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Effect of different illumination types on *in vitro* growth and development of potato (*Solanum tuberosum* L.) microplants

Sumon Karmakar[1], Rashed Zaman[2*], M Nasiruddin[3], Monzur Hossain[4]
[1-2] Department of Genetic Engineering and Biotechnology, University of Rajshahi, Rajshahi, Bangladesh
[3-4] Department of Botany, University of Rajshahi, Rajshahi, Bangladesh

Abstract

As light plays an important role for the development of microplants thus, this investigation was aim to identifying different developmental stages includes shoot length, number of leaves, number of nodes and number of roots under six illumination types (white, blue, red, blue-red, blue-white and red-white). The results reveals that the red light is more effective for increasing shoot length per microplants instead of other light condition and blue light which were reduce the plant height. The highest number of leaf per microplants were obtained under blue light and approximately resemble at the combination of blue-white light and red light is responsible to reduce the number of leaves. In case of nodal development the highest number of nodes were formed by blue-red light. The number of roots was increased by red-white light but it was decreased in red light with increased thickness of roots.

Keywords: Illumination, tissue culture, potato, micropropagation, light effect

1. Introduction

Potato is one amongst the foremost consumed vegetable crops next to the rice, wheat, and corn throughout the planet [1]. It's a wonderful supply of carbohydrates, free essential amino acid largely lysine, a decent supply of protein, fibers, minerals, and vitamins [2]. Potato is cultivated more or less 150 countries everywhere the planet [3], and therefore the most typical vegetable crops within the world [4]. Potato is propagated vegetatively exploitation virus-free seed potatoes for the higher production. Virus free seed potatoes are obtained by exploitation tissue culture techniques that signify 17% to 21% of the whole crop costs [5]. *In vitro* micropropagation is that the simplest manner for the assembly of potato microplants that is free from virus and enhances the assembly rather than the standard methodology [6]. Micropropagation method depends on the composition of the culture medium [7]. *In vitro* propagation strategies exploitation plant tissue, nodal segments, leaf segments, internodes, energid and microtubers to keep up the genetic integrity of the multiple clones underneath the disease-free condition and conjointly maintain the genetic uniformity of an individual. Succeeding organogenesis or embryogenesis that convoying genetic changes are reportable [8]. Plants that regenerate from *in vitro* propagation of serial culture of individual's nodal segments the process is incredibly advanced that embrace physiological, biochemical and structural changes were discovered for disease-free seed production of potato [9]. However, *in vitro* micropropagation of potato microplants that improved by exploitation the freshly accessible light that may cut back the assembly costs, particularly for seed potato production [10]. Light is that the supply of energy for photosynthesis process that regulates the event of plants that called photomorphogenesis and pigment is that the crucial pigment for the photosynthesis process, since its capture light energy and reworked into energy [11]. The wavelength of light between 390 and 760 nm (visible light) used plants for chemical change [12]. The effectiveness of chemical change is influenced by the standard of light, the wavelength of light, light period and light intensity [13]. Though natural daylight is often used as a supply of energy for plants full-grown however just in case of micropropagation in laboratories, the white fluorescent lamps are used worldwide. The qualities, amount of light and photoperiod have shown a necessary component for photosynthesis, photomorphogenesis and phototropism [14]. The quality of light plays a significant role in morphological characteristics like shoot, root, leaf size and nodal development of microplants [13]. Red and blue color LEDs are won't to enhance the expansion of microplants [15]. It absolutely was reportable that LEDs appropriate for the space-based plant culture system [16]; and it had been additionally reportable that red and blue LEDs light enhance the expansion and development of cymbidium microplants underneath *in vitro* condition [17] and each *in vitro* and resulting growth of banana microplants were improved underneath blue and red LEDs [13].

Therefore, several fascinating analysis works are conducting in many plant species grownup underneath LEDs like cherry [18], banana [13], strawberry [19], cotton [10], and so on. So, the intention of this analysis is to reassure that color of light is

healthier for the development of potato plantlet (shoot, leaf, node, and root) underneath *in vitro* condition.

