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LASER APPLICATION IN AGRICULTURE AND ITS PHYSIOLOGICAL EFFECT ON PLANT: A REVIEW

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Abstract

From the past century till now Laser applied in our society. Laser knows that is the light amplification by stimulated emission radiation. Laser rays are non-ionizing rays and exit from the outer orbits of the atom in straight line. Environmental and biological factors influential the effect of laser on plant. Many researches through their studies stated that the use of laser rays in controlled land leveling system which raise the use efficiency fertilizers, pesticide and environmental hazard, which led to save water, fertilizer and reduce agriculture cost. The application of laser is used as biostimulator in which when used on seeds and/or seedling with low intensity, where plants absorb light via their photoreceptor and control all development stages. In this concern Photochemical effect is a result of the direct interaction between laser photon and molecules. The leaf is considered the principles organ for both photosynthesis and transpiration and this affected by morphological and cell distribution, this characters important in influencing physiological processes. Thus laser treatments modified components of plant cell and affected differentiation, morphology, rooting and shooting behavior and those according to type of laser, source, and time exposure, thus, the proceeding finding indicated that, laser He-Ne irradiation had a positive effect on essential oil and its components in fennel plants, unsaturated and saturated fatty acids in *Ricinus communis* as well as anticancer alkaloid components (vinblastine and vincristine) in vinca plants.

Key words: Laser application, physiological effect, *Ricinus communis*

Introduction

Laser is one of the important rays, which were used in the past and until now in leveling the earth for its numbers for cultivation. It was also widely used in medicine in lithotripsy, ophthalmic treatment, etc. The use of laser is part of or one of the branches of biotechnology in what is called Photobiology, Photochemical, where laser have recently been used in the treatment of serious diseases such as cancer using gold particles and the effect of heat resulting from the rays on the cancerous cell. The word laser is an acronym which is formed with primary letters of the phrase (light amplification by stimulated emission of radiation). This technology is becoming a well-known and acceptable technique to the farmers. Now it has also proven that this technology is no longer as costly and within the reach of a farmer for his specific requirements Sami (2010). Today some tools are supplemented with space age technologies that allow the farmer to raise their crop in more precise and efficient ways. Some of these technologies include global positioning systems (GPS), geographic information systems (GIS), yield mapping, variable- rate technology, controllers, laser and remote sensors (http://www.ptroptics.com/lasers-in-agriculture/). Precision farming (the art of using these technologies to control land leveling, increase yields and profits while protecting the environment) is becoming more prevalent in farming operations. The results achieved in the application of laser irradiation of plant organisms still continue to attract the scientific interest –in the past realized by He-Ne lasers, and nowadays – by semiconductor lasers Subrata and Atanu (2013).

The aim of this article is to throw more light on laser application on agriculture processes, and its effect on Plant growth, flowering, anatomical structure and chemical constituents.

Properties of laser light

The laser differs from all other light on three characters:

(1) It is a coherent beam, (2) Nearly collimated, (3) Monochromatic.

Type of Laser

(1) Solid state laser (ND YAG, Diode laser, Ruby) (2) Gas lasers (CO_2, N, He-Ne, Ar), (3) Dye lasers (cumarin)

Effect of Laser on tissue

The interaction between laser light and biological

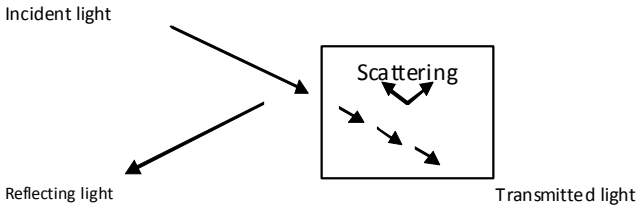


Fig. 1: Geometry of reflection, absorption and scattering. (Absten, 1992).

tissue can be described in terms of reflection, scattering, transmission and absorption Absten (1992).

The difference between gamma and laser rays

Gamma rays are ionizing rays that exit from the nucleus and may have dispersal, diffusion or distribution other than laser rays, which are unionizing rays and exit from the outer orbits of the atom in straight lines.

