EFFICACY OF DIFFERENT PHOTOSELECTIVE FILMS AS RECENT TECHNIQUE FOR CONTROLLING THE COTTON APHID, *APHIS GOSSYPII (GOLVER.)* ON CUCUMBER (*CUCUMIS SATIVUS* L.)

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INTRODUCTION

Integrated pest management (IPM) involve the use of multiple tactics to optimize the control of all classes of pests by reducing pesticide application, providing economic saving for the farmer, and protecting both the environment and human health is recognized as one of the most robust strategies to control major insect pests, practically in protected cultivation(Ehler, 2006). Alternative pest control strategies are required to reduce the insect toxic applications and pesticides. Among the control tactics that should be developed in the new integrated pest management strategies, the use of physical or mechanical methods, which avoid residues on commodities and minimize damage to the environment. In addition, Raviv & Antignus (2004) demonstrated that, solar ultraviolet (UV) radiation particularly in the UV- A+B range (280-400 nm), is an abiotc factor that has major consequences for insect pests, reported as to modify their orientation towards potential hosts, alight, arrestment, light activity, feeding behavior and interaction between sexes. In this regard, the technology of UV-absorbent photoselective films have been reported as successful technique for reducing insect damage and protecting crops, thus they should be involve among IPM programs as they interfere with insects visual responses and behavior (Costa *et al.*, 2003; Antiguns & Ben Yakir, 2004; Weintraub & Berlinger, 2004; Kumar & Poehling, 2006; Doukas & Payne, 2007b and Legarrea *et al.*, 2012). The first publication on the effect of UV-blocking plastic films on aphid, *Aphis gossypii* Clover, was conducted in Japan about 34 years ago. Since then, research has been carried out on other green house insect pests. Aphids has a trichromatic system in the compound eye with an UV receptor peaking at three regions (320-330 nm &440-480 nm and around 530 nm)with a maximum sensitivity (Briscoe & Chittka, 2001; Kirchner *et al.*, 2005 and Skorupski *et al.*, 2007). Aphids is one of the most serious crop pests world wide, which inhibit plant growth and cause economic losses for crop productivity in both open field and protected cultivation, not only because of the direct damage that cause but also because its alimentary habits involving transmission of plant viruses (Hull, 2002). The common types of protected cultivation in Egypt are the plastic low tunnels and the single span plastic house (El-Aidy *et al.*, 2007). In Egypt, Saad (2002) stated that vegetable under protected cultivation are attacked by numerous insects and mites caused serious damage and high yield losses. The photoselective film is one of an emerging approach, which introduces additional benefits, on the top of various protective techniques that is known to provide better protection against most pests particularly sucking insect pests, relative to cladding materials (Antiguns and Ben Yakir, 2004). Aphids have been reported to drastically reduce their flight activity and limiting the dispersal behavior under deficient ambient with low level of UV radiation under cladding material (Diaz *et al.*, 2006 and Doring & Chittka, 2007). Moreover, recently many researchers in the field of photobiology recognized that, the next generation of horticultural plastic films modified for limiting and impacting the quantity and quality of UV light reaching the crop and its associated insect pests, thus resulted great improve in plant growth yield with major minimizing of insect pests infestation (Kuhlman & Müller, 2009; Wargent *et al.*, 2011; Legarrea *et al.*, 2010 and Legarrea *et al.*, 2012). The present work aims to investigate the influence of certain modifying UV- blocking films with special light properties in comparison with the local recommended Egyptian cover as a recent technique for minimizing Aphids, *A. gossypii* infestation as well as the impact of these technology on resulted yield of cucumber plants in order to improve the integrated pest management programs, thus resulted a major protection for human, plant and environmental system.

