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Pest Control on Pea Plant (*Pisum sativum*) in Greenhouse using Led Light Traps

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ABSTRACT

Pea (*Pisum sativum*) is a valuable legume crop widely cultivated for its nutritional and economic importance. However, greenhouse-grown pea plants are highly susceptible to a range of insect pests such as aphids, thrips, whiteflies, and moths, which can cause significant yield losses. In this study, we evaluated the efficacy of LED light traps as a sustainable and non-chemical method for pest control in a controlled greenhouse environment. Different wavelengths of LED lights—particularly blue (450 nm), ultraviolet (UV-A, 365 nm), and green (525 nm)—were tested to determine their attractiveness to target pest species. The traps were deployed at strategic locations in a randomized block design, and pest capture data were collected over eight weeks. Results indicated that UV-A and blue LED traps were most effective in reducing pest populations, with statistically significant reductions in aphid and thrip densities compared to the untreated control. Crop health and yield parameters also improved in LED-treated sections. This study demonstrates that LED light traps offer a promising, eco-friendly alternative to conventional pesticide applications for integrated pest management (IPM) in greenhouse pea cultivation.

INTRODUCTION

An essential grain, the pea plant (*Pisum sativum*), belongs to the family Fabaceae (Leguminosae). It has been regarded as one of the extensively cultivated grains during winter (Villegas-Fernández *et al.*, 2021; Hussain *et al.*, 2022; Aboelfadel *et al.*, 2023 & Khan *et al.*, 2015). They have been an important source of protein and various essential nutrients in the diet of human beings (Sandhi and Reddy 2020). They have been widely grown all across the world, especially in Asia and Africa (Kong *et al.*, 2017), as they can thrive in tropical and sub-tropical regions. Pakistan is one of the biggest producers of the pea plant along with India, Burma, and Africa (Villegas-Fernández *et al.*, 2021; Hussain *et al.*, 2022; Aboelfadel *et al.*, 2023 & Khan *et al.*, 2015).

The lower production and cultivation of pea plants in major countries during winter is caused by lower levels of natural light. To minimize this issue, the farming of pea plants has been shifted to cultivation in greenhouses (Kong & Zheng, 2019). The most noticeable advantage that the greenhouses share over the cultivation in conventional agricultural lands is that the conditions of the crop fields can be managed according to the requirements for a particular crop. Also, it can be made possible to implement any kind of control to save the crop from harsh environmental conditions, as well as pest outbreaks (Pikington *et al.*, 2009). Artificial lights, being a non-chemical technique, have been used intensively in conventional farming to avoid pests (Jonason *et al.*, 2014). The use of light traps has improved their importance as a significant technique in IPM (Park & Lee, 2017).

Light plays a vital role in the development of plants. It can also affect the morphology and physiology of the plants (Lazzarin *et al.*, 2021, Shimoda & Honda, 2013). Light not only affects the plants but also leaves a negative impact on the behavior of insects that are directly associated with the survival of the insect (Johansen *et al.*, 2011). With the help of different wavelengths and intensities of LED lights, the insects can be attracted or repelled (Park & Lee, 2021, Shimoda & Honda, 2013). The use of LED lights provides several advantages, including an environmentally friendly technology that improves the growth of the plants, lowers the consumption of electricity, and is discerning in selecting the specific wavelength and intensity of the light (Park & Lee, 2017). The use of typical insecticides has led to resistance in several pest insects. To cope with this problem, the use of LED light traps has proved to be an efficient method (Athanasiadou *et al.*, 2024). Nowadays, new varieties of LED light traps have been generated. These are the semiconductor light sources that can be beneficial in attracting the insects and trapping them (Zhang *et al.*, 2020). The emergence of photovoltaic solar panels has been considered an important agricultural light trap (de Carvalho *et al.*, 2021). This study aims to control the most important pests of pea plants in the greenhouse using the physical method, i.e., the LED light traps.

LITERATURE REVIEW

Yang *et al.* (2015) studied, under ideal conditions, the phototactic behavioural reactions of western flower thrips to light-emitting diodes (LEDs) (light sources,

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luminance intensities, and light-exposure durations). According to the western flower thrips' attraction rate (percent) in ideal conditions in the dark, yellow LEDs (590 nm) had the highest rate (48.0 percent), followed by green LEDs (520 nm), blue LEDs (470 nm), red LEDs (625 nm), white LEDs (450-620 nm), infrared LEDs, and yellow LEDs (730 nm, 10.3 percent). The yellow LED was almost 1.2 times more active toward western flower thrips than the black light bulb (BLB), which served as the positive control. The BLB's activity level was 39.0 percent. The yellow LED should be effective in this aspect for controlling western flower thrips.