There are factors that reduce the effect of radiation which are

1. Environmental factors (Oxygen, cell water content, temperature)
2. Biological factors (genetic differences between species and size of nucleus and chromosomes).

Laser application on Agricultural processes

In agriculture land leveling System laser had controlled it. This kind of technology decreases the cost 6.3% up to 15.4% of production of most crops such as wheat, rice, cotton, soybean as well as corn. laser benefits in agriculture includes, (1) Save water where laser controlled land leveling, (2) Save fertilizers by increasing land flatness, (3) Increasing emergency of the seedling, (4) Control land leveling technology to control the ridges, (5) Making fingerprint for pesticides and fertilizer, (6), Estimate the purity of fertilizer and pesticides, (7) Laser can be use to kill the weeds without hurting the surrounding plants or main crop, (8) Detection of the following toxic materials that may be mixed with imported foodstuffs, (9) Grain yield estimation and their size was estimated, (10) Measure things bruising on fruits and vegetables, (11) Laser enhancing plant growth and chemical constituents. Farmers frequently fertilize their crops. Lasers can now scan the density of the soil. The idea is that less dense soil is probably more fertile because it is packed with organic matter. This can help a farmer determine what they need to do to prepare the soil for new crops before they ever plant or how much fertilizer he needs to apply once they are already growing. These results recorded by Subrata and Atanu (2013). There are studies that prove that lasers can be used to kill weeds without hurting the surrounding plants. Laser technology is currently very expensive, but it can save large farms money in the long run (Laser 2013). Unleveled field become less productive compared to leveled fields. Unleveled fields also give rise to salinity and water-logging problems. In this context, leveling of fields is essential to maintain soil fertility and productivity and to save irrigation water. Further, Taylor *et al.,* (2004) recorded that, using agriculture nozzles, the spray quality generated is important for the pesticide application processes by affecting spray deposits and drift-ability. These results hold true with Klein *and* Johnon (2002) and Wolf, (2002).

Effect of laser on some physiological processes in plant

7-1- On plant growth

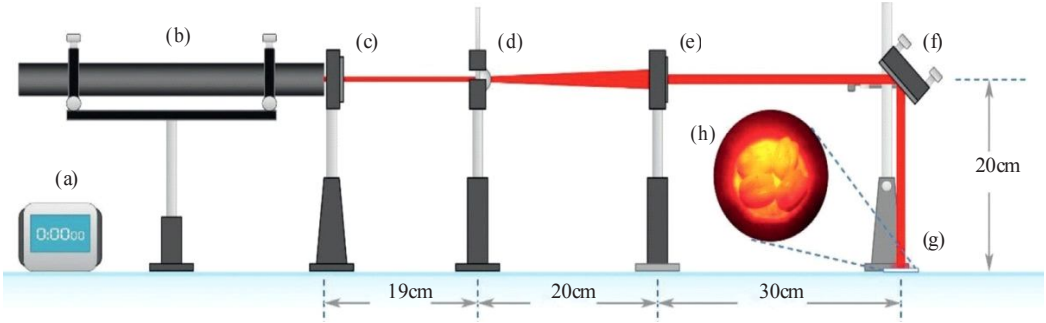


Fig. 2: System of optical for rays of laser: (a) digitalstopwatch; (b) laser; (c) neutraldensityûlter (d) lens; (e) aperture; (f) mirror; (g) mungbeanseeds; (h) actualimageofirradiatedseeds.? (Rayno *et al.,* (2019).