2. Materials and Methods

2.1 Plant material

The economically important potato genotype 'Cardinal' were collected from 'Aka-Fuji Agro Technology Laboratory', Katakhali, Rajshahi, Bangladesh; and *in vitro* cultural operation were performed in Biotechnology laboratory at 'Institute of Biological Science', University of Rajshahi, Rajshahi-6205, Bangladesh.

2.2 Culture technique

Nodal segments of 10-15 millimeter length were used, that originated from two consecutive subcultures in MS medium [20] supplemented with 30 g/L sucrose and 7 g/L agar, the pH of the medium was maintained at 5.8 before autoclaving and autoclaving at a pressure of 15 psi and 121 °C temperature for 20 min. The Cultures were incubated in growth chambers that contain 22 W two LEDs rod light per rack six forms of lights (white, blue, red, blue-red, blue-white and red-white) shown in Fig 1. Every chamber separated from another one by exploitation aluminium foil. To judge the completely different light impact on *in vitro* development of potato microplant single explants per culture vessel and every treatment have 10 culture vessels (number of replication). The cultures were maintained within the growth chamber at 25±2 °C beneath a photoperiod of 16/8 h (light/dark cycles).

2.3 Data assortment and applied math analysis

Each treatment consisted of 10 replications with six treatments. The physical measuring involves shoot length in cm, range of leaves, nodes and roots of microplants were recorded 15th, 21st and 30th days once immunization. Collected information was analyses exploitation Microsoft excel and IBM SPSS-2001 software package.

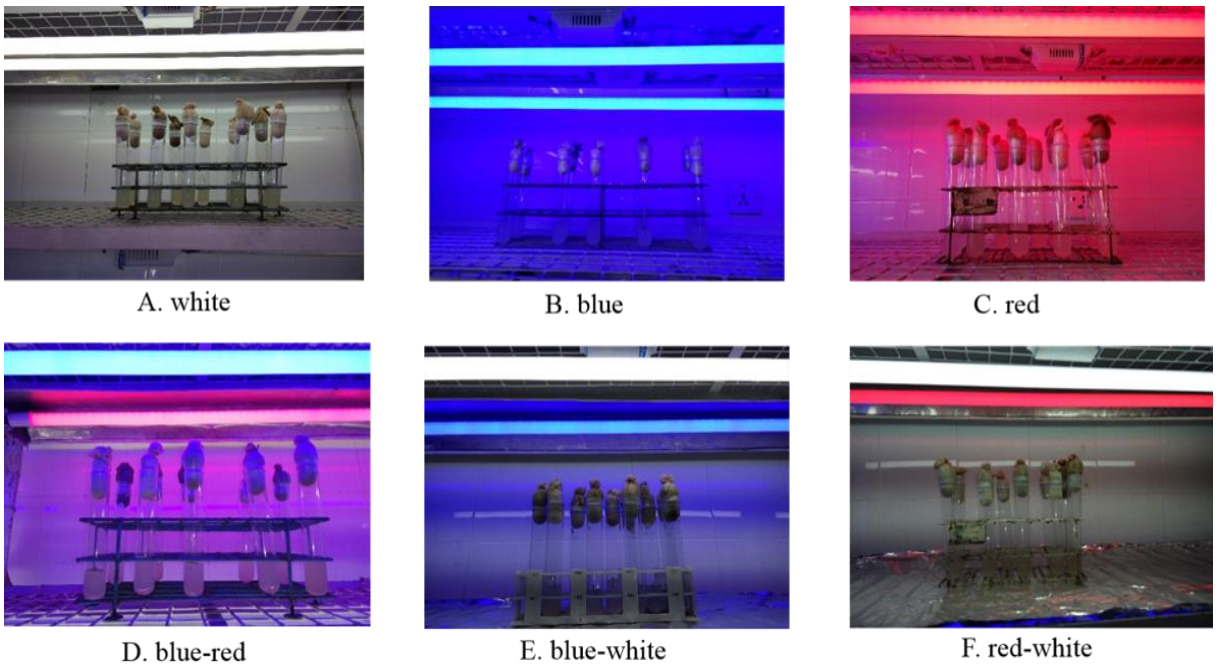

Fig 1: Completely different light arrangements in growth chamber to realize uniform light unfold in an exceedingly given shelf space (A. white, B. blue, C. red, D. blue-red, E. blue-white and F. red-white light).

