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Effects of Different Colors of Light Source on Probe Trap Catch of Cow-Pea Weevil Infesting Stored Cowpea

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Abstract

The unlighted probe traps are effective in detecting cowpea weevil in stored cowpea but due to time constraint, its use has been neglected. In order to improve on the performance of this important Integrated Pest Management tool for early detection and management of *C. maculatus*, investigations were carried out to search for means that can improve the performance of the trap and light was reviewed to be a workable means to giving reliably early indications of insects that move readily in grains for necessary control measures to be initiated. Seven different probe traps comprising of six different color lighted probe traps and a control (unlighted) traps were evaluated. Each treatment (trap) was repeated three times and in three different insect population densities (3 insects per kg, 7 insects per kg and 15 insects per kg) artificially infested into 10 kg cowpea grains contained in plastic storage buckets. Traps were inspected every 24 hours for five days, data collected were subjected to ANOVA and means were separated using Students Newman Keuls test at 5% confidence level. Ambient light source was the best mean in probe trap catch of *C. maculatus* infesting stored cowpea. Therefore, ambient light source should be incorporated into probe traps for early detection and management of cowpea weevils.

1. Introduction

Cowpea, *Vigna unguiculata* (L) Walp is one of several species of the widely cultivated genus *Vigna*, and one of the most important food legume crops in the semi-arid tropics covering Africa, Asia, Southern Europe, Central and South America [14]. Nigeria produces more than two million tons [1] which represents 58% of the total world cowpea production annually [16]. Like many other grain crops grown in the semi-arid tropics, cowpea post-production system in developing countries is an important constraint [5]. Cowpea bruchid, *Callosobruchus maculatus* (F) (Coleoptera: Chrysomelidae) is a cosmopolitan pest that causes considerable economic damage to dried cowpea and other related stored legumes, and is the main constraint to increased cowpea production and storage [5]. The main method of transmission is via infested seed, either from the paddock into storage, or in contaminated seed within and between storage facilities [20]. The pest multiplies rapidly in storage, giving rise to a new generation every month in grain at temperatures of 35°C and Relative Humidity of 70% to 90% [7].

Accurate information on early pest infestation can only be obtained through regular inspection and sampling procedures [19]. This is imperative in formulating sound management decisions involving the adoption of early remedial action against the cowpea bruchid (*C. maculatus*) or to determine the effectiveness of previous insect control treatments or the disposal of cowpea grains with due cognizance to the condition of both the commodity and the storage facility [9]. Attractants/lures and probe traps are useful tools for sampling grain insect populations [18]. Light is an important component in the environment of insects which may act as a token stimulus guiding the insect to situations where it may find the optimal requirements for existence [2, 3, 4, and 6] and therefore, light lures or repellants can be useful in the practice of Integrated Pest Management (IPM), in order to limit the use of toxic insecticides during storage of grains [11].

Insect probe trap, originally conceived by Loschiavo is a type of pitfall trap which is buried in grains and it catches insects which drop through small pitfall apertures into the trap, and helps in early detection of insects in stored grains leading to timely control [10]. This trap is a hollow metal plate tube with series of perforations (holes) all along the sides. The top is a cap, and the bottom is a cone-like plastic that screws in place. Although considered of major importance, the insect probe trap is more often than not underestimated or in fact neglected, because it is time consuming [17].

Unless improved probe traps are introduced in commercial grain storage practice, the potential benefits of any new technique will be lost. In order to modify this important IPM tool in the form more acceptable among grain handlers, investigations were conducted to search for alternative means that could facilitate the performance of the device. Some factors that can influence the efficacy of an insect trap include; Light intensity and color [11, 13 and 20]. Therefore, an attractant trap such as a lighted probe trap may be helpful in giving reliably early indications of the presence of bruchids that move readily in grains for necessary control measures to be initiated.

1.1. Justification

Farmers are faced with a lot of problem in monitoring insect pests of stored cowpea. The standard probe trap is used to monitor *C. maculatus* infestations in stored cowpea but it is not efficient in trapping the insect due to variation in atmospheric conditions, leading to inappropriate management decisions regarding the action threshold. Great numbers of insect species are attracted to light of various intensities or colors. Therefore, a lighted probe trap can be helpful in giving reliably early indications of the presence of bruchids that move readily in bulk grain. The use of light trap is easily repeatable, cost effective in terms of labour and skills required, and many types of insect specimens collected with light traps or probe traps are undamaged and so are good for research purpose. Use of light traps reduces the risks of pesticide residues in food, unlike insecticides. Insecticides are also effective but when used excessively, pests develop resistance. Light trapping, once standardized and targeted to the species of interest could be very effective in monitoring that species.

