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Effect of Light Emitting Diode (LED) on the Growth and Photosynthetic Characteristics of *Brassica Juncea*

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Abstract: Light is fundamental precursor for plant growth and development. LED provides a uniform source of light for closed plant farming practices. The present study was carried out to investigate the effect of various wavelength light-emitting diodes (LEDs) on photosynthetic parameters of *Brassica juncea*. Under red light treatment, number of leaves, fresh and dry mass of roots and shoots was increased. While under blue light, stem length was longer than other lights. In combination of both lights, root length, area of leaves was greater as compared to others. Moisture content was more in plant growing under red light. The contents of chlorophyll a were higher under blue LEDs light while chlorophyll b concentration was higher under red. However, the plants grown under blue and red light exhibited closed stomata and fewer in number. The concentration of total soluble protein and soluble sugar were found highest under blue LEDs. From these results, we can conclude that red light is most significant for biomass production and chlorophyll b contents while blue light is preferable for soluble proteins and sugar concentration and chlorophyll a.

Key words: LEDs, Growth, Chlorophyll, Stomata, Brassica

Introduction

Brassica is a perennial herb belongs to family *Brassicaceae*. *Brassica* is an edible crop, grown around the world especially a country like china, Pakistan, Germany, France, Australia, Poland and India. It is mostly known for its food and healing applications. Beside these, *Brassica* has been exploited for production of biofuel (Jam et al., 2009). *Brassica* is a good source of fats, proteins and natural antioxidants (Das et al., 2009). As the arable land is limited, the food problem continues for modern era and next generations (He et al., 2012). Indoor farming would be a solution for these challenges, but they need a uniform source of light not for making food only but as an inducer for morphogenesis (Berry et al., 1982; Sager et al., 1992). Artificial lighting practices have been used to cultivate vegetables for almost over a century (Pfeiffer, 1976). As light is a vital precursor for plant normal growth, it drives several biochemical pathways such as photosynthesis. Rate of photosynthesis is affected by various characteristics like quality, duration and intensity (Bula et al., 1992). Green plants capture energy via chlorophylls and use in the process of photosynthesis. Sun light emits various

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wavelengths of light; plants capture some of them via photoreceptors like phytochromes (mostly absorbing red), and cryptochromes or phototropins (absorb blue mostly) (Mo¨glich et al., 2010). As a contrast to traditional lighting practices, LEDs have provided a uniform set of light. which was a big problem early on (Matsuda et al., 2008; Ohashi-Kaneko et al., 2007).

LEDs have increased the productivity, yield, and other components of plant growth pathways (Massa et al., 2008). Based on the known advantages of LEDs, scientists immediately started to think about their possible use in horticultural crops. Foremost, red LEDs elevate assembly of biomass (Ohkan et al., 2008). While blue light mostly uplifts photosynthetic process and move for compartmentation of chlorophylls, and has no activity in cell growth (Wu, et al. 2007; KiHo et al., 2012). The blend of both LEDs improved the photosynthetic reaction in contrast to alone red and blue (Savvides et al., 2012; Goins et al., 1997; Samuolienė et al., 2011). It has been reported that green light reduces stem length, chlorophyll content, inhibits stomata opening and growth (Savvides et al., 2012; Talbott et al., 2002; Terashima et al., 2009). The aim of the present research was to investigate the effect of different wavelengths of light on the photosynthetic parameters of *Brassica juncea* at juvenile stage, to identify a good set of environments for cultivation of seedlings.

Materials and Methods

Seeds Germination

Experimentation was accomplished in the green house in Kohat University of Science and Technology (KUST), Kohat, Pakistan. Seeds of *Brassica* were collected from National Agriculture Research centre (NARC) Islamabad. Seeds were first neutralized with (3.5%) of sodium hypochlorite solution for 5 minutes. After seven days of growth, the seedlings were placed below different wavelengths of LEDs.

Light treatments

A series of LED lights with different wave lengths were fitted above the plants (Dyne Bio, Korea). Such as red (R) 660 nm, blue 460 nm, a combination of (blue and red light) and fluorescent lamp was set as a control. *Brassica* seedlings were grown for 21 days under diverse LEDs lights. Duration of the light treatments was 16 hours per day at 30±2ºC.

Growth measurements

The growth parameters such as length, mass or root, shoot and leaves were recorded. For dry weight measurement, roots and shoots were placed in an incubator for 48 hours at 80ºC.

