LED lighting in Tissue Culture

A thesis submitted in partial fulfillment of the requirements for the award of Degree of

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In

Physics

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For their love, support and encouragement

I dedicate this work to my parents and to the most

adorable person of life my brother "Himanshu Mehta"

CERTIFICATE

I hereby declare that the work which has been presented in this dissertation entitled **"LED lighting in Tissue Culture"** is an authentic record of my own work carried out for the partial fulfillment of the requirement for the award of the degree of Masters of Science in Physics at Thapar Institute of Engineering & Technology, Patiala (Punjab) under the guidance of **Dr. Soumendu Jana**, Associate Professor, School of Physics and Materials Science. The matter submitted in this dissertation report has not been submitted in part or full for the award of any other degree.

Date: 31/07/18
Place: Patiala

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This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge and belief.

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Simran

Date: 31/07/18

Simran Mehta

CONTENTS

ABSTRACT

Due to rapid increase in the world's population, there is reduction in agricultural lands and accommodation space. Thus, to assure a peaceful, hunger free and healthy world for next generations, plant tissue culture is the best alternate and LEDs are the supplementary light sources for the growth of plants in tissue culture process. In this thesis we show the design of an LED panel followed by fabrication of a prototype. In this we use different combination of light that is red and blue. LEDs are better source of light than conventional lamps as they have lower power consumption and do not have high touch temperature. As the process of photosynthesis do not require constant light of full spectrum. LEDs can produce specific wavelength of sufficient photon fluxes. Physiological features of plant growth can be regulated and controlled by using sources of LED lights by varying distance of LED lights from the plant or by varying the intensity of LEDs.

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CHAPTER 1

INTRODUCTION TO TISSUE CULTURE AND ARTIFICIAL LIGHTING FOR TISSUE CULTURE

1.1 Tissue culture

Plant tissue culture may be defined as growing and reproduction of cells, tissues and organs of plants on required solid or liquid medium under sterile and controlled conditions [1]. The whole plant can be revived from a young tissue in a proper culture medium. The saplings so created are known as tissue culture raised plants [2]. These plantlets are the exact copies of the mother plant and show features similar to the mother plant [3]. Presently, with the help of tissue culture technology many plant species are being propagated successfully. This ability of a single cell to grow into a complete plant is termed as Totipotency [4]. In tissue culture a small part or tissue of the plant is put in a nutrient medium that allows the production of roots, shoots after which they are nourished and transferred back to soil [5]. The mother plant should be healthy that is there is no signs of any disease or pest [6]. The whole plant can be consequently regenerated [7]. The plants which are raised with the help of tissue culture process are characterized by healthier root system, disease free growth, bushier branching, more fibrous and a higher survival rate [8].

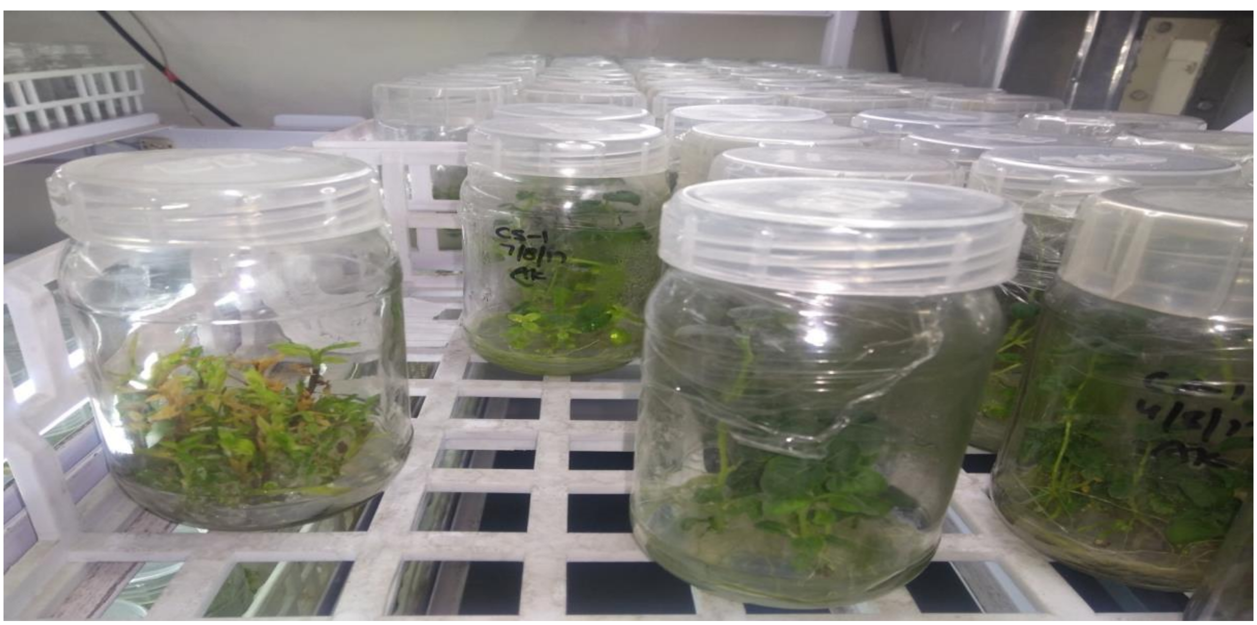

Fig.1.1 Jar used in tissue culture (Tiffacore, TIET).

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1.2 Why tissue culture?

- Variations in the lighting conditions of environment
- Improper lighting in winter season
- Climatic factors also cause crop failures in maximum area of the world [9].

1.3 Advantages of tissue culture technology

Plant Tissue Culture technology is rapidly becoming popular for the commercial reproduction of important rare species, plant species and also for some of the plants which are difficult for propagation. The important applications of plant tissue culture technology can be divided into following fields: plant modification, cell behavior, germplasm storage, clonal propagation, pathogen free plants and product formation [10]. Micro propagation has many advantages over conventional methods of propagation as follows:

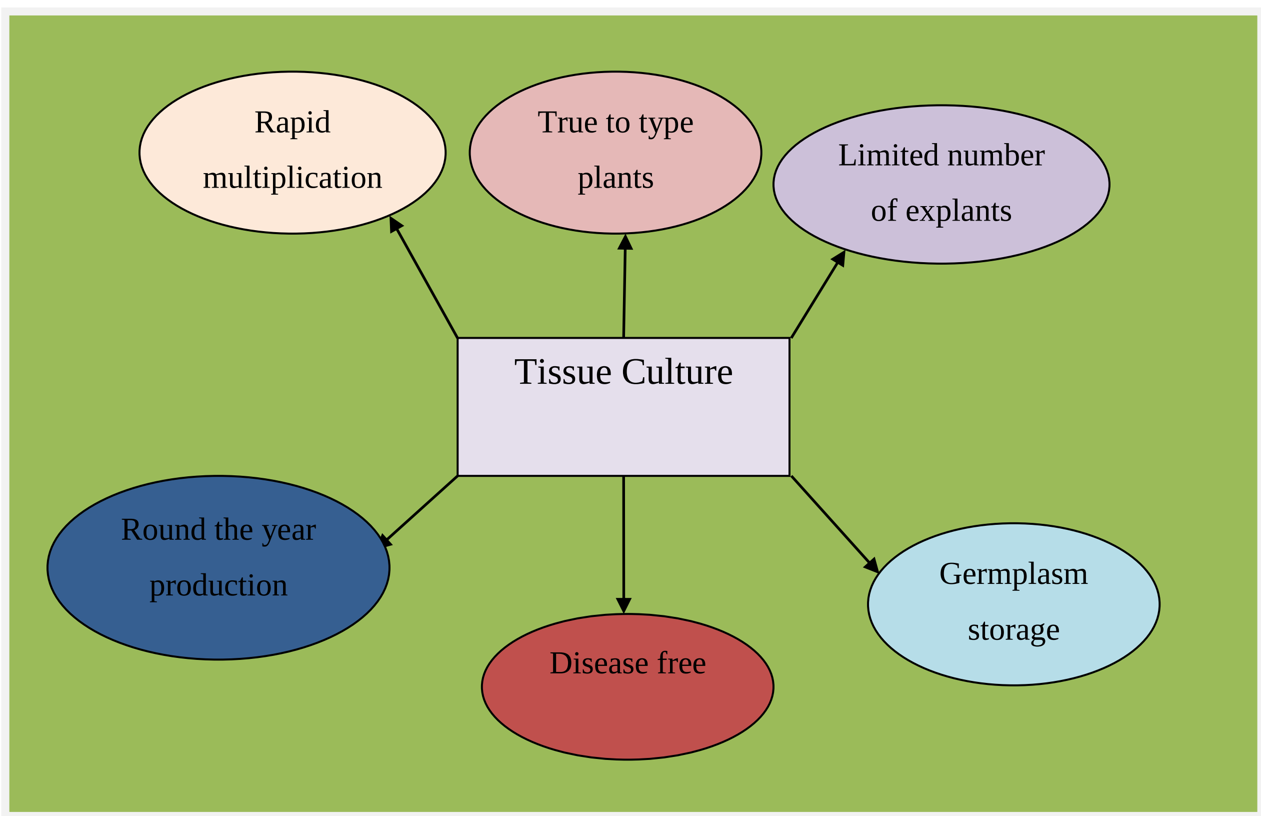

Fig.1.2 Advantages of tissue culture.

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- **Rapid multiplication:** Micro propagation offers fast increase in desired plant species.
- **Requirement of only limited number of explants:** Very small pieces of explants / tissues can be used to yield a large number of plants in a comparatively small space.
- **Uniform or true to type plants:** Micro propagation assigns a high degree of physical uniformity.
- **Germplasm storage:** Plants can be stored in a small space and there is requirement of less labor for the maintenance of plants.
- **Disease free planting material:** Plantlets which are produced by tissue culture technology are usually disease free. With proper consideration, elimination of bacteria, fungus can be done.
- **Round the year production:** Micro propagation is not dependent on season. As micro propagation is carried out throughout the year, the production can be raised to meet our peak demands. For species that produce less seeds, requires long generation time and rapid generation is done through tissue culture. So, with the help of tissue culture the year production is increased [11].

Table 1.1 Type of plants that are commercially propagated [1].