1.2. Objective of the Study

To investigate the effect of light colors, on the performance of a perforated insect probe trap for early detection of *C. maculatus* infesting stored cowpea.

2. Materials and Method

2.1. Research Location

Evaluation of the effect of light colors, on the performance of the insect probe trap for detecting *C. maculatus* infesting stored cowpea was conducted in the Entomology Laboratory of Nigerian Stored Products Research Institute (NSPRI), Kano Sub-Station (coordinate 11°30’N, 8°30’E) Nigeria, between March 2016, to October 2016, at average temperatures of 29 ± 3°C and 52 to 75% relative humidity.

2.2. Trap Description

Unlike other grain insect probe traps, the caps of the probe traps used for the study was color lighted to evaluate the attraction of the insect to different light colors. Like most other perforated probe traps, the bottom is cone-shaped with an elongated steel cylinder containing 4 mm diameter perforations to allow the entry of cowpea bruchids but precluding the grains. Trapped insects will pass through the funnel into a detachable reservoir from where they can be disposed. The receptacle (trapping chamber) is large, making it appear as a pit inside or a tunnel, which prevents captured insects from escaping.

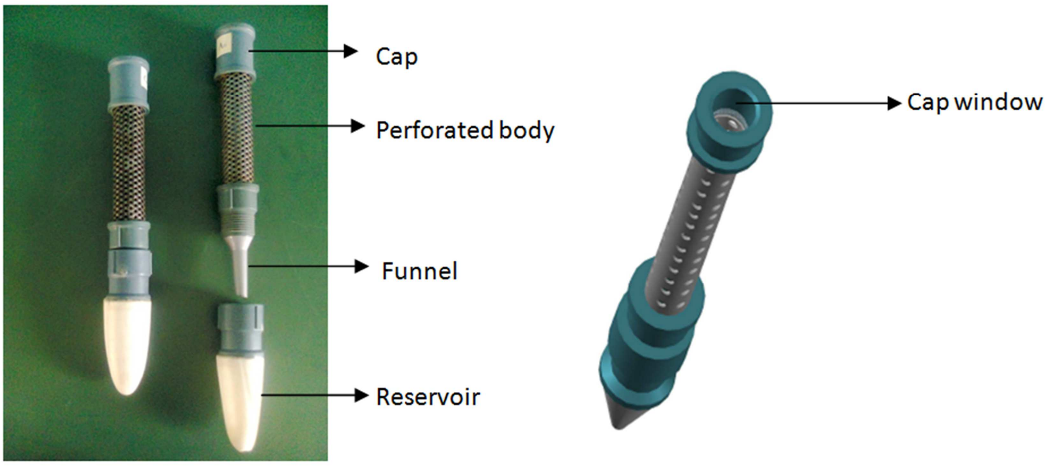

Figure 1. *Components of the insect probe trap.*

Seven different types comprising of six colored lighted traps and an unlighted/control probe traps were used for the research.

Figure 2. *Respective trap caps (from right to left: unlighted/control, natural/ambient, red, blue, purple, yellow and green).*

2.3. Research Materials

The experimental materials used in evaluating the performance of the traps were: cowpea grains (*Kananado* variety), cowpea bruchids (0 – 24 hours of emergence), moisture analyzer (OHAUS MB25®), digital probe thermometer (HANNA® instruments), digital thermo-hygrometer (BRESSER® meade instruments Europe), illuminance-meter (Konica Minolta® T-10, Japan), freezer, kilner jars, weighing scale, polyethylene bags, ropes, probe traps, insect aspirators, insect collection bottles, storage buckets (34 cm depth with 1037.1 mm body diameter), torch lights, batteries (lionell 1.5 v) and clock.

