Adv. Hort. Sci., 2011 25(1): 26-31

Photoselective shade nets reduce postharvest decay development in pepper fruits

A. Goren, S. Alkalia-Tuvia, Y. Perzelan, Z. Aharon, E. Fallik*
Department of Postharvest Science of Fresh Produce, ARO, The Volcani Center, P.O. Box 6, 50250 Bet Dagan, Israel.

Key words: Capsicum annuum, postharvest, shelf life, storage.

Abstract: During two-year studies, we evaluated the influence of photoselective coloured shade nets on the quality of fresh harvested pepper fruits (*Capsicum annuum*) after prolonged storage and shelf life simulation. Pepper cultivar 'Romans' grown in a semi arid region under 35% pearl and yellow shade nets significantly maintained better pepper fruit quality after 16 days at 7°C plus three days at 20°C, mainly by reducing decay incidence during two consecutive years (2008 and 2009), compared to commercial black and red nets. No significant differences were observed in percentage of weight loss, firmness and total soluble solids in fruit harvested under the different coloured shade nets. The skin colour of fruit harvested under Pearl net was significantly lighter than that of fruit harvested under red and black shade nets and this fact can be associated with inhibition of fruit ripening during growth. After storability and shelf life simulation however skin colour was red to dark red under all shade nets. Pearl and yellow shade nets significantly reduced *Alternaria* spp. population in the field, which was evaluated with *Alternaria*-selective growing medium. The highest *Alternaria* population was found under red shade net. The significant low decay incidence in fruit harvested under pearl and yellow shade nets can be explained by the low inoculum level of *Alternaria* spp. in the field, and inhibition of fungal sporulation, and/or by a slowing of fruit ripening during its growth, reducing fruit susceptibility to fungal infection in the field due to the scattered light, its quality and the ratio between the light spectrum under the two shade nets.

1. Introduction

Sweet bell pepper (*Capsicum annuum* L.) is an important export commodity in Israel with more than 120,000 tons per year. Fruits may be green (unripe), red, yellow, orange, or brown when ripe. Peppers are rich in vitamins, minerals and dietary fibres, and are low in calories (Kevers *et al*., 2007) and they have become popular decorative items (Frank *et al*., 2001). However, to extend the export season with high pepper quality during the summer season, shade netting is necessary to protect agricultural crops from excessive solar radiation and pests (Shahak, 2008).

In recent years coloured shade netting (photoselective shade nets), designed specifically to manipulate plant development and growth, has become available. These nets can be used outdoors as well as in greenhouses. They can provide physical protection (from birds, hail, insects, excessive radiation), affect environmental modification (humidity, shade, temperature) (Perez *et al*., 2006), and increase the relative proportion of diffuse (scattered) light as well as absorb various spectral bands, thereby affecting light quality (Shahak *et al*., 2004). These effects can influence crops as well as the organisms associated with them. The effect of colour shade nets on plant development in crops, foliage crops, fruit trees and vegetables has been studied in recent years (Nissim-Levi *et al*., 2008; Shahak *et al*., 2008).

Bell peppers are grown commercially in semi-arid regions of Israel under black shade nets. Netting is frequently used to protect pepper plants from excessive solar radiation (shade-nets), environmental hazards (e.g. hail-nets), or pests (bird, or insect-proof nets) (Shahak *et al*., 2004). Shahak (2008) reported that productions of three cultivars of bell pepper were increased by 16 to 32% under pearl and red netting compared with equivalent black shade netting, or with open field production. In addition, Elad *et al*. (2007) reported that blue-silver, green and red nets were associated with lower levels of powdery mildew disease, caused by *Leveillula taurica* in pepper field experiments. Other studies have suggested differential effects of photoselective screens and shade nets on pest infestation and vector-borne viral diseases (Ben-Yakir *et al*., 2008). In a preliminary research conducted in 2007,

*Corresponding author efallik@volcani.agri.gov.il
Received for publication 10 February 2011.
Accepted for publication 18 February 2011.

