

The effect of different shading net on the Quantum Efficiency of PS II in chilli pepper cultivar ‘Star Flame’

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SUMMARY

The study was undertaken to identify the effect of different shading net on the quantum efficiency of PS II on ‘Star Flame’ chilli pepper (*Capsicum annum*) over a period of time cultivated under plastic house environment. ‘Star Flame’ pepper was grown under red shading net and samples without shading were used as control. Analysis of photosynthetic activity revealed a significant difference ($p < 0.05$) between Fv/Fm values in control and red shading at the end of July ($p = 0.031$) after the first harvest. Chlorophyll fluorescence parameter Fv/Fm reflects the maximum quantum efficiency of photosystem II (PS II) used in the detection of early stress in plants.

Keywords: shading nets, chlorophyll fluorescence, harvesting time, greenhouse

INTRODUCTION

Pepper (*Capsicum sp.*) is a member of the Solanaceae family and commonly divided into two groups known as pungent and non-pungent. Hot pepper is one of the vegetable crops commonly grown and consumed in Countries like China, Africa, Korea and many other countries for its nutritional composition such as antioxidant compounds and natural colors, like carotenoids and vitamin C (Howard et al., 2000). Hot peppers contain capsaicinoids that gives the fruit its pungency as well as their pharmacological attributes (Thiele et al., 2008). The use of shading net is mostly done to protect cultivated crops from excessive solar radiation, improve thermal climate (Kittas et al., 2009), providing shelter for crops against wind and hail and also prevent birds and insects from transmitting viral diseases (Teitel et al., 2008). Assertion made by Kittas et al. (2009) indicates that net shading of crops can result in changes on both local microclimate and crop activity. These changes may modify CO₂ assimilation and consequently improve crop growth and development. The use of shading nets modifies light environment, thus affecting light regulated activities in plants (Fallik et al., 2010). Combining different shading nets techniques resulted in better crop yields and lower susceptibility to decay during post-harvest storage compared to traditional shading methods (Stamps, 2009; Shahak, 2014). Yellow coloured mesh shades increased open field pepper yield and quality compared to traditional black nets (Fallik et al., 2009), while both yellow and pearl coloured nets reduced the occurrence of *Alternaria* and improved post-harvest qualities of the product (Goren et al., 2011).

Ilic et al. (2011) observed that red and pearl shade nets significantly increased the total yield (43.5 % and 49.5 %) which was as a result of both higher productivity for number of fruits produced per plant and larger fruits. Pepper plants grown under black shading nets with 40 % shade had higher yield (10.5 %) than plants grown without shading nets. Sharma et al. (2004) found out that cultivating of California Wonder species under greenhouse produced a greater number of

fruits (15.03), fruit weight (723.28 g plant⁻¹) and more yield (5.35 kg m⁻²). It also recorded maximum plant height (56.00 cm), number of branches (5.86) and number of leaves (80.76) when compared to open field conditions.

Abiotic stress can have significant effects on photosynthetic activities of pepper plants and therefore the use of chlorophyll fluorescence measurements can give an indication on how healthy a plant looks (Nagy et al., 2017). When plants are not under any kind of stress, the optimal photochemical quantum efficiency of PS II, meaning the Fv/Fm measurement using a chlorophyll fluorescence meter, is usually expected to be 0.72–0.85 (Bolhar-Nordenkamp et al., 1989). In agreement to this assertion, a decrease in fluorescence was observed by Guang-cheng et al. (2011) in hot pepper during water stress. Chlorophyll fluorescence imaging (Chl-FI) is an important tool that is used to study the spatial and temporal heterogeneity of leaf photosynthesis under biotic stress and their responses to the stress (Nedbal and Whitmarsh, 2004) which could be related to physiological alterations in bacteria affected plants (Bonfig et al., 2006). The current study aimed to investigate the effect of red shading net on the quantum efficiency of PS II in ‘Star Flame’ chilli pepper grown under plastic house environment.

MATERIALS AND METHODS

Plant material

The study was conducted at the experimental field of the Horticulture Institute, Szent István University, Gödöllő, Hungary (lat. 47°61' N, long. 19°32' E) with soils mainly sandy loam classified as Cambisol with 1.8–2% humus content and an approximate pH of 7. *Capsicum annum* L. hybrid, ‘Star Flame’ seeds were purchased from Seminis® (Kecskemét, Hungary) and were nursed on February 29, 2014 in propagation trays with holes. Seedlings were then transplanted on April 27, 2014 into a 30 m (length) × 4 m (width) × 2.5 m (height) greenhouse in twin rows with a spacing of 0.4 m between plants and rows, and 0.8 m between twin rows, therefore creating a planting density of 4.167

plants m⁻² out into individual pots in a greenhouse that had an average daytime temperature of 20°C.