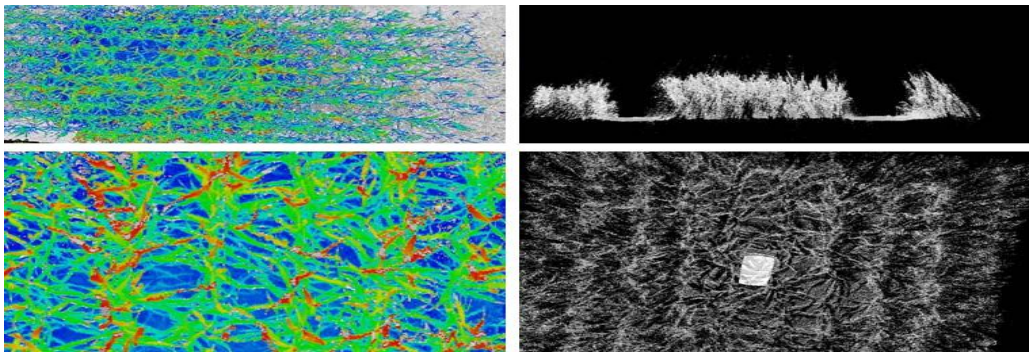


Fig. 3: Schematic view of Laser controlled land leveling system. Subrata and Atanu (2013).

Fig. 4: Images of 3D point cloud data (Lumme*et al.,*2008) Application in fertilizer &herbicide use.

Laser radiation showed a different effect on plant growth, such as increasing or decreasing plant height, leaves number, leaves area, flowering date as well as flower number, seed germination….act. The increase or decrease on these plants due to laser application may be due to synthetic compounds such as (e.g. IBA, cyocel, NAA, ethereal and others) and growth hormone, that rivaling naturally occurring plant hormone, or may be natural hormones that were extracted from plant tissue, which may produce their effects the part in which they were not synthesizes. The principal auxin in higher plants is Auxins (IAA, IBA), cytokinins, as well as gibberellins (GA). In this respect Sami (2010) in gerbera plant found that, GA, cytokinen, ABA and IBA increased and accompanied by increments in growth in most cases. Total control of the plant is robed not a single hormone type but is shared by several specifically auxins, cytokinens, gibberellins and miscellaneous group including dormins and other naturally occurring inhibitors (Bandurski *et al.,* 1995).

On gerbera plant using laser He-Ne as well as argon with different doses and different wave length affected on plant length and this reflected on cell division of shoot tap and followed by cell division of all cells whether in vegetative and/or flowering stage Sami (2010). Also GA formation is promoted by red light treatment had the same effect on the plant (Kamiya *et al.,* 1999). This means that the complex cycle of GA promoted by red light, which induced GA_3 B hydroxylase gene, S3hI expression. This expression is inhibited by far red light treatment. This means that monochromatic light is the only possible way to promote GA B hydroxyls gen S3hI expression. So red light laser (He-Ne) can induce this effect but not polychromatic light (sunlight). (Macleod and Millar 1962) revealed that, the increase in plant height was followed by increase in branches and leaves number/plant which induced high fresh and dry weights. This may be due to the role of gibberellin in cell elongation, where GA may cause cell elongation by induction of enzymes that weaken the cell wall. Also, revealed that argon treatments were more effective on increasing number of shoots/plant than He-Ne treatments. The effect of the spectral influence of the laser radiation, Burges (1999), Mori and Takatsuji (1998), and others, excites a change in the plants functions, activates the speedier cell-division, rate of growth and development, better resistance to unsuitable conditions and increase of the productivity and the quality of plant production. Galal *et al.,* (2020) revealed that irradiated *Adansonia digitata* seeds with He-Ne

laser induced high Plant growth parameters to control.

7- 1-1- On seed germination

In this respect, studding the effect of laser rays on vigor of seed, germination and seedling development Hernandez *et al.,* (2010) mentioned that absorbed energy from laser light, increased activities of biochemical and physiological processes of seeds by the transform of light energy to chemical energy.

María *et al.,* (2019) studied the effect of the pre-sowing laser (632 nm, 10 mW) biostimulation on germination and seedlings growth of Jacaranda" (*Jacaranda mimosifolia*) and "mezquite" (*Prosopis laevigata*). They recorded that, the highest number of germinated seeds (96%) was obtained from (90 second and 150 second) in compared with untreated seeds recorded germination percentage (16%). Laser treatment increased the amylolytic enzyme activity, in seeds and seedlings Podlesny *et al.,* (2012). Galal *et al.,* (2020) revealed that irradiated *Adansonia digitata* seeds with He-Ne laser (10 mW/2 min.) induced the highest germination and phenolic contents for seeds compared to control and other He-Ne laser treatments.