MATERIAL AND METHODS

Tunnels, plastic films, plants and cultivation system

To evaluate the potential effect of UV- blocking films as a recent method for controlling aphids, *A. gossypii* as well as to examine their efficacy on cucumber crop yield, the present investigation was carried out during 2014 and 2015 (Third week of February) as a spring plantation at the experimental farm of the Environmental Studies & Research Institute, University of Sadat City, Menofiya, Egypt. Seedling of two cucumber, *Cucumis sativus*, namly: "Aseel Hy", (Syngenta) and "Safa 62 F1"; (Horticultural Research Institute, Dokki, Egypt) were planted under all examined plastic tunnels. Factorial design with three replicates was followed, using eight high structure of polytunnels each of them measuring, 2.5 m high x 6 m wide x 12 m long. Each plot (9 m^2) involve around 36 plants. Six polytunnels were clad with three tested blocking material of spectrally modifying plastic covers in addition to the recommended Egyptian cover (two replicates for each one). Each tunnel was divided into two equal sections (each /cultivar) in order to study the influence of different tested photoselective films versus the local cover for protecting two cucumber cultivars from aphids damage. The spectrally modifying films were produced by Bpi Visqueen (British Polythene Industries PLC, UK)which ,allowed plants to be grown under three different environments of (i) a UV transmitted cover (UVT), (ii) standard cover (STD) and (iii) a UV opaque cover (UVO). Spectral transmissions of the four studied covers were determined for triplicate samples (minimum $4cm^2$) using a 75W Xenon arc lamp (LOT Oriel, Leatherhead, UK) with a 10 cm integrating sphere, and a double scanning spectroradiometer (Macam Photometrics, Livingston, UK). Both UVT and UVO covers had light diffusion property of 90% but local and STD films were clear covers. Average of maximum and minimum temperature (°C) was measured during the experimental periods across all tested plastic films using LCD data logger.

Assessments

The work focused on aphid population dynamics during the two growing seasons 2014 and 2015overtime (12 to 14 weeks). Population density of *A. gossypii* on the two tested cucumber cultivars were estimated under all tested UV- absorbent photoselective material and the local Egyptian cover during the two growing seasons 2014 and 2015. Ten plants were randomly selected from the middle row in each plot. Five leaves were examined per plant. Samples were collected weekly, transferred in polyethylene bags to the laboratory, carefully examined and recorded as mean number of aphid/$inch^2$ /leaf. Sampling started from the beginning of March and continued till the end of May during 2014 and 2015. All data were statistically analyzed by using (SAS, 2003) program V.16. The LSD values were used to determine the significant between means of treatments at $p < 0.05$.

The population fluctuation of aphids was illustrated. For crop yield measurements, ten plants were randomly chosen and marked from each plot. Fruit harvest was started at the third week of March and continued till the end of May. Total yield was determined by weighting all fruits of marked plants whenever reached the marketable size (15 cm long) and presented as total yield per plant (kg).

RESULTS AND DISCUSSION

The light characteristics transmission of examined plastic during the experimental period, scanning data evidence that, total transmission of UVT cover through the photosynthetic active radiation (PAR), UVB (280-315 nm) and the UV-A (315-400 nm) regions were 86%, 67% and 75%, respectively Fig. (1A). Standard cover had a total PAR transmission of 85%, approximately 39% UVA, and less than 6% UVB. The UV opaque cover had a PAR transmission of 91%, only 3% UVA, and zero UV-B. The local Egyptian covered a PAR transmission of 82%, transmission of 59% and 7% of UVA and UVB, respectively Fig. (1A) thus, in the first season. No changes within light transmission through all cover treatments apart of UVO which showed increase in UVA transmission above 355 nm by 44% Fig. (1B) in the second season.

