Micro-climatic effect of plastic nets for crop protection in greenhouse

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Summary

Excessive levels of solar radiation may negatively influence crop growth, with sunburns or other possible crop damages, while increasing the internal greenhouse temperature above levels that are tolerable for plants and workers. In order to control hot air temperature inside a greenhouse, one of the most common solutions traditionally employed by growers in Southern Europe is whitening the external side of its cladding material, by painting it with liquid calcium carbonate. More recently, the use of plastic shading nets is progressively affirming, thanks to their cheaper price and some improved technical characteristics that enable them to act as a "passive" tool for controlling internal microclimate and produce suitable environmental conditions. A comparative analysis between a plastic net and a traditional whitening technique, aimed to critically assess the efficacy of the two different shading methods to modify and control the internal microclimate inside a plastic-covered greenhouse, is presented in this paper. A trial was carried out in Pontecagnano (Southern Italy), where one small-scale tunnel was shaded with a plastic net characterized by 60% of shade effect, while another identical small-scale tunnel was whitened with liquid calcium carbonate on the external side of the cladding plastic film. The radiometrical characteristics both of the plastic net and the whitened film were determined in the laboratory of the SAFE School of the University of Basilicata (Italy). The results obtained through these experimental trails enabled a comparative analysis of the performances of the two tested shading methods, confirming the relationship among the shading conditions and the transmittance in the solar range, highlighting the role that a correct solution may play on the final results in terms of crop protection from high temperatures and sunburns.

1. Introduction

Excessive levels of solar radiation may determine negative effects on the crop growth. Plants that are not adapted to intense sunlight can develop heat stress. Most of these negative effects may be avoided, mostly in the case of crop protection under greenhouse, when suitable shading devices are employed (Castronuovo et al., 2015). To control hot indoor air temperature, one of the most common traditional solutions utilized by growers in Southern Europe is the summer shading of the greenhouse against excessive solar radiation through the application of calcium hydroxide (*i.e.*, slaked lime) or other chemicals on the cover of the greenhouse (so-called, *whitening, i.e.*, white shading paint). Whitening can be achieved by spraying the exterior cover surface with an aqueous solution of hydrated Calcium oxide ($Ca(OH)_2$). Whitening the greenhouse roof is inexpensive and has positive effects on both microclimate and crop behaviour, being considered an efficient mean for alleviating large heat loads during summer that, at the end of the summer season, is naturally washed away by autumn rains. More recently, the use of plastic shading nets is progressively affirming, thanks to a cheaper price and improved photo-selective properties (Sica et al., 2008). Plastic nets are usually characterized by a shading factor, ranging from 10% to 90%, which represents the capacity of the net to reduce the incoming solar radiation, related to the average value of the transmissivity of the net in the solar wavelength band from 380 nm to 760 nm (Schettini et al., 2012). A plastic net, due to its influence on the main microclimatic parameters (temperature, relative humidity, carbon dioxide concentration, solar radiation, *etc.*), could play a fundamental role on creating more favourable environmental conditions during the crop growth (Picuno & Abdel-Ghany, 2016; Abdel-Ghany et al., 2016). On the other hand, plastic covers play a crucial role not only towards the internal environment, influencing the crop growth, but also towards the external surrounding landscape, strongly affecting the visual aspect of the rural land (Picuno et al., 2011; Statuto et al., 2016). With the aim to critically assess the efficacy of these two different shading methods to modify and control the internal microclimate inside a plastic-covered greenhouse, in this paper the results of a comparative analysis between a plastic net and a traditional whitening technique are presented.

2. Materials and Methods

Two small tunnels (fig. 2.1) reproduced in scale were realized in an experimental area located in pontecagnano (southern italy) during summer 2016. these experimental small-scale tunnels, both covered with an eva plastic film, were left without any cultivation. one of them was whitened with an aqueous solution of 20% hydrated calcium oxide ($ca(oh)_2$) – i.e., a dose of 0.2 kg l^{-1} – while the second one was externally covered with a 60% plastic shading net adhering to the film. air temperature and relative humidity inside each tunnel were measured by relevant probes (cs500-l modified version of vaisala's 50y humitter, campbell scientific inc. utah, usa). data were recorded into a cr10x data-logger (campbell scientific inc. utah, usa).

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Figure 2.1: Trial small-scale tunnel covered with a 60% shading net adhering to the EVA film (left) and with the same EVA film whitened with Calcium Oxide (right)

The radiometrical characteristics in the uv-vis-nir wavelength [200 – 2.500 nm] of both the eva film + 60% shading plastic net and the whitened plastic film were determined in the laboratory of material tests of the safe school of the university of basilicata (italy) through a jasco v-570 spectro-radiometer.

3. Results and Discussion

The results of the spectro-radiometrical analysis over the tested materials are reported in table 3.1, in terms of the main characteristics measured in different significant ranges within the solar spectrum. figure 3.1 shows the diagrams of solar transmittance and reflectance of the two tested methods, together with that one of the eva film without any shading effect.

Table 3.1: Results of the spectro-radiometrical analysis on the tested shading methods.

