Journal of Engineering Research and Applied Science
Available at www.journaleras.com
Volume 13 (2), December 2024, pp 2622-2629
ISSN 2147-3471 © 2024

The Development of Pest Scaring Mechanism for Rice Plantation in Nigeria

Peter Kayode Oke, Olatunbosun David Igbalajobi*

Mechanical Engineering, Federal University of Technology Akure, Ondo State, Nigeria

Accepted 23 November 2024

Abstract

This project address the persistent challenge of pest management in rice plantations through the development of a pest scaring mechanism with sound and lighting systems. Pests such as rodents and birds pose significant threats to rice crops, leading to substantial economic losses and environmental concerns. Traditional pest control methods often fall short in providing comprehensive and sustainable solutions. Hence, this study proposes a multifaceted approach that combines time component with sound and lighting systems to effectively deter pests during both day and night. The primary objective is to design, develop, and implement a holistic pest management solution tailored specifically for rice plantations. The project involves the design and integration of scare crows, time component, sound, and lighting systems into a cohesive unit. The outcome of the project is the creation of a versatile and environmentally friendly pest scaring mechanism capable of protecting rice crops round-the-clock while promoting agricultural sustainability. This study holds significance in providing rice farmers with an innovative tool to combat pests, reduce crop damage, and enhance agricultural productivity in a sustainable manner. The result **evaluated the importance of the modernized scarecrow over** the traditional scarecrow, the modernized scarecrow's varied sound and light reduced pest activities considerably, it is more effective, leading to much lower percentages of damaged crop. The modernized scarecrow resulted in higher crop yields due to reduced pest interference. It has higher upfront costs due to the technology but lowers long-term costs by reducing reliance on pesticides and repairs. A significant reduction in pesticide usage was recorded with the modernized scarecrow, the use of minimal power, sustained through solar energy makes it effective for longer period of time. Due to better performance and ease of use, the modernized scarecrow gives higher satisfaction.

Keywords: *Pest-scaring, scarecrow, time component, traditional, modernized*

1. Introduction

Rice holds significant agricultural and economic importance both in Nigeria and globally, playing a vital role in food security and livelihoods. In Nigeria, rice is a staple food and a major component of the daily diet. The country has witnessed substantial growth in rice production over the years, and efforts have been made to reduce reliance on imports and boost local cultivation. Government initiatives, such as the Rice Anchor Borrowers' Program, aim to support local farmers, enhance productivity, and contribute to the overall development of the agricultural sector [1]. The challenges faced by rice farming in Nigeria include issues like inadequate infrastructure, limited access to credit, and vulnerability to climate change impacts. Despite these challenges, the resilience of Nigerian rice farmers, coupled with government interventions, has led to increased domestic production and a reduced need for rice imports [2]. Globally, rice is a staple food for more than half of the world's population, particularly in Asia, where the majority of global rice production occurs. Advances in agricultural technologies and practices have contributed to increased global rice yields. Sustainable rice farming practices, precision agriculture, and innovations in crop management have been crucial in meeting the rising demand for rice while addressing environmental concerns [3]. However, global rice production also faces challenges such as water scarcity, climate change impacts, and the need for sustainable intensification. Initiatives make their focused on improving rice varieties, optimizing water use efficiency, and promoting resilient farming systems are ongoing to ensure the continued sustainability of rice production worldwide [4, 5].

Sustainable rice farming practices gained prominence in response to environmental concerns and the need for resilient agricultural systems. The System of Rice Intensification (SRI) is one such innovative approach that focuses on optimizing plant spacing, transplanting

*Corresponding author: olatunbosunigbalajobi@gmail.com

young seedlings, and utilizing organic inputs [6] SRI has been recognized for its potential to increase yields while reducing water and chemical inputs. Advancements in precision agriculture technologies have also played a role in modern rice farming. Remote sensing, satellite imagery, and drone technology offer farmers valuable tools for monitoring crop health, detecting diseases, and optimizing resource use [7]. These technologies contribute to data-driven decision-making in rice cultivation.

Early agricultural societies relied on manual methods for pest control, employing labor-intensive techniques such as handpicking insects and utilizing scare tactics to deter birds and rodents from crops [8]. These traditional practices laid the groundwork for the recognition of the need to protect crops from potential threats. The mid-20th century witnessed a transformative shift with the widespread adoption of chemical pesticides in rice farming. Synthetic pesticides, such as DDT and organophosphates, became instrumental in addressing pest and rodent infestations, contributing to significant increases in global rice production [9]. However, the environmental and health repercussions of indiscriminate pesticide use prompted a reevaluation of pest control strategies.

