Activity of Two Photosensitizer Compounds for Sustainable Control of the Egyptian Cotton Leafworm, *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae)

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ABSTRACT

Activity of two photosensitizer compounds were studied on different stages of *Spodoptera littoralis* under laboratory conditions. Copper chlorophylline and magnesium chlorophylline as a photosensitizer compounds with different concentrations were tested on *S. littoralis* immature stages, egg, larvae and pupae. Data showed that copper chlorophylline has a slight effect while magnesium chlorophylline has no effect on egg stage of *S. littoralis*. The copper chlorophylline was more toxic on 2nd and 4th instar larvae than magnesium chlorophylline under both dark and photo conditions. Therefore, both compounds were more toxic under sunlight than dark conditions when pupae were immersed at different concentrations of the both photosensitizers' compounds. These results reflected that photosensitizers could be a potentially effective for *S. littoralis* control in Egypt.

Key words: Photosensitizer; Sustainable Control; Cotton Leafworm; *Spodoptera littoralis*

INTRODUCTION

The Egyptian cotton leafworm, *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) is considered as a serious agricultural pests that can attack important crops and causes considerable damage throughout the year in Africa, Asia and Europe (Pineda *et al.* 2007; Shairra and Nouh, 2014). In addition to the cotton, the *S. littoralis* larvae attack a critical plant species belonging to 40 families causing considerable losses of the infested crops. The spacious application of commercial insecticides to control this pest led to development of resistance to this chemical insecticides (Ishaaya *et al*., 1995). Furthermore, Chemical insecticides frequently show distasteful side effects. For instance, notable toxicity has been noticed in nontarget organism's *e.g.* beneficial insects, fish, or mammals. Chemical insecticides also affect human health, as their toxic residues can remain in drinking water and be accumulated in the food cycle. At the present time, there is a need for novel environmental friendly control strategies to suppress *S. littoralis* population.

As a result of an increasing world population, a 70% expand in global food production is needed, requiring sustainable intensification of agricultural production. One of a promising unconventional insecticides is using the photoactive substances for controlling insect pests (Filiberti *et al*., 2009; Dondji *et al*., 2005). These substances are known as Photosensitizers which are converted into a toxic photoproducts (Spikes, 1986). Photosensitization includes activation of light-sensitive compounds, which producing chemical reactions that cause damage or demolish for the cells. The photosensitizing catalyst by sunlight or artificial light sources irradiation (Ben Amor *et al*. 2000) have been shown to be cumulatively in remarkable significant amounts by a diversity of insects when they are administered in association with suitable baits. The aim of this study was to evaluate the efficiency of photosensitizers including; Copper chlorophylline and Magnesium chlorophylline as photoinsecticides were applied on the different immature stages of *S. littoralis* to determine their effectiveness for *S. littoralis* management.

MATERIALS AND METHODS

Insect culture

Laboratory strain of *S. littoralis* used in this study has been reared in the laboratory in the absence to any insecticides as described by El-Defrawi et al. (1964).

Chemicals

Two photosensitizer Copper chlorophylline (Cu) and Magnesium chlorophylline (Mg) were taken out from laboratory of stored product insects, Department of Economic Entomology and Pesticides, Faculty of Agriculture Cairo University.

Bioassays of Photosensitizer in *S. littoralis* stages

Toxic effect on egg stage

Toxicity of the two photosensitizer (Copper chlorophylline and Magnesium chlorophylline) under dark and photo conditions were tested on two egg masses of different ages (24 and 48 h old). Stock solution (1 mg/L) of each testing compounds was diluted with water to get a serial concentrations of 0.01, 0.001, 0.0001 and 0.00001 mg/L (ppm). Small pieces of egg batches papers were cut and dipped for 5 second in each concentration. The treated and untreated (which dipped in only water)

eggs were taken to a clean petri-dish after drying and kept at 25±1 °C, 70±5% RH. The mortality of treated eggs was calculated daily till 5 days post-treatment.