Fallik *et al*. (2009) demonstrated the potential use of coloured shade nets to maintain the postharvest quality better of sweet pepper grown under red and yellow nets, during prolonged storage and shelf life.

Therefore, we undertook the two-year study presented in this work to evaluate, on a commercial growth scale, the influence of different coloured shade nets on the quality of fresh harvested bell pepper after prolonged storage and shelf life in order to understand, in part, the mode-of-action of those shade nets on harvested fresh produce.

2. Materials and Methods

Plant materials and coloured net shades

Red sweet bell pepper (*Capsicum annuum* L.) cv. 'Romans' was grown at the B'sor Experimental Station in the south-west of Israel (31.271° N; 34.389° E), using commercial cultivation practices (planting seedlings directly into the soil [~ 90% sandy regosol and ~ 10% arid brown soil], automatic drip fertigation), under four different coloured shade-nets, as follows: red, yellow, pearl and black (commercial shade net) with 35% relative shading (in PAR) (Polysack Plastics Industries, Nir-Yitzhak, Israel under the trade mark ChromaticNet), in four random replicates of 18 x 18 m each, all within one large horizontal net-house, 2.5 m high. Plants were planted during the third week of May, both in 2008 and 2009, and harvested as described below.

Light measurements under the nets

Measurements of light spectra, light scattering and microclimate parameters under the nets were taken as described previously by Shahak *et al*. (2008). Spectra of solar radiation outside and under the nets were measured by a spectroradiometer PS-100 (Apogee Instruments Inc. Logan UT, USA) which employs a light diffuser of 4 cm diameter above the 300 µm fiber optics. The diffuser was oriented along the sun beams. A round opaque plate of 6 cm diameter was held at 40 cm above the diffuser to block the direct light to measure the scattered light. Direct radiation was measured through a 4 x 45 cm tube placed on top of the diffuser. The radiation was measured three times at noon in the middle of August 2009 (Fig. 1).

Quality parameters

Fruit samples for storability and shelf-life were harvested five times each year, every three weeks, between the beginning of September and the end of November 2008 and 2009. Fruits (185±10 g) without defects or diseases were harvested without a calyx, at ~85% light red/red colour (~16% green 'cheek'), rinsed and brushed in hot water as described by Fallik *et al*. (1999) and packed in four 6.5 kg corrugated cartons. Fruit quality parameters were evaluated immedi-

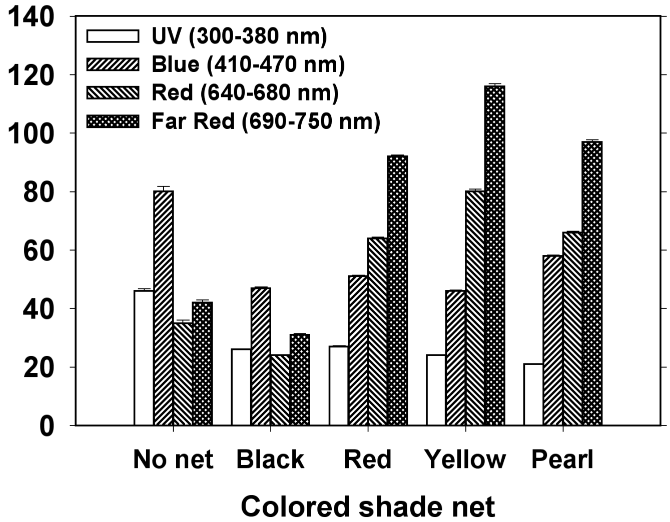

Fig. 1 - Influence of coloured shade nets on the scattered light under the different nets. Measurements were taken at noon in August 2009. Scattering relate to PAR (in µmol m^{-2} s^{-1}). The values represent integrals of the spectra over the following wavelength ranges: PAR: 400-700 nm; UV: 300-380 nm; Blue: 410-470 nm; Red: 640-680 nm; Far Red: 690-750 nm (Means of 3 replicates ± SE).