Plant type	Name of plant
Medicinal plants	Aloe Vera, Neem
Ornamentals	Lily, Syngonium
Woody plants	Teak, Bamboo
Bio fuel	Jatropha, Pongamia

1.4 Introduction to artificial lighting in tissue culture

Solar energy is the primary energy source that supports life on the earth. The solar energy has a wide wavelength in the range of 350 to 1000 nm. But only 50% of solar radiation is accessible to plants and consists of the wavelength ranging from 400 to 700 nm [12]. The growth and development of plant depends upon the light availability. In areas where the solar energy is not enough for the advancement of plants then supplementary light sources are preferred [13]. Other

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light energy sources such as metal halide and high pressure sodium lamps are not very useful and produce large amount of radiant heat [14]. So, the additional light sources play very important part in the study and development of plant [15]. The associated cooling energy required to remove the excessive heat is the outrageous factor in a culture room [16]. Lighting in a culture room uses 65% of the entire energy consumption in a culture room when illuminating with fluorescent tubes [17]. Mostly warm white fluorescent tubes or cool white lights are in use to improve the plant quality [18].

1.5 History and working principle of conventional lamps

Conventional lighting sources include metal halide, incandescent, fluorescent, high pressure sodium lamps [19]. Incandescent lamp releases light when filament of metal gets heated up and the corresponding phenomenon is known as incandescence. The metal halide, incandescent and fluorescent lamps are gas discharge lamps as they releases light produced from an ionized gas through an electrical discharge [20].

1.5.1 Incandescent Lamps

The Incandescent lamps works on the principle that the solid starts emitting electromagnetic radiations upon being heated [21]. The first design of incandescent lamps was suggested in 1840 by Rue. In evacuated glass tube there is a platinum coil. ILs has many disadvantages which are as follows:

- Short life span of the filament
- Due to burning of the filament there is blackening of the bulb.

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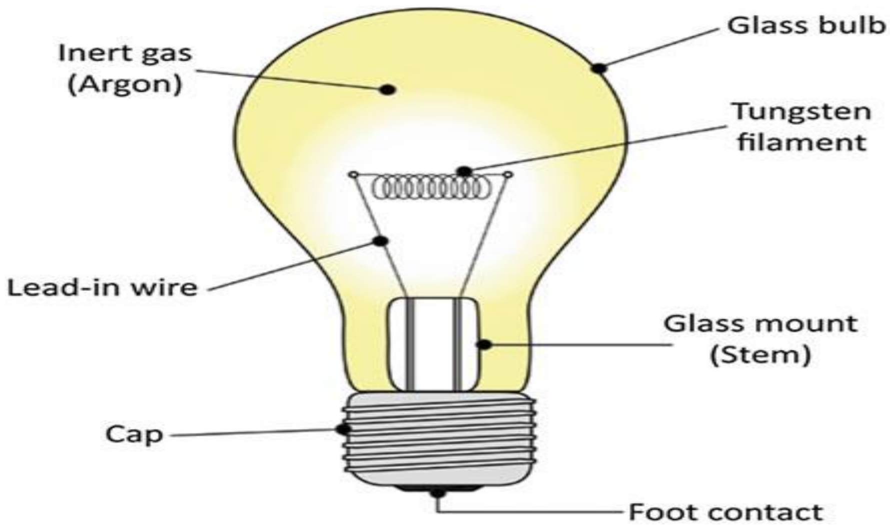

Fig.1.3 Structure of an incandescent lamp [20].

1.5.2 Gas Discharge Lamps

The gas discharge lamp was established in 1809 by Sir Humphry Davy. The working principle of gas discharge lamp is the flow of electricity between the two electrodes through gaseous medium.

1.5.2.1 Fluorescent Lamps

FLs are also called as low pressure mercury vapor lamps. They work on the principle of fluorescence. FLs may be classified on account of their size and shape:

- Tubular
- Compact (see fig.2.2).

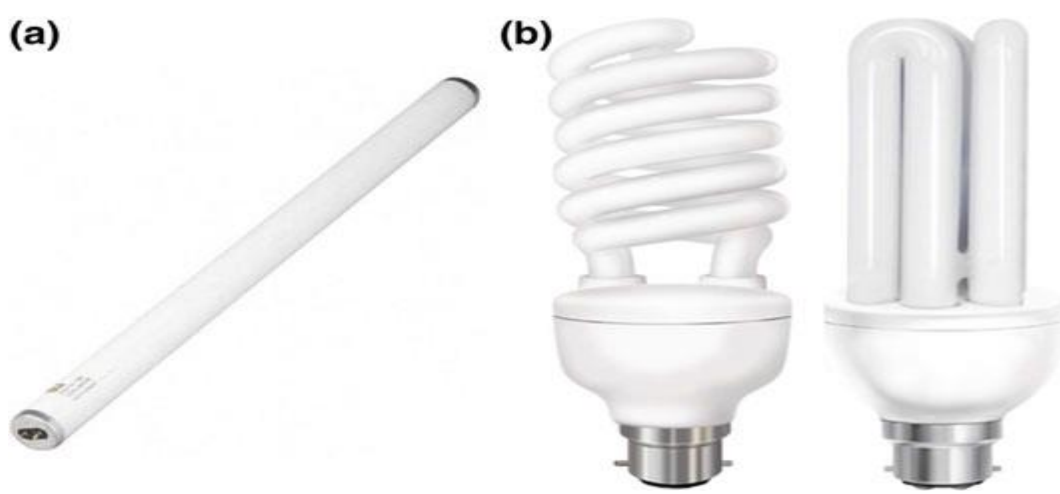

Fig.1.4 (a) Tubular and (b) Compact fluorescent lamps [20].

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The emission spectrum of FLs relies completely on phosphor coating. So, various kinds of phosphor are used. FLs have many disadvantages which are as follows:

- The filament gets heated up [22].
- Energy loss is very high.
- The energy conversion efficiency is below 30% [23].

1.5.2.2 High Intensity Discharge Lamps

HIDLs are also called as high pressure discharge lamps. They function at very high temperature as well as pressure. But the high operating temperature as well as pressure results in improving the luminous efficacy and spectral output [21]. HIDLs can be categorized on the basis of used vapor or fill gas.

- mercury
- sodium
- metal halide

Fig.1.5 (a) High pressure mercury lamp (b) High pressure sodium lamp (c) Metal halide lamp [20]

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1.6 Light Emitting Diodes (LEDs)

LED is a distinctive kind of semiconductor diode. The semiconductor material is doped with impurities. This leads to the generation of a p-n junction. Current flows from p-side to the n-side [24]. It is of two types:

- DIP LEDs
- High power LEDs

The most commonly used LED design is DIP LEDs but the newly developed high power LEDs has good efficiency. High power LEDs has more luminosity as compared to DIP LEDs due to large amount of current flow.

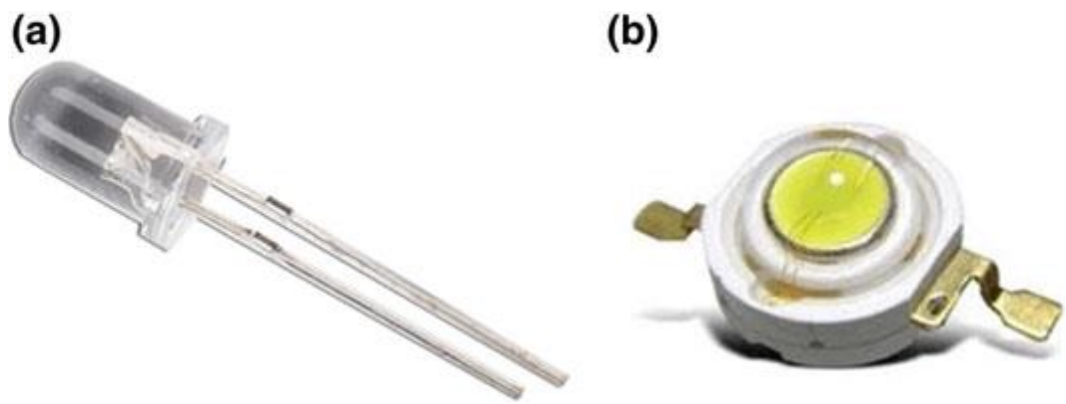

Fig.1.6 (a) Dual in line package (b) and high power light emitting diodes [20].

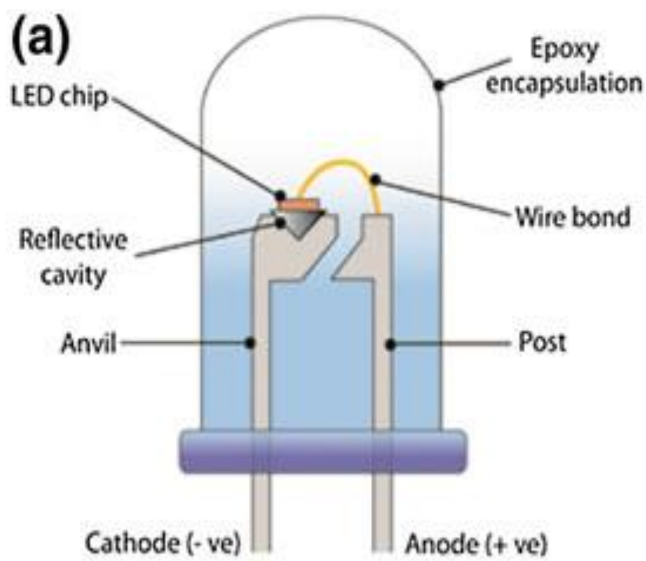

Fig.1.7 The key structure of an LED [20].

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1.6.1 Working principle of an LED

- LED works on the principle that it generates light when current is appertaining through the device.
- Two elements of n type and p type semiconductor material are placed in absolute contact. They form the p-n junction.
- The current flows from anode to cathode. Negatively charged electrons diffuse from n to p side and holes diffuse from p to n side with different voltages. A potential barrier is created. When a negative charged electron combines with a positive charged hole then it drops into the level of less energy. Then, it releases energy in the form of a photon. It works on phenomena called electroluminescence.
- Energy gap/ band gap regulates the wavelength of the light [25].