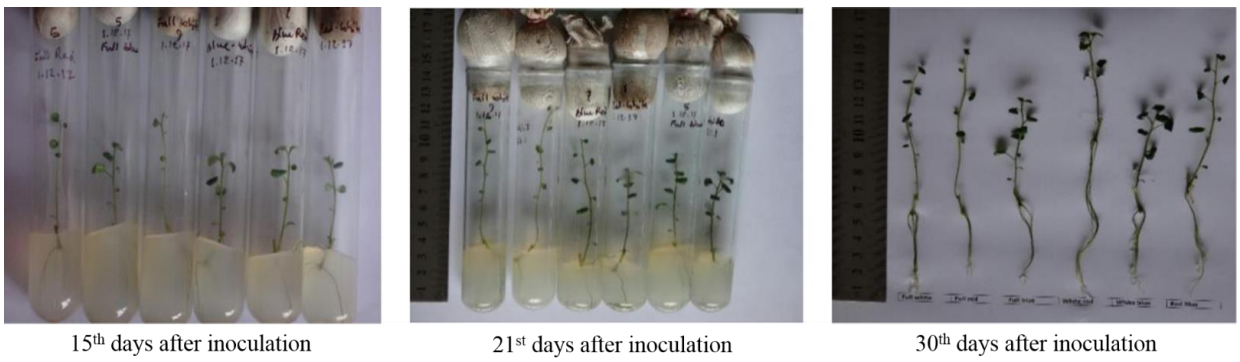

Fig 2: Effect of six illumination types on different developmental stage of the microplants in different day's interval after inoculation.

3. Results

All data were recorded on physical growth of potato microplants under *in vitro* condition, which were shoot length (cm), number of leaves, number of nodes and number of roots in six different colors of light (a. white b. blue c. red d. blue-red e. blue-white and f. red-white) (Fig 1 and Fig 2). Plants structure is controlled by the signaling of light. During first week of culture, all sample started to develop shoots, data was recorded after second week, third week and end of week four after inoculation.

3.1 Shoot Length (cm)

The function of red light is to induce the average highest shoot length (7.46 ± 0.32 cm), and it was followed by blue-red (6.39 ± 0.46 cm), white (5.6 ± 0.33 cm), red-white (5.26 ± 0.30 cm), blue-white (4.46 ± 0.26 cm) after 30 days of inoculation (Table-1 and Fig 2). The average lowest shoot length of potato microplants were observed in blue light (4.42 ± 0.16 cm) after 30 days of inoculation. All the days' interval during *in vitro* propagation of potato microplants the microplants shoot growth trend was statistically similar. No morphological abnormalities of the plantlet were observed. Changes in plant morphology indicate physiological impairments or somaclonal variation.

3.2 Number of Leaves

The highest number of leaves per microplants were found in blue light (10.1 ± 0.64) and it was followed by blue-white (9.8 ± 0.13), white (9.7 ± 0.49), red-white (9.400 ± 0.29), blue-red (8.8 ± 0.33) after 30 days of inoculation. The lowest number of leaves were observed in red (8.556 ± 0.33) (Table-2 and Fig 2). Approximately resemble at the combination of blue-white light where no significant differences were found among all light conditions. On the other hand, red light was the least responsive light condition since it showed the least number of leaves per plantlet (Table-2 and Fig 2).

3.3 Number of Nodes

In case of nodal development under different colors of light highest number of nodes were found in blue-red (8.3 ± 0.30), and it was followed by blue (7.7 ± 0.21), white (7.6 ± 0.16), red-white (6.88 ± 0.33), and red (6.8 ± 0.38) after 30 days of inoculation. The lowest number of nodes was observed in blue-white (6.7 ± 0.26) were shown in (Table-3 and Fig 2).