Lethal effect on larval stage

Susceptibility of 2nd and 4th instar larvae of *S. littoral* to Copper chlorophylline and Magnesium chlorophylline under dark and photo conditions were investigated by using the leaf dipping technique. Four different concentrations from each compound; 0.01, 0.001, 0.0001 and 0.00001 mg/L (ppm) were prepared. The castor bean leaves were immersed in each concentration for 20 second, while control leaves were treated with Tab water. After drying, a pair of leaves was placed into a glass jar (0.5 L) with larvae (Hamada *et al.,* 2018). Four replicates (25 larvae/ replicate) for each concentration were allowed to feed on treating leaves for 24 hrs. Then, the larvae were transferred to a clean glass jar to fed on untreated leaves. Mortality percentage was recorded after 4 days after treatments (96 hrs post-treatment).

Activity on pupal stage

The serial concentrations of both photosensitizer, which described above were used to test their activity on the pupae (24 h old) of *S. littoralis*. Three replicates (10 pupae/ replicate) were used. Mortality of pupae and adult emergence were taken and recorded daily till a period of 10 days.

Statistical Analysis

Data were analyzed with the aid of the regression analysis and one way ANOVA (the d.f., F and P-values were established) included in the Graph Pad Prism 4 software (Graph- Pad Software Inc., La Jolla, CA).

RESULTS

Ovicidal activity of Photosensitizer compounds

Effect of photosensitizer compounds on two different egg ages of *S. littoralis,* under sunlight and dark conditions, was presented in Figure 1 and 2. The results showed that the mortality was about 32% and 32% in eggs (24 h old) that were treated with the copper chlorophylline (Cu) at 0.01 mg/L under sunlight and dark conditions, respectively. While, the mortality was 23% and 25% in eggs (48 h old). In contrast, there was no effect on both egg masses' ages after treated with magnesium chlorophylline (Mg), data doesn't shown.

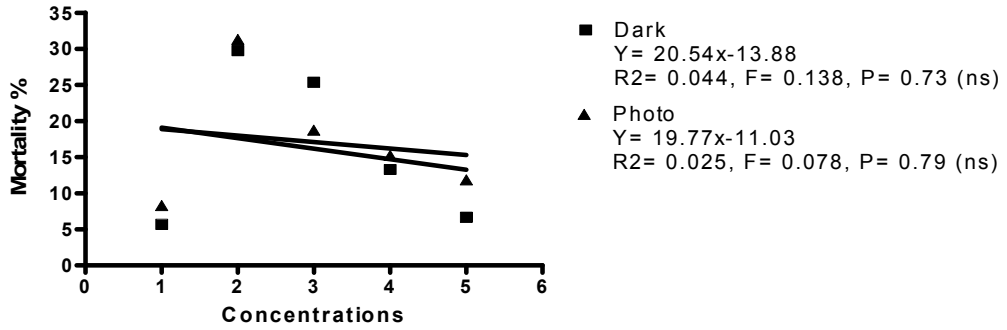

Fig. 1: Effect of different concentrations (1=control, 2=0.01, 3=0.001, 4=0.0001, and 5=0.00001 mg/L) of photosensitizer (Cu) on egg masses (24 h old) of *S. littoralis*.

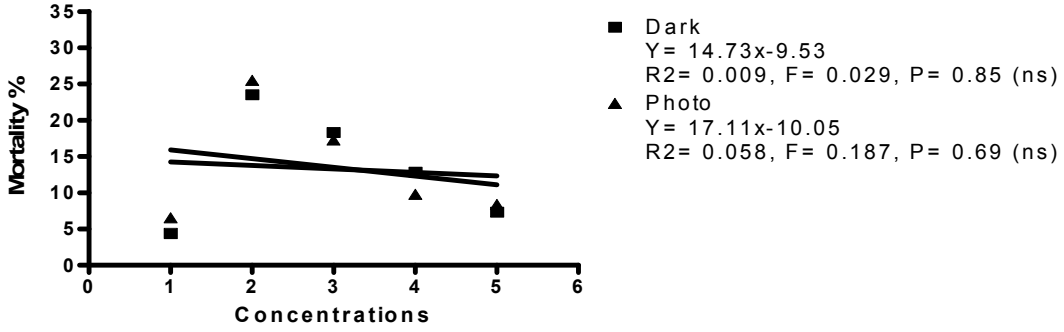

Fig. 2:

Fig. 2: Effect of different concentrations (1=control, 2=0.01, 3=0.001, 4=0.0001, and 5=0.00001 mg/L) of photosensitizer (Cu) on egg masses (48 h old) of *S. littoralis*.