Chu *et al.* (2004) observed that to increase pest insect capture rates in the lab and greenhouses, light-emitting diodes (LEDs) were fastened to sticky cards and plastic cup traps. 530 nm lime green LED-equipped plastic cup traps were more effective than plain plastic cup traps in capturing adult *Pialeurodes vaporariorum* (Westwood) and *Bemisia tabaci* (Gennadius) biotype B. In greenhouse cage studies using shell beans, *Phaseolus vulgaris* (L.) and cotton, *Gossypium hirsutum*, yellow sticky card (YC) and clear plastic sticky card (CS) traps caught more adult *T. vaporariorum*, *B. tabaci* biotype B, *Aphis gossypii* (Glover), and *Bemisia coprophila* (Lintner) than did unlit traps of each type (L.). The lime green LED-equipped YC traps could be used in greenhouses for insect capture.

Hajime *et al.* (2014). used 17 different coloured resin sheets, 8 LED lights, and two different types of plates to conduct melon thrips, *Thrips palmi*, trapping tests. More thrips were caught by resin with a peak spectral reflectance between 481 and 523 nm among the coloured resin traps. More thrips were caught by LED light traps with peak wavelengths of 500 or 525 nm among the 8 LED light traps covered with a diffuser. When the LED light traps were protected by a clear acrylic plate, the 470-nm LED trap and the 525-nm LED trap both achieved the highest capture rates and trapped an equal number of thrips. In an experiment using LED traps with one of three wavelengths (470, 500, or 525 nm) and either a diffuser or a transparent plate, the 470-nm LED trap captured fewer thrips than the other combinations, and the 470-nm trap covered by a diffuser captured significantly fewer thrips than the same trap covered by a transparent plate. Transparent plates placed over 500 or 525 nm LEDs allowed for noticeably better capture rates. Melon thrips were afterwards consistently drawn to light with wavelengths between 500 and 525 nm.

MATERIALS AND METHODS

Experimental site

This study was carried out in the greenhouse of Lahore College for Women, University from November to March 2022.

Cultivation of the pea plant

Pea (*Pisum sativum*) seeds were obtained from the Ahmed garden farm and nursery in Lahore, Pakistan. The seeds

were planted in appropriately sized containers (12 cm diameter and 20 cm depth). The soil was made up of 50% vermicompost and 50% garden soil. The plants were divided into three basic groups (Group A, Group B, and Group C), with each group having three plants labelled as Plant 1, Plant 2, and Plant 3.

Environmental data

Temperature, humidity of the surroundings, and soil pH were all carefully managed because they all had a substantial impact on plant growth. During the trial, the plants were exposed to sunlight for around 5-7 hours every day. From January to March, the average daytime temperature ranged between 18.2 and 27°C, and the average nighttime temperature ranged between 5.9 and 11°C. Humidity also has a profound effect on the conditions within the greenhouse if left uncontrolled. During the trial, which lasted from January to March, the average humidity reported was 55-67%. To limit the incidence of sunlight in the greenhouse, blackout screens were utilized. Exhaust fans were also installed in the greenhouse to remove excess heat that became trapped within and to keep temperature ranges moderate.

Pest counting

The infestation of aphids in pea plants was recorded every week. To record the aphid's population, pea plants of group A, group B, and group C were selected, which further contain 3 pots each, marked as plant 1, plant 2, and plant 3, respectively. In the greenhouse, aphids on plant leaves were counted visually. The sampling technique was basically used to record the pre- and post-treatment data, and the adult aphid and whitefly populations were recorded from 3 leaves (top, middle, and bottom) per plant from each group. The data was finally reported as the mean number of whiteflies and aphids per leaf.

LED light source selection

The plants were placed under three lighting strategies to find out which lights attracted, repulsed, or were harmful and resulted in the death of the pest species. Red (640-700nm), tunable Blue (400-450nm), and Green (520-555nm) LED lights. Lights were suspended above plants in the greenhouse.

