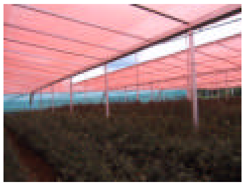


How smart additives can improve productivity for rose growers?

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1 Introduction

Increased yields, shorter growing cycle and increased quality of roses are of major importance during periods like Mother's or Valentine's days, when the rose farmers need to deliver large quantity of high quality roses in a very short period of time. These are the periods when the value of the roses reaches their peak. As an example, Ecuadorian flower growers harvest 22-25% of their annual revenue during the period near Valentine's Day.

Besides the improved quality of rose bre eds, modernized greenhouse systems and better cultivation practices farmers can improve the productivity of their farms by using 'functionalized' greenhouse films. These films, by incorporation of "functional" additives, can modify the quantity and quality of light transmitted through the plastic film and as such deliver a strong positive effect on crop productivity, quality and precocity [1-3]. For example, UV absorbers block excessive UV light, causing burning and necrosis of plant tissue and blackening of the petals [4]. They can also prevent the spread of fungi and viruses [5].

Anti-drip additives, in general, increase the light transmission, as the formation of drops is prevented. This reduces total reflection. Additionally, anti-drip additives prevent petal and leave burning.

Additionally, a new photoselective additive, Ciba® SMARTLIGHT™ RL 1000, was designed to shift the UV light (generally not used for plant's photosynthesis) to red light which is highly beneficial for crop growth. In this article, we present the mechanism of action of this new additive as well as the agro-economic benefits it can bring to the rose growers. Results were obtained from field trials carried out in major cut flower markets around the world.

2 Light quality and plant growth

Plant growth is stimulated by the presence of water, nutrients, carbon dioxide, temperature and several light regulated processes like photosynthesis, photomorphogenesis and photoperiodicity. In these processes the light intensity, quality, direction and duration are important.

The plant photosynthesis depends strongly on the total amount of light received by the plant in the PAR (photosynthetic active radiation ranging from (400 to 700 nm) with major contributions from the blue (400-500nm) and red light (600-700nm), [Figure 1]. Production of plant mass is enhanced by more red radiation. This can lead to increased yield of roses, tomatoes and other crops, particularly in regions with high irradiation.

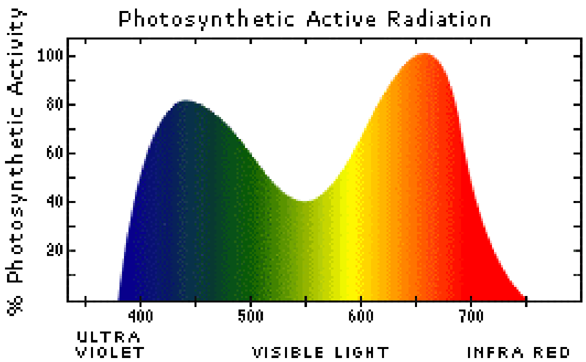

Fig.1 Absorption spectrum of the extract of photosynthetic active pigments of a leaf (according to Mermier and Baille, 1998).

The wavelengths of light that affect plant photomorphogenesis depend on the plant species as well as on the plant variety. Not only UV (300-400nm) and blue radiation (400-500nm), but also red (600-700nm) and far-red radiation (700-800nm) strongly influence several physiological processes in the plant via different photoreceptors (phytochrome, B/UVA-receptor, UVB-receptor). These photoreceptors can act independently from each other, or they rely on interdependence for a specific response [6-11].

Red radiation contributes to photosynthesis, but can inhibit stem elongation and branching of plants. They cause the leaves to be sometimes smaller and thicker. This results in inhibition of flowering of short-day plants, but promotion of flowering of long-day plants.

On the other hand, an increase of far-red radiation (700-800 nm) leads to an increase in stem-elongation of the plant. Filtering out the far-red part of the solar spectrum can produce shorter plants. However, flowering can also be inhibited in some plant species if far-red radiation is missing.