ately after each harvest and at the end of 16 days storage at 7°C and relative humidity (RH) of ~ 94%, plus three days at 20°C (RH ~ 70-75%) as follows: Weight loss was expressed as percentage of weight loss from the initial weight of ten fruits. Fruit firmness was measured on ten fruit as described by Ben-Yehoshua *et al*. (1983). Each fruit was placed horizontally between two flat surfaces and a 2 kg weight loaded on top of the flat surface. A dial fixed to a graduated plate recorded the deformation of the fruit in millimetres. Full deformation was measured 16 s after exerting the force on the fruit, then the weight was removed and the residual deformation was measured 16 s later. Fruit was considered very firm with 0-1.5 mm deformation; firm = 1.6-3 mm deformation; soft = 3.1-4.5 mm deformation; very soft = above 4.6 mm deformation. Total soluble solids (TSS) were measured on the same ten fruits tested for firmness, by squeezing out juice from fruits onto an Atago digital refractometer (Atago, Tokyo, Japan) and taking readings. The development of fruit colour was expressed as colour index (CINX) – on a scale of 1 to 4 with 1 = light red with 10-16% green peel; 2 = light red; 3 = red; and 4 = dark red. The index was calculated as follows: (number of fruits at light red colour X 1 + number of fruits at light red X 2 + number of fruit at red colour X 3 + number of fruits at dark red X 4)/total number of fruits. Decay incidence was considered once fungal mycelia appeared on fruit pericarp and/or calyx. Decay was expressed as a percentage of the total initial fruit number.

Evaluation of total microorganism population levels and Alternaria *spp. levels under coloured shade nets*

Population levels of conidia in the greenhouse environment were evaluated according to Elad (1997) by exposing 90 mm Petri dishes, under each net, containing PDA (Potato Dextrose Agar, Difco) supplemented with chloramphenicol (Sigma chemicals, 50 µg/ml) at a height of 60 cm above the ground, in five different places (five plates) under each coloured shade net for 60 min. Plates were then incubated for four days at ~22°C and colonies were counted. Based on preliminary results obtained in 2007, the main decay-causing agent on pepper fruits after harvest was *Alternaria alternata*. Population levels of *Alternaria* spp. were evaluated by exposing 90 mm Petri dishes containing selective medium for Alternaria (Soon Gyu and Pryor, 2004), as described above. Colonies were counted after 10 days incubation at ~22°C. The plates were exposed horizontally 60 cm above the ground. Each evaluation was repeated three times from the beginning of October to the end of November.

Statistical analysis

All the results were analyzed using a one- or two-way Anova statistical analysis at P=0.05 using JMP 6 Statistical Analysis Software Program (SAS Institute Inc. Cary, NC., USA) (Sall *et al.*, 2001).

3. Results

Light quality under different shade nets

Figure 1 shows the spectra of the scattered light under the different nets. The pearl net significantly reduced UV, while it significantly increased the blue light, thus significantly increasing the ratio between blue/UV compared to all other shade nets. The yellow net significantly increased the scattered red light compared to all other shade nets, while the blue light under this net was significant lower compared to red and pearl nets (Fig. 1). The three shade nets significantly increased the far-red scattered light compared to the commercial black net.

Quality evaluation

After 16 days storage at 7°C plus three days at 20°C, the major differences in fruit quality were found between 2008 and 2009 in weight loss and fruit firmness. However, TSS was similar in the two years (Table 1). In 2008, fruits lost less weight under the red net (2.9%), while under the yellow net weight loss was higher (3.5%). In 2009, percentage of weight loss under the four shade nets was similar (between 3.4 to 3.6%).