Moisture content

Moisture content was measured by using protocol of khan and kulachi (2002). Fresh leaves of *Brassica juncea* were weighed via an electrical balance, then later incubated at 80°C for 48 hr. The total moisture content was found according to a formula:

(Moisture content = Initial Weight – Final Weight/Initial Weight × 100)

Total soluble protein measurements

Liquid nitrogen was used to bash leaves, a 5ml solution of potassium phosphate was added as a buffer (0.067 mole/l), then extract was purified by the filter paper. After purification, residues were isolated by centrifuged for 10 minute 12,000g. Absorbance of residues was noted at 595 nm (ρ) wavelength via UV-visible spectrophotometer. The amount of soluble proteins was calculated by using the following formula (Li et al., 2010).

Soluble protein (mg / g) = ρ V1 / W V2.

(ρ) is the optical density (OD) of Total soluble protein

V1 is the volume of 5ml liquid nitrogen

V2 is the volume of 1ml extract

W is the fresh weight of leaves

Total soluble sugars measurement

Dilutions were made by mashing of 50 gm fresh leaves in 3ml warmed 90% ethanol solution and incubated at 60 to 80 ºC for 1 hour. The residues were placed in separate tube and debris was mashed again, incubated repeatedly at 60°C to 80°C for an hour. From both solutions the supernatants were mixed and a 15ml volume was made by diluting it with pure water. Extract of 1 ml was blended with 1ml (5%) phenol; later 5ml of concentrated sulfuric acid was supplementary, added gradually to the solution and final volume of 10 ml was made. The solution was mixed, via shaker and placed in incubation for 30 minutes. The absorbance of the mixture was noted at 485nm against distilled water as blank. Concentration of soluble solids (sugars) was assessed from a standard curve of glucose (Zhang, 2009).

Stomata observations

From the leaves, the cuticle was removed and placed on a glass slide, and glycerin was introduced on its surface. The surface of leaf was examined under a (DM4000) light microscope (Leica-Wetzlar, Germany) at 10 and 40X magnification. The no of stomata was measured by count total no of stomata in leaf. The stomata bulk was measured 10 times in 1 grid area.

Chlorophyll pigments measurements

Dry sample of plant was mixed with 25 mg of MgO in a falcon tube to stop the production of acids and pheophytin. Later on, 5ml of methanol was added to the solution and homogenized on a shaker for 2 hours. The plant extract was centrifuged at 4000 rpm for 5 minutes. The final residue was separated and absorbance was noted at 666 nm, 653 nm, and 470 nm, against a blank methanol via a spectrophotometer. The pigments contents i.e., chlorophyll a chlorophyll b and total carotenes was measured by a method proposed by Lichtenthaler and Wellburn (1985).

$Ca = 15.65\ A666 - 7.340\ A653$

$Cb = 27.05\ A653 - 11.21\ A666$

$Cx+c = 1000\ A470 – 2.860\ Ca – 129.2\ Cb/245$

Results and Discussion

The growth of *Brassica* juncea

The effects of different LEDs sources on growth of *Brassica juncea* seedlings were recorded for 21 days. Under red light treatment, the no of leaves, fresh-dry mass of shoot and roots was greater than others. While under blue light, stem length was longer as compared to others. In combination of lights, the root length and the area of leaves were greater as compared to others (Table 1 and 2), which provides an evidence that LED light is a worthy source for growth. The present study is not in correlation with those previous findings (Lichtenthaler and Wellburn, 1983; Kim et al., 2004). Both blue and red light are at the most responsible for leaf growth and accumulation of biomass (Hogewoning et al., 2010). Our findings are also similar to the report observed by Yorio et al. (2001).

Moisture contents

Moisture contents were measured to know the amount of water in *Brassica juncea* plant. *Brassica juncea* grown under different LEDs lights showed that moisture content was more in plants growing under red light follow by the control, red plus blue and blue light. Moisture content was less under blue LED light as shown in Fig. 1. These results suggest that moisture content was increased when plants are grown under red light.

Stomata observations

It has been reported that blue and red LEDs induce stomatal opening (Assmann, 1993). The plants cultivated under blue LEDs at 200 μ $molm^{-2}s^{-1}$ exhibited well systematized guard cells with exposed stomata and the number of stomata was higher in number. However, the plants grown under blue and red light exhibited closed stomata and fewer in number (Fig. 2). Transportation and other activities of stomata are dependent on its environment (Hattori et al., 2007). Our results are similar with a previous research finding that blue LEDs lights are more affective in stomatal opening. The number of stomata was found to be more in plants grown under blue light. These factors also depend on other parameters (Kim et al., 2006).

