The Optimum Usage of Different Light Spectrum in Agriculture

Abstract

During photosynthesis in green plants, light energy is captured and used to convert water, carbon dioxide, and minerals into oxygen and energy-rich organic compounds. The lights spectrum that will cause photosynthesis action in plants are key to improving energy utilization and production. The purpose of this research was to find the optimum usage of different light spectrum in agriculture and we demonstrate the effects of different optical treatments on different growth processes of different plants such as flowering process, fruit process in greenhouses, vegetative growth, growing of beans and etc.

Introduction

Photosynthesis is the process of converting light energy ($E = h\,\vartheta$) to chemical energy and storing it in the chemical bonds of sugar-like molecules. Plants need only light energy, CO_2, and H_2O to make sugar. The process of photosynthesis takes place in the chloroplasts (chloro = green; plasti = formed, molded), specifically using chlorophyll (phyll = leaf), the green pigment involved in photosynthesis.

Photosynthetic pigments:

- the pigments are mainly for absorbing light energy, then converting it to chemical energy
- they are located on the chloroplast membranes
- the pigments in the chloroplast are in the form of a mixture
- they can be separated by paper chromatography when the green pigment is extracted from leaves with acetone

As early as 1640, people have demonstrated that photosynthesis was a means of converting carbon dioxide in the air into plant material. Thus, photosynthesis has been studied by many scientists.

The photosynthesis is a very complicated process, and we can only give an introduction here. Photosynthesis reduces carbon dioxide into carbohydrates:

$$6CO2+12H2O+h\vartheta \longrightarrow C6H12O6+6O2+6H2O \quad (1)$$

Thus, both electrons and energy are required. The electrons come from water molecules, and the energy is first absorbed by pigments known as chlorophylls and carotenoids. There are

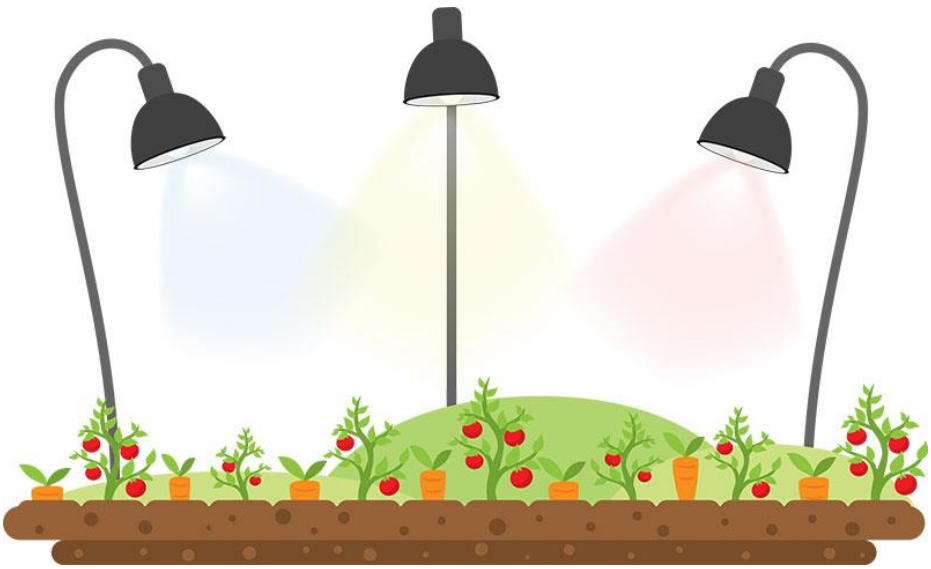
many varieties of pigments. They are bonded to proteins which provide pigment molecules with the appropriate orientation and position with respect to each other. After absorption by pigment, light energy is transferred to chlorophylls that are bonded to special proteins. Pigments and protein involved with this actual primary electron transfer event together are called the reaction center. A large number of pigment molecules (100-5000), collectively referred to as antenna, "harvest" light and transfer the light energy to the same reaction center. The purpose is to maintain a high rate of electron transfer in the reaction center, even at lower light intensities.

Significance of photosynthesis:

1.produce food for all the living organisms directly or indirectly
2.provide raw materials for building, or making other useful products, e.g. timber, furniture
3.balances the composition of atmospheric air by releasing oxygen and removing carbon dioxide from the air
4.formation of fossil fuels

Site of photosynthesis:

The major photosynthetic organ is the leaf. Its structure and function are closely related, i.e. the structure of the leaf is highly adapted to satisfy the process. Leaf anatomy in relation to photosynthesis:
a) leaves are thin, flattened and with large area to volume ratio, so as to have maximum exposure to sunlight
b) chloroplast mostly found in palisade mesophyll in the upper layer of the leaves
c) possessing stomata for gases exchange, mainly in the lower surface for dicotyledonous plant
d) extensive system of intercellular space provide an internal atmosphere in contact with large number of cells
e) the walls of the cells are saturated with water to dissolve and transport CO_2
f) many small veins (with vascular bundles) bring a supply of water and minerals salts from roots in the xylem and carry away the food produced in the phloem
g) a layer of transparent cuticle on upper and lower epidermis protects the leaf from desiccation and infection



Plants use light as an energy source for photosynthesis and as an environmental signal. Plants need a persistent energy source for growth and they receive it from light. Light influences on plants' "physiological, morphological, and biochemical" properties with its three aspects "intensity, quality and length of radiation". A major challenge to plants is controlled by supplying sufficient quantity and quality of light intensities [1,2]. Light is not the only source of photosynthesis but is the important and influential signal of the growth stages of plants from germination to flowering. Responses of plants to the light in the growth environment to the function of photosynthetic pigments are different with the function of other pigments in the presence of different light spectrums. Nowadays, grow light is recommended in production of greenhouse plants in order to create favorable growth conditions for products. Recently, light emitting diodes called, LED, have been proposed to optimize light dependent processes in plant products due to their benefits such as longer lifetimes than other bulbs, generating special wavelengths, low energy consumption, and the ability to adjust the intensity and quality of the light for different types of plants. Also LEDs has been proposed as a light source for controlled environment agriculture facilities and space based plant growth chambers because they exhibit desirable characteristics such as small mass, safety and durability [3–5].

The structure and physiology of plants are particularly regulated by light signals from the environment [6], as the primary response of plants during photosynthesis completely depends on light conditions. Plant growth and productivity depends on the light conditions [7] and photosynthetic metabolism is detrimentally affected by light intensity.

On the other hand, the stomata are important channels for the exchange of water and gases with external environmental conditions. Light influences stomata conductivity and proton motive forces [8]. The development of stomata has been related to light intensity [9]. Recent studies result show that color of LEDs are more efficient in stomatal structure and opening and closing of stomata.

Results

In this study, we demonstrate the effects of different optical treatments on different growth processes of different plants.

The results of the research are as the followings:

1. For the flowering process, white fluorescent composition is suitable.
2. For the fruit process in greenhouses; combination of yellow, white and red lights is suitable.
3. For vegetative growth when the focus is on the growth of the plant leafs and stems, using yellow light is proposed.
4. For ornamental plants growth, yellow light is preferred.
5. For growing of plants that their roots are used, combination of yellow and white light is suitable.
6. For breeding and growing of beans, yellow light is suitable.

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