7-1-2- On Plant height

Ritambhara and Girjesh (2013) showed that the He-Ne laser can be exhibited wide range of mean plant height both higher and lower values as compared to that control of *lathyrus sativas*.

7- 1- 3-On Shoot number

Danaila *et al*., (2011) studied the effect of red light laser on *petunia hybrida* and *Dianthus caryophyllus* plants. They found that the most effective dose of radiation was found to be 0.88J/cm^2 and 5 min. exposure time, this dose had significant positive differences in terms of growth rate, number of shoots and number of formed leaves. Rania *et al*., (2015) studied the effect of Helium neon (He-Ne) and Argon (Ar.) laser radiation for 3 to 15 min with wave length of lasers rays 632.8 and 514.5nm, respectively, on Jojoba (*Simmondsia chinensis* L.). They indicted that exposing shootlets to red laser (He-Ne) and green laser (argon) enhanced shoot length and leaf number compared to control and other time exposure.

7-1-4- On fresh and dry weight

Al-Sherbini*et al*. (2015) exposed seeds of pea to helium neon rays for 10 min. gave the highest values of plant dry weight compared to untreated plants and other period (2 and5 min).

7-1-5- On yield of herbs

Mohammed (2005) studied the effect of He-Ne laser on sage plant (*Savia officinalis*) at different exposure time (0, 2, 5,10min.), he found that laser at 5 min had higher yield of herb compared with the other types of laser.

7-1-6- On rooting

Auxins (IAA, IBA) have several physiological effects. Regulation of elongation growth in young stem, low level of auxins are required for root elongation and root lateral root development, In these respect.

(Kamiya *et al*., 1999) mentioned that the complex cycle of GA_3formation is promoted by red light. This induction of gibberellic induced formation of protolytic enzymes that would be expected to release tryptophan precursor of IAA (Van and Overbeek 1966).So it means

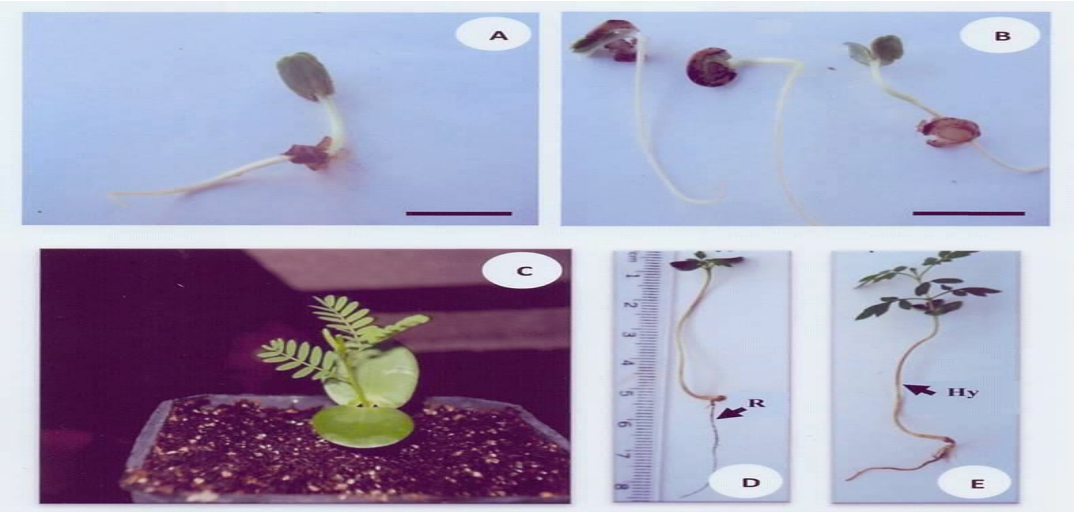


Fig. 6: Seedlings of *Prosopis laevigata*(A and C) and *Jacaranda mimosifolia*in the early stage of its growth; seedling from untreated seeds (D); B and E, seedlings from irradiated seeds (60 second).Maria *et al*., (2019).

that laser enhanced GA_3 formation and encourage the release of IAA which had promotive effect on root growth, nutrient and water uptake and this reflected in plant growth.

