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A SIGNIFICANT TOOL IN AGRICULTURE: LASER

A. H. AL MAMOORI[1,2*] AND S. A. SADAT NOORI[1]

[1]Department of Agronomy and Plant Breeding, Campus of Abouraihan, University of Tehran, Tehran, Iran.
[2]College of Biotechnology, Al Qasim Green University, Babylon, Iraq.
Email: alialmamoori2018@gmail.com

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ABSTRACT

The present study was planned to be compatible with the current issues around the world such as water supply, climate change, energy, poverty, injustice, and need for food. For instance, one of the problems all over the world is the quality and quantity of agricultural grains and food. This seems to be clearer in developing countries, leading to different diseases as well as malnutrition. In this study, the advantage of laser technology was specified when applying it to agriculture. A study on its application was indicated on one of the physiological grains of the plant in order for it to contribute to enhancing the agricultural quality and productivity. Furthermore, its application can be regarded as a maintainable tool existing today, an invention from the past to the future.

Keywords: Laser; biostimulation; photoreceptors grains; agriculture.

INTRODUCTION

50 years ago, through using a flash lamp pump crystal sapphire as medium, Maiman [1] detected laser (light amplification by stimulated emission of radiation). The concept of stimulated emission of radiation was first seen by Einstein [2], however, it was used to reinforce the practical of electromagnetic waves in 1951,; in 1954 the first such devices, the microwaves were used (microwave amplification of induced emission). Leading to a wave of work in many locations to form such an instrument [3].

Lasers are employed in different medical and industrial fields [4]. Recent reviews indicate that laser radiation influences the cells of the plant and many plant functions, spreading the effect of effective lasers to the agricultural texture. Laser light affects the plant cell [5]. Red light has to stimulate or activate the special enzymes affecting growth, cells' elongation and roots' formation. Blue light invigorates or alerts the enzymes for cytokine synthesis that affect cell division and plant tissue [6]. Keeping in mind that the effect of the laser differs based on the exposure time, the dose used, the quality of the used vegetable tissue (seeds, seedlings, plant tissues), and the quality of laser. Those lasers have been demonstrated useful in the field of agriculture in the plant growth and early flowering payment, to obtain high quality of growth and flowering, and in the seeds payment for rapid germination [7]. This research is presently being carried out through using laser beams to modify the plants grown under unfavorable environmental conditions; after treating with laser, it has been found to make the plant resistant to intense thirst or salinity situations.

Synergism between the polarized monochromatic laser beam and the photoreceptors is the foundation of the mechanism of stimulation in any plant's physiological stage [8,9] that, once it is started, activates several biological reactions [10]. There are large evidence indicating the biostimulating process of laser radiation on different organs and tissues of plants and animals [11]. Photoreceptors of the plants absorb light [12]. They manage all development steps of the plant [13,14,15,16, 17,18]. Laser activation of plants leads to increase in their bioenergetic potential, resulting in higher activation at phytohormone, phyochrome and fermentative systems, in the form of stimulating their physiological and biochemical processes [19].

The present review has aim to consider if laser is a valuable tool in agriculture and its potential to contribute in improving the quantity and quality of yield.

APPLYING LASER IN AGRICULTURE

Since 1948, Borthwick and Hendricks et al. [20] carried out experiments for establishing their own central hypothesis of phytochrome action: the photoreceptors are in two photo-convertible forms including Pr and Pfr; Pr is biologically inactive; it is converted to Pfr (the active form) through absorbing red photons. By far-red photons, Pfr is converted to Pr, again (Borthwick et al. [20,21,22,23]).

The photoconversions involve a number of intermediate forms in both directions, and even at daylight irradiance levels, it takes several minutes to create the equilibrium between Pr and Pfr. Experiments of lettuce seed germination performed by Hendricks and Borthwick [24] demonstrated that a reversible photoreaction managed the process.

The pigment responsible for this effect was purified and they named it phytochrome; they also described its role in seedling development, seed germination, and flowering. In addition, they investigated the photo-transformation time for going from one state to the other in the phytochromes. To change its state by applying red light from a fluorescent lamp emitting at 700 nm wavelength, Hendricks computed the irradiation intervals on phytochromes [25,26]. Meanwhile, as those experiments were conducted in this knowledge arena, the laser and its incursion in biology were discovered.

Bessis et al. [27] entered the laser incursion in biology with applying a ruby laser on cellular organelles. It was shown by Rounds et al. [28] that of the extent of damage to the pigmented and non-pigmented tissues from laser radiation depends on the ability of the cell to absorb the imposed energy. According to Johnson et al. [29], the amniotic tissue's respiratory activity was suggested to be temporarily inhibited by laser irradiation. It was reported by Rounds et al. [30] that inhibition of the oxygen consumption rate by brain cells after green laser radiation implicitly suggests this biochemical pathway as a cellular injury. Their experiments resulted in clarification of the fact that damage to the respiratory enzymes mediated the brain cells' injury. Laser applications focused on the micro-irradiation that is one of the major areas of biology. Mester et al. [31] first considered and published the laser biostimulation phenomenon; they conducted some experiments on mice. The hair of their backs was shaved off; they were divided into two groups and were irradiated. One group had a low-powered ruby laser. Surprisingly, the hair back of the intervention group grew more quickly than that of the untreated group. This was called 'Laser Biostimulation'. As biostimulator, the laser light has been applied in the agriculture that some scientific reports indicate its usefulness.