3 Manipulation of light spectrum by SMARTLIGHT

3.1 Mechanism of action

The above-mentioned concepts, obtained from a thorough knowledge of plants physiology, apply to the SMARTLIGHT additive. By its intrinsic chemical nature, it converts UV-light into red light (635 nm) by luminescence. Therefore it can be thought of as a solar concentrator that increases the amount of red light useful for enhancing the photosynthetic process with minimum variation of the PAR.

Through the boosting of the red region by SMARTLIGHT one also increases the ratio of red to far red light (730nm) influencing the physiological processes in the plant. The Red/Far-Red ratio, which is around 1.0 at midday on a sunny day, is by far higher under a greenhouse film containing SMARTLIGHT and is independent of the condition of the sky (clear to cloudy). Thus, the beneficial effects through luminescence can also be expected under conditions of lower irradiation.

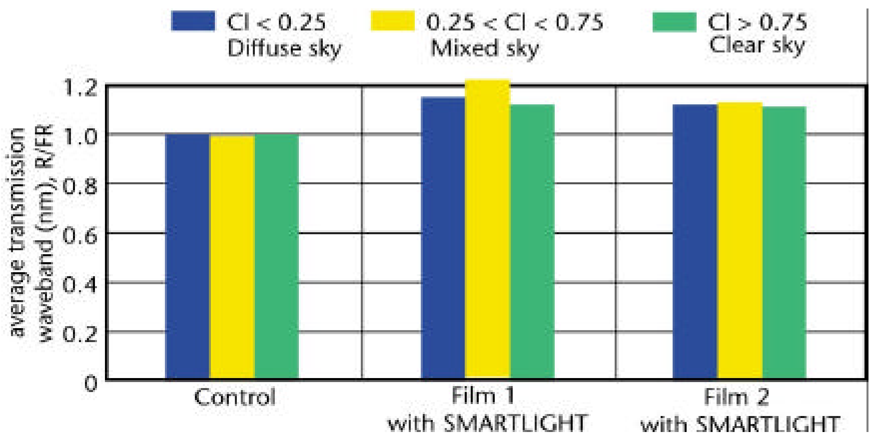

Fig. 2: Red/Far-Red ratio for polyethylene test films for different sky conditions (CI = Clearness Index).

Red/Far-Red measurements performed on films used in field trials confirmed a consistent and lasting effect, with a ratio higher than 1.0 (for polyethylene film containing SMARTLIGHT) for up to two agricultural seasons.

3.2 Materials and Methods

SMARTLIGHT was incorporated at a level of around 0.5-1% depending on the thickness of the greenhouse film and the intended duration of the luminescence effect. The Red/Far-Red ratio was measured by means of CR 10X LI-COR radiation sensors, one placed over the greenhouse film and the other underneath it. A series of Red/Far-Red measurement data were collected to evaluate SMARTLIGHT performance as a function of exposure time.

The greenhouse films were stabilized with Ciba® TINUVIN® NOR™ 371 and Ciba® TINUVIN® 327 to give optimal light and thermal stability in the presence of elemental sulfur (a pesticide used widely in rose cultivation), and to block the excessive UV radiation.

3.3 Agro-economic results of field trials on roses

SMARTLIGHT was evaluated in the major cut flower markets in order to get a better view of its performance under a variety of conditions e.g. climatic, rose variety, greenhouse design, greenhouse film structure, farming practices etc. Results obtained on red and pink rose varieties from e.g. Rosen-Tantau and Meilland are listed below.

Production data (number of commercial roses per square meter, yield/m^2) of the red rose 'Escada' under a SMARTLIGHT-based greenhouse film were collected weekly and compared to a reference film having similar thermal/optical properties (no luminescence) in figure 3.

