

Construction and Deployment of a Solar Powered Pest Detection and Control System for Improved Crop Yield

Emmanuel Ndubuisi Okoronkwo^a and Uchenna Godswill Onu^{*, b}

^a Department of Food Technology,
Akanulbiam Federal Polytechnic, Unwana

^{*, b} Department of Electrical/Electronic Engineering Technology,
Akanulbiam Federal Polytechnic, Unwana

* Corresponding author email: uchmangod@gmail.com

Abstract:

Background: As global population continues to rise; food security has become an important concern all over the world. Several efforts are geared towards ensuring food sufficiency and security. Pest management schemes are targeted at minimizing the devastating effects of pests on food production. Environmental and health issues around existing pest management strategies call for the development of more healthy and environmentally sustainable pest management schemes. This research presents the effect of construction and deployment of an intelligent solar powered pest detection and control system for improved crop yield.

Materials and Methods: The research explores experimental deployment of the constructed pest control system aimed at assessing the effectiveness and energy consumption of a modified solar powered intelligent pest detection and control system. The system uses passive infrared sensors to detect the presence of rodent and bird pests and actuates the scaring signals of sound, motion and light to protect the farm.

Results: The results show 51% reduction in energy consumption by the modified system. Yield losses due to rodent and bird pest was reduced by 54%.

Conclusion: The modified pest control system can intelligently simulate human presence in the farm through the detection and scaring of rodent and bird pests from the farm through sound, motion and light signals with reduced energy consumption and minimal health and environmental risks.

Date of Submission: 13-03-2023

Date of Acceptance: 28-03-2023

I. Introduction

The sustainability of food supply for a rapidly increasing global population has become a serious concern. The need to maintain dietary requirements in the face of enormous pressure on natural resources complicates the challenge for the agricultural sector [1]. Over 800 million people globally have no access to adequate food with about two billion people suffering from hunger and malnutrition [2]. Africa despite having the largest part of the world's rural population is enmeshed in hunger, malnutrition, and poverty [3]. This is not unrelated to the poor application of technology in rural agriculture in Africa and other rural economies. Pest management is an important component of crop production. Ensuring global food security requires a continuous improvement in pest control technologies aimed at improving crop yields with minimal environmental impact [4].

The economic implication of agricultural pests has received little attention from the research community. Estimating pest intensity, experimenting on the technical and economic efficacy of pest control methods, participatory evaluation and impact assessment of pest control methods are vital to effective pest management [5]. Losses associated with pest in crop production had since been qualified as light, severe or disastrous. Though farmers are quite aware of the enormity of losses arising from pests' attacks, there is the need for a quantitative assessment of crop losses due to pests [6]. Sankoh et al. [7] had identified the biggest challenges of farmers as pest control. Rodents, birds, insects and other pests can drastically reduce crop yields. Farmers resort to the use of pesticides to control these pests. Available reports show that these chemicals have negative impacts on the environment and the health of farmers.

As a measure to address the negative effects of chemical pesticides on the environment and human health, Onu and Okpo [8] developed a solar powered automatic pest control system that has the capacity to mimic human presence in the farm to scare rodent and bird pests away from the farm using the three signals of sound, light and motion. This system was deployed by Okoronkwo and Onu [9] to assess its functionality and effectiveness in pest control. The results showed improved crop yield. However, the system was faced the problem of diminishing efficiency due to the time-based nature of the scaring signals. Another problem with this

system was high power consumption due to constant operation of the system irrespective of whether pests are present or not.

In order to resolve the problems with the design in [8], Onu [10] proposed an intelligent pest control system that can detect the presence of rodent and bird pests in the farm and respond by actuating the scaring signals to control the pests with higher efficiency and lower power consumption.

This research constructed and deployed the intelligent pest control system developed by Onu [10] to assess the effectiveness and energy consumption of the system.

II. Materials and Methods

A. Materials

The following materials were used to construct the intelligent solar powered pest detection and control system.

- DC electric motors
- Vehicle horns
- Light Emitting diodes
- Light dependent resistor
- Solar panel
- Battery
- Charge controller
- Passive infrared sensors
- Connecting wire
- Transistors
- Resistors
- IC NE555 timer
- Switches
- Capacitors
- Mechanical support

B. Methods

The materials listed in section A were connected according to the circuit diagram in Figure 1. Uniform farm practices were carried out on the divided portions of farm land cultivated with rice of the same variety. Figure 2 is the control unit of the solar powered pest detection system with the sensors. Figure 3 shows the deployment of the system in a cultivated rice field while Figure 4 shows the portion the farm without the deployment of the pest control system.

