Journal of Engineering Science and Technology
Special Issue on ICLBPPGT2024 Vol. 19, No. 5 (2024) 145 - 152

TECHNO-ECONOMIC EVALUATION FOR DESIGN OF PEST INSECT TRAP

MUHAMMAD ZAINAL FANANI[1]*, FINA UZWATANIA[2], NANI YULIANTI[1], YANYAN MULYANINGSIH[1], HELMI HARIS[1], AGUSTINA MULTI PURNOMO[1], RADIF KHOTAMIR RUSLI[1]

[1]Universitas Djuanda, Jl Tol Ciawi No. 1, Bogor, West Java, Indonesia
[2]Burningham University, Edgbaston, Birningham, United Kingdom
*Corresponding Author: muhammad.zainal@unida.ac.id

Abstract

Trap is one of the promising ways in integrated pest insect management. This study was objected to evaluate the techno-economics for design pest insect trap of rice stem borer. We used an economic analysis of commercial equipment to design the insect trap. Economic analysis was used to calculate production potential from raw material, including return rate, gross margin, sales profit percent, BEP, and others. This study reported that production of design for insect trap to control the rice stem borer has important prospective to be developed especially in agricultural country. Production of the insect trap was friendly because using solar panel as the electric energy source. This study had the good contribution to support the integrated pest management in the future.

Keywords: Insect trap, Pest control management, Rice stem borer, Techo-economic.

1. Introduction

The problem of plant pest is the main obstacle in increasing production and resilience crops, mainly on the rice plant as main source of carbohydrates in many countries Thus effect in quite large losses in the form of loss of yield, reduction in quality, disruption of production continuity, as well decrease in farmer income. Attack pests, especially stem borers can cause damage ranging from light intensity to empty grain. Prevention and controlling of stem borer pest rice especially in the pre-moth phase when laying eggs will reduce potential losses yield so that rice productivity increases. Therefore is needed to monitoring the insect pests, related researches are being carried out on mealybug and caterpillar pests [1-4].

Several methods of pest insect traps using solar panels, which provides the prospect of converting pest insects into valuable materials [5]. The aim of this research is to highlight the economic feasibility of pest insect trap manufacturing using solar panel, insect trap, and microcontroller. Several economic evaluation parameters (i.e. gross profit margin (GPM), internal rate of return (IRR), payback period (PBP), cumulative net present value (CNPV), break-even point (BEP), break-even capacity (BEC), return on investment (ROI), and profitability index (PI)) are explained to inform the production potential of valuable materials from rice straw. Then, the economic parameters are tested by changing various economic conditions, such as labor, sales, raw materials, utilities, as well as external conditions (i.e. taxes and discount rates). A lot of researches related to the techno-economic have been reported (Table 1). The aim of this study was to evaluate the techno-economics for design pest insect trap of rice stem borer.

Table 1. Previous reports related with techno-economic analysis.

No.	Title	Ref.
1	A comprehensive review on techno-economic assessment of hybrid energy storage systems integrated with renewable energy	[6]
2	Techno-economic evaluation of biodiesel production from edible oil waste via supercritical methyl acetate transesterification	[7]
3	Techno-economic assessment of a power to green methanol plant	[8]
4	Techno-economic evaluation of the production of resin-based brake pads using agricultural wastes: Comparison of eggshells/banana peels brake pads and commercial asbestos brake pads.	[9]
5	A comprehensive techno-economic analysis and multi-criteria optimization of a compressed air energy storage (CAES) hybridized with solar and desalination units	[10]
6	Techno-economic analysis for the production of LaNi5 particles	[11]

2. Method Theoretical of Pest Attack Early Warning System and Its Trap Controller

Early detection of plant herbivore are observation activities carried out early on in the development of an pest attack, so it is possible taking technical action as an effort preventive measures to prevent further damage large size on plants can be avoided. An early warning is a report about possibility alertness occurrence of attacks by pest insect due to an increasing trend in population density or level attack. Delays in controlling the pest attacks can result in greater losses for farmers. Efforts to manage data and information through pest traps become an early warning system for pest attacks. Pests caught in traps can be used as indicators of the arrival of pests at the planting location, so that traps can be used as monitoring tools, reducing pests, and determining economic thresholds [12].

