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Effect of Led Spectrum on Potato Growth in *Vitro*

Nada A. Elsabaa^{1*}; M. E. Ahmed¹; N. A. Younes¹ and Mona N. Shehata²

¹Vegetable Crops, Faculty of Agriculture, Al-Azhar University Assiut Branch

²Vegetable Crops, Faculty of Agriculture and Natural Resources, Aswan University



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ABSTRACT

The experiment was carried out to investigate the growth behavior in-vitro plant tissue culture of Potato plantlets under different light spectra. The 3rd generation in vitro plantlets of potato was used. The experiment included 5 treatments were conducted as factorial based on completely randomized design (CRD) with five replications and each replication included five jars with 3 plants per each one. The adventitious shoots of *S. tuberosum* (0.5–1 cm in length) were exposed in jars containing approximately 30 ml of the Murashige and Skoog (MS) salt medium. The cultures were kept under each light LEDs (W, Y, G, B and R) separately, for 15 days (subculture period). Results of 3 subcultures indicated a significant increase of multiplication rate under all light conditions, which recorded the highest mean value with green light followed by blue then red. Also, an increase in shoot length due to the optical spectrum lights and the highest value recorded with the blue light followed by red one. Number of leaves scored the highest value with the blue light. As for the fresh weight of plant found that the highest mean values recorded with blue light followed with the red one. While the lowest mean values for all parameters recorded with the yellow light. The highest quantities of glucose, fructose, sucrose, soluble carbohydrates, amino acid and tocopherol recorded the highest values under blue light, while soluble protein and anthocyanin scored the highest values under red light.

Keywords: LED, red, yellow, green and white light.



INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most widely consumed vegetable on the planet and a major source of carbs, fiber, and potassium for human use (ABBA, 2014; Abd El-Hady and Shehata, 2019; Hamaiel *et al.*, 2021; Abd El-Hady *et al.*, 2021 and El-Sherpiny *et al.*, 2022). In vitro potato reproduction is influenced by a variety of parameters such as growth regulators, cultivar, photoperiod, temperature and light quality, since it is an economically important crop (Rehana *et al.*, 2018).

Tissue culture is one of the most essential procedures for cultivating plant cells, tissues, or organs in an aseptic environment in order to research or genetically manipulate the plant (Espinosa-Leal *et al.*, 2018). The explant is a portion of the plant that has been separated from its intact body and placed in or on a nutritional medium suited for its growth and propagation (Molnár *et al.*, 2011). The nutritional medium has two purposes for the cultured plant cells' growth: first, it serves as a replacement for the natural plant's surrounding elements, and second, it serves as a supply of nutrients (Chimdessa, 2020). The ability of the plant cell to grow a whole plant from any explant, which is known as cellular totipotency of the plant cells (Fehér, 2019), is what the plant tissue culture relies on. The tissue culture nutritional media must meet all cell growth needs, which vary depending on the plant tissue employed (Bhatia, 2015). Energy sources, vitamins, amino acids, and growth regulators such as plant growth hormones are all included in standard medium (Leva and Rinaldi, 2012). The pH of the media must be adjusted to meet the cell's development requirements, which is usually 5.7. It is possible to employ both liquid and solid media (Arab *et al.*, 2014 and San Pedro *et al.*,

2017). Finally, the physical conditions include temperature, which should be kept constant during the experiment and should vary from 20 to 30 degrees Celsius (Arab *et al.*, 2014; San Pedro *et al.*, 2017).

Light plays an important function in the growth and development of in vitro culture plants. During seed germination, leaf development, neighbor evasion, stem lengthening, blossom initiation, pigment synthesis, and de-etiolation, light has a direct impact on plant structure and form. Regardless of plant type, artificial lighting at night causes to differences in plant attributes such as height, leaf number, biomass, and growth when compared to plants that dislike light at night (Flowers and Gibson, 2018). Because of the significant effects of light on plant growth, artificial lighting is frequently employed to control growth systems and make efficient use of resources. Artificial lighting has evolved into one of the most basic and safe technologies for regulating the appropriate lighting conditions for maximum plant growth and development (Lu *et al.*, 2017).