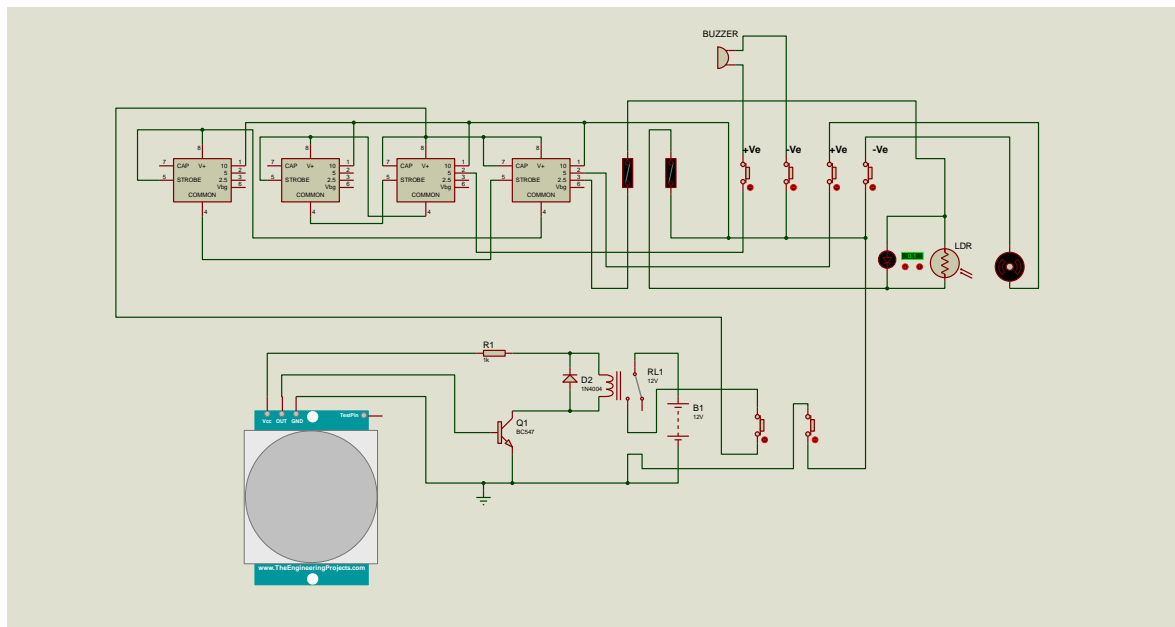


Figure 1: Circuit diagram of Solar Powered Pest Detection and Control System [10]



Figure 2: Developed control unit of Solar Powered Pest Detection and Control System [10]



Figure 3: Deployed Solar Powered Pest Detection and Control System



Figure 4: Portion without Solar Powered Pest Detection and Control System

III. Results

A. Average daily energy consumption

Energy consumption of any electrical system affects the cost and sustainability. Therefore, to measure this important parameter, an energy meter was deployed. The average daily energy consumption of the intelligent pest control system[10]constructed was recorded as 744Whrwhile the average daily energy consumption of the original version developed by Onu &Okpo[8] was 1512Whr. Figure 5 shows the typical daily load profile of the time-based automatic pest control system in Onu &Okpo[8], while Figure 6 shows the typical daily load profile of the solar powered pest detection and control system constructed and deployed in this research as proposed by Onu [10].

