International Research Journal of Natural Sciences

Vol.3, No.4, pp.35-58, December 2016

Published by European Centre for Research Training and Development UK (www.eajournals.org)

PHOTOBIOSTIMULATION OF *SESAMUM INDICUM* L. SEEDS USING LOW INTENSITY HE-NE LASER RADIATION: SEED GERMINATION AND PLANT GROWTH

Shemah Ali Al-Jehani, Dina Zein El Abdin Abdel Kader[1], Mohsen Kamal Hassan Ebrahim

Biology Department, Faculty of Science, Taibah University, KSA

ABSTRACT: *Seeds of Sesamum indicum L. were subjected to He-Ne laser radiation with wavelength (λ) 632.8 nm, power intensity 3 mW.cm^{-2} for different time periods (0, 1, 3, 10, 30, 60, 180, 600 and 1200 seconds). Artificial sun-light treatments (lamp Model 400 W/ 220 v/ 60 hz. China) and integrated white light treatments (400- 760 nm, 3 mW. cm^{-2}) were employed in parallel experiments for the same time periods to compare the effect of different radiations on seed germination and growth parameters. Seed germination percentage was significantly increased in response to laser radiation pretreatment. Meanwhile, the shoot and root length, leaf area and biomass (fresh and dry weights) were significantly improved. Pretreatment of sesame seeds with He-Ne-laser for 120, 300 and 600 sec. were the most effective dose.*

KEYWORDS: *He-Ne- laser; sesame; germination percentage; growth parameters.*

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest oil seed crops. It has been cultivated in Asia from ancient times. Sesame oil has medicinal and pharmaceutical value, and is being used in many health care products. Sesame seeds contain 50- 60% oil and 25% protein with antioxidants lignans such as sesamolin, sesamin. They have been used as active ingredients in antiseptics, bactericides, viricides, disinfectants, moth repellants and anti-tubercular agents (Bedigian *et al*. 1985). Also, they are considered as a source of calcium, tryptophan, methionine and many minerals (Johnson *et al*. 1979). These highly important characteristics have encouraged researchers to develop interest in biochemical analysis and in identifying the accessions having rich beneficial oil contents, in order to make efforts for the improvement of this crop using advanced technologies.

However, sesame production is below expectation and the potential could be considerably higher. The low production is due to some reasons such as low inputs and poor management (e.g., low or non-fertilization, irrigation, pest control, etc), occurrence of biotic and abiotic stresses and more importantly, a lack of an appropriate breeding program.

The development of modern agriculture and the propagation of rules for the national use of natural resources related there to demand a search for a safe method of increasing the size and improving the quality of cultivated plants. The appropriate preparation of the sowing material is an important yield generating factor which aims to improve seed sprouting ability and the vigour of the seedlings grown from them (Górecki and Grzesiuk, 1994). Young and more vigorous plants develop better, and are better suited to endure unfavorable habitats. They are also less susceptible to disease and require less intensive chemical protection. These initial growth stages decide then, to a higher degree, the further development of plants and their ultimate yield.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

Many chemical, physical and physiological methods for improving sowing material are well known at present. The best recognized and the most often used methods in actual practice are chemical methods of seed dressing with various substances (seed dressings, growth regulators, *etc*.). The substances used, even though highly efficient, pose a danger to the environment, since many active substances can penetrate the seed and modify its chemical composition, and pollute the soil environment. Hence, in recent years, more attention has been paid to some physical factors that favorably influence the sowing material of cultivated plants (Drozd, 1994; Phirke *et al*., 1996). The prevailing opinion is that physical methods for the processing of pre-sowing seed stimulate only the physiological and biochemical changes in the seeds (Grzesiuk and Kulka, 1986; Galova, 1996; Anisimov *et al*., 1997; Podleśny, 2000a) and hence, are safe for the environment. One of the physical methods which can be applied to the improvement of the sowing material is seed treatment with laser light (Koper, 1994; Ivanova, 1998; Podleśny, 2002).

Laser has many types such Argon laser (Blue), Cobalt laser (Green) and many other types. One of those types is Helium Neon laser (HE-Ne). It is the most familiar and least expensive gas laser. It emits a fraction of milli to tens of milli watts (mW) of red light at 632.8 nanometer (nm).
The amazing characteristics of the laser radiation, such as monochromatism, polarization, coherence and high density, can be used not only in all spheres of engineering but also in biology and plant growing.

Previous studies have shown that suitable doses of He- Ne and CO_2 lasers (continuous wave) have a positive effect in accelerating plant growth and metabolism (Paleg and Aspinall, 1970; Govil *et al*., 1991), increasing germination percentage (Abu-Elsaoud et al., 2008), improving the concentration of proteins and enzyme activities (Qi *et al.*, 2000). Such doses also improved the yield and quality of Chinese traditional herbal *Isatis indigotica* Fort (Chen *et al*., 2005b) and significantly influenced both number of fruits formed per plant, and total production of sweet pepper (Capsicum annuum L.) variety "Buzau 10" and eggplant (*Solanum melongena* L.), variety "Dragaica (Burnichi *et al*., 2011). In addition, previous studies have also illustrated that lasers not only protect the seed cells from damage by enhanced ultraviolet (UV)-B, but can also repair seedling damage by enhanced UV-B (Qi *et al*. 2002).

Muthusamy *et al*., (2016) studied the influence of He–Ne laser irradiation on in vitro seed germination, growth of seedlings and withanolide contents of Withania. They reported that He-Na radiation increased seed germination and fresh weight of Withania plants.

The present research aimed to assess the effect of He–Ne laser pretreatment of ***Sesamum indicum*** seeds on germination, growth parameters and some physiological parameters, and to provide beneficial information for future investigation about how and why laser treatment or both improve sesame growth and productivity. It was reported that the effects of laser irradiation on organisms are chiefly of a light effect, an electromagnet effect, a temperature effect, and a pressure effect. Generally, low-power lasers, especially laser of a visible wavelength, produced little heat and pressure effects. Therefore, the mechanism of action responsible for the effect of laser irradiation may be through its light and electromagnet effects (Xiang 1995). To confirm this, we used artificial sunlight lamp (400 W/ 220 v) and integrated white light (3 mW/ cm^2) to pre-treat seeds and compared their effect on ***Sesamum indicum***.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

MATERIAL AND METHODS

Plant material: *Sesamum indicum* seeds were obtained from the Agricultural Research Center (Giza, Egypt). He-Ne Laser irradiations were carried out using He-Ne Laser LG-75, with wavelength (λ) 632.8 nm, power intensity 3mW.cm^{-2}. Artificial sun-light treatments were carried out using lamp (Model 400 W/ 220 v/ 60 hz. China), while integrated white- light treatments were carried out using a PHILIPS lamp with wavelengths ranging from 400-760 nm, power intensity of 3 mW.cm^{-2}, and beam diameter of 10 x 15 cm.

He-Ne laser treatments: Seeds of sesame were firstly surface sterilized using 70% ethyl alcohol. Seeds were treated with the three radiations for 0, 1, 3, 10, 30, 60, 180, 600 and 1200 seconds one by one. The irradiated seeds were cultivated on moistened filter paper in *petri* dishes (germination experiment). For growth experiment, the irradiated seeds were planted in half-filled pots with sand-peatmoss (1:1). The pots were irrigated to full humid capacity and allowed to grow. Experiments were conducted in the Department of Biology, Faculty of Science, Taibah University, K.S.A.

Germination percentage: Germination percentage of control and treated sesamum seeds were calculated.

Plant growth parameters: Shoot and root length (cm), leaf area (cm^2), plant fresh and dry weights (g) were measured after one, two, three and four months post sowing.
Statistical analyses: statistical analyses (Two way analysis of variance (ANOVA) and regression analysis) were carried out using SPSS statistical software ver. 9 and Microsoft Excel package 2007.

Photosynthetic pigments (Chlorophylls and Carotenoids): Contents of chlorophyll a and b as well as total carotenoids were expressed as mg/g tissue and calculated through the following equations (Metzner *et al*., 1965).

Total Carbohydrates: The total carbohydrates were measured by acid hydrolysis of polysaccharides into simple sugars and estimated by the spectrophotometric method recommended by Hedge and Hofreiter (1962).

Total Protein: Total protein was measured according to **Gornall** *et. al*.,(1949).

Oil content: Oil from a known quantity of the seed is extracted with petroleum ether. It is then evaporated completely, dried, the oil weighed and the % oil is calculated.

RESULTS:

Germination %: Data showed that radiation pretreatments significantly increased germination % in comparison with control (Table 1). He-Ne laser irradiated seeds germinated faster than control (data not shown). Higher doses of He-Ne laser irradiation (120, 300 and 600 sec.) increased the number seeds, that had germinated to a greater extent than the lower ones. The same trend was observed with seeds pretreated with integrated white light or artificial sunlight.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

Table (1): Interactive effects of He-Ne laser, white light and artificial sun-light irradiations, and time intervals on seed germination of ***Sesamum indicum***.

Seed germination %			
Treatments Time/ sec.	HE-NE Laser	White Light	Artificial Sun Light
0 sec.	81.0	81.0	81.0
(control)	94.7	97.9	97.2
1 sec.	96.4	97.4	98.9
3 sec.	97.3	95.1	98.5
5 sec.	95.7	96.1	98.1
10 sec.	96.3	97.0	98.1
30 sec.	97.1	96.0	96.3
60 sec.	98.5	97.0	95.4
120 sec.	98.9	98.5	97.6
300 sec.	99.9	99.1	97.6
600 sec.	96.6	97.1	97.7
1200 sec.			

Shoot length (cm): Differences were observed in shoot growth and development between plants produced from He-Ne laser treated seeds and either untreated or treated with artificial sun-light or integrated white light seeds; these were distinct all over the plant growth developmental stages (Figure 1, a-d). The highest increase in shoot length was observed at 120, 300 and 600 sec. He-Ne Laser pretreatments.

Root length (cm): The highest increase of root length for sesame plants occurred during the last two months of growth period. All radiation pretreatments increased root length when compared to control. He-Ne- laser was more effective, particularly, at 120, 300 and 600 seconds (Figure 2, a-d).

Leaf area (cm^2): The leaf area of plants grown from pretreated seeds increased significantly as compared with control. The increase of leaf area was concomitant with increasing dose period. It reached its highest values at 120, 300 and 600 seconds (Figure 3, a-d). The effect of He-Ne laser was more pronounced than artificial sun-light or integrated white light.

Fresh and Dry weights: Comparing with control, laser pretreatments caused a significant increase in fresh and dry weights **(Figures 4 & 5, a-d)**. This increase reached its highest value after four months at 300 sec. (99.3%). Comparing with laser pretreatment, integrated white light and artificial sunlight (at 1200 sec.) increased fresh weight with 57.7% and 55.8 %, respectively.

