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Assessing the diversity of insect pests of grain legumes using different types of light traps

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ABSTRACT

A set of three types of light traps namely black light at rooftop, black light above ground, and normal light above ground were installed at five places of the open grain legumes cropping area of Grain Legumes Research Program, Khajura, Banke, Nepal from January to December, 2017 for evaluating comparative efficacy of light trap on monitoring the abundance, diversity and population trends of important insects with elevation and prevailing weather conditions. Black light trap was found more effective for monitoring vague diversity of insect species and their abundance than ordinary light trap. Placing black light trap at higher elevation further increased its efficiency to attract many species of night flying adult population (1419 adults comprising of 35 species) as compared to the same trap placed above ground level (766 adults with 35 species) and ordinary trap placed above ground level (701 adults with 33 species). Higher number of insect species (31) were captured in black light trap placed at higher elevation in spring night followed by clear night (22), rainy/cloudy night (10) and winter night (5), respectively. This indicates the abundance of insect population is higher in spring and reaching to few numbers in winter season. As the environment and cropping system is changing, continuous monitoring of insects is required to have their better estimates and information in advance for their management.

Keywords: Abundance, diversity, insect population, monitoring

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1 Introduction

Insects are remarkable groups of animals living in different ecological niches and habitats, i.e. forest, soil, pond, cultivated crops, river, ocean etc. and occupying over three-fourth of the total living beings on the earth (Yazdani and Agarwal, 1997). From the economic point of view, they are either beneficial or harmful to us. Beneficial insects like bees, silkworms, natural enemies, predators, parasites and pollinators etc. are helpful while harmful insects such as insects injurious to various crops, stored grains, including human, animals, birds etc. are problematic in many ways (Atwal and Dhaliwal, 2009). Harmful insects are production constraints in agriculture damaging our crops at various stages of the plants from sowing seeds to harvest and even during the post-harvest storage. Panwar et al. (1984) reported that ICRISAT has recorded 54 lepidopterans, four hemipterans, three coleopterans, 6 hymenopterans, two orthopterans, one dictyopteran and one odonatae through light trap catches utilizing light traps in pest management on their mandate crops.

Many insects (mostly nocturnal) are attracted towards artificial light (Beck and Linsenmair, 2006; Bhandari et al., 2018) and entomologist has been utilizing this phenomenon to capture night flying adult insects. In fact, light trap has been more and more popular for survey, detection and control of insect pest population in different crops and there has been a continuously increasing interest of scientists on the use of environmentally safe tools like light traps (Brehm and Axmacher, 2006; Panwar et al., 1984). Light traps can be of different design with varying source of light which have influence on the efficiency of insect catch (Intachat and Woiwod, 1999). The light trap has also been used to attract insect pests on seasonal and environmental basis (Beck and Linsenmair, 2006; Jonason et al., 2014; Nowinszky and Puskas, 2017). Furthermore, light traps are the most effective and safe tools used for the IPM purpose. In recent years, use of light trap occupied one of the important monitoring tool for nocturnal insects and as a component of IPM (Sharma and Bisen, 2013). Therefore, this study aims to assess the performance of different types of light trap to estimate population abundance, diversity and seasonal variations of insects at Grain Legumes Research Program, Khajura, Banke, Nepal with different elevation.

2 Materials and Methods

2.1 Study site

The geographical location of National Grain Legumes Research Program at latitude 28°6′35″ N, longitude 81°35′38″ E and altitude of 181 meter above sea level (masl). It has sub-tropical climate with cool winter (<6 °C temperature) and very hot summer (>40 °C temperature) with a relative humidity of 27-94%. The annual average rainfall is 1000-1500 mm.

2.2 Management of light traps

Three types of light traps namely black light trap at roof top, black light above ground level and normal light trap above ground level were installed as treatments to monitor adult insect catches in an open grain legumes cropping area at National Grain Legumes Research Program from January to December, 2017. These light traps were installed in five places of the field; one set at centre and four sets at corners of the field. One set consisted of three types of light traps; thus there were 15 light traps in total in the experiment. The observations were made once in a week from dusk to down in the fixed days. Adult insect population captured in each light trap overnight were collected and randomly divided into three groups for sorting, counting and identifying major insect and non-insect pests.

