INSECT ORIENTATION TO VARIOUS COLOR LIGHTS IN THE AGRI-CULTURAL BIOMES OF FAISALABAD

M. Ashfaq, Rashid A. Khan*, M. Ahsan Khan, Fahad Rasheed* and Shahid Hafeez*
Department of Agri Entomology, University of Agriculture, Faisalabad.
*Department of Forestry, Range Management and Wildlife, University of Agricutlure, Faisalabad.

ABSTRACT

This experiment was conducted in the area of Punjab Agriculture Research Station (PARS) and Chak No.33 JB Faisalabad to evaluate the response insects to varying wavelengths of light. During experiment, lights of six different colors (blue, green, yellow, red, black and white) were tested. All lights were arranged in a line on agriculture land, close to Faisalabad Airport. Tree rows/blocks, forest nursery, fruit garden, wheat, maize and fodder crops were the main vegetative covers in the vicinity. Each selected color light was properly projected on $1m^2$ vertical screen (made of white cotton fabric) placed one meter high above the ground. All lights were kept on simultaneously for half an hour and the insects attracted on both sides of the screens were collected in tubs containing soapy water. At the end of experiment, the collection was shifted to properly labeled storage bottles for counting and identification into respective orders. The highest number of insects was observed in container placed under black light (ultraviolet light), while the lowest in that of red light. Similarly, the common insect orders frequented among all color lights were Diptera, Coleoptera and Lepidoptera respectively. The experimental results indicated that insects are attracted in more number on lights with short wavelengths and high frequencies and vice a versa.

INTRODUCTION

In Pakistan, pest control strategy is mainly based on chemical pesticides ultimately environmental hazards are arising fast. Highly toxic chemical pesticides are being added in the agro-ecosystem, which are damaging for all living beings. This situation invites the attention scientists to devise some non-chemical pest control technologies. In Western countries, light traps have been successfully used against house hold pests but this technology has been hardly tried on farmlands. This study has been conducted to identify the most effective light spectrum, which could attract higher number and diversity of insects on a screen at night (Baker and Sadovy 1978, Butler and Kondo 1991). This data could be highly valuable for designing a light trap to be used against crop insect pests.

To fully understand the concept of this experiment, background knowledge of light and insects is essential. There are seven colors in the light spectrum: red, orange, yellow, green, blue, indigo and violet. Six of these were used in the experiment (red, yellow, white, black, green and blue). These seven colors lights are known as visible lights (Henderson, 1996). Each light color has a different wavelength and frequency. Red has the longest wavelength and lowest frequency and violet has the shortest wavelength and highest frequency. The wavelengths of visible lights range from 400-700 nanometers (White, 1980; Ditchburn, 2001).

Insect are living entities with segmented body divided into head, thorax, and abdomen (Burnie, 1970). All insects belong to Class Insecta, which consists of almost 30 different orders. From agriculture point of view orders like Lepidoptera, Diptera, Hemioptera, Coleoptera and Orthoptera are considered to be more important (Burnie 1970, Pedigo 1996). Lepidoptera, also known as butterflies and moths, have two pairs of wings with overlapping scales, large eyes, and mouthparts specialized for sucking nectar from plant flowers. Diptera, which includes mosquitoes and black flies, normally have a single pair of wings and a structure that helps them maintaining balance during flight. Hemioptera, also named bugs and cicadas, are known for their sucking mouthparts, which help them to feed on plants and animal tissues. Coleoptera, also known as beetles and fireflies, are characterized by their hard bodies, chewing mouthparts. Adults normally have two pairs of wings. Orthoptera include grasshoppers and crickets. These are mostly ground devilling insects with chewing type mouth parts and two pair of wings (Borror and White 1970, Pedigo 1996).

All living beings have some weaker links in their lifecycle these could be exploited for controlling their populations. Phototropism in insect is one of the classic example that led to the fabrication of electrocutes to be used against house pest (Cantelo 1974). This is convincing that comprehensive research studies on insect response to different light spectrums be organized to generated useful data to be helpful in revolutionizing light trap technology for field use (Jessica and Curtis 2001).

METHODS

This experiment was conducted at night from 9.00 to 9.30 hours in the dark during the year 2004. In order to cover diversity of crops and forest vegetation (Chaudhry 1969), two areas i.e. PARS farm and Chak No.33 JB were selected for the layout of said experiment. All six lights were arranged in line at 6 meter apart from each other to let the insect to orientate toward their most favorite light color. All lights were simultaneously kept on for half an hour and each of them was suitably projected on white fabric screen. The fabric screens were placed separately on stands almost one meter high above ground to be visible from distance. Plastic tub containing soapy water was placed under each light to gather the attracted insects. Soft brush was used to push the insects down in tubes. At the end of experiment, insect material of each tub was transferred to properly labeled bottles (with color light, site, date and time etc.) containing 10% alcohol and collection was transferred to laboratory for identification (Chaundy 1999). In the laboratory, contents of each collection bottle were added in a large dish separately, exact number of insects was counted and each of them was identified for respective insect order (Pedigo 1996). The same procedure was adopted for all six collection bottles containing insect collection gathered at each light color. Most of the insects were identified by naked eye and field lens (10x) was also used where needed to confirm the diagnostic feature of smaller insects. The data were tabulated as percentages of insects attracted per light color and overall number of insect order collected at each light spectrum according to the following criterion (White 1989).