Metwally *et al*., (2013) they mentioned that exposing *Celosia argentea* seeds to (He-Ne) laser for 2min recoded significantly increase in number of root and length of root per shootlet compared to control.María*et al* (2019) studied the effect of the pre-sowing laser biostimulation of Jacaranda" (*Jacaranda mimosifolia*) and "mezquite" (*Prosopis laevigata*).They mentioned that, the 30 second treatment produced a considerable effect on root parameters.These results hold true with Samiya *et al.,* (2019) on wheat seeds.

7-2- On flowering

The leaves are the sensitive argon to the length of light period and the type of light. The compounds that make up the flower hormone (Florigen) are synthesized in the leaves and then transmitted to the shoot apex regions through the phloem to occur flowering.

Laser radiation was found to have an effect on the flowering (delay, earlier and Preventing flowers and decreased or increased flowers vase life) of plants. The laser effect varies depending on the type of laser, the dose used, the exposure time and the type of plant exposed to the laser.

Danaila *et al*., (2011) studied the effect of red light laser in the spectral range of 660-680nm radiation, on *petunia hybrida* and *Dianthus caryophyllus*plants. They mentioned that the maximum dose ($1.75J/cm^2$) with 10min of exposure time led to decrease the number of flowers. Metwally *et al*., (2013) on *Celosia argentea* varcristata mentioned that He-Ne lasers treatments led to decreased flowers vase life, the low times exposure 2 and 3 min were led to reduce the flower vase life to the minimum values, reached to 6.00 and 6.66 days compared to 10.33 days for control plants.

Effect of laser on anatomical structure of plants

Laser treatments showed great differences on anatomical structure of some plants leaves.

20min. Helium neon laser 20min argon laser 20 min. Cadmium laser

Fig. 8 Shows leaf anatomy of *Eustoma grandiflorum* under effect of three types of laser rays, microphotograph showing transverse section through the blade of the third *in vitro* plant leaf developed on the main stem. The section shows Thickness of medvein, and Thickness of lamina, vascular bundle, (number of vessels and number of xylem rows, Xylem Rows and Number of vessels Abou-Dahabe *et al.,* (2018).

In gerbera plant Sami (2010) revealed that, laser radiation increased leaf growth parameters and also showed increments in number of vascular bundle, thickness of midvein, thickness of lamina and xylem rows. Also, Bedour *et al*., (2012) found that the highest number of vascular bundles was recorded by treating plants with Argon rays treatment at exposure time 7.5 min, the single treatment of helium neon at exposure time 1 min. recorded high values on number of xylem row and thickness of lamina compared with control. Abou-Dahabe *et al.,* (2018) *on Eustoma grandiflorium* indicated that, plant exposed to short time (Helium neon laser and Cadmuim laser) recorded the increase in thikness of midveine, thikness of lamina and dimention of vascular bundle, while argon laser treatments led to decrease in thickness of midvein as compared to control.

On Photosynthetic and anthocyanin pigments

The laser rays promote GA formation which increases photosynthetic pigments contents and sugar concentration. While argon laser was more effective than He-Ne laser in increasing carotenoids concentrations in plant tissue. Al-Sherbini *et al*., (2015) studied the effect of He-Ne laser irradiation on seed pea (*Pisum sativum* L.). They showed that the seeds were treated with He-Ne laser irradiation for 10 min increased the chlorophyll content. Rania *et al*., (2015) on Jojoba (*Simmondsia chinensis* L.) mentioned that helium neon laser for 3min significantly increased both chlorophyll a and b, total chlorophyll as well as carotenoids to the highest values compared to control and argon treatments.

Chlorophyll a and b content of *Catharanthusroseus* plants were increased with the application of He-Cd and Ar laser treatments. While Argon laser was more effective than He-Cd laser in increasing carotenoids concentrations in the plant tissues. Sami *et al.,* (2019) on vinca plants. Kurata *et al*., (2000) found that cadmiun (blue) and helium neon laser rays able to enhance anthocyanin content. Anthocynine was increased with both green and red light laser, these results confirmed by Abou-Dahabe (2018).