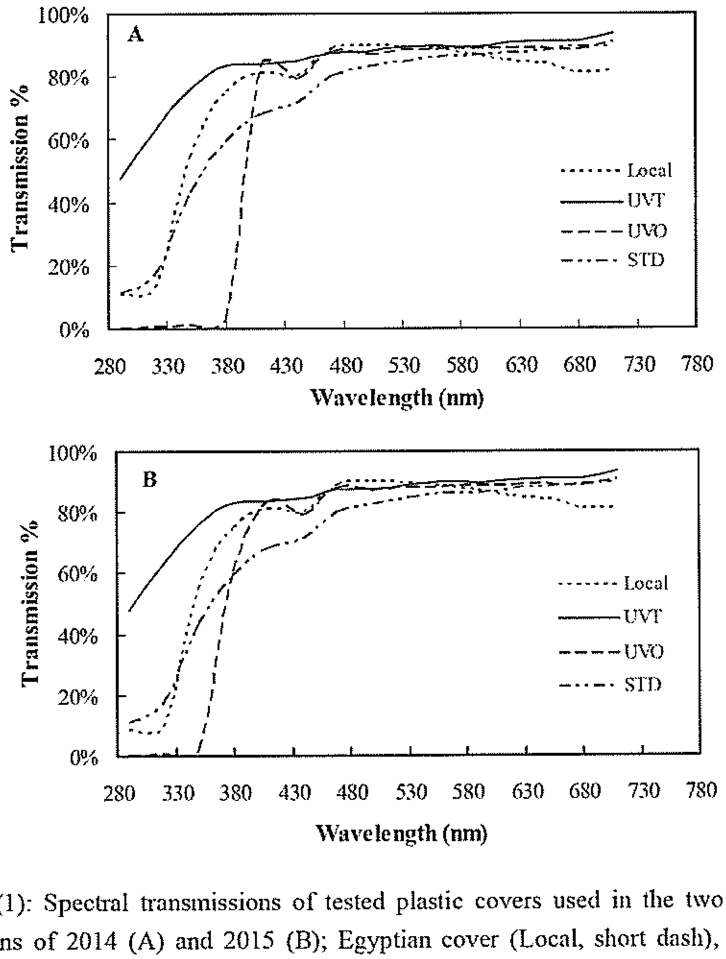

Fig. (1): Spectral transmissions of tested plastic covers used in the two growing seasons of 2014 (A) and 2015 (B); Egyptian cover (Local, short dash), Standard cover (STD, long dashed line), UV-opaque cover (UVO, dots) and (UVT, no dash). Variation between multiple samples of identical covers was negligible and standard errors are too small to present

Performance of the tested modified UV-blocking films versus the local plastic cover as recent control method to combat *A. gossypii* on the foliage of Aseel and Safa cucumber varieties during the two successive seasons was obtained in Fig. (2 and 3). Aphids population varied sharply according the two tested cultivars under the examined covers.UVO cover showed the lowest mean number of aphids during the two successive seasons for both cultivars. In addition UVO cover delayed the aphids' appearance to the third week on both Aseel and Safa62 cultivars comparing to other tested covers Fig.(2 and 3), while the pest reached its peak around the third week of May under all plastic films for two cucumber cultivars in both seasons.

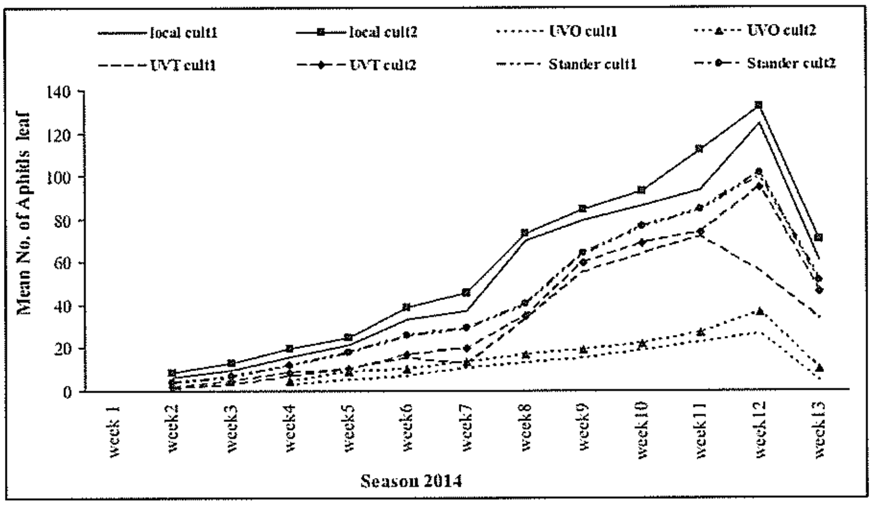

Fig. (2):Weekly abundance of aphids, *A. gossypii* on Aseel and Safa 62 cultivars under different UV-blocking films during 2014
*Cult 1: refer to Aseel *Cult 2: refer to Safa 62

Generally, results revealed highest population density of the pest associated with plants growing under local cover in all studied weeks. Moreover, UVT performed second degree of efficacy with moderate level of plant protection, thus resulted relatively low mean of the pest at the same criteria.

