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Research Paper

Effect of Phototactic Behavioural Response of *Rhyzopertha dominica* to Different Light Emitting Diodes (Leds)

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A B S T R A C T

Insects are highly influenced by wavelengths, exposure and luminance intensities of light emitting diodes (LEDs). Recently, light emitting diode (LED) lights have been applied to check the behavior of crop insects towards light. *Rhyzopertha dominica* is an important agricultural pest. In this work the phototactic behavioral response of *Rhyzopertha dominica* adult pests to light emitting diodes of five different wavelengths, luminance intensities and exposure time were determined under laboratory conditions. Based on phototactic response of *Rhyzopertha dominica* pests, it was found that the green and red LEDs are most attractive as compared to other LED lights. There are various other factors that play a significant role including exposure time in darkness, age etc. on the phototactic response of *Rhyzopertha dominica*. The application of LED technology is effective in containing the agricultural pests and stored food insects. The findings indicate that a green LED trap could prove useful to control *Rhyzopertha dominica* pests.

Key words**:** Agricultural pests, Light emitting diodes, Light trap, Phototactic response, *Rhyzopertha dominica*

The main aim of agriculture is to meet the food needs of society, but the increasing growth of pests and the damage caused by them on different agricultural crops have become a major problem for agricultural sector. In quest of controlling the alarming pest population, synthetic pesticides are being used by many countries to control the influence of pests [1, 2]. However, the excessive use of pesticides and insecticides has increased the resistance of insect pests. Moreover, the indefinite uses of pesticides have lead to many harmful consequences which in turn have affected the crop yield very badly. The consequences are not only limited to the instability of ecosystem but, it has lead to some serious problems such as hazards to human health, environmental pollution, sudden outbreak of insect pests, damage to beneficial flora and fauna and resurgence of new insect pest species. Efforts are being made to minimize the use of pesticides and insecticides and develop alternative eco-friendly methods [3, 4]. *Rhyzopertha dominica* also known as the lesser grain borer is considered as one of the primary pest of stored food grains. The insect damages many food grains like cereals, rice, wheat and corn. It is one of the most economically recognized pest throughout the world. Entomologists have made various efforts to devise methods in order to control the damage caused by *Rhyzopertha dominica* on stored grain [5]. But, the control of lesser grain borer is mainly done through the use of pesticides and insecticides. The use of pesticides to control food/stored product pests has however decreased as it has lead to negative impacts on the health of farmers, environmental pollution, ozone depletion, pest resistance [6]. Thus, there is a need to find alternative measures to control the damage on stored food products caused by *Rhyzopertha dominica*.

Non-chemical methods are getting popularity because of their harmless impact on environment. Furthermore, they do not accumulate the food grains with chemical residues and insect pest resistance is not caused [7]. Among the non-chemical methods for controlling pests, insect phototaxis is widely used to control or monitor the agricultural pests. The phototaxis method provide an alternative to pesticides and insecticides to control pests and occur as an advantage for pest control strategies satisfying the aim of controlling insect pests and environmental pollution [8, 9, 10]. Phototaxis is defined as the behavior of insect species in response to light sources. This response relies on the wavelength of light source and the intensity of light source [11]. In addition, the phototactic response also depends on several other factors including insect's age, mating status, exposure time in darkness etc. [12, 13, 14]. The use of artificial lights to control pests has gained much popularity globally. Recently, light emitting diodes have proved very effective and have become an important practice to develop modern agricultural systems [15, 16]. The advantages of using LED technology include adjustable intensities, selective wavelengths, low weight, eco-friendly, energy efficient, long life etc. [17, 18, 19]. These specific advantages of LEDs have made them an alternative to conventional pesticides and insecticides for stored insect pests [20]. The studies on use of LED technology in modern agricultural practices are growing globally. However, the primary focus lies on identifying special wavelengths of light

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sources that attract the insect pests at a very high rate [21]. In this study, the behavioral effects of *Rhyzopertha dominica* insect pests in response to LED light sources were examined and monitored under laboratory conditions for different wavelengths and luminance intensities.

MATERIALS AND METHODS

Stored grain insects

The insects used for the experiment were *Rhyzopertha dominica* which were reared on infested wheat cultured in the laboratory. These insects were reared in containers at a temperature of 35°C and a relative humidity of 65 ± 5%. Only the adult species of *Rhyzopertha dominica* insect pests were used for experimental analysis.

Light sources

The light emitting diode sources were purchased from an electrical appliances shop located in the local market. Five different LEDs were chosen for testing namely violet, yellow, green, blue and red. The wavelengths of these LEDs used for testing is given as follows; violet (420 ± 5 *nm*), blue (460 ± 5 *nm*), green (530 ± 10 *nm*), yellow (560 ± 10 *nm*), red (620 ± 10 *nm*). The LED boards were mounted on circuit board within a chamber. The control circuit board controlled the wavelengths of the LED sources.

