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Moth Repellent Yellow-Specific Bulbs for the Management of Lepidopteran Pod Borers and Leaf Eating Caterpillars on Vegetable Pest Management Programs in Sri Lanka

K.M.D.W.P. Nishantha[1], W.R.G.M.I. Siriwardhana[1], L.G.S. Kumari[1], K.V.A.I.K. Vithana[1], W.M.D.K. Wijerathnayake[2], M.G.N. Sandamalee[3],

[1]Horticultural Crops Research and Development Institute, Gannoruwa, Sri Lanka
[2] Plant Protection Service, Gannoruwa, Sri Lanka
[3]Provincial Department of Agriculture, Central Province, Peradeniya, Sri Lanka

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***Abstract*—*The study was conducted research field at Horticultural Crops Research and Development Institute (HORDI), Gannoruwa, Sri Lanka and different farmer fields to determine the efficacy of yellow bulbs during nights for the management of lepidopteran Pod borers and leaf eating caterpillars on brinjal, okra and cabbage. Three research field experiments at HORDI, Gannoruwa during, 2018 Minor (Yala), 2018/2019 Major (Maha) and 2019 Yala and-farmer field demonstrations were conducted to determine the effectiveness of the yellow bulbs for the management of Brinjal Shoot and Pod Borer, Okra pod borer and Cabbage leaf eating caterpillars. Research fields measuring 100 m^2 – 200 m^2 were selected for each treatment at ~~the~~ HORDI research fields and 1,000 m^2 fields for farmer field demonstrations. Yellow LED bulbs (at the rate of nine 1.5W bulbs /1,000 m^2 were installed . Replication were done by dividing each plot into four sub-plots. Lands were prepared and bulbs were installed in the yellow bulb treatments and planting was done each plot. Data were recorded from randomly selected twenty plants from each sub plot for pest damage in weekly intervals. Yield was recorded at harvest to measure the yield loss due to pest damage. Data revealed that fields illuminated with yellow bulbs has given significantly low number of pest damage in each crops. It was reported from the cabbage experiment conducted during yala 2018, significantly low number of caterpillar damage in yellow bulb treatment compared to untreated control and chemical treatment. Similar results gave from the experiment conducted during Maha 2018/2019 for the same crops. Results of the experiment conducted against the okra pod borer during Yala 2019, revealed that significantly low-percentage of pod damage on plots exposed to yellow light. Field trials conducted on farmer fields and research farm further confirmed the results with low number of pest damage on okra and brinjal crops.*

***Keywords*— Specific Yellow Bulb, Okra pod borer, Cabbage caterpillars, Brinjal shoot and pod borer**

I. INTRODUCTION

Damage caused to vegetables by noktunoid lepidopteron larva is a serious issue in sustainable vegetable production in Sri Lanka. Among them okra, tomato and brinjal pod borers and leaf eating caterpillars of Cabbage are the major pests damaging to the marketable harvest of these crops **(Nishantha *et al.*, 2017)**. There are several species of lepidopteron pod borers, such as *Earias vittella*, (the Okra shoot and pod borer), *Helicoverpa armigera*, (the tomato fruit borer) and *Leucinodes orbonalis*, (the brinjal pod borer) . Among the leaf eating caterpillars *Spodoptera litura*, *Hellula undalis*, *Chrysodeixis eriosoma*, *Crocidolomia binotalis* and *Plutella xylostella* are most harmful ~~to~~ pests of cabbage. Farmers indiscriminately use heavy doses of insecticides, especially IGRs for the management of these pests **(Nishantha *et al.*, 2017)**. Therefore, most of theese vegetables available in the market may be contaminated with pesticide residues **(Gapud and Canapi 1994; Orden *et al*., 1994)**.

The use of “yellow-specific lamp to repel caterpillars that are harmful to leaves and fruit/pods” are one of mature technologies use in green houses in Japan to avoid damage caused by these nocturnoid lepidopteran moths. The Most specific features of this yellow color bulbs are Nocturnoid lepidopteron specificity with emitting yellow color, regulated with 570 – 590 nm wavelength, which is detect by the moth during nights and when its blinking during nights, the moth compound eyes determine it as day time and it will stop come into crop for egg laying **(Shimoda M & Honda K, 2013)**.