Several species of rat occur in rice fields and can cause considerable damage throughout a community. Rats often migrate locally from usually permanent habitats to rice areas as the food supply changes throughout a yearly cycle. The rice plant is most preferred after the panicle has emerged. Although natural enemies of rats do exist (especially snakes), pesticides and other measures taken by farmers often suppress their populations and thus make possible the survival of large rat populations. Rat management strategies have comprised determining the main species of rat present in order to ensure that baits are appropriate and then developing community-level mapping methods to plan and carry out continuous trapping along feeding routes, fumigation or digging of rat holes, modification of appropriate habitat and establishing early season bait stations using second-generation anticoagulant baits. (Although the highly toxic zinc phosphide and repackaged and unlabeled aldicarb (Temik), are still commonly seen, they are strongly discouraged in most countries following instances of the deaths of children and small livestock.) Community programs can include educational activities on rat biology and behavior to improve strategy development and participation in programs [10]. Year-round community-level management with emphasis on early-season vegetative-stage action (before booting) is considered to be the key to rat management [11, 12]. An innovative owl habitat program in Malaysia has been successful in increasing owl levels as a means of reducing rat populations in rice and plantation crops. A trap-and-barrier system with plastic has also achieved good results in rice fields [13].

The latter part of the 20th century saw the emergence of integrated pest management (IPM) as a more sustainable approach in rice farming [14]. IPM emphasizes a holistic strategy that incorporates biological control, cultural practices, and judicious pesticide use. This paradigm shift aimed to reduce the ecological impact of pest control while maintaining effective crop protection. Bird control in rice farming initially relied on traditional scare tactics, such as scarecrows, to deter avian pests. As technology advanced, auditory and visual deterrents, including reflective tape and bird distress calls, were introduced to create an environment hostile to birds without resorting to harmful chemicals [15].

Birds can be very damaging to rice, especially when they occur in large flocks. The red-billed quelea (*Quelea quelea*) in sub-Saharan Africa and various species in Asia are known as persistent problems in rice ecosystems. In most Asian countries and in Chad, netting is used to trap large numbers of birds for sale as food. Mass nest destruction is also possible for some species. In Asia, these methods have effectively reduced pest bird populations to very low numbers. In Africa, the capture method may bring benefits to local people in terms of income or additional dietary protein, but the impact on pest bird populations has been minor. During the ripening period in northeast Asia, some fields are protected by being covered with bird nets, which are widely available. The nets are also often used to protect seed production fields. In both Asia and Africa various forms of bird-scaring are used to try to keep birds out of the fields. Reflective ribbons or used video or cassette tape are widely used to scare birds in Asia. Scaring in the form of people shouting or hurling dried mud at the birds is common in Africa. Sound cannons and owl or hawk look-alikes are also used in many developed countries. Scaring with devices that are not backed up by people is seldom effective for long, as the birds become accustomed to the device. The use of poisoned baits and the destruction of nesting habitat are discouraged because they are seldom effective and because of the potential negative effects on non-target species in adjacent aquatic environments.

In the 21st century, the evolution of pest, bird, and rodent control in rice farming has been marked by technological innovations aligned with sustainable agriculture. Precision agriculture technologies, including satellite imagery and drone-based monitoring, provide farmers with real-time data for detecting and responding to pest infestations more accurately [16]. Additionally, sensor-based technologies like motion-activated systems and ultrasonic deterrents offer non-intrusive, environmentally friendly means of pest control [17]. Innovative physical barriers and traps are a prominent feature of ecologically based rodent and snail management in rice fields, and an essential feature in controlling storage pests including rodents and insects.

Recent research has attempted to improve rice production by developing technologies to better detect pests including using remote sensing applications [18, 19]. It will be necessary to continually update damage thresholds and estimated yield losses as climates and crop management practices change and because different rice varieties often have specific responses to pest attack. It is apparent therefore that, despite calls for changes in crop management, there has been little investment in the science needed to predict responses by pests and disease. Light traps have featured in the management of certain insects, particularly planthoppers, networks of light traps have operated throughout north-eastern China and Japan to detect waves of migrating planthoppers. During the northern hemisphere spring, brown and white-backed planthoppers migrate several thousand kilometers from South East Asia to the north east of Asia. Light traps have been used to determine the extent, direction and climatic conditions that generate these migrations and to act as an early warning system for rice farmers before planthoppers alight in their fields. For example, rustic light traps have been operated in Vietnam as part of a successful ‘escape strategy’ whereby farmers determine rice planting dates based on the occurrence of peak planthopper densities in light traps (planting only after the peak has passed) [20].