2.4. Evaluation of Light Sources

Illuminance meter (Konica-Minolta® T10) was used to determine the intensity of coloured light coming through the caps of the different probe trap and the results were recorded in Lux. An empty cap with the transparent plastic and without artificial light source nor colored material was measured in the laboratory environment using the same method as the other light sources to determine the illuminance intensity of ambient/natural light source in the laboratory and same was done to determine the condition for the control/unlighted traps' cap.

Figure 3. *Different light source caps and illuminance meter.*

Three hours interval measurements of illuminance intensity of light color from the sources, and also at the end of every 24 hours, revealed the reduction in light intensity with time as a result of battery power reduction together with the average illuminance intensity for ambient/natural light source within 24 hours period.

Probe thermo-hygrometer and BRESSER® thermo-hygrometer was used to determine the temperature and relative humidity of the grain bulk and the ambient on daily bases.

2.5. Procurement and Disinfestations of Cowpea Grains Used for the Experiment

Cowpea grains (700 kg) collected in sealed polypropylene bags were bought from Dawanau grain market, Kano, Nigeria and disinfested by freezing at temperatures of -20°C to -24°C for 72 hours [8 and 15]. After three days, the grains in sealed bags were removed from the freezer and left under ambient conditions for 27 hours to prevent condensational effect on the seeds before use.

2.6. Determination of Moisture Content of Cowpea Grains Used

Determination of moisture content of grain was done before and after the experiment using the moisture meter [12], to ascertain if the grain moisture level was affected due to artificial infestations or abiotic conditions; and moisture content of cowpea grains used was determined to be 13.9% before and 14.1% after the experiment.

2.7. Insect Culture

Adults of *Callosobruchus maculatus* were collected from an existing pure culture in the Laboratory. Clean cowpea grains were disinfested using the cold shock method, to exterminate any insect contamination on the grains prior to culturing of the beetles. The stock culture of *C. maculatus* were raised by paring 50 adults (male and female respectively) in each two-liter kilner jar containing 2kg of disinfected cowpea and numbering five (5 jars) to mate and oviposit. The kilner jars (cultures) were covered with netted cover to prevent the bruchids from escaping. The jars were left to stand for about 30 days until adult emergence, under prevailing laboratory conditions with temperature ranging from 29°C to 35°C and relative humidity of 52 to 75%. Freshly emerged adult beetles (0 to 24 hours old) were sieved out, with stipulated numbers counted using an aspirator and placed into the collection bottles, for artificial infestation.

2.8. Treatments and Infestation Rate

A total of seven treatments were used and these include different color lighted probe traps: red, yellow, green, blue, purple, ambient and unlighted (control) probe traps; these treatments were repeated three times and in three different population densities; low (30 bruchids), medium (70 bruchids), and high (150 bruchids), artificially infested into 10 kg cowpea samples contained in grey plastic storage buckets (34 cm depth and 1037.1 mm body diameter). Cowpea bruchids in the collection bottles were artificially infested into cowpea (10 kg) grain samples in accordance with the labeling on the bottles and grain storage buckets. The bruchids were infested into each cowpea grain sample after each quarter of grain is placed into each labeled storage containers. Respective traps were inserted into the buckets, labeled accordingly and catches were recorded after every 24 hours for 5 days.

In order to prevent insects from either leaving or entering samples, barrier was created, while also considering the working conditions. Storage plastic container covers were re-constructed for easy insertion and removal of the trap from samples without having to open the covers completely; such a container also ensured the vertical placement of probe traps as required for its functionality as well as preventing insects crossing (figure 4).

The buckets used for the study proper, were grey in color (figure 6) and resistant to passage of ambient light which prevents insects from being disturbed by ambient light or movement of persons/objects.