Statistical analysis showed positive correlation (R^2=0.81) between UV-A transmission level under all tested plastic films and the aphids population density. Regarding, the susceptibly of examined cultivars, illustrated results demonstrated that, Safa62 cultivar seems to be more susceptible to aphids infestation, recorded relatively a heavy infestation with greater mean of the pest population throughout all studied weeks under all studied covers than Aseel Fig. (2 and 3).

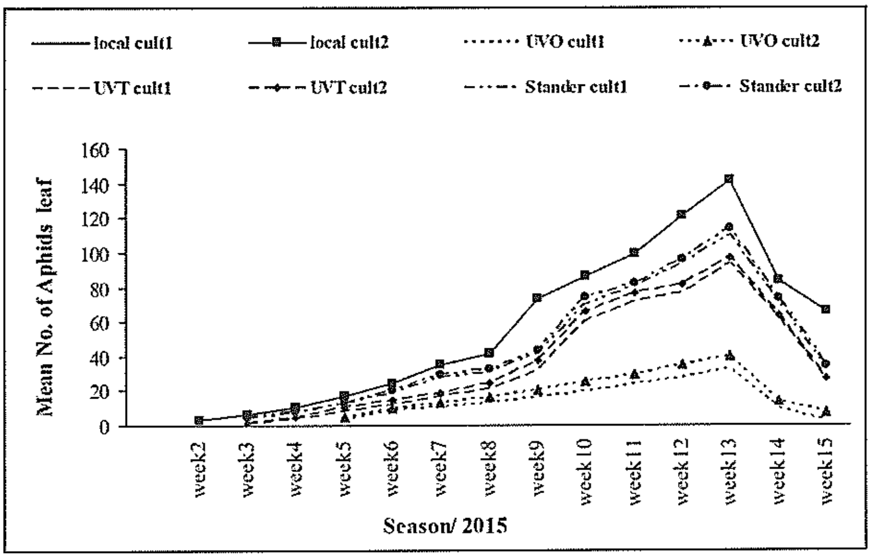

Fig. (3): Weekly abundance of aphids, *A. gossypii* on Aseel and Safa 62 cultivars under different UV-blocking films during 2015
*Cult 1 refer to Aseel *Cult 2: refer to Safa 62

These results might be in agreement with those of (Diaz *et al.*, 2006 and Doring & Chittka, 2007) who reported major reduction of aphids population and limiting the dispersal behavior under deficient ambient with low level of UV radiation under cladding material. Furthermore, significant reduction resulted in the pest within UV- deficient showed harmony performance with the fact that says, aphids have a trichromatic system in the compound eye with an UV receptor peaking at three regions, at UVA light (320-330 nm), in the blue region at (440-480 nm), and at a third green receptor with a maximum sensitivity around (530 nm), thus resulted greatly orientation towards potential hosts (Kirchner *et al.*, 2005and Skorupski *et al.*, 2007). Moreover, results observed negligible increases by 0.15 % and 0.31 % of UVB and UVA transmission below 330 nm, respectively under UVO cover in the second season 2015 (Fig. 1B). Therefore, UVO aphid's infestation were consistent in both seasons. According the relatively high amount of solar radiation (transmits 59% UVA and 7% UVB) recoded through the recommended Local cover, scanning results obtained the highest population dynamic of aphids in both seasons under this cover. This increase accompanied with highest average temperature under local cover Table 1. A significant positive effect of temperature on aphid population was observed for all tested covers through the experimental periods. Moreover, aphid population increased sharply and recorded its peak by (86.10, 66.53, 20.70 and 74.22) and (76.42, 21.03, 67.05 and87.99) individuals/inch^2/leaf under Loc., UVT, UVO and STD at (28.01,25.81,32.71and 27.41)C° and (28.06, 25.83, 23.75 and 27.43) in both seasons, respectively.