As agriculture faces new challenges, the evolution of pest control in rice farming continues to prioritize sustainable and environmentally conscious practices. The integration of cutting-edge technologies alongside traditional ecological principles signifies a holistic approach to pest, bird, and rodent control that ensures the long-term health of both crops and ecosystems. This evolutionary trajectory is essential for fostering resilient and sustainable agricultural systems.

2. Materials and Methods

2.1. Methodology

During the day from 7am to 6pm, birds play a significant role in rice plantations, exhibiting various behaviors that can impact rice crops. Birds, such as sparrows, herons, and egrets, are active foragers during daylight hours, moving across rice fields in search of food sources. They typically fly between different areas of the field; perch on rice plants or nearby structures, and actively scan for insects, seeds, and grains, including rice grains. Birds feeding on rice grains in the field can lead to significant yield losses, particularly during the ripening stage when grains become accessible and desirable food sources. These avian pests peck at rice panicles, causing damage to individual grains and reducing overall grain quality. Additionally, bird droppings in the field can contaminate rice grains and pose hygiene concerns, affecting the marketability of the harvested crop.

Rodents such as rats and mice are nocturnal pests that primarily operate effectively at night within the hour of 7pm to 6am in rice plantations. These rodents are opportunistic feeders, consuming various food sources, including rice grains, seeds, and plant tissues, under the cover of darkness. They move stealthily through the rice field, using vegetation and soil cover for concealment, and target ripe or maturing rice grains for consumption. Rodent infestations in rice plantations can lead to extensive damage, with rodents gnawing on rice stems, roots, and grains, causing lodging, yield losses, and contamination of stored grains.

To address the challenges posed by avian and rodent pests in rice farming, innovative solutions such as design analysis of pest scaring mechanism have been developed. These mechanism with timer component utilize sound frequency during the day and night at different intervals and light emitting to deter both birds and rodents from approaching rice fields. The timer component feature ensures that the device is triggered to release different sounds and light flashes at intervals and within a specific range (half plot of land), conserving energy and minimizing unnecessary sound, providing a targeted and non-lethal approach to pest control in rice farming.

2.2.Design Analysis of the Mechanical Components

2.2.1. Design Analysis of the Frame

The frame is design to accommodate the battery, the electrical components (microcontrollers, passive infrared sensors, integrate circuits), metal round bar, solar panel and the pipes which hold the light bulbs and the speakers. The material used is mild steel.

