

Review Article

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Ex-situ Conservation of Crops through Vertical Pink Farms

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ABSTRACT

One of the recent innovations in the field of agriculture is Pink Farming. It is a ex-situ farming technique using pink colored illumination for the cultivation of crops. This pink-colored light is a mixture of red and blue lights from LEDs (Light Emitting Diodes). are being converted into vertical pink farms are made by transformation of large warehouses located in the suburbs of the cities, growing crops arranged in shelves, top to bottom, one over other. Japan has the World's biggest indoor vertical pink farm, Mirai Co. is situated at Japan. Visible light spectrum (V-I-B-G-Y-O-R) is constituted of seven different colors of different wavelengths. However, plant photosynthetic machinery absorbs wavelengths of red (630 nm – 750 nm) and blue light (450 nm -490 nm) efficiently. Since, red light promotes plant elongation and blue light enhances metabolites in crops. LEDs used in the pink-houses are cooler than the HPS (High – Pressure Sodium) lamps used in greenhouses, so they can be placed in the vicinity of plants. They have low power consumption, high brightness and nominal heat generation. Parameters such as water level, CO₂ level, nutrient level, lighting, temperature and humidity can be precisely controlled in a vertical pink-house. Pink-houses can cultivate nutrient – dense, seasonal crops as well as medicinal plants all year round. A pink-house shows 20% faster growth rates in plants and 75% less energy consumption as compared to a greenhouse. Plants in a pink-house do not require sunlight or natural rainfall and are grown without the use of chemical fertilizers or pesticides.

Keywords

Vertical farming,
Pink-house, LEDs,
Visible spectrum,
Photosynthesis,
Stomata, Guard Cell

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Introduction

Prologue to vertical pink farming

Recent innovations in organic farming strategies such as pink farming has revolutionised agricultural technology. Pink farming is a expandable sustainable *ex-situ*

farming technique that cultivates crops utilizing pink-colored illumination (Bridgette, 2013). A major problem with vertical farming is sunlight. In a vertical farm, plants are

stacked on top of each other in shelves. The alternative to this is to illuminate it with artificial lights (Michaeleen, 2013). Vertical pink farms can employ blue and red LEDs (Light Emitting Diodes) to cultivate organic, climate-controlled, temperature-modulated and pesticide-free crops indoors without the necessity of real sunlight (Gray, 2013). 'Pink-houses' used for growing plants fluoresce magenta or pink from the blend of blue and red LEDs (Bridgette, 2013). Vertical farms can be worked up in large warehouses situated in the outskirts of the cities, where real-estate and electricity costs less (Abbie Stutzer, 2013). Engineers and Architects have extended the concept of skyscrapers that could be turned into urban food centers of the next generation (Michaeleen, 2013). 2.2 million Plants are irradiated with pink light as a result of fusion of blue and red LEDs in a pink-house at Caliber Biotherapeutics, Bryan, Texas (Mark Prigg, 2013). LEDs are energy-efficient and cost-effective and can be adjusted to specific wavelengths at the time of production. LEDs are cooler than HPS (High-Pressure Sodium) lamps; they can be set in the vicinity of plants (Orion Jones, 2016). Pink farming is a sound choice for growing *métier* crops round the year, since it is competent in terms of energy and water consumption (Susan, 2012). This technique is burgeoning across Asia, Mongolia, Hong Kong, Mainland China and Russia (Kurt, 2015). Japan has the world's largest indoor vertical pink farm, Mirai Co. that raises 10,000 heads of lettuce per day which is 100 times more per square foot than conventional methodology (Greg, 2015) (Figs. 1 and 2).

Visible light spectrum

The visible light spectrum is the portion of electromagnetic spectrum perceptible to the human eye. There are seven colors in the visible light spectrum namely violet, indigo, blue, green, yellow, orange and red with

wavelength ranging from 400 nm- 700 nm (Kartik, 2013; Cohen, 2003) (Table 1).