Immediately after harvest, fruits picked from the pearl net treatment were significantly lighter in their red colour index (2.33) than fruit picked from the commercial black or red shades (2.60 and 2.64, respectively) (Table 2). No significant differences were observed in fruit colour index between the yellow and pearl treatments. After 16 days at 7°C plus three additional days at 20°C, all fruits turned almost dark red, however fruits picked under the red shade were significantly darker (3.86) than fruits picked under yellow and pearl shades (3.76 and 3.75, respectively) (Table 2).

Decay incidence

In both years, decay incidence under yellow and pearl shade nets were significantly lower compared to fruit picked under the commercial black or red net (Fig. 2). In 2009, the average decay incidence was higher than in 2008. In 2008, the highest decay incidence was observed on fruit picked under black and red shade nets, which was significantly higher than on fruit picked under the yellow and pearl shade nets. In 2009,

Table 2 - The influence of coloured shade net on fruit colour index (CINX) development immediately after harvest and after 16 days at 7°C plus three days at 20°C (means of five experiments each year, with four 6.5 kg boxes per treatment)

Colored shade net	Immediately after harvest (1-4) [z]	After storage and shelf life (1-4)
Black	2.60 a [y]	3.80 ab
Red	2.64 a	3.86 a
Yellow	2.46 ab	3.76 b
Pearl	2.33 b	3.75 b

[z] Colour Index: 1= light red with 10-16% green peel; 2= light red; 3= red; and 4= dark red.

[y] Values within a column followed by the same letter do not significantly differ at P= 0.05 according to Duncan's multiple range test.

Table 1 - The influence of coloured shade nets on weight loss, firmness and TSS after 16 days at 7°C plus three days at 20°C (means of five experiments each year, with four 6.5 kg boxes per treatment)

Colored shade net	Weight loss (%) [z]		Firmness (mm) [y]		TSS (%) [x]	
	2008	2009	2008	2009	2008	2009
Black	3.2 ABb [w]	3.6 Aa	2.1 Ab	3.0 Aa	6.7 Aa	6.6 Aa
Red	2.9 Bb	3.4 Aa	2.3 Ab	3.0 Aa	6.4 Aa	6.4 Aa
Yellow	3.5 Aa	3.5 Aa	2.3 Ab	2.7 Ba	6.6 Aa	6.6 Aa
Pearl	3.3 Ab	3.6 Aa	2.0 Ab	2.9 ABa	6.5 Aa	6.4 Aa

[z] Percent weight loss from initial.

[y] Firmness - millimeter deformation (flexibility).

[x] Percent total soluble solids.

[w] Values followed by the same upper-case letter do not significantly differ between the treatments, while values followed by the same lower-case letter, do not significantly differ between the harvest seasons at p=0.05 according to Duncan's multiple range test.

a significantly lower decay incidence was observed on fruit picked under the pearl shade net, whereas the highest one was observed on fruit picked under the red shade net (Fig. 2).

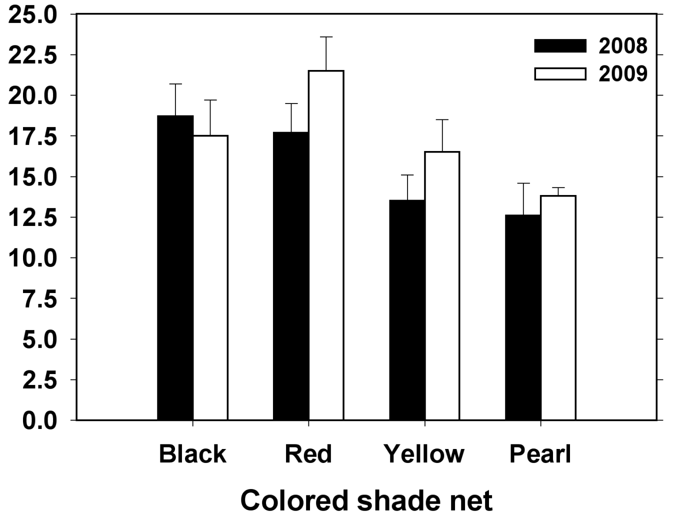

Fig. 2 - Influence of coloured shade nets on decay incidence in fruit of cv. Romans, in 2008 and 2009 after 16 days at 7°C plus three days at 20°C. (Means of five experiments with four 6.5 kg boxes per treatment ± SE).