A ruby laser and He Ne were first and respectively used in the agriculture by Wilde et al. [32] and Paleg and Aspinall [33]. Wilde et al. [32] indicated that the exposure of certain seeds to laser radiation seemed to speed up the germination and growth of their plants. He announced, in case that these preliminary outcomes are borne out, the technique can enhance per-acre returns and decrease the requirements for troublesome pesticides. Paleg and Aspinall [33] suggested that the phytochrome system was activated by laser emission of 632.8 nm, and it was possible to generate phytochrome response at a large distance. From these first reports by now, there have been many studies applying laser in agriculture and they have indicated the capability of applying it in this field. The number of reviews has grown in this century because of the need for stopping the destructive processes of the soil and the environment, and thus, to ensure the protection of the food that influences the human health. Different laser light types have been employed, from ultraviolet to far infrared, including UV (200-400 nm), visible light (400-700 nm), near infrared radiation (750- 2 500 nm) and far infrared (5000-106 nm) from the first time that laser was used in agriculture up to now. Solid, gaseous and semiconductor lasers were used in agriculture, for instance, we can refer to ruby laser (694 nm), He-Ne (632.8 nm), nitrogen laser (337.1 nm), argon (514.5 nm), YAG: Nd laser (532 nm), diode laser (510, 632, 650, 670, 810, 940 and 980 nm), AsAlGa semiconductor laser (650, 660 and 850), and CO2 (10 600 nm). These lasers have been both used alone or in a combination, with simple or several irradiation regimes. Red is the laser light wavelength that has been most frequently used in the biostimulation process in which the phytochrome absorbing happens. Phytochrome is localized at the mitochondrial and chloroplast membranes, plasmalemma, endoplasmic reticulum, possibly in the cell nuclei [34], as well as in the seeds' embryo [35]. In addition to the photoreceptors that are responsible for light absorption, a system of interconnected membrane structures operates in the cell and accounts for utilizing and transforming the absorbed light energy. Because of the transformation of light energy to chemical energy, the energy of the laser light absorbed in the seed operates physiological and biochemical processes.

One of the physical methods is the laser treatment that also includes electromagnetic treatment [36,37,38] and/or electric treatment [39] that are able to improve the quality of sowing and the final product (food), increase higher productivity, and reduce the risk of contamination from soil and water simultaneously [40]. Based on our literature review on the application of laser in Agriculture for the seed treatment, it is recognized that the important parameters include the seed characteristics, the seed's position during the laser irradiation, and the parameters of laser irradiation.

Therefore, light is life for plants. A plant's capacities to sense, evaluate, and respond to light quality, quantity, and direction show its ability to maximize its photosynthetic productivity. Numerous studies on some cereals root crops and vegetables have already proved the good impacts of the pre-sowing laser biostimulation of seeds on germination, initial development, and yield. The author's published papers have provided the evidence that such treatment both under strictly controlled conditions and in field experiments favorably affect the development and yield of some legumes. Although, the impact of laser light has not been fully recognized and explained yet since there are just fragmentary studies or hypotheses that may only help explain this effect. Hence, we must run a deeper investigation concentrated on the physiological and biochemical processes occurring in the treated seeds and plants. The studies were aimed to assess some biochemical and physiological transformations in the seeds as well as giving a detailed description of the dynamics of the accumulation of faba bean's dry matter after applying the pre-sowing biostimulation of seeds with laser light.

The enzyme activity in the seeds was significantly changed due to irradiation, especially at the initial stage of their germination.

Biostimulation of faba bean seeds resulted in an increase in the amylolitic enzymes' activity for three- and five-fold doses after 12, 24, 48, 72, 96, 120 and 144 h after sowing by 18.1, 77.4, 114.0, 90.2, 40.0, 16.6, and 21.2%, respectively. Also, the transformations of the enzymatic activity of some varieties of winter wheat after irradiation of kernels by He-Ne laser light, was reported. The activity of amylolitic enzymes, particularly in the initial stages of germination was significantly changed by the irradiation of seeds of the faba bean variety Nadwioelañski. Although both the three- and five-fold treatment of seeds were the most favorable ones, they had a similar impact on increasing enzyme activity.

Light technology maintains food fresher for longer and consequently solves the world's hunger. Since the global population has been predicted to be more than nine billion in 2050, it is forecasted that demand for food will increase by 70 percent – and technology could play a significant role in bridging the gap. The team of scientists behind the invention claims that they used relatively cheap laser equipment for growing crops including tomatoes, cucumbers, radishes and dill more quickly and with higher yields. In a greenhouse, the prototype equipment moves through rows of plants blasting them with light leading to boosting their growth and killing their diseases. The researchers behind the invention say the technique produces ecologically clean plants since no pesticides or other chemicals are needed to fasten their growth. It has been Proved That Blue Lasers Stimulate the Flowering of Rice and the Its Grain Production. The plasmalemma, mitochondrial and chloroplast membranes, endoplasmic reticulum, possibly the cell nuclei and the embryo of the seeds are the locations of phytochrome. In addition to the photoreceptors that are responsible for absorbing light, a system of interconnected membrane structures operates in the cell and accounts for utilization and transformation of the absorbed energy from light. Due to the transformation of light energy to chemical energy, the physiological and biochemical processes are initiated by the energy from the laser light absorbed in the seed. In addition, experimental laboratory and field tests have been conducted whose reports exist in the scientific literature, indicating the impacts of laser therapy on different seeds, seedlings, plants and irrigation water. There are other studies on laser irradiation in agriculture indicating its potential function as an herbicide, insecticide, and fungicide as well as in pollination process.

CONCLUSIONS

1. The laser is a great tool in agriculture.
2. It has a great effect on seed characteristics.
3. Laser irradiation for biostimulation can have positive, negative or no effects.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between the authors. Author SASN designed the study and author AHAM wrote the first draft of the manuscript and managed the literature searches. The authors read and approved the final manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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