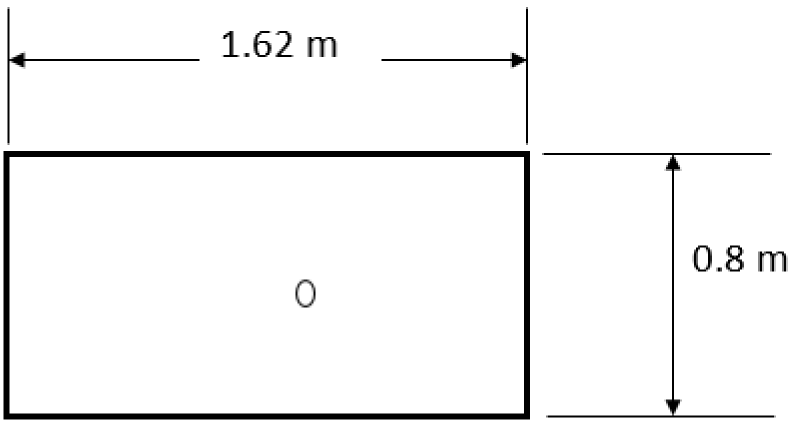

Figure 1: The Frame

2.2.2. Design Analysis of the Metal Long Bar

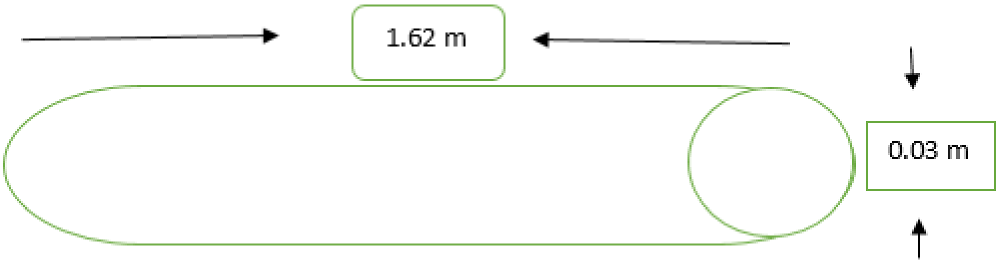

Figure 2: The Metal Long Bar

2.2.3. Design Analysis of the Long Hand Metal Bar

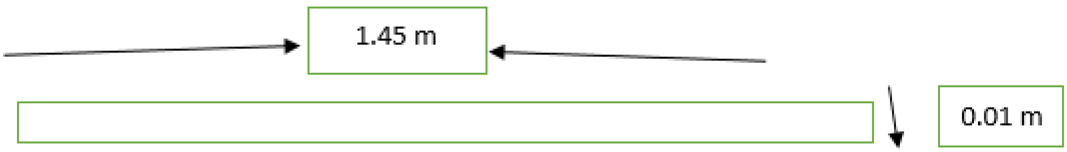

Figure 4: Long hand bar

2.2.4. Design Analysis of the Battery and Solar Panel

Components of solar pest scaring mechanism

The component part that will be consuming power in the developed pest scaring machine include:
Florescent light = 50W
Siren speakers (2 pieces) = 20W * 2 = 40W
Microcontroller = 1.35W
First, let's calculate the total power consumption of all components
Total Power Consumption = (Number of LED light * Power per LED light) + (Number of siren speakers * Power per siren speaker) + Power of microcontroller
= (1*50) + (2*20) + 1.35
= 50 + 40 + 1.35
Total Power Consumption = 91.35W
Capacity of the Battery
The required battery capacity based on the total power consumption and desired runtime:
Battery Capacity = <u>Total Power Consumption * Runtime</u>

Battery Voltage

Since the voltage is specified, battery voltage is 12 volts for this calculation.

$$\text{Battery Capacity} = \frac{91.35 * 12}{12}$$

Battery Capacity = 91.35Ah

Battery Capacity = 100Ah

So, a battery with a capacity of approximately 100 ampere-hours (Ah) is needed to power the system for 24 hours with the specified loads. This calculation provides an estimate, and actual battery selection which varies based on factors such as battery chemistry, efficiency, and depth of discharge considerations.

Solar Panel Capacity

To calculate the solar panel size needed to support the specific loads, we will consider the total daily energy consumption of the system and the average solar insolation in the location. Solar insolation is the amount of solar radiation received per unit area at a given location and is typically measured in peak sun hours per day.

Given:

Total daily energy consumption of the system: 91.35 watt-hours (Wh)

Desired runtime: 24 hours

An average solar insolation = 6 peaks sun hours per day

First, let's calculate the total energy consumption per day:

Total Energy Consumption per day = Total Power Consumption * Runtime

= 91.35 watt * 24 hours

Total Energy Consumption per day = 2192.4 Wh

Next, let's calculate the size of the solar panel needed to generate this amount of energy:

$$\text{Solar Panel Size} = \frac{\text{Total Energy Consumption per Day}}{\text{Average Solar Insolation per Day}}$$

$$= \frac{2192.4}{6}$$

Solar Panel Size = 365W

Solar Panel Size = 400W

So, we need a solar panel with a size of approximately 400 watts to generate enough energy to power the specified loads for 24 hours per day.

This calculation provides an estimate, and actual solar panel selection may vary based on factors such as geographical location, shading, panel efficiency and seasonal variations in solar insolation.

