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Samsung Horticulture LEDs

Apr. 2019

The Impact of Plant Nutritional Values on People

The overall horticulture lighting market is expected to grow from $3.8 billion in 2017 to $8.6 billion by 2022, at a CAGR of 17.8%, owing to rapid population growth and increasingly scarce agricultural land [1]. The full extent of this accelerated evolution will strongly depend on several market dynamics.
Today, market growth trends are primarily focused on two areas.

Vegetable production: "low-cost / high-volume products"

Medicinal plant production: "high-quality / high-content products"

Most horticultural lighting applications are now being impacted by genetic differences and environmental influences, as well as the interaction between these two factors. Among environmental considerations, light is one of the most important factors. LED lighting is considered a highly promising light solution with its exceptional energy efficiency and ease of control, compared to traditional 'grow' lighting such as fluorescent, high-pressure sodium and metal halide lamps. In recent research papers, Samsung has proved the effects of light quality on the production of leafy green vegetables and fruit. Now, we will discuss how light affects nutritional values (primarily the phytochemicals in plants).

As often noted, meals that are rich in fruits and vegetables reduce the risk of cancer, disease and diabetes, the interests in and the need for high quality foods has steadily increased [2-5]. By applying optimized horticultural practices and environmental controls, we also have been able to extract enriched antioxidants from popular fruits and vegetables such as tomatoes, lettuce and strawberries.

How Light Influences Plant Nutrition

Plants have a variety of photoreceptors that serve different functions and synergistically regulate each other. Chlorophyll, phytochrome and cryptochrome are the principal photoreceptors (Fig. 1). Chlorophyll is a molecule that traps light and converts energy through photosynthesis, while phytochrome regulates the germination of seeds, or flowering. Cryptochrome is a photoreceptor that regulates the circadian clock and can have a major influence on phytochemical formations. Cryptochrome is stimulated in the UV-A/blue region of the spectrum and will activate specific defense reactions. When a defense reaction is activated, plants will consume energy in ways other than photosynthesis, producing secondary metabolites, such as vitamin C, anthocyanins and phenolic compounds that are valuable in nutritional eating.

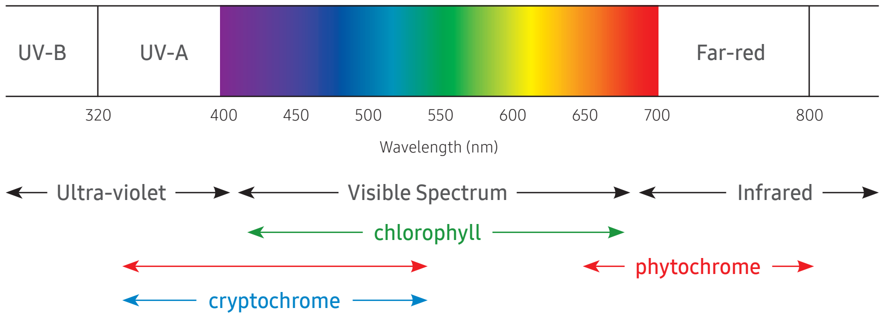


Figure 1. Visible wavelength with various photoreceptors

Horticultural Plants

There are plenty of horticultural crops, such as leafy vegetables, root-based foods and fruits that are easily accessible in day-to-day living. They contribute to healthier lifestyles, since they are important sources of many nutrients, including all types of antioxidants, vitamins and minerals. In this chapter, the effects of light quality on horticultural plant nutrition are discussed, with lettuce, tomatoes and strawberries having horticulture lighting applied during their cultivation.


The effects of supplemental blue light on the growth and phytochemicals of lettuce (*Lactuca sativa L.*) have been thoroughly investigated by a team of researchers led by T. Quzounis [6]. They determined that phytochemical concentrations and morphology in lettuce were significantly affected by blue light treatment, as shown in Fig. 2. The concentration of phenolic acid (chlorogenic acid) more than doubled the outcome was especially effective in *'Lollo Rossa'* rather than *'Batavia'*, when compared to those plants under the control of white light.

