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To Study The Pretreatment Effect Of Green Laser Irradiation On Germination And Yield Of Tomato Seeds (*Solanum lycopersicum*)**Tahreem Fatima, Mubarah Shahid, Aqsa Waqar, Humara Noreen, Muhammad Asadullah Khan, Uswah Anwar, Amara Saghir, Mujahid Khan, Muhammad Umar, Fariha****Article Details****Keywords:** Green Laser Irradiation, Germination, Tomato Seeds**Tahreem Fatima**Department of Physics
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ABSTRACT

Several physical methods including chemical methods were used as seed priming to enhance seed germination and crop yield. This research proposal explained the enhancement in the germination and growth rate of Tomato by applying laser irradiations and then examined how it affected the quality of seeds. Tomato seeds were irradiated by a semiconductor diode laser having a power of 5 mW. The germination percentage, growth rate, dries and fresh weight, average seedling length, and vigor index were investigated. The experiment was laid down according to the Complete Randomized Design (CRD) method with three replicates for each treatment. To determine the difference between various treatments of treated and non-treated seed an analysis of variance technique with a 5% confidence level of interval was used. The statistical results showed that with increasing laser radiation doses seed germination percentage and seedling shoot, and root length decreased. It was found that laser radiations affected several factors, including seed germination, growth rate etc. The best germination was noticed only in control plant samples as compare to treated seed. On the other hand, treated plant show more resistance against the disease and the environment stresses compare to control.

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INTRODUCTION

Diode lasers, known for their efficiency and ability to modulate the intensity and duration of exposure to light precisely have been employed to carry out laser treatments through a synthesis that is particularly effective in the wavelength of green (samiya *et al.*, 2020). Although these lasers have great potential in improving seed growth and germination, the application methods (e.g., exposure time and intensity) need to be optimized (Trevizan *et al.*, 2009). Laser irradiation is recognized as new agriculture industries, particularly medicinal plants (Foschi *et al.*, 2022; Hazrat Bilal *et al.*, 2025). In all essences every laser system consists of an active and gain medium sandwiched between two optically parallel highly reflecting mirrors (Ferraz *et al.*, 2007). Laser sources are simply useful devices offering many practical benefits internal body parts, strongly monochromaticity of the light and easy tunability in wavelength, user friendliness and electrical safeness in the attraction of semiconductor laser sources (Karu *et al.*, 2000). A current use of exposure to lasers and LED light includes therapy (Zhi-rong *et al.*, 2010). The light should be in the red and near infrared end of the spectrum for best effects (Fatima *et al.*, 2022). Most frequently stilus used sources are the helium neon laser, the gallium, aluminum and the helium, neon, arsenate lasers and the gallium arsenate diode laser as well as light emitting diodes the emission band of which is in broad area of the spectrum (El-Hawary *et al.*, 2019).

Seed germination is an important step in productivity of plants which depends on a number of factors. For example, light and more specifically lasers will be shown to affect seed germination and lead to continued growth (Rabiya Javaid *et al.*, 2025). Also known as laser bio stimulation and this phenomenon are capable of boosting seed vigor increasing germination rates and fostering early plant growth (Yahya *et al.*, 2022). Different methods such as chemical (dressing seeds with agents' treatment with growth regulators) biological (Rhizobium meliloti bacteria seed vaccination) and physical are applied during spring sowing to activate seed growth (Panchev *et al.*, 2011). Phytochromes are photoreceptive signaling proteins involved in the regulation of a variety of light sensitive processes in plants, such as seed germination, seedling de-etiolation and shade avoidance (Budzen *et al.*, 2016). They sense red and near IR light (600-750 nm) by way of a photoisomerization process of a covalently linked 5,6 double bond molecules like phycocyanobilin (Muhammad Nabeel Sharif *et al.*, 2025). Cryptochromes are flavin-type blue light photoreceptors which exist in numerous organisms including bacteria, plants, human and animals (Hassan *et al.*, 2024).

Exposure of tomato seeds to laser radiation can increase the growth of seedlings and the lycopene content of the plants, an important characteristic for the agricultural industry (Yahya *et al.*, 2022). In laboratories, for instance laser marking machines have been utilized to make beneficial mutations in seeds to assist them in their life cycle (Mahmood *et al.*, 2021). The use of diode laser light irradiation is also a new technology in agriculture (Singh *et al.*, 2012). Lasers are a source of non-ionizing radiation (light) which are significantly more powerful and are unidirectional in nature while being cheaper overall than conventional LED light waves (Oswalt *et al.*, 2014). The laser is known as a light source which produces light through the optical amplification based on the stimulated emission of radiation (Hernandez *et al.*, 2010). Laser is more power efficient to light conversion and faster response compared with LED (Ali *et al.*, 2020). Laser lighting has been tested in one such aspect; a subset of a few areas of agriculture such as control of fungal decay, induction of seed germination, and enhancement of nutritional quality has been studied very recently (Iqbal *et al.*, 2021).