Light-emitting diodes (LEDs) offer unique features that have the ability to manage plant growth and development as an alternative artificial light source. LEDs are a promising gadget for the future of controlled agriculture since they provide numerous benefits in plant trial research and commercial plant production. LED lamps have been presented as the most efficient alternative source of light in regulated agricultural contexts since their advantages outweigh those of standard artificial lighting systems (Lu *et al.*, 2017). In comparison to traditional lighting sources such as incandescent and fluorescent bulbs, LEDs have a longer life cycle and are more solid, making them more versatile for installation and manipulation (Chang *et al.*, 2012).

* Corresponding author.

E-mail address: nadaelsaba@yahoo.com

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Fluorescent lights are the traditional light source for *in vitro* propagation (FLs). However, FL is costly and produces a wide range of wavelengths (350–750 nm) that are unsuitable for plant growth. Plant growth must be optimized for maximum energy conversion through photosynthesis and other biochemical activities throughout their life cycle. By providing optimal illumination conditions, maximum chemical buildup can be achieved. LEDs may be fine-tuned to solely emit the spectrums that plants require for morphogenic responses in this way. The purpose of this study was to compare the effects of conventional light (545–610 nm) vs yellow LEDs (585–600nm), red LEDs (660 nm), blue LEDs (460 nm), and green LEDs (520–555 nm) on potato micropropagation.

MATERIALS AND METHODS

This study used *S. tuberosum* *in vitro* plantlets and carried out in the Plant Tissue Culture laboratory of Scientific and Technological Applications Unit, Al-Azhar University Assiut branch, Assiut Egypt between August and November of 2020 to investigate the growth behavior *in vitro* plant tissue culture of Potato plantlets under different light spectra. The 3rd generation *in vitro* plantlets of potato (*Solanum tuberosum*) cv. “Diamond” was used in this study as described in Table A. Adventitious shoots from the axillary buds of *S. tuberosum* were obtained from the Technological Applications Unit, Al-Azhar University, Assiut branch in Egypt, as the experimental material.

Table A. Description of potato Diamond variety:

Variety	Diamond
Maturity	Med Late 110-115 day
Shape	Oval
Size	Big
Color	Yellow cortex, creamy flesh
Productivity	12-15 tuber/plant
Dry matter	23.6%

Optical spectra system experiments were performed in a culture room with $80 \pm 5\%$ relative humidity, photoperiod (16 h light/8 h dark), and 25 ± 2 °C. Light sources used in this experiment were FL (Control): fluorescent lamps emitting light at broad wavelengths of 400–700 nm, Y: Yellow LEDs with a wavelength of 585–600 nm, G: Green LEDs with a wavelength of 520–555 nm, R: Red LEDs with a wavelength of 660 nm and B: Blue LEDs with a wavelength of 460 nm.

Explants in the shoot proliferation and rooting phases were incubated under the different LED treatments strips (IP65 model, SMD 5050 RBG supplying 12 V and 1W per module, Techno Light®, Egypt). The distance between these and the light source was kept constant and equal in all treatments. Irradiation intensity of artificial light was set to $40 \mu\text{mol m}^{-2} \text{s}^{-1}$.

The culture media of shoot induction contained of MS (Murashige and Skoog, 1962) salts medium supplemented with 3% (w/v) of sucrose, 1.5 mg/L of BAP (Benzyl Amino Purine) hormone for growth with 0.1 mg/L of IBA (Indole-3-Butyric Acid) for induce rooting, 100mg/L myo-inositol and 100mg/L of Ferrum. The pH of the medium was adjusted to 5.7 to 5.8. afterwards, the medium was solidified with 2.5 g L^{-1} Gelrite™ (Sigma-Aldrich, Merck Egypt: Agitech) before autoclaving at 121 °C and 124 kPa for 15 min.

