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Increasing The Plant Metabolism In Polyhouse Farming Using Colour Filters

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***Abstract:** With the advancement in horticulture various types of protected cultivation practices suitable for a specific type of agro climatic zone have emerged. Among these protective cultivation practices, polyhouse, shadehouse, plastic tunnel are receiving wider attention. Protected cultivation under different types of structures would save plants from winter and extends the cultivation period for off season crop production. This paper presents a novel method for polyhouse farming based on the increased absorption of white light by the chlorophyll pigments in the red and blue frequency range. The proposed idea has been experimented on water plant and it was observed that the rate of photosynthesis increased appreciably when it was allowed to occur beneath red and blue filters. Further, the idea was tested on plant and it was observed that the growth of the plant has improved to a greater extent. The related theory and experimental investigations are discussed.*

***Keywords:** Polyhouse farming, blue and red filter, chlorophyll*

I. INTRODUCTION

With the advent of green revolution, more emphasis is laid on the quality of the agricultural product along with the quantity of production to meet the ever- growing food and nutritional requirements. Both these demands can be met when the environment for the plant growth is suitably controlled. The need to protect the crops against unfavourable environmental conditions led to the development of protected agriculture. Polyhouse is the most practical method of achieving the objectives of protected agriculture, where natural environment is modified by using sound engineering principles to achieve optimum plant growth and yield. Poly house cultivation has become an important policy of Indian Agriculture. Our country is self dependent on food grain production but to fulfill the nutritional security, the gap between increasing demand of horticultural produce has to be filled. This gap cannot be filled by the traditional horticulture which required large area under horticulture to increase the production for the ever growing population. Polyhouse technology has potential to produce more produce per unit area with increased input use efficiency. Therefore, this problem can be tackled by adopting green /poly house technology for the horticultural production. For example if one lakh hectare area under vegetable cultivation is brought out under poly house cultivation the annual availability of vegetable will be increased by at least 100 lakh tons. Besides this it will also increase the significant job opportunity for the skilled rural men, youth and rural women.

Figure 1: polyhouse constructed using glass sheet

POLYHOUSE FARMING

Polyhouse farming is a special type of farming, where we are cultivating crops by giving artificial atmospheric condition to plants. The main advantage of poly house farming is that even if the climate is unfavorable for the growth of plants, artificial suitable climate can be created for the perfect growth of the plants. Poly house farming is advanced methods of farming where we can give 100% care to the plants. Poly houses are constructed by making structures in the shape of houses using steel or wood and cover the whole structure with polythene sheet. It is a transparent plastic sheet. The polyhouses are like glass houses where it will be working on the principle of greenhouse effect. When light energy from the sun get inside to the polyhouse the polythene sheet do not allow the heat to get outside. Because of this, the plants always get the heat energy which is very essential for their growth and the heat inside the house can always be maintained by using an exhaust.

Figure 2: Artifical way of giving water to the plants

Figure 3: Yield produced inside the polyhouse

Since, Polyhouses are closed there will not be any pest attack or any insect attack and the evaporation of water to the atmosphere will not happen. The evaporated water will be stuck on the sheet and collected and reused. In all ways poly house farming is a perfect method of cultivating crops because we can give suitable climate for the plants, pest attack is under control, less water is only required because of less evaporation, and it is one of the cost effective way of cultivation.

PHOTOSYNTHESIS

Photosynthesis is a process through which plants prepare food using sunlight, water, and carbon dioxide. These are the essential elements for the growth of plants. Plants obtain light energy from sun, water from soil and Co2 from atmosphere. Sun light plays a major role in photosynthesis because it is the energy source.Chlorophyll is an important biomolecule, critical in photosynthesis, which allows plants to absorb energy from light. Chlorophyll is responsible for the green colour of plants. There are several types of chlorophyll, but all share the chlorin magnesium ligand.

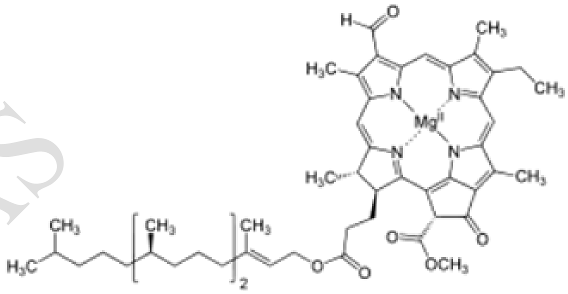

Figure 4: Organic stature of chlorophyll a

Chlorophyll molecules are specifically arranged in and around photosystems that are embedded in the thylakoid membranes of chloroplasts. In these complexes, chlorophyll serves two primary functions. The function of the vast majority of chlorophyll is to absorb light and transfer that light energy by resonance energy transfer to a specific chlorophyll pair in the reaction center of the photosystems. The two currently accepted photosystem units are photosystem II and photosystem I, which have their own distinct reaction centers, named P680 and P700. These centers are named after the wavelength of their red-peak absorption maximum. The identity, function and spectral properties of the types of chlorophyll in each photosystem are distinct and determined by each other and the protein structure surrounding them. Once extracted from the protein into a solvent such as acetone or methanol, these chlorophyll pigments can be separated into chlorophyll a and chlorophyll b. These are the major chlorophyll in plants.