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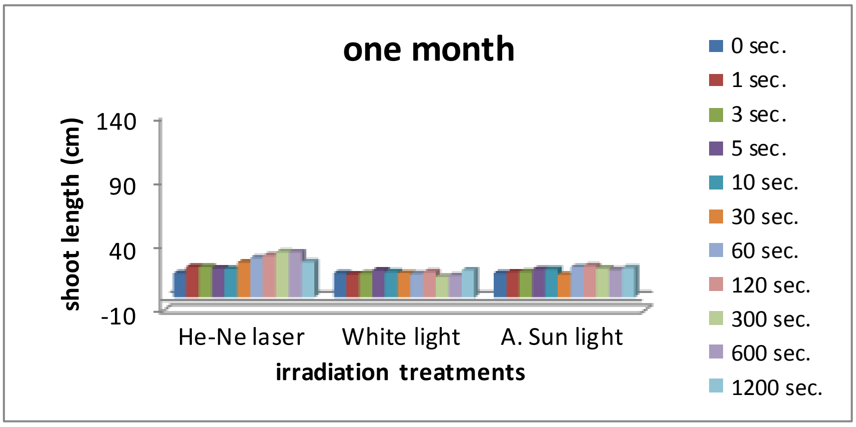

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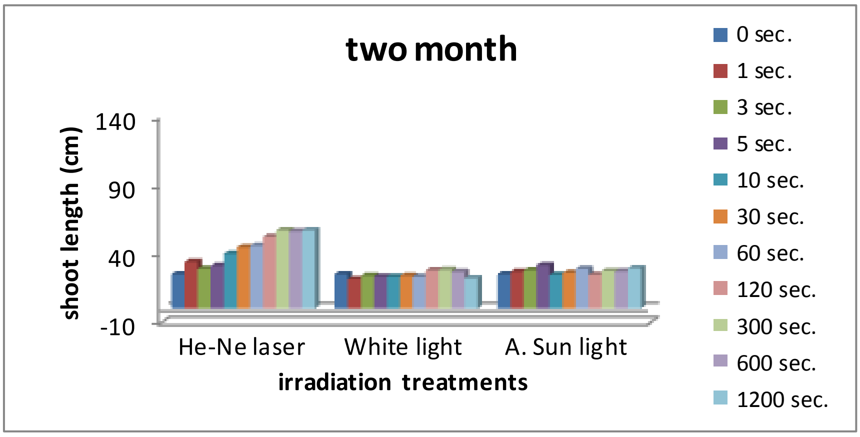

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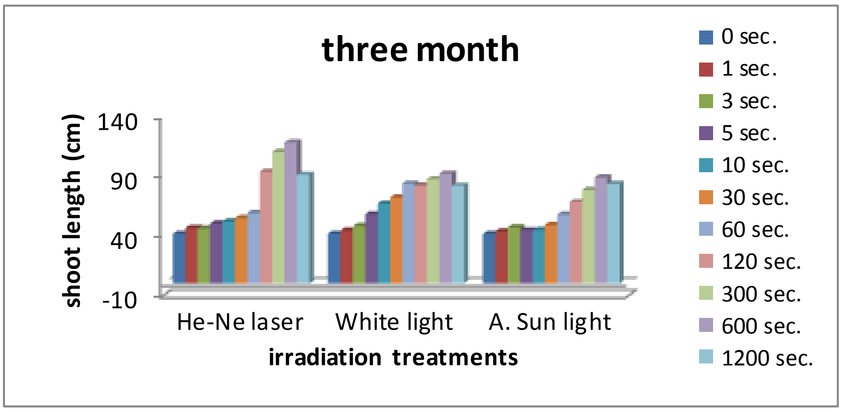

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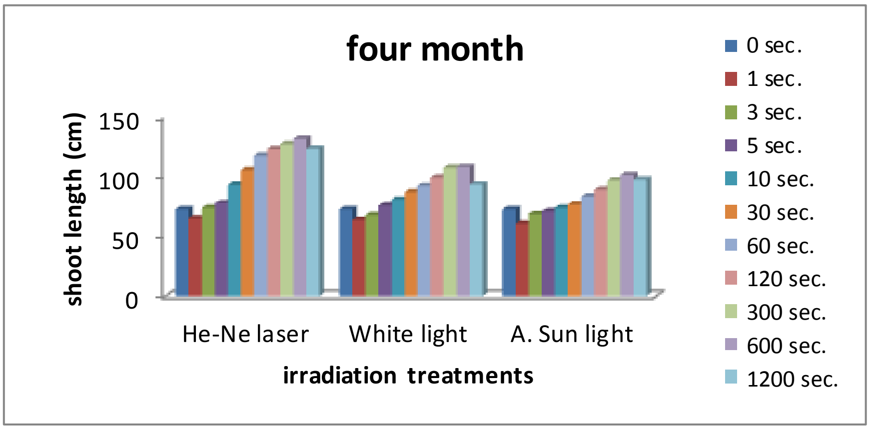

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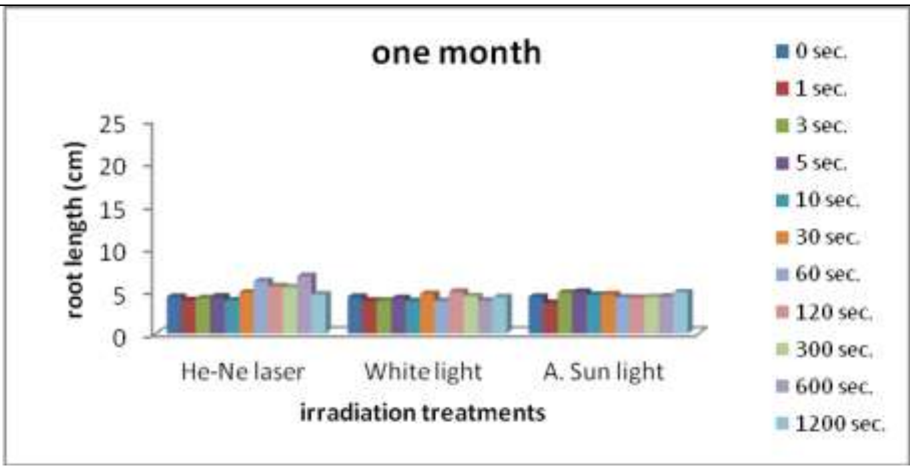
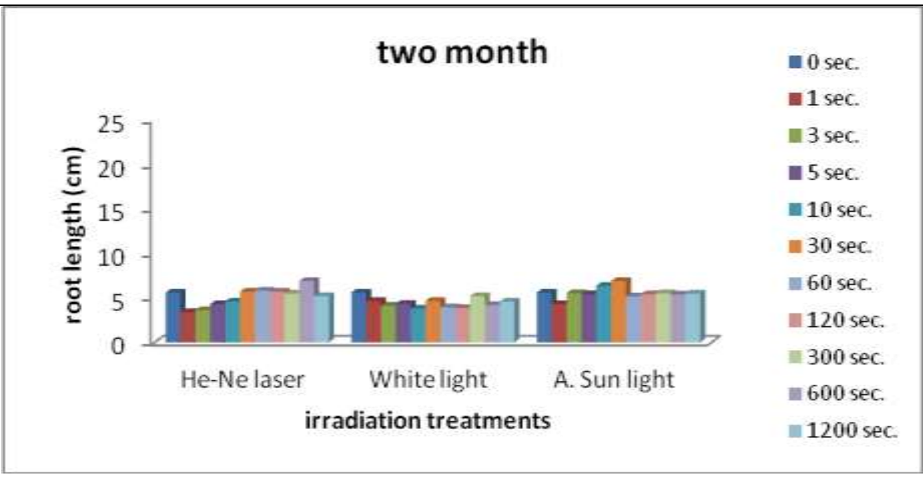
Figure (1, a-d): Interactive effects of He-Ne laser radiation, integrated white light and artificial sun-light, and seed pretreatment with different time intervals on Sesame plant shoot length. Data represents mean of 10 plants ±SE