The experiment included 5 treatments were conducted as factorial based on completely randomized design (CRD) with five replications and each replication included five jars with 3 plants per each one. The adventitious shoots of *S. tuberosum* (0.5–1 cm in length) were exposed in jars containing approximately 30 ml of the MS salt medium. The cultures were

kept under each light LEDs (W, Y, G, B and R) separately, for 15 days (subculture period).

At the end of the intervals the parameters investigated were, multiplication rate MR (were calculated as the difference in mean shoot number between the mean numbers of shoots derived before and after subculture from one culture at the end of each passage), shoot length cm (SL), number of leaves (NL), number of roots (NR), root length cm (RL), plant fresh weight g (PFW), number of micro tubers (NMT) and weight of micro tubers g (WMT).

To find out the effect of different LEDs light on the physiological properties of tissue culture plants, some physiological analyzes were performed on the continuous optical spectrum experiment for 15 days, freshly collected samples of each treatment in three replicates was used to determine the following physiological characteristics.

Protein content was determined using alkaline reagent solution according to the method of (Lowery, 1951), and the Folin solution was used as a guide for protein detection. The glucose and fructose mg/g DW were estimated in aforementioned extract using the anthrone-sulfuric acid method for both (Halhoul and Kleinberg, 1972), while the total soluble carbohydrate in the same extract (mg/g DW) was estimated by Fales, (1951). Total amino acid in leaves was determined according to (Moore and Stein, 1948). Anthocyanin pigments were determined according to (Krizek *et al.*, 1993). α -Tocopherol was estimated following to (Kivcak and Mert, 2001).

ANOVA was used to analyses the data, which corresponded to a completely randomized design (Gomez and Gomez, 1984). To distinguish substantially different means and provide homogeneous groups for the means (at $p < 0.05$), the Duncan post hoc multiple range test was used.

RESULTS AND DISCUSSION

The experiments data for the subcultural after 15 days were reported in Table 1. As tested the effect of optimal spectrum light on potato plantlets, results indicated a significant increase of multiplication rate under all light conditions, which recorded the highest mean value with green light followed by blue then red. Results also, showed an increase in shoot length due to the optical spectrum lights and the highest value recorded with the blue light followed by red one. Number of leaves scored the highest value with the blue light. As for the fresh weight of plant found that the highest mean values recorded with blue light followed with the red one. While the lowest mean values for all parameters recorded with the yellow light.

Root system as number and length significantly affect with all light conditions were realized in Table 1. Number of roots were obtained the highest value under blue light followed by red. About root length, results showed a significant difference between the optical spectrum light and the highest value was recorded with red light followed by the blue and green light. On the other hand, yellow light was the least responsive light condition. Number and weight of micro-tubers were recorded the highest values with the blue light with a significant differences found among between them. On the other hand, yellow light did not have any tubers.

Table 2 revealed the effect of different light-emitting diode (LED) spectra on *in vitro* explant development of potato plant after 15 days in 2nd subculture. Data in Table 2 indicated an increase in all parameters comparing with the 1st subculture.

Data in Table 2 showed that, multiplication rate significantly recorded the highest value with the green light followed by the blue light. About shoot length, found that blue light recorded the highest value followed by red light. Number of leaves recorded the highest value with blue

light significantly followed by the red light. Treatment of blue light recorded the highest value of plant fresh weight followed by the red light. While, the yellow light recorded the lowest mean values for all parameters.

Table 1. Effect of different optical spectrum LEDs light colors on *in vitro* explant development of potato plant after 1st subculture at 15 days:

Char. Treat	Multiplication rate	Shoot length cm	Number of leaves	Plant fresh weight g	Number of roots	Root length cm	Number of micro tubers	Weight of micro tubers g
White	5.63 ^d	3.16 ^d	5.18 ^d	3.22 ^d	1.47 ^c	0.61 ^d	1.94 ^d	0.84 ^d
Yellow	4.11 ^e	2.21 ^e	3.48 ^e	2.11 ^e	1.05 ^d	0.48 ^e	0.00 ^e	0.00 ^e
Green	8.23 ^a	4.13 ^c	7.54 ^c	4.81 ^c	1.33 ^c	0.84 ^c	2.36 ^c	1.03 ^c
Red	5.87 ^c	5.64 ^b	9.38 ^b	5.74 ^b	2.18 ^a	1.18 ^a	2.71 ^b	1.22 ^b
Blue light-emitting diodes	7.11 ^b	6.71 ^a	10.16 ^a	6.48 ^a	1.77 ^b	0.96 ^b	3.48 ^a	1.94 ^a

LEDs: light-emitting diodes

As for the root system, found that number of roots recorded the highest value with red light, also the root length recorded the highest value with red light significantly followed by blue one.