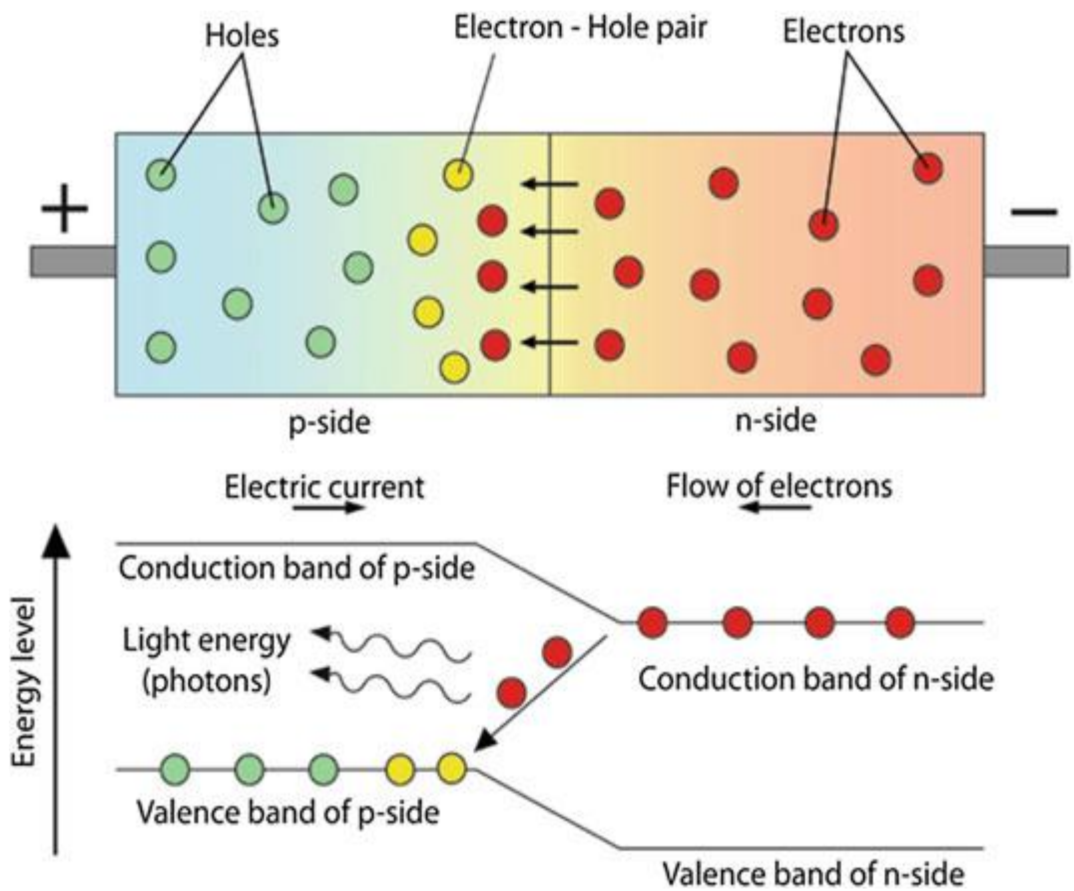

Fig.1.8 Working principle of an LED [20].

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1.7 Comparison between LED and conventional lighting systems

LED lighting systems	Conventional lighting systems
Low electricity requirement	High electricity requirement
High efficiency	Low efficiency
Low heat generation	More heat generation
Low investment in cooling system	More investment in cooling system
Long life	Less life
High initial investment	Low initial investment

1.8 Advantages of LED

- **Low power requirement:** The energy requirement for an LED is very low to produce the desired results that make them suitable for generation of plants both in vitro and in vivo.
- **Long life:** The life span of LEDs is very large as compared to other lamps. Generally, the lifetime of LEDs ranging from 25,000 h to 100,000 h.
- **High efficiency:** Nearly, all energy which is provided to an LED is transformed into desired radiation. That results in minimal heat production. The productivity of LEDs is independent of size and shape of the tubes or bulbs.
- **Color:** LEDs can emit light of desired color. For the development of plants LEDs can be fine tuned to produce the desired colors. Monochromatic LEDs emits light at particular wavelengths whereas fluorescent light emits light of wavelength 450-700 nm wavelengths.
- **Cool light:** Generation of heat is very low in LEDs as compared to fluorescent lamps. This made the tissue culture jars to be placed adjacent to the light source.
- **Size:** The LEDs can be of very small in size.

So, all these features make LEDs a perfect light source for its usage in plant tissue culture technology [26].

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1.9 Literature review on artificial LED based lighting

For future generation, providing sufficient quality and quantity of food is a great challenge. Plants take energy or prepare its food from sunlight [27]. In early 20th century, the idea of tissue culture was proposed by Haberlandt (a German Scientist) who believed in the idea of totipotency [28]. Tissue culture is the study of rapidly increasing plants in vitro culture under controlled environment [29]. When plants grow inside the laboratories then there is some light deficit as the physical structure shades the plant. Complementary lighting takes into account that what quantity as well as quality of light plants get and what they need to flourish [30]. To increase the production capacity and to produce disease free plants, there is the need of the development of artificial lighting [31]. Henry Josef (British experimenter) while doing the experiment, he coincidentally noticed that when a current flows through the material, a light was being released from a SiC crystal. From this, the journey of LEDs began [17]. The evolution of LED presents huge prospective for making growth systems more sustainable and for improving plant growth [32]. Varieties of applications are there of using Light emitting diodes (LEDs) over standard forms of tissue culture. The small size as well as long lifetime of LEDs makes them suitable for uses based on plants, they exhibit cool emitting temperature and have option to choose specific wavelengths for specific plants [33]. As the heat production is very less in LEDs that leads to increase the light conveyance for large as well as for small tissue culture area but also for multi layered panels in tissue culture [34]. Besides, increasing the spectrum quality and energy efficiency of LEDs to improve plant growth and can also reduce power consumption [13]. Plant lighting systems have been developed. This lighting structure was so outlined for internal applications [35]. Optimum wavelength of red and blue light is required for normal plant growth. The addition of green light for improved plant growth has been addressed [36].

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Table 1.2 shows some common LED colors and their respective wavelengths [37]:

Wavelength range (nm)	**Color**
<400	**Ultraviolet**
400-450	**Violet**
450-500	**Blue**
500-570	**Green**
570-590	**Yellow**
590-610	**Orange**
610-760	**Red**
<760	**Infrared**
700	**Red**
730	**Far red**

Several reports have firmed that under LED illumination there is successful growth of plants [38]. For the process of photosynthesis, red light is required and for stomatal opening, synthesis of chlorophyll as well as chloroplast development blue light is required [39].

1.10 Gaps

As low pressure mercury lamps, fluorescent lights contain mercury that's why they need to be managed vigilantly to suppress damage. Earlier, the tissue culture is done with the help of fluorescent lamps. They both have lots of disadvantages for raising tissue culture plants [40].

Light emitting diodes (LEDs) possess some of the properties which make it acceptable for the food industry. Such properties include low radiations of heat, high transmission of monochromatic light, electroluminescence and efficiency of photon, long life expectation and mechanical robustness. Therefore, they diminish thermal damage, abasement in crops and foods and are acceptable in cold storage applications [41]. Thus, there is the need for creating a suitable led panel. The panel we created is stage specific and with a tuner which helps to regulate the intensity of light. This improves the quality of our plants, can grow large number of plants in a small area and can increase our production as per our demands.

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Fig.1.9. Use of fluorescent tube in tissue culture (Tiffacore, TIET).

1.11 How does light affect plant growth?

Supplemental lightning is necessary because it leads to the difference between what quality and quantity of light plants gets and what they need to flourish. The requirement of light for the plants is throughout their life duration from sprout to seed production. The most important factors that plays an effective role:

- **Light quantity:** Chemical reaction, photosynthesis.
- **Light quality:** Green, far- red as well as blue light have a great influence on plant development.
- **Light duration:** Affects flowering [42].

1.12 How much light is optimum?

If you want to develop best lighting approach then it is necessary to have qualitative and quantifiable realization of how plants implements light. How much light is optimal for plants can be categorized into two components:

- Utilization of absorbed radiations of light
- Absorption of light radiations [43].

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1.13 Motivation

The amount of light tissue culture raised plants acquire from the sun is highly uncertain. Due to the fact that because of changing weather conditions it can vary within a couple seconds. Electrical light energy is the only form of light energy accessible for the growth of crops in inner production artifact [44]. Currently most of the tissue culture farms are using fluorescent lighting system. Some of them are however using LED lighting system. Commercially available LED lighting for tissue culture are costly and more importantly are not comfortable to the stage specific radiation or lighting. Thus, we proposed a LED based lighting system which is stage specific as well as economic. The main purpose of having controlled environmental tissue culture is to provide growers with the facilities to have control over the surrounding conditions in which the crops are introduced that affects the production crop quality, multiplicative production as well as extending the growing season [45].

1.14 Objective

- To design an LED lighting system for uniform and patterned illumination.
- To design the LED panel for stage specific tissue culture.
- To tune the LED lighting for stage specific purpose of tissue culture.

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CHAPTER 2

METHODOLOGY

2.1 Introduction

An LED panel having dimensions 15 cm × 30 cm was assembled by using 8 mm diameter LEDs. The LEDs which we use for creating the panel are of two types: red and blue. For the activation of photosynthesis process, the blue types LEDs are used. The wavelength of blue LED light with 450 nm λ [46]. However, for enhancing the photosynthesis orange red light with 630 nm λ is used [47]. The wavelengths that lie in the region of 660-735 nm cover the emission spectra of plant just as flowering and photoperiodic responses [48]. The primary part of the (PAR) photo synthetically active radiation is occupied by wavelength ranging from 660 nm [15]. One hundred sixty two LEDs composed of the red and blue LEDs and were organized in a basic rectangular pattern.

2.2 Methodology

In this we will discuss how to use the combination of lights in tissue culture to get efficient output. We will design/ arrange our tissue cultures jars in the form of the matrix by placing red and blue LEDs row wise. Now, measure the length of the tray, width of the jar, height of the jar, and distance from LED panel to the jar. We will set LED lights in order to get efficient light on the jars and that is stage specific as well [49]. By using tuner we can control the intensity of light and this has lots of advantages. By using matrix representation we will further plan the designing and can tune the intensity of light. To separate the five PFDs (Photon Flux Density) from the calculated SPFD (Spectral Photon Flux Density) curve, a Gaussian function is used [50]. The average intensity of light needed for tissue culture raised plants is 45μ mol m^{-2} s^{-1}. This deals with the results obtained from the MAT LAB of the different intensity profile of the LEDs.

For having uniform intensity, we have use this formula

$$I = I_0\, e^{\left(-\left(\frac{X^2}{a^2}+\frac{Y^2}{b^2}\right)\right)}$$

Where I = Intensity.