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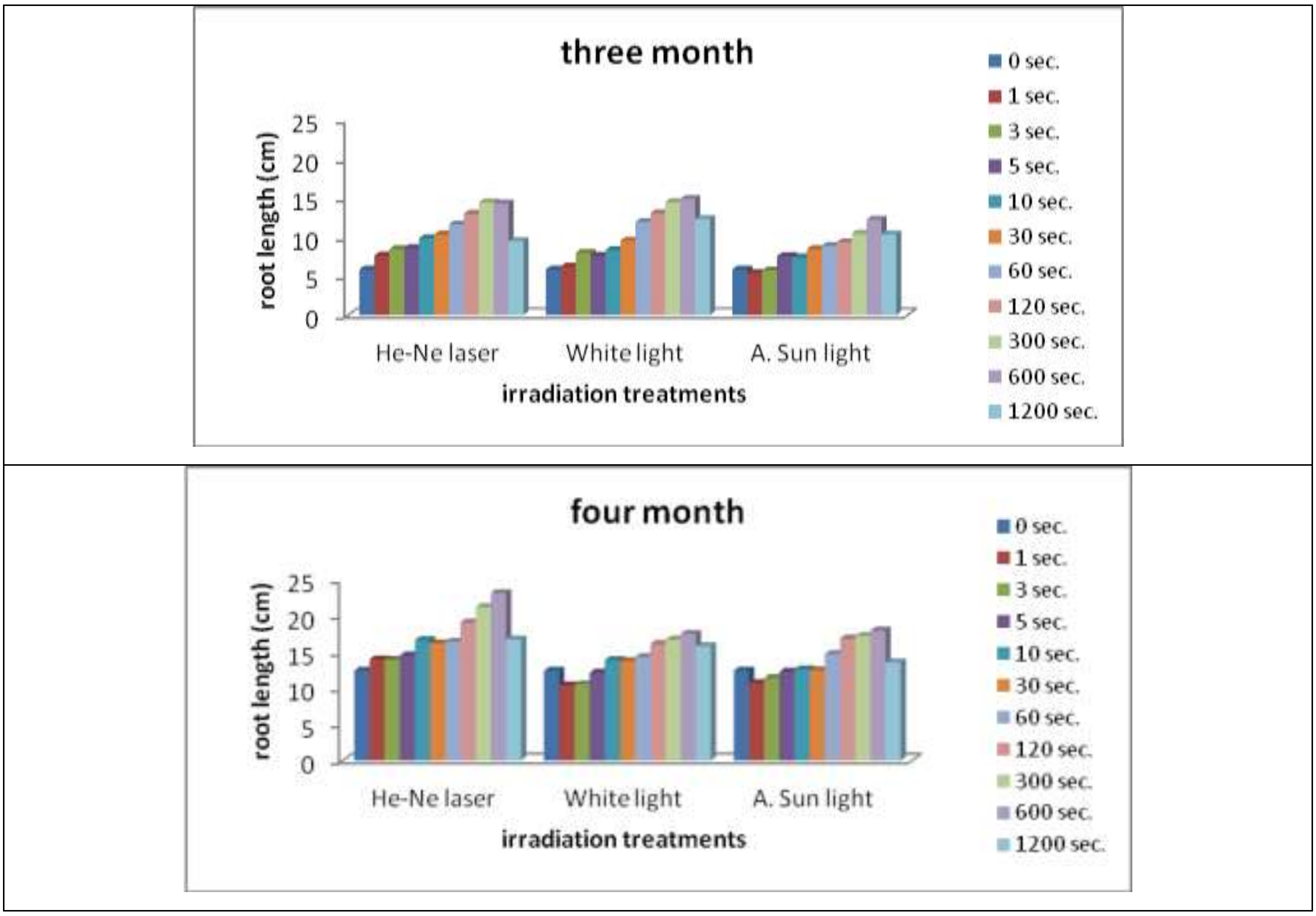
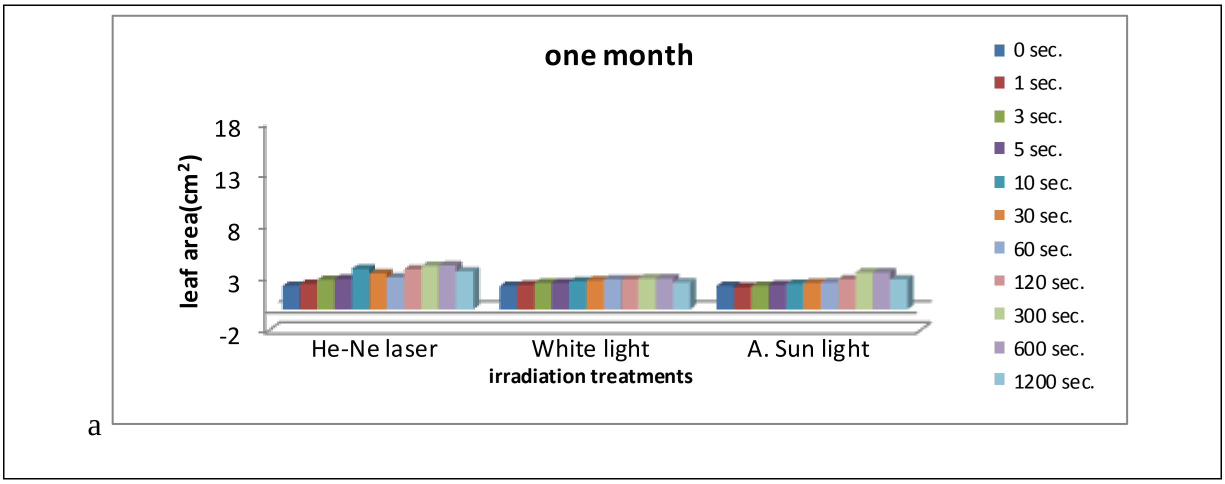


Figure (2, a-d): Interactive effects of He-Ne laser radiation, integrated white light and artificial sun-light, and seed pretreatment with different time intervals on Sesame plant root length. Data represents mean of 10 plants ±SE



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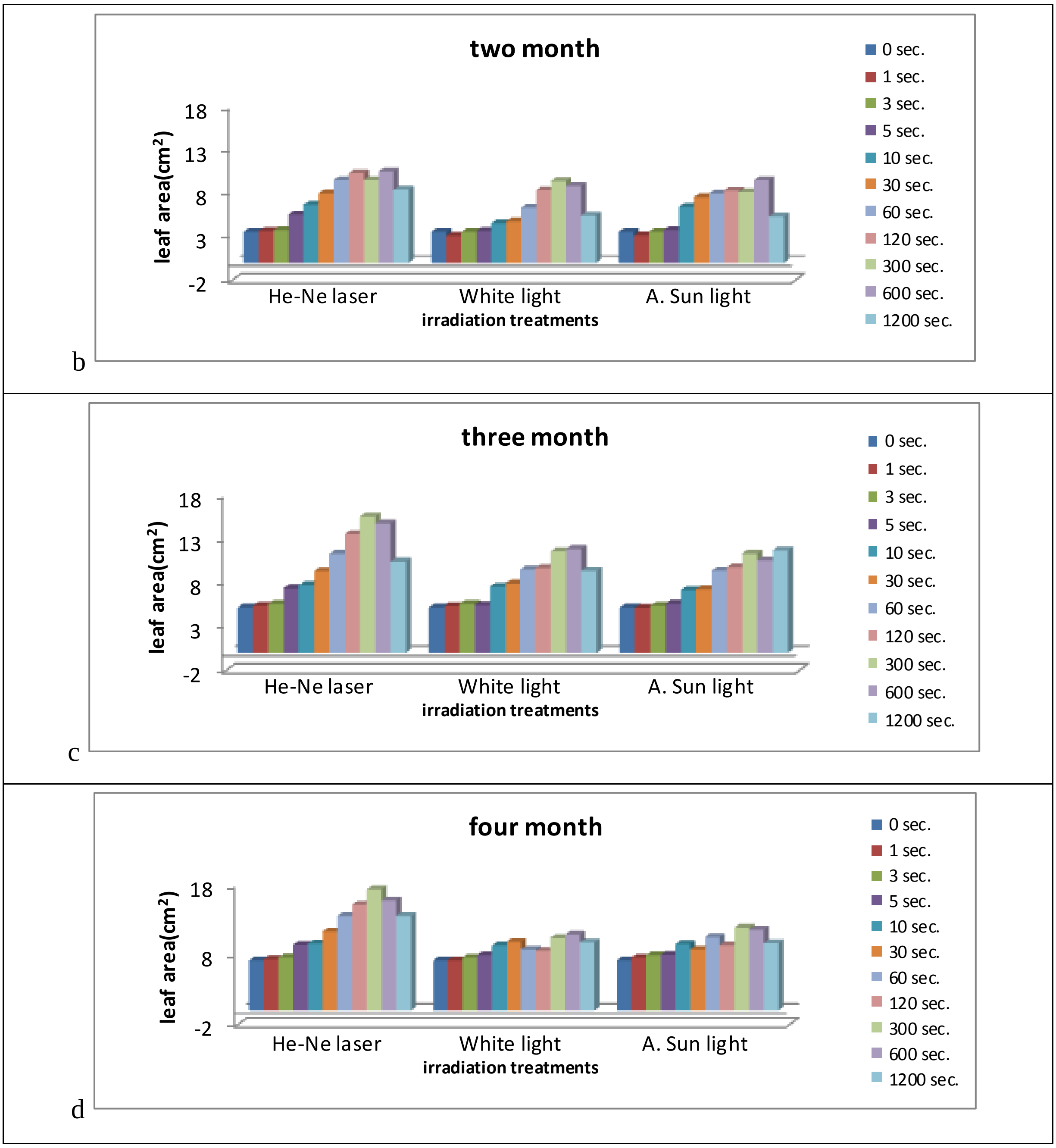
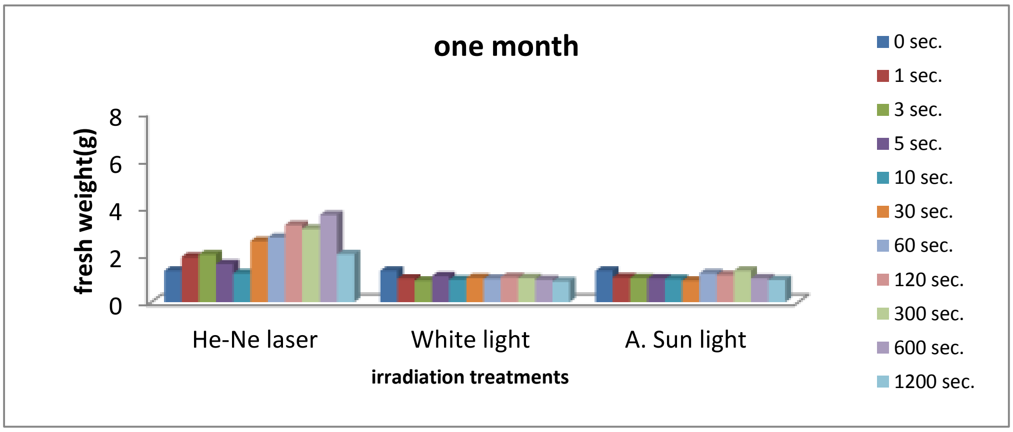


Figure (3, a-d): Interactive effects of He-Ne laser radiation, integrated white light and artificial sun-light, and seed pretreatment with different time intervals on Sesame plant leaf area Data represents mean of 10 plants ±SE



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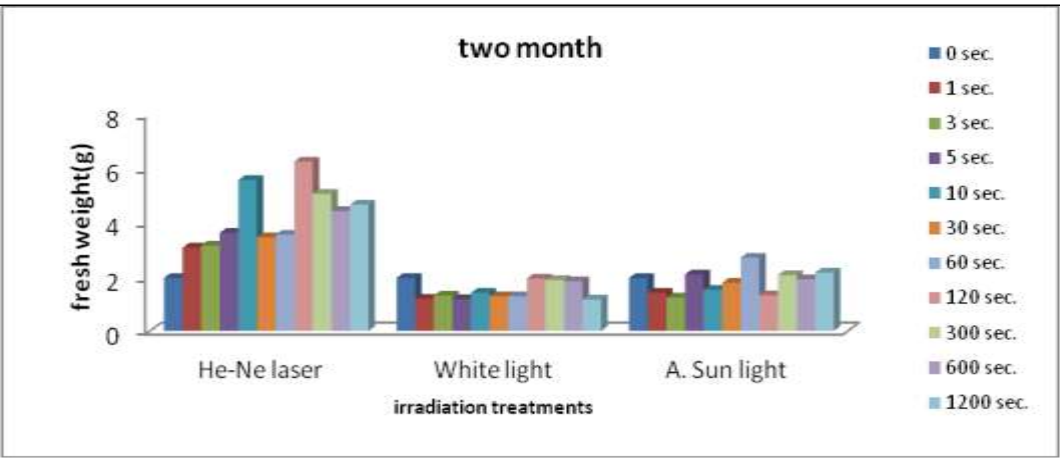