Evaluation of total microorganisms population levels and Alternaria *spp. levels under coloured shade nets*

The epiphytic population of fungi evaluated on a regular PDA medium was lower under the pearl net, compared to the population that was counted under the red or black shade nets. However, no significant difference between treatments was found (Fig. 3).

Using a selective medium for *Alternaria* spp., a significant reduction in its population was observed under pearl and ellow shade nets (Fig. 4). The highest *Alternaria* population was found under the commercial black shade net (Fig. 4).

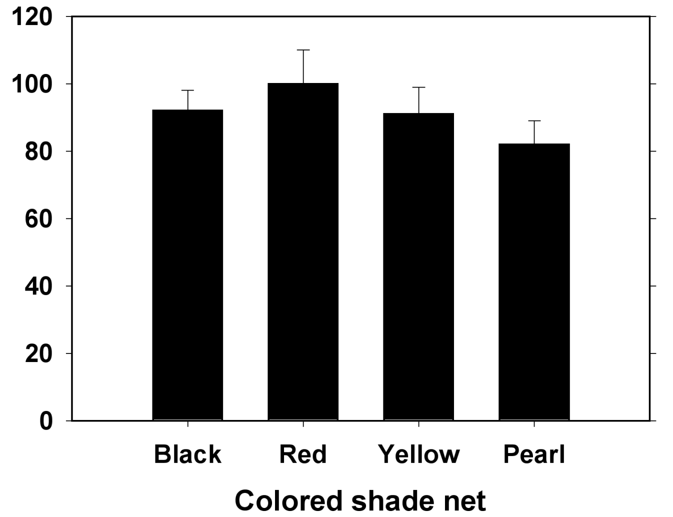

Fig. 3 - Influence of coloured shade nets on the epiphytic population of fungi detected under the nets (CFU/plate – means of 3 experiments conducted in 2009 ± SE).

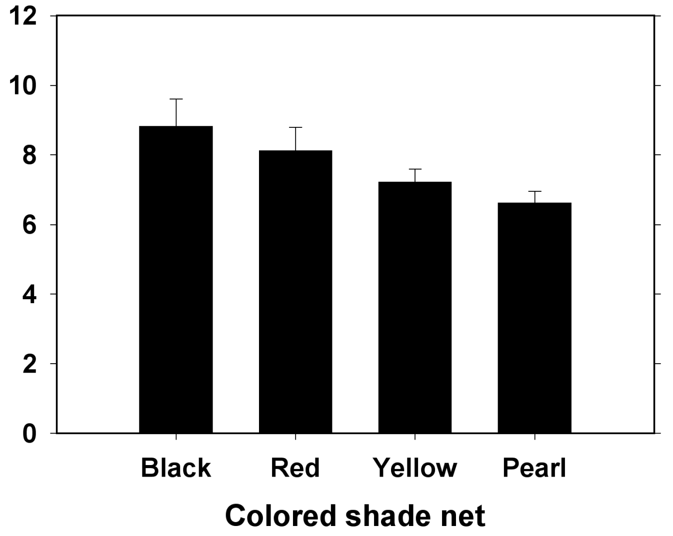

Fig. 4 - Influence of coloured shade nets on the *Alternaria* spp. population detected under the nets using selective medium (CFU/plate – means of 3 experiments conducted in 2009 ± SE).