I_0 = Peak intensity.

X and Y are the space co-ordinates.

a and b are width of profile along X axis and Y axis.

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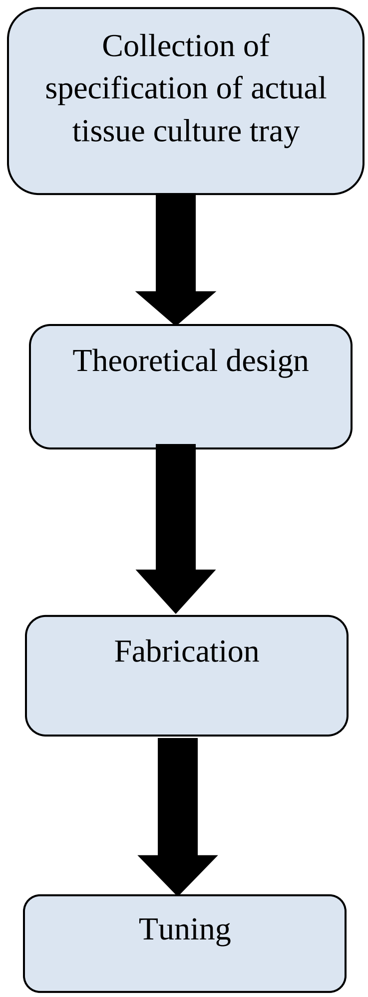
Now, for two color LED's (Red and Blue) which we place row wise, we use inverse square law for having uniform Intensity by taking LED at distance (d)

$$I = \left(\frac{I_0}{d^2}\right)$$

Where d is the distance of LED from jars.

In general, it consists of following steps:



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2.3 Why red and blue LEDs?

Most LED lights are fabricated to supply light within region of 400–700 nm, nowadays, the wavelength of the light used lies in the region of 675 to 700 nm. The red (650–665 nm) LEDs preferred because these wavelengths perfectly fit with the absorption peak of chlorophylls [51] and phytochrome. While the growth under natural light could be lowered using blue and red LEDs. Thus, for providing a better excitation of the different types of photoreceptors, the blue and red combination is preferred because it allows a higher photosynthetic activity than that under any monochromatic light [52].

2.2 Types of LED panel

LED panel can be in rectangular form, square form or circular form. It comprises of different combination of LEDs. The growth of plants can be controlled by adjusting the panel height or by increasing or decreasing intensity. Different forms of LED panel which are used in tissue culture are as follows:

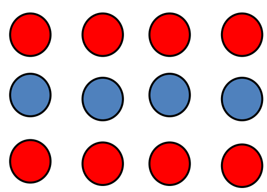

Fig. 2.1 Rectangular form of an LED panel. It comprises of red and blue LEDs. First row consists of red LEDs while second row consists of blue LEDs.

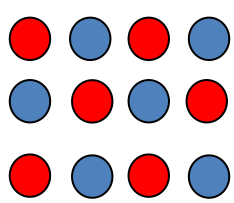

Fig.2.2 Rectangular form of an LED panel. It comprises of only red and blue LEDs. Red and blue LEDs are placed alternatively.

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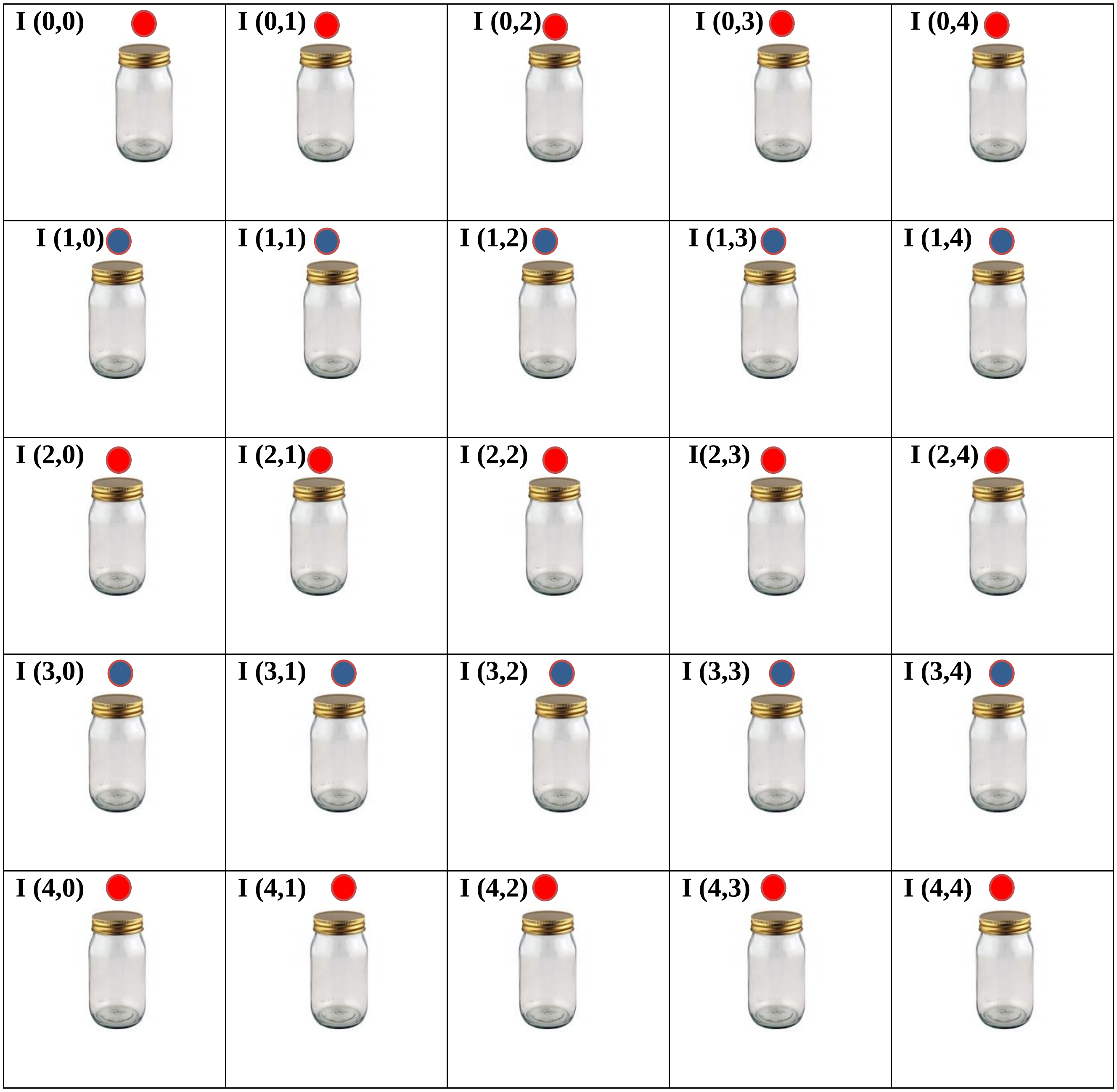
2.5 Designing

Let us suppose, we want to design a rack of 25 jars containing tissues along 5X5 LED's as shown in figure below



Where I (0,0), I (0,1), I (0,2), I (0,3), I (0,4), I (1,0), I (1,1), I (1,2), I (1,3), I (1,4), I (2,0), I (2,1), I (2,2), I (2,3), I (2,4), I (3,0), I (3,1), I (3,2), I (3,3), I (3,4), I (4,1), I (4,2), I (4,3), I (4,4), I (4,5) shows the intensity of LEDs on jar 1,2,3…..25. Red color shows red LED and blue color shows blue LED. We put each container in rack in such a way that each tissue in jar get the proper light

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intensity I. (I= I (0,0), I (0,1), I (0,2), I (0,3), I (0,4), I (1,0), I (1,1), I (1,2), I (1,3), I (1,4), I (2,0), I (2,1), I (2,2), I (2,3), I (2,4), I (3,0), I (3,1), I (3,2), I (3,3), I (3,4), I (4,1), I (4,2), I (4,3), I (4,4), I (4,5)).

There are various stages of tissue culture to which we are using tune able LED panel.

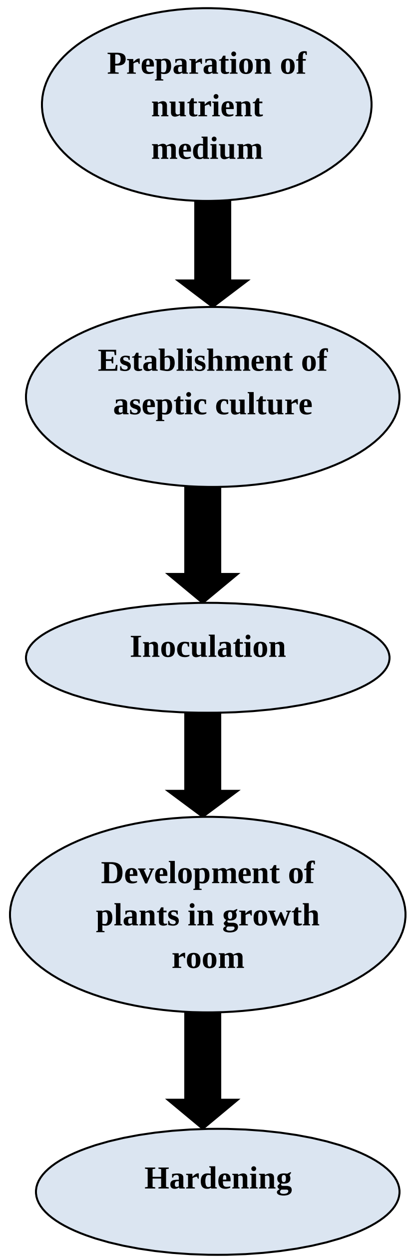

Fig. 2.1 Stages of tissue culture [53].

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Preparation of nutrient medium: A nutrient medium is prepared with the help of double distilled water having micro as well as macro elements including amino acids, iron source, vitamins and carbon source like glucose and phyto hormones [54].

Establishment of hygienic culture: The material for the tissue culture procedure is specifically a fastly growing terminal bud or shoot tip of axiliary plant. The tissue culture process starts by the selection of mother plants having all the desired characteristics [55].

Inoculation: Inoculation process is carried out under sterile conditions. In this process micro shoots or explants are transferred on to the aseptic nutrient medium [56].