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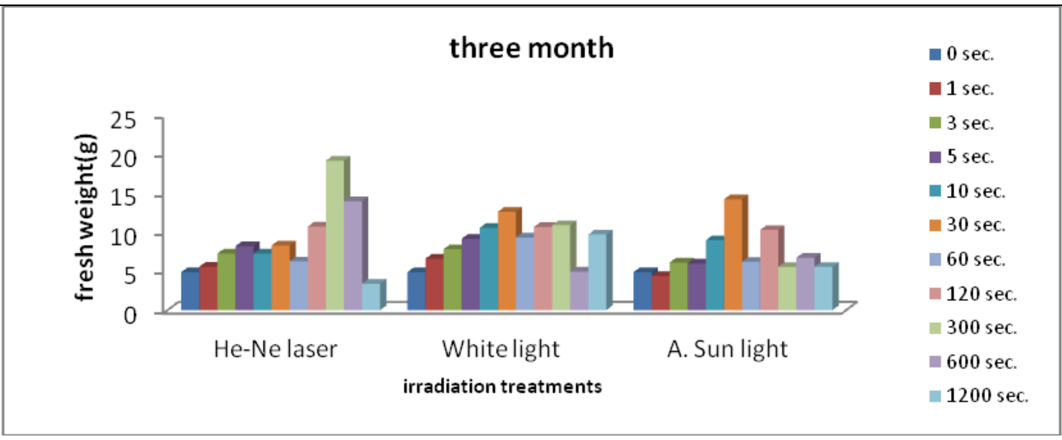

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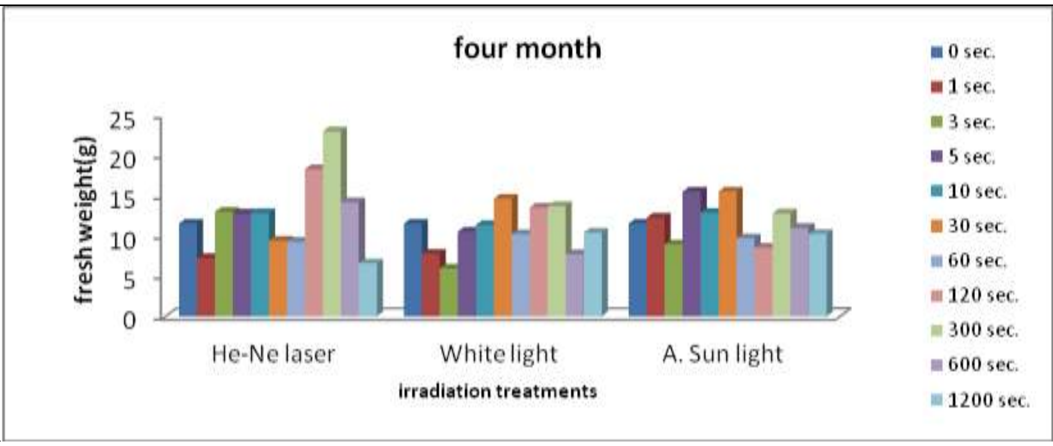
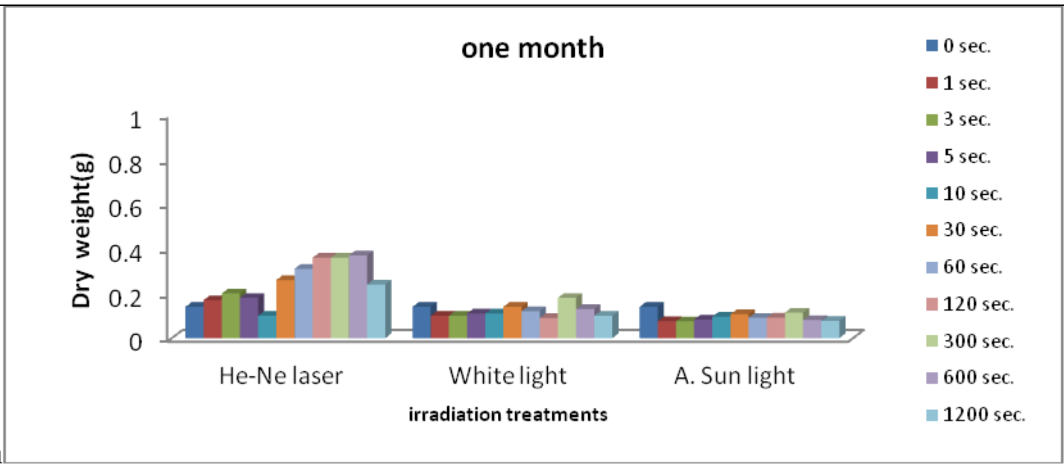


d

Figure (4, a-d): Interactive effects of He-Ne laser radiation, integrated white light and artificial sun-light, and seed pretreatment with different time intervals on Sesame plant fresh weights. Data represents mean of 10 plants ±SE.



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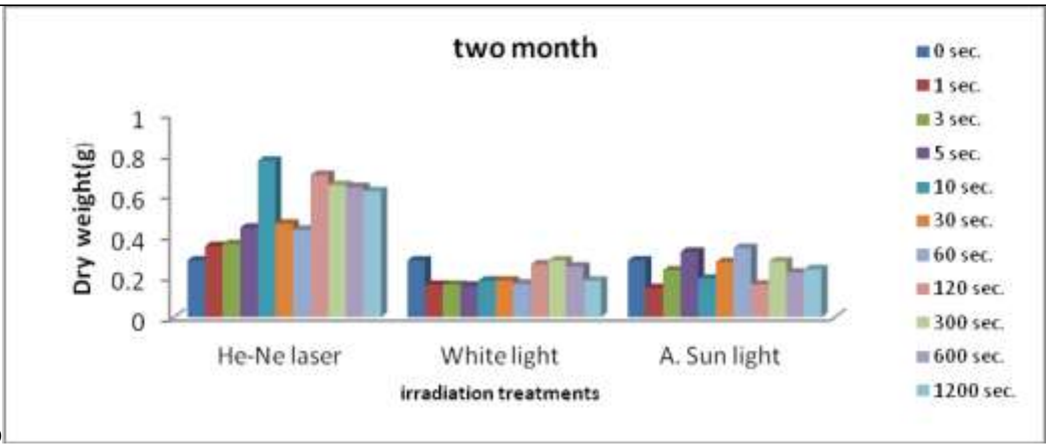

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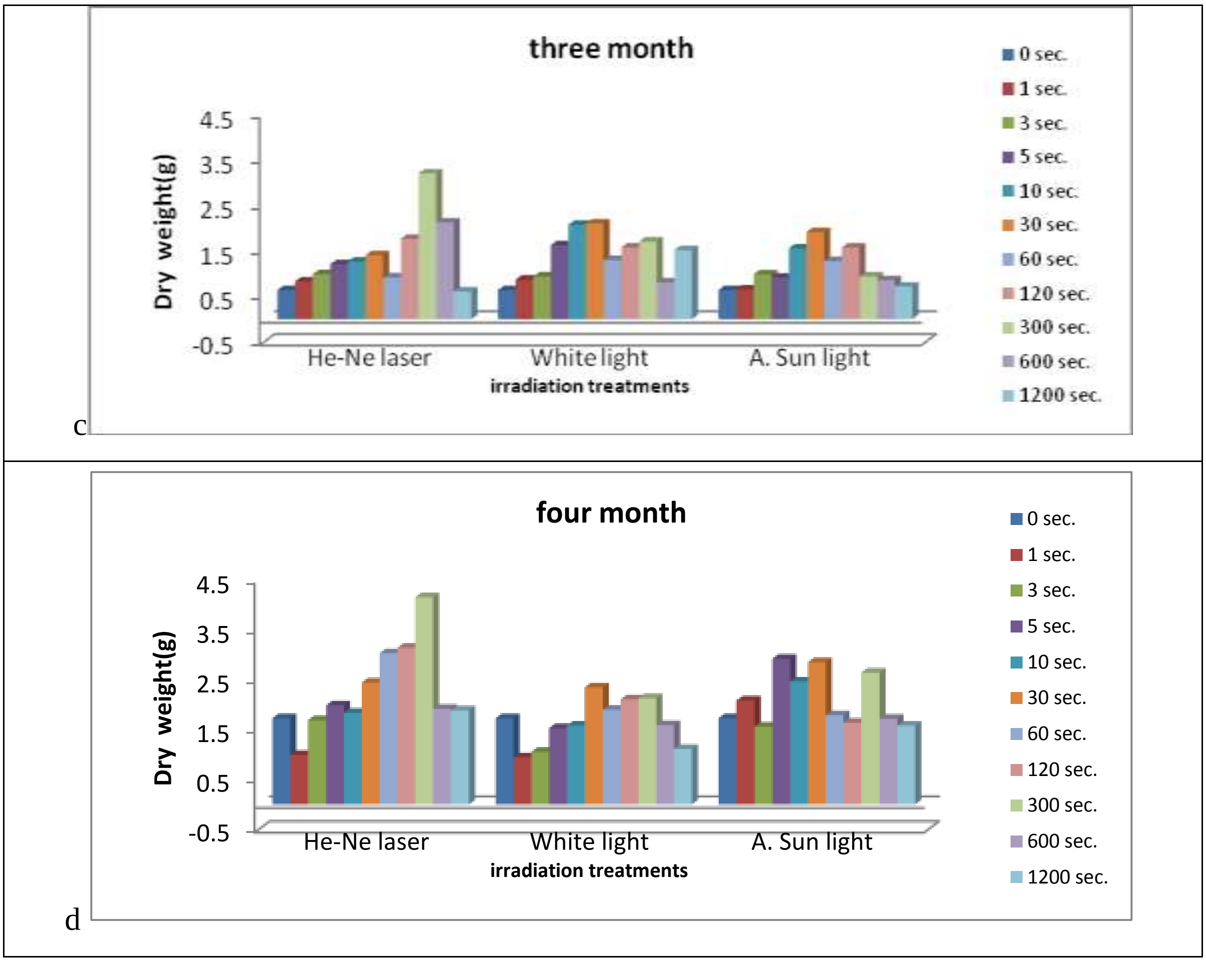

Figure (5, a-d): Interactive effects of He-Ne laser radiation, integrated white light and artificial sun-light, and seed pretreatment with different time intervals on Sesame plant dry weights. Data represents mean of 10 plants ±SE.

5- Chlorophyll (a & b)

Laser radiation induced a significant decrease in chlorophyll a & b content in sesame plants compared to control (table 1, figures 6-8). For, pretreatment with different concentrations of induced a significant increase in chlorophyll a & b content both directly and after recovery in comparison with the positive control. Pretreatment with gave the highest values of chlorophyll content with 120,300, and 600sec of He-Ne laser respectively. When recovered, the application of gave obvious increase with 300and 600sec of He-Ne laser while the application was more effective with 600sec of He-Ne laser radition.