LED light treatment on pea plants

Pea plants of Group A were subjected to LED lights of different wavelengths, i.e., Blue, Green, and Red LED lights, twice a week. The exposure time of each LED was 12 hours. To prevent the light pollution between treatments, plants were separated by white plastic sheets. During the trial, the plants received a DLI (daily light integral) of 5 to 7 hours, respectively. But later on, when the temperature increased in March, the exhaust fans were turned on to remove the extra heat. At last, the mean population of aphids and whiteflies per leaf was estimated after the light treatment.

RESULTS AND DISCUSSIONS

Seed plantation

In the last week of November, nine pots were sown with pea seeds and placed in the greenhouse for testing purposes.



Figure 1: Showing the pea seeds planted in pots.

Pest infestation in pea plants

The first pest to attack the pea plant was a caterpillar known as *Cydia nigricana*. Later, the occurrence of two sucking insect pests, aphid (*Aphis fabae*) and whitefly (*Trialeurodes vaporariorum*) on pea plants was detected, as shown in Figure 2. The first aphid sighting came in the last week of January, with a mean density of 1.22 aphids per leaf. Following that, there was a progressive increase with a mean population of 4.77 aphids per leaf, followed by an increase in the last week of March with 8.88 aphids per leaf.

The first incidence of whitefly was observed in the last week of February, with a mean density of 1.11 whiteflies per leaf. Following that, a modest increase was recorded in the second week of March with 2.88 whiteflies per leaf, peaking at 5.0 aphids/leaf in the last week of March. By the end of March, the aphid and whitefly populations had reached their peak.

Results show that LED lights were not lethal for insects; however, they played a role in attracting and repelling the aphids and white flies.

Group A plants exposed to LED lights



Figure 2: Showing Pea plants of group A exposed to LED lights of various wavelengths (a) red LED with wavelength 640-700nm, (b) green LED with wavelength 520-555nm, (c) blue LED with wavelength 400-450nm.

Impact of Blue, Green, and Red LEDs on pest population

The three major light sources, Red, Green, and Blue LEDs, were used to assess the change in aphid and whitefly population density. Each LED was exposed for

Table 1: Population density of aphids when exposed to Blue, Green, and Red LED lights in February.

Weeks	LED equipped	No. of aphids/leaf					
		Before treating with LED			After treatment with LED		
		Upper layer leaves	The middle layer leaves	Lower-layer leaves	Upper layer leaves	The middle layer leaves	Lower-layer leaves
Week 1	Blue	11	13	18	17	15	14
Mean		1.22	1.44	2.0	1.88	1.66	1.55
S.D ± S.E		0.440± 0.146	0.527± 0.175	1± 0.333	0.833± 0.277	0.5± 0.166	0.527± 0.175
Week 2	Green	21	20	19	28	25	21
Mean		2.33	2.22	2.11	3.11	2.77	2.33

S.D± S.E		0.866± 0.288	0.971± 0.323	0.781± 0.260	1.269± 0.423	1.563± 0.521	0.866± 0.288
Week 3	Red	31	29	29	26	33	35
Mean		3.44	3.22	3.22	2.88	3.66	3.88
S.D± S.E		1.130± 0.376	1.201± 0.400	1.201± 0.400	0.781± 0.260	1.531± 0.523	1.364± 0.454
Week 4	Blue	29	35	38	37	33	34
Mean		3.22	3.88	4.22	4.11	3.66	3.77
S.D± S.E		1.201± 0.400	1.364± 0.454	1.201± 0.400	1.054± 0.351	1.5± 0.5	0.833± 0.277

12 hours, and data was collected appropriately. A regular increase in aphid population density was observed, with an average of 1.88 aphids/leaf in the first week of February and 8.88 aphids/leaf in the last week of March, as shown

in Tables 1 and 2. Similarly, the population density of whiteflies in the first week of March was 1.11 whiteflies/leaf, with a progressive increase to 5.0 whiteflies/leaf in the last week of March, as shown in Table 3.



Figure 1: Showing the aphid infestation in pea plants under Blue, Green, and Red LED lights in February.

Table 2: Population density of aphids under Blue, Green, and Red LED lights in March.

