

Performance Analysis of a Proposed Ultrasonic Pre-Harvest Bird Deterrent System (Electronic Scarecrow)

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ABSTRACT: Food loss estimates have always been quantified however attempts to measure losses suffer from predators is extremely complex. Clear evidence exists of substantial losses caused by weaver birds to wheat, maize and rice fields. To get round this problem the African farmers use scarecrows, use traps or deploy people to chase the birds in addition to numerous other methods by donors, governments and technical assistance agencies over the years to reduce pre-harvest losses in developing countries. Despite these efforts, losses are generally considered to remain high. One problem is that while engineers have been successful in developing innovations used in post-harvest processing as drying and storage these innovations don't look at solutions before harvest innovations that could be cheap and feasible to be adopted by small farmers.

This research proposes a pre-harvest predator deterrent system by using a series motion sensors with audio speakers that scares the birds once the zone of influence detects intruder motion, for the project to be feasible sensor range of 100 meters or more is considered with the understanding of the feeding pattern of weaver birds in a wheat field.

KEYWORDS: Comsol Multiphysics Analysis, Pre-Harvest Losses, Weaver Birds, Motion Sensors, Birds Feeding Pattern. Scare Crow

I. INTRODUCTION

The grain loss estimates attempts to measure losses suffer from predators is an extremely complex. Clear evidence exists of substantial losses caused by weaver birds to wheat, maize, sorghum and rice fields. African farmers use scarecrows, bird and traps or even deploy people to chase the birds during the day.

There have been numerous attempts by donors, governments and technical assistance agencies over the years to reduce pre-harvest losses in developing countries. Despite these efforts, losses are generally considered to remain high, probably

Because engineers have been successful in developing innovations in post-harvest processing as drying and storage although these innovations don't look at solutions before harvest.

Our objective in this research is to displace birds from the farm through annoyance. Deterrent methods like to mimic voices of prey. The effects of using acoustic mimics alone are short term as depicted in Bamford and O'Brien 1990. When such sounds are reinforced by shooting or another real threat, the behavioural avoidance lasts much longer Dolbeer et al. 2003. There are many mimic-model systems in nature that could be employed depending on the species of bird to deter.

The table 1 below summarizes a few examples of the scale of destruction cause by these birds to rice, wheat, millet and Sorghum farms in different African countries that justifies research in pre-harvest predator deterrent methods

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Table 1 Documented Grain Losses in Different Region

Country	Crops	Major Species	Losses
Botswana	Sorghum Rice, Wheat, Millet, Corn, Sorghum	Laughing Dove, Cape, Turtle Dove	Field and storage losses
Mali	Rice, Wheat, Millet, Corn, Sorghum	Red-billed Qualia, Golden Sparrow, Weavers, Starlings	Irrigated rice schemes have Weavers, Parrots, annual damage
Ethiopia	Wheat, Rice, , Millet, Sorghum	Red-billed Qualia, Golden Sparrow, Weavers, Starlings, Doves	In 1952, \$0.7 million loss; 100,000 bags
Kenya	Wheat, Rice, , Millet, Sorghum	Red-billed Qualia, Golden Sparrow, Weavers, Starlings	0.2 million tons lost annually Wheat loss most severe;\$4.0 million loss
Nigeria	Rice, Wheat, Millet, Sorghum ,Corn, Palms	Red-billed Qualia, Golden Sparrow, Weavers, Starlings	\$2.8 million/year loss in one province

II. LAYOUT AND EXPERIMENTAL SETUP

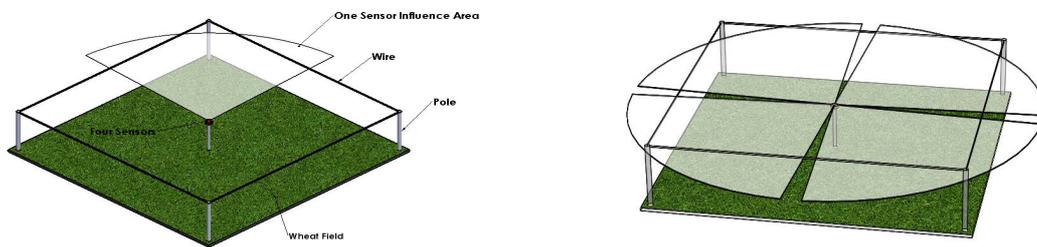


Fig 1. Sensor Position

Figure 1 show the arrangement and location of the sensor mounted on top of a pole at the centre of the wheat or rice field. Depending on the size and shape of the field multiple sensors can be mounted in such a manner as to cover the whole farm either using 45° or 180° Sensors, the sensor zone of influence should be positioned such that the boundary wire surrounding the farm is above it. The zone of influence is represented by the transparent ultrasonic sound pressure wave from the sensor.