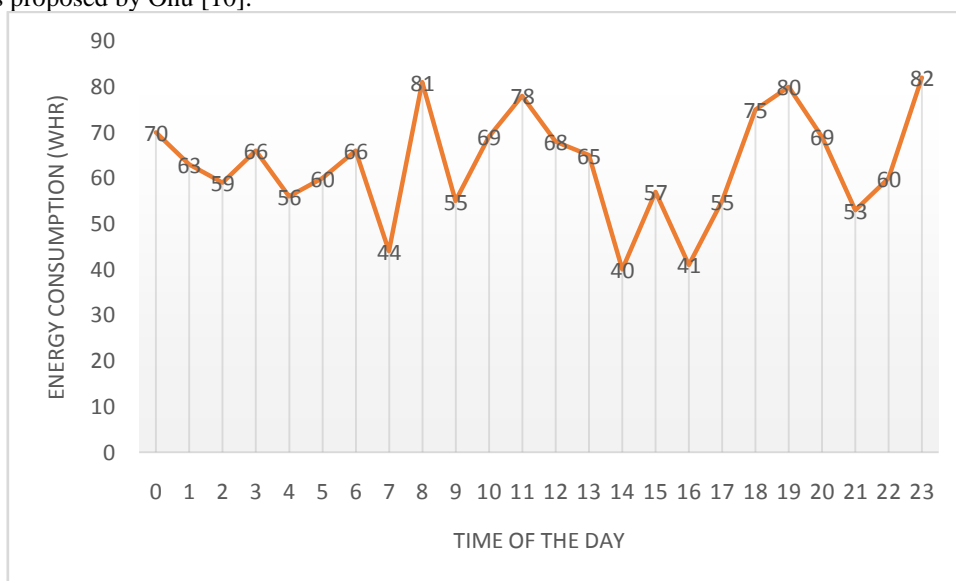


Figure 5: Typical daily Load Profile of thetime-based automatic pest control system

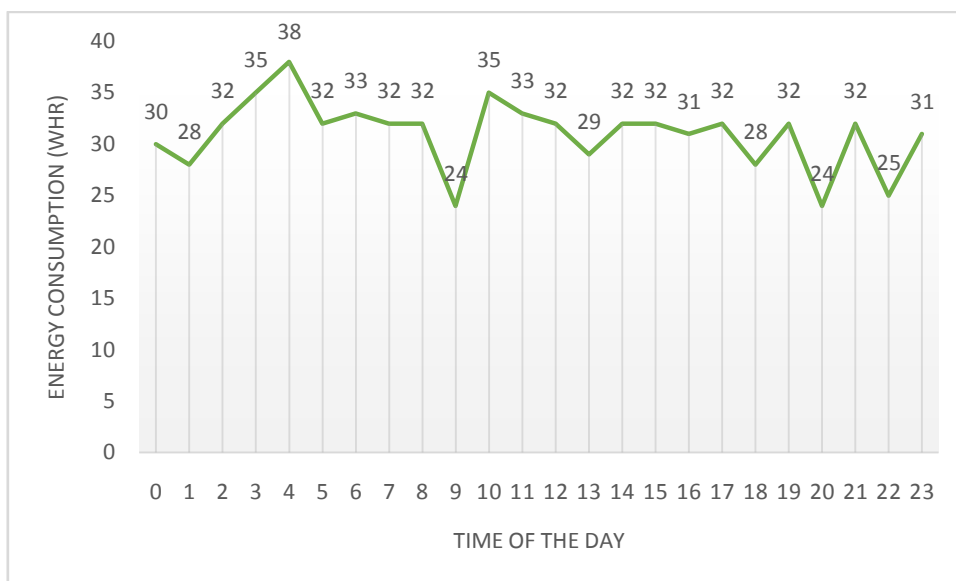


Figure 6: Typical daily Load Profile of the intelligent (detection and control) automatic pest control system

B. Crop yield

The effectiveness of the design in rodent and bird pest control was assessed through the measurement of crop yield in the partitions of the farm as shown in Table 1. Partitions P1, P2 and P3 are areas with the pest detection and control system while partitions P1C, P2C and P3C are the areas without the pest detection and control. Table 2 compares the yields in the areas with and without pest detection and control system.

Table 1: Rice yield in partitions

Farm Portion	Land Area (Acre)	Crop Yield (kg)
Partition 1 (P1)	0.166	435
Partition 1 Control (P1C)	0.166	200
Partition 2 (P2)	0.166	447
Partition 2 Control (P2C)	0.166	198
Partition 3 (P3)	0.166	438
Partition 3 Control (P3C)	0.166	204

Table 2: Yield comparison

Partitions with pest detection and control system		Partitions without pest detection and control system	
Partition	Yield (kg)	Partition	Yield (kg)
P1	435	P1C	200
P2	447	P2C	198
P3	438	P3C	204
Total	1320	Total	602

Average yield per acre in portion **with** pest detection and control system = $\frac{1320}{3 \times 0.166} = 2650.60 \text{ kg/acre}$.