Net characteristics

Different sections of the plastic house were covered with red (ChromatiNet, Ginegar, Israel) shading nets to alter the light environment. A non-shaded net (control) was also used in the same greenhouse. Each net was specified by the manufacturer to have a 40% shading ratio. Nets were placed perpendicular to the twin rows over a space 8 m in width, thus creating a block under which four biological replicates were randomly appointed. Ten plants were selected from each replicate, which were used to measure chlorophyll fluorescence (quantum efficiency of PS II).

Measurement of Light Parameters

A portable PAM 2500 fluorometer (Walz-Mess und Regeltechnik, Germany) was used to measure chlorophyll fluorescence in experimental plants. One measurement was made per week during a four-week period on a sunny day at noon before each harvest time, whereby four fully developed top leaves of a single plant from each replicate were affixed with leaf clips for a 35 min dark adaption before fluorescence measurement. Maximum quantum efficiency of PSII was quantified using the Fv/Fm ratio determined by the fast kinetics method in the PamWin 3.0 software (Van Goethem et al., 2013).

Statistical Analyses

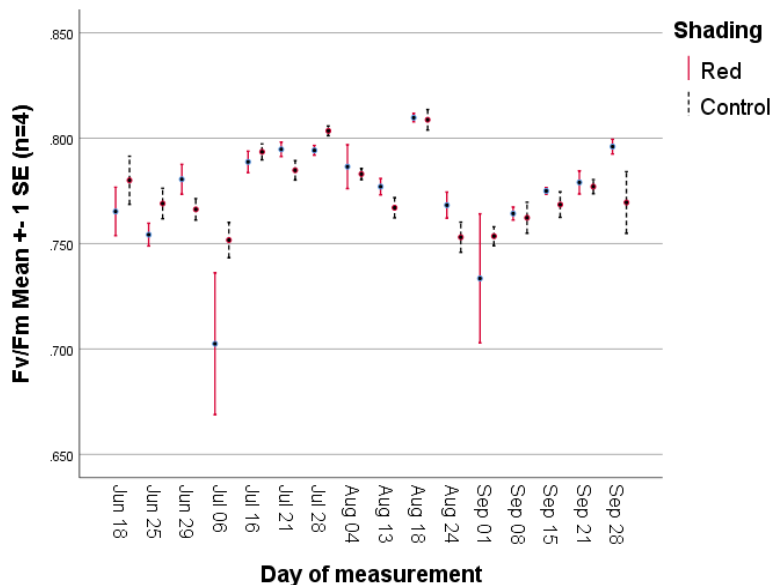
Results were expressed as mean of four replicates ± standard errors. Mean separation of light parameters and day of measurement was investigated using independent sample test with $p < 0.05$. Statistical

analyses were performed using IBM SPSS 22 software (IBM, USA).

RESULTS AND DISCUSSION

From the investigation in *Figure 1*, the use of red shading net had no significant difference in the Fv/Fm values measured between June 18 and July 28. It was observed after the first harvest a significant difference ($p < 0.05$) in the measurement of Fv/Fm values $p = 0.031$ that indicated stress in plants which corroborates with the assertion made by Guang-cheng et al. (2011). A decrease in fluorescence measurement indicates a decrease in chlorophyll which could be as a result of poor irrigation or possibly high temperature stress causing Fv/Fm values to decrease (Hanying et al., 2001). Photosynthetic activities are influenced by a number of factors such as leaves position, stage of development, light intensity and composition (Borisev et al., 2012). Chlorophyll fluorescence accounts for only 1–2% of the total absorbed light which practically quantifies abiotic factors. For this quantification, the Fv/Fm value is used, which is the quotient of the variable fluorescence and the maximum fluorescence, with this value being characterized by the maximum quantum efficiency of the PSII photosynthetic system. Measurement of Fv/Fm values of red shading net between August 04 and September 28 indicated no significant differences ($p < 0.05$). Zhu et al. (2012) investigated that Fv/Fm values of peppers grown on shadowing (unshaded, 30%, 70%) and on the surface water capacity (40–55%, 55–70%, 70–85%, 85–100%) was found that 70% shielded and 55–70% moisturized plants are the highest.

Figure 1: Influence of different shading net on the quantum efficiency of PS II in ‘Star Flame’ chilli pepper grown under greenhouse environment (Fv/Fm values)



CONCLUSION

The use of different shading nets provides a new, multi-benefit tool for crop protection. Changing the light intensity in a greenhouse environment has a great impact on the microclimate and energy consumption are influenced, costs and benefits are affected. Research on different light exposure in the agricultural system is necessary for a sustainable and market-oriented greenhouse production of crops in the future

even though red shading nets used in this experiment did not extensively affect fruit quality.

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