Mechanism of stomatal opening and photosynthesis in plants

Stomatal openings are exterior orifices, featuring intracellular crevices present in leaves acting as a channel for gaseous exchange (CO₂ and O₂) and even water vapors (H₂O). The stomal opening and closing is regulated by a pair of Guard cells, having greater elasticity than the other epidermal cells (Swahney and Israel Zelitch, 1964; John Whitmarsh and Govindjee). Photosynthesis can be termed as a physico-chemical process in autotrophs converting carbon dioxide (in the presence of sunlight, chlorophyll and water) into glucose and oxygen (Elhaddad *et al.*, 2014). The guard cells regulate the opening and closing of stomata in response to the stimulus of light intensity, so stomatal conductance increases in red and blue light stimulus (Carl Freer, 2016).

Importance of red and blue light in photosynthesis

The plant photo system is tuned to absorb red and blue light of the visible spectrum more efficiently (Nishio, 2000). A wavelength of 450 nm (blue light) and 650 nm (red light) are absorbed at the upper surface of leaf by chlorophyll a and chlorophyll b, respectively due to the abundance of chloroplast cells in this region and also scattered by structures such as mitochondria, nuclei, ribosomes, starch grains and other plastids (David *et al.*, 1965; and Suetsugu *et al.*, 2014). The stomata open at the wavelengths of red and blue lights, while it remains closed at the wavelength of green light (Suetsugu *et al.*, 2014). Opening of stomata caused by blue light is increased by the red light (Massa *et al.*, 2008).

Table.1 Wavelength ranges for monochromatic light (in nm) (John gray, 1919)

Color	Wavelength Range (nm) λ
Red	630- 750 nm
Orange	590- 630 nm
Yellow	570- 590 nm
Green	490- 570 nm
Blue	450- 490 nm
Indigo	420- 450 nm
Violet	380- 420 nm

Table.2 Advantages of pink farming over conventional farming

Sr. No.	Basis	Pink Farming	Conventional Farming
1	Space efficiency	Vertical pinkhouses are space-efficient, since plants are stacked on top of each other in shelves (Michaeleen, 2013)	Conventional agricultural farms are spread over a vast area of land (Maurizio <i>et al.</i> , 2011)
2	Use of pesticides	Pesticide-free crops are grown (Gray, 2013)	Pesticides and chemical fertilizers are sprinkled to increase the yield of crops (Tiziano <i>et al.</i> , 2011)
3	Wavelength adjustments	LEDs used in pink houses can be adjusted to specific wavelengths required by the plant photosystem (Orion, 2016)	No wavelength adjustments can be made in conventional farming, since white light is the source of illumination having wavelengths ranging from 400 nm- 700 nm (Orion, 2016)
4	Growth rate	Observed growth rate of plants is 20% faster than in conventional farming (Michaeleen, 2013)	Comparatively, slower growth rate than pink farming (Michaeleen, 2013)
5	Adjustment of other parameters	Parameters such as temperature, nutrient level, water level and CO ₂ level can be precisely controlled in a pink house (Maurizio G <i>et al.</i> , 2011)	The environmental or natural parameters cannot be adjusted according to the requirements of the crop (Maurizio G <i>et al.</i> , 2011)
6	Level of sustainability	More sustainable (Bridgette, 2013)	Less sustainable (Tiziano <i>et al.</i> , 2011)