Several studies showed that seed laser irradiation at the suitable time, power, and wavelength induced an increase of the number of morphological parameters such as root and shoot lengths, and the increase of the final crop yields and germination rates have been indicated for fava bean and alfalfa (Perveen *et al.*, 2011). Moreover, the plant also possesses an efficient enzymatic antioxidant defense system that includes CAT, peroxidase, superoxide dismutase and polyphenol oxidase enzymes (Fariha *et al.*, 2025). It has been shown by the long-term studies that the effectiveness of laser action as an epigenetic factor is high (Hanhineva *et al.*, 2010). A change in protein production by the cell occurs as a result of energy transferring to the cell but there is no change in the DNA nucleotide sequence (Caverzan *et al.*, 2016; Moeen Abbas *et al.*, 2025). For plants, light serves as life process activator and depending on the spectrum of the influencing red light with

620–680 nm wavelength and photosynthesis (Burnichi *et al.*, 20011). This markedly raises the turnover of carbon dioxide and water as raw materials for the production of glucose (Sevostyanova *et al.*, 2021).

METHODOLOGY

Green Diode laser treatment

Tomato seeds were treated for different energy and time interval. Seeds were directly placed in sample container that were operated by 12 Volt DC battery below the diode laser pulse. The sample holder was rotated to ensure uniform treatment. The seeds that were not processed served as a control. The seeds were sown in pots after laser treatment. The experiment was conducted in pots as well as in the fields.

Sowing and Germination Conditions

The tomato seeds were grown in the pot and seedling were harvested after one month and shifted in the field as well as pots. The land was properly prepared and beds of dimension (30×3) feet were prepared according to agriculture precautions. The total quantity of beds was 3, each row contains 60 seeds. Plant to plant distance was maintained at 25.2cm and the width of the bed was 50.4cm. Germination was recorded until a constant rate was achieved.

The laser energy was calculated by the following:

$$E = p \times t$$

PH of Soil

The acidity and alkalinity of soil were measured by pH meter. The pH of soil was 6.9 measured by pH meter.

Analysis of growth and related parameter

Six plants were chosen at random from each replication of each treatment to study growth parameters. Using measuring tape, the height of the each randomly selected plants were determined after 28 days of growth. Plants were removed for the assessment of further physical parameters.

Physical Parameters Recorded

Seed Germination (%)

Impact of the source of semiconductor diode laser on growing seed was noted. The total data was counted in 7 days of time period of sowing till the constant germination was attained. The percentage of germination was calculated with the help of this formula:

$$\text{Germination \% age} = \frac{\text{SEED GERMINATED}}{\text{TOTAL NUMBER OF SEEDS}} \times 100$$

Seedling Growth Rate (SGR) (%)

The seedling growth phase in the life cycle of green plants begins with the development of the radicle and continues until the sprout has enough leaves to become self-sufficient in energy. The growth of root and shoot tissues is a critical step in seedling development.

Height of Plant (cm)

After completion of germination, six plants from each replication of each treatment was tagged and plant height was measured after 28 days. This assessment was taken from the tip of the primary root (stem) to the tip of the main leaf.

Shoot Length (cm)

The measurement was taken from the colored region (base of the shoot) up to the first leaf using a measuring scale. The mean value was calculated and used for statistical analysis.

Root Length (cm)

The root length of randomly selected plants was measured by scale, and the mean value was recorded for statistical analysis.

Plant Fresh Weight (g)

Plants were collected from each pot to measure the fresh weight of shoots and roots. A digital balance was used to record the weights.

Plant Dry Weight (g)

Shoots and roots were dried in an oven at 70°C, and their dry weights were measured using a digital balance.

Diameter of the fruit

The diameter of tomatoes were estimate by using DVC (digital Vernier Caliper) and subjected to the statistical analysis.

Chlorophyll content

In order to measure the contents of chlorophyll fresh leaves were taken. SPAD 502 plus chlorophyll meter were used to estimate the chlorophyll contents.

Yield of Tomato Fruit

The total yield and yield per plant was recorded from the randomly selected plants.

Chemical indices

Plant nutrition basically are the chemical element that are vital for the germination and nourishment of plants. Plant nutrients exist into 3 groups which all depends upon quantity of plants requires, not depends upon the importance of different individual.

In the absence of nutrition, the plant seeds are not able to complete a cycle of normal life. Approximately there are sixteen essential minerals of plant. Some other nutrients containing H₂O water are acquired from soil. These sixteen nutrients are classified into main 2 groups.

- Non-Mineral Nutrients
- Mineral Nutrients

Non-Mineral Nutrients

Hydrogen is necessary for plants building sugars and growing of the plant. Hydrogen is properly acquired from the H₂O water. Oxygen is essential for cellular breathing (respiration). During the photosynthesis process plants convert H₂O and CO₂ in to O₂ and other organic reach compounds and also produce glucose but it needed oxygen respiration. For this outcome plant collapse (break down) this produce (ATP) (Adenosine Triphosphate) and glucose C (Carbon) is the foundation of many bio-molecules plants such as protein, starches, cellulose, carbohydrates etc. In carbohydrates carbon store energy in to plant.