2.3 Estimation of diversity

Shannon-Wiener Insect diversity was calculated for insect collected from light traps with different seasonal variation. The types of diversity used here is α- diversity which is the diversity of species within a community or habitat.

$$H = -\sum P_i ln P_i \qquad (1)$$

where, H = Shannon-Wiener diversity index, P_i = Number of individuals of one species. It entailed dividing number of an individual species by the total number of all species. The lnP_i was natural logarithm (ln) of the value P_i. Finally, the symbol ($\sum$) implied summation of the outputs with the final value multiplied by negative one (-1).

2.4 Statistical analysis

The collected data of insects were compared and statistically analyzed with based on light trap types, position and climatic conditions prevailing over seasons. One way ANOVA was conducted for different insect's pests with the light traps situated at different position and light source from five places of field. Analysis of variance was also done for the number of species captured from different light trap with seasonal variations. Information was processed in the computer using Excel and SPSS 16 software program (SPSS, 2016). The significant differences between treatments were determined using the least significant difference (LSD) test at 1% or 5% level of significance (Gomez and Gomez, 1984; Shrestha, 2019).

3 Results

3.1 Assessment of insect population

Despite of many unknown insect species, only known 35 species of insects consisting of 9 orders with 24 families were trapped in light trap placed at different elevation (Table 1). In trapped insects population, 7 families of Lepidoptera, 3 families of Hemiptera , 3 families of Hymenoptera , 3 families of Coleoptera , 3 families of Orthoptera , 2 families of Diptera , 1 family of Homoptera , 1 family of Ephemeroptera and 1 family of Neuroptera were recorded. While comparing efficiency of light traps to capture insects, installed at different places, the black light trap at rooftop captured greater numbers of clearing moth population with mean occurrence number (2.67±0.33), followed by black light trap above ground leve1 (1.33±0.33), while the normal light above ground level did not attract any of this insect (F2, 8=24.00, P=0.001). Similarly, wild honeybee (mean occurrence number = 3.00, P=0.04), black hairy-caterpillar (mean occurrence number = 3.33 ± 0.33, P=0.03), *Earia* sp (mean occurrence number 1.33±0.33, P =0.03) and mole cricket (mean occurrence number 9.00±2.00, P=0.05) were captured in greater number by black light trap at roof top followed by black light trap and normal light trap installed above ground level and the result was statistically significant. ($F_{2,8}$=5.43, P=0.45). Therefore, placing black light trap at higher elevation further increased its efficiency to attract more number of night flying adult insect population as compared to the same trap and normal light trap placed above ground level (Table 2).

3.2 Insects diversity

With different seasonal variation, the black light trap installed at roof top captured higher number of total insects (1419) with greater species (35), followed by light trap above ground level (768 insects and 35 species) and the normal light trap above ground level (701 insects and 33 species), respectively. In spring season, higher insects number (550) with species (31) were captured in roof top with black light followed by clear night (139 insects and 22 species), rainy night (70 insects and 10 species) and winter (31 insects and 5 species), respectively. Minimum insect number (31) with species (2) were captured by normal light trap installed above ground (Table 2). Total diversity index (H) was found higher (2.443) in insects captured by black light trap installed at rooftop followed by above ground with normal light (2.328) and above ground with black light (2.317), respectively. The diversity index of insects captured with rooftop black light was found greater (2.157) in spring followed by rainy night (1.819), clear night (1.016) and winter (0.701), respectively.