TABLE (I)

Effect of different UV- blocking films on the average temperature and natural *A. gossypii* infestation during 2014 and 2015 seasons

	Average temperature (°C)				Mean No. of aphids/ inch^2 /leaf			
Season 2014								
Covers/ Months	Local	UVT	UVO	STD	Local	UVT	UVO	STD
March	20.11	19.42	16.22	19.71	7.90	2.92	0.80	5.21
April	24.41	20.31	17.51	23.91	40.60	20.11	10.81	27.73
May	28.01	25.81	23.71	27.41	86.10	66.53	20.70	74.22
* (R^2)	0.981	0.981	0.872	0.938				
Season 2015								
	Average temperature (°C)				Mean No. of aphids/ inch^2 /leaf			
Covers/ Months	Local	UVT	UVO	STD	Local	UVT	UVO	STD
March	20.15	19.47	16.24	19.76	8.48	2.98	0.96	5.29
April	24.46	20.35	17.54	23.95	42.36	20.90	11.38	28.06
May	28.06	25.83	23.75	27.43	87.99	67.05	21.03	76.42
*(R^2)	0.979	0.978	0.860	0.935				

* Correlation coefficient

Therefore, Statistical analysis showed significant positive correlation coefficient between the average of temperature and scored values of cotton aphid population for the all tested covers Table 1 and Fig. (4 -7), R^2= (0.981, 0.981, 0.872 & 0.938) and (0.979, 0.978, 0.860 &0.935) for Local, UVT, UVO and STD plastic films in May of both 2014 and 2015, respectively. The greater value of infestation demonstrated with highest average of temperature that associated with gradually increase of highest level of transmitted radiation, resulted in final rapidly growth rate of aphid build up and then population development gave the highest statue.

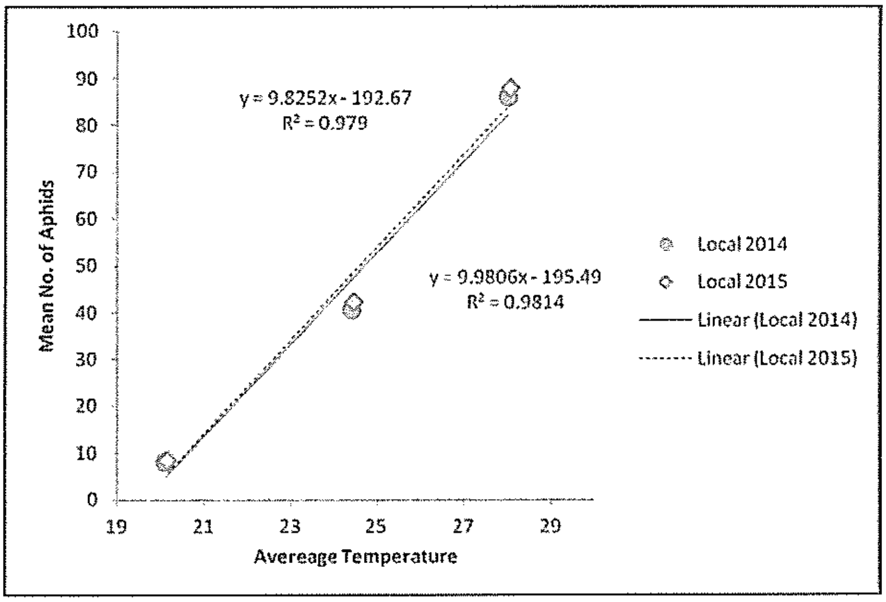

Fig. (4): Regression line of average temperature and mean number of *A. gossypii* under local plastic cover in 2014 and 2015