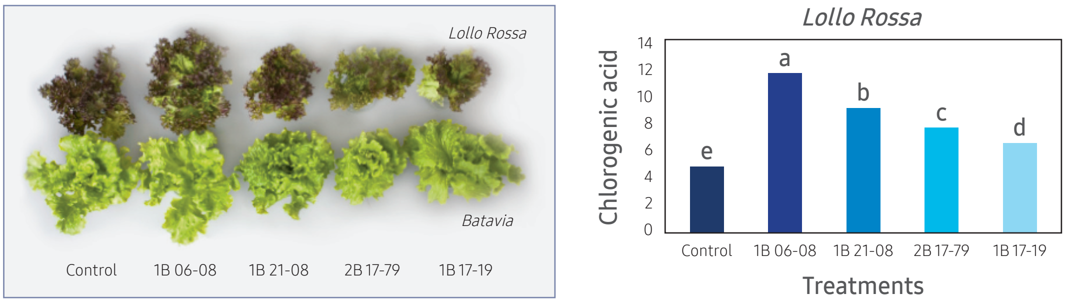


Figure 2. Morphological differences and phenolic acid (chlorogenic acid) of *'Lollo Rassa'* grown under the different LED treatments

The effectiveness of green light's impact on plant phytochemicals was also observed. A team led by G. Samuoliene demonstrated the increased effectiveness of green LED lighting (505, 535 nm) on vitamin C, total phenol, and tocopherol content as compared to blue light (455, 470 nm) for baby leaf lettuce [7]. As green light is efficiently transmitted through a plant's tissues, it may also trigger desirable reactions when not directly exposed to light stimuli, such as the metabolism of antioxidants. Even though the influence of light quality on plant nutrition varies by crop or cultivar and is dependent on the growing season, the positive response of phytochemical formation with both blue and green light is demonstrated in various leafy green vegetables [8-11]. Fig. 3 shows how certain spectra including UV and infra red influence groups of plant compounds [12].