Development of plants in tissue culture room: After the procedure of inoculation, the jars are closed tightly and shifted into tissue culture room to undergo nurturing process under artificial light source at 25 ± 2 ℃ and 50 to 60% of humidity [1]. The requirements of light and temperature vary from plants to plants and sometimes the various stages of developments also play a very important role. The development of shoots generally occurs after 4 weeks. After the development of enough numbers of shoots in every container (normally 10 to 17) having an average height of about 2 cm. After that, they are moved to another medium for the rooting process [57]. Within 2 to 4 weeks roots are generally formed. At this stage plants are very subtle and needed to be handled carefully [58].

Hardening: The plants removed from the aseptic medium are washed properly and are recovered with clean transparent plastic or maintained under intermittent mist. Under high humidity after 10 to 15 days, the plants are moved to green house where they are maintained for next 4 to 5 weeks. Then they are finally ready to be shifted to net house or the field [59].

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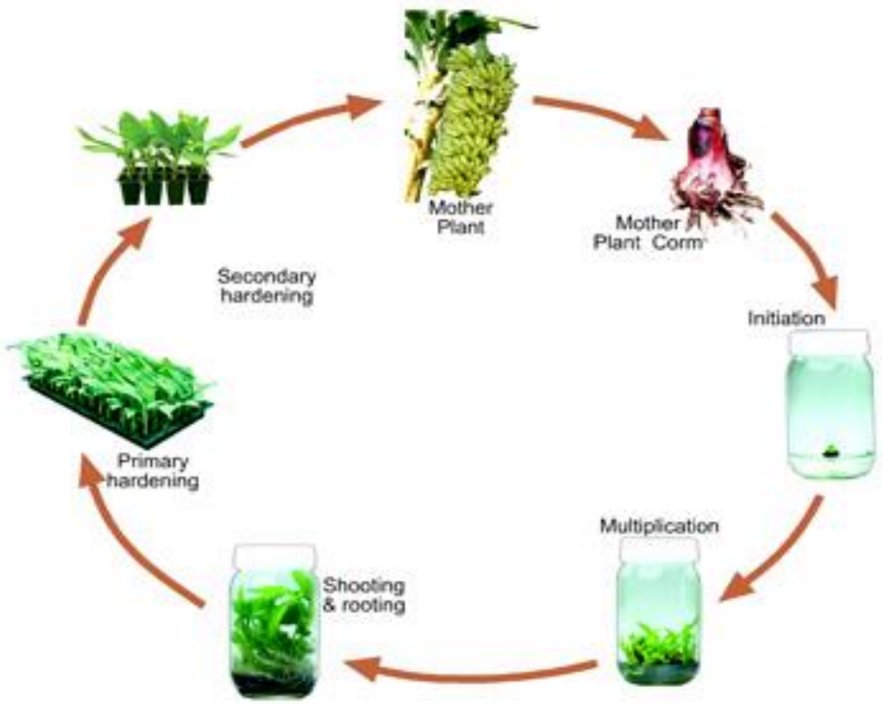

Fig.2.2 Stages of tissue culture [60].

For different stages of tissue culture, our LED panel is effective. It is because there is no need to move the jars from one place to another as done previously.

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CHAPTER 3

RESULTS AND DISCUSSION

3.1 Theoretical modeling

We have taken a rack and we have placed 25 jars in it. Then we take 25 LEDs in such a way that each jar can have 1 LED. Now, we can get uniform intensity by combining the intensity of each LED using the required formula. The intensity of LED increases naturally as we increase the number of LEDs. We study the different intensity profile by varying intensity or by varying distance between the LEDs. The equation is as follows:

$$I = A\, e^{\left(-\left(\frac{(x-l)^2}{a^2}+\frac{(y-m)^2}{b^2}\right)\right)}$$

Here, A is the amplitude.

l and m is the distance between the LEDs.

a and b are width of profile along X axis and Y axis.

3.1.1 LED lighting design with variable intensity

- We take 36 LEDs and arrange them in square form. Fig. 3.1 portrays the resultant intensity profile for 6X6 square LED configuration having parameters A=9, a=1, b=1, l=1.5, m=1.5.

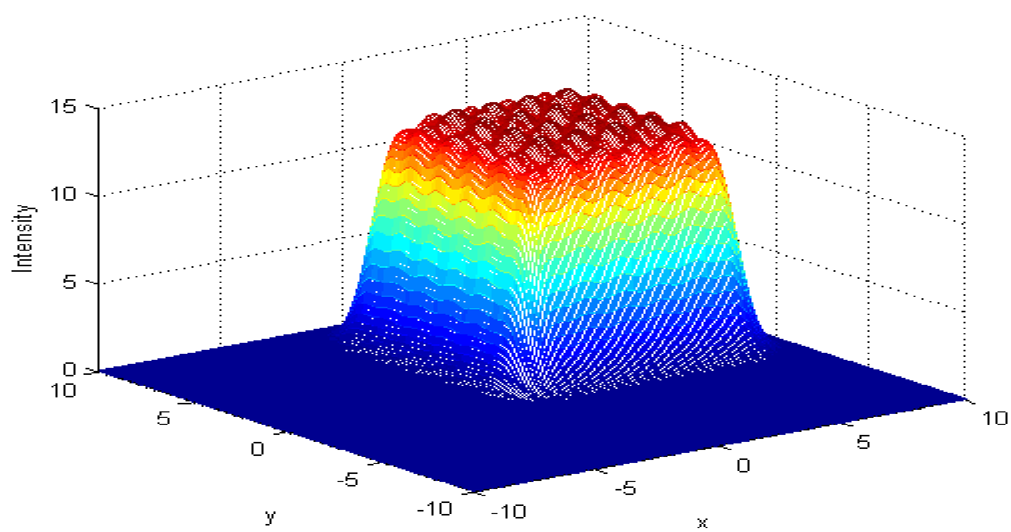

Fig. 3.1 The resultant intensity profile for 6X6 square LED configuration having parameters A=9, a=1, b=1, l=1.5, m=1.5.

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- We take 36 LEDs and arrange them in square form. In this, we vary the intensity parameter but the other parameters like the distance between the LEDs is remained same.

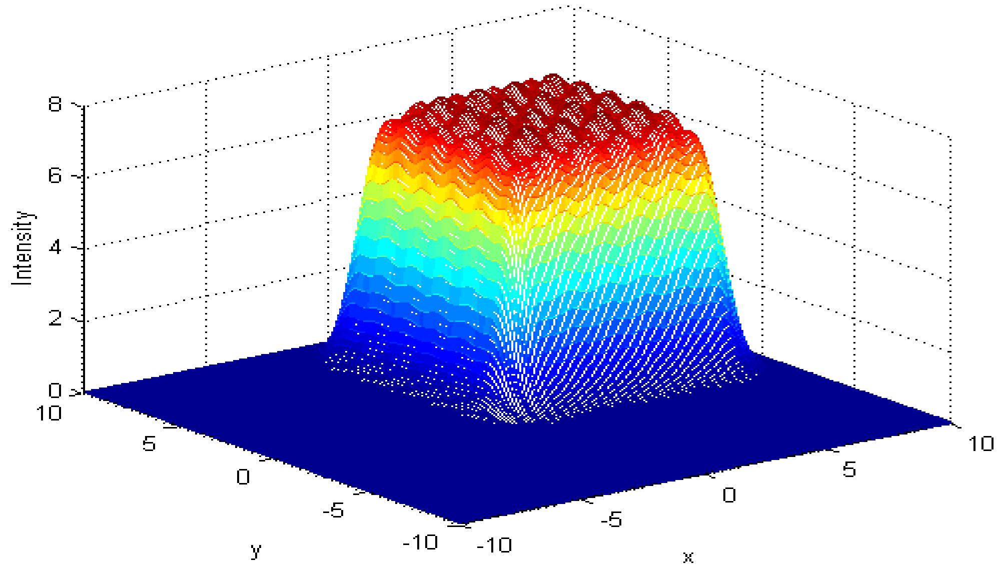

Fig.3.2 The resultant profile for 6X6 square LED configuration having A=5. Others parameters are similar to figure 3.1 a=1, b=1, l=1.5, m=1.5.

- We take 36 LEDs and arrange them in square form. In this, we vary the intensity parameter but the other parameters like the distance between the LEDs is remained same.

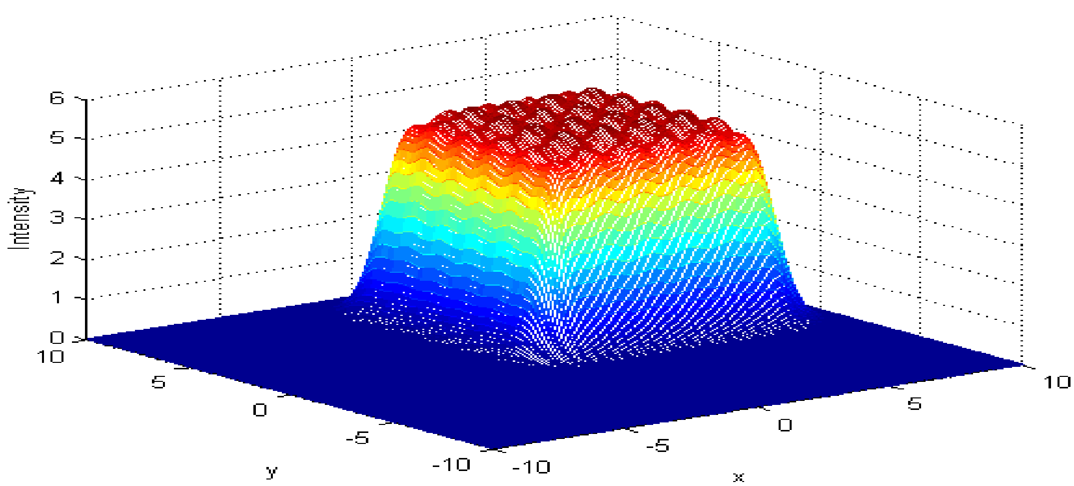

Fig.3.3 represents the resultant profile for 6X6 square LED configuration having A=3.5. Other parameters are similar to figure 3.1 that are as follows a=1, b=1, l=1.5, m=1.

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- We take 36 LEDs and arrange them in square form. In this, we vary the intensity parameter but the other parameters like the distance between the LEDs is remained same.