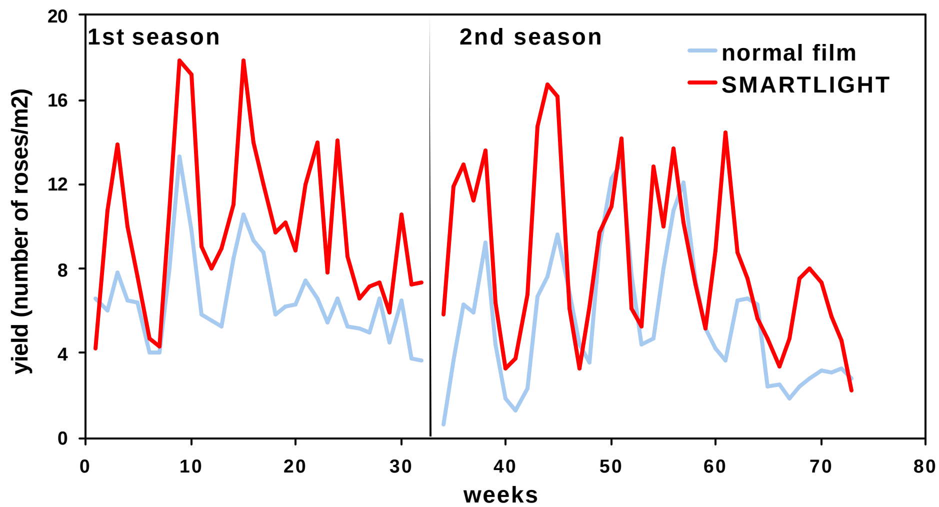

Fig. 3: two growing seasons (2000,2001) red roses production in Zimbabwe under a SMARTLIGHT containing film vs. a standard greenhouse film.

During the period of two growing seasons a 50% higher production yield was obtained under the film containing SMARTLIGHT. This substantiates the above measured persistency of the red luminescence generated by SMARTLIGHT.

More than 50% increase in productivity of red rose variety 'Black Magic' was obtained in Saudi Arabia, comparing the rose productivity under a Ni-Quencher greenhouse and a SMARTLIGHT greenhouse. About 70% more top quality roses were grown and less petal blackening was observed in the SMARTLIGHT greenhouse. The farmer commented that the population of red spiders, which damage the roses and make them unmarketable, was much lower under the SMARTLIGHT greenhouse. Already after the 6 months the farmer started to cover all his roses with SMARTLIGHT.

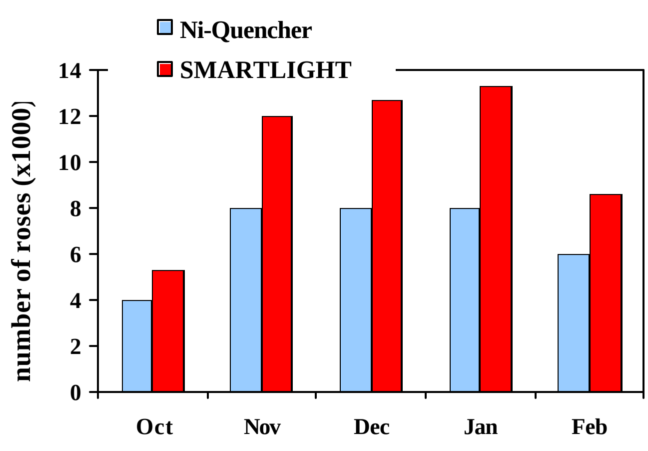

Fig. 4: red roses production in Saudi Arabia under a SMARTLIGHT containing film vs. a Ni-Quencher greenhouse film (2003).

The picture below shows the comparative density of young rose bushes (variety 'Grand Gala') grown in the canopy: one under a standard greenhouse film and the other under a film containing SMARTLIGHT. In this field trial the farmer realized a 20% increase in productivity and also longer, thicker stems and bigger bulbs.

Fig. 4: 1st seasons' (2002) roses production in Zimbabwe under a standard polyethylene film (picture on the left) and a SMARTLIGHT-containing film (picture on the right).