On the other hand, the average yield per acre in portion **without** pest detection and control system = $\frac{602}{3 \times 0.166} = 1208.84 \text{ kg/acre}$.

Percentage yield loss per acre **without** pest detection and control system = $\frac{2650.60 - 1208.84}{2650.60} \times 100 = 54.39\%$.

Figure 7 shows the yield in a pie chart with percentage values.

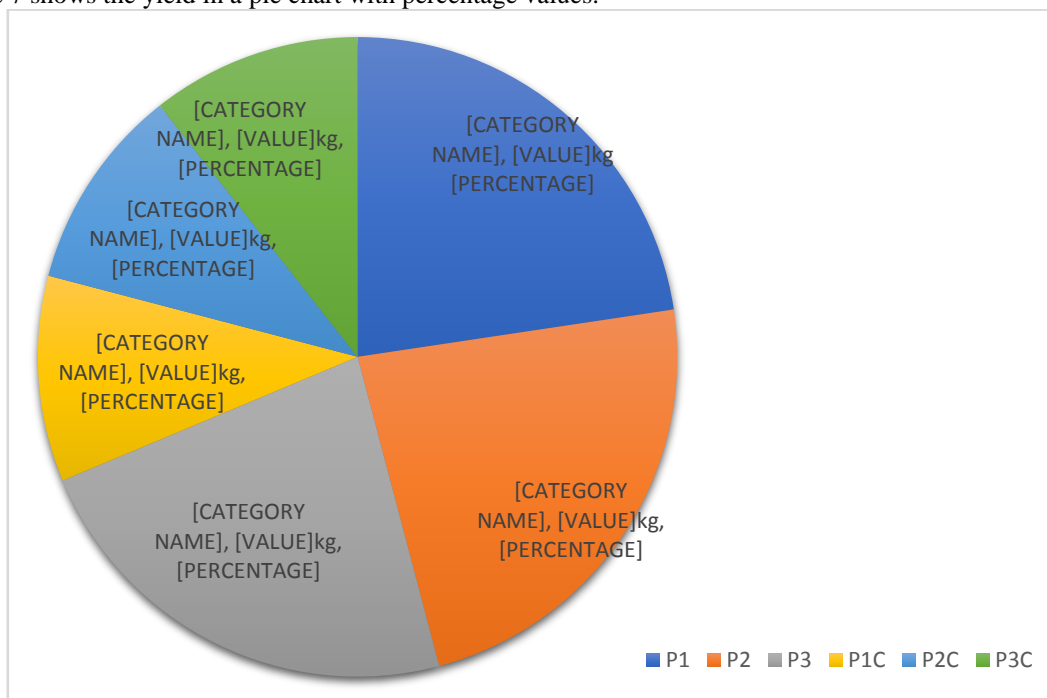


Figure 7: Yield details in chart

IV. Discussion

The performance of the solar powered pest detection and control system is discussed based on the two perspectives of energy consumption and crop yield levels. Figures 5 and 6 indicate approximately 51% reduction in daily energy consumption by the system. This implies that the pest detection and control system constructed and deployed in this research is more economical in comparison with the original version proposed by Onu & Okpo[8]. This is traceable to the fact that the original version in Onu & Okpo[8] was time-based and does not take cognisance of whether or not there is pest in the farm. This short coming increased the power consumption. The present design only actuates the scaring signals on the detection of the presence of pest. This reduced the power consumption.

On the other hand, there was an increase in yield level with the present design due to improved sensitivity of the system. This is because pest scaring became more precise due to actuation of scaring signals only on detection of pests. This eliminated the conditioning of pests to constant scaring signals as in Onu & Okpo[8]. From Figure 7, it can be seen that the yield with the present system is 69% as against the original version with 64%. There was 5% increase in the yield due to increased precision. Through the deployment of pest detection and control, 54.39% yield loss was averted when compared with the farm portions without the deployment of pest detection and control system.

V. Conclusion

The research explores experimental deployment of the constructed pest control system aimed at assessing the effectiveness and energy consumption of a modified solar powered intelligent pest detection and control system. The system uses passive infrared sensors to detect the presence of rodent and bird pests and actuates the scaring signals of sound, motion and light to protect the farm.

The results show 51% reduction in energy consumption by the modified system. Yield losses due to rodent and bird pest were reduced by 54%.

