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The Effect of Fabrication and Deployment of a Solar Powered Automatic Pest Control System on the Yield Level of Rice

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Abstract:
Background*: Crop production as an agricultural practice has remained a veritable source of livelihood for the human race. It provides man with food and raw materials for production of other industrial goods. Rodent and bird pests constitute major source of losses in crop production. Existing pest control methods pose environmental and health challenges to humans. There is the need to develop more efficient, human and environmentally friendly systems in the control of pests. This work studied the effect of fabrication and deployment of a solar powered automatic pest control system on the yield level of rice.*
Materials and Methods*: The research used experiments in field deployment of the fabricated system to assess the effect of the system on the yield level of rice. The three basic signals of motion; sound and light used by humans to scare rodent and bird pests from the farm were deployed by the system.*
Results*: Results obtained from the rice field after six months of deployment and monitoring over a combined land mass of one acre showed that the device was able to improve rice yield by averting 49% loss due to rodent and bird pest attack.*
Conclusion: *The system has the capacity to simulate human presence in the farm by producing the three signals of sound, motion and light used by humans to scare bird and rodent pests from the farm automatically with no environmental or health hazards.*
Key Word*: Automatic*; *Pest control; Rice; Solar powered; Time based.*

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I. Introduction

Crop production is one of the most sustainable sources of livelihood for the human race. [1] identified pests as a major challenge of crop production in Nigeria and proposed integrated pest management for pest control in order to enhance yield. A typical experience while growing up as a child was the use of children of school age for bird pest control in rice farms in south east Nigeria. These children were usually stationed in the rice farm especially after casting of seeds to scare birds away from the farm by shouting and casting of stones. Through this method, local farmers are able to control the devastating effects of bird pests in the farm with the health and educational disadvantage it exposes the children to. As an electrical engineer, I am inspired to develop a system that can be deployed autonomously to perform these functions more efficiently and reliably.

As a matter of fact, pests of various species attack crops from planting to maturity stages. Losses associated with pest have been estimated to lie between 5 and 40 % as in [2]. Man has continuously evolved strategies to minimize the damaging effects of pests. These methods span from physical, chemical, cultural practices, biological control to ecological methods [3]. Generally these methods suffer some level of drawbacks that affect their efficiency hence the need to employ a more reliable and efficient method of pest control. According to [4], integrated pest management (IPM) has enjoyed wide patronage by farmers for a long time. Farmers deploy IPM as an optimal method based on decisions about pest management approaches that are most economically viable, knowledge-oriented with the best environmentally and human friendly attributes. There is the need to develop and deploy methods that do not increase environmental and health hazards. This research adopts the simulation of the three basic signals used by humans to scare rodents and birds from the farm. These signals include motion, sound and light. A solar powered automatic pest control system designed to generate to and fro motion, sound and light signals at determined intervals will be used to simulate the presence of human in the farm to scare rodents and birds from the farm.

On the other hand, Physical control of pests involves all the techniques geared towards limiting access of pests to the crop by inducing behavioral changes or death of the pest through a mechanical, electrical/electronic means [5]. The method to be employed in this research will use electrical energy converted from solar radiation to drive mechanical, acoustic and photo devices to limit rodent and bird pest from accessing

the crops [6]. Existing physical control methods include thermal shocks, and electromagnetic radiations [7]. Physical control methods impact minimal environmental damage.

Biological control of pests involves the reduction of pest population by the use of their natural enemies and as such involves human effort [8]. This limitation of human involvement is to be minimized by the deployment of an automatic system known as a solar powered automatic pest control system. Over dependence on single control method of pest like pesticides has been associated with environmental degradation, food contamination, chemical residue and even resistance by targeted pests [9]. The use of ecological method involves the sustainable application of all known pests control methods such as physical, cultural, chemical and biological methods in a way to exploit their inherent strength in pest management.

The deployment of an electrically automated system in pest control is a good advancement. [10] reviewed trends in electronic pest repelling schemes using a band of frequency within (10 - 100 kHz) that are not audible to humans but stressful to animal pests. However, including motion and light to pest repelling mechanisms in electrical pest control systems will make the farm look like a human abode where rodent and bird pests are afraid of human attacks.

II. Material And Methods

The following electrical and mechanical components form the parts of the design.

- Dc electric motors
- Dc horns
- Bulbs
- Light dependent resistor
- Solar panel
- Battery
- Connecting wire
- Mechanical support

Method

The above components were connected using the circuit diagram in figure 1 below. Specifications of the components were according table no 1. The constructed solar powered automatic pest control systems were deployed in each of one portion of three sets of farm locations consisting of both the experiment and control. Uniform farm practices were carried out on all the farm locations. Yield data were collected after harvest.