On Enzyme activity

Laser He-Ne and argon treatments increased activities of proxidase, acid phosphatase, IAA, ABA, GA-like substances and the decrease in catalase and alkaline phosphatase activity were observed in gerbera plants, laser exposure enhanced GA production.

Effect of laser on proteins

Laser radiation was found to have an increasing effect

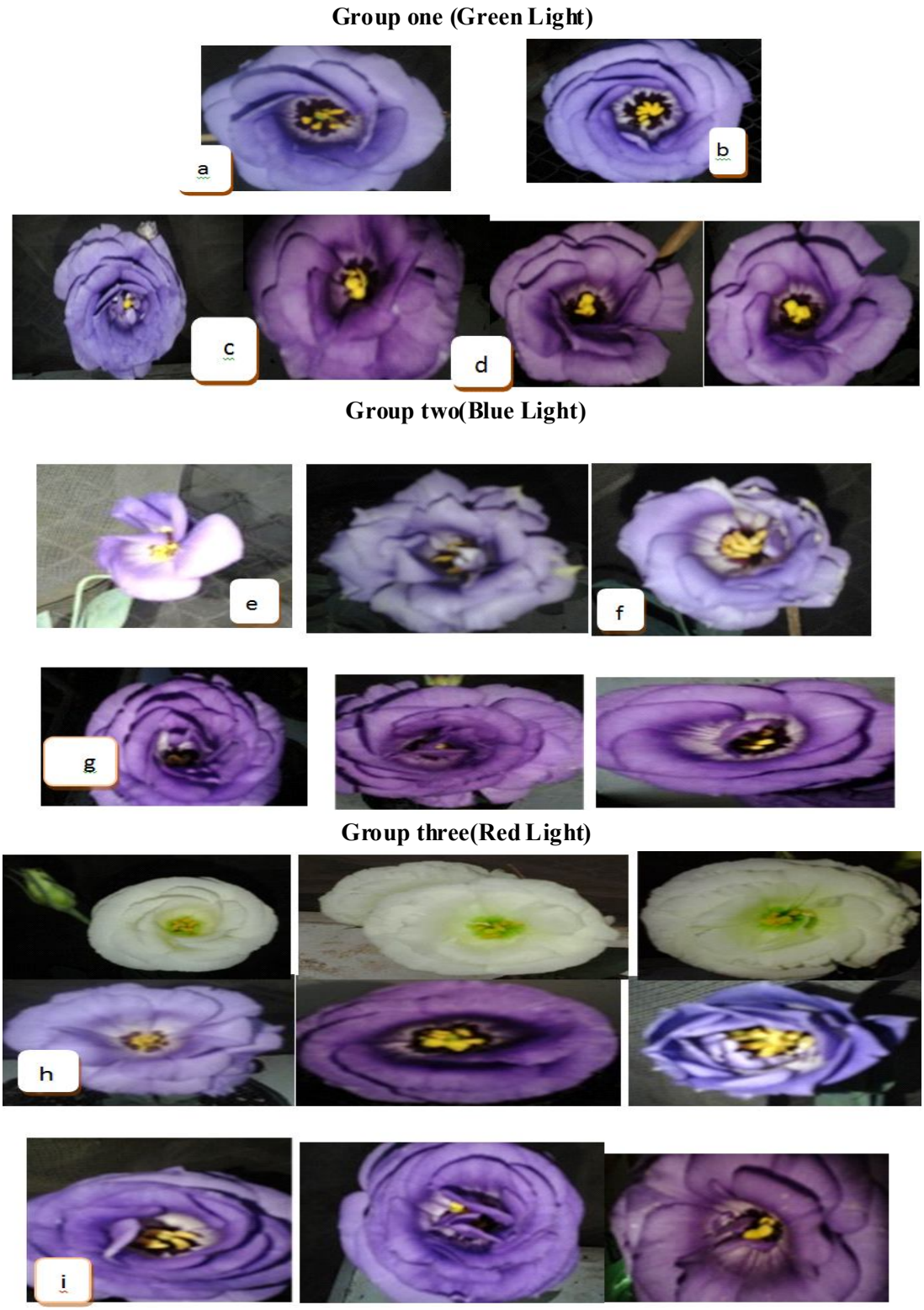
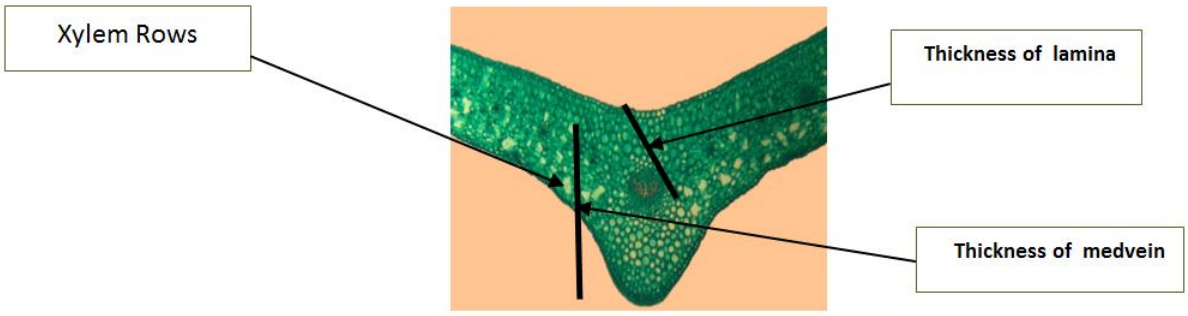
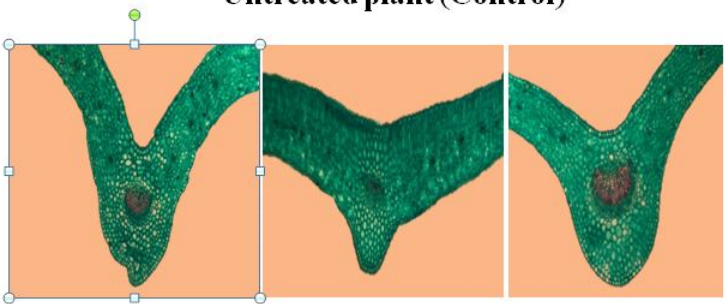