3. Method

This study was carried out in several steps, namely basic design of the tool, assembly or manufacture of the tool, testing the design results, observation and data analysis. The research process for production of pest trap of automatic control system can be showed in Fig 1.

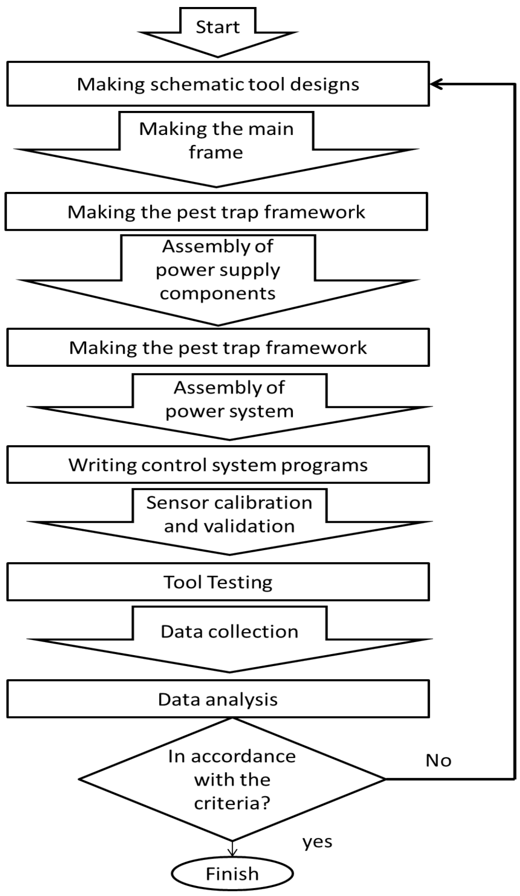

Fig. 1. Process flow diagram for production of insect pest trap.

Tool design includes making control system schematics, sensor schematics, installing the power supply, and installing all components to microcontroller. Once installed, continue with circuit verification by re-checking all components. Then continue with perform system calibration and sensitivity. In this research, the sensitivity of the infrared sensor was tested by looking response speed of the infrared sensor when objects pass through the sensor with response to turning on a fan. As well as carrying out water pump performance tests on draining and filling water in the storage tank in the morning. The control system design (Fig. 1) shows that the system input is the E18-D50NK sensor and the real time clock. The output of the control system is lights, water pumps and fans. As a power source for the control system, it uses power from solar panels.

This study used some data based on the average price of products commercially available on online shopping webs to guarantee the current price of materials. All data was calculated using simple mathematical analysis. To confirm the economic evaluation of this project, several economic evaluation parameters were used: CNPV, GPM, PBP, BEP, BEC, IRR, ROI, and PI (as novelty). Then, during the feasibility evaluation, various conditions are tested, including changes in raw materials, sales capacity, labour conditions, interest rates, etc. Detailed information for the calculation is explained elsewhere [13, 14].

4. Results and Discussion

4.1. Structural design of pest insect trap

The design process consists of several stages, namely design of the tool shape, assembly of the control system hardware and assembly of the pest trap frame. For the control system hardware assembly, a block diagram was made that connects the components as in Fig 2. In the control system hardware assembly section, the sensors are connected to the microcontroller. The sensor was placed on the insect trap at the top and facing downwards, so that the sensor can detect insects that enter the pest trap.