Therefore, with worldwide information and the published fact on this product, The Horticultural Crops Research and Development Institute of the Department of Agriculture initiated research programmes to introduce “Novel High tech introductions for pesticides free Agriculture” for the country in management of pests specially pod borers and leaf eating caterpillars without using-pesticides.

The experiments were started on research fields at HORDI and a few farmer fields to test the effectiveness of the yellow light for managing **nocturnoid** Lepidopteran pest of Cabbage, brinjal and okra during growing seasons of 2018 *Yala*, 2018/2019 *Maha* and 2019 *Yala*.

II. METHODOLOGY

2.1 Research Field Experiments

Three seasons experiments were conducted for cabbage and okra. Three large plots were prepared, each with 100 m^2 – 200 m^2 area. Each plot was divided into four sub plot for replication. Yellow bulbs were installed as the First treatment at the rate of 9 bulbs (1.5 W) /1,000 m^2 (570-590 nm/ emitting color yellow- blinking) and insecticide treated and untreated control plots were also maintained.

During the bulb installation, the distance between two bulbs were kept 7 to 10 meters and height of the bulbs from the crop canopy was kept about 2 to 2.5 m above from the crop (Plate 01 and Plate 02). All the plots treated with yellow bulbs were established with 40 mesh insect proof nets around the field to avoid entering of other pest species damaging to these crops. Crops were established and lights were switch on every day at 6.00 pm and switch off on the following day at 6.00 am. The plots designated for insecticide applications were treated with recommended insecticides in seven day intervals.

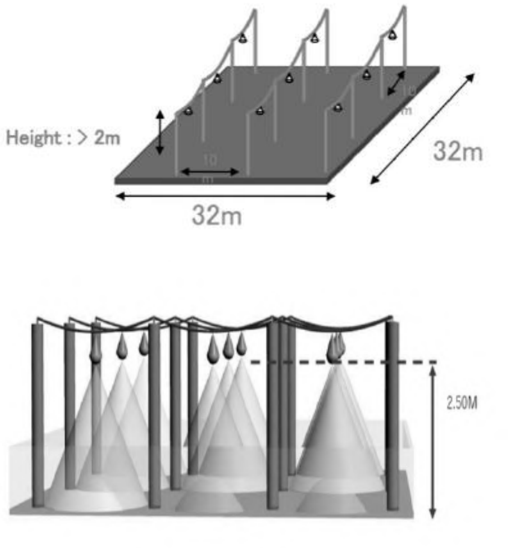

Plate 01: Dramatic Installation of the installation technique of the yellow bulbs for 1000 m^2 area, field layout and height of the bulbs to installed

2.2 Farmer Field Experiments

Three experiments were conducted in three locations in three different time periods. Three large plots were prepared, each measuring 1,000 m^2. Nine bulbs were installed according the layout given in the plate 01 and plate 02. Physical barriers for other pests were made by establishing forty mesh insect proof nets were placed around the field and crops were established. Lights were switch on every day at 6.00 pm and switch off following day 6.00 am. Insecticide treatment were treated with recommended insecticides in seven day intervals. Data were recorded all the treatments according the procedure followed at research field experiments. All treatments were replicated three times, and the crop yields, insect populations were subjected for ANOVA.

III. RESULTS

3.1 EXPERIMENT 1: Effect of yellow-specific bulbs to repel Cabbage caterpillar complex during *Yala* 2018 season

The data on Table 01 revealed that highest number of larva were recorded from untreated control and it was significantly higher than the other treatments. The lowest number of larva were recorded from yellow bulb and it was not significantly different to the chemical control. Larger population of *Crocidolomia binotalis* and second highest was *S. litura*. However, the most serious pest, *P. xylostella,* diamondback moth caterpillar larva was recorded in lowest numbers this season in all the treatmented plots

According to results (table 02) highest yield was recorded from the plots exposed to Yellow bulb treatment (39.375 t/ha) and lowest was recorded from the Chemical control treatment (14.676 t/ha). Marketable yield (28.035 t/ha), marketable leaf weight (8.325 t/ha) were highest on treatments with yellow bulb and lowest was from plots treated with Flubendiamide 20% SG. The main reason for lowest yield from chemical treatment field was due to prevailed water logging condition of the plot. Therefore, plants were not grown well and heads were not formed properly.