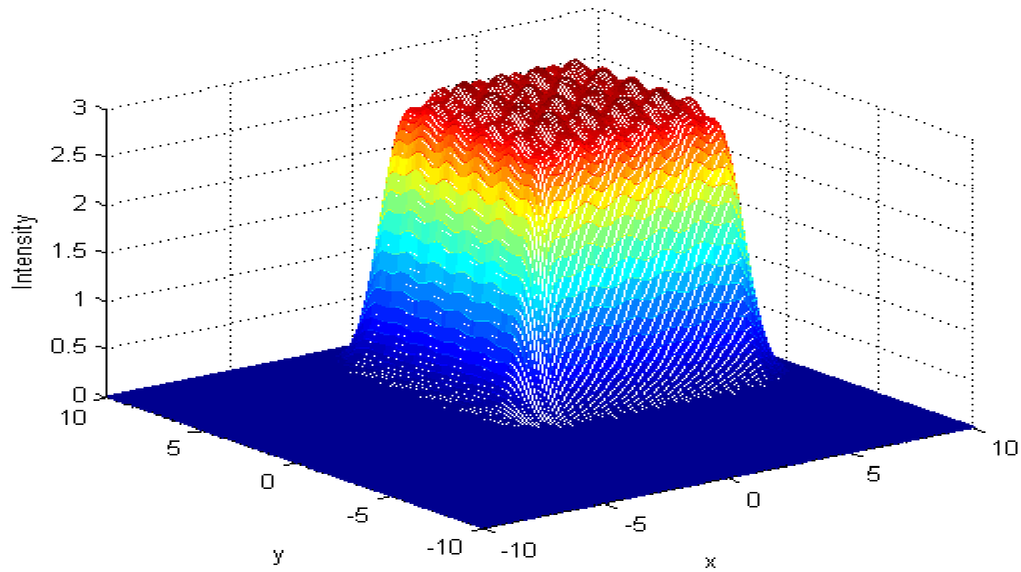

Fig.3.4 represents the resultant profile for 6X6 square LED configuration having A=2. Other parameters are similar to figure 3.1 as follows a=1, b=1, l=1.5, m=1.5.

- We take 36 LEDs and arrange them in square form. In this, we vary the intensity parameter but the other parameters like the distance between the LEDs is remained same.

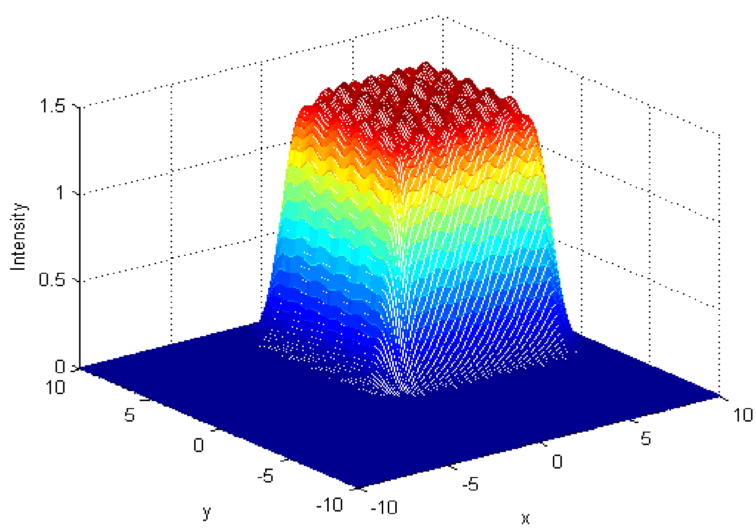

Fig.3.5 represents the resultant profile for 6X6 square LED configuration having A=1. Other parameters are similar to figure 3.1 a=1, b=1, l=1.5, m=1.5.

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3.1.2 LED lighting design with variable distance of LEDs

- We take 36 LEDs and arrange them in square form. In this, we vary the distance between the LEDs but the other parameters like the intensity of the LEDs is remained same.

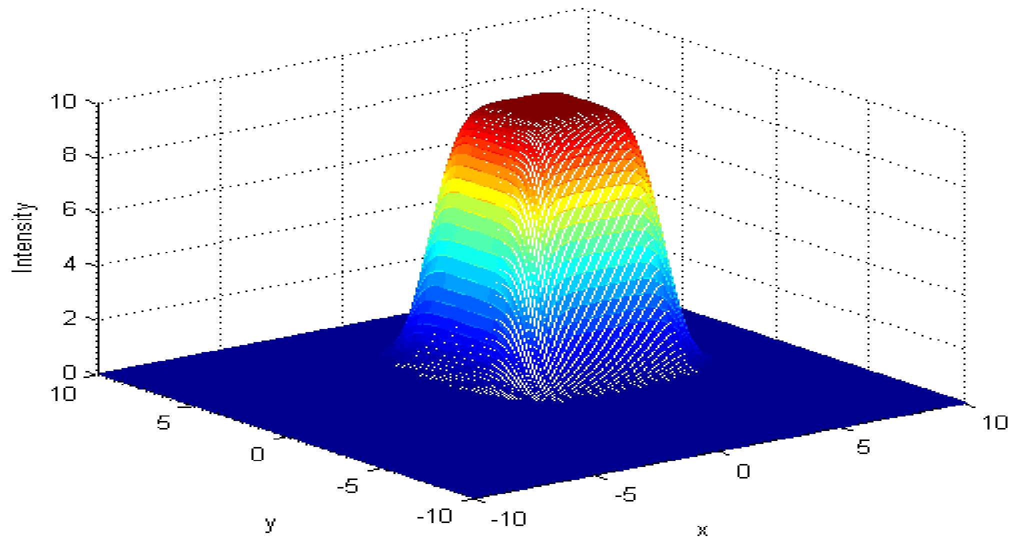

Fig.3.6 represents the resultant profile for 6X6 square LED configuration having parameters A=3, a=1, b=1, l=1, m=1.

- We take 36 LEDs and arrange them in square form. In this, we vary the distance between the LEDs but the other parameters like the intensity of the LEDs is remained same.

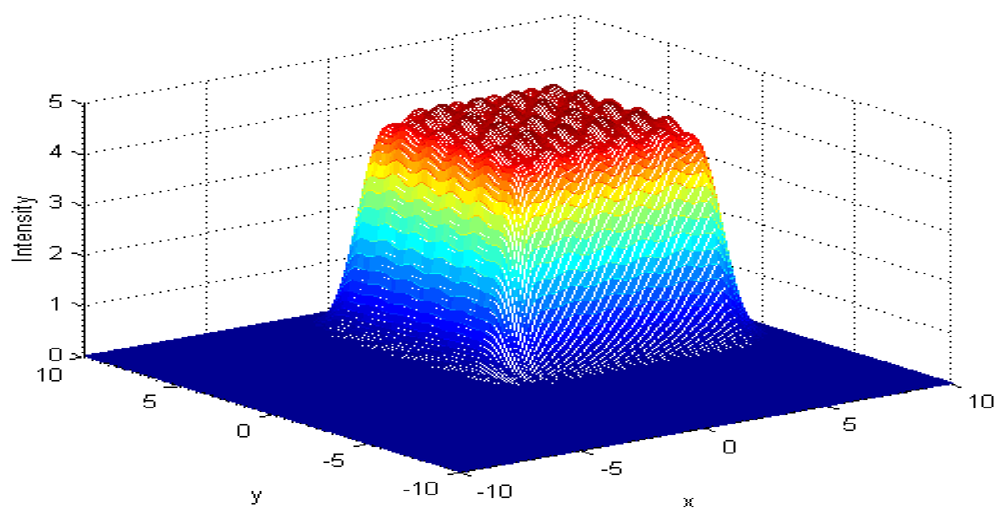

Fig.3.7 represents the resultant profile for 6X6 square LED configuration having A=3. Other parameters are similar to figure 3.6 as follows a=1, b=1, l=1.5, m=1.5.

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- We take 36 LEDs and arrange them in square form. In this, we vary the distance between the LEDs but the other parameters like the intensity of the LEDs is remained same.

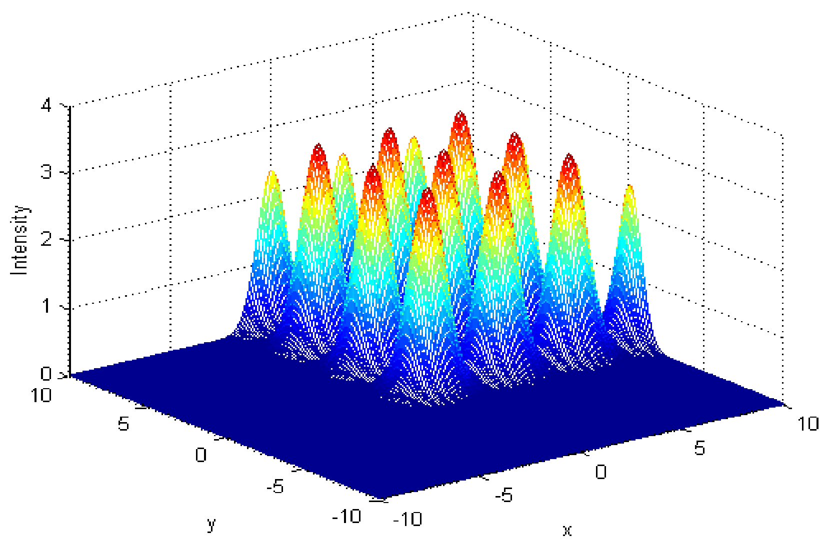

Fig.3.8 represents the resultant profile for 6X6 square LED A=3.

Other parameters are similar to figure 3.6 as follows a=1, b=1, l=3, m=3.

- We take 36 LEDs and arrange them in square form. In this, we vary the distance between the LEDs but the other parameters like the intensity of the LEDs is remained same.