3.3 Insect species

Higher number of insect species were collected in spring (25.67±2.37), followed by clear night (20.67±0.72), rainy night (8.67±1.09) and winter (3.33±0.72) on different light traps placed at different elevation with different condition of weather (Table 3). The number of insects trapped in different light sources with placements (rooftop and above ground) gave statistically highly significant result ($F_{2, 36}$=9.61, P<0.001). Similarly, the number of insects trapped in different light sources with seasons was found highly significant ($F_{3, 36}$=171.59, P<0.001). The interaction between light trap placement and season with the number of insects trapped on different sources of light gave statistically non-significant result ($F_{6, 36}$=1.53, P=0.21).

4 Discussion

Different light sources that attract nocturnal insects, emit a relatively large amount of UV radiation (blue fluorescent lights, black lights and mercury lamps) exert the strongest attraction (Aoki and Kuramitsu, 2007; Cowan and Gries, 2009). Light trap was used for a variety of purposes, ranging from the investigation in biodiversity, to pest monitoring, to taxonomic collection and for surveying a wide range of insect taxa (Baker, 1985; Beck and Linsenmair, 2006). Nielsen et al. (2013) also reported the exponential increase in the catch of pentatomid bug when black light trap was used.

Our study showed that the highest abundance of the insect was caught by the black light trap (BLT) placed at rooftop followed by trap with same source place at ground level than the trap with the ordinary trap placed at ground level. In the trapped insects' population, Lepidoptera was the dominant order with higher number but coleopteran, especially chaffer beetle was also caught in considerable number in BLT than the normal light source. Ashfaq et al. (2005) observed the highest number of insects in a container placed under the black light (UV light) and the lowest under the red trap. However, Dadmal and Khadakkar (2014) observed that Coleopterans were the dominating order caught. Similarly, Bhandari et al. (2018) reported highest caught insects were Coleopterans followed by Lepidopteron and Hemipterans in BLT. Our study suggests that a higher number of Lepidoptera may be due to more attraction for macrolepidoptera to the BLT with UV source (Nowinszky, 2013; Infusino et al., 2017) which may due to the prevalence of insects depending upon the vegetation of the area where light trap was installed and also the distance of the habitat of the Lepidopteran moth from the light source (Truxa and Fiedler, 2012). The black light trap at rooftop captured more numbers of insects like Clearing moth with mean occurrence number, wild-honeybee, black hairy-caterpillar, *Earia* ssp and mole cricket than the insect number captured by other two trap, separately. This result was similar to the result reported by Muirhead-Thomson (1991) that the black light had consistently caught higher abundance and a greater variety of insects during mid-April to mid-August than other trap. Black light trap captured higher number of Chaffer beetle adult (73.33±3.18) than normal light trap (60.33±4.33) when placed above ground level from January to December 2017. A similar performance was suggested by Kalleshwaraswamy et al. (2016) who collected 131 adults during the trapped period of 30 June -15 October 2013 using black light trap. Likewise, Dadmal and Khadakkar (2014) reported that in total 19 species of scarab beetle belonging to 10 genera were the prominent visitors of black light trap. The highest number of adult insects trapped in case of black light trap was chaffer beetle (405) where as it was only 22 from ordinary light trap (Thapa, 2007).

Our study revealed that the collection of insects was higher in the clear sky than cloudy sky because cloud cover reduces illumination (Bowden, 1982) of the light source because due to cloudy condition the sky glow which caused ecologically light pollution

Table 1. Capture of insects on different light traps with placement of various elevation