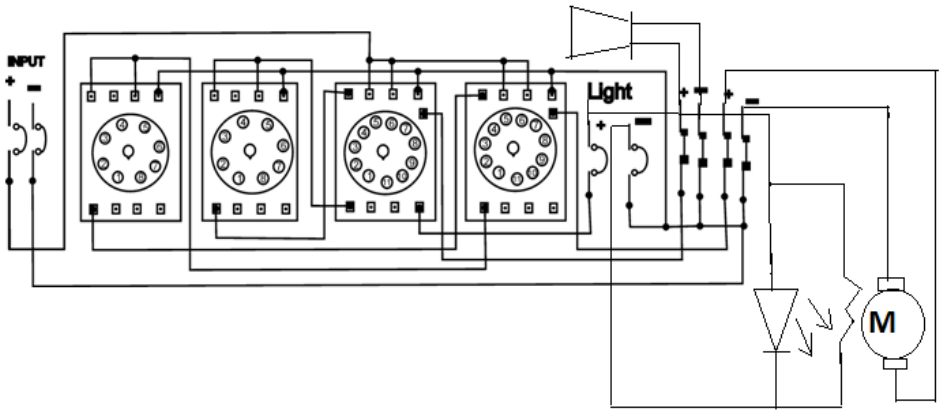

Figure 1: Circuit diagram of automatic pest control system [6]

Design specifications

Table no1: Design specifications

S/No	Component	Description	Specifications
1	Dc Motor	Wiper motor with mechanical accessories for rotary to oscillatory motion conversion	**Parameter** / **Formula/Evaluation** / **Value/unit** Rated voltage / V / 12volts Rated current / I / 2A Speed / N / 30rpm Power / $P = IV = 2x12$ / 24watts
2	Horn	Trailer truck horn	**Parameter** / **Formula/Evaluation** / **Value/unit** Rated voltage / V / 12volts Rated current / I / 2A Power / $P = IV = 2x12$ / 24watts

			Intensity in Decibel	β	100dB
			Minimal intensity	I_0	10^{-12}w/m^2
			Intensity	$\boldsymbol{\beta = 10log(I/I_0)}$ $I/I_0 = 10^{\frac{\beta}{10}}$ $I = 10^{\frac{100}{10}} x\ 10^{-12}$	10^{-2}w/m^2
3	Bulbs	Dc bulbs	**Parameter**	**Formula/Evaluation**	**Value/unit**
			Rated voltage	V	12volts
			Rated current	I	0.5A
			Power	$P = IV = 0.5x12$	6watts
4	Resistor	Light Dependent Resistor	**Parameter**	**Formula/Evaluation**	**Value/unit**
			Rated voltage	V	12volts
			Maximum resistance	R	500Ω
			Maximum Power	$P = \frac{V^2}{R} = \frac{12^2}{500}$	0.288watts
5	Solar panel	Mono crystalline	**Parameter**	**Formula/Evaluation**	**Value/unit**
			Rated voltage	V	12volts
			Rated current	I	29A
			Power	P	350watts
6	Battery	Deep cycle non-spillable	**Parameter**	**Formula/Evaluation**	**Value/unit**
			Rated voltage	V	12volts
			Rated capacity		300AH
			Charging current	I	25A
			Charging Duration	T	12Hours
7	Charge controller	PWM	**Parameter**	**Formula/Evaluation**	**Value/unit**
			Rated voltage	V	12/24volts
			Rated current	I	30A
8	Relays and Timers	Dc Relays and timers	**Parameter**	**Formula/Evaluation**	**Value/unit**
			Rated voltage	V	12volts
			Rated	I	10A
			Time Range	T	0-60mins
9	Wire	Stranded cables	**Parameter**	**Formula/Evaluation**	**Value/unit**
			Cross sectional area	A	6mm^2
			Rated Voltage	V	600volts
10	Circuit Breakers		230v/30A		

Source:[6]

Figure 2: Solar powered automatic pest control system [6]

Figure 3: Field deployment of solar powered pest control system

Figure 4: Portion without solar powered automatic pest control system (control)

III. Results

The following yield data were obtained from the field.

Table no 2: Rice yield per portion

Farm Portion	Land area(Acre)	Yield(kg)
A1	0.166	400
A2(control)	0.166	202
B1	0.166	402
B2(control)	0.166	206
C1	0.166	401
C2(control)	0.166	200
Total	~1acre	1811

Table no 3: Yield comparison between portions with automatic pest control and portions without automatic pest control

Portions With automatic pest control system		Portions Without automatic pest control system	
A1	400	A2	202
B1	402	B2	206
C1	401	C2	200
Total	1203kg	Total	608kg

Figure 5: Bar chart for yield level against farm portions

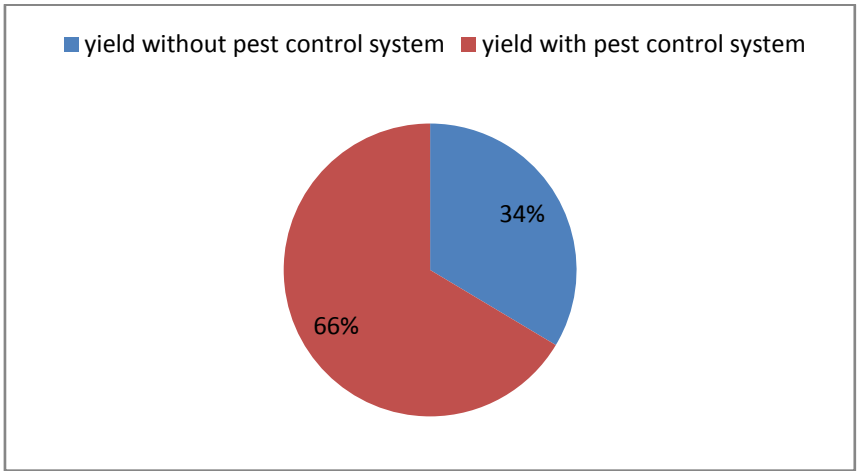

Figure 6: Pie chart showing yield result

From table 3: Average Rice yield per acre without solar powered pest control system $= \frac{608}{3x0.167} = 1213.57kg/acre$