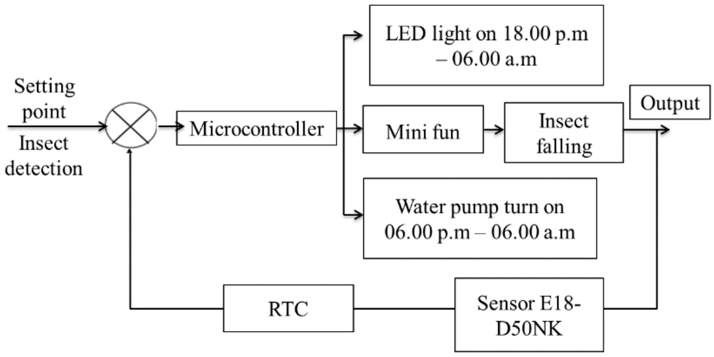

Fig. 2. Block diagram of insect capture control system.

This insect pest trap was divided into several parts, namely solar panels, solar panel pole frames, power boxes, control system boxes, pest traps, insect containers, attractant containers, E18-D50NK sensors and water containers (Fig. 3). Each part of this insect trap was installed based on the design and functional design of theoretical calculations. The pest trap frame was made using aluminum. The pest trap frame has dimensions (l = 140 cm, h = 40 cm, d = 20 cm). The top of the pest trap was cone-shaped (l = 60 cm, h = 40 cm). The bottom of the pest trap is cone-shaped (d = 20 cm, h = 40 cm). The insect collection box was made of aluminum (l = 40 cm, h = 30 cm, d = 20 cm). The control system box is made of a panel box. There are components such as arduino uno, real time clock (RTC), SD card reader and writer and a power supply as a power supply for the microcontroller. The microcontroller was connected to the E18-D50NK sensor, RTC, liquid crystal (LCD) and actuator. The actuators used are fans, LED lights, and pumps. The power box is made of angle iron. There are components such as batteries, inverters, and solar control charges. The solar panel pole frame is made of 4 inch round iron with a height of 4 meters. On this pole there are solar panels, power boxes, control boxes, and pest traps.

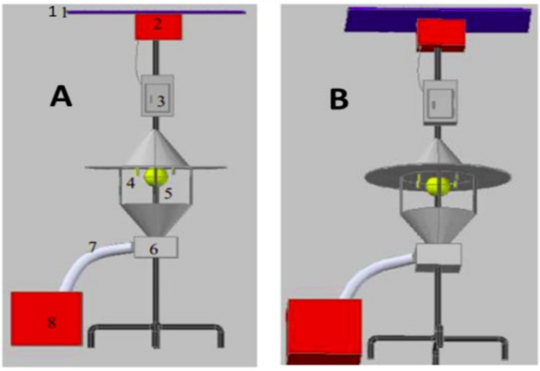

Fig. 3. Design of the rice stem borer trap (A) front view (B) looks slanted (1. solar panel; 2. power storage box; 3. automatic control box; 4. infrared sensor; 5. LED lamp; 6. insect container; 7. water house; 8. water tub).

4.2. Economic analysis and evaluation

A detailed explanation of the specific conditions of the need for raw materials and equipment, and factors for estimating production cost (Table 2-4).

Table 2. Raw material.

No	Material	Small Scale production requirements (kg/hour)	Price (IDR)	Total (IDR)	Total ($)
a	Attractant	4	25,000	25,000	1.55
b	LED lamp	1	50,000	50,000	3.11
c	Small fan	1	60,000	60,000	3.73
d	Iron pole	4	25,000	25,000	1.55
e	Iron elbow	8	30,000	30,000	1.86
f	Aluminum foil	1	15,000	15,000	0.93
g	Acrylic	4	15,000	15,000	0.93
h	Battery	2	22,700	22,700	1.41
i	Roll cable	3	3,000	3,000	0.19
j	Iron bolts	8	5,000	5,000	0.31

Table 3. Equipment cost.