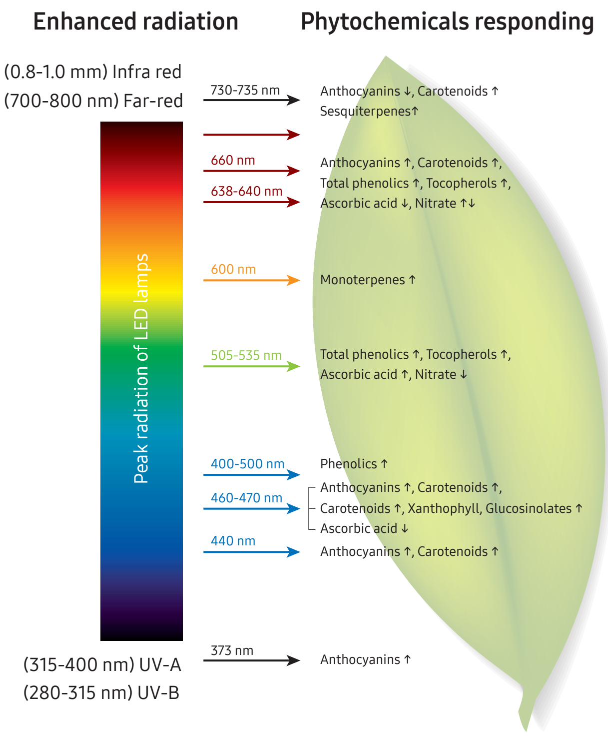
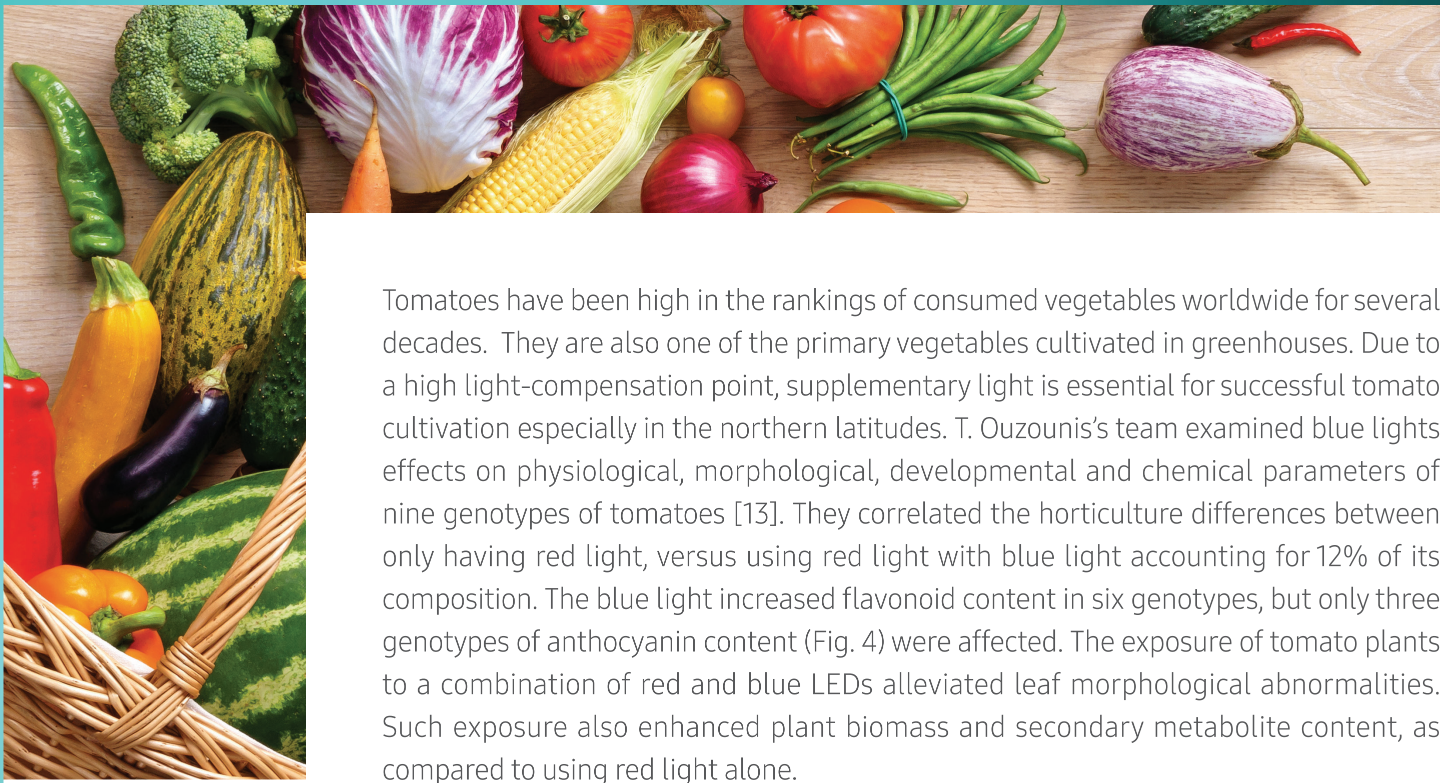


Figure 3. Plant response to light quality [12]



Tomatoes have been high in the rankings of consumed vegetables worldwide for several decades. They are also one of the primary vegetables cultivated in greenhouses. Due to a high light-compensation point, supplementary light is essential for successful tomato cultivation especially in the northern latitudes. T. Ouzounis's team examined blue lights effects on physiological, morphological, developmental and chemical parameters of nine genotypes of tomatoes [13]. They correlated the horticulture differences between only having red light, versus using red light with blue light accounting for 12% of its composition. The blue light increased flavonoid content in six genotypes, but only three genotypes of anthocyanin content (Fig. 4) were affected. The exposure of tomato plants to a combination of red and blue LEDs alleviated leaf morphological abnormalities. Such exposure also enhanced plant biomass and secondary metabolite content, as compared to using red light alone.

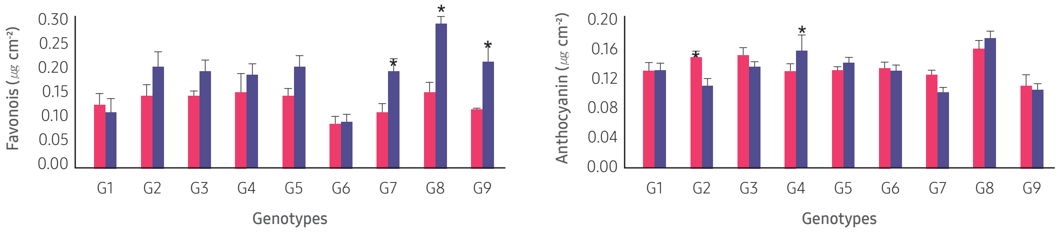


Figure 4. Flavonoids and anthocyanin effects on nine tomato genotypes grown under 100R or 88R/12B LED lighting [13].