2.3. Stimulation of The System Design

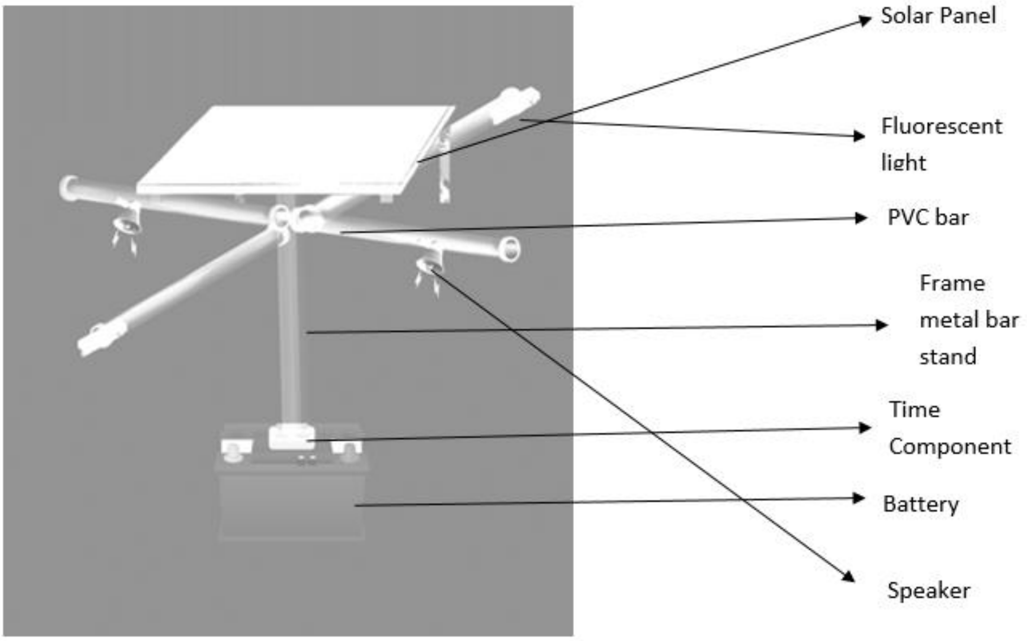

Figure 4: Design Stimulation

Table 1: Result of Tradition scarecrow to Modernized Scarecrow

Parameter	Traditional Scarecrow	Modernized Scarecrow
Pest Count (per week)	10-20 rodents/birds sighted	2-5 rodents/birds sighted
Crop Damage (% of plants)	10-15% damaged plants	2-4% damaged plants
Yield per Hectare (kg/0.25 ha)	600-800 kg	850-1000 kg
Grain Quality (% damaged grains)	10-12% of grains damaged	2-4% of grains damaged
Cost of Pest Control (₦)	₦5,000-₦10,000per growing season	₦15,000-₦25,000 (initial investment, but lower over time)
Pesticide Reduction (%)	No significant reduction	20-40% reduction in pesticide use
Energy Efficiency (watt-hours/day)	N/A	5-10 watt-hours/day from solar panel
Pest Familiarization (weeks)	Effectiveness reduces after 4-6 weeks	Remains effective over 12+ weeks
Farmer Satisfaction (1-5 rating)	2-3	4-5

3. Results and Discussion

The evaluation was carried out on a half plot of land (approximately 0.25 hectares).

From the result as shown in table 1 it was evaluated that with a traditional scarecrow, pests are likely to become familiar over time, hence the higher pest count. The modernized scarecrow's varied sound and light reduced pest activities considerably. Traditional scarecrows can reduce damage, but the modernized is more effective, leading to much lower percentages of damaged crop. The modernized scarecrow resulted in higher crop yields due to reduced pest interference. A lower percentage of damaged grains suggests better quality in the modernized scarecrow area. The modernized scarecrow has higher upfront costs due to the technology but lowers long-term costs by reducing reliance on pesticides and repairs. A significant reduction in pesticide usage with the modernized scarecrow was recorded. The modernized scarecrow uses minimal power, sustained through solar energy. Pests quickly become accustomed to traditional scarecrows, whereas the modernized scarecrow remains effective for longer period of time. Due to better performance and ease of use, the modernized scarecrow gives higher satisfaction.

4. Conclusion

In conclusion, the development of pest scaring mechanism with integrated sound and lighting systems holds tremendous potential for revolutionizing pest management practices in rice plantations. By leveraging innovative technologies and a holistic approach, this project aims to provide rice farmers with an effective, environmentally friendly, and sustainable solution to mitigate crop damage caused by pests during both day and night. The integration of motion detection, sound, and lighting systems into a cohesive unit offers a comprehensive defense against pests while minimizing reliance on harmful chemicals and minimizing disturbances to non-target organisms.

As this project progresses, it is essential to heed the recommendations outlined, including continuous optimization, monitoring, and adaptation to local conditions, to ensure the long-term success and widespread adoption of the pest scaring mechanism. Collaboration with agricultural experts, community engagement, and further research and development efforts will be crucial in refining the system's efficacy, reliability, and applicability to diverse rice farming contexts.

Ultimately, the implementation of this innovative pest management solution has the potential to transform rice cultivation practices, safeguarding crop yields, livelihoods, and environmental health for generations to come. By embracing technological advancements and sustainable approaches, we can pave the way for a more resilient and prosperous agricultural future.