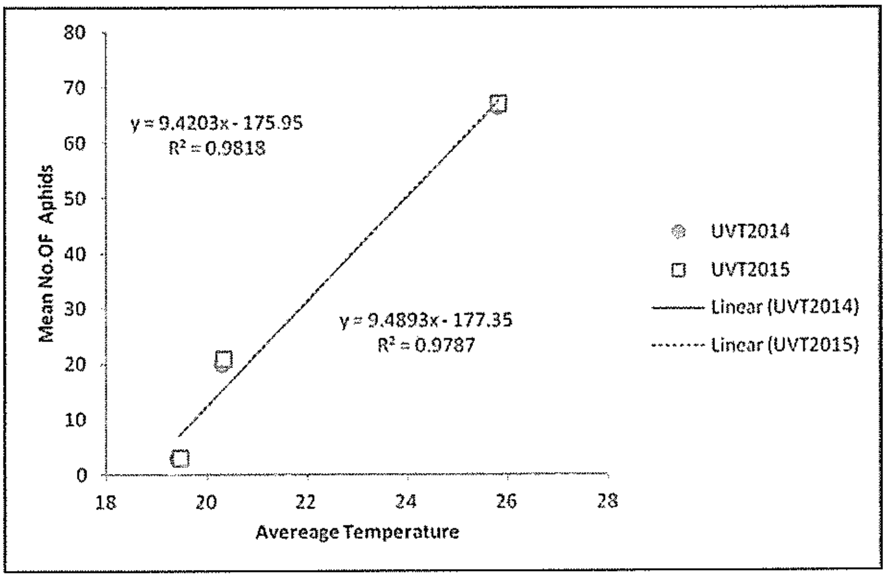

Fig. (5): Regression line of average temperature and mean number of *A. gossypii* under UVT cover in 2014 and 2015

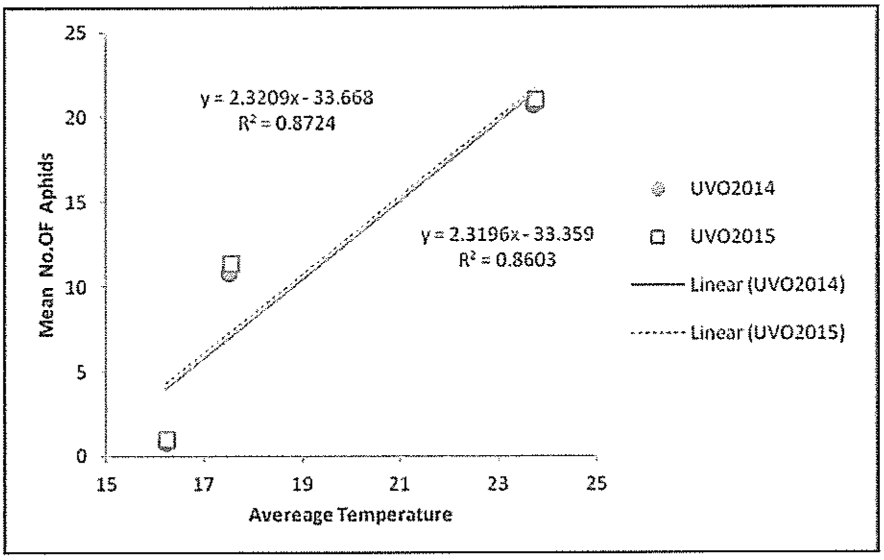

Fig. (6): Regression line of average temperature and mean number of *A. gossypii* under UVO cover in 2014 and 2015

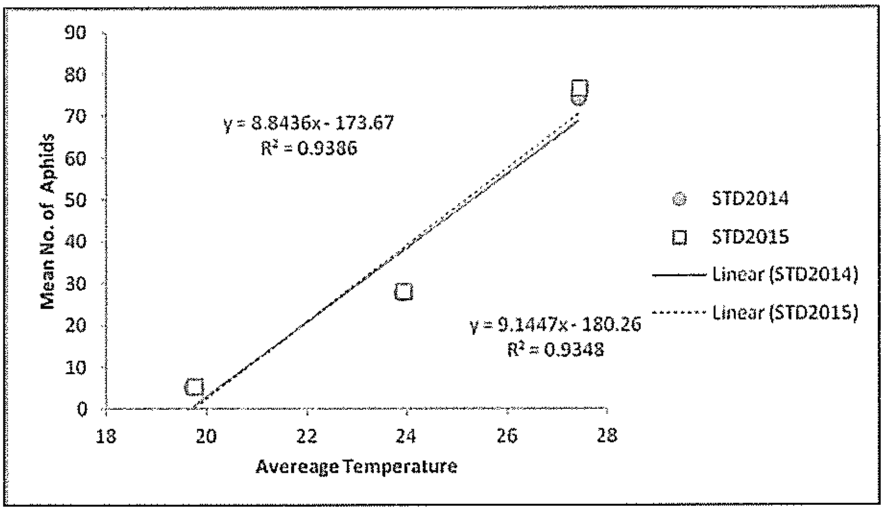

Fig. (7): Regression line of average temperature and mean number of *A. gossypii* under STD cover in 2014 and 2015

Moreover, linear relation was found between average temperature and mean number of aphid under all tested cover in both seasons fig. (4-7), this relationship evidence that pest population increased dramatically with increasing temperature.