Strawberries (*Fragaria × ananassa, Duch.*) are one of the more highly regarded fruits for their aroma characteristics. They are one of the horticultural plants to which artificial lighting is most frequently applied, especially in northern Asian countries. A team led by Z. Yang determined that blue light has an important influence on anthocyanin in strawberries [14]. In fact, a blue light treatment increased total anthocyanin content during storage. This suggested that the increase might be a result of greater activation of anthocyanin-biosynthesis enzymes, as demonstrated in Fig. 5. These results are particularly meaningful in demonstrating that blue light can affect the nutritional composition of strawberries, even after harvest – resulting in improved nutritional values without any yield reduction.

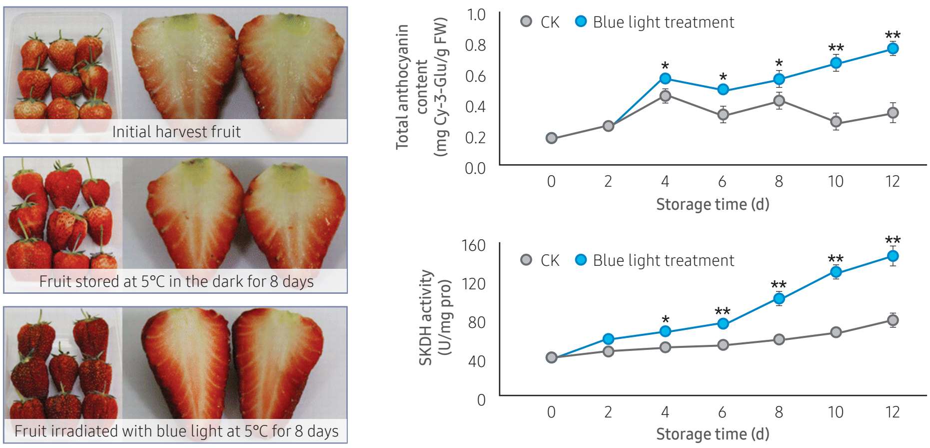


Figure 5. Comparison of strawberry coloring with/without blue light treatment and the impact of anthocyanin and related enzymes (SKDH) during storage at 5°C [14].

Medicinal Plants

The benefits of plants, of course, are not limited simply to fruits and vegetables. Much research has been conducted on a range of medicinal plants, particularly the medicinal components found in a plant's roots, stems, leaves and flowers. Among them are plants that mainly extract medicinal value from their flowers, which reduces pain and lessens the effects of some mental illnesses, as demonstrated in Table 1. In this section, the impact of light quality on medicinal flowering plants will be examined, and delineated by a plant's growth stage.

Molecules	Hairy roots	Root		Seed		Stem		Leaves		Pollen		Flower	
		Fiber-type	Drug-type	Fiber-type	Drug-type	Fiber-type	Drug-type	Fiber-type	Drug-type	Fiber-type	Drug-type	Fiber-type	Drug-type
Midicinal components	1.04[a]			0-12 (<0.5 in kernel)[C]	36-174 (<2 in kernel)[C]	196-475[l]	3000[b]	2000[l]	60300[g] 22000[g] 8000[g]		31230[h]	963000[l]	95100[g] 34000-200000[g] 152000[g]
	1.67[a]	14.3[b]		67-244[d]	15-70[d] 4.2-78[d]	179[b] 7850-18090[l]		1790[b] 20000[l]	11200[g] 3000[l]		440[h]	8590[b] 6000[l]	109000[g] <600[g]
				2-7[d]	3.4-8.4[d]	0-47[l]			800[g]		1350[h]		600[g]
	1.63[a]							2000[l]	1000[l]		1310[h] 510[h] 3240[h]	<600[l] <600[l] 4 600[l]	34000-200000[l] (<600) - 13000[l] 900-2200[l]

Table 1. Concentrations of medicinal components found in different parts of flowering plants known for their medicinal value [15].