This arrangement is strategically chosen after watching the behaviour of the weaver bird as they approach the field. Interestingly they prefer stopping at a higher point before settling down to feed, having the wire at a higher point ensures that when they tend drop to feed on the grain they cut through the radio frequency emitted by the transmitter triggering the speaker prey mimic sounds or cracking sound that scares them away.

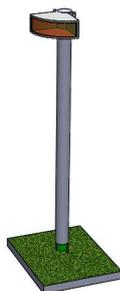


Fig 2. Sensor Installation at the Centre of Field

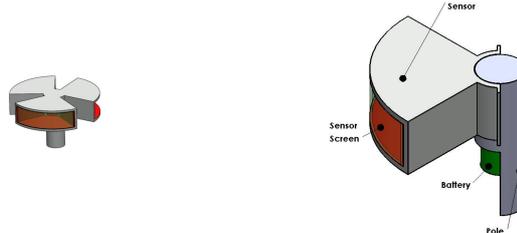


Fig 3. Sensor Power and Mounting Points

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The sensors is mounted onto a pole standing 1.2 meters high and operated by 12 volts DC batteries, the birds only feed on the grains towards the last two months of grain maturity before harvesting and therefore the system operates only at this stage of grain growth. Perimeter wire stands 1.5 meters high and of a diameter that is visible and comfortable for the birds to settle on.

Alternative ultrasonic sound only audible and irritating to birds is played on triggering the sensor. As it might be expected, species differ in their sensitivities to sound and range of sensitivities to frequencies of sound differ depending on species. Birds have the greatest sensitivity to sounds within a relatively narrow range. For most avian species it is around 1-4 kHz, but some species are sensitive to lower or higher frequencies Konishi 1970, Heinz et al. 1977. Pigeons are most sensitive to sound between 1-2 kHz, with an upper limit of about 10 kHz (Goerdel-Leich and Schwarzkopf 1984).

There are several devices on the market that produce varying audio frequencies Table 2. Below

Table 2 Commercial Audio devices that can be used to deter birds

Device Company	Frequency Range	Sound Level	Comments
Bird XPeller Pro Super Bird XPeller Pro Bird-X	3-5 kHz	105-110 dB @ 1m	Distress calls
Broad Band Pro Bird-X	3-5 kHz, 15-25 kHz	102-110 dB @ 1m	Audible and Ultrasonic
Critter Blaster Bird-X	2-10 kHz	105-110 dB @ 1m	
Quadra blaster QB-4 Goose buster Bird-X	20 kHz, 20-30 kHz, 500-1500 Hz	110 dB @ 1m	Warble, alert and alarm calls
Yard Guard Bird-X	15-25 kHz, 17-65 kHz	114 dB @ 1m	Random frequencies
Silent Bird Scarer Pestoff	22 kHz	112 dB @ 1m	