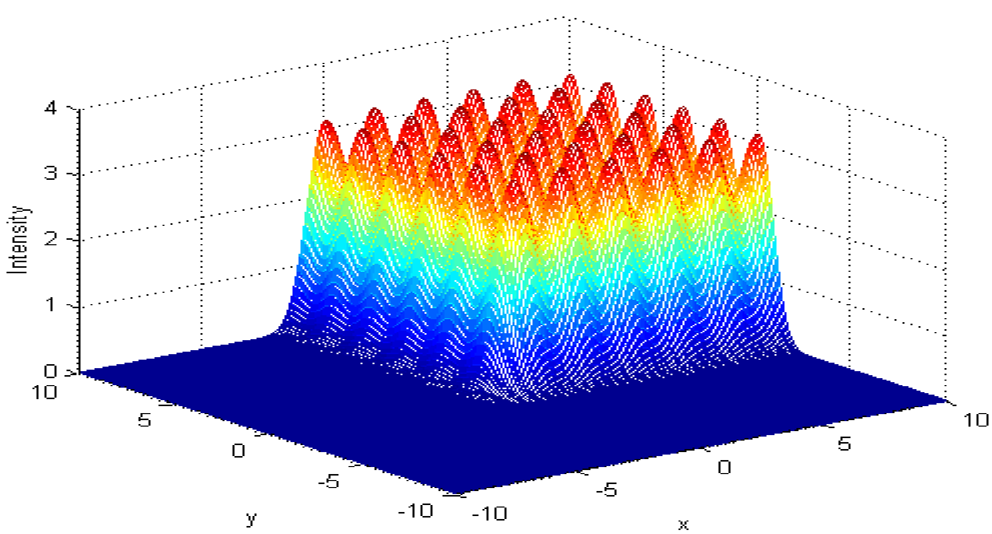

Fig.3.9 represents the resultant profile for 6X6 square LED configuration having A=3.

Others parameters are similar to figure 3.6 as follows a=1, b=1, l=3, m=3.

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- We take 36 LEDs and arrange them in square form. In this, we vary the distance between the LEDs but the other parameters like the intensity of the LEDs is remained same.

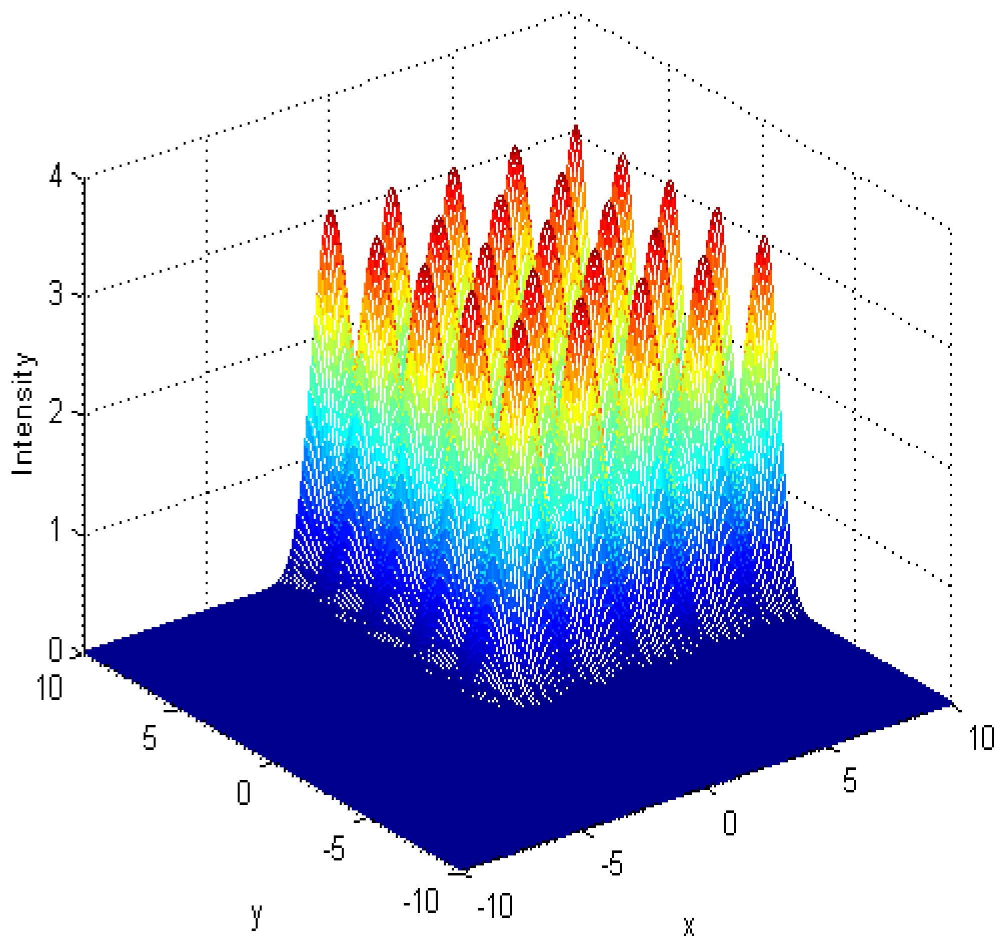

Fig.3.10 represents the resultant profile for 6X6 square LED configuration having A=3. Other parameters are similar to figure 3.6 as follows a=1, b=1, l=2.5, m=2.5. There are many fluctuations in this intensity profile which is not useful.

3.2 Fabrication: We design an LED panel by using MATLAB. By varying the intensity of LEDs and by varying the distance between the LEDs, different intensity profile can be determined. With the help of tuner, we can control the intensity of LEDs, that plays a very important role in tissue culture technology. We fabricated the LED panel by combining red and blue LEDs and with a tuner attached to it.

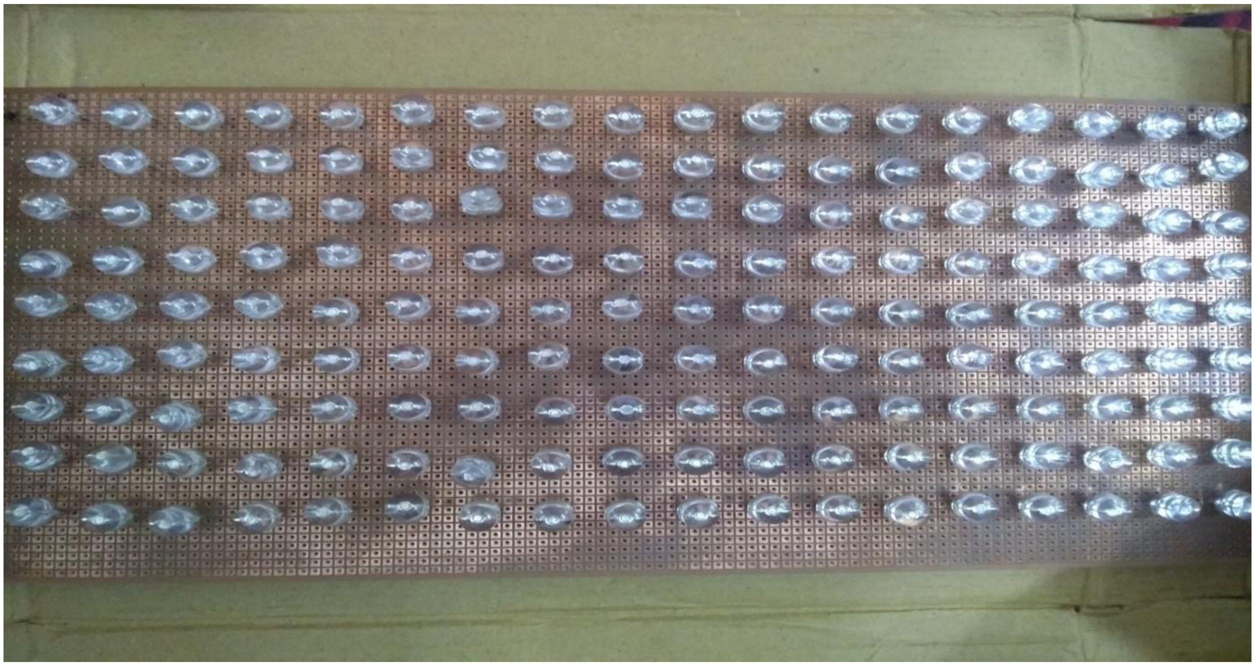

Fig. 3.11 LED panel.

We can control the plant growth by increasing and decreasing intensity of the panel. This can be done with the help of tuner.

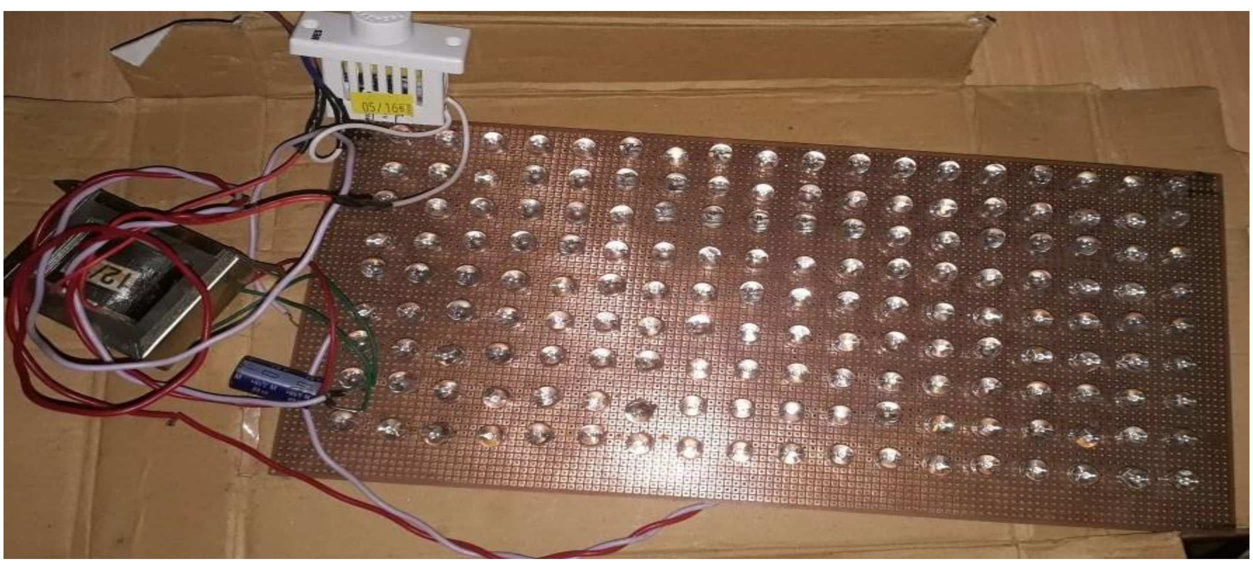

Fig.3.12 LED panel with tuner.

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By tuning the intensity i.e. we start with the 1st to 3rd rotation, then only red color LED dominates.