Common name	Family	Mean occurrence (No±SE)			F value	P value
		T1	T2	T3		
Black hairy caterpillar	Arctiidae	3.33 ± 0.33a	1.67±0.33b	2.67±0.33ab	6.33	0.03*
Cabbage leaf folder	Pyralidae	1.00±0.58a	1.00±0.00a	1.00±0.00a	0	1
Cabbage semi looper	Noctuidae	16.67±0.88a	17.67±0.88a	18.33±2.03a	0.38	0.7
Caster hairy- caterpillar	Arctiidae	0.33±0.33a	1.00±0.58a	0.33±0.33a	0.8	0.49
Chaffer beetle	Scarabaeidae	64.00±6.35a	73.33±3.18a	60.33±4.33a	1.95	0.22
Cutworms	Noctuidae	6.000±0.58a	7.33±0.88a	5.67±1.20a	0.91	0.45
Syntomids	Syntomidae	19.00±2.88a	17.67±2.73a	17.67±2.60a	0.08	0.93
Dusky cotton bug	Lygaeidae	2.00±0.58a	1.67±0.33a	1.00±0.00a	1.75	0.25
Eariassp	Nolidae	1.33±0.33a	0.00±0.00b	0.33±0.33ab	6.5	0.03*
Field cricket	Gryllidae	2.33±0.33a	2.00±0.58a	2.00±0.577a	0.14	0.87
Gram pod borer	Noctuidae	16.67±2.40a	20.67±2.40a	16.33±0.88a	1.4	0.3
Green bug	Pentatomidae	1.00±0.58a	1.000±0.58a	1.00±0.58a	0	1
Green leafhopper	Cicadellidae	0.33±0.33a	0.33±0.33a	1.33±0.33a	3	0.13
Ground beetle	Carabaedae	1.67±0.88a	1.000±0.58a	2.00±0.58a	0.54	0.61
Hawk moth	Spingidae	1.00±0.000a	0.33±0.333a	0.67±0.33a	1.5	0.3
Katydid	Tettigoniidae	0.33±0.33a	0.68±0.33a	0.33±0.33a	0.33	0.73
Mole cricket	Gryllotalpidae	9.00±2.00a	6.00±0.587ab	3.33±0.33a	5.43	0.05*
March fly	Bibionidae	70.68±2.60a	74.68±4.63a	66.00±4.51a	1.16	0.37
Red ant	Formicidae	2.33±0.88a	1.33±0.33a	1.33±0.88a	0.6	0.58
Rice case worm	Pyralidae	3.33±0.88a	2.33±0.33a	3.00±0.58a	0.64	0.56
Soybean hairy caterpillar	Arctiidae	2.67±0.333a	1.67±0.33a	2.00±0.58a	1.4	0.32
Tobacco caterpillar	Noctuidae	5.00±1.115a	6.67±0.88a	6.00±1.155a	0.61	0.57
Tabanid	Tabanidae	0.67±0.333a	0.67±0.33a	0.00±0.00a	2	0.22
Wite stem borer	Pyralidae	2.00±0.58a	2.33±0.33a	1.667±0.333a	0.6	0.58
Yellow Stem borer	Pyralidae	1.33±0.88a	0.33±0.33a	2.33±0.33a	3	0.13
Tiger beetle	Cicindellidae	6.00±1.53a	5.67±1.76a	5.67±1.45a	0	0.99
Rice earhead bug	Coreidae	1.67±0.67a	0.00±0.00a	0.33±0.33a	4.2	0.07
Armyworms	Noctuidae	1.33±0.33a	0.67±0.33a	0.33±0.33a	2.33	0.18
Barconids	Braconidae	1.67±0.33a	0.67±0.33a	0.67±0.33a	3	0.13
Cabbage leaf webber	Pyralidae	0.67±0.33a	0.333±0.333a	0.67±0.33a	0.33	0.73
Clearing moth	Sesiidae	2.67±0.33a	1.33±0.33b	0.00±0.00c	24	0.00**
Wild honey bee	Apidae	3.00±0.00a	2.00±0.000ab	1.00±0.577b	9	0.020*
Mayfly	Ephemeridae	2.00±0.00a	1.33±0.88a	0.67±0.33a	1.5	0.3
Neuropterans	Neuroptera	8.00±1.528a	6.67±0.88a	6.00±1.53a	0.57	0.59
Pyralids	Pyralidae	1.33±0.33a	1.33±0.88a	1.67±0.88a	0.07	0.94

Data comprised of average number of insects of different species on three light traps placed at five different places observed weekly during 2017. Same letter for mean incidence are not significantly difference ($P \leq 0.05$). ** = highly significant at $P \leq 0.01$,*=significant at $P \leq 0.05$; T1=At rooftop with black light, T2=Above ground with black light, T3= Above ground with normal light