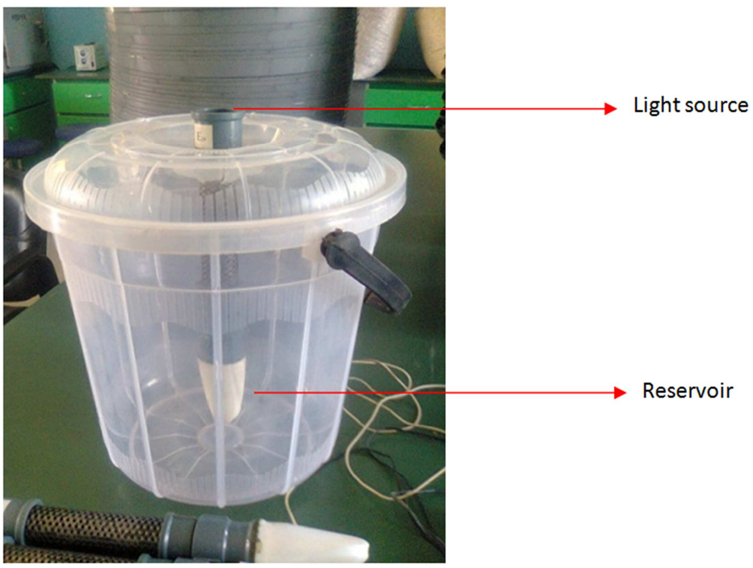

Figure 4. *Vertical position of the probe trap in the storage buckets when in use.*

All the traps (63) used for the study were coded and labeled base on light source and population density of the insect infested. Insect collection bottles containing the three different insect densities were labeled as: L, M, and H for low, medium and high insect densities respectively. Plastic storage buckets used were also labeled in-line with the insect collection bottles "L, M, and H" respectively for easy applications of treatments as shown in figure 5.

Figure 5. *Labeled storage buckets and insect collection bottles.*

The samples after artificial infestation were arranged in Complete Randomized Design (CRD) format on laboratory benches as shown in figure 6.

Figure 6. *Layout of samples.*

2.9. Use of Traps

Traps were pre-assigned to treatment levels (coded) and then arranged on the laboratory bench for easy allocation to cowpea samples and data collection (figure 7).

Figure 7. *Traps arranged for easy allocation to treatments.*

Traps were first inspected for any residual sample or other contaminants, cleaned, screwed and inserted vertically into the grains through the circular window created on the storage buckets' cover. The traps' body was inserted vertically into the grain bulk excluding the cap of the traps, at grain depth of 26 cm, when fitted, color cartridge and light source is then inserted into the caps.

Figure 8. *Process of trap insertion into cowpea samples infested with live bruchids.*

Light sources were first removed, hours directly after every 24 for 5 days, then traps were pulled out from the buckets and gently hit on a hard surface while still in vertical position to ensure trapped insects were in captured position, before un-screwing to inspect.

Considerations were made in keeping insects in place during inspection of trap catch each day as shown in figure 9.

Figure 9. *Barrier control during trap inspection each day.*

Water was also used to wet trapped insects in the reservoir before they were discharged and counted. Traps after inspection each day were cleaned and returned into respective grain samples and batteries were also replaced.

2.10. Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using the Statistical Analysis System (2000) package, version 9.0 and means were separated using the Duncan's Multiple Range Test (DMRT) at 5% confidence level.

3. Results

3.1. Results of Illuminance Intensity of Respective Light Sources

The result of illuminance intensity of respective colored light sources is shown in figure 10. There was no significant difference in temperature between the traps location or grain mass and the ambient.

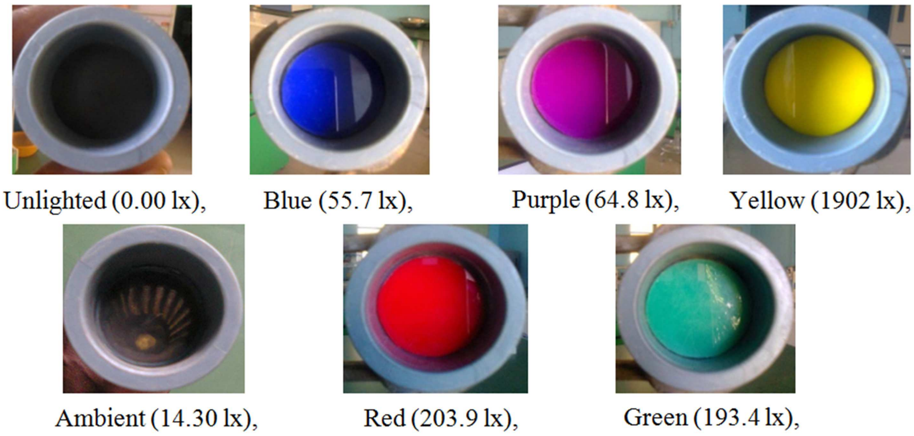

Figure 10. *Colored trap caps with illuminance value in parenthesis.*

3.2. Daily Trap Catches

The result of daily trap catches from the different traps is illustrated in table 1. The result showed that the ambient lighted trap had the best mean catches, while the unlighted/control trap had the least trap catch mean, but there were no significant difference among the traps in all the trapping days.