The modified pest control system can intelligently simulate human presence in the farm through the detection and scaring of rodent and bird pests from the farm through sound, motion and light signals with reduced energy consumption and minimal health and environmental risks. The reduction in the energy requirement of the new system and improved yield loss reduction qualifies the new design as a replacement for the existing system in Onu & Okpo[8].

Acknowledgment

We thank the Almighty God for the inspiration to develop this system. In a special way, we thank the Tertiary Education Trust Fund (TETFund), No 6 Zambezi Crescent, off Aguiyi Ironsi street, Maitama Abuja Nigeria for funding this research through their institution-based research initiative.

Authors' Contribution

Emmanuel Ndubuisi Okoronkwo carried out all the necessary farm practices in rice cultivation. On the other hand, Uchenna Godswill Onu conceived, designed and constructed the solar powered pest detection and control system deployed in this research.

References

- [1]. J. P. B. Rodrigues et al., "Agri-Food Surplus, Waste and Loss as Sustainable Biobased Ingredients: A Review," *Molecules*, vol. 27, no. 16. MDPI, Aug. 01, 2022. doi: 10.3390/molecules27165200.
- [2]. O. G. Oladipo, D. A. Ogunkanbi, and R. A. Ayo-Lawal, "Assessing the efficacy of *Azadirachta indica* seed extract on *Fusarium oxysporum*," *West African Journal of Applied Ecology*, vol. 23, no. 2, pp. 73–81, 2015, [Online]. Available: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84958033651&partnerID=40&md5=838459f0b48455c4d9eb764d83e8c035>
- [3]. V. O. M. Martín, L. M. J. Darias, and C. S. M. Fernández, "Balance of agrarian reforms in Africa under the one-party governments (1945-1980); [BALANCE DE LAS REFORMAS AGRARIAS EN ÁFRICA BAJO LOS GOBIERNOS DE PARTIDO ÚNICO (1945-1980)]," *Estud Geogr*, vol. 80, no. 286, 2019, doi: 10.3989/estgeogr.201921.004.
- [4]. W. J. Moar, K. S. Giddings, K. E. Narva, and M. E. Nelson, "Enhancing global food security by using bacterial proteins with improved safety profiles to control insect pests," *J InvertebrPathol*, vol. 187, p. 107704, 2022, doi: <https://doi.org/10.1016/j.jip.2021.107704>.
- [5]. H. de Groote, "Economic analysis of pest problems in agriculture and food chains in Africa," *Curr Opin Insect Sci*, vol. 54, p. 100969, 2022, doi: <https://doi.org/10.1016/j.cois.2022.100969>.
- [6]. P. T. Walker, "Crop losses: The need to quantify the effects of pests, diseases and weeds on agricultural production," *Agric Ecosyst Environ*, vol. 9, no. 2, pp. 119–158, 1983, doi: [https://doi.org/10.1016/0167-8809\(83\)90038-5](https://doi.org/10.1016/0167-8809(83)90038-5).
- [7]. A. I. Sankoh, R. Whittle, K. T. Semple, K. C. Jones, and A. J. Sweetman, "An assessment of the impacts of pesticide use on the environment and health of rice farmers in Sierra Leone," *Environ Int*, vol. 94, pp. 458–466, 2016, doi: <https://doi.org/10.1016/j.envint.2016.05.034>.
- [8]. U. Godswill Onu and C. N. Okpo, "Design and Construction of a Solar Powered Automatic Pest Control System," 2020. [Online]. Available: www.ijltemas.in
- [9]. E. N. Okoronkwo and U. Godswill Onu, "The Effect of Fabrication and Deployment of a Solar Powered Automatic Pest Control System on the Yield Level of Rice," vol. 13, no. 10, pp. 52–58, 2020, doi: 10.9790/2380-1310015258.
- [10]. U. Godswill Onu, "Integrated Design of Photovoltaic Power Generation Plant with Pumped Hydro Storage System and Agricultural Facilities in Uhuelem-Amoncha African Community," 2022. Accessed: Jan. 03, 2023. [Online]. Available: https://repositorio.unifei.edu.br/jspui/bitstream/123456789/3433/1/Disserta%20a7%20a3o_2022140.pdf

Emmanuel Ndubuisi Okoronkwo, et. al. "Construction and Deployment of a Solar Powered Pest Detection and Control System for Improved Crop Yield." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 16(3), 2023, pp. 61-67.