Regarding ***sesmum indicum***, pretreatment with significantly raised the chlorophyll content with 300 and 600 sec. of He-Ne laser. Moreover, pretreatment increased chlorophyll a & b content at 300 and 600 sec of He-Ne laser. In case of recovered seedlings, pretreatment with also caused a significant increment with 300and 600laser of He-Ne laser while the application was more effective with 300sec of He-Ne laser radiation.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

Table (1): effect of He-Ne laser radiation. White light and artificial sun light seed pretreatments with different time intervals on **Chla** of Sesame plant. Data represents mean of 10 plants ±SE.

		Chla in plants pretreated with He-Ne laser (mg/g) mean±SE							
		Time (months)							
		first		**second**		**third**		**fourth**	
He-Ne	Control	8.6000	±0.2887	8.7400	±0.802	15.7067	±0.5812	7.413	±0.070
	1	4.5667	±0.8819	5.4300	±0.351	15.4400	±0.03055	8.573	±0.092
	3	5.5300	±0.3512	6.4233	±0.393	13.7367	±0.03180	10.060	±0.060
	5	13.6600	±0.7024	4.5000	±0.000	12.1000	±0.05774	12.313	±0.585
	10	11.4100	±0.5859	17.9733	±0.371	20.2300	±0.23714	8.317	±0.145
	30	11.0233	±0.9062	14.9367	±0.2601	24.6467	±0.17751	22.400	±1.242
	60	12.2933	±0.11566	18.3233	±0.3930	21.0867	±1.37047	26.800	±0.551
	120	9.6533	±0.8667	21.2433	±0.1283	18.9867	±1.19160	31.700	±0.493
	300	11.5567	±0.14449	19.8300	±0.351	23.8500	±2.19905	35.367	±0.176
	600	9.2400	±0.14468	12.6000	±0.577	19.5700	±0.3346	38.633	±0.088
	1200	5.1500	±0.2887	20.7267	±0.371	20.4500	±0.30139	11.833	±0.033
WL	Control	8.6000	±0.02887	8.7400	±0.0802	15.7067	±0.5812	7.420	±0.070
	1	7.1800	±0.01000	13.7167	±0.600	11.7967	±0.64240	15.270	±0.203
	3	2.2700	±0.14224	13.2333	±0.0881	21.6567	±0.28085	16.400	±0.058
	5	1.5100	±0.04933	20.3200	±0.0416	8.5567	±0.02963	16.380	±0.081
	10	1.4167	±0.06642	17.9633	±0.03180	17.8033	±0.14948	17.097	±0.032
	30	5.6133	±0.04667	15.1267	±0.0636	18.4867	±0.49347	19.610	±0.602
	60	3.5067	±0.05812	9.1133	±0.0466	22.8233	±0.03930	23.923	±2.302
	120	2.0600	±0.03055	21.9600	±0.0305	15.4033	±0.23096	18.787	±0.227
	300	8.1533	±0.02906	13.4267	±0.0371	24.4733	±0.28990	19.533	±0.088
	600	5.9100	±0.05859	12.5033	±0.0578	21.9267	±0.51515	19.810	±0.030
	1200	1.5100	±0.05859	10.1100	±0.04933	14.1767	±0.60378	20.760	±0.617
S	Control	8.6000	±0.0288	8.7400	±0.0802	15.7067	±0.5812	7.420	±0.070
	1	3.1400	±0.13013	14.1000	±0.20817	22.5567	±0.29418	19.68	±0.017
	3	1.2033	±0.0578	9.4600	±0.0702	22.5567	±0.29418	24.58	±0.361
	5	1.2367	±0.03180	14.1767	±0.0233	11.6800	±0.3200	20.23	±0.058
	10	5.3700	±0.03512	8.2433	±0.0296	17.3333	±0.33333	19.79	±0.219
	30	2.7033	±0.05783	17.9533	±0.0290	18.4433	±0.49418	5.71	±0.655
	60	1.1167	±0.04410	12.3633	±0.0318	13.6633	±0.21528	15.71	±0.081
	120	6.7433	±0.02963	17.3433	±0.0296	18.9700	±0.98500	16.99	±0.067
	300	7.2333	±0.03333	12.4267	±0.0371	14.7467	±6.87683	15.250	±0.058
	600	2.6433	±0.02963	14.1400	±0.03055	14.9000	±0.75056	21.94	±0.252
	1200	6.5300	±0.03512	16.7033	±0.0578	17.0800	±0.38436	22.67	±0.088

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

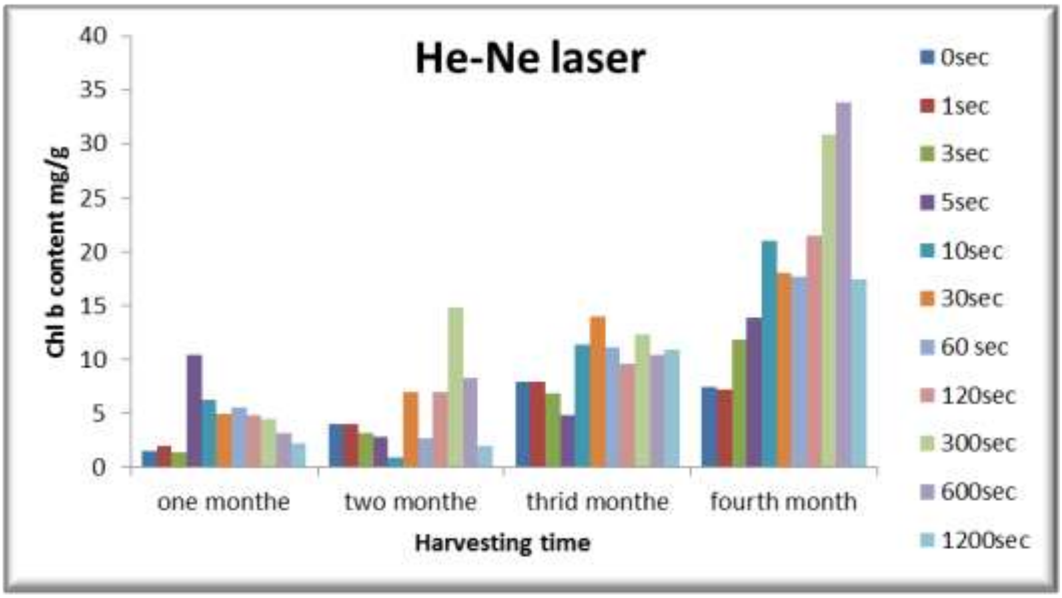

Fig (6): Effect of He-Ne laser radiationt seed pretreatments with different time intervals on Sesame plant Chl b content. Data represents mean of 10 plants ±SE.

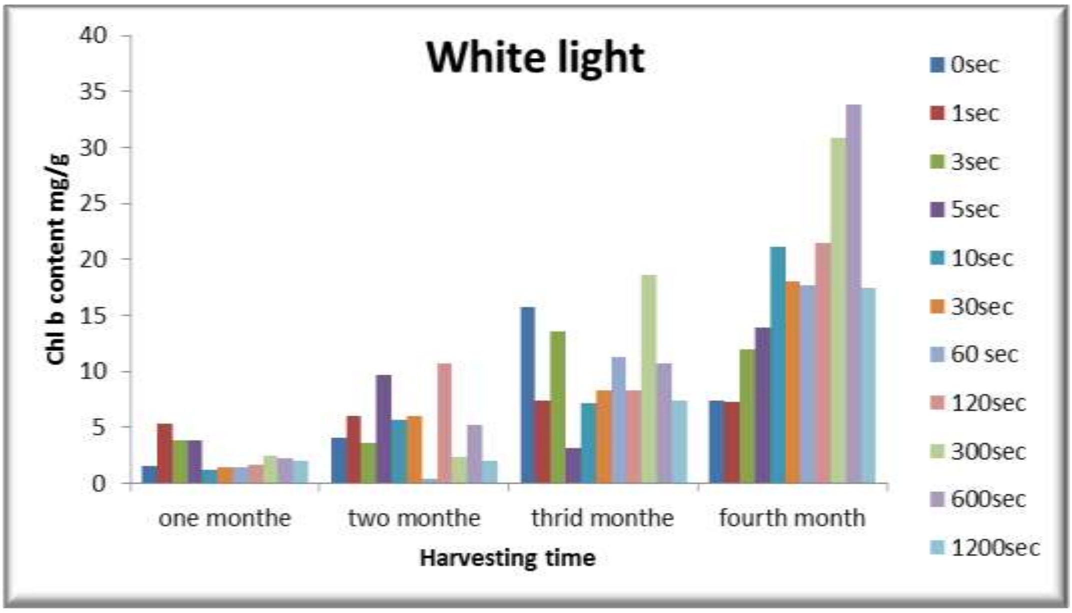

Fig (7): Effect of white light seed pretreatments with different time intervals on Sesame plant Chl b content . Data represents mean of 10 plants ±SE.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

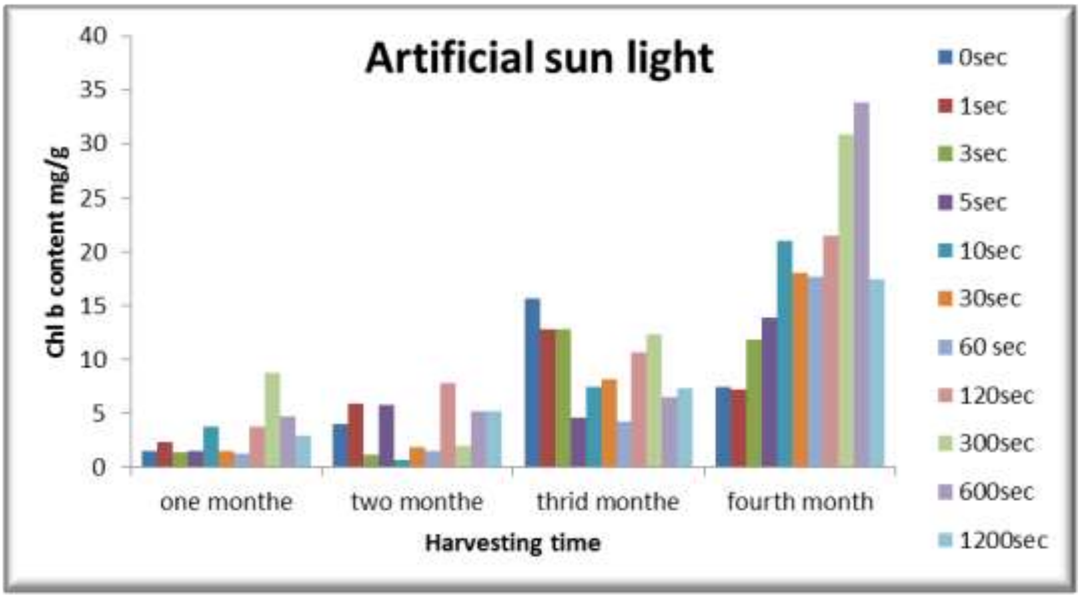

Fig (8): Effect of artificial sun light seed pretreatments with different time intervals on Sesame plant Chl b content. Data represents mean of 10 plants ±SE.