Table 01 - Total Number of different types of larvae per ten on cabbage crop on different treatments - Yala 2018 season HORDI, Gannoruwa

Treatment	***Spodoptera litiura****	***Crocidolomia binotails****	***Crisodeixis erisoma****	***Plutella xylostella****
T_1 - Yellow bulb	2.5	2.25	1.25	1
	(1.6975 b)	(1.6075 b)	(1.1900 a)	(1.0625 b)
T_2 - Flubendiamide 20% SG (recommended rate)	4.0	4.25	1.5	0
	(2.10 b)	(1.9425 b)	(1.2475 a)	(0.7100 b)
T_3 - untreated Control	10.0	70.0	1.5	10.5
	(3.1925 a)	(8.335 a)	(1.2475 a)	(3.2850 a)
CV	18.26	27.69	39.75	33.84

*$\sqrt{X+0.5}$ values were subjected to analysis and are given within the brackets

* Mean values within a column followed by the same letter(s) are not significantly different at p<0.05 based on the LSD test

Table 02 - Yield data of the cabbage crop at the end of the Yala 2018 season (HORDI, Gannoruwa)

Treatment	**Total weight (t/ha**	**Marketable yield (t/Ha)**	**Marketable leaf weight (t/Ha)**	**Undamaged weight (t/Ha)**	**Damage weight (t/Ha)**
Yellow bulb	39.375	28.035	8.325	36.362	3.013
Flubendiamide 20% SG	14.676	6.585	5.089	11.674	3.001
Control	25.335	12.165	6.428	18.594	6.741

Table 03 - Summary of the different types of larvae per ten plants in each treatment during Maha 2018/2019 (HORDI, Gannoruwa)

Treatments	***Spodoptera litura***	***Crocidolomia binotails***	***Chrysodeixis erisoma***	***Plutella xylostella***	***Aphids***
Yellow bulb	4.00	1.00	0.33	-	235.67
	(2.11 a)	(1.17 a)	(0.88 a)		(15.25 b)
Azidaractin 5% EC	12.67	1.67	2.67	-	62.67
	(3.61 bc)	(1.26 a)	(1.77 bc)		(7.81 a)
Spinosad 2.5 % SC	14.33	6.33	2.00	-	94.67
	(3.85 c)	(2.61 c)	(1.56 b)		(9.73 a)
Flubendiamide 20 % SG	6.00	5.67	3.67	-	111.00
	(2.51 ab)	(2.48 bc)	(2.04 c)		(10.43 a)

Control untreated	18.33 (4.22 c)	59.00 (7.67 c)	10.00 (3.24 d)	-	630.33 (24.97 c)
CV	19.44	23.30	11.15	-	15.88

*√X+0.5 values were subjected to analysis and are given within the brackets

* Mean values within a column followed by the same letter(s) are not significantly different at p<0.05 based on the LSD test

The data on Table 03 indicating highest number of larva from untreated control and it was significantly higher than the other treatments. The lowest number of larva were recorded from yellow bulb and it was significantly lower than the chemical control and untreated control. Highest number of caterpillar type was *C binotalis* and second highest was *S litura*. Most importantly no diamondback moth caterpillar larva was recorded from any treatment in this season too. However, in addition to the larval caterpillars, aphids were recorded in higher numbers in all the treatments. This was significant in yellow bulbs treatment (235.67) compared to other insecticides treatments and significantly lower compared to the untreated control (630.33).