Medicinal plants require the appropriate light recipe for each growth stage in order to increase their medicinal effects. In particular, the yield and chemical composition of flowers are mainly determined according to the quality of light in a given flowering stage, as shown in Fig. 6. In terms of the maximum value of the medicinal component, high flower yields can be obtained by using adequate amounts of red light. Moreover, a high concentration of the medicinal component during flowering can be obtained by increasing the amount of blue/UV light. In addition, enriched-green light maximizes the medicinal effects of certain chemicals. Some producers have already proved these effects by applying an innovative light recipe for certain medicinal plants [16].

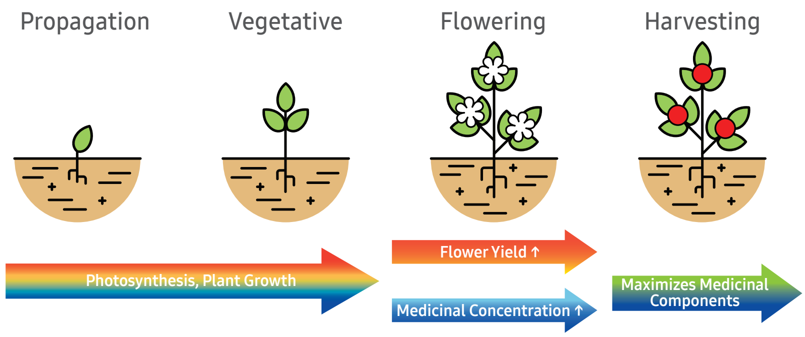
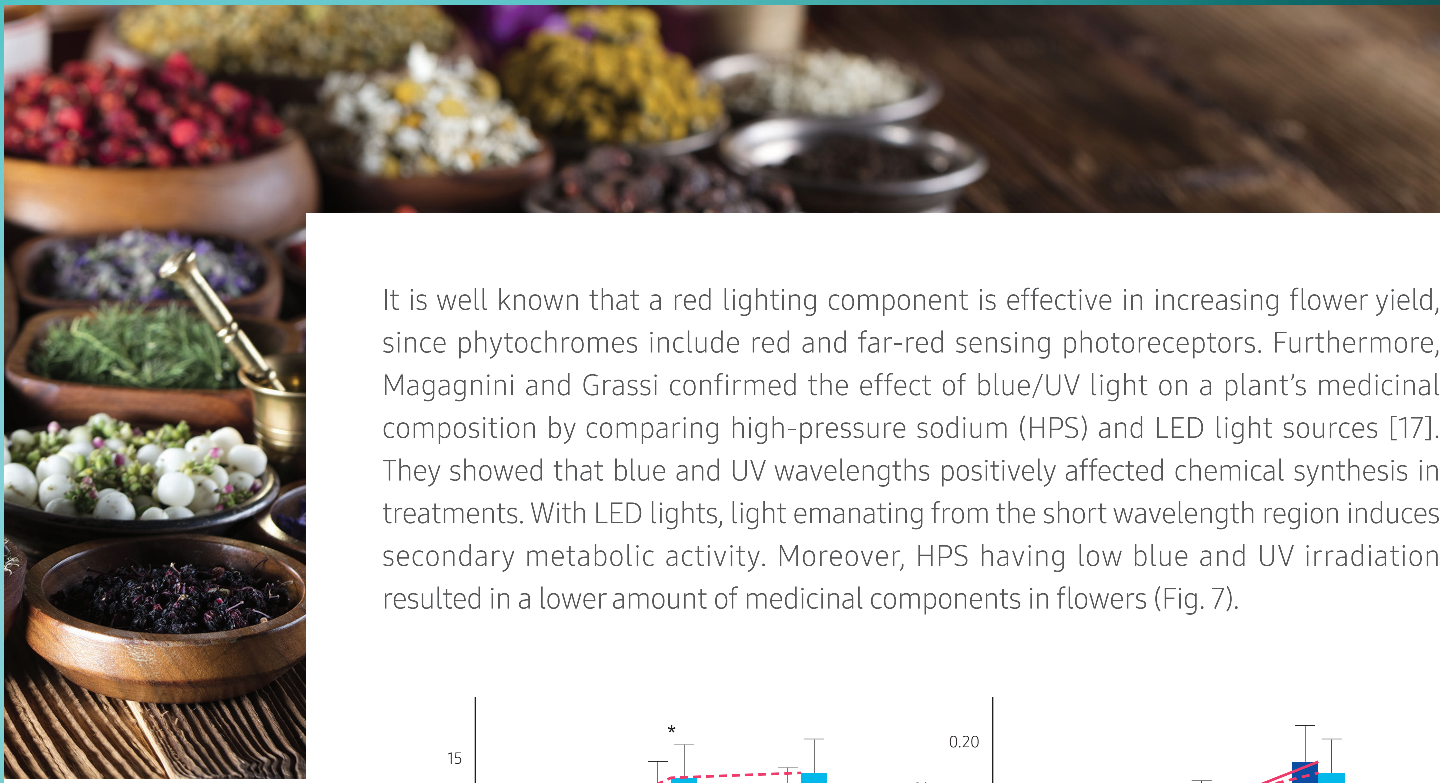


