Samsung Horticulture LEDs

Photoperiod and Strawberry

Dec. 2018

Strawberry Production Worldwide

Strawberries (*Fragaria* × *ananassa*, Duch.) are widely appreciated for their characteristic aroma, bright red color, juicy texture and a splendid balance of sweet and sour taste. They are cultivated in many countries worldwide including China, the United States, Mexico, Spain, Japan and South Korea, as shown in Fig. 1 [1]. In the United States and several countries in Europe, strawberries are mainly grown in open fields. But, in the northern portion of countries in the East, almost all strawberry production is greenhouse-based. Over the years, the cultivation area and production levels of strawberries have steadily increased as shown in Fig. 2 and continue to do so today, with a projected annual market value of over $20 billion in 2020 [2]. Amid heightened demands for environmental protection and more local food supply (for instance, 'food miles'), greenhouse horticulture is expected to grow around the globe, even in the United States and Europe. To improve production and the quality of strawberry harvests, horticulture lighting is essential for greenhouse-based cultivation.

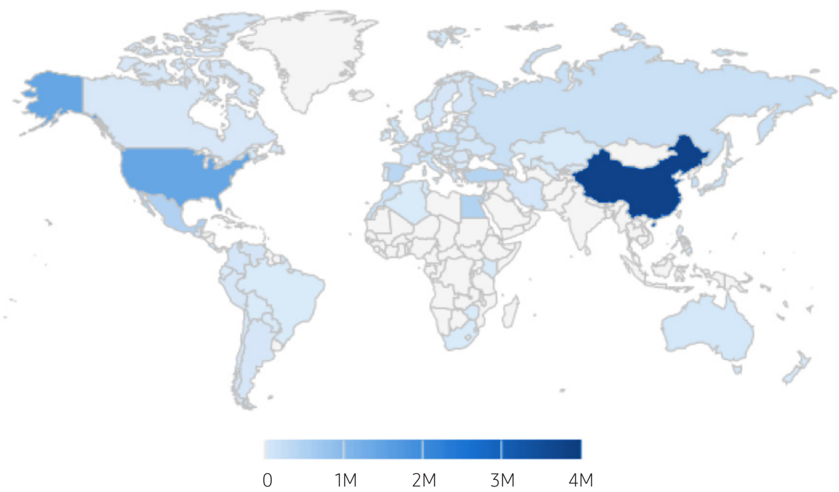


Figure 1. Worldwide strawberry cultivation area

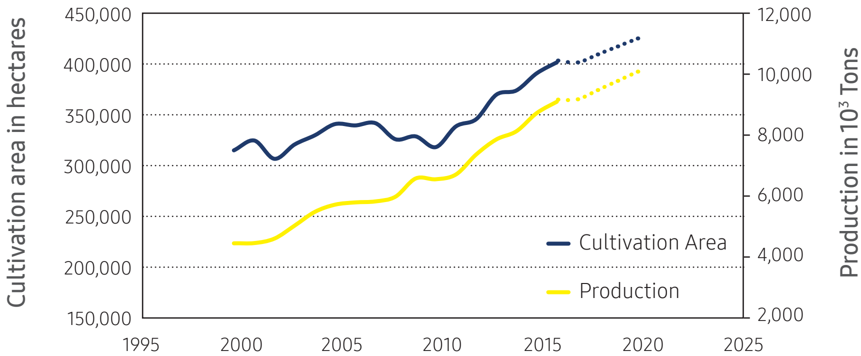


Figure 2. Cultivation area and production levels for strawberries

Supplementary Lighting for Strawberries

Supplementary lighting for strawberry cultivation is playing an important role in not only promoting vegetative growth and regulating the photoperiod, but also in improving the propagation rate. The primary influences of supplementary lighting are demonstrated in Fig. 3. Strawberries are short-day (SD) cultivars, and their floral induction takes place in early autumn. In fact, as the saturated PPFD (photosynthetic photon flux density) is reportedly 800-1,200μmol/m^2/s, to satisfy the light requirement for winter strawberry production is not easy, especially when multi-layered screens are covered for heat insulation in greenhouses. Using supplementary lighting can provide enough PPFD even in winter, resulting in significant additional vegetative growth.