Table 04 - Summary of the number of different types of natural enemies per ten plants in each treatment during Maha 2018/2019 HORDI Gannoruwa

Treatments	***Natural enemies of aphids***	***Spider spp.***	***Ladybird spp.***
Yellow bulb	20.67 (3.97 a)	4.67 (2.11 a)	0.66 (1.05 a)
Azidaractin 5% EC	5.67 (1.87 a)	2.67 (1.61 a)	0.00 (0.71 a)
Spinosad	2.00 (1.48 a)	4.67 (2.27 a)	0.33 (0.88 a)
Flubendiamide 20% SG	29.33 (3.94 a)	6.33 (2.61 a)	1.33 (1.29 ab)
Control	12.67 (3.53 a)	5.33 (2.39 a)	3.33 (1.89 b)
CV	99.00	32.52	34.44

*√X+0.5 values were subjected to analysis and are given within the brackets

* Mean values within a column followed by the same letter(s) are not significantly different at p<0.05 based on the LSD test

According to data on table 04, higher number of natural enemies were recorded from yellow bulb treated fields and it was not significantly different from other four treatments. However, highest number natural enemies as aphids' natural enemies. It may be due to high population of aphids record on yellow bulb treatment. Natural enemies recorded can be categorized as surphid flies, ladybirds, spiders and parasitoid, *aphidius* spp. Highest yield loss was recorded from untreated control treatment (Fig 01) and lowest yield was recorded from yellow bulb treatment. However, yield loss due to chemical treatments were also reduced compare to the untreated control and it was comparatively high compare? to the yellow bulb treated plots.

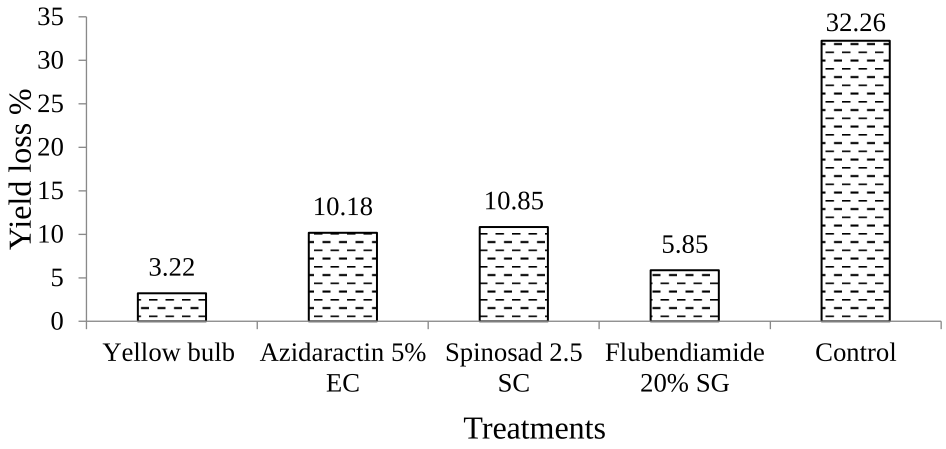

Fig.1: Percentage yield loses at the end of the Maha 2018/2019 season on cabbage

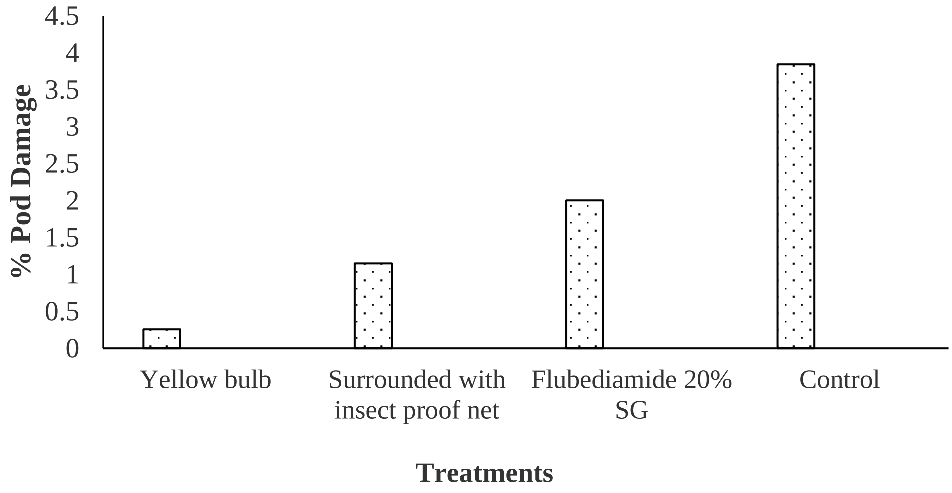

Fig.2 - Percentage Pod damage at the end of the Yala 2019 season in each treatment on okra crop