Figure.1 Plants illuminated through pink LEDs in a pink farm



Figure.2 An illustration of vertical pink farm



Figure.3 (a) Light spectrum; (b) Combination of various colors

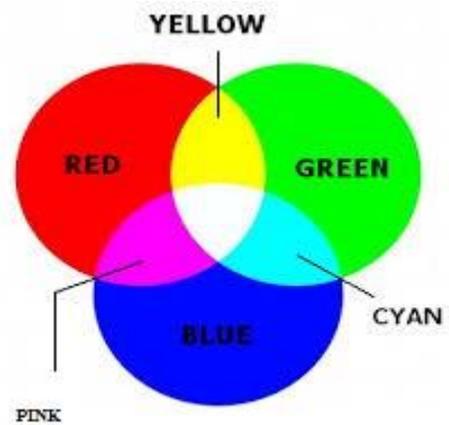
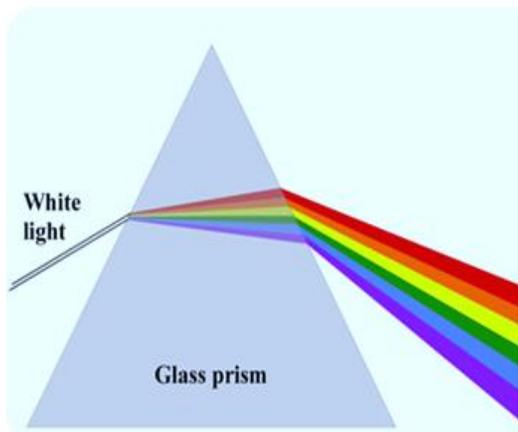
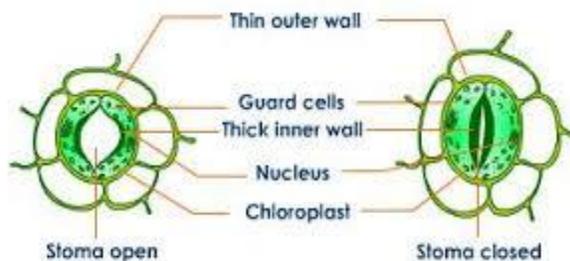


Figure.4 An illustration of stomatal cells



LEDs possess enormous potential as sole-source of lighting or supplementary source of lighting for crop cultivation (Kamine, 2014). LEDs have longer life expectancy, low power consumption, high brightness, high endurance to humidity and nominal heat generation by lighting (Erik, 2016). Red light promotes plant elongation and favours flowering in some long- day plants (Dean *et al.*, 2015). Concentrations of nutritionally significant metabolites are enhanced in crops by the blue light of LEDs (Sindy, 2014).

Other aspects of pink farming

Parameters such as water level, CO₂ level, nutrient level, lighting, temperature and humidity can be incisively controlled in a pink house (Maurizio *et al.*, 2011). Each shelf in a vertical pink house has its own water trickler that drizzles water into pans when needed and the excess water is also continuously recycled. A constant temperature is maintained and the lights turn on and off, imitating day and night according to the photoperiodicity of plants. Sensors detect missing nutrients and purvey them in precise amounts (Orion Jones, 2016; and Michaelen, 2013). Pink houses are used to grow seasonal plants and other plants with medicinal values (Nishio, 2000). Nutrient-dense crops such as tomatoes, yellow bell peppers, strawberries, basil, etc. can be cultivated in the shelves of a vertical pink house (Michaelen, 2013) (Table 2).

In conclusion as a result of burgeoning world's population, there is an obvious surge in demands of nutrition. Vertical pink farms could resolve and address issues of water crisis and secure nutritional requirements. If the visible spectrum of light (V-I-B-G-Y-O-R), is divided into two regions through the green sector *viz.* the upper region and lower region. Upper region consisting of violet, indigo and blue wavelengths and the lower regions consisting of yellow, orange and red wavelengths, the red light has the maximum wavelength among all the colors and blue has the maximum wavelength in the upper region yielding to its consequent absorbance by plants. Therefore, red and blue lights are effectively absorbed by the plants, hypothesizing pink light absorbance. Future, vertical farms will be equipped with organic LEDs (or OLEDs) instead of LEDs to curb power consumptions in these organic farms or 'Plant scrapers', so that natural renewable source could meet energy requirements in these vertical pink farms (Figs. 3 and 4).

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