3.4 Number of Roots

The highest number of roots were found in red-white (5.7 ± 0.21), and it was followed by white (4.9 ± 0.23), blue-white (4.8 ± 0.21), blue-red (4.4 ± 0.22), and blue (4.3 ± 0.24) after 30 days of inoculation. The lowest number of roots were observed in red light (3.9 ± 0.22) (Table-4 and Figure 2). Combination of blue-red light, whereas no significant differences were found in other light. For the *In vitro* elongation of root and increase the number of it's effected by red-white light but in case of red light the number of root is decrease and thicker roots were obtained from each microplants (Table-4 and Fig 2).

Table 1: The development of shoot length (cm) of potato microplants underneath *in vitro* condition on completely different illumination sorts

Illumination type	Days after culture inoculation			Treatment mean± SE	CV%
	15th	21st	30th		
White	1.9 ± 0.11^{b}	3.68 ± 0.24^{bc}	5.6 ± 0.33^{bc}	3.72± 0.23^{C}	0.49
Blue	1.53 ± 0.13^{b}	2.89 ± 0.18^{d}	4.42 ± 0.16^{d}	2.94 ± 0.16^{F}	0.49
Red	2.56 ± 0.17^{a}	4.83 ± 0.19^{a}	7.46 ± 0.32^{a}	4.95 ± 0.23^{A}	0.49
Blue-White	1.81 ± 0.15^{b}	3.32 ± 0.15^{cd}	4.46 ± 0.26^{d}	3.19 ± 0.19^{E}	0.41
Blue-Red	1.97 ± 0.13^{b}	4.31 ± 0.27^{ab}	6.39 ± 0.46^{b}	4.22 ± 0.29^{B}	0.52
Red-White	1.87 ± 0.19^{b}	3.44 ± 0.27^{cd}	5.26 ± 0.30^{cd}	3.52 ± 0.25^{D}	0.48
Days interval mean± SE	1.94±0.15^{C}	3.74±0.22^{B}	5.59±0.30^{A}		
CV%	0.17	0.18	0.20		

N.B. *Different letters indicate they are significantly different from each other according to DMRT (Duncan Multiple Range Test) test at 5% probability level.*

Table 2: The number of leaves per microplant underneath *in vitro* condition on completely different illumination sorts

Illumination type	Days after culture inoculation			Treatment Mean ± SE	CV%
	15th	21st	30th		
White	3.5±0.22^{a}	5.6±0.30^{c}	9.7±0.49^{ab}	6.26±0.34^{B}	0.50
Blue	3.8±0.20^{a}	7.3±0.21^{a}	10.1±0.64^{a}	7.06±0.35^{A}	0.44
Red	2.7±0.21^{b}	5.9±0.34^{bc}	8.556±0.33^{b}	6.00±0.30^{C}	0.55
Blue-White	3.7±0.15^{a}	7.1±0.31^{a}	9.8±0.13^{ab}	6.86±0.20^{AB}	0.44
Blue-Red	3.6±0.26^{a}	5.8±0.24^{bc}	8.8±0.33^{ab}	6.06±0.26^{C}	0.43
Red-White	3.1±0.31^{ab}	6.6±0.30^{ab}	9.400 ±0.29^{ab}	6.08±0.32^{C}	0.45
Days interval Mean± SE	3.4±0.22^{C}	6.38±0.28^{B}	9.39±0.37^{A}		
CV%	0.12	0.11	0.06		

N.B. *Different letters indicate they are significantly different from each other according to DMRT (Duncan Multiple Range Test) test at 5% probability level.*

Table 3: Number of nodes per microplant underneath *in vitro* condition on completely different illumination sorts

Illumination type	Days after culture inoculation			Treatment mean± SE	CV%
	15th	21st	30th		
White	1.8±0.13^{abc}	5.1±0.45^{b}	7.6±0.16^{abc}	4.83±0.25^{B}	0.60
Blue	1.28±0.15^{c}	4.4±0.16^{b}	7.7±0.21^{ab}	4.46±0.17^{C}	0.71
Red	1.4±0.17^{bc}	4.3±0.26^{b}	6.8±0.38^{bcd}	4.16±0.27^{E}	0.64
Blue-White	1.7±0.21^{abc}	5±0.39^{b}	6.7±0.26^{d}	4.46±0.28^{C}	0.56
Blue-Red	1.9±0.10^{ab}	6.2±0.35^{a}	8.3±0.30^{a}	5.46±0.25^{A}	0.59
Red-White	2±0.14^{a}	4.3±0.26^{b}	6.88±0.33^{cd}	4.39±0.24^{D}	0.55
Days interval Mean± SE	1.68±0.15^{C}	4.88±0.31^{B}	7.33±0.27^{A}		
CV%	0.16	0.15	0.08		