3.3 EXPERIMENT 3: Effect of Use of yellow-specific bulbs to repel okra pod borer, *Earias vitella* during Yala 2019

The okra trial in Yala 2019 reveled the number of pod damage (Figure 02) plots treated with yellow bulbs gave lower yield loss compared to the other treatments. However, highest pod damaged was recorded from untreated control and it was significantly higher compared to Yellow bulbs and chemical control treatment.

3.4 FARMER FIELD DEMONSTRATIONS

Table 05 - Effect of yellow-specific bulbs to repel different caterpillars on different seasons at farmer fields

Location	Season/time period	Treatment	Total yield (Kg/1000m^2)	Damage yield (Kg/1000m^2)	% Damage
Manik~~k~~hinna, Kandy	*Yala* 2022	Yellow bulb	719	48	6.67
		Control	373	45.6	12.23
Palugaswawa, Anuradhapura	*Yala* 2022	Yellow bulb	346.5	3.5	1.01
		Control	257.2	31.3	12.17
Madurankuliya,	*Yala* 2020	Yellow bulb	691.6	18	2.60

Kalpitiya		Control	691.25	51.38	7.43
Gampaha, Meerigama	*Yala* 2018	Yellow bulb	2975	0	0
		Control	1785.2	175.8	9.84

Farmer field demonstrations further confirm the results of the research field experiments, that plots treated with yellow bulbs has given significant reduction in yield losses. Data from all the five locations indicate that higher yield from yellow bulb treatment compared to the control treatment.

Plate 02: Cabbage Field during Yala 2018

Plate 03: Cabbage Field during Maha 2018/2019

Plate 04: Okra Field during Yala 2019

Plate 05: Brinjal Field during Yala 2020

Plate 06: Field layout of the farmer field Meerigama

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IV. DISCUSSION

According to **Nomura (1967)**; **Nomura *et al*. (1965)**, Fruit-piercing moths such as *Eudocima tyrannus* Guene and *Oraesia emarginata* Fabricius damage fruit in orchards in Japan.

They were able to manage the damage by successively using yellow fluorescent lamps in the orchard at night. Therefore, this strategy was clearly explained by **Meyer-Rochow, 1974; Walcott, 1969** that when moths encounter light above a certain brightness at night, under which their compound eyes are light-adapted as in the daytime. The light adaptation suppresses nocturnal behaviors such as flying and mating.

Therefore, in this study effect of yellow LED bulbs for the management of Pod and fruit borers and leaf eating caterpillars has proven the success. In this study we were manage major pest of okra, brinjal and cabbages under yellow bulbs. According to **Yase *et al.* 1997** and **Yase *et al.* 2004** this technique has also practice to prevent damage to chrysanthemums and carnations by the cotton boll worm *H. armigera*, damage to green perilla by the common cutworm *S. litura* , and damage to cabbage by the webworm, *H. undalis* .

It is also elaborate from the references from **Yamada *et al*. 2006**; **Kono and Yase 1996**; **Yase *et al*. 1997,** recently, green fluorescent lamps have also been developed for the control of nocturnal moths. Agreeing to them, these lamps suppress the behavioral activity of a number of moth species in the same way as yellow fluorescent lamps but have little effect on the growth of plants compared to the yellow lamps. Consequently, LED lighting is becoming considerably cheaper and therefore, it is becoming very practical and cheaper method for the yellow-emitting LEDs applied to control the behaviors of nocturnal moths (**Hirama *et al*., 2007; Yabu 1999; Yoon *et al*. 2012**). Also with the possibility of LEDs can produce highly unicolor lights (i.e., with a narrow range of wavelength) through the spectrum from UV to red, this character of LEDs is an advantage for controlling pest behavior and their practical application is expected in the near future **(Shimoda & Honda, 2013)**.