In this regard, Satar *et al.* (2008) detected significantly faster development and greater growth rate of *A. gossypii* at 22.5 and 30.0 C° while higher mortality occurred at cooler temperature, 15.0 and 17.5 C°. However, high ambient of UV-radiation transmission through plastic film resulted higher temperature that caused aphid' growth rate build up rapidly and peak with highest population. These finding is harmony with those of Doukas (2002) who mentioned that the pest prefers high UV-condition for potential modified insect visual responses, disperse and behavior feeding. The previous results was in line with those of Amna *et al.* (2012) who recorded the greatest mean of *A. gossypii* on cucumber crop in May under polyethylene sheet comparing to that under photoselective. nets. In addition, Aphids showed major preference towards high ambient UV- radiation (Costa *et al.*, 2002; Chyzik *et al.*, 2003 and Diaz *et al.*, 2006) Highly significant differences were stated between tested cover for both obtained cucumber fruit yield and aphid infestation Table (2). Obtained results, stated significantly increasing of infestation with higher level of transmitted radiation that, reflect sharply higher decrease of yield. The polyethylene plastic covers could be arranged on order as follow: UVO, UVT and STD and local cover for both greatest values of contributed yield and the major minimizing of pest population density in both seasons. Scanning results showed greatest mean value of cucumber fruit yield (5.63 and 4.54Kg/plant) were accompanied with lowest mean number of aphid/leaf (9.9 and 15.22 individuals/leaf) on Aseel Varity under opaque film (UVO)in 2014 and 2015 seasons, respectively. The UVO cover clad major amount of UV-(A and B) Fig. (1B) thus reduced average temperature then introduce greatest host plant protection of aphid infestation reflects the greatest host plant protection and resulted finally highest crop yield (Table 2). Previous results concluded that low amount of ultraviolet radiation act vital and essential role for reducing natural aphid infestation thus, reflected higher plant protection (Chyzik *et al.*, 2003 and Diaz & Ferers, 2007). Relative enhancement of plant defense by increasing secondary metabolites may be achieved for major reduction of natural cotton aphids infestation across modified UV environment (Wargent *et al.*, 2011).

TABLE (II)

Effects of certain photoselective films versus the recommended plastic cover on the seasonal population density of *A. gossypii* and cucumber crop yield during 2014 and 2015

Cultivar	Aseel				Safa62			
	Total yield (Kg/plant)		Mean No. of Aphids/ inch^2 /leaf		Total yield (Kg/plant)		Mean No. of Aphids / inch^2 /leaf	
Cover	2014	2015	2014	2015	2014	2015	2014	2015
Local	3.74^c	3.37^c	41.01^a	57.59^a	2.83^c	2.58^c	58.54^a	67.95^a
UVT	5.36^a	4.33^{ab}	26.55^c	37.14^c	3.83^a	3.35^a	35.81^c	40.19^c
UVO	5.63^a	4.54^a	9.90^d	15.22^d	3.89^a	3.46^a	14.08^d	19.50^d
STD	4.69^b	3.89^b	32.26^b	46.16^b	3.22^b	2.97^b	42.06^b	48.04^b