N.B. *Different letters indicate they are significantly different from each other according to DMRT (Duncan Multiple Range Test) test at 5% probability level.*

Table 4: The number of roots per microplant underneath *in vitro* condition on completely different illumination sorts

Illumination type	Days after culture inoculation			Mean of treatment ± SE	CV%
	15th	21st	30th		
White	4.1±0.23^{a}	4.4±0.24^{ab}	4.9±0.23^{b}	4.46±0.23^{B}	0.09
Blue	2.6±0.33^{c}	4.1±0.24^{b}	4.3±0.24^{bc}	3.66±0.27^{E}	0.25
Red	2.9±0.27^{bc}	3.8±0.24^{b}	3.9±0.22^{c}	3.53±0.24^{F}	0.15
Blue-White	3.55±0.16^{abc}	4.6±0.24^{ab}	4.8±0.21^{b}	4.31±0.20^{C}	0.15
Blue-Red	3.7±0.33^{ab}	4.3±0.24^{ab}	4.4±0.22^{bc}	4.13±0.26^{D}	0.09
Red-White	4.1±0.48^{a}	5.2±0.24^{a}	5.7±0.21^{a}	5.00±0.31^{A}	0.16
Days interval Mean± SE	3.49±0.30^{C}	4.4±0.24^{B}	4.66±0.22^{A}		
CV%	0.178	0.109	0.133		

N.B. *Different letters indicate they are significantly different from each other according to DMRT (Duncan Multiple Range Test) test at 5% probability level.*

4. Discussion

Light is an essential factor for the growth and development of plantlet. This study was targeted at improving tissue culture systems by improving the supply of light source required for efficient plant growth and morphogenesis. White light is commonly used in tissue culture laboratory [21]. In case of our study red light is more effective for increase the shoot length decrease in blue light. Poudel *et al.* [22] demonstrated that plant height and internodes length were longer in grapes plants cultured under red LEDs and it was also observed by Kim *et al*. [23] and Rocha *et al*. [24] that the longer plantlets of chrysanthemum and strawberry when grown under red LEDs light. Wilson *et al*. [25] were found that longer plantlets of potato under red LEDs, compared to plantlets grown under white fluorescent lamps or even under blue LEDs. Continuous red radiation significantly stimulated shoot elongation of sweet potato plantlets *in vitro* [26].

It was observed by Xiao *et al*. [27], red and blue light spectrum strongly shaped plant morphology and red light increases the number of leaves. But in our study blue light have shown the highest number of leaves instead of other types of light. It has been also reported that red LEDs affect stem elongation, leaf expansion [28]. According to Kim *et al*. [23] red light enhance the number of leaves. In case of *Rosa kordesii* after four week of inoculation red light increase the number of leaves studied by Azmi *et al*. [29].

In our study the number of nodes per plantlet was increased significantly the combination of blue-red light and other light have no significant differences.

The number of roots is highest under *in vitro* condition in white light was observed by Bello-Bello *et al*. [30] in vanilla plantlet. Tripathy and Brown [31] demonstrated that the decrease in totally fresh and dry weight and of root weight of plantlets under red LEDs was less than that of plantlets under blue LEDs. This was also observed in our study that the number of root per plantlet in potato increase by the combination of red-white light. After four weeks of transfer to rooting medium, significant differences were observed in rooting responses under different LED wavelengths observed by Vandita Billore *et al*. [32] that blue and red light induced increased root length followed by yellow light treatment. However, white light treatment induced shorter root length than all LED treatments. This is suggestive that different light treatments. The LEDs have been shown to induce increase in length of roots per explants in different plant species grown in vitro [33].

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