6- Carotenoids content
The data in Figs. 9, 10 and 11 showed that carotenoids content increased with increasing age of sesame plants. Pretreatment with He-Ne laser radiation significantly increased carotenoids content when compared to control. The increase was obvious at 60, 120, 300 and 600 seconds laser treatments. Artificial sun light and white light pretreatments induced non-significant changes in carotenoids content when compared to control content.

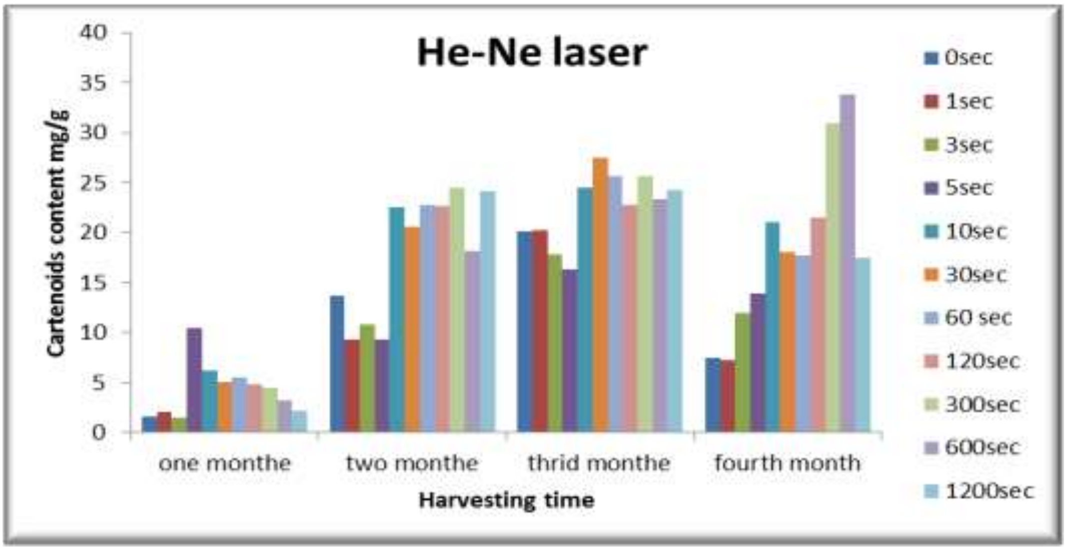

Fig (9): Effect of He-Ne laser radiation seed pretreatments with different time intervals on Sesame plant Carotenoids content. Data represents mean of 10 plants ±SE.

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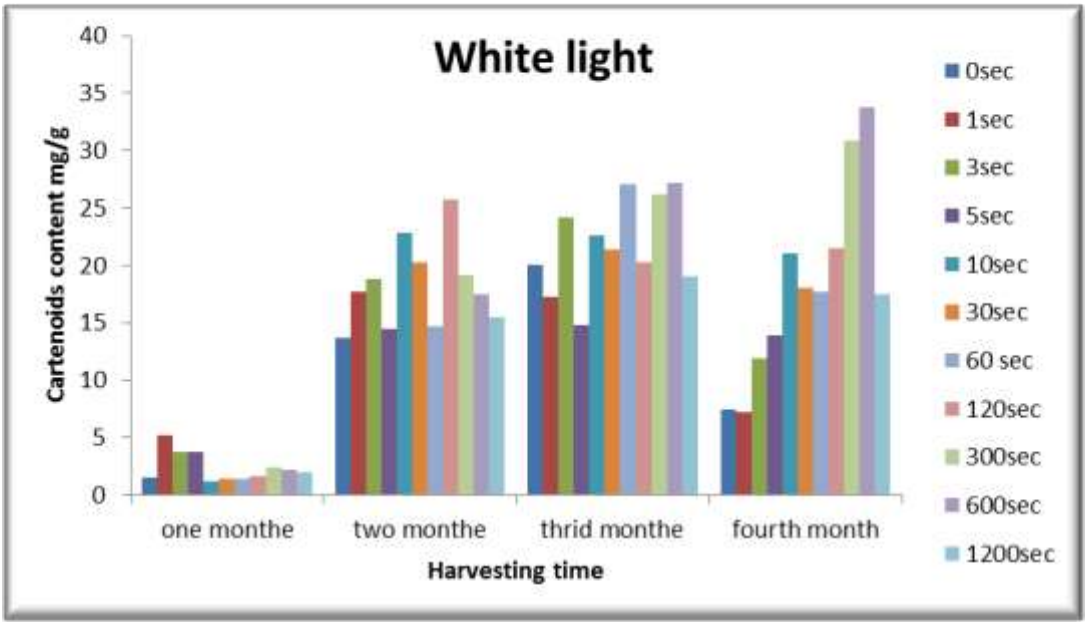

Fig (10): Effect of white light seed pretreatments with different time intervals on Sesame plantCartenids content . Data represents mean of 10 plants ±SE.

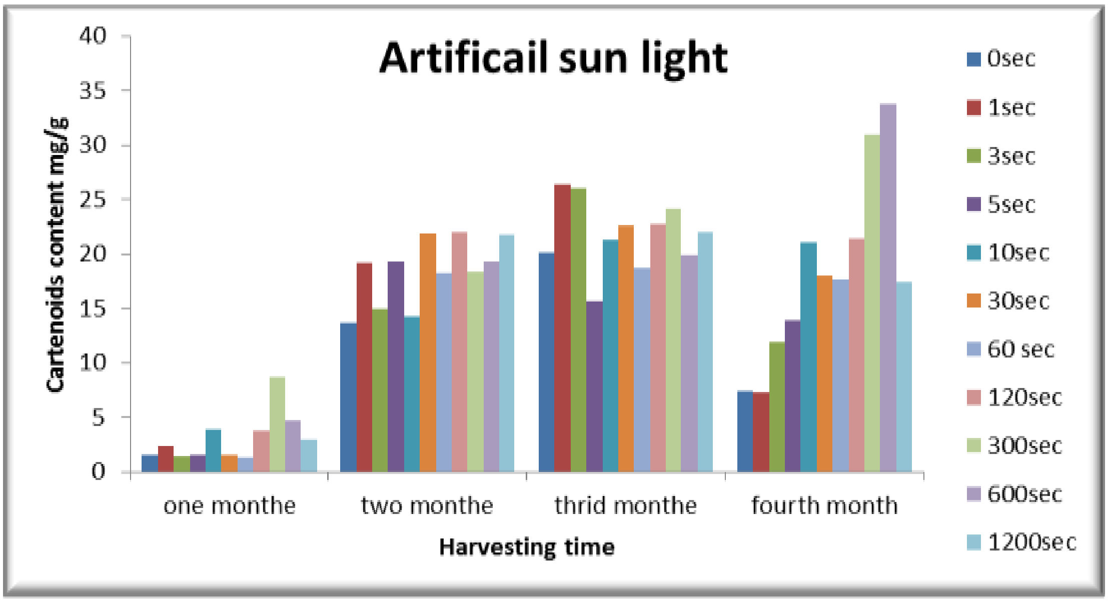

Fig (11): Effect of artificial sun light seed pretreatments with different time intervals on Sesame plant Cartenoids content. Data represents mean of 10 plants ±SE.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

Total carbohydrates content

He-Ne laser radiation a significant decline in total carbohydrates of both cultivars when compared to negative control. Subjecting He-Ne seedlings to effective with He-Ne laser periods 120,300 and 600sec respectively (figures 12-14).Whereas after recovery, were successful respectively at the with same He-Ne laser periods. One the other hand, pretreatment of ***Sesamum indicum*** seedlings significantly increased the carbohydrates content at 120 and 600sec of He-Ne laser while at 300sec of He-Ne laser, was effective. After recovery, succeeded with 120sec of He-Ne laser, while was more successful with 300 and 600sec of He-Ne laser radition.

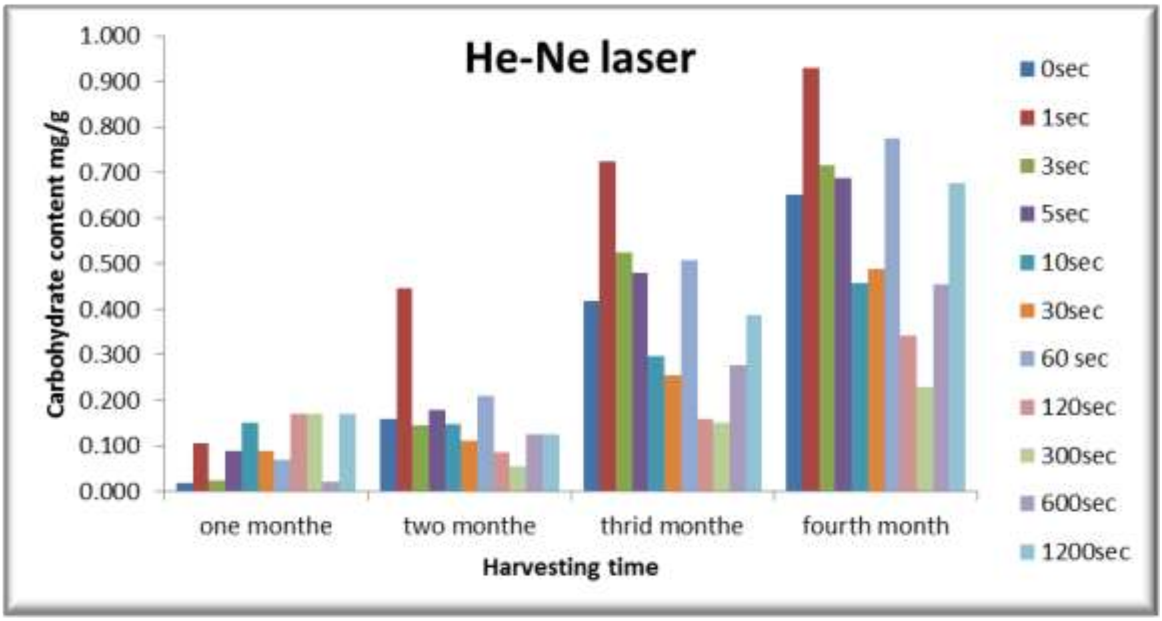

Fig (12): Effect of He-Ne laser radiationt seed pretreatments with different time intervals on Sesame plant Carbohydrate content . Data represents mean of 10 plants ±SE.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