No	Equipment	Price (IDR)	Unit	Total Price 2026 (IDR)	Price total ($)
a	Solar panel	120,000	1	120,000	7.45
b	Inverter	447,000	1	447,000	27.76
c	Solar control	100,000	1	100,000	6.21
d	Arduino	60,000	1	60,000	3.73
e	Water pump	53,000	1	53,000	3.29
f	Relay	25,000	3	75,000	1.55
g	Real time clock	20,000	1	20,000	1.24
h	Sensor E18	30,000	1	30,000	1.86
i	Auto CAD	20,000	1	20,000	1.24
j	Hot melt glue	18,500	1	18,500	1.15

Table 4. Factors for estimating production cost.

Component	Parameter	Cost (IDR)
Fixed cost	Capital related cost	352,413,642
	Depreciation	30,791,983
	Total fixed cost	383,205,625
Variable cost	Raw material	80,610,000
	Utilities	55,785,000
	Operating labor (OL)	18,000,000
	Labor related cost	5,400,000
	Sales related cost	112,000,000
	Total variable cost	271,795,000
% Profit estimated	Sales	1,600,000,000
	Manufacturing cost	624,208,642
	Investment	330,047,854
	Profit	0.61
	Profit to sales	2.96
BEP	Unit	800
	Fixed cost	383,205,625
	Variable cost	271,795,000
	Sales	1,600,000,000
	BEP	230,811,132
	Percent profit on sales	0,609869599
	Return on investment	3,168978522
	Pay out time	0,305905956

Based on the above analysis, the project in ideal conditions is prospective. However, when there is a change in economic conditions, the project for the manufacture of insect trap is only profitable under certain economic conditions. In short, if the project is carried out under conditions that are outside certain economic conditions, the project will be at a loss. The targeted sales capacity is 8 packs per day or an estimated 800 packs per year with a selling price of 2,000,000.00 per pack with an annual income of 1,600,000,000.00.

4.2. Ideal condition

In ideal condition was showed on graphic of the CNPV and total investment cost (TIC) with parameters of various techno-economic evaluations (IRR, PI, ROI, BEP, PBP, and GPM). Based on economic analysis described the conversion of design for insect pest trap was excellent and promising perspective (Fig. 4).

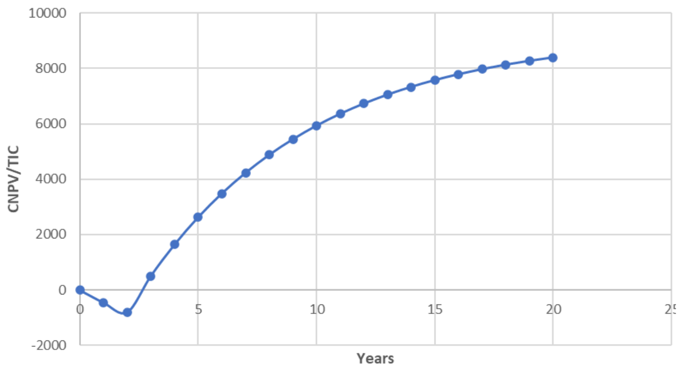

Fig. 4. CNPV with various economic evaluation parameters.

5. Conclusion

This study reports the design of a product design for a rice pest trap, based on engineering evaluation because the process was be done using commercially available equipment. Economic analysis of GPM, PBP, BEP, CNPV, and PI showed positive results, while analysis of IRR and ROI showed negative results, indicating that the project is profitable but less attractive to industrial investors. In ideal and worst-case conditions, the CR method was found to be better than CPR. This analysis was also supported by the cost-economic parameter analysis which gives positive values. Analysis of several sensitivity parameters was also carried out, indicating some limiting conditions for obtaining benefits. This project should be carried out in agricultural countries.