4. Discussion

Photoselective coloured shade nets (ChromatiNets™) have been developed over the last decade to filter selected regions of the spectrum of sunlight, concomitantly with inducing light scattering, and are designed specifically to modify the incident radiation (spectrum, scattering and thermal components) (Shahak *et al*., 2004). Depending on the pigmentation of the plastic and the knitting design, the nets provide varying mixtures of natural, unmodified light together with spectrally modified scattered light. They are aimed at optimizing desirable physiological responses, in addition to providing physical protection to the crop, thus improving plant growth, flowering and yield and fruit quality (Rajapakse and Shahak, 2007; Shahak, 2008; Shahak *et al*., 2008).

The most prominent effect of the coloured shade nets was found on decay incidence in fruit harvested under pearl and yellow nets, without affecting fruit quality after prolonged storage and shelf life. It is well known that light plays an important role in plant growth. Red light induced resistance in broad bean against *Botrytis cinerea* (Islam *et al*., 1998) and *Alternaria tenuissima* (Rahman *et al*., 2003), and in rice against *Magnaporthe grisea* (Arase *et al*., 2000). Tabira *et al*. (1989) reported that continuous irradiation of visible light of 570-680 nm protected apple leaves by inducing insensitivity to *Alternaria alternata* apple pathotype. Disease suppression under red light was also observed in glasshouse-grown *Corynespore cassiicola*-inoculated cucumbers, and indicated that delay and suppression of Corynespora leaf spot of cucumber were due to induction of resistance in cucumber, and not to differences in environmental conditions or fungal populations between the two greenhouses (Rahman *et al*., 2009). We therefore speculate that under yellow net, significantly more scattered red light penetrates into the plant and fruit (Fig. 1), which in turn inhibits fruit ripening as shown by fruit colour index (Table 2) and/or, indirectly, induces resistance against *Alternaria alternata* infection after harvest. Preliminary results have revealed high amounts of chlorophyll in fruit harvested under pearl and yellow nets and relatively low amounts of carotenoids, which might indicate slow fruit ripening (Fallik and Goren, unpublished).

In parallel, it was found that under the pearl and yellow shade nets the population of *Alternaria alternata*, the main decay-causing agent after harvest, was significantly low compared to commercial black nets. Light has profound effects on fungal biology. Growth and development of many fungal species are intricately regulated by light (Springer, 1993; Purschwitz *et al*., 2006). Fungal responsiveness to different wavelengths of light has been well documented, and blue light/UV and red/far-red light are two types of photoresponses primarily observed (Mooney and Yager, 1990; Griffith *et al*., 1994; Purschwitz *et al*., 2006, 2008; Olmedo *et al*., 2010). Blue light or a high ratio of blue to UV radiation was inhibitory to the sporulation of many important phytopathogens (Raviv and Antignus, 2004; Paul *et al*., 2005). Increases in the spectral ratios between transmitted light:Blue/near-UV was found to inhibit the sporulation of several isolates of the fungal pathogen *Botrytis cinerea* in tomato (Kotzabasis *et al*., 2008). Hence, the ability of the pearl and yellow shade nets to filter UV light and enrich the blue spectrum (Shahak *et al*., 2008) and the blue/UV (Fig. 1) may be involved in *Alternaria alternata* inhibition in the field, thus reducing inoculum levels and fruit infection during its growth and thereafter decay development during prolonged storage and shelf life (Barkai-Golan, 2001).

In conclusion, based on our results from two consecutive years of study which have shown a significant reduction in decay development on pepper fruit harvested under pearl and yellow shade nets, it seems that these two coloured shade nets influence both the pathogen in the field and the fruit ripening and its susceptibility to pathological deterioration after harvest.

Acknowledgements

This research was supported by grant No. 430-0184-08/09 from the Chief Scientist of the Ministry of Agriculture and Rural Development, Israel. Contribution from the Agricultural Research Organization, the Volcani Center, Bet Dagan, Israel, No. 588/10.