Weeks	LED equipped	No. of aphids/leaf					
		Before treating with LED			After treatment with LED		
		Upper layer leaves	The middle layer leaves	Lower-layer leaves	Upper layer leaves	The middle layer leaves	Lower-layer leaves
Week 1	Green	39	37	39	43	40	36
Mean		4.33	4.11	4.33	4.77	4.44	4.0
S.D ± S.E		1.118± 0.372	1.054± 0.351	1.118± 0.372	1.481± 0.493	1.236± 0.412	1.118± 0.372
Week 2	Red	47	45	39	43	48	45
Mean		5.22	5.0	4.33	4.77	5.33	5.0
S.D± S.E		1.715± 0.517	1.414± 0.471	1.118± 0.372	1.481± 0.493	1.732± 0.577	1.414± 0.471
Week 3	Blue	55	61	59	66	58	56
Mean		6.11	6.77	6.55	7.33	6.44	6.22
S.D± S.E		2.420± 0.806	2.166± 0.722	2.351± 0.783	2.291± 0.763	1.878± 0.626	2.048± 0.683
Week 4	Green	69	75	80	74	78	69

Mean		7.66	8.33	8.88	8.22	8.66	7.66
S.D± S.E		3.872± 1.290	3.674± 1.224	2.934± 8.888	3.073± 1.024	2.738± 0.912	2.121± 0.707

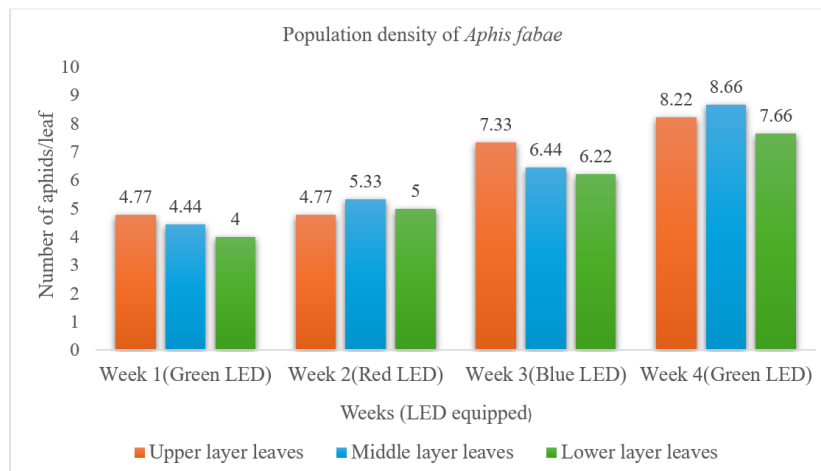


Figure 2: Showing the aphid infestation in pea plants under Blue, Green, and Red LEDs in March.

Table 3: Population density of whiteflies under Blue, Green, and Red LED lights in March.

Weeks	LED equipped	No. of aphids/leaf					
		Before treating with LED			After treatment with LED		
		Upper layer leaves	The middle layer leaves	Lower-layer leaves	Upper layer leaves	The middle layer leaves	Lower-layer leaves
Week 1	Green	10	12	17	19	14	11
Mean		1.11	1.33	1.88	2.11	1.55	1.22
S.D ± S.E		1.054± 0.351	1± 0.333	0.834± 0.277	0.782± 0.260	0.521± 0.175	0.444± 0.146
Week 2	Red	17	21	25	21	23	26
Mean		1.88	2.33	2.77	2.33	2.55	2.88
S.D± S.E		0.833± 0.277	0.863± 0.288	1.563± 0.521	0.864± 0.288	1.011± 0.337	0.788± 0.261
Week 3	Blue	22	26	31	18	29	38
Mean		2.44	2.88	3.44	2.0	3.22	4.22
S.D± S.E		1.130± 0.376	0.788± 0.260	1.133± 0.376	1± 0.333	1.201± 0.400	1.321± 0.683
Week 4	Green	26	34	45	39	36	34
Mean		2.88	3.77	5.0	4.33	4.0	3.22
S.D± S.E		0.781± 0.260	0.833± 0.277	1.414± 0.471	1.11± 0.372	1.118± 0.372	0.833± 0.277

4.3.2. Population density of aphids and whiteflies

There was no significant reduction in the population size of aphids and whiteflies measured as the number of individuals per leaf at the time of evaluation under different LEDs. However, the position of the leaf affected population size, with fewer aphids per leaf on the upper leaf layer in the case of Red LED compared to the leaves on the middle and lower leaf layers. In the case of green and blue LEDs, the upper layer leaves had a higher number of aphids per leaf. The difference in

aphid numbers between leaf layers is determined by light treatments, with green and blue being more appealing. The attraction towards the green light was observed in the case of whiteflies. But no lethal effect of these LEDs was found on the population of aphids and whiteflies.