Table 1. Effect of different LEDs on growth parameters (root, shoot, leaf length, leaf width and leaves number) of *Brassica juncea*.

Light type	Root length (cm)	Shoot length (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaves
Control	1.0	1.5	0.8	1	3
Red	0.9	2.5	2	1.6	6
Blue	2.8	1.4	1.7	1.7	4
Red + Blue	4.2	1.7	1.8	1.4	5

Table 2. Effect of different LEDs on growth parameters (fresh and dry root and shoot) of *Brassica juncea*.

Light type	Fresh root mass (g)	Dry root mass (g)	Shoot fresh weight (g)	Shoot dry weight (g)
Control	1.5	0.01	0.9	0.01
Red	2.2	0.02	9	0.9
Blue	2.6	0.03	4	0.03
Red + blue	2.9	0.06	2	0.02

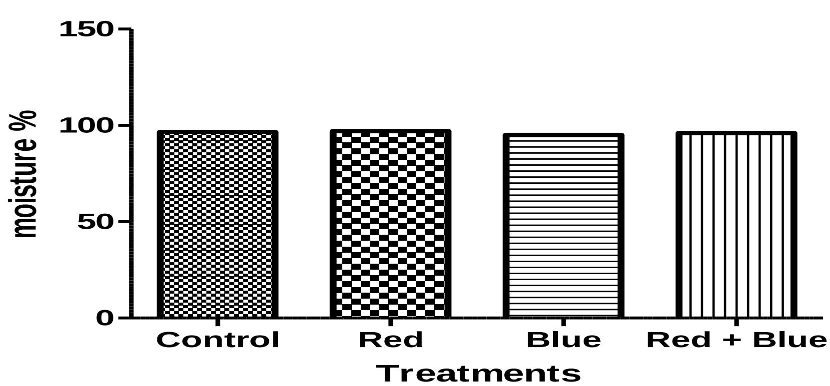

Figure 1. Effect of different LEDs on moisture contents (%) of *Brassica juncea*.

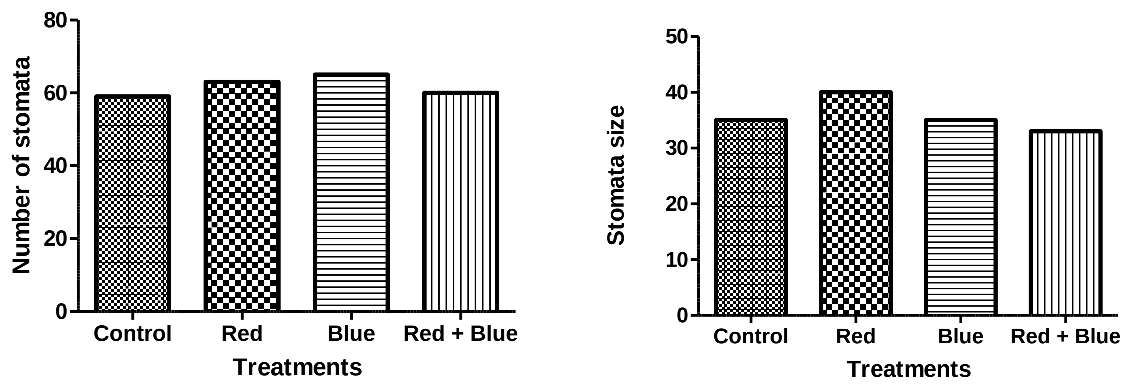

Figure 2. Effect of different LEDs on stomata number and stomata size of *Brassica juncea*.

Pigment's concentration

Photosynthetic pigments absorb light energy and convert it into chemical energy through photosynthetic machinery. Photosynthetic pigments were different in *Brassica juncea* under varied light emitting diodes. The concentration of chlorophyll a was higher under blue LEDs light while chlorophyll b concentration was higher under red. The current findings revealed that the concentrations of chlorophyll a and b were maximum in seedlings grown under blue and red LEDs and minimum in seedlings grown in fluorescent lamps (Fig. 3). Stunted pigmentation may arise from fall in level of nitrogen (Kim et al., 2004). The present results are not in line with previous findings of different scientists (Senger et al., 1982; Sæbø et al., 1995).

Total soluble proteins

The total soluble protein (TSP) content of *Brassica juncea* in varied LEDs were found in following order, highest under blue, followed by red plus blue, control and red LEDs respectively (Fig. 4). These findings are in correlation with previous finding of Yang et al., (2010) and Zhang et al., (2010).