References

ARASE S., FUJITA K., UEHARA T., HONDA Y., ISOTA J., 2000 - *Light-enhanced resistance to* Magnaporthe grisea *infection in the rice Sekiguchi lesion mutant*. - J. Phytopathol., 148: 197-203.

BARKAI-GOLAN R., 2001 - *Postharvest diseases of fruits and vegetables: development and control*. - Elsevier Science BV, Amsterdam, The Netherlands, pp. 423.

BEN-YAKIR D., HADAR M.D., OFFIR Y., CHEN M., TREGERMAN M., 2008 - *Protecting crops from pests using Optinet® screens and Chromatinet® shading nets*. - Acta Horticulturae, 770: 205-212.

BEN-YEHOSHUA S., SHAPIRO B., CHEN J.E., LURIE S., 1983 - *Mode of action of plastic film in extending life of lemon and bell pepper fruits by alleviation of water stress*. - Plant Physiol., 73: 87-93.

ELAD Y., 1997 - *Effect of filtration of solar light on the production of conidia by field isolates of* Botrytis cinerea *and on several diseases of greenhouse-grown vegetables*. - Crop Prot., 16: 635-642.

ELAD Y., MESSIKA Y., BRAND M., RAV-DAVID D., SZTEJNBERG A., 2007 - *Effect of colored shade nets on pepper powdery mildew (*Leveillula taurica*)*. - Phytoparasitica, 35: 285-299.

FALLIK E., ALKALAI-TUVIA S., PERZELAN Y., AHARON Z., ELMANN A., OFFIR Y., MATAN E., YEHEZKEL H., RATNER K., ZUR N., SHAHAK Y., 2009 - *Can colored shade nets maintain sweet pepper quality during storage and marketing?* - Acta Horticulturae, 830: 37-44.

FALLIK E., GRINBERG S., ALKALAI S., YEKUTIELI O., WISEBLUM A., REGEV R., BERES H., BAR-LEV E., 1999 - *A unique rapid hot water treatment to improve storage quality of sweet pepper*. - Postharvest Biol. Technol., 16: 25-32.

FRANK C.A., NELSON R.G., SIMONNE E.H., BEHE B.K., SIMONNE A.H., 2001 - *Consumer preferences for color, price, and vitamin C content of bell peppers*. - HortScience, 36: 795-800.

GRIFFITH G.W., JENKINS G.I., MILNER-WHITE E.J., CLUTTERBUCK A.J., 1994 - *Homology at the amino acid level between plant phytochromes and a regulator of asexual sporulation in Emericella (*=Aspergillus nidulans*)*. - Photochem. Photobiol., 59: 252-256.

ISLAM S.Z., HONDA Y., ARASE S., 1998 - *Light-induced resistance of broadbean against* Botrytis cinerea. - J. Phytopathol., 146: 517-523.

KEVERS C., FALKOWSKI M., TABART J., DEFRAIGNE J.O., DOMMES J., PINCEMAIL J., 2007 - *Evolution of antioxidant capacity during storage of selected fruits and vegetables*. - J. Agric. Food Chem., 55: 8596-8603.

KOTZABASIS K., NAVAKOUDIS E., VAKALOUNAKIS D.J., 2008 - *Photobiological control of crop production and plant diseases*. - Zeitschrift für Naturforschung Section C., 63(1-2): 113-123.

MOONEY J.L., YAGER L.N., 1990 - *Light is required for conidiation in* Aspergillus nidulans. - Genes Dev., 4: 1473-1482.

NISSIM-LEVI A., FARKASH L., HAMBURGER D., OVADIA R., FORRER I., KAGAN S., OREN-SHAMIR M., 2008 - *Light-scattering shade net increases branching and flowering in ornamental pot plants*. - J. Hort. Sci. Biotechnol., 83: 9-14.

OLMEDO M., RUGER-HERREROS C., CORROCHANO L.M., 2010 - *Regulation by blue light of the fluffy gene encoding a major regulator of conidiation in* Neurospora crassa. - Genetics, 184: 651-658.