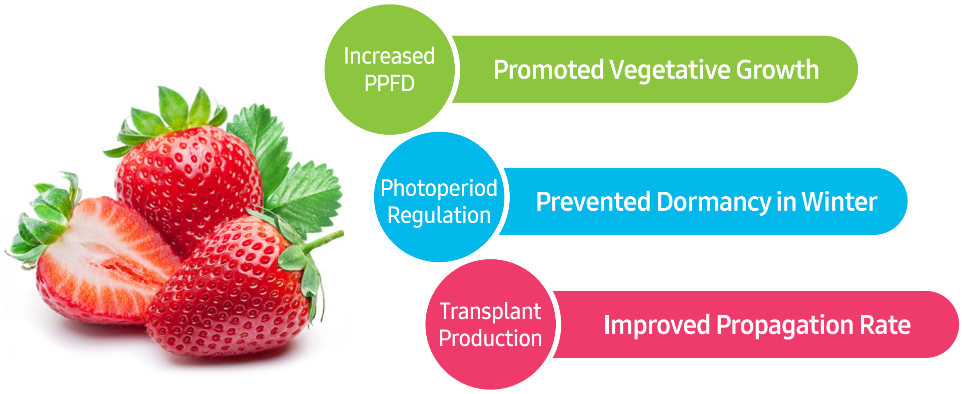


Figure 3. Effects of artificial lighting on strawberry production

In northern Asian countries, supplemental lighting is applied mainly to prevent the plants from entering dormancy. Dormancy can stop growth throughout an entire winter, under natural conditions. Yet, by applying day extension or night breaking using supplementary lighting, strawberries can maintain healthy vegetative growth resulting in a more robust plant architecture, which largely affects lighting absorption. A practical application of supplementary lighting for day extension in greenhouses is shown in Fig. 4.

Figure 4. Application of day extension/night breaking in strawberry cultivation

Day length can affect flowering induction of SD plants. However, the flowering response of strawberries to day length is closely impacted by temperature. When the average wintertime temperature is lower than the threshold temperature (13°C on average), most SD cultivars cultivated in northern Asian countries develop flowers regardless of the photoperiod. In such cases, day extension lighting will not inhibit flowering induction. This treatment to create a long-day (LD) condition (13-16 hours light) is usually applied after inflorescence of the 2nd series of flower clusters and requires only very low light intensity (2-5 μmol/m^2/s).

Figure 5. Applying artificial lighting to transplant production

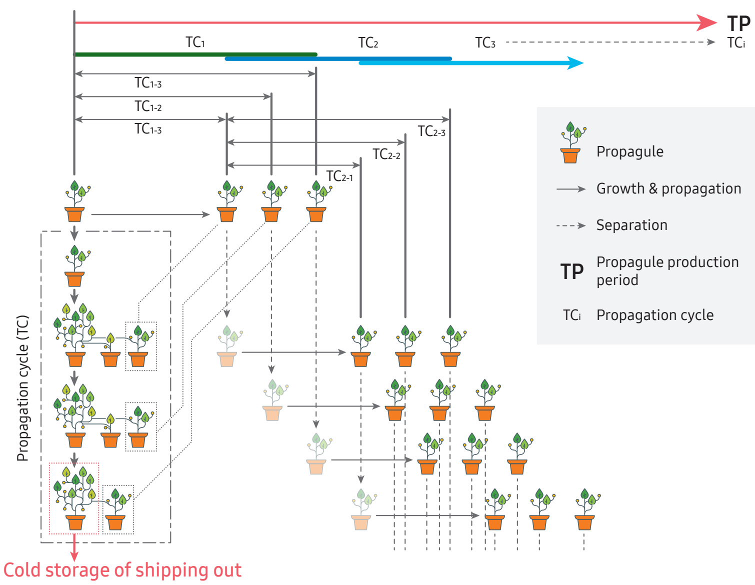


Figure 6. Schematic diagram of the ATPM in a plant factory

Transplant production of strawberries typically requires procedures that are slow, laborious and expensive. Propagating about 25-30 runner plants per mother plant per year will take at least 6 years to diffuse one billion transplants of newly-bred cultivars. Recently, Prof. C. Chun, Seoul National University in Korea, developed the autotrophic transplant production method (ATPM). ATPM is a unique methodology for producing strawberry transplants in a plant factory using artificial light (PFAL), as shown in Fig. 5 [3]. This novel propagation process differs from conventional approaches in: 1) the small size of propagules, 2) high plant density, 3) early fixation of unrooted runner tips, 4) use of generated runner plants as propagules for subsequent propagation cycles, 5) a fast propagation cycle, 6) year-round propagation, 7) uniformity of propagules, runner plants and harvested plug transplants, and 8) simultaneous growth of multiple propagules to attain a sufficiently-sized plug transplants for shipment or cold storage. Fig. 6 shows a schematic diagram of the newly developed ATPM. With this unusual but highly effective method of ATPM using the white-based full spectrum of LED, required time for one billion transplants can be reduced to 2 years (36 m^2 of cultivation area) [4].

Signaling Effects and Samsung Horticulture LEDs

Spectral band quality also affects the photoperiod in various plant cultivation. Particularly, red and far-red lights play an important role in improving day extension, while flowering time is impacted by phytochrome regulation. [5]. Phytochrome has two different chemical structures (P_r, P_{fr}) that are inter-convertible. They absorb red light (660 nm) and far-red light (730 nm), respectively (Fig. 7). When P_r absorbs red light, it is converted to P_{fr}, a biologically active form of phytochrome. A typical lighting source for photoperiodic control has been incandescent lamps, which usually emit adequate amounts of red and far-red light.