Table 1. *Daily trap catches.*

Trapping days						
Treatments	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Total**
Insect densities						
High density	39.5^{a}	11.2^{a}	6.9^{a}	2.6^{a}	2.4^{a}	62.5^{a}
Medium density	12.0^{b}	5.9^{b}	2.7^{b}	1.2^{b}	0.5^{b}	22.2^{b}
Low density	6.3^{c}	2.8^{c}	1.5^{c}	0.9^{b}	0.4^{b}	11.9^{c}
SE ±	0.84	0.50	0.37	0.25	0.27	1.00
Trap types						
Ambient	21.0^{a}	8.2^{a}	3.8^{ab}	2.0^{a}	1.6^{a}	36.6^{a}
Blue	20.4^{a}	6.4^{ab}	3.9^{ab}	1.6^{a}	1.0^{a}	33.3^{a}
Purple	20.2^{a}	6.3^{ab}	3.8^{ab}	2.1^{a}	0.8^{a}	33.2^{a}
Yellow	18.2^{a}	7.4^{ab}	4.8^{a}	1.3^{a}	1.1^{a}	32.9^{a}
Red	18.7^{a}	7.2^{ab}	3.2^{ab}	1.8^{a}	1.3^{a}	32.2^{a}
Green	19.9^{a}	6.3^{ab}	3.0^{ab}	1.2^{a}	0.7^{a}	31.0^{a}
Unlighted/Control	16.3^{a}	4.3^{bc}	3.4^{ab}	1.1^{a}	1.0^{a}	26.2^{b}
SE ±	1.28	0.77	0.56	0.38	0.41	1.53
Density * Trap	NS	NS	NS	NS	NS	*

Note that means with the same letter are not significantly different at 5% level of significance using SNK.

3.3. Total Trap Catches

The result of total trap catches from the different trap is presented in table 1. It revealed that ambient light source had higher trap catch mean value (36.6) than all other traps, and it was similar ($P \geq 0.05$) to blue (33.3), purple (33.2), yellow (32.9), red (32.2) and green (31.0) light sources. All the lighted traps were significantly higher ($P \leq 0.05$) than the unlighted/control trap (26.2) which had the least mean catch.

3.4. Correlation of Trap Catches Between Population Density and Light Intensity

Results on correlation between population densities and light intensities to trap catches are shown in table 2. There was a negative (-0.247) correlation in high insect density, medium insect density (-0.079) and also in low insect density (-0.285), which were not significant.

Table 2. *Correlation matrix of trap catches between light intensities and population density.*

	Light intensity	**High PD**	**Medium PD**	**Low PD**
Light intensity	1			
High PD	-0.247^{NS}	1		
Medium PD	-0.079^{NS}	-0.342^{NS}	1	
Low PD	-0.285^{NS}	-0.021^{NS}	0.807^{**}	1

Note: PD (population density), NS (not significant), ** (highly significant) * (significant).

3.5. Pest Populations Detected by the Traps

The number of bruchids caught by respective trap per day in the different population densities (high, medium and low) was as shown in figure 11. Thirteen (13) bruchids was the average number caught by the traps per day in samples with high insect population density. In medium insect population density the average number of bruchids caught by the traps per day was 5. Also, the average number of bruchids detected by the traps in sample with low insect density was 2 per day.