Figure 6. The role and condition of light at each plant growth stage



It is well known that a red lighting component is effective in increasing flower yield, since phytochromes include red and far-red sensing photoreceptors. Furthermore, Magagnini and Grassi confirmed the effect of blue/UV light on a plant's medicinal composition by comparing high-pressure sodium (HPS) and LED light sources [17]. They showed that blue and UV wavelengths positively affected chemical synthesis in treatments. With LED lights, light emanating from the short wavelength region induces secondary metabolic activity. Moreover, HPS having low blue and UV irradiation resulted in a lower amount of medicinal components in flowers (Fig. 7).

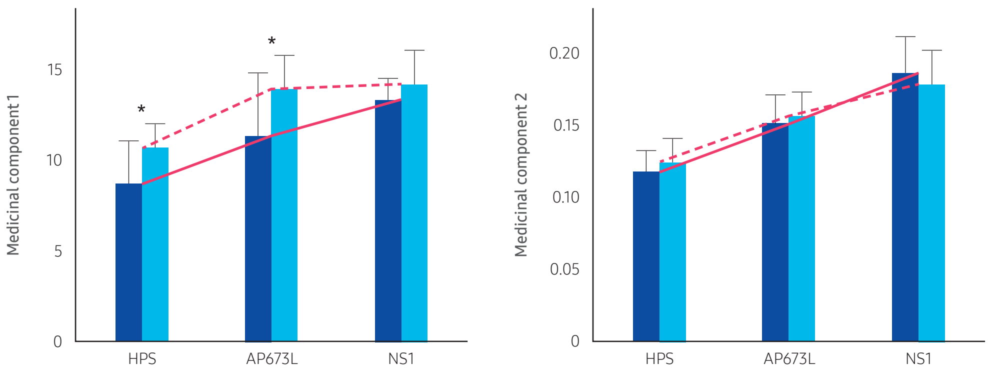


Figure 7. Amount of medicinal component according to its light condition (AP673L, NS1: LED lighting) [17].

Recently, some studies have shown that plants up-regulated a specific chemical synthesis by supplementing additional light, particularly green light [18]. D. Hawley and his colleagues indicated that enriched-green light increased the yield of medicinal floral tissues (Fig. 8) and maximized the amount of medicinal components. Specific compounds that absorb the green light cause an 'entourage effect' with medicinal components, which maximizes its positive impact.

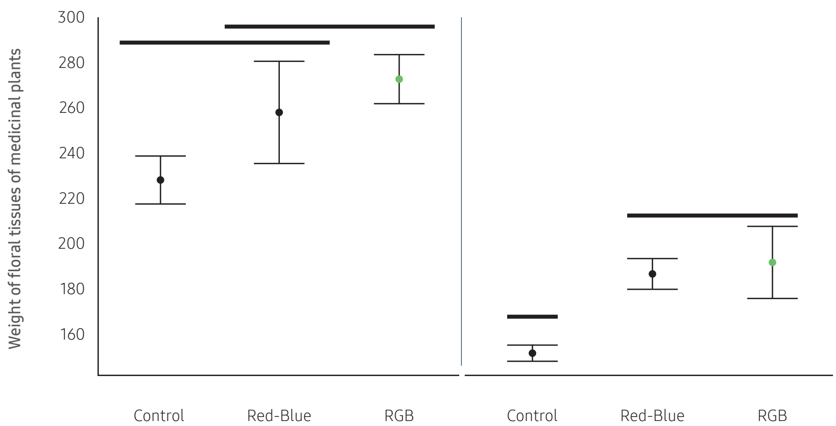


Figure 8. The yield of floral tissues in medicinal plants under different light conditions