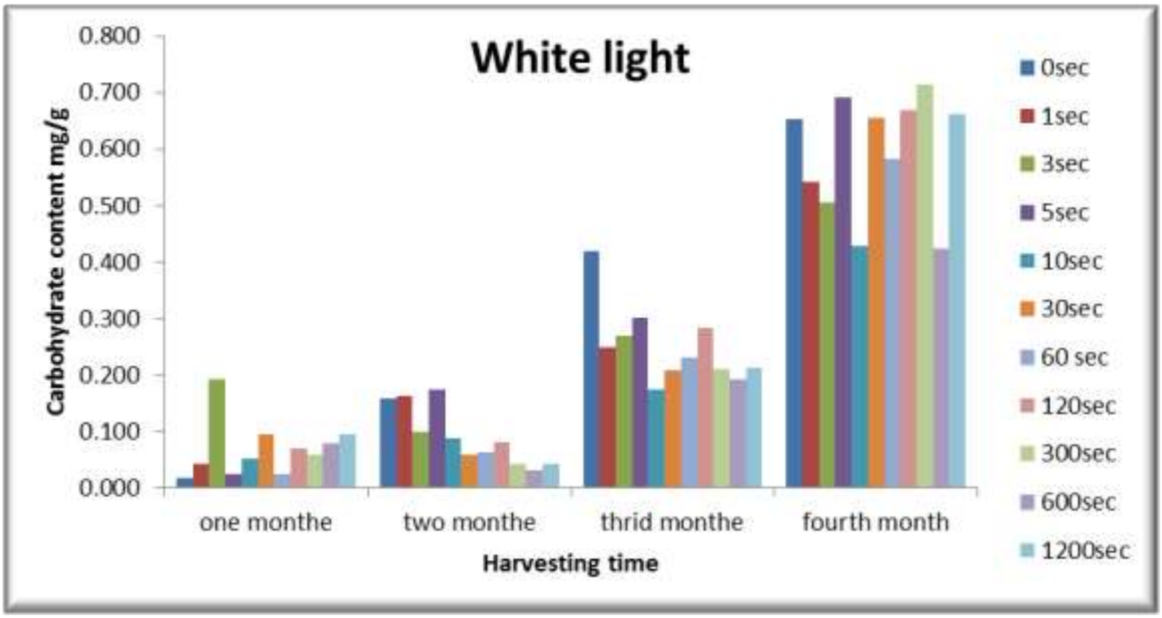

Fig (13): Effect of white light seed pretreatments with different time intervals on Sesame plant Carbohydrate content. Data represents mean of 10 plants ±SE.

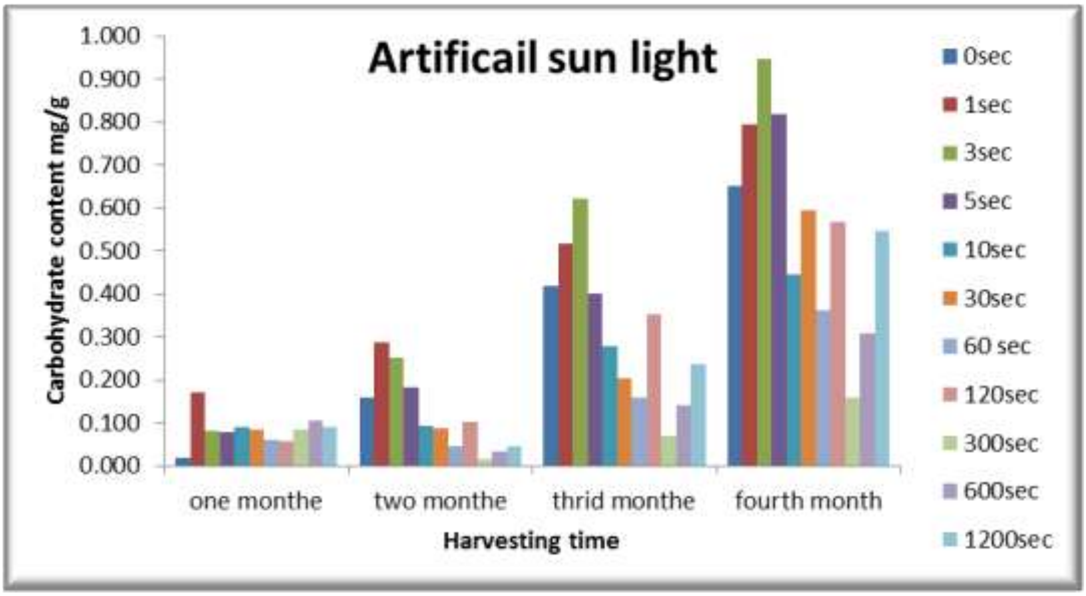

Fig (14): Effect of artificial sun light seed pretreatments with different time intervals on Sesame plant Carbohydrate content. Data represents mean of 10 plants ±SE.

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8- Total proteins

The data in table (15, 16 and 17) show that He-Ne laser radiation induced a significant increase in total protein content He-Ne laser seedlings. This increase enhanced with increasing the He-Ne laser period. The increase reaches its highest value after 4 month at 120 sec. (158%) and 300, 600 sec. respectively, compared to the control.

White light induced a significant increase in protein content specially after 4 month at 120, 300 and 600 sec.

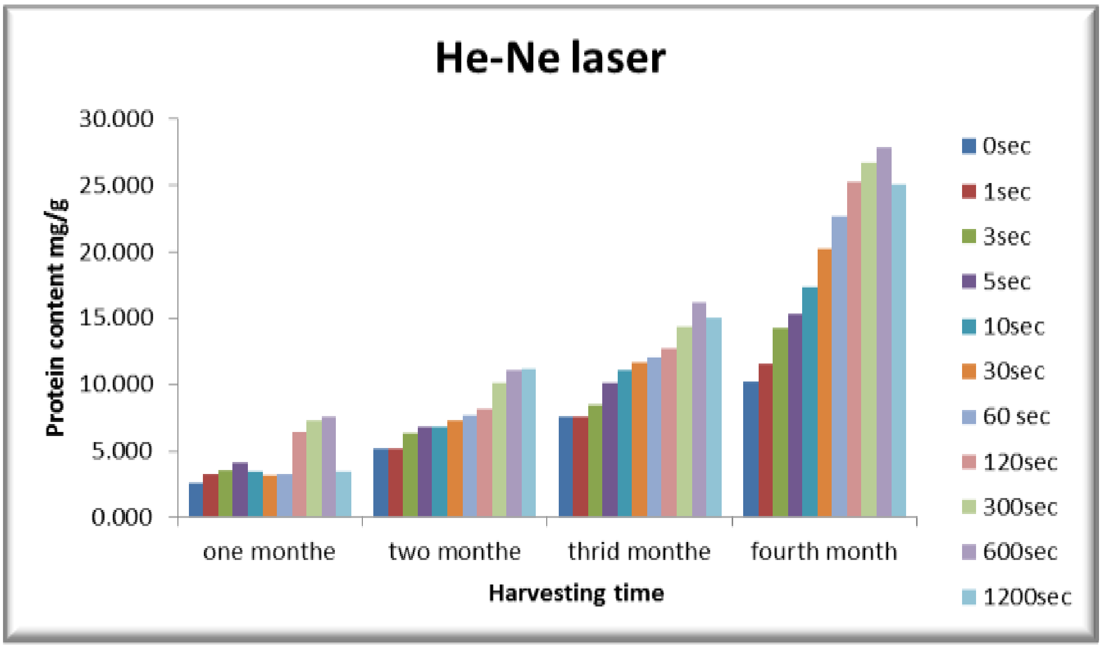

Fig (15): Effect of He-Ne laser radiationt seed pretreatments with different time intervals on Sesame plant Protein content. Data represents mean of 10 plants ±SE.

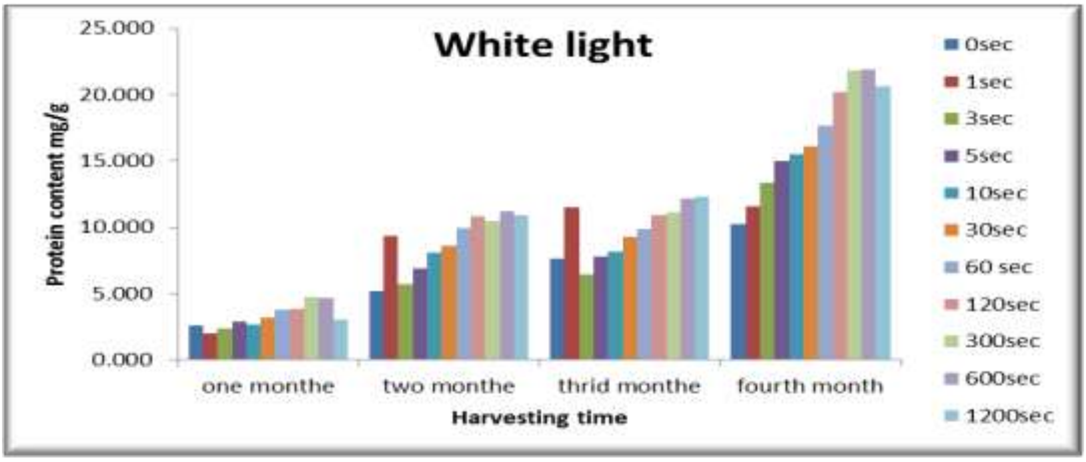

Fig (16): Effect of white light seed pretreatments with different time intervals on Sesame plant Protein content. Data represents mean of 10 plants ±SE.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

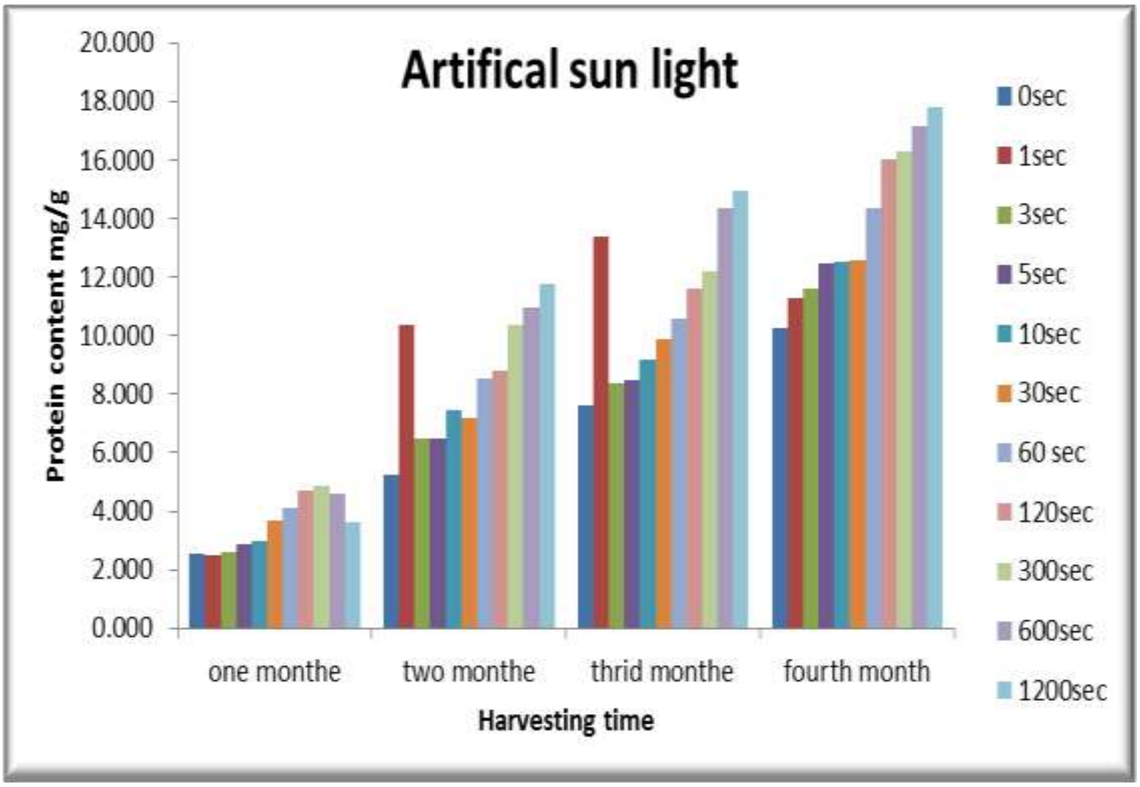

Fig (17): Effect of artificial sun light seed pretreatments with different time intervals on Sesame plant Protein content. Data represents mean of 10 plants ±SE.