* Means with the same letter are not significantly different

In addition, exposure to high dose of ultraviolet radiation was recognized as potential effect on insect pests development, fecundity and fertility by modify the environmental condition inside the tunnel (Dader *et al.*, 2014). UVT cover achieved second degree of efficacy for minimizing pest infestation that is in agreement with results of Burdick *et al.* (2015) who demonstrated that, increasing artificial UV radiation decreased soybean aphids population size compared to low UV environment. Therefore, integrated pest management program must include this technique to avoid serious aphid damage and have best plant protection as well as protecting the environmental system from insecticide pollution, (Antignus *et al.*, 2001; Costa *et al.*, 2002 and Doukas & Payne, 2007a). Nevertheless, local cover transmission of relatively high level of UV-B and UV-A with 85% of PAR, recorded the highest aphids' population (58.54 and 67.95individuals/leaf) associated with lowest mean of obtained fruit yield (2.83 and 2.58Kg/plant) on Safs variety in 2014and 2015 respectively. Statistical analysis reflect significant negative correlation between total cucumber fruit yield and mean number of the pest / leaf, R^2= (-0.92302 and -0.95186), (-0.90133 and 0.99777) for Aseel and Safa62 during 2014 and 2015, respectively. Concerning total fruit yield per plant, it is obvious that this trait was affected significantly according the efficacy of tested covers, performance of both cultivars and the degree of aphids infestation in both seasons (Table 2). Generally, highest fruit yield was obtained on Aseel cultivar under UVO with lowest number of the pest thus, might be due to low amount of ultraviolet radiation through this cover that caused improvement plant production by modifying the plant morphology, might alters reproductive processes that ends finally yield formation (Kakani *et al.*, 2003) as well as introduce major plant protection from pest damage thus, caused increase of net photosynthetic rate, best vegetative growth and produced highest crop yield (Wargent *et al.*, 2011). Moreover, significant reduction of this trait was found under local and standard covers when compared with all tested covers. Reduction in fruit yield under local and STD covers may be due to direct and indirect effect of serious damage from highest cotton aphids infestation, shortage of photosynthetic rate, reduction in plant growth rate that caused by the lack of penetrated light reached to growing plants under these covers because of a relatively higher ambient of UV-A and B transmission through them. Furthermore, growing plants under UVO cover have good balance between vegetative growth and fruit development as well as major protection from serious aphid damage would have no reduction in crop yield Elfadly *et al.* (2012). Furthermore, Ultraviolet UV-absorbing films has been recognized as photoselective barrier to control insect pests, it can serve as a safe method for reducing natural abundance, limiting insect growth rate, fecundity and fertility, thus caused a major plant protection and resulted highest crop yield (Wargent *et al.*, 2011and Dader *et al.*, 2014).

CONCLUSIONS

- The photoselective blocking films can introduce safety and potential role for minimizing the natural abundance of cotton aphids on cucumber plant compared with the Egyptian local cover.
- Cladding materials has a photoselective barrier for controlling insect pests by modifying environmental conditions inter tunnels, thus limit significantly aphids growth rate and resulted higher crop yield.
- The UV-absorbing films offers a good efficacy for reducing seasonal pest infestation and resulted finally higher crop yield for both studied cultivars.
- Photoselective cladding materials can be used safely for two years under the Egyptian climate as the film has a stable transmission in UVB wavelengths and simultaneously blocks wavelengths within UVA range (320-330nm) which is vital for aphid's insect visual system.

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SUMMARY

Present investigation was carried out during 2014 and 2015 seasons at the experimental farm of the Environmental Studies & Research Institute, University of Sadat City, Menofiya, Egypt, to evaluate the efficacy of different

cladding films with different light transmission properties versus the commercial local cover on the natural abundance of cotton aphids, *Aphis gossypii* Clover on two commercial cucumber (*Cucumis sativus* L.) cultivars namely, Safa62 and Aseel and study the performance of seasonal population density of the pest on attributed crop yield. The cladding treatments included plastic covers of (standard clear (STD), ultraviolet transparent (UVT) and ultraviolet opaque (UVO) as well as the traditional local clear film (Local). Highly significant differences were recorded between all tested plastic covers for both reduction of aphids population and increasing crop yield through the experimental period. Positive correlation (R^2=0.81) appeared between UV-A transmission level under all tested plastic films and the aphids population density. Results, showed significantly increasing of aphids infestation with higher level of transmitted radiation. Moreover, the Egyptian local cover had (highest ambient of UV- radiation transmission), resulted higher temperature, with highest population density of the pest and produced finally the lowest values of fruit yield especially with Safa 62 cultivar. UVO cover showed the lowest mean number of aphids during the two successive seasons for both cultivars. The lowest mean number of aphid was mentioned integrated with greatest values of yield on Aseel cultivar under UVO cover. However, both UVT and UVO covers exhibited a higher yield in comparison with standard and local films especially with cultivar Aseel.

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