. R., and M.A. Akmal. 2005. Roundtable guidelines for sustainable palm oil (RSPO) on the principles and criteria for sustainable palm oil in the palm oil industry. Journal of Oil Palm Research 13(2):85–101.

Fan, Y., O. Roupsard, M. Bernoux, G. Le Maire, O. Panferov, M.M. Kotowska, and A. Knohl. 2015. A sub-canopy structure for simulating oil palm in the Community Land Model (CLM-Palm): Phenology, allocation and yield. Geoscientific Model Development 8(11):3785–3800.

Gromikora, N., S. and Yahya. 2014. Modeling of oil palm growth and production at different levels of frond pruning growth and production modeling of oil palm at different levels of front pruning. Agron Journal 42

(3):228–235.

Helmi, D. Sulistyanto, and Purwatiningsih. 2015. Application of biological control agents on pest populations on cabbage plants in Kalibaru Kulon Village, Banyuwangi Regency. Journal of Basic Sciences 16(2):55 –62.

Jamian, S. 2017. Role of Beneficial Plants in Improving Performance of Predators of Oil Palm Bagworm. University Putra Malaya.

Libing, P.R.S., S. Wijayani, and P.B. Hastuti. 2017. The effect of kinds and dosages of organic materials on the growth of *Turnera ulmifolia* cuttings. Agromast 2(2):67–73.

Lubis, R.E, and A.P. Lontoh. 2016. Palm oil harvest management (*Elaeis guineensis* Jacq.) in Adolina Gardens, Serdang Bedagai, North Sumatra. Agrohorti Bulletin 4(2):144–154.

Muliani, S., A. Ridwan, and, H.J. Saputra. 2017. The attack rate of several types of pests on oil palm plantations (*Elaeis guineensis* Jacq.) at PT Widya Unggul Lestari, Mamuju Regency. AgroPlantae 6 (1):29–33.

Peng, R.K., and K. Christian. 2005. Integrated pest management in mango orchards in the Northern Territory Australia, using the weaver ant, *Oecophylla smaragdina*, (Hymenoptera: Formicidae) as a key element. International Journal of Pest Management 51(2):149–155.

Pradana, M.G, H. Priwiratama, T. Ahmad, P. Rozziansha, W.O Purba, and A. Susanto. 2020. Minor pest explosion small fire caterpillar *Olona gateri* and *Penthocrates* sp . (Lepidoptera: Limacodidae) in oil palm plantations. PPKS News 25(3):123–132.

Pradiko, I., S. Rahutomo, E. Ginting, and H. Siregar. 2017. Compilation of a model for estimating the monthly productivity pattern of oil palm based on the depth and rainy days. J. Pen. Palm Oil 25(3):117–136.

Rosenfield, M.J. 2015. Practical Applied Statistics for Sociologists 7:20.

Salmiyati, A. I. Heryansyah, I. Idayu, and E. Supriyanto. 2014. Oil palm plantations management effects on productivity Fresh Fruit Bunch (FFB). APCBEE Procedia 8:282–286.

Salmiyati, A., B. Heryansyah, B. Kuncahyo, I.I. Muhamad, and E. Supriyanto. 2016. Partial substitution of inorganic with organic fertilizer for enhancement Fresh Fruit Bunch (FFB) productivity in oil palm plantations. Expert Opinion on Environmental Biology 5 (2):2–6.

Sembiring, N., U.M. Tarigan, and Lisnawita. 2013. The attack rate of Metisa plana Walker (*Elaeis guineensis* Jacq.) bagworm in Matapao Gardens PT. Indonesian Soffin. Online Journal of Agroecotechnology 1 (3):362–373.

Seprido, and Mashadi. 2019. Utilization of *Tyto Alba* as rat pest control in oil palm plantation in Kuantan Singingi Regency. Scientific Journal of Agriculture 16(1):1–7.

Sipayung, E.R., S.F. Sitepu, and F. Zahara. 2018. Evaluation of rice rat (*Rattus argentiventer* Robb & Kloss) attacks after the release of an owl (*Tyto alba*) in Deli Serdang Regency. Journal of Agroecotechnology 6(2):345–355.

Susanto, A. 2011. Information on plant pest organisms. Palm Oil Research Center 1 (51):3–6.

Susanto, A., A.E. Prasetyo, H. Priwiratama, Y. Loren, and T.A.P. Rozziansha. 2020. Android system for monitoring pests and diseases in oil palm plantations. PPKS News 25(1):17–22.

Uwin, S., Sabarudin, and N.D. Saraswati. 2017. Technical Guidance Survey on Independent oil palm smallholder characteristics. In S. Saihatun, and G.B. Indiarto (Eds.). SPKS.

Wardati, I., D.N. Erawati, C. Triwidiarto, and U. Fisdiana. 2013. Potential control with various biological agents on cotton top borer pests (*Gossypium hirsutum* L.). Agritrop: Journal of Agricultural Sciences 1:81–88.