Range	Wavelenght	EVA film + 60% Shading Net		Whitened Film	
	nm	□□□□□□	□□□□□□	□□□□□□	□□□□□□
Solar	200 - 2500	45.19	27.82	41.09	51.73
PAR	400 - 700	28.90	47.46	31.81	59.99
Solar IR	700 - 2500	52.15	26.75	46.79	51.38
UV	280 - 380	6.75	6.66	2.77	45.50
UVA	320 - 380	6.78	6.91	4.48	49.74
UVB	280 - 320	6.71	6.25	0.15	39.14

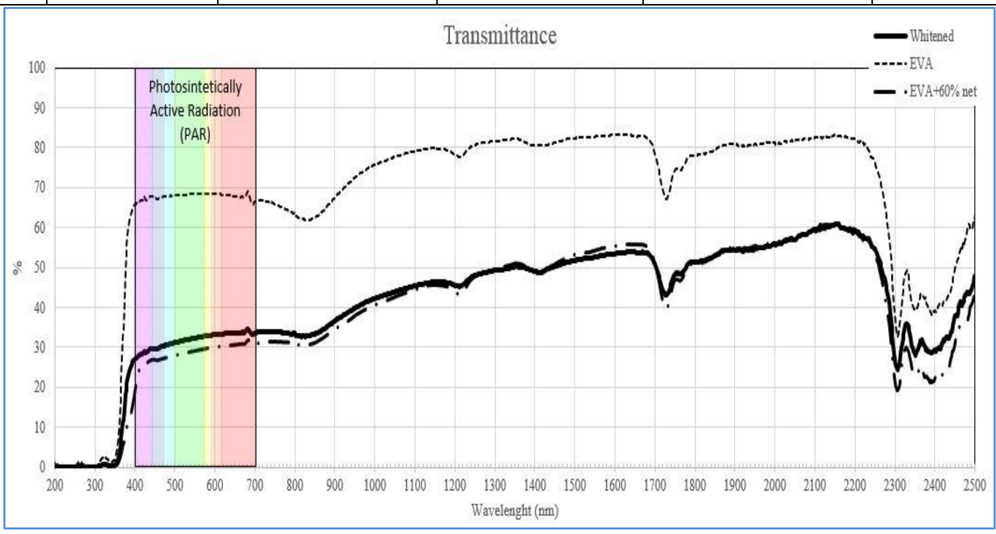

figure 3.1: transmittance and reflectance low of the film + 60% shading net, the whitened film and the eva film.

From the results of the spectro-radiometrical analysis performed in the solar range, it would be firstly deduced that the shading effect declared by the plastic net producer seems sufficiently close to the value that was detected. the very small difference in the radiometrical characteristics of the two shading methods did not seem to have any significant influence on the thermodynamic behaviour within the two different small-scale tunnels during the testing period. the temperatures that were measured inside the two small tunnels during the testing period were indeed almost similar (fig. 3.2), showing very little differences mostly during daytime (about 1°c higher in the whitened tunnel), so confirming that the two tested methods produce almost similar effects toward the internal microclimate. anyhow, their different reflectance asks for further analysis on the effect on the surrounding landscape.

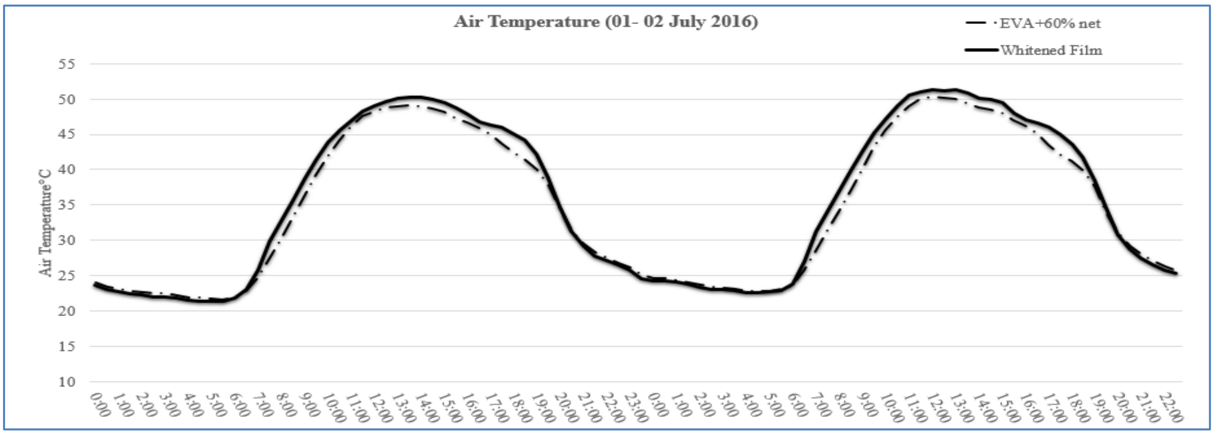

figure 3.2: air temperature inside differently shaded trial greenhouses.

4. Conclusions

Both shading traditional techniques – *e.g.*, whitening – and new materials, as plastic nets, deserve a more deep analysis of their performances in shading a greenhouse, protecting the internal cultivation while influencing the surrounding environment. Further studies are therefore necessary for examining how to improve the selective filtering effect of both these techniques, enhancing agronomic production while reducing their impact on the visual quality of the rural landscape as well.

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