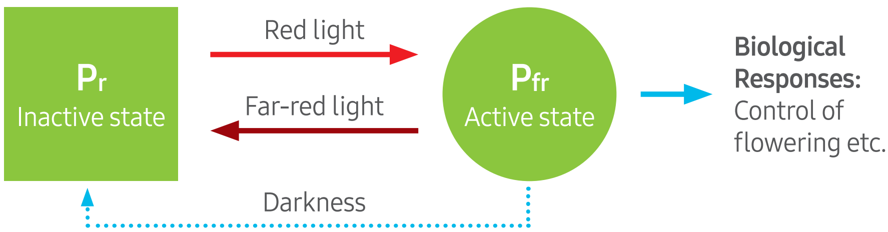


Figure 7. Schematic representation of phytochrome with two inter-convertible forms (P_r, P_{fr})

However, because of the low efficiency and short lifetime of incandescent lamps, there is a need for an alternative. With high efficiency, long lifetime and spectrum control of LEDs, flowering can be regulated more efficiently under a variety of red: far-red ratios. Previous investigations have indicated that LEDs with more far-red are highly effective in day extension or night break treatment. This shows that LEDs are efficient in promoting flowering or delay dormancy in various SD and LD species [6-11]. A. Yamada's research indicate that the date of visible budding by long-day treatment (low red: far-red ratio) can be accelerated by about 20 days, as in the case of E. grandiflorum (LD) (Fig. 8) [10]. According to D. Craig and E. Runkle, a moderate to high R: FR (0.66 or greater) was most effective at interrupting the long night for SD plants, while blue light was not needed to interrupt the night (Fig 9.) [11].

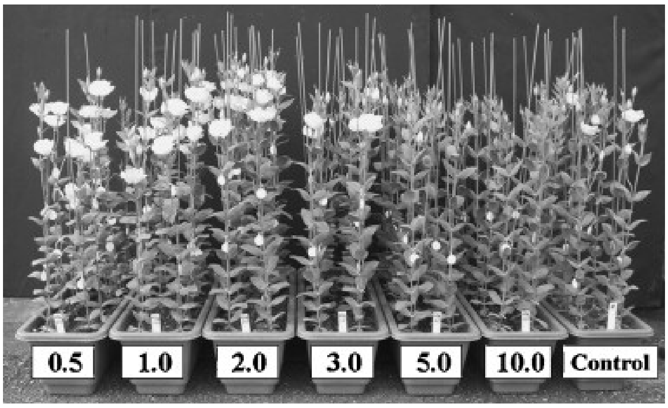


Figure 8. Comparative flowering of E. grandiflorum using light sources with different red: far-red ratios [10]

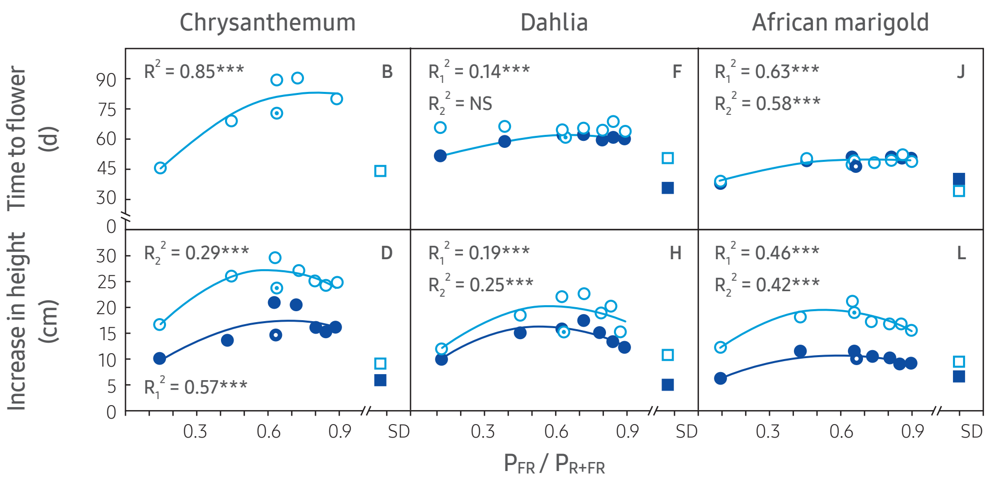
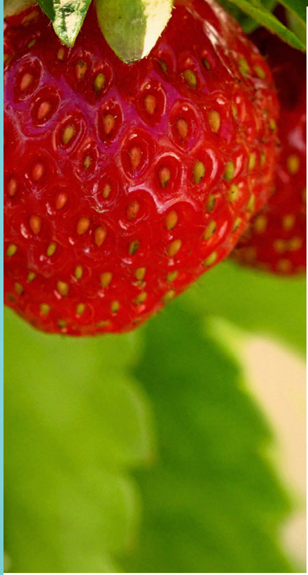