II. LITERATURE REVIEW

Bernard et al (1989) have demonstrated that both the concentration of open PS II reaction centres and the efficiency of excitation capture by these centres will determine the quantum yield of non-cyclic electron transport in vivo and that deactivation of excitation within PS II complexes by non-photochemical processes must influence the quantum yield of non-cyclic electron transport. Patricia et al (2001) have concluded that the application of new and diverse techniques, from chemistry to genetics to ecology, will be necessary to understand qE, a nearly ubiquitous response of photosynthetic eukaryotes to excess light energy.

III. METHODOLOGY

PHOTOSYSTEM MECHANISM

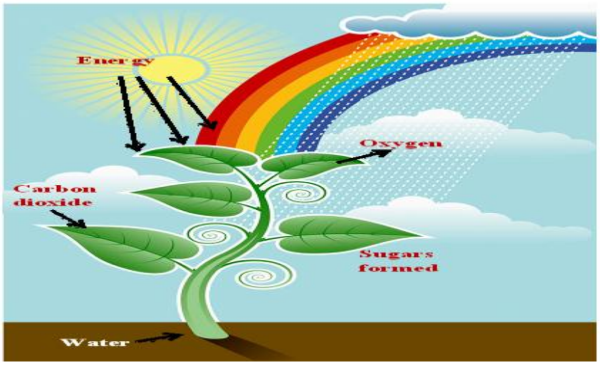

Figure 5: Absorption of vibgyor by plant leaves

The function of the reaction center of chlorophyll is to absorb light energy and transfer it to other parts of photosystem. The absorbed energy of the photon is transferred to an electron in a process called charge separation. The removal of the electron from the chlorophyll is an oxidation reaction. The chlorophyll donates the high energy electron to a series of molecular intermediates called as electron transport chain. The charged reaction center of chlorophyll is then reduced back to its ground state by accepting an electron stripped from water. The electron that reduces P680+ ultimately comes from the oxidation of water into O_2 and H+ through several intermediates. The electron flow produced by the reaction center chlorophyll pigments is used to pump H+ ions across the thylakoid membrane, setting up a chemiosmotic potential used mainly in the production of ATP (stored chemical energy) or to reduce NADP+ to NADPH. NADPH is a universal agent used to reduce CO^2 into sugars as well as other biosynthetic reactions.

SPECTROPHOTOMETRY

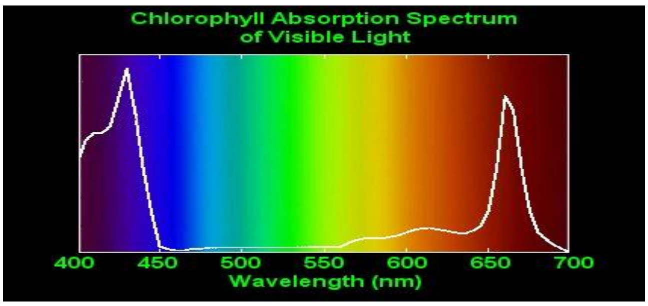

Figure 6: Chlorophyll absorption spectrum of visible light

Chlorophyll absorbs light most strongly in the blue portion of the electromagnetic spectrum, followed by the red portion. Whereas, it is a poor absorber of green and near-green portions of the spectrum which it reflects, hence the chlorophyll remains green in colour. An absorption spectrum defines the spectrum of electromagnetic radiation that plants absorb. This depends on the cellular and molecular build-up of the plant. An action spectrum defines the spectrum of electromagnetic radiation most effectively used for photosynthesis This action spectrum plays major role in the plant growth and metabolism.

ABSORPTION SPECTRUM

The absorption spectra of isolated pigments in vitro (i.e. studies performed with cells or biological molecules outside their normal biological context) do not represent the portion absorbed by the whole plant. Each pigment has a specific absorption spectrum, and in living systems, pigments never exist alone. Pigments are always bound to proteins and this changes their absorption spectrum. This phenomenon explains the reason for absorption of wavebands belonging to a single wavelength.