Discussion

The findings of this study highlight the growing limitations of chemical insecticides in managing greenhouse and field pests such as aphids and whiteflies.

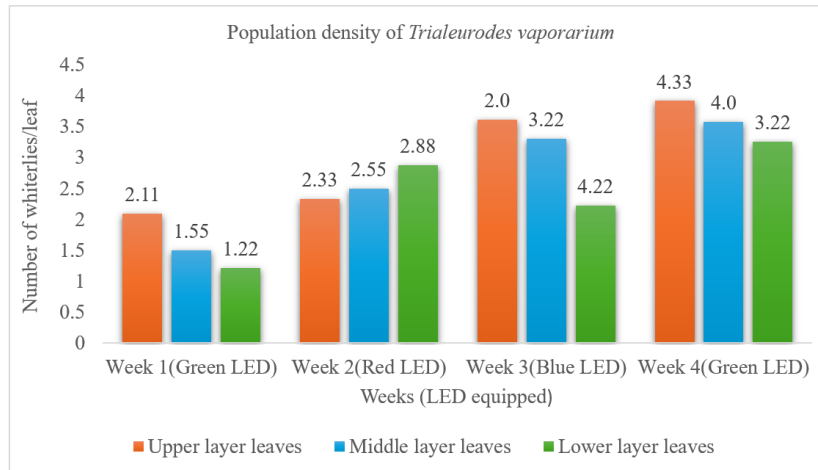


Figure 3: Showing the whitefly infestation in pea plants under Blue, Green, and Red LED lights in March.

Pesticide resistance, environmental contamination, and health hazards have prompted the search for safer and more sustainable alternatives (Desneux *et al.*, 2007; Sparks & Nauen, 2015). In this context, light-based pest control—particularly the use of LEDs—has emerged as a promising physical control method due to its energy efficiency, environmental safety, and species-specific attraction properties (Shimoda & Honda, 2013; Chu *et al.*, 2006).

Our study found no significant overall reduction in aphid and whitefly populations under different LED light treatments. However, the spatial distribution of pests varied across leaf layers depending on the LED color. Red LED light was associated with fewer aphids on upper leaf surfaces, whereas green and blue LEDs attracted more aphids to these areas. These results are in line with previous findings indicating that different insect species exhibit varying phototactic behaviors depending on light wavelength (Stukenberg *et al.*, 2018).

The three LED lights were found to be appealing to the population density of aphids and whiteflies. Light is an important cue for insect orientation and host location. The peak sensitivity of the greenhouse whitefly optical receptors occurred at 525 nm, around green light. The opponent mechanism of positive input from the green receptor coupled with negative input from the blue or UV receptor enables greenhouse whiteflies or aphids to differentiate various colors and thus respond differently. The experiment demonstrated a high attractiveness of green LED light for *T. vaporariorum* and its potential for improving trap efficacy under typical greenhouse conditions in comparison with yellow-colored card traps. Studies with combinations of the yellow traps and green LEDs, as well as those demonstrating a high attraction to green light-emitting diodes by *B. tabaci* and *T. vaporariorum* under dark conditions. Insects generally see in three specific colors: ultraviolet, blue, and green. Observed a strong positive response of the greenhouse whitefly *T. vaporariorum* (Westwood), occurring in yellow-green region (520-610nm) and a moderately positive response to ultraviolet (360-380 nm), whereas the blue light energy

(400-490 nm) inhibited greenhouse whitefly capture (Stukenberg *et al.*, 2019; Doring *et al.*, 2004; Briscoe *et al.*, 2001)

CONCLUSION

Farmers frequently use chemical insecticides, but as the pests develop resistance, the pesticides lose more and more of their effectiveness. These pesticides are toxic, and exposure to them can have a variety of negative health impacts in addition to lowering crop yields. The present study explored the influence of different LED light wavelengths on the behavior and distribution of two major greenhouse pests—aphids and whiteflies. While no significant reduction in overall population density was observed under different LED treatments, clear behavioral responses were recorded. Green and blue LED lights were found to be more attractive to both aphids and whiteflies, particularly influencing their presence on upper leaf surfaces. In contrast, red LED light showed a tendency to deter aphids from the upper canopy.

Overall, LED and UV light traps represent a sustainable alternative to chemical insecticides, especially in greenhouse and post-harvest storage systems. Future research should focus on optimizing wavelength combinations, evaluating long-term effects, and integrating light-based methods with biological and cultural control practices to achieve more comprehensive and effective pest management solutions

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