In the presented study, number and weight of micro-tuber recorded the highest mean value with the blue light, while the other light treatments recorded medium values and the yellow light did not had any production.

Table 2. Effect of different optical spectrum LEDs light colors on *in vitro* explant development of potato plant after 2nd subculture at 15 days:

Char. Treat	Multiplication rate	Shoot length cm	Number of leaves	Plant fresh weight g	Number of roots	Root length cm	Number of micro tubers	Weight of micro tubers g
White	7.11 ^d	5.18 ^d	8.16 ^d	5.43 ^d	1.94 ^d	1.66 ^d	2.13 ^d	1.64 ^d
Yellow	5.38 ^e	4.11 ^e	6.74 ^e	3.87 ^e	1.56 ^e	0.88 ^e	0.00 ^e	0.00 ^e
Green	10.18 ^a	6.43 ^c	9.94 ^c	6.98 ^c	2.33 ^c	1.98 ^c	3.09 ^c	1.81 ^c
Red	8.36 ^c	7.67 ^b	11.22 ^b	8.26 ^b	3.31 ^a	2.64 ^a	5.27 ^b	2.13 ^b
Blue	9.74 ^b	8.41 ^a	12.64 ^a	9.18 ^a	2.98 ^b	2.37 ^b	6.11 ^a	2.61 ^a

Presented data in Table 3, revealed the effect of different optical spectrum LEDs light colors on *in vitro* explant development of potato plant after 15 days in 3rd subculture. It is obvious from the results indicated in Table 3 that the parameters under investigation recorded the highest mean values in the 3rd subculture comparing with the two previous data in Tables 1 and 2.

Optical spectrum lights (white, yellow, green, red and blue) significantly affected all parameters. Multiplication rate significantly increased under all light condition comparing with the white light and scored the highest value with green light followed by blue and red light. Treatment of blue light recorded the highest value of shoot length followed by blue light. As for number of leaves found that, blue light significantly recorded the highest mean value followed red light. Plant fresh weight scored the highest value under blue light significantly followed by the red and green light. The lowest mean values recorded with all treatments under yellow light.

Root system increased under all lights as results revealed in Table 3. Number of roots recorded the highest value with the red light followed by blue light. Highest mean values of root length were realized under the red light significantly followed by the blue light. As for the micro-tuber production found a significant effect was happened under all light conditions and the highest mean values for

both number and weight of micro-tubers were recorded with blue light followed by red one and the yellow light did not gave any production.

Table 3. Effect of different optical spectrum LEDs light colors on *in vitro* explant development of potato plant after 3rd subculture at 15 days:

Char. Treat	Multiplication rate	Shoot length cm	Number of leaves	Plant fresh weight g	Number of roots	Root length cm	Number of micro tubers	Weight of micro tubers g
White	13.26 ^d	6.72 ^d	9.23 ^d	8.11 ^d	3.71 ^d	2.67 ^d	5.11 ^d	2.16 ^d
Yellow	10.18 ^e	5.37 ^e	7.31 ^e	6.18 ^e	2.46 ^e	2.01 ^e	0.00 ^e	0.00 ^e
Green	18.36 ^a	8.13 ^c	11.18 ^c	9.34 ^c	4.21 ^c	3.27 ^c	6.74 ^c	2.71 ^c
Red	15.61 ^c	9.78 ^b	12.71 ^b	10.94 ^b	5.13 ^a	4.34 ^a	7.61 ^b	3.18 ^b
Blue	17.21 ^b	11.48 ^a	13.14 ^a	11.78 ^a	4.64 ^b	3.81 ^b	8.48 ^a	3.47 ^a

The most significant aspect of a micropropagation procedure is its effectiveness, which is determined by the number of explants obtained from a single donor plant, such as micro shoots and single-nodes (the So-called propagation ratio). Previous research has found that light quality has a species-specific effect on this parameter (Gupta and Jatothu, 2013).