PAUL N.D., JACOBSON R.J., TAYLOR A., WARGENT J.J., MOORE J.P., 2005 - *The use of wavelength-selective plastic cladding materials in horticulture: understanding of crop and fungal responses through the assessment of biological spectral weighting functions*. - Photochem. Photobiol., 81: 1052-1060.

PEREZ M., PLAZA B.M., JIMENEZ S., LAO M.T., BARBERO J., BOSCH J.L., 2006 - *The radiation spectrum through ornamental net houses and its impact on the climate generated*. - Acta Horticulturae, 719: 631-636.

PURSCHWITZ J., MÜLLER S., KASTNER C., FISCHER R., 2006 - *Seeing the rainbow: light sensing in fungi*. - Curr. Opin. Microbiol., 9: 566-571.

PURSCHWITZ J., MÜLLER S., KASTNER C., SCHOSER M., HAAS H., ESPESO E.A., ATOUI A., CALVO A.M., FISCHER R., 2008 - *Functional and physical interaction of blue- and red-light sensors in* Aspergillus nidulans. - Curr. Biol., 18: 255-259.

RAHMAN M.Z., HONDA Y., ARASE S., 2003 - *Red-light-induced resistance in broad bean (*Vicia faba *L.) to leaf spot disease caused by* Alternaria tenuissima. - J. Phytopathol., 161: 86-91.

RAHMAN M.Z., KHANAM H., UENO M., KIHARA J., HONDA Y., ARASE S., 2009 - *Suppression by red light irradiation of Corynespora leaf spot of cucumber caused by* Corynespora cassiicola. - J. Phytopathol., 168: 378-381.

RAJAPAKSE N.C., SHAHAK Y., 2007 - *Light quality manipulation by horticulture industry*. - In: WHITELAM G., and K. HALLIDAY (eds.) *Light and plant development*. Blackwell Publishing, UK, pp. 290-312.

RAVIV M., ANTIGNUS Y., 2004 - *UV radiation effects on pathogens and insect pests of greenhouse-grown crops*. - Photochem, Photobiol., 79: 219-226.

SALL J., LEHMAN A., CREIGHTON L., 2001 - *Fitting linear models and multiple regression* pp. 277-303. - In: SALL J., L. CREIGHTON, A. LEHMAN (eds.) *JMP Start Statistics. A guide to statistics and data analysis using Jmp and Jmp in software*. 2nd edition, SAS Institute Inc. Duxbury, USA, pp. 580.

SHAHAK Y., 2008 - *Photo-selective netting for improved performance of horticultural crops. A review of ornamental and vegetable studies carried out in Israel*. - Acta Horticulturae, 770: 161-168.

SHAHAK Y., GAL E., OFFIR Y., BEN-YAKIR D., 2008 - *Photo-selective shade netting integrated with greenhouse technologies for improved performance of vegetable and ornamental crops*. - Acta Horticulturae, 797: 75-80.

SHAHAK Y., GUSSAKOVSKY E.E., GAL E., GANELEVIN R., 2004 - *ColorNets: Crop protection and light-quality manipulation in one technology*. - Acta Horticulturae, 659: 143-161.

SOON GYU H., PRYOR B.M., 2004 - *Development of selective media for the isolation and enumeration of* Alternaria *species from soil and plant debris*. - Canadian J. Microbiol., 50: 461-468.

SPRINGER M.L., 1993 - *Genetic control of fungal differentiation: the three sporulation pathways of* Neurospora crassa. - Bioessays, 16: 365-374.

TABIRA H., OTANI H., SHIMOMURA N., KODAMA M., KOHMOTO K., NISHIMURA S., 1989 - *Light-induced insensitivity of apple and Japanese pear leaves to AM-toxin from* Alternaria alternata *apple pathotype*. - Ann. Phytopathol. Soc. Japan, 55: 567-578.