III. SYSTEM OPERATION

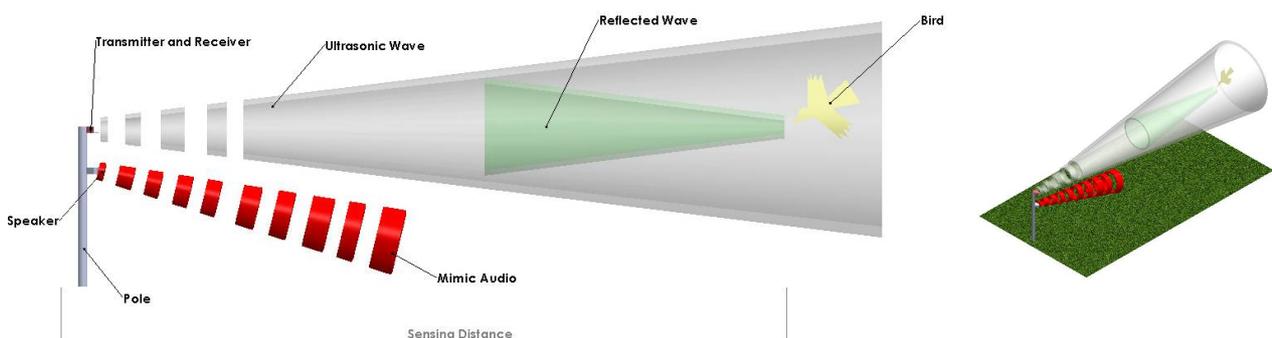


Fig 4. Sound wave, reflected wave and mimicked audio wave arrangements

The ultrasonic motion detector uses Doppler Effect in detecting the motion of an object. It has an ultrasonic transmitter that sends out square waves and a receiver module that detects the returning pulse signal the intrusion distance is calculated as

$$\text{Distance} = \text{High level time} \times \text{Velocity of Sound (340m/s)} / 2$$

Considering the relationship between the frequency of sound produced by a transmitter moving with velocity V and the frequency received by a receiver moving with velocity V_r. assuming that both the source and the receiver are moving in a straight line in the same direction. At time t = 0, the source (S), and receiver (R) are separated by a distance (d).

III. BOUNDARY CONDITIONS

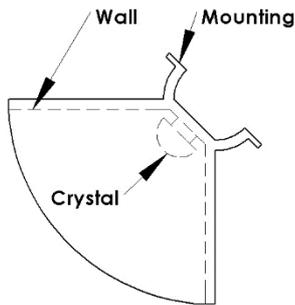


Fig 5. Sensor configuration

Item	Value
Material	PZT-5H Zirconate Titanate
Electric Potential	12 Volts
Sensor Angle	90°
Frequency	40 kHz
Velocity of Sound	340 m/s

Table 3. Known parameters

Simulation of the ultrasonic transducer in Comsol Multiphysics is achieved by choosing Acoustic- Piezoelectric together frequency domain, the ultrasonic sound pressure is generated by the crystal as a result of inducing electric potential on one face on sensor while grounding the opposite face the vibration send sound wave outwards in the direction as controlled by the sensor walls.

If the sent sound wave is obstructed reflected wave travel back to the receiver converting sound wave into electric signal read as intrusion or the presence of unwanted object. This triggers the alarm sound

freq(1)=2.0000E5 Surface: Total acoustic pressure field (Pa)

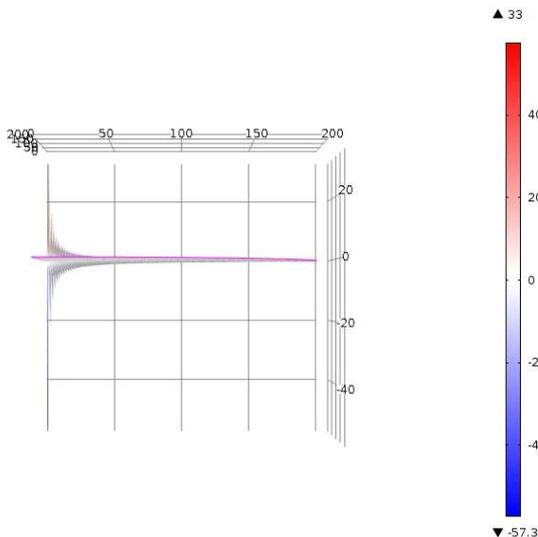


Fig 6. Side view of the total acoustic pressure field

freq(1)=2.0000E5 Surface: Total acoustic pressure field (Pa)