As a result, identifying a single light spectrum suited for the propagation of all plant species is difficult. Bello-Bello *et al.*, (2016) found that blue and red LED light alone inhibited the proliferation of *Vanilla planifolia* Andrews, whereas white LED, a combination of blue and red LED, and FL offered the best propagation ratio. The propagation ratio of *Panax vietnamensis* was observed to be two times higher under red:blue LED light in a 60:40 ratio than under FL 11.21 and 5.8, respectively (Nhut *et al.*, 2015). FLs, white LED, and blue LED light, on the other hand, improved the propagation ratio of *G. jamesonii* 'Rosalin' (Gök *et al.*, 2016). The favorable influence of LED light on the *in vitro* growth and development of the examined potato cultivars was confirmed by these findings. Red and blue lights, according to (Folta and Maruhnich, 2007), cause faster plantlet growth than white light, but green light, which is absorbed by phytochromes and cryptochromes, influences events that limit vegetative development. In light of the aftereffects of bud number per plantlet and plantlet length, Omar (2017) found that different light sources altered potato plantlet development: red and green LEDs were the most and least prescribed for plantlet advancement, respectively. The stems of potato plantlets developed *in vitro* under pure red light exhibited shorter cells than those grown under blue

light, according to histological examinations (Wilson *et al.*, 1993). This could explain R and B's height performance in our experiment. Phytochrome and cryptochrome absorb red (600–700 nm) and blue (400–500 nm) light, respectively (Smith, 1993).

During the *in vitro* rooting of diverse plant species, light quality has a differential impact in the root system, with the main effect being an increase in the quantity and length of roots per explant (Kwon *et al.*, 2015). LEDs were found to have a similar effect on the number of roots per explant and root length in potato plants as conventional FL light. Furthermore, when Chinese foxglove was grown under blue LEDs, Manivannan *et al.*, (2015) obtained a larger number of roots. Reactive oxygen species and hormone signaling are employed by plants to optimize light acclimatization and immunological defenses (Szechynska-Hebda *et al.*, 2017). According to Solano *et al.*, (2020), pea and watermelon seedlings that were exposed to red light for 15 minutes had the greatest increase in fresh weight and height.

The formation of potato microtubers is a complex process that is influenced by a variety of circumstances. Gibberellic acid (GA), a plant hormone, is a vital factor in potato tuber induction and initiation (Roumeliotis *et al.*, 2012). The formation and growth of microtubers were mediated by light spectral quality, which regulated hormone concentrations, particularly GA. Potato tuber induction and

initiation are hampered by high levels of GA. Blue light suppressed tuberization of day-neutral potatoes by increasing GA production and accumulation, according to previous study (Fixen *et al.*, 2012). This could explain the micro tuberization seen in blue light. Plant organs' sink capacity is thought to be enhanced by IAA (Kara *et al.*, 1997). Under red light, the content of IAA in potato plantlets rose (Segeeva *et al.*, 1994). As a result, the increased concentration of IAA may encourage assimilates to flow into the tubers. That could explain why red light had a higher amount of microtubers. Micro tuber formation may necessitate a wide variety of light wavelengths. That could explain why the combined spectrum of red and blue LEDs contained the majority of big micro tubers.

The present work in Tables 4 we used red, blue, green, yellow, and white LEDs constantly to detect their role for morphological and developmental changes, as well as physiological changes also occurred accordingly.

In the present study, we succeeded to induce the formation of micro-tubers by changing the light spectrum of monochromatic light chips using light-emitting diodes (LEDs). The using of different LEDs effects on the callus differentiation and hence their morphology and the ability to produce potato microtubers. Plant growth is very important in the production of microtubers, and in general, plants with more shoots produce more microtubers (Morais *et al.*, 2018).