Toxicity on 2nd and 4th larval instars to photosensitizer compounds

Toxicity of copper chlorophylline and magnesium chlorophylline on 2nd and 4th instar larvae of *S. littoralis* under dark and photo conditions was presented in Figures 3 and 4. The rat of mortality after treated 2nd and 4th instar larvae with 0.1 mg/L of copper chlorophylline was 29.5% and 76%, respectively, under dark condition (Figure 3) and was 38.9% and 96%, respectively, under photo condition (Figure 3). In contrast, the mortality ratio after treated the larvae with magnesium chlorophylline was 49.5% and 54.9%, respectively, under dark condition (Figure 4) and was 59.1% and 52%, respectively, under photo condition (Figure 4).

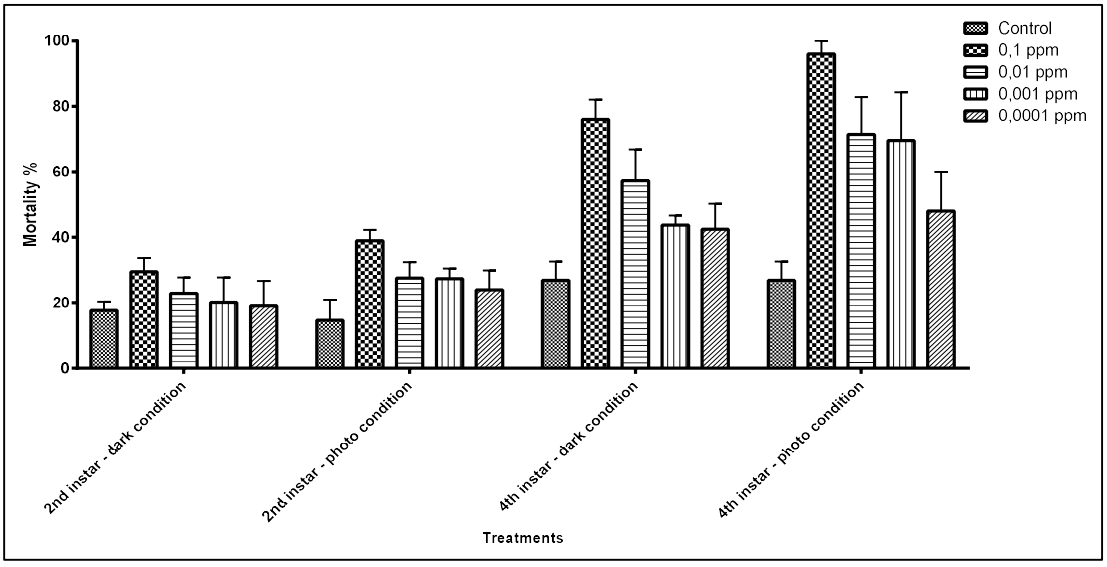

Fig. 3: Effect of photosensitizer (Cu) on 2nd and 4th instars of *S. littoralis* larvae after 4 days post treatment under dark and photo conditions.