References

1. Fanani, M.Z.; Rauf, A.; Maryana, N.; Nurmansyah, A.; and Hindayana, D. (2019). Geographic distribution of the invasive mealybug *Phenacoccus manihoti* and its introduced parasitoid *Anagyrus lopezi* in parts of Indonesia. *Biodiversitas,* 20(12), 3751-3757.
2. Fanani, M.Z.; Rauf, A.; Maryana, N.; Nurmansyah, A.; Hindayana, D; and Rochman, N. (2023). Functional response of endoparasitic wasp, *Anagyrus*

lopezi on cassava mealybug, *Phenacoccus manihoti* by parasitism and host-feeding. *Journal of Engineering Science and Technology*, 18(3), 129-136.

3. Waliyudin, M.; Rochman, N.; and Fanani, M.Z. (2023). Attack of *Spodoptera frugiperda* JE Smith (Lepidoptera: Noctuidae) and its parasitoid in parts of Bogor, Indonesia. *Jurnal Agronida*, 9(2), 93-102.
4. Fanani, M.Z.; Rauf, A.; Maryana, N.; Nurmansyah, A.; Hindayana, D.; Rahayu, A.; and Roestamy, M. (2024). Suppression of the cassava mealybug populations, *Phenacoccus manihoti* (Hemiptera: Pseudococcidae) by natural enemies. *ASEAN Journal of Science and Engineering*, 4(2), 317-330.
5. Telaumbanua, M.; Anggraini, R.; Sasongko, F.I.; Fitri, A.; Sari, R.F.M.; and Waluyo, S. (2018). Control system design for rat pest repellent in the rice field using a modified AT-Mega 328 microcontroller modified with ultrasonic sound wave. *International Journal of Engineering Inventions*, 7(8), 22-28.
6. Emrani, A.; and Berrada, A. (2024). A comprehensive review on techno-economic assessment of hybrid energy storage systems integrated with renewable energy. *Journal of Energy Storage*, 84, 111010.
7. Nandiyanto, A.B.D.; Soegoto, E.S.; Maulana, S.A.; Setiawan, A.W.F.; Almay, F.S.; Hadinata, M.R.; and Luckyardi, S. (2022). Techno-economic evaluation of biodiesel production from edible oil waste via supercritical methyl acetate transesterification. *Nigerian Journal of Technological Development*, 19(4), 332-341.
8. Pratschner, S.; Radosits, F.; Ajanovic, A.; and Winter, F. (2023). Techno-economic assessment of a power-to-green methanol plant. *Journal of CO2 Utilization*, 75, 102563.
9. Ragadhita, R.; Al Husaeni, D.F.; and Nandiyanto, A.B.D. (2023). Techno-economic evaluation of the production of resin-based brake pads using agricultural wastes: Comparison of eggshells/banana peels brake pads and commercial asbestos brake pads. *ASEAN Journal of Science and Engineering*, 3(3), 243-250.
10. Alirahmi, S.M.; Mousavi, S.B.; Razmi, A.R.; and Ahmadi, P. (2021). A comprehensive techno-economic analysis and multi-criteria optimization of a compressed air energy storage (CAES) hybridized with solar and desalination units. *Energy Conversion and Management*, 236.
11. Nandiyanto, A.B.D.; Maulana, M.I.; Raharjo, J.; Sunarya, Y.; and Minghat, A. D. (2020). Techno-economic analysis for the production of LaNi5 particles. *Communications in Science and Technology*, 5(2), 7-8.
12. Han, Y.; Song, Z.; Yi, W.; and Zhan, C. (2024). Design of and experimentation with a suction-based pest-capture machine for the tea pest empoasca vitis. *Agriculture*, 14(6), 964.
13. Fiandini, M.; and Nandiyanto, A.B.D. (2024). How to calculate economic evaluation in industrial chemical plant design: A case study of gold mining using amalgamation method. *ASEAN Journal for Science and Engineering*, 3(2), 75-104.
14. Nandiyanto, A.B.D. (2018). Cost analysis and economic evaluation for the fabrication of activated carbon and silica particles from rice straw waste. *Journal of Engineering Science and Technology*, 13(6), 1523-1539.