Field experiments carried out with SMARTLIGHT in Colombia on the rose variety 'Charlotte' also showed good precocity where the growing cycle was shortened by 7%.

In Thailand, the increase in productivity and the improvement in quality of roses of the variety 'Saphir', accounted for an overall increase in earnings of 61%. In figure 5 one can find the comparative data for accumulated number of high-quality roses collected during 2002 under a standard vs. SMARTLIGHT containing 150 micron greenhouse film. The accumulated yield of high-quality roses being a 100% higher under the SMARTLIGHT greenhouse. During that same period 39% more roses, without distinction of their classification, where pruned under the SMARTLIGHT greenhouse.

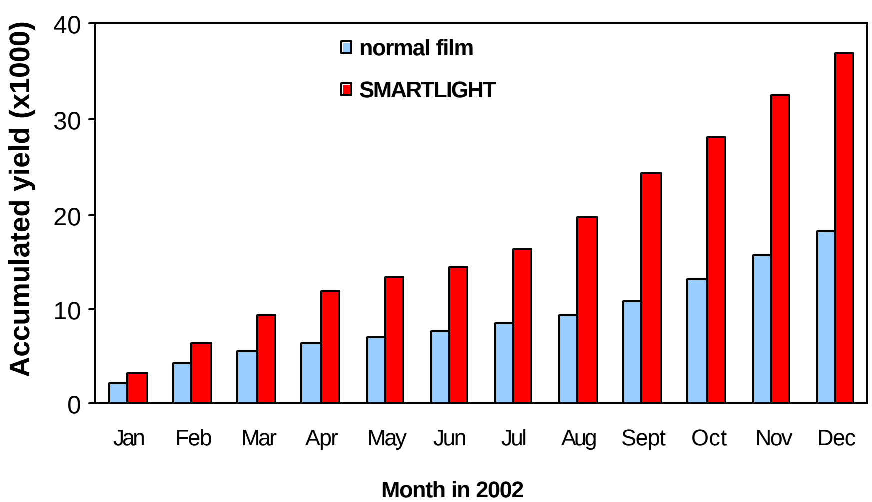

Fig. 5: Accumulated roses of high quality during 1 year (2002) rose production in Thailand.

Similar results were obtained on the yellow rose variety ’Skyline’, the white variety ‘Viviane’ and the purple rose variety ‘Maritim’.

Sulfur was extensively used inside rose greenhouses with no detrimental effect on the service life or mechanical properties of the greenhouse film (stabilized with TINUVIN NOR 371). When combined with TINUVIN 327 petal blackening was prevented.

4 Conclusions

The traditional idea of ‘greenhouse’ has been going through a continuous change over the last few years due mainly to new and more efficient light transforming additives. As presented in this article, by using proper light managing additive, the performance of the greenhouse can be improved dramatically and thus, more valuable crops can be grown.

It was shown that new SMARTLIGHT RL 1000 transforms the sometime harmful UV-light into useful red light in a unique way. When incorporated into a greenhouse film it can increase yield (up to 50%), shorten growing cycle (about 7%) and improve quality of roses (up to 100% more high quality roses). Field trials confirm the luminescence performance up to 280kLys. Typically, farmers can expect these agronomic benefits coming from SMARTLIGHT RL 1000 up to two consecutive agricultural seasons.

TINUVIN NOR 371 has delivered good light stability protection for the very critical rose greenhouse films in high irradiation countries such as Colombia, Kenya or Israel where the use of heavy doses of elemental sulphur is prevalent.

Although major benefits of SMARTLIGHT can be observed on several varieties of roses, one must remember that the degree of growth of these crops is dependent on the crop variety, nutrition, growing substrate, climate, etc. Therefore it is absolutely imperative that this new technology is evaluated via a field trial under the local conditions specific to the farmer.

5 Acknowledgments

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