E1, E1a + E1b = T1 per light color→ AvT1 per light color→ Percentage of AvT1
E2, E2a + E2b = T2 per light color→ AvT2 per light color→ Percentage of AvT2
Percentage of AvT1+ Percentage of AvT2 = Av of the two percentages of two Experi.
Experiment one (E1), Replications (a,b), Total insects (T1, Average (Av), Experiment 2 (B2).

The materials used during experimentation included tube lights in six colors, storage tubs containing soapy water, fabric screens, storage bottles, source of electricity, small jars, forceps, brushes etc.)

RESULTS AND DISCUSSION

Table 1 and Table 2 represent the percentages of the total numbers of insects caught at each colored light. The experiments E1 and E2 were repeated twice at each site. Total collection of insects per light color was added up separately for each experiment and then percentage of insects attracted at each light spectrum was computed to be tabulated in Table 1 and 2. Finally the percentage of insects oriented toward different light colors during both experiments E1 and E2 were separately added for respective light colors to compute the cumulative percentage of insect attracted per light color for more comprehensive and precise results.

According to the cumulative percentages of insect collection gathered per light, the lowest number of insects has been attracted at red color light i.e. 2.3%. Back light attracted the highest figure of 46.5% insects. Blue light was rated to attract the second highest insect numbers of 20.35% during both the light experiments conducted at different sites. The Chi-square calculation of 3814 is greater than the chi-square critical value of 15.1 (d.f= 5, p.=0.01). This is a highly significant difference supporting the hypothesis that different wavelengths of light will attract different number and variety of insects (White 1989).

Table 1: Percentage of insects attracted at different colored light during night hours in the field area of PARS Farm from 21to 22.07.2004

Red	2.20%
Yellow	10.60%
Green	4.70%
White	18.00%
Black	42.10%
Blue	22.40%
Total insects caught	1020

Table 2: Percentage of insects attracted at different colored light during night hours in the field area of Chak No.33/ from 28 to 29.07.2004.

Red	2.40%
Yellow	8.50%
Green	3.10%
White	16.70%
Black	50.90%
Blue	18.30%
Total insects caught	2302

The data collected during both the experiments E1 and E2 have given similar results of insect orientation toward specific light colors in spite of the fact that the two experimental sites were distinctly located. This phenomenon certifies the validity of the generated data.

Table 3 shows the order vise distribution of insects attracted at red, blue and black lights. The ultimate aim of this research study was to identify the most effective light color that could attract the highest number of insects at night. Thus the field data strongly convince about black and blue lights to be highly effective in attracting diversity and number of insects and red light was the

Table 3: Total number of insects representing each orders collected at red, blue and black color lights.

Orders	Red		Blue		Black		Total	
	E1	E2	E1	E2	E1	E2	E1	E2
Lepidoptea	3	8	11	26	31	57	45	91
Diptera	18	41	72	152	87	189	177	382
Coleoptera	12	23	54	101	69	135	135	259
Ephemoptera	0	4	2	5	0	1	2	10
Hemioptear	4	9	12	22	23	43	39	74
Orthoptera	4	5	10	19	2	7	16	31
Dermaptera	1	7	20	39	14	27	35	73
Plecoptera	0	1	4	6	9	15	13	22
Total	42	98	185	370	235	474	462	942

lowest. It was necessary to segregate the insect collection of these three light colors into respective insect orders to provide useful information for further studies.

According to Table 3, all three lights have been found to attract almost all the eight insect orders, however the members of Diptera, Coleoptera and Lepidoptera were found to be attracted in higher number. The Dipterus insects were attracted in the highest number i.e. 189 and have been found responding black light whereas lowest number of 41 responded to red color. The Coleopterus insects were counted to be 135 and appeared as the second highest number on black light. Lepidopterus insects were rated to be at third place with the highest number of 57 insects. The data of both experiments E1 and E2 show that all insects followed the same pattern of attraction for all three colored lights (the red, blue and black (Jessica and Curtis, 2001).

In conclusion, the results of experiments E1 and E2, have been found to be highly convincing that red light with low frequency and high wavelength attract the lowest number of insects. Accordingly, the black light (ultraviolet) with high frequencies and low wavelength was observed to attract the highest number of insects. Similar pattern of insect orientation toward light has been observed by Luettich 2003 in his experiment conducted in Wilmington, North Carolina, USA, however, the number of insect responded was found to be less then present study (Jessica and Curtis 2001, Holyoak *et al*., 1997). This could be due to difference in the flora, local temperature and humidity which highly effect insect activity in any location.

My null hypothesis was that different insect orders didn't have differential attraction for various wavelengths of light. The chi-square test rejected this hypothesis because there was a clear difference between the calculated and the expected values, which supports our finding of this study. The results showed that most of the orders were attracted to blue and black lights (Thomas 1996). This attraction is merely due to shorter wavelengths and higher frequency while the red light is otherwise which makes it harder for the insects to detect. Insects have three special eyes, called ocelli, with the specific job of identifying light and not movement (Burnie 2003). The shorter the wavelengths are easier for the ocelli to detect (Henderson 1996, Burnie 2003).

Present study provides scientific information on insect attraction to different light spectrums and their order vise distribution with respect to light colors for two particular sites under specific environmental conditions of soils, temperature, humidity and flora. However, further input is required to investigate how temperature, elevation and other local conditions or locations affect insects respond to the lights (Hardwick 1972). For example, experiments could be done to see how temperature affects insect attraction to black light all the year round? How ambient humidity changes and affects the activity of insect orientation toward light? This must be taken as continuous research effort to generated scientific data to be useful in devising light traps for crop land to curtail the use of pesticides in the agro-ecosystem (McGeachie 1989, Korat and Lingappa 1995).

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