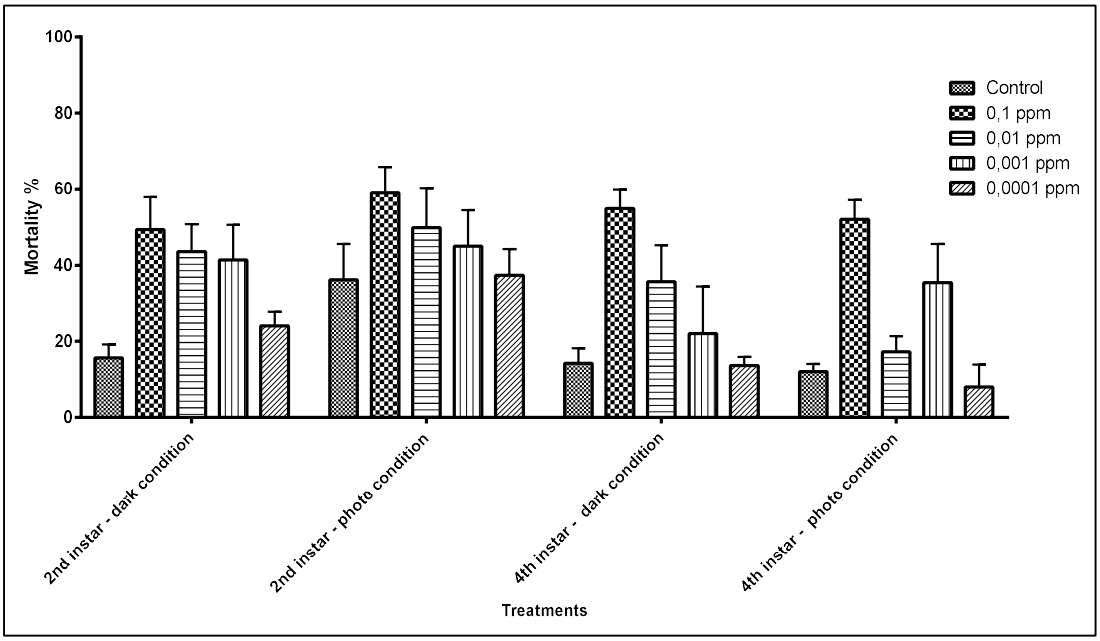

Fig. 4: Effect of photosensitizer (Mg) on 2nd and 4th instars of *S. littoralis* larvae after 4 days post treatment under dark and photo conditions.

Effect of photosensitizer compounds on pupal stage

Result showed that both photosensitizer compounds including; copper chlorophylline (Cu) and magnesium chlorophylline (Mg) at sunlight condition, were more influential than at dark conditions, after treated pupal stage of *S. littoralis* with different concentrations of those compounds (Figures 11 and 12). In contrast, copper chlorophylline (Cu) was more influential than magnesium chlorophylline (Mg) after treated the pupae in both dark and sunlight conditions with mortality of 58% and 85% in case of Cu and 43% and 35% in case of Mg at 0.01 mg/L, respectively. Pupal mortality of the control was below 10%.

DISCUSSION

In Egypt, Agriculture is one of the important section of the Egyptian economy. Safer methods are needed to conserve the economic crops from potential insect pests. The use of the photochemicals products have been examined against several species of insects under different conditions (Rebeiz *et al.,* 1991) or field conditions (Lenke *et al.,* 1987). The results presented in this study confirmed the efficiency of a two of photosensitizer including; copper chlorophylline (Cu) and magnesium chlorophylline (Mg) against immature *S. littoralis*. The results showed a slight effect of copper chlorophylline (Cu) on egg stage while with magnesium chlorophylline (Mg) was not. In contrast, both substances exhibited a significant impact on larval stage of *S. littoralis*.

On the flesh fly, *Parasarcophaga argyrostoma*, a high mortality ratio in adult flies reached to 96% has been obtained after treated to the photosensitizer (Hematoporphyrin IX) and sunlight in sugar bait traps (El-Tayeb *et al.,* 2011). Therefore, Berni et al. (2009) tested the effect of Xanthene dyes as photoinsecticides on various species of dipteran insect pest, and they found that Phloxine B which ingested by *Ceratitis capitata* larvae was decreased the toxicity under dark conditions, while acute light-dependent toxicity was obtained when the insects were exposed to light during the dispersion stage before pupation. In addition, the photosensitizer of hematoporphyrin dimethyl ether caused a fast death of *Liriomyza bryoniae*, Diptera: Agromyzidae (Lukšiene *et al.,* 2007).