Total soluble sugars

The sugar concentrations of *Brassica juncea* change in plant grown under various lights signals. The soluble sugar amount was respectively highest under blue LEDs, higher under red LEDs following by red plus blue and lower under control treatment (Fig. 5). These results are coherent with prior findings of Yang et al. (2010) and Zhang et al. (2010).

Conclusion

In conclusion, growth of *Brassica juncea* under different light treatments have a significant impact on the growth parameters. Growth parameters like length and width of roots and shoots were highest under combination of red and blue treatments, while concentration of soluble sugars and proteins contents were highest under blue treatment. The biomass was highest under red treatment. From these results, we can conclude that red light is most significant for biomass production and chlorophyll b contents while blue light is preferable for soluble proteins, sugar concentration and chlorophyll a.

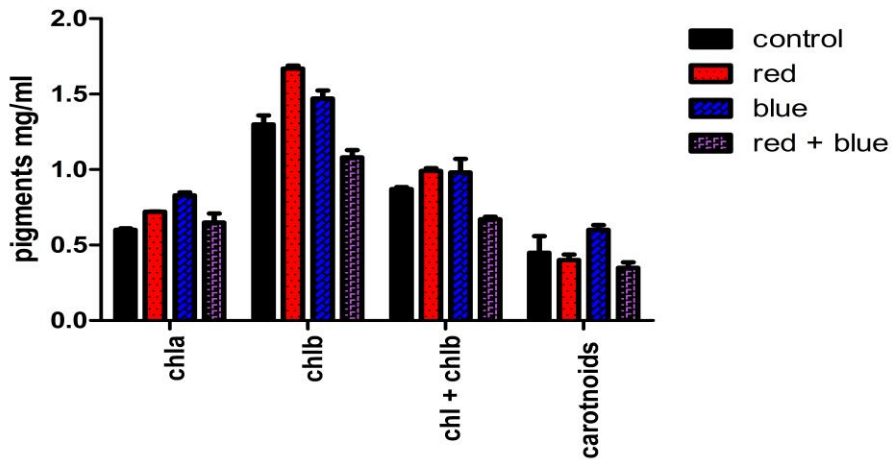

Figure 3. Effect of different LEDs on chlorophyll a, chlorophyll b and carotene contents of *Brassica juncea*.

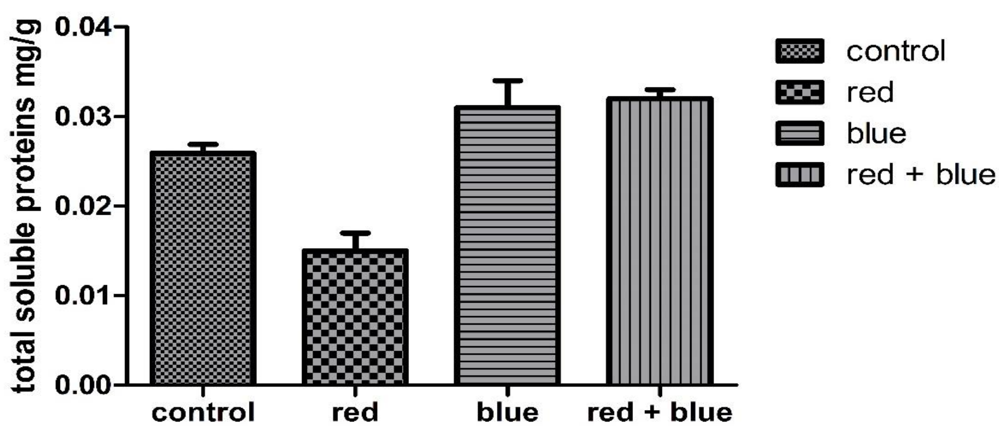

Figure 4. Effect of different LEDs on protein content of *Brassica juncea*.