V. CONCLUSIONS

The field experiments conducted in three seasons, indicated that the moth repellent yellow bulbs successfully control the Lepidopteran Pod Borers and leaf eating caterpillars. These bulbs found to be effective if they are illuminated throughout the cropping season according to the given recommendations. Field observations has shown no side effects on the other organisms especially natural enemies in the environment. Therefore, the technology can be introduced as a component of Integrated Pest Management programs, it also can be recommended to use under organic farming system and ecofriendly agriculture systems as a component of pest management tool.

REFERENCES

[1] Gapud VP, Canapi BL. 1994. Preliminary survey of insects of onions, eggplant and string beans in San Jose, Nueva Ecija. Philippines Country Report, IPM CRSP – First Annual Report. http://www. oired.vt.edu / ipmcrsp / communications / annrepts / annrep94 / Phil_country_rpt.html

[2] Hirama J, Seki K, Hosodani N, Matsui Y (2007) Development of a physical control device for insect pests using a yellow LED light source: results of behavioral observations of the Noctuidae family. J SHITA 19:34–40

[3] Kono S, Yase J (1996) Characteristic of physical control and using technology. Utilization of color sense of insects. Prant Prot 50:30–33

[4] Meyer-Rochow VB (1974) Fine structural changes in dark-light adaptation in relation to unit studies of an insect compound eye with a crustacean-like rhabdom. J Insect Physiol 20:573–589

[5] Nishantha KMDWP, AL Sandika, AGC Babu, HASN Hettiarachchi, K Pushpanjali, PD Abeytilakeratna, MM Nugaliyadde (2017). Farmers' knowledge and attitudes on pesticide usage in vegetable cultivation in Sri Lanka, Tropical Agricultural Research & Extension 19 (2): 244 – 252.

[6] Nomura K, Oya S, Watanabe I, Kawamura H (1965) Studies on orchard illumination against fruit-piercing moths. I. Analysis of illumination effects, and influence of light elements on moths' activities. Jpn J Appl Entomol Zool 9:179–186

[7] Nomura K (1967) Studies on orchard illumination against fruit-piercing moths. III. Inhibition of moths' flying to orchard by illumination. Jpn J Appl Entomol Zool 11:21–28 (in Japanese with English summary)

[8] Orden MEM, Patricio MG, Canoy VV. 1994. Extent of pesticide use in vegetable production in Nueva Ecija: Empirical evidence and policy implications. Research and Development Highlights 1994, Central Luzon State University, Republic of the Philippines. p. 196-213.

[9] Shimoda M, Honda K (2013). Insect reactions to light and its applications to pest management, Appl Entomol Zool (2013) 48:413–421.

[10] Walcott B (1969) Movement of retinula cells in insect eyes on light adaptation. Nature 223:971–972

[11] Yabu T (1999) Control of insect pests by using illuminator of ultra high luminance light emitting diode (LED). Effect of the illumination on the flight and mating behavior of *Helicoverpa armigera*. Plant Prot 53:209–211

[12] Yase J, Yamanaka M, Fujii H, Kosaka S (1997) Control of tobacco budworm, *Helicoverpa armigera* (Hubner), beet armyworm, *Spodoptera exigua* (Hubner), common cutworm, *Spodoptera litura* (Fabricius), feeding on carnation, roses and chrysanthemum by overnight illumination with yellow

fluoresent lamps. Bull Natl Agric Res Cent West Reg 93:10–14

[13] Yase J, Nagaoka O, Futai K, Izumida T, Kosaka S (2004) Control of cabbage webworm, *Hellula undalis* Fabricius (Lepidoptera: Pyralidae) using yellow fluorescent lamps. Jpn. J Appl Entomol Zool Chugoku Bra 46:29–37

[14] Yamada M, Uchida T, Kuramitsu O, Kosaka S, Nishimura T, Arikawa K (2006) Insect control lighting for reduced and insecticide-free agriculture. Matsushita-Denko-Giho 54(1):30–35

[15] Yoon JB, Nomura M, Ishikura S (2012) Analysis of the flight activity of the cotton bollworm *Helicoverpa armigera* (Hubner) (Lepi-doptera: Noctuidae) under yellow LED lighting. Jpn J Appl Entomol Zool 56:103–110.