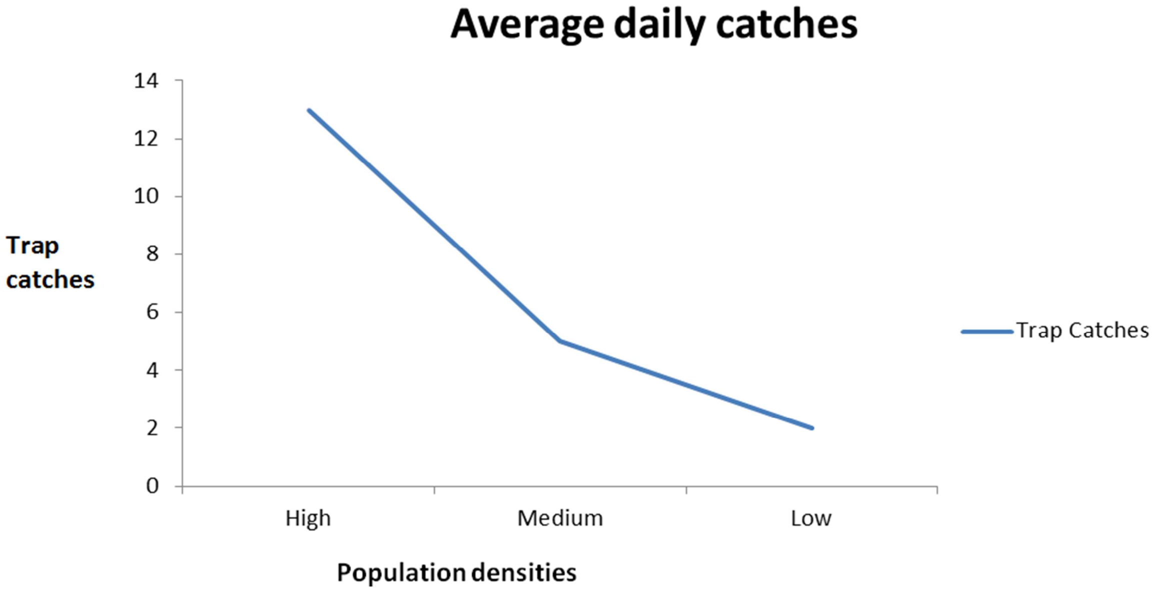

Figure 11. *Average trap catches per day (24 hours interval trapping duration).*

4. Discussions

4.1. Illuminance Intensity of Respective Lights Colours

There was no heat generated by the light sources evaluated, though they had varied illuminance intensities, to lure cowpea bruchids. This means the light source (torch light) had no effect on the temperature of the trap and its surrounding and therefore, temperature of grain bulk was not affected by the use of artificially lighted probe trap in this research.

4.2. Trap Catches

Lighted traps caught relatively higher number of bruchids compared to the unlighted trap. This means that light was effective in improving the probe trap for early detection of *C. maculatus* infesting stored cowpea. Findings by Ashfaq *et al.*; Dadmal and Suvarna described that insects (Coleopterans) are attracted to light [4 and 6], and this according to Adriana and Lars; Arnold *et al.* was due to visual stimuli [2 and 3].

The ambient/natural light source was more effective in improving the efficiency of the trap, because it had the least illuminance intensity compared to the other light sources, which supports the finding by Ashfaq *et al.* who reported that insects are attracted in more numbers on lights with short wavelengths and high frequencies [4]. The result also showed that light color had no effect on the performance of the trap, and this finding also supports findings of Ashfaq *et al.*; Dadmal and Suvarna who reported that insects of the order Coleoptera are attracted to all colored lights [4 and 6]. By these findings, light irrespective of color was what made the difference between the lighted traps and the unlighted traps.

4.3. Correlation of Trap Catches Between Population Densities and Light Intensities

The result of correlation between population densities and intensity of light sources used showed that trap catches increased with increase in bruchids density and vise versa; this supports Toews and Phillips [18]. On the other hand, trap catches increased with decrease in light intensity and vise versa. This supports Ashfaq *et al.*, who reported that insects are more attracted to lights with reduced intensity [4]. The weak negative correlation that existed between the variables can be attributed to reduction of light intensities due to battery power reduction which affected respective traps over time.

5. Conclusion

Light irrespective of color was effective in improving the probe trap for detection and management of *Callosobruchus maculatus* infesting stored cowpea, but the best light which detected the bruchids most among the selected light sources was the natural (ambient) light source because it had the least illuminance intensity. This means that the cost of trap production (i.e. artificial light source) as well as use-maintenance (i.e. battery) is reduced for fabricators and users.

Recommendations

From studies carried out in this work, recommendations are that:

1 Ambient light source should be incorporated into probe traps made for detecting cowpea beetles infesting stored cowpea.

2 Another modified probe trap (i.e. with lighted cap) can have a pheromone in order to increase its trapping ability.
3 It is also desirable to extend the study to different types of stored products under various climatic conditions on other stored grain pests to determine how to best control stored grain insects using probe traps.

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