Table 4. Effect of various optical spectra for a continuous period on physiological parameters of potato plant.

Char. Treat	Glucose mg/g DW	Fructose mg/g DW	Sucrose mg/g DW	Soluble carbohydrates mg/g DW	Starch mg/g DW	Soluble protein mg/g DW	Amino acids mg/g DW	α-Tocopherol	Anthocyanins μmol/gm FW
White	2.84 ^b	1.85 ^c	3.96 ^c	12.80 ^c	15.19 ^c	8.22 ^c	0.877 ^c	270.80 ^c	2.06 ^d
yellow	1.90 ^c	1.89 ^c	4.80 ^{bc}	10.47 ^d	13.35 ^c	8.07 ^c	1.078 ^c	317.79 ^c	1.89 ^d
green	3.06 ^b	2.43 ^{bc}	5.34 ^b	13.13 ^c	16.04 ^c	10.75 ^{bc}	1.543 ^b	434.68 ^b	3.14 ^c
Red	3.58 ^b	2.95 ^{ab}	6.86 ^a	15.95 ^b	19.02 ^b	17.42 ^a	1.188 ^c	520.81 ^b	5.77 ^a
Blue	5.27 ^a	3.18 ^a	8.20 ^a	18.87 ^a	22.68 ^a	13.18 ^b	2.148 ^a	644.34 ^a	4.22 ^b

Certain wavelengths of green light have been shown to penetrate deeper into leaves, while red and blue light are successfully absorbed toward the leaf surface (Zheng and Van Labeke, 2017), triggering phytochrome and cryptochrome-mediated phytohormone re-localization for photomorphogenesis (Miler and Zalewska, 2006).

The presence of large quantities of glucose and fructose in potato tissues was confirmed by our investigation. Cióć *et al.*, (2021) found similar results in gerbera tissues where glucose and fructose were elevated under blue and red lights. Signal metabolites such as glucose and fructose can alter gene expression (Smith and Stitt, 2007). Together with a slew of bioactive chemicals, they form a complex network that triggers a variety of actions, either alone or in concert. Plant growth dynamics are affected by changes in glucose content. Corrêa *et al.*, (2005) found that the glucose-to-sucrose ratio affects morphogenesis through regulating the rate of cell division. The highest quantities of glucose and fructose were detected in plants cultivated under monochromatic red light in tests on the bulb plant *Lachenalia* (Bach *et al.*, 2018). Glucose can also regulate early seedling growth and modify the plant's heterotrophic-to-autotrophic transition (Cho and Yoo, 2011).

Carbohydrates produced by potato plantlets are a significant material source for plantlet and micro tuber growth in this regard. Tuberization is also known to be influenced by carbohydrate availability, particularly sucrose,

a sugar that is transported and required for starch production (Abelenda *et al.*, 2019). Micro tuber production and growth are also regulated by sugar distribution and movement among leaves, stems, and micro tubers (Li *et al.*, 2020). Though sucrose is the most significant component in plant growth and development, light intensity and spectrum are also important for *in vitro* morphogenic and developmental processes (Batista *et al.*, 2018). Phytochromes absorb red and far-red light, while phototropins and cryptochromes absorb blue light, and use this information to control photomorphogenic processes (Parihar *et al.*, 2016). Thus, the current investigation confirmed that tuber growth and weight under various LEDs were associated with increased glucose, fructose, starch, and maybe sucrose accumulation.

In the present study, the accumulation of tocopherol in response to different light intensities is a major cause of chlorophyll biosynthesis stability. The data of present work denoted high accumulation of α-tocopherol content in the order, blue>red> green>yellow>white and further accumulation was denoted for the combined light treatments. The activation of combined light treatments and more especially blue light for various metabolic products produce vigorous plantlets, higher tuberization rate as well as high tuber numbers.