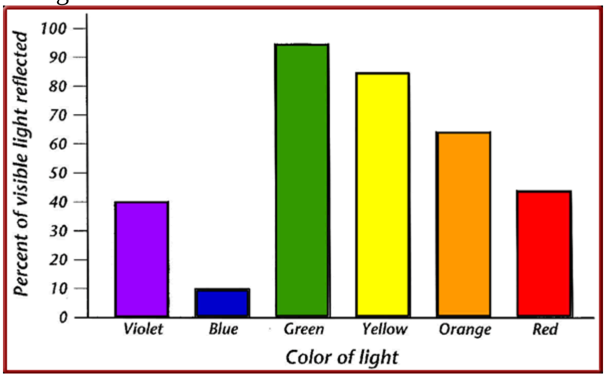

Figure 7: The percentage of light rays reflected by the leaves

The probability of a pigment absorbing light absorption depends on the:

- ✓ specific protein that the pigment is bound to;
- ✓ orientation of the pigment-protein complex within the cell;
- ✓ forces exerted by the surrounding medium on the pigment-protein complex.

There is very little absorbance of green light (500-600 nm) in extracted chlorophyll molecules

REACTIONS OF PHOTOSYNTHESIS

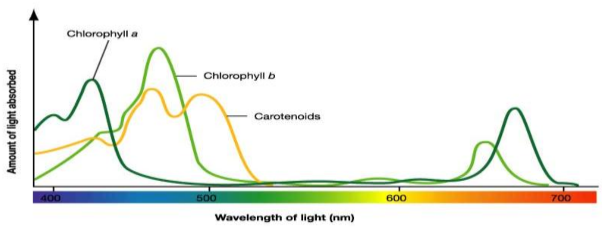

Figure 8: Light rays absorbed by different chlorophyll pigments

LIGHT SPECTRUM

This is the absorption spectrum of both the chlorophyll a and the chlorophyll b pigments. The use of both together enhances the quantity of absorbed light for producing energy. Chlorophyll a is the most widely occurring and universal type of Chlorophyll. It is found in plants, algae and many other aquatic organisms. Chlorophyll a's molecular structure consists of a chlorine ring with magnesium at its centre. It also has side chains and a hydrocarbon trail. It absorbs light from red, blue and violet wavelengths and gets its colour by reflecting green. Chlorophyll b is a type of Chlorophyll that is mostly found in plants. It aids the process of photosynthesis and primarily it absorbs blue light. The pigment itself is yellow in colour. Similar to Chlorophyll a, Chlorophyll b's molecular structure has a 4-ion Nitrogen ring with magnesium in the centre, with side chains and a hydrocarbon trail. Chlorophyll *a* absorbs light within the violet, blue and red wavelengths while mainly reflecting green. This reflectance gives chlorophyll its green appearance. Accessory photosynthetic pigments broaden the spectrum of light absorbed, increasing the range of wavelengths that can be used in photosynthesis. The addition of chlorophyll *b* next to chlorophyll *a* extends the absorption spectrum. In low light conditions, plants produce a greater ratio of chlorophyll *b* to chlorophyll *a* molecules, increasing photosynthetic yield.

EXPERIMENTAL SETUP

Figure 9: Photosynthesis experiment

Photosynthesis analysis experiment is a method for analyzing the rate of photosynthesis happening in plants in a particular time. For doing this experiment we use a water plant called centalla. The main specification of centalla is within a short period time, it produce large amount of oxygen. Oxygen is the byproduct of photosynthesis. By measuring the rate of oxygen produced, we can analyses the rate of photosynthesis.

Figure 10: Photosynthesis experimental setup 1

In this experiment, 4 beakers of 500ml, 4long size test tubes and 4 funnels which can perfectly placed in the bottom of the beaker were used. The weight of centalla was measured without water and centrally placed in the beaker. The centalla was covered by keeping the funnel inversely. Equal amount of water is poured in the beakers. The long sized test tubes are kept on the tube in such a way that the conical part of the funnel is filled with water.