Chamber

The test chamber was constructed consisting of an acrylic body and two transparent acrylic walls located on both sides of the chamber to allow the light pass through the chamber and to observe the behavior of insects. The entrance hole was made in between separating the darker and light sides and the outside part was covered with net to stop the insects from escaping. The light source was kept at a distance of 20 cm. The chamber was kept in laboratory at a temperature of 65 ± 1°C and relative humidity of 65%.

RESULTS AND DISCUSSION

Classification of phototactic behavioral responses to light sources of Rhyzopertha dominica

The response of insects towards light is varied and can be classified in many ways. This response of insects to light is called as phototaxis. Insects are both attracted towards light (positive phototaxis) and repelled away from the light (negative phototaxis). Other factors that affect the response of insects to light are intensity of light, exposure time, wavelength of light. These factors play a significant role to the phototactic response of insects [22, 23]. Negative phototaxis play a very useful role to prevent the insect pests from entering into food stores, granaries and greenhouses [24, 25]. Before the start of experiment, the insect collection box was kept shut with the light and darker sides separated by two boards. The phototactic response of *Rhyzopertha dominica* adult insects to LEDs were monitored in the chamber under different wavelengths, exposure time to light and luminance intensities. The *Rhyzopertha dominica* insects were collected and released through the insect entrance hole of the chamber. The boards separating the light and dark sides were removed and the light side was kept light after turning on the LED light source. The dark side was kept dark during the whole experiment. The phototactic responses of the insects towards light were monitored based on the number of insects in the light and darker sides of the chamber. Forty *Rhyzopertha dominica* adult insect pests were released through the insect entrance hole. The attraction rates of *Rhyzopertha dominica* insects were monitored at four luminance intensities of five different wavelengths of LEDs namely violet, yellow, green, blue, and red. The light durations were measured as 3 hours under optimal light conditions. Each calculated value is the average of five determinations after a three-hour exposure time and forty adult insects of *Rhyzopertha dominica* were used for each trial. The attraction rate of *Rhyzopertha dominica* adults pests to five different wavelengths were monitored at a light exposure time of three hours and four luminance intensities (50, 60, 75, 100 *lx*). At a 75 *lx* luminance intensity, green (530 ± 10 *nm*) attracted the most number of insects at an attraction rate of (89%), whereas the other attraction rates of green LED were (84.0, 85.5 & 77.5%) at each luminance intensity of (50, 60, 100 *lx*) respectively. Moreover, red (620 ± 10 *nm*) and blue (460 ± 5 *nm*) LEDs attracted the insects at attraction rates of (71.0, 73.5, 77.5 & 64.5%) and (55.0, 58.0, 61.5 & 50.0%) respectively. However, violet and yellow showed low attraction responses (Table 1).

Table 1 Phototactic response of *Rhyzopertha dominica* adults to LED sources of five different wavelengths under four luminance intensities

Color wavelength		Attractive rate (Mean ± SEM)			
		Luminance Intensity (lx)			
		50	60	75	100
Violet	(420 ± 5 *nm*)	15.6 ± 0.5	16.2 ± 0.5	17.2 ± 0.5	14.6 ± 0.6
Yellow	(560 ± 10 *nm*)	17.6 ± 0.5	18.2 ± 0.4	19.2 ± 0.4	16.6 ± 0.5
Green	(530 ± 10 *nm*)	33.6 ± 0.6	34.2 ± 0.6	35.6 ± 0.8	31.0 ± 0.5
Blue	(460 ± 5 *nm*)	22.0 ± 1.1	23.2 ± 1.2	24.6 ± 1.4	20.0 ± 0.8
Red	(620 ± 10 *nm*)	28.4 ± 0.5	29.4 ± 0.5	31.0 ± 0.7	25.8 ± 0.6

The attraction rate of *Rhyzopertha dominica* adult insects to five different wavelengths were monitored at a light exposure time of two hours and luminance intensity of 40 *lx*. The details are shown in (Table 2). At 40 *lx* luminance intensity green (530 ± 10 *nm*) LED was the most attractive with an attraction rate of 83.5%. Red (620 ± 10 *nm*) LED was the second most attractive with an attraction rate of 69.5% followed by blue (460 ± 5 *nm*) with an attraction rate of 53.5%. However, yellow (560 ± 10 *nm*) and violet (420 ± 5 *nm*) LEDs show attraction rates at 38.5% and 35.5% respectively. Each calculated value is the average of five determinations and forty *Rhyzopertha dominica* insect pests were used for each trial.

The results shown in (Table 1) show the attraction rates of *Rhyzopertha dominica* insects to five different wavelengths at four luminance intensities. While, the attractive rates of

Rhyzopertha dominica adults at five different wavelengths evaluated at a luminous intensity of 40 *lx* were shown in (Table 2). The results show that light traps with green, red and blue LEDs have a higher intensity to control pests.