Figure 9. Influence of estimated P_{fr}/P_{fr+r} in night interruption lighting on flowering characteristics [11]



The newly designed Samsung Horticulture Lighting for signaling effects are white-based and uses full spectrum to allow sufficient red and far-red light, while enabling a better working environment for people. It can also be a very powerful tool for ornamental plant growers who manipulate photoperiodic responses for scheduling. Furthermore, Samsung's approach goes beyond the standard of horticulture lighting by providing the highest efficacy of 2.74 µmol/J, a dramatically extended non-yellowing lifetime and better PPFD uniformity. Furthermore, Samsung Horticulture LED has a full line-up of these — with high efficient blue, deep red, and far-red packages. You can apply Samsung Horticulture Lighting virtually anywhere such as in greenhouse and indoor farming, where dynamic growth lighting is needed.

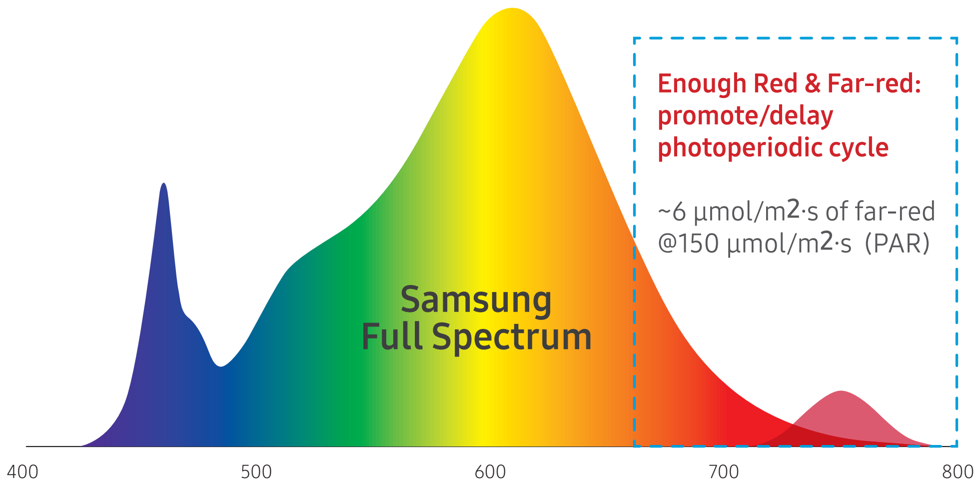


Figure 10. Spectrum of Samsung Horticulture LEDs

Figure 11. Line-up of Samsung Horticulture LEDs

[1] FAOSTAT, National Earth, Strawberries, production quantity (www.factfish.com).
[2] FAOSTAT, Food and agriculture data (http://www.fao.org) (2018).
[3] T. Kozai, G. Niu, and M. Takagaki, "Plant factory:An indoor vertical farming system for efficient quality food production", p. 260-269. (2016).
[4] H. Lee, "Application of white LEDs to promote growth and propagation rates of strawberry transplants", Master Thesis, Seoul National University (2019).
[5] K. Halliday, M. Koornneef, and G. Whitelam, "Phytochrome B and at least one other phytochrome mediate the accelerated flowering response of Arabidopsis thaliana L. to low red/far-red ratio". Plant Physiol. (1994).
[6] G. Deitzer, R. Hayes, and M. Jabben, "Kinetics and time dependence of the effect of far red light on the photoperiodic induction of flowering in wintex barley", Plant Physiol. (1979).
[7] I. Ilias and N. Rajapakse, "Growth and flowering responses of petunia x hybrida to different photoperiods, light qualities and temperatures does light quality affect photosynthetic apparatus of petunia", Phyton. Horn. (2012).
[8] T. Cerny, J. Faust, D. Layne and N. Rajapakse, "Influence of photoselective films and growing season on stem growth and flowering of six plant species", J. Am. Soc. Hortic. Sci. (2003).
[9] W. Owen, Q. Meng and R. Lopez, "Promotion of Flowering from Far-red Radiation Depends on the Photosynthetic Daily Light Integral", Hortscience (2018).
[10] A. Yamada, T. Tanigawa, T. Suyama, T. Matsuno, and T. Kunitake, "Red:far-red light ratio and far-red light integral promote or retard growth and flowering in Eustoma grandiflorum (Raf.) Shinn", Scientia Horticulturae (2009).
[11] D. Craig and E. Runkle, "A Moderate to High Red to Far-red Light Ratio from Light-emitting Diodes Controls Flowering of Short-day Plants", Horticultural Science (2013).

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Dec. 2018

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