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LASER- INDUCED ENHANCEMENT OF SEED GERMINATION AND EARLY GROWTH IN LEGUMES

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ABSTRACT

Laser technologies are emerging as promising tools in precision agriculture for enhancing plant development and productivity. This study investigates the effects of low-power laser irradiation (532 nm, 1W) on the seed germination and early growth of mung beans (Vigna radiata). Seeds were exposed to laser light prior to planting, and their germination performance, leaf expansion, chlorophyll content, and shoot length were measured and compared to untreated control seeds. The laser-treated seeds exhibited a higher germination rate, faster emergence, and greater vigor index compared to controls. Additionally, the SPAD chlorophyll index indicated enhanced photosynthetic potential in the treated group. These results support the hypothesis that laser-induced energy absorption enhances metabolic activation during germination and improves early-stage plant development. This approach provides a clean, residue-free method for promoting crop growth and offers new opportunities for sustainable agriculture.

Keywords: Legume, laser-induced germination, early growth.

INTRODUCTION

In recent years, laser technology has been increasingly explored in the agricultural sector for its potential in enhancing seed performance and plant growth (Hasan, 2021). Seed priming with lasers, particularly using low-power monochromatic light, has shown promise in stimulating enzymatic activities, cellular metabolism, and physiological responses that lead to improved germination and seedling vigor. Among various wavelengths, green lasers (532 nm) have demonstrated effective interaction with plant biomolecules, facilitating energy transfer and biological activation. This study focuses on evaluating the biological response of mung bean seeds to green laser exposure at a controlled power and time duration, with the aim of assessing its feasibility as a pre-sowing treatment in precision agriculture.

MATERIALS AND METHODS

Mung bean (Vigna radiata) seeds, screened for uniformity in size and weight, were subjected to laser irradiation utilizing a green diode-pumped solid-state (DPSS) laser operating at a wavelength of 532 nm with a 1 W output power. Individual seeds were irradiated directly at the

hilum region for a duration of 99 seconds within a stationary apparatus under controlled ambient conditions. The experiment was structured with a treatment group (laser-irradiated seeds) and an untreated control group, each comprising three replicate pots with five seeds sown per pot. All replicates were cultivated under identical conditions of light, temperature, and irrigation. To evaluate the effects of the laser treatment, the germination rate was determined by daily counts over a seven-day period, while shoot length and leaf area were measured at 10 and 20 days post-sowing. Additionally, the relative chlorophyll content was quantified as a SPAD value using a SPAD-502 chlorophyll meter.

RESULTS & DISCUSSION

Irradiation of Vigna radiata seeds with a 532 nm laser at 1 W for 99 seconds resulted in a significant enhancement of both germination and early seedling growth. The laser-treated cohort achieved a 100% germination rate, in stark contrast to the untreated control group which exhibited asynchronous germination and diminished seedling vigor. Furthermore, plants developed from the irradiated seeds displayed demonstrably greater shoot length, increased leaf area, and higher SPAD values, indicative of an elevated relative chlorophyll content. These results strongly suggest that the laser exposure augmented the seeds' physiological activity, potentially through photostimulation of the hilum, which in turn may have facilitated more efficient water imbibition and the mobilization of metabolic energy required for robust growth.

CONCLUSIONS

The application of green laser irradiation serves as an effective physical method for stimulating germination and enhancing the early seedling vigor of Vigna radiata. The significant improvements recorded in key agronomic parameters, including germination rate, shoot elongation, and relative chlorophyll content, underscore the potential of this technique as a straightforward, non-chemical, and environmentally benign tool for crop enhancement within the framework of sustainable agriculture.

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