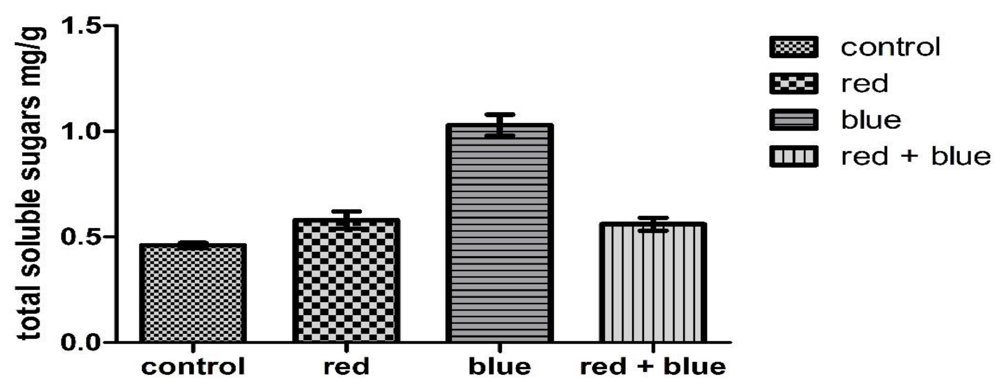

Figure 5. Effect of different LEDs on soluble sugar content of *Brassica juncea*.

References

Assmann, S. M. 1993. Signal transduction in guard cells. Plant Trop. 9: 345–347.

Avercheva, O. V., Berkovich, Y. A., Erokhin, A. N., Zhigalova, T. V., Pogosyan, S. I. and Smolyanina, S. O. 2009. Growth and photosynthesis of Chinese cabbage plants grown under light-emitting diode-based light source. Russ. J. Plant Physiol. 56: 14-21.

Bula, R.J., Tibbitts, T.W., Morrow, R.C. and Dinauer, W.R. 1992. Commercial Involvement in the Development of Space-Based Plant Growing Technology. Adv. Space. Res. 12: 5-10.

Berry, J. A., and Downton, W. J. S. 1982. Environmental regulation of photosynthesis. Photosynthesis, 2: 263-343.

Das, M., Ganguly, A. and Haldar, P. 2009. Space requirement for mass rearing of two common Indian acridid adults (Orthoptera: Acrididae) in laboratory condition. Am. Euras. J. Agric. Environ. Sci, 6: 313-316.

Goins, G. D., Yorio, N. C., Sanwo, M. M. and Brown, C. S. 1997. Photomorphogenesis, photosynthesis, and seed yield of wheat plants grown under red light-emitting diodes (LEDs) with and without supplemental blue lighting. J. Exp. Bot. 48: 1407-1413.

He, J. and S. Lee. 2012.Impact of climate change on food security and proposed solutions for the modern city. In International Symposium on Soilless Cultivation. 1004-1006.

Heo, J. W., Kang, D. H., Bang, H. S., Hong, S. G., Chun, C. and Kang, K. K. 2012. Early growth, pigmentation, protein content, and phenylalanine ammonia-lyase activity of red curled lettuces grown under different lighting conditions. Korean J. Horti. Sci. Technol. 30: 6-12.

Hogewoning, S. W., Trouwborst, G., Maljaars, H., Poorter, H., van Ieperen, W. and Harbinson, J. (2010). Blue light dose–responses of leaf photosynthesis, morphology, and chemical composition of Cucumis sativus grown under different combinations of red and blue light. J. Exp. Bot. 61: 3107-3117.

Hattori, T., Sonobe, K., Inanaga, S., An, P., Tsuji, W., Araki, H. and Morita, S. 2007. Short term stomatal responses to light intensity changes and osmotic stress in sorghum seedlings raised with and without silicon. Environ. Exp. Bot. 60: 177-182.

Johkan, M., Shoji, K., Goto, F., Hashida, S. N., andYoshihara, T. 2010. Blue light-emitting diode light irradiation of seedlings improves seedling quality and growth after transplanting in red leaf lettuce. Hort Sci, 45: 1809-1814.

Jham, G. N., Moser, B. R., Shah, S. N., Holser, R. A., Dhingra, O. D., Vaughn, S. F. and Walter, E. L. 2009. Wild Brazilian mustard (*Brassica juncea* L.) seed oil methyl esters as biodiesel fuel. J. Ameri. Oil Chem. Soc. 86: 917-926.

Kim, H. H., Goins, G. D., Wheeler, R. M., and Sager, J. C. 2004. Green-light supplementation for enhanced lettuce growth under red-and blue-light-emitting diodes. Hort Sci, 39: 1617-1622.

Kim, H. H., Wheeler, R. M., Sager, J. C., Gains, G. D. and Naikane, J. H. 2005. Evaluation of lettuce growth using supplemental green light with red and blue light-emitting diodes in a controlled environment-a review of research at Kennedy Space Center. Inter. Sym. Art. Light. Horti. 711: 111-120.