SAMSUNG Horticulture for Plant Nutrition

Samsung Horticulture Lighting provides the means for increasing growth, while controlling the period of photosynthesis and the level of nutritional value, based on systematic research and repeated growth testing. In our tests, we constructed a line-up for monochromatic packages (blue, red and far-red), while offering a full spectrum to supply all of the wavelength needed to optimize plant growth (Fig. 9). In particular, the green wavelength region has potentially major advantages in enhancing every aspect of morphology, plant growth and the secondary-metabolite formation of plants. Samsung horticulture lighting of white-based full spectrum provides the world's highest level of efficiency in middle power packages with color temperatures of 2700 to 6500K, so growers can choose to meet their needs in the fastest, most efficient and most beneficial ways.

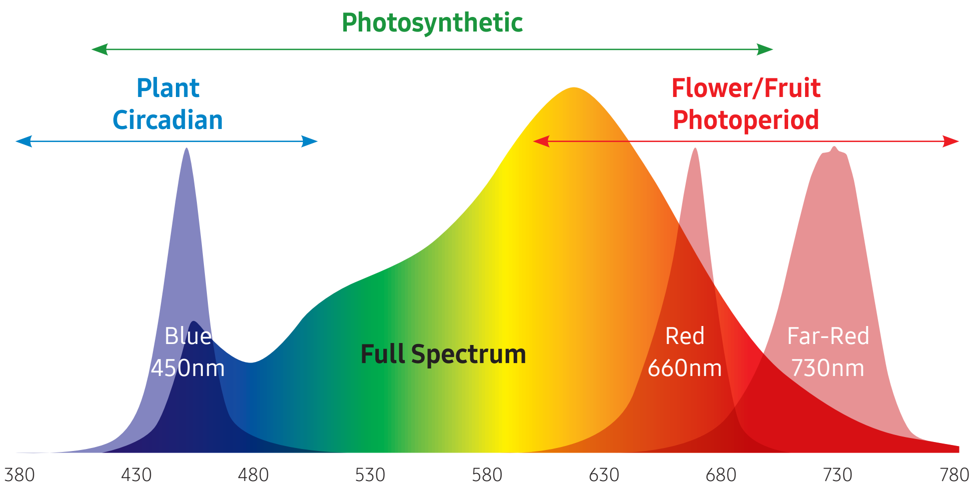
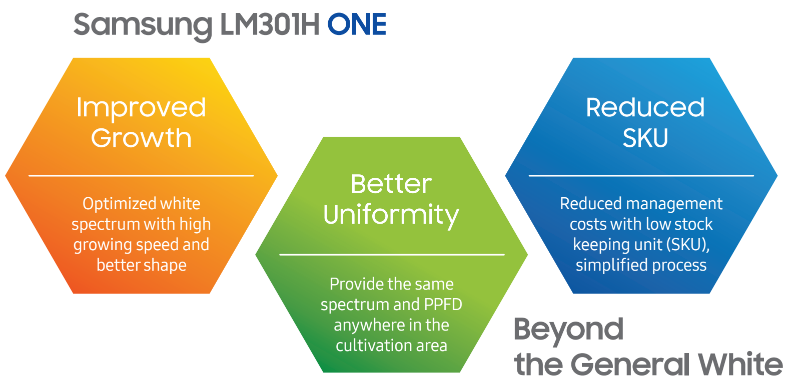


Figure 9. Spectra of Samsung Horticulture LEDs

Indeed, Samsung has actually developed a solution that goes beyond traditional white lighting – providing advantages that can significantly reduce the cost of production and harvest management. This growth-optimizing and cultivation-enhancing solution will be released in 2019.



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