Fig.7: Chages in *Eustoma grandiflorum* flowers colour and form after irradiation with different time expouser of laser rays a. Control, b. 10min, argon, c. 20min. argon, d. 25min. argon, e. 5min. cadmuim laser, f. 10 min. cadmuim , g. 20 min. cadmuim, h. 20 helium neon and i. 25min helium neon Abou- Dahab (2018).



Untreated plant (Control)



on the tryptophan. Thus tryptophan is the precursor of IAA growth regulator Wessam (2005) and Sami (2010) on *Salvia officinalis* plants *and Gerbera jamsonii* seeds exposed to helium neon and argon laser increased significantly protein content.

Effect of laser on antioxidant enzyme under stress conditions

It is found that He-Ne laser irradiation can increase plant tolerance to drought stress by improving activities of enzyme activities of enzyme antioxidants system such as ascorbate peroxidase (APX), superoxide dismutase (SOD) and ascorbate peroxidase (APX) and decreasing malondialdehyde (MDA) concentration, beside alternate of several genes related to nutrient uptake, photosynthesis and transport (Qiu *et al.,* 2017; Qiu *et al.,* 2018 Samiya*et al* 2019).

In this respect, the He-Ne laser pretreatment as an adequate method to attenuate the negative effects of drought stress in *Celosia. argentea.* These findings are in accordonce with (Metwally *et al.,* 2014; Qiu *et al.,* 2017; Qiu *et al.,* 2018; Sami *et al.,* 2020).

Effect of laser on fatty acids

The interactive effect of helium neon laser rays and irrigation regime on the fatty acids composition in *Celosia argentea* recorded that, increase of irrigation regime showed a negative effect on saturated fatty acids, and positive effect on unsaturated fatty acids,, as well as polyphenolic compounds, Sami *et al.,* (2020), these findings are in harmony with the former reports discussed the effect of drought stress on fatty acids composition in sunflower and *Ricinus communis* (Petcu *et al.,* 2001 and Metwally *et al.,* 2014).

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