Table 2 Phototactic response of *Rhyzopertha dominica* adults to LED sources of five different wavelengths under the luminance intensity of 40 *lx*

Pests	Color (Wavelength)		Luminous Intensity (lx)	Time (Mins.)	No. of Adults (Mean±SEM)			Attraction rates (%)
					Light side	Dark side	No option	
R. dominica	Violet	(420 ± 5 *nm*)	40	120	15.2 ± 0.7	15.8 ± 0.5	10.0 ± 0.5	35.5%
	Yellow	(560 ± 10 *nm*)	40	120	15.4 ± 0.8	13.4 ± 0.6	11.2 ± 0.3	38.5%
	Green	(530 ± 10 *nm*)	40	120	33.4 ± 0.8	4.4 ± 0.6	2.0 ± 0.3	83.5%
	Blue	(460 ± 5 *nm*)	40	120	21.4 ± 1.6	12.2 ± 0.9	6.4 ± 0.7	53.5%
	Red	(620 ± 10 *nm*)	40	120	29.8 ± 1.0	8.0 ± 1.0	4.2 ± 0.5	69.5%

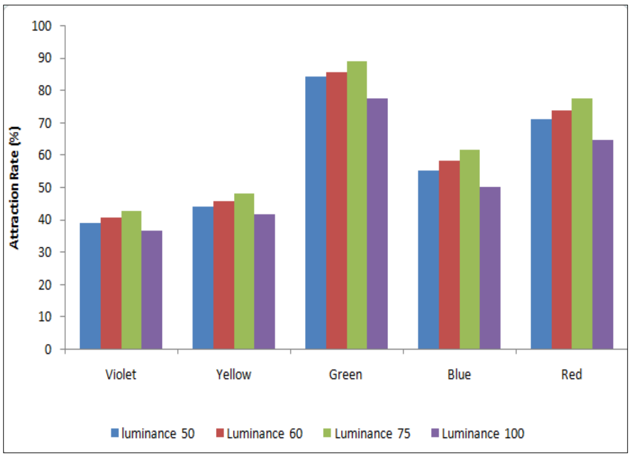

Fig 1 Photo-tactic responses of *R. dominica* to LED lights of several wavelengths. The experiment was executed under (50, 60, 75, 100 *lx*) luminance intensities and 180 min (exposure time) conditions for reach group. The value of each bar indicates the attraction rate of the adults to the LED light

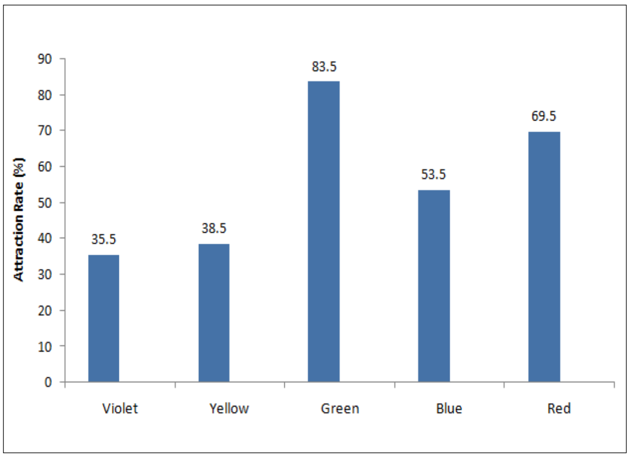

Fig 2 Photo-tactic responses of *R. dominica* adults to LED lights of several wavelengths. The experiment was conducted under 40 *lx* (luminance intensities) and 120 min (exposure time) conditions for reach group. The value of each bar indicates the attraction adults to the LED light

Previous studies have shown that blue 84.3% LED was the most attractive to *Sitophilus oryzae*, followed by green 74.3% red 64.3% and UV 63.3% [26]. The phototactic behavior of *Trialeurodes Vaporarium* to yellow-green (520 ± 610 *nm*) LED and ultraviolet (360 ± 380 *nm*) was observed and shown in [27]. Other studies have shown that red LED (625 *nm*) is more attractive to *Tribolium castaneum* (97.8%) and *Sitophilus zeamis* (59.8%). While the same red LED has shown less effect on attracting *Lasioderma serricorue* (31.0%) and *Tyrophagus putresceniae* (18.0%) [28]. Green LEDs have proven much effective to attract *Plodia interpunctella* (52.2%. The highest attraction rate against *S. careallella* (61.7%) and *P. interpunctella* (81.5%) have been shown by red LED [29]. In another study, it has been found that for trapping *A. pomorum*, green and blue LEDs have a higher attraction rate than UV light [30]. Other study has found that UV light has a higher effect in reducing the incidence of *Frankliniella occidentalis, Bemisia tabaci, Liromyma trifolli* [31].

CONCLUSIONS

In conclusion, LED technology can be adapted and encouraged in modern agricultural practices to reduce the incidence of insect pests on agricultural crops, food grains, granaries etc. In present study, green LED has shown more attraction rate to *Rhyzopertha dominica* as compared to other LEDs. These findings further suggest that green light equipped traps can be used to control and reduce the damage of *Rhyzopertha dominica* insect pests on agricultural crops. However, further research is needed to check the effectiveness and efficiencies of LED lights like wavelength, luminous intensity, exposure time etc. In addition, LED light that attract parasitoids that are natural enemies of insect pests must be experimented to reduce the incidence of pests.

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