Figure 11: The experimental setup covered with red transparent colour filter

Figure 12: The experimental setup covered with blue transparent colour filter

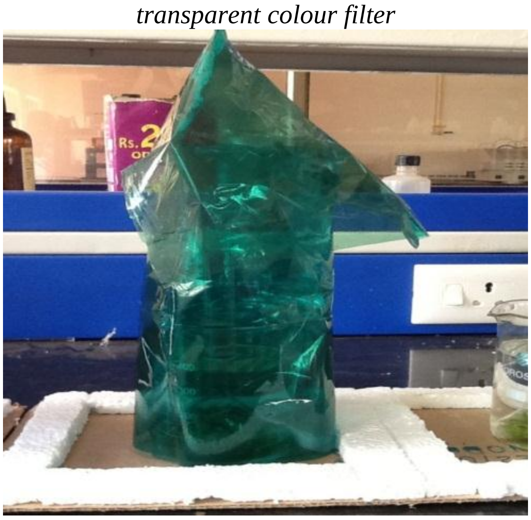

Figure 13: The experimental setup covered with green transparent colour filter

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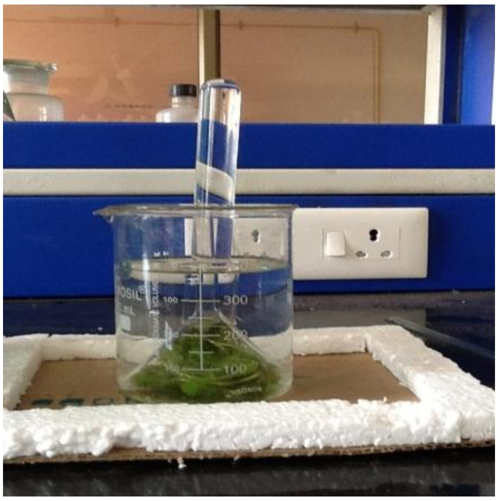

Figure 14: The experimental setup not covered with colour filter

The experimental setups were kept under normal light source. After some time, it was observed that oxygen bubbles emanated from the bottom of the beaker where centalla was placed and was collected in the test tube that is inversely placed on the tube portion of the funnel. This oxygen is formed because of the action of photosynthesis.

Figure 15: Air bubbles accumulated on the top of test tube, which was covered with blue colour filter

Oxygen has less density than water therefore it rises up from the water and goes to the atmosphere. In this setup, it is a closed path therefore it is stored in the test tube because of which the water level in the test tube decreases and the water level in the beaker increases.

IV. RESULTS AND DISCUSSION

After 2 hours it was observed that the setup which was covered with blue transparent cover had a high oxygen stored rate and the setup which was covered with red transparent cover also showed that the oxygen stored rate is similar to blue. But the rate of oxygen stored rate in the setup which was covered with green and normal were very less. The setup which was covered with green cover, had less oxygen stored rate. By observing the water levels in the test tube and in the beaker in experimental setups it was calculated that the photosynthesis rate was very high in the setup covered with blue transparent sheet, and second highest was with the red transparent sheet.

Figure 16: Blue lights rays are passing through blue colour filters

The main property of transparent color filters are it only allows the light rays of its wavelength pass through the color filter and it will trap the other light rays. It will also reflect the light ray of its wavelength. In the experimental setups, when we are covering it with blue, red and green color filters only the corresponding rays pass into the filter.

Figure 17: The experimental setup of photosynthesis experiment and the plants which are allowed to grow in particular light rays

The same experiment was tried in the field also. We planted similar type of plants in 4 plots, covered it with blue, red and green color filters. After 2 weeks, it was observed that the plants which only received blue light rays have grown more than other than other plants. The plant which received only red light rays showed nearly the similar growth of first. The plant which was grown in normal condition showed less growth than red and blue and the plant which received only green light showed the least growth.

V. CONCLUSION

The major chlorophyll pigments are chlorophyll a and chlorophyll b. The chlorophyll a only absorb the light rays having the wavelength between 380nm-500 nm and chlorophyll b only absorb the light rays having the wavelength between 600nm-800nm. The absorbing rate of green light is very less i.e., 500nm-600nm. So by giving a particular color light rays like blue or red lights ray to the plants will lead to increase of major chlorophyll pigments in plant leaves. By increasing the major chlorophyll pigments in plant leaves, the plants can absorb more blue light rays which plays major role in the growth of the plant and the photosynthesis action will take place in the plants. It was proved experimentally and in the field also.

In our study, we conclude that by replacing colorless transparent sheet with blue colour filters, more photosynthesis can take place in plants and it will increase the yield and it was also observed that temperature fluctuations were also controlled.

REFERENCES

[1] Dodd AN, Salathia N, Hall A, Kévei E, Tóth R, Nagy F, Hibberd JM, Millar AJ and Webb AA (2005), Plant circadian clocks increase photosynthesis, growth, survival, and competitive advantage, *Science*, Vol. 309, Issue 5734, pp. 630-633.

[2] Robert E Blankenship (2014), Molecular mechanisms of photosynthesis, Wiley Blackwell Ltd.

[3] Bernard Genty, Jean Marie Briantais and Neil R. Baker (1989),The relationship between the quantum yield of photosynthetic electron transport and quenching of chlorophyll fluorescence, Biochimica et Biophysica Acta, Volume 990, Issue 1, pp. 87-92.

[4] Patricia Müller, Xiao-Ping Li and Krishna K. Niyogi, Non-Photochemical quenching, A response to excess light energy, plant physiology, April, 2001 vol. 125 no. 4, pp.1558-1566

[5] Ernst-Detlef Schulze and Martyn M. Caldwell (1995), Ecophysiology of photosynthesis, Springer.