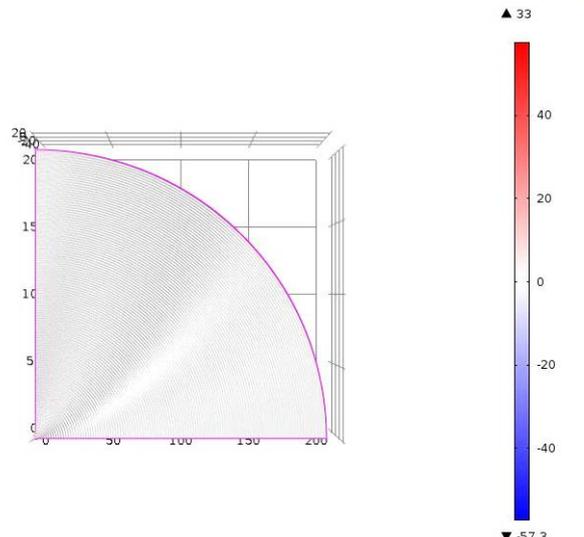


Fig 7. Plan view of the total acoustic pressure field

Figure 6 AndFigure 7Shows the side and plan view of simulation result givingthe total acoustic pressure field, the wave's travels from one sensor as it weakens to a distance of 200 meters, with the arrangement of the sensors as in figure 1. We can conclude that an area close to 400 square meters can be monitored. Since the waves expands outwards in a circular pattern small sections of the field at the corners is left out as seen in figure 7

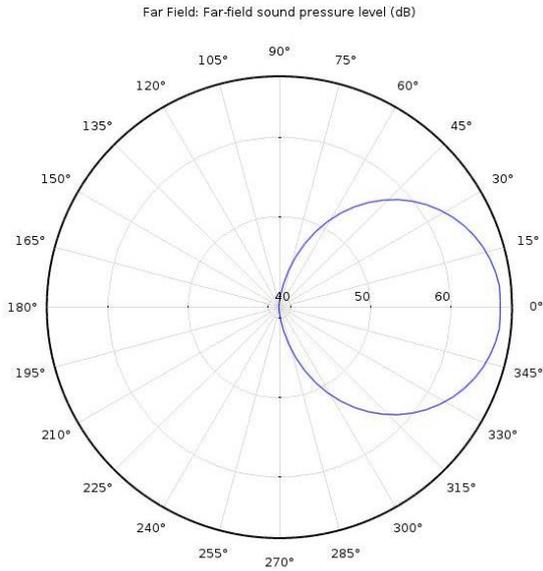


Fig 8. Operation layout

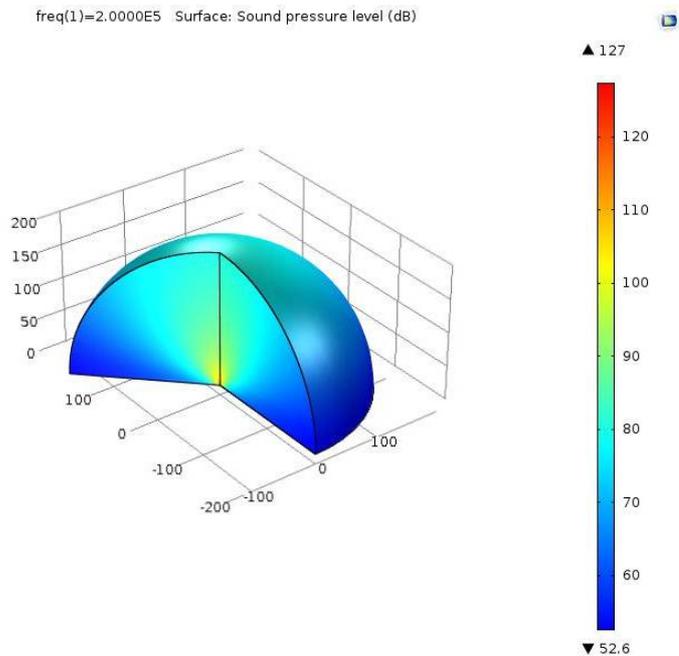


Fig 9. Operation layout

Figure 8 Indicates the far field pressure level in (dB) indicating excitation frequencies requires to cover the 200 meter distance, figure 9 Adjacent shows that sound of 52.6 dB will be reaching the far field still strong to be reflected back to the receiver

IV. SIMULATION RESULTS

In this study the sensor excitation frequency of 40 kHz ultrasonic frequency not audible to human beings is induced by applying 12 volts electric potential to the upper surface of the transducer while the bottom is grounded the results has successfully indicated that it is possible to monitor about 400 sq. meters with a 4 sensor arrangement pattern while still having the sound pressure strong enough to be reflected back to the receive

V. CONCLUSION

Acoustic devices are effective method of dispersing birds in pre-harvest stage of plant growth. Different prey mimics can be played to scare off birds of different species in addition to scary cracking noises. Future research should be focused on determining the relative contributions of visual, acoustic, and lethal or painful experiences to deter birds in an integrated management program

VI. ACKNOWLEDGEMENT

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