Oil content (fig. 18):

Pretreatment with He-Ne laser radiation induced an increase in seed-oil content at all doses except at 5, 10 and 30 sec. The increase was highly significant at 60, 120, 300 and 600 sec. while there was non-significant increase at 1 and 3 sec.

White light pretreatment significantly reduced oil content at most doses except at 120 sec. it induced a significant increase in oil content. The effect of artificial sunlight pretreatment was fluctuated.

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

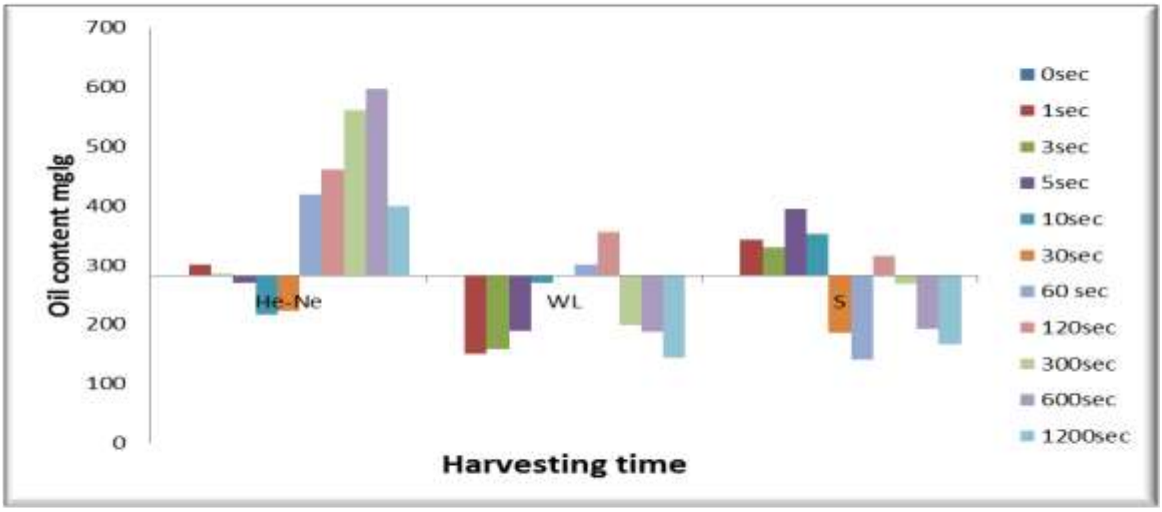

Fig (18): Effect of He-Ne laser radiation, White light and Artificial sun light seed pretreatments with different time intervals on Sesame plant Oil content. Data represents mean of 10 plants ±SE.

DISCUSSION

The effect of laser irradiation on organism is chiefly of light effect, electromagnetism effect, temperature effect and pressure effect. The laser light of low intensity produces biostimulation when used on seeds, seedlings and plants (Perveen *et al*., 2010). Therefore, some researchers hold that the influence mechanism of laser irradiation is most likely attributed to its light effect and electromagnetism effect (Xiang, 1995).

The results in the present experiment demonstrated that not only germination % was increased but also the growth and development of seedlings and the whole plant were significantly enhanced because of He-Ne Laser pretreatments.

The basis of the stimulatory mechanism in any plant physiological stage is the synergism between the polarized monochromatic laser beam and the photoreceptors (Koper *et al*., 1996). Laser activation of plants results in an increase of their bioenergetic potential, leading to higher activation at phytochrome (probably because its wavelength is close to the absorbing wavelength of Pr.), phytohormone and fermentative systems, as a stimulation of their biochemical and physiological processes (Vasilevski *et al*., 2001). Subsequently, the activities of related enzymes, that were modulated by phytochrome, could be enhanced and phytochrome-mediated responses, e.g., the decomposition rate of lower entropy macromolecule are accelerated. Accordingly, the entropy and internal energy of seeds were enhanced during seed germination.

Chen *et al*. (2005) demonstrated that the thermodynamic parameters of germinating seeds were greatly increased after stimulating seeds with He–Ne laser radiation. Therefore, the role of laser pretreatment was a long-term effect. Pretreated seeds with laser have to absorb more energy from the surrounding than that of the control in the course of the individual development, because laser broke the kinetic equilibrium of germinating seeds and enhanced the internal energy of seeds (Yan and Zhan, 1997). They also reported that as an open system, the living organism must exchange

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energy with the surrounding system to keep its high order state of the system when this order is broken. In a word, laser pretreatments induced the enzymatic activities, changed thermodynamic parameters, accelerated physiological and biochemical metabolism, and accordingly enhanced the growth of seedlings.

Chen e*t al*. (2005) demonstrated that enzyme activities in the cotyledon were significantly enhanced following He-Ne laser and microwave stimulation. In addition, their results demonstrated that the microcalorimetric parameters of germinating seeds at 25 °C were significantly changed by He-Ne laser and microwave radiation.Chen e*t al*. (2005) measured biophoton emission to address long-term effects of He-Ne laser pretreatment on plants because various physiological processes, such as membrane transport, growth, and differentiation, can be investigated by monitoring biophoton emission (Roschger *et al*., 1993). Their results showed that He-Ne laser and microwave stimulation enhanced the intensity of biophoton emission. They concluded that He-Ne laser pretreatment accelerates cell division and the growth of seedlings of *indigotica*. These could explain the enhanced effect of He-Ne laser pretreatments on growth of sesame seedlings and plants.

The plant growth is controlled by many enzymes and hormones, i.e., gibberellic acid (GA) and cytokinin. The red light have important role on GA formation and the endogenous content of GA, the main biological active GA in lettuce seeds increases after red light treatment (Kamiya *et al*., 1999). This means that, the complex cycle of GA formation is promoted by red light which induces GA α-hydroxylase gene expression. This expression is inhibited by far red light, which means that, monochromatic light is the only possible way to promote GA α-hydroxylase gene expression. This also means that, red light laser can induce this effect other than the polychromatic light, sunlight (Osman *et al*., 2009).The GA mainly induces cell elongation and many other effects, i.e., weaken the cell wall (Macleod and Miller, 1962), formation of proteolytic enzymes (Van-Oberbeek, 1966), increase of auxin content (Kuraishi and Muir, 1963), hydrolysis of starch which increases the concentration of sugars, thus rising the osmotic pressure in cell sap so that water enters the cell and tends to stretch it (Kamiya *et al*., 1999).

Osman *et al*. (2009) found that the cell elongation causes an increase of plant height in plants treated with helium-neon than untreated ones, so the shoot internode increase which gives a chance for growing more branches as well as umbels of fennel and coriander plants.Many researchers claim that the effects resulting from seed irradiation with laser light are especially visible in sprouting seeds and seedlings (Drozd and Szajsner, 1997; Szyrmer and Klimont, 1999), which suggests that the reasons for the influence of irradiation should be investigated using biochemical and physiological studies of seeds and young plants. The feasibility of such a line of thinking was proved by the studies by Durkova (1993), Galova (1996) and Podleśny (2000a) that showed the positive influence of laser light on α-amylase activity and the concentration of free radicals in the seeds of several winter wheat varieties as well as faba bean and white lupine. In a very small number of studies, other changes in seeds subjected to irradiation with laser light were also found. For example, Chuvaeva *et al*. (1981) and Sebanek *et al*. (1989) who found an increase in the activity of some phytohormones, mainly indol-3-acetic acid (IAA), in the irradiated seeds of sowing pea and maize.The larger leaf surface area during the period of the vegetative growth of the plants from the laser irradiated seeds probably resulted from the faster growth of these plants as compared with the control ones (Figure 3, a-d)

ISSN 2053-4108(Print), ISSN 2053-4116(Online)

An increase in leaf surface area can lead to an increase in the productivity of photosynthesis. In the studies of other authors, no significant differences in the number of leaves on the plants from the irradiated and non-irradiated seeds were observed. Hence, an increase in the total leaf surface area of a plant was due to an increase in the surface area of the individual leaves. Podleśny and Podleśna (2004), and Inyushin *et al*. (1981) stated that plants grown from irradiated seeds produced larger leaf surface areas than plants grown from non-irradiated seeds. They added that an increase of this surface was noticed as a result of an increase in both leaf number and size.

The stimulatory effect of He-Ne laser on seed germination % could be referred to the activation of laser to photoreceptors that, when triggered, activate numerous biological reactions (Hernandez *et. al*., 2010; Karu, 1989), increasing activity of α- amylase (Chen *et al*., 2005) which lead to starch hydrolysis required for germination process. Moreover, laser could increase the free radical production (Podleśny *et al*., 2001) and this might lead to breaking seed dormancy. With referring to its effect on growth, laser radiation induces the expression of GA_3 genes and increases the activity of IAA genes. These two phytohormones increase plant growth through internodes' elongation and enhancing cell division, and as a result the plant growth increases. Moreover, the observed increase in leaf area increases the photosynthesis, and subsequently the fresh and dry matter production.

CONCLUSION

The results obtained from this work recommend the use of He-Ne- laser radiation at time intervals of 120, 300 1nd 600 sec. for irradiating seed to improve the vegetative growth and biomass production of sesame plant. The use of He-Ne laser is not expensive and did not pollute the environment with chemicals.

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