Table 2. Total abundance and Shannon-Weiner diversity index of insects collected on three light traps placed at different height for different seasonal variations at five places of field

Seasonal parameters	No. of species			No. of insects			Diversity index (H)		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Spring	31	25	21	550	531	139	2.157	1.944	2.154
Winter	5	3	2	31	34	32	0.701	0.346	0.311
Clear night	22	21	19	139	133	124	1.016	1.247	1.169
Rainy/cloudy night	10	10	6	70	70	61	1.819	1.227	1.157
Total	35	35	33	1419	768	701	2.443	2.317	2.328

T1=At rooftop with black light, T2=Above ground with black light, T3= Above ground with normal light

Table 3. Mean number of species collected on light traps at different source of lights placed at different elevation with different condition of weather parameters at five places of field

Seasonal parameters	Average number of species (No±SE)
Spring	25.67±2.37a
Winter	3.33±0.72d
Rainy/cloudy night	8.67±1.09c
Clear night	20.66.33±0.72b
Light traps	0.001**
Season	<0.001**
Light traps × season	0.21ns

Data comprised four seasonal parameters and three light traps placement (at five locations of field) observed weekly on number of insect species trapped in different light trap placed at three places during 2017and on insect occurrence. Same letter for mean incidence are not significantly difference ($P \leq 0.05$). ** = highly significant at $P \leq 0.01$,*=significant at $P \leq 0.05$, ns = non-significant.

and amplify the degree of luminance of the sky which ultimately disrupts the natural cycle and impact the behavior of organisms far from the light sources (Kyba et al., 2011). This was further evidenced by the study by the Nowinszky (2010) where they found that increase of cloud cover results in a reduction of the insect catch. They further found out that the number of the Macrolepidoptera individuals are caught higher in a clear sky. In our light trap experiment the catch was higher in spring than winter where Nowinszky et al. (2012) also noted that the efficiency of light traps increases with higher temperature and a high proportion of polarized moonlight which occurs mainly in spring and summer than autumn and winter.

Among different types of the light trap, the black light trap is used for collecting many insects that are active and flying at night and are attracted to UV light. They have consistently caught a higher abundance and greater variety of insects than other traps (Neupane, 1985; Muirhead-Thomson, 1991; Bhandari et al., 2018). Their key feature is the low wave length light attractant, which lures a diversity of flying insects from the surrounding habitat. Attracting nocturnal insects with ultraviolet light is now in general use and presents the most effective collecting method for nocturnal species of the orders; Coleoptera, Orthoptera, Lepidoptera, but also for many species of Hymenoptera, Diptera, Neuroptera (Sotthibandhu and Baker, 1979). Light trap catching of insects in the past has shown encouraging results with a reduction of their population in various crops. Patel et al. (1981) reported that Gujarat hairy caterpillar, *Amsacta* spp. a serious pest of Kharif crop was controlled by using a light trap continuously for five years and the white grub, *Holotrichia consangnuinea* Blanch, the population was reduced to more than 50% through light trap catching of adults in India. Light trap not only used for a survey of insects, in addition, could be a useful component of IPM (Sridhar and Kumaran, 2018) to reduce the pest population which ultimately reduces the use of pesticides maintaining ecological balance. In this regard, if the source of artificial light prevails, a light trap can be one of the best monitoring and management tools for the insect pests of crops, which are attracted by lights.

5 Conclusion

The black light trap has captured more number of insect species, families and orders than normal light trap. Placing black light trap at higher elevation further increased its efficiency to attract many species of night flying adult insect population as compared to the same trap placed above ground level and ordinary trap placed above ground level. Thus, it can be concluded that monitoring of insect species with black light trap placed at higher elevation can provide through knowledge of insect arthropod composition of an agro-ecosystem, there by identification of pest species, their economic level to start management strategy.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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