References

[1] Olayide, O. E., & Heidhues, F. (2019). Food security in Nigeria: An overview. In Sustainable Food Security in West Africa (pp. 41-53). Springer

[2] Ayinde, O. E., Muchie, M, & Adewumi, M. O. (2020). Impact of government credit interventions on rice farmers' productivity and efficiency in Nigeria. Land Use Policy, 90, 104318.

[3] Pandey, S., Velasco, M.L., Moya, P.F, & Estrada, B. (2019). Sustainable rice production: A review. Agronomy for Sustainable Development, 39(4), 30.

[4] Khush, G. S. (2013). Strategies for increasing the yield potential of cereals: Case of rice as an example. Plant Breeding, 132(5), 433-436.

[5] Bouman, B. A., Humphreys, E., Tuong, T. P, & Barker, R. (2007). Rice and water. Advances in Agronomy, 92, 187-237.

[6] Uphoff, N. (2003). Higher yields with fewer external inputs? The system of rice intensification and potential contributions to agricultural sustainability. *International Journal of Agricultural Sustainability,* 1(1), 38-50.

[7] Jiang, H., Sun, X., Lu, C., Zhang, F., Tang, S., Liu, M, & Chen, S. (2019). An evaluation of rice growth parameters and mapping of rice yield prediction models using UAV-based multispectral imagery. Remote Sensing, 11(3), 286.

[8] Khush, G. S. (2013). Strategies for increasing the yield potential of cereals: Case of rice as an example. Plant Breeding, 132(5), 433-436.

[9] Oerke, E. C., Dehne, H. W., Schönbeck, F, & Weber, A. (1994). Crop production and crop protection: Estimated losses in major food and cash crops. Elsevier.

[10] FAO. **(**1988). Integrated management of rice rats in Indonesia, by A.P. Buckle. FAO Plant Protection Bulletin No. 36. pp. 111-118

[11] Buckle, A.P. and Smith, R.H. (1994). Rodent pests and their control. Wallingford, UK, *CAB International.*

[12] Leung, L., Singleton, K. P. and Sudarmaji, G.R. (1999). Ecologically-based populations management of the rice-field rat in Indonesia. In G.R. Singleton, L. Hinds, L. Herwig & Z. Zhang, eds. *Ecologically-based rodent management*. pp. 305-38. Canberra, *Australian Center for International Agricultural Research.*

[13] Murakami, O., Priyono, J. & Triastiani, H. 1991. Population management of the rice rat in Indonesia. In G.R. Quick, ed. *Rodents and rice*. Los Baños, Laguna, the Philippines, *International Rice Research Institute*. pp. 49-60.

[14] Nwilene, F.E., Nacro, S., Tamo, M., Menozzi, P, and Heinrichs, E.A. (2013). Managing Insect Pests of Rice in Africa. In: Realizing Africa's Rice Promise, Wopereis, M.C.S., D.E. Johnson, N. Ahmadi, E. Tollens and A. Jalloh (Eds.). Chapter 18, *CAB International*, UK., ISBN-13: 9781845938123, pp: 229-240.

[15] Moorcroft, D., Whittingham, M. J., Bradbury, R. B, & Wilson, J. D. (2018). The selection of stubble fields by wintering granivorous birds reflects vegetation cover and food abundance. Bird Study, 65(2), 151-159.

[16] Sankaran, S., Khot, L.R., Espinoza, C.Z, Jarolmasjed, S. (2015). Low-altitude, high-resolution aerial imaging systems for row and field crop phenotyping. A review. *European Journal of Agronomy*. 70:112-123.

[17] Bruggers, R.L, and Jaeger, M.M. (1981). Bird pests and crop protection strategies for cereal of the semi-arid African tropics. International Symposium on Sorghum.

[18] Lamb, D. W. and Brown, R. B. (2001). PA – precision agriculture: Remote-sensing and mapping of weeds in crops. *Journal of Agricultural Engineering Research*, 78, 117–25.

[19] Jhonattan, M., Ponce, P., Molina, A. and P. Wright, P. (2019)."Sensing, smart and sustainable technologies for Agri-Food 4.0," *Computers in Industry*, vol. 108, pp. 21-36, 2019.Available at: https://doi.org/10.1016/j.compind.2019.02.002

[20] Bentley, J. W. (2009). Impact of IPM extension for smallholder farmers in the tropics. In Peshin, R. and Dhawan, A. K. (eds), Integrated Pest Management: Dissemination And Impact, *Springer Science,* pp. 333–46.