Average Rice yield per acre with solar powered pest control system $= \frac{1203}{3x0.167} = 2401.20kg/acre$

Percentage yield loss per acre without solar powered pest control system $= \frac{2401.20-1213.57}{2401.20} x100 = 49\%$

IV. Discussion

The results obtained from the yield date reveal a significant difference in the yield between portions of the farm with automatic pest control system and that without automatic pest control system. The average yield in the portion with automatic pest control system stood at 2401.20kg/acre. On the other hand, the portions without automatic pest control system produced an average yield of 1213.57kg/acre.

Percentage yield loss in the portion without automatic pest control system was 49%.The system uses solar panels to trap solar energy from the sun and converts such energy to electricity and stores the energy in a chemical cell (battery) through the help of a charge control system. It supplies the stored electric energy to connected output devices that include dc motor, horn and LED lamps through the control of connected timer relays which determine the duration and interval of operation of each output device. Light dependent resistor only allows the LED lamps to come ON in the night when its resistance tends to maximum. These three output devices namely dc motor, horn and light simulate the three basic signals of motion, sound and light used by man to scare rodent and bird pests away from the farm. The system continues to perform this human presence simulation in the farm and as such scares bird and rodent pests away for as long as the sun continues to shine on daily basis till the life span of the battery or solar panel is exhausted. The system if operated with specified conditions has life span depending on the battery and solar panel life [6].

[11] opined that general management of rodent pests in Africa is largely dependent on the use of chemical pesticides. He also decried the adverse health and environmental effects of chemicals and called for a more sustainable approach different from poison-based rodent management with attention to non-chemical technologies and environmentally friendly measures. The deployment of a solar powered automatic pest control system is a paradigm shift from chemical pesticides to an environmentally sustainable technology.

[12]identified application of electricity as one of the ways of controlling rodent pests in rice farms. They however lamented the safety concerns posed by the method as electrocution of rodents could be a source of electrical hazards to humans. Children who may not be so cautious of the danger posed by current carrying bare conductors may be victims of electrocution. They also observed that there are no safe commercially available electrical devices for killing rodents. This practice could also induce faults in the electricity supply network. As a result of the above, safe electricity driven device for pest control in farm setting is of eminent importance. The solar powered automatic pest control system in this research can safely simulate human presence in the farm by deploying sound, motion and light to mimic human presence. This will be free from electrocution hazards as the control circuits and output devices are fully insulated.

The damaging effects of rodent and bird pests on rice production has attracted the attention of many scholars , in traditional rice farming systems, losses due to rodents have been estimated between 5–10% per annum. While in some areas, the magnitude of losses has risen rapidly in recent times, going as high as 50% and in severe cases complete crop loss and this has greatly affected farmers in their decisions to engage in rice farming in certain locations and times of the year. Most of the current rodent control activities used by farmers are reactive rather than proactive [13]. This brings to the fore the urgent need to device methods that are not only effective but proactive in the management of rodent and bird pests.

[14]expressed concerns about the limited exchange of ideas among countries on research progress in the area of rodent pest management. They encouraged information sharing in the effective control of pests. They lamented the unavailability of good quality educational courses for both scientists and technical personnel in rodent management. In order to fill this perceived gap in information sharing and personnel, this research has tried to provide all technical details and precautions needed to effectively deploy the system under study.

Operational Precautions

The following precaution should be taken for safe and effective use of the solar powered automatic pest control system.

i. Always wear hearing protective devices like ear plugs or muffs while working within 25meter range from the system to avoid hearing damage due to prolonged exposure to high intensity sound [15].
ii. Ensure the battery is housed to maintain temperature changes within acceptable limit for the battery.
iii. Ensure location of the system within 25meter radius of targeted area.
iv. Avoid the direct exposure of the control unit to adverse weather conditions like rain, excessive heat and humidity.
v. Use thread and light weight materials like polythene bags to transfer motion from the moving arms of the motor system to various parts of the farm.
vi. Protect the motor from water and humidity [6].

V. Conclusion

The results obtained from field data show that the solar powered automatic pest control system fabricated and deployed in this research can effectively improve yield level of crop production by preventing losses due to rodent and bird pests. This is evident in the results as percentage yield loss in the portion without automatic pest control system was 49%. The system has the capacity to simulate human presence in the farm by producing the three signals of sound, motion and light used by humans to scare bird and rodent pests from the farm automatically with no environmental or health hazards. Hence, the system deployed in this research can efficiently replace existing rodent and bird pest control measures.

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Authors' Contribution

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

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