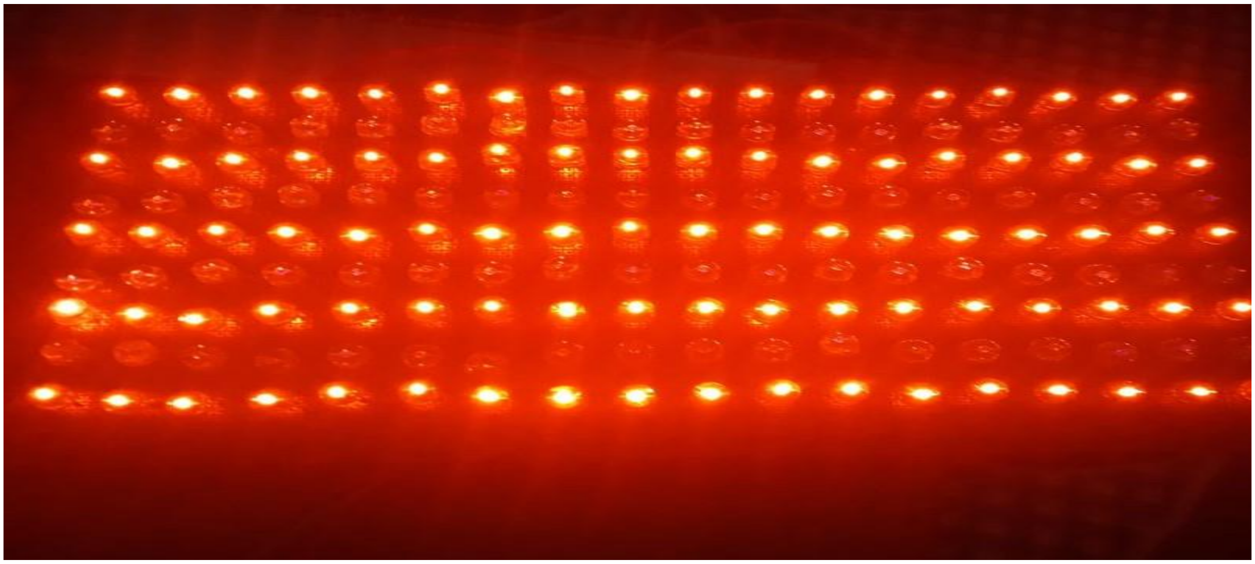

Fig.3.13 Dominating Red color LEDs.

After that in 4th rotation we find that only blue color LED dominates.

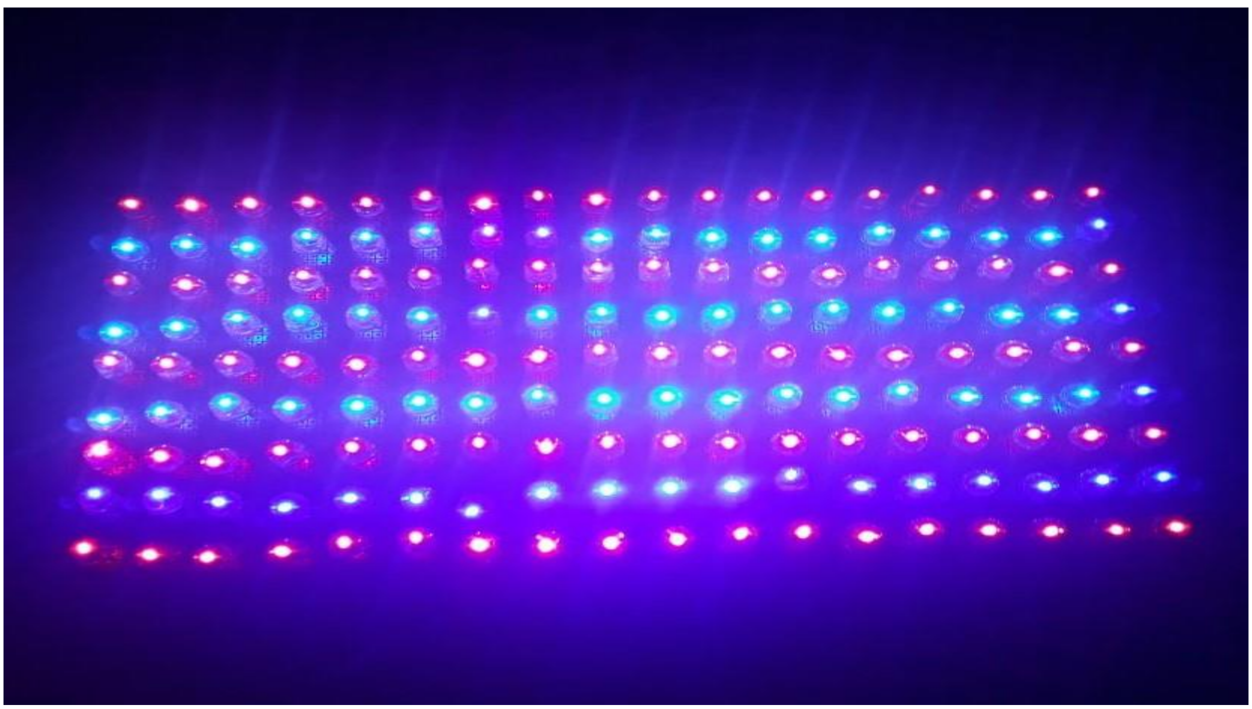

Fig.3.14 Dominating blue LEDs

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At last i.e. in 5th rotation we find that both red and blue LEDs glow.

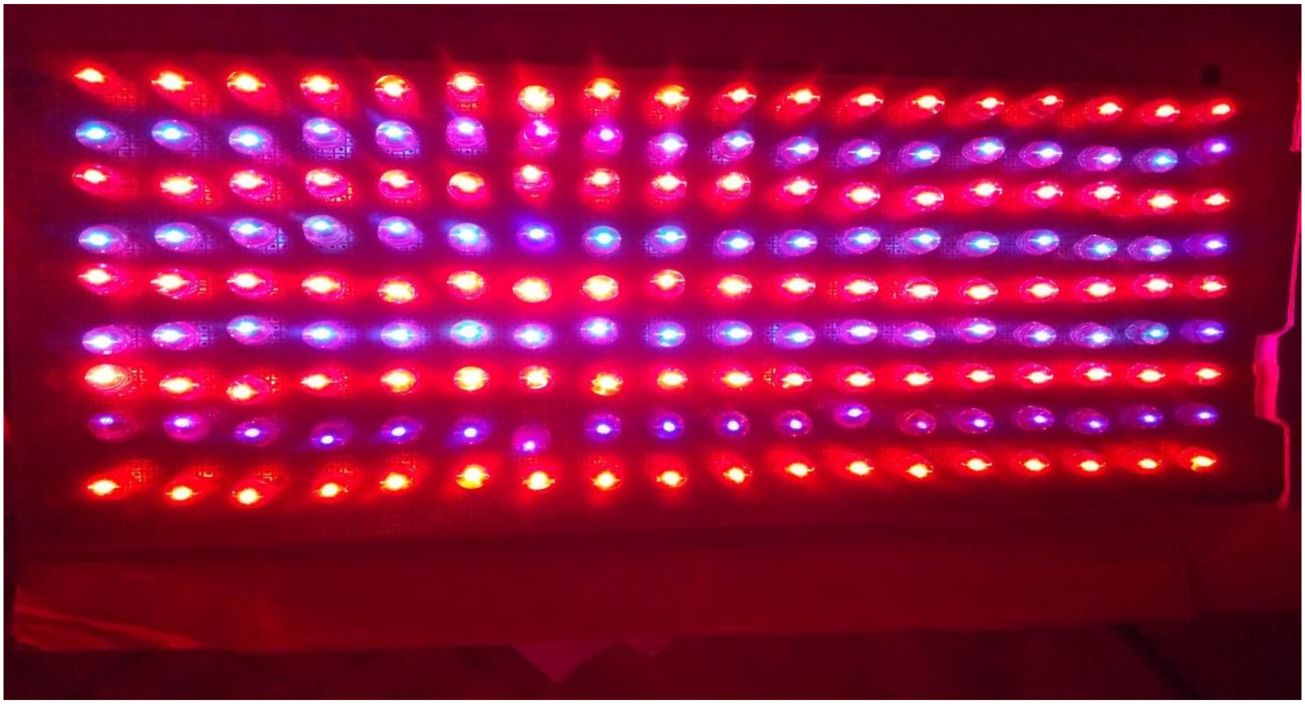

Fig.3.15 LED panel showing red and blue LEDs.

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Chapter 4

Conclusion and future scope

4.1 Conclusion

Tissue culture plays a very important role in our lives. In the coming decades as the world's population is increasing day by day so there is reduction in agricultural lands and accommodation space. Keeping all these things in mind, we have to assure a peaceful, hunger free and healthy world for next generation. There is no alternate other than to do plant tissue culture. In the process of tissue culture, those light LEDs can be used which provide total or even partial light. LEDs have the capability to provide true spectral composition control that allow wavelengths to complement to plant photoreceptors for optimize production. LEDs can be easily assimilated into digital control systems and do not contain mercury. LEDs are safer than current lamps as they do not have high touch temperature. As the process of photosynthesis do not require constant light of full spectrum. LEDs can produce specific wavelength of sufficient photon fluxes. Physiological features of plant growth can be regulated and controlled by using sources of LED lights. We have fabricated an LED panel using blue and red LED lights. Various light spectrums have different consequences on the growth of plant. Most studies show the effect of LED light on morphology of plants that have included only blue and red LED lights. Green LED lights are examined as photo synthetically inefficient. But it gives a great contribution in the development of plants and growth in orchestration with red as well as blue light as established by some recent studies. It is expected that LED systems with lower price, good semi conductor materials and intensity so it will be the considerable light sources for micro propagation systems in future.

5.2 Future scope

The lighting industry should provide ecologically and energy efficient lamps to the consumers. LEDs provided with chips can provide some benefits of efficiency, operational flexibility, controllability and reliability for tissue culture lighting system. It is expected that tissue culture propagation under controlled conditions will enlarge in the future. The new scientific approach provide feasibility for economically efficient light energy for tissue culture propagation both in space and on earth in future and may contribute to feeding the growing human population and maintaining outdoor ecosystems and thus to the protection of the Earth. Further examinations are required to study the role of green light in the development of flowering, vegetative development, stomatal opening, stem elongation and plant stature.

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