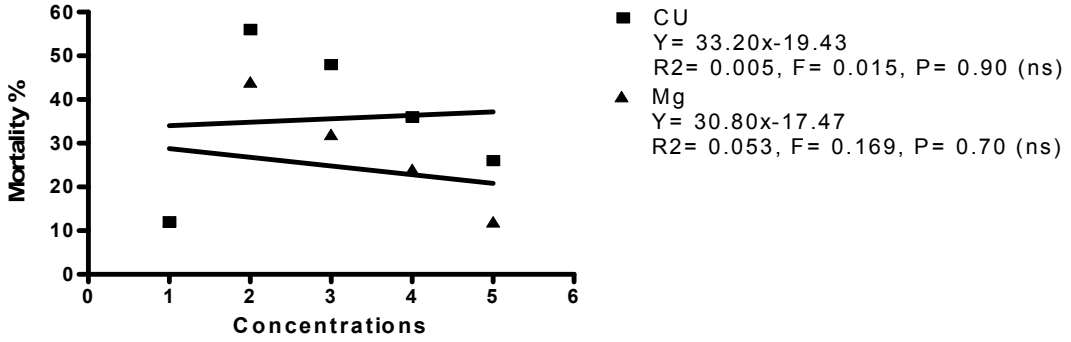

Fig. 5: Effect of different concentrations (1=control, 2=0.01, 3=0.001, 4=0.0001, and 5=0.00001 mg/L) of photosensitizer (Cu & Mg) on pupal stage of *S. littoralis* under dark condition.

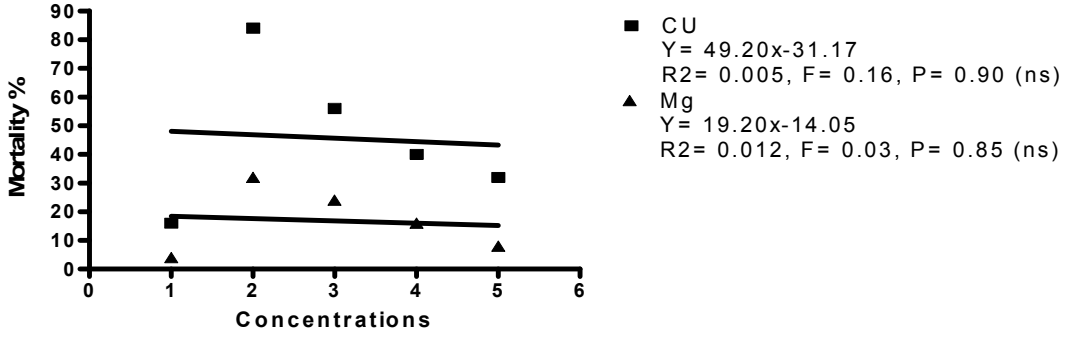

Fig. 6: Effect of different concentrations (1=control, 2=0.01, 3=0.001, 4=0.0001, and 5=0.00001 mg/L) of photosensitizer (Cu & Mg) on pupal stage of *S. littoralis* under photo condition.

Moreover, the photosensitizers exhibited lethal effects against fourth instar larvae and adults of mosquitoes under laboratory and field conditions (Helleck and Hartberg, 2000; Dondji *et al.,* 2005).

The obtained data suggested that suppressing the cotton leafworm, *S. littoralis*, and population using photosensitizers as photoinsecticides will participate in the protection of cultivation of several vegetables and crops which will have a great impact on the economic development of agriculture.

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الملخص العربي

نشاط اثنين من المستحثات الضوئية في المكافحة المستدامة لدودة ورق القطن

مني عوض

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أجريت دراسة لنشاط أثنين من المستحثات الضوئية على الأطوار المختلفة من حشرة دودة ورق القطن *Spodoptera littoralis* تحت الظروف المعملية. حيث تم غمر لطع البيض عمري ٢٤ و٤٨ ساعه بتركيزات من المستحثات الضوئية من النحاس والمغنيسيوم. وأظهرت النتائج أن المستحث الضوئي النحاسي له تأثير طفيف في حين أن المستحث الضوئي المغنيسيومي ليس له أي تأثير على طور البيض من *S. littoralis*. وبالإضافة إلى ذلك، كان المستحث الضوئي النحاسي أكثر سمية علي يرقات الطور الثاني والرابع من المستحث الضوئي المغنيسيومي تحت الأظلام. في حين كان كلا المركبين أكثر سمية تحت الأضاءة مما كانت عليه في ظل ظروف مظلمة وذلك عندما تم معاملة طور العذارء في تركيزات مختلفة من كلا من المستحث الضوئي النحاسي والمغنيسيومي. الأمر الذي يشير إلى أن المستحثات الضوئية من الممكن أستخدامها في مكافحة حشرة دودة ورق القطن في مصر.