Lichtenthaler, H. K., and Wellburn, A. R. 1983. Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Biochem. Soc. Transac. 11: 591-592.

Möglich, A., Yang, X., Ayers, R. A., and Moffat, K. 2010. Structure and function of plant photoreceptors. Ann. Rev. Plant. Biol, 61: 3-12.

Matsuda, R., Ohashi-Kaneko, K., Fujiwara, K. and Kurata, K. 2008. Effects of blue light deficiency on acclimation of light energy partitioning in PSII and CO2 assimilation capacity to high irradiance in spinach leaves. Plant. Cell. Physiol. 49: 664-670.

Massa, G. D., Kim, H. H., Wheeler, R. M. and Mitchell, C. A. 2008. Plant productivity in response to LED lighting. Hort Sci, 43: 1951-1956.

Matsuda, R., Ohashi-Kaneko, K., Fujiwara, K. and Kurata, K. 2007. Analysis of the relationship between blue-light photon flux density and the photosynthetic properties of spinach (Spinacia oleracea L.) leaves with regard to the acclimation of photosynthesis to growth irradiance. Soil. Sci. Plant. Nutrition, 53: 459-465.

Ohashi-Kaneko, K., Takase, M., Kon, N., Fujiwara, K. and Kurata, K. 2007. Effect of light quality on growth and vegetable quality in leaf lettuce, spinach and komatsuna. Environ. Cont. Biol, 45: 189-198.

Pfeiffer, N. E. 1926. Microchemical and morphological studies of effect of light on plants. Bot. Gaze. 81: 173-195.

Savvides, A., Fanourakis, D. and van Ieperen, W. 2012. Co-ordination of hydraulic and stomatal conductances across light qualities in cucumber leaves. J. Exp. Bot. 63: 1135-1143.

Sager, J. C., and Wheeler, R. M. 1992. Application of sunlight and lamps for plant irradiation in space bases. Adv. Space. Res, 12: 133-140.

Senger, H. 1982. The effect of blue light on plants and microorganisms. Photochem. Photobiol. 35: 911-920.

Sæbø, A., T. Krekling, and Appelgren, M. 1995. Light quality affects photosynthesis and leaf anatomy of birch plantlets in vitro. Plant Cell, Tissue and Organ Culture 41: 177-185.

Samuolienė, G., Sirtautas, R., Brazaitytė, A., Sakalauskaitė, J., Sakalauskienė, S. and Duchovskis, P. 2011. The impact of red and blue light-emitting diode illumination on radish physiological indices. Cent. Europ. J. Biol, 6: 821-834.

Son, K. H., Park, J. H., Kim, D. and Oh, M. M. 2012. Leaf shape index, growth, and phytochemicals in two leaf lettuce cultivars grown under monochromatic light-emitting diodes. Horticul. Sci. Technol. 30: 664-672.

Talbott, L. D., Nikolova, G., Ortiz, A., Shmayevich, I., and Zeiger, E. 2002. Green light reversal of blue-light-stimulated stomatal opening is found in a diversity of plant species. Am. J. Bot, 89: 366-368.

Terashima, I., Fujita, T., Inoue, T., Chow, W. S. and Oguchi, R. 2009. Green light drives leaf photosynthesis more efficiently than red light in strong white light: revisiting the enigmatic question of why leaves are green. Plant cell. Physiol, 50: 684-697.

Wu, M. C., Hou, C. Y., Jiang, C. M., Wang, Y. T., Wang, C. Y., Chen, H. H. andChang, H. M. 2007. A novel approach of LED light radiation improves the antioxidant activity of pea seedlings. Food. Chem. 101(4): 1753-1758.

Wang, H., Gu, M., Cui, J., Shi, K., Zhou, Y., andYu, J. 2009. Effects of light quality on CO2 assimilation, chlorophyll-fluorescence quenching, expression of Calvin cycle genes and carbohydrate accumulation in Cucumis sativus. J. Photochem. Photobiol. 96:, 30-37.

Yorio, N. C., Goins, G. D., Kagie, H. R., Wheeler, R. M. and Sager, J. C. 2001. Improving spinach, radish, and lettuce growth under red light-emitting diodes

(LEDs) with blue light supplementation. Hort Sci. 36: 380-383.

Yang, X.J., Liu, S.Q., Zhang, Z.K., Ma, L., Zhang, Y. and Wei, H. 2010. Effects of different light emitting diode sources on nutritional quality of garlic seedling. Acta. Nutri. Sinica, 32: 518-520.