In the present study, the contents of amino acids and proteins exhibited accumulation trend with variant degree depend on type of light used. Generally, the combined light had the highest accumulation of amino

acids and proteins compared to monochromatic light. For monochromatic light, the blue light recorded the most accumulation of amino acids and proteins compared to other lights. The following pattern emerged in the augmentation of amino acids and proteins: blue>red>green> yellow> white light. According to Kowallik (1982), blue light increases dark respiration and organic acids produce amino acids during dark respiration, resulting in increased protein synthesis. Blue was good for protein accumulation in potato plantlets in vitro, according to Chang *et al.* (2009), and shorter wavelengths of the same spectrum were favourable for protein accumulation, according to Johkan *et al.*, (2010), which was consistent with our findings. Blue light at 445 nm was found to be more advantageous for protein accumulation in potato plantlets in vitro than blue light at 465 nm, according to Li *et al.*, (2018).

In a similar vein, anthocyanins, a key component of secondary metabolites, were found to be increased by the LEDS. Anthocyanins are water-soluble glycosides and acylglycosides of anthocyanidins, a phenolic chemical class found in nature (Lian *et al.*, 2019). Blue light and plants subjected to multiple light cycles were found to have the most accumulation. Anthocyanins are induced by visible, ultraviolet, and various forms of LED lights in general (Hasan *et al.*, 2017). For *Gynura procumbens*, similar increases in phenolics, flavonoids, and anthocyanins were observed under various LEDS, with the biggest effect occurring when calli was exposed to blue light rather than red or white light (Lian *et al.*, 2019).

CONCLUSION

This study demonstrated that the different LEDS light spectrum produce a positive effect on growth and development during the *in vitro* culture of *Solanum tuberosum*. The use of light-emitting diodes (LEDs) could be very useful to solve various problems which occur frequently in the *in vitro* culture under fluorescent lighting such as e.g., elongation of shoots and roots, as well as the increase in the content of photosynthetic pigments. So, it could be concluded that, the use of blue followed red LEDS, stimulates the morphological traits and micro tubers formation than the other LEDS or traditional fluorescent.

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تأثير أطيف مصابيح الليد على نمو البطاطس في المزارع تحت النسيجية
ندى أشرف السبع¹، محمود الشريبي أحمد¹، نبيل أحمد يونس¹ و منى نمر شحاته²
¹محاصيل الخضر كلية الزراعة جامعة الأزهر فرع أسبوط
²محاصيل الخضر كلية الزراعة والموارد الطبيعية جامعة أسوان

أجريت هذه الدراسة وذلك بهدف دراسة سلوك نمو نباتات زراعة الأنسجة تحت نظام الأطيف الضوئية معملياً. تم استخدام برامج إبطية بطول (0.5-1 سم) من المزارع التحت نسيجية الثالثة لنبات البطاطس وتم وضعها في برطمانات تحتوي على 30 مل من بيئه MS. اشتملت التجربة على 5 معاملات في 5 مكررات كل مكرره تحتوي 5 برطمانات بكل منها ثلاث نباتات تم تصميم التجربة إحصائياً في صورة تجربة عاملية بتصميم كامل العشوائية. تم الإحتفاظ بالمزارع تحت كل ضوء (أبيض، أصفر، أخضر، أزرق و أحمر) بصوره منفصله لمدة 15 يوم. أشارت النتائج أنه يتقدم المزارع التحت نسيجية حتى المرحلة الثالثة أدى إلى زياده معنويه في معدل النمو تحت جميع الأطيف الضوئية و التي سجلت أعلى معدل نمو مع طيف الضوء الأخضر يليه الأزرق ثم الأحمر. أشارت النتائج أيضا إلى زياده في طول الأفرع، عدد الأوراق، الوزن الطازج للنبات نتيجة للتعرض للضوء الأزرق يليه الضوء الأحمر بينما سجل الضوء الأصفر أقل القيم لصفات النمو. أعلى محتوى للجلوكوز، الفركتوز، السكروز، الكربوهيدرات الذائبة، الأحماض الأمينية مبنية والتوكوفيرول سجلت تحت طيف الضوء الأزرق بينما البروتينات الذائبة و الأنثوسيانين سجلت أعلى القيم مع طيف الضوء الأحمر.