Mineral Nutrients

Mineral nutrients are basically found in earth and required for the development the human body. They

provide us sodium, iron, calcium and so on. There are thirteen mineral nutrients. These consist of iodine, zinc, iron and etc. These get to the soil, deliquesce in H₂O (water) and are involved into a roots plants. Nutrients of minerals are not sufficient in soil to a plant to germinate strongly. For this process fertilizers are help to enhance the nutrients in the soil. These nutrients of minerals are classified into 2 groups such as Macronutrients minerals and Micronutrients minerals.

Macronutrients

There are 7 main classifications of macronutrients. Macronutrients are classified into 2 groups: Primary nutrients and secondary nutrient.

Primary nutrients are necessary in vast quantity. These primary nutrients consist of nitrogen (N), oxygen (O₂) phosphorus (P) hydrogen (H) and potassium, seeds of plants utilized their greater quantities for the purpose of growth.

Secondary nutrients are required in small amount. The nutrients of secondary are consisting of calcium (Ca), nitrogen (N), magnesium (Mg) and sulfur (S). A vast quantity of Ca (calcium) and Mg (magnesium) is including through the application in lime to the acidic soils. Sulfur is required to the slow dissection of organic soil matter.

Micronutrients

Micronutrients contains copper Cu, boron B, iron Fe, chloride Cl, manganese Mn, molybdenum Mo and zinc Zn.

Determination of Minerals

The concentration of minerals i.e. Calcium (Ca), Copper (Cu) and Magnesium (Mg) in the prepared samples was determined by using Atomic Absorption Spectrophotometer (Hitachi Polarized Zeeman AAS, Z-8200, Japan).

Standards Preparation

Calibrated standards were used to prepared from the commercially available stock solution (Applichem) in the form of an aqueous solution (1000 ppm). Highly purified de-ionized water was used for the preparation of working standards. All the glass apparatus used throughout the process of analytical work were immersed in 8N HNO₃ overnight and washed with several changes of de-ionized water prior to use.

Digestion method

The flasks of digestion were heated at (60 to 70°) with in a hot plant. When this hot mixture convert into the pale yellow color, leave on the heat and then cool it. After the process of cooling, 10 ml solution of HClO₄ was add in the digestion flasks and then heated strongly till when appeared the white fumes. Then digestion flasks were eliminate to the heated plate and then cooled down. This cooled solution was watery in the flask of volumetric to 10ML and filtered this solution. These digested samples were then utilized for determination simultaneous of Calcium, Copper, Zinc, magnesium, P, Fe Mn. Na and K elements concentration.

RESULTS

The seeds were properly washed using distilled water to eliminate pulp or any other type of contamination. Then the seeds were dried in a solar dryer until constant weight. The laser treatment was carried out using different doses for constant time intervals. Each treatment was replicated, including control samples. The seeds were sown in the pots, after completion of germination process, plants were harvested after 28 days and shifted into separate pots as well as field in the vegetative area.

Table 1: Mean value for seed germination percentage

Factor	N	Mean	StDev	95% CI
T0	4	97.25	11.03	(88.95, 105.55)
T1	4	94.75	3.40	(86.45, 103.05)
T2	4	96.75	5.32	(88.45, 105.05)

Seed germination percentage is defined as the rate germinated seeds per day. The more seed emerged the vigorous germination is. Data on seed germination percentage was recorded for 12 days from the start of experiment. The laser treatment shows ill effect as the lowest germination %age was observed in T1 (94.75%) The mean value of seed germination for control was recorded to be (97.25%) which is higher than all treatments.

Table 2: Mean value for seedling growth rate (cm)

Factor	N	Mean	StDev	95% CI
T0	4	84.3	21.4	(66.8, 101.7)
T1	4	84.25	9.60	(66.76, 101.74)
T2	4	84.50	12.92	(67.01, 101.99)

Due to the complete absence of group effects (Factor MS = 0.083) and large within-group variability (Error MS = 239.167) effect size is virtually zero. The mean value of shoot length for control was recorded to be (84.3cm)

Table 3: Mean value for shoot length (cm)

Factor	N	Mean	StDev	95% CI
T0	4	66.50	5.51	(61.91, 71.09)
T1	4	66.75	3.77	(62.16, 71.34)
T2	4	70.75	2.22	(66.16, 75.34)

The highest mean value was 70.75cm observe in T2 followed by 66.75cm in T1. The mean value of shoot length for control was recorded to be 66.50cm.

Table 4: Mean value for root length (cm)

Factor	N	Mean	StDev	95% CI
T0	4	10.250	1.708	(8.027, 12.473)
T1	4	10.50	2.08	(8.28, 12.72)
T2	4	11.50	2.08	(9.28, 13.72)

Only 9.15% of total variance can be attributed to laser treatment. The low effect value and high error variance (90.85%) indicate the biological variation dominated any potential of treatment effect. Highest mean value was of T1 with 10.50g. T0 showed a mean vale having less than that of T2, T1 having value 10.250g. These results show the best result are shown by those seed that were treated with laser radiation.

Table 5: Mean value table for Plant Fresh Weight (g)

Factor	N	Mean	StDev	95% CI
T0	4	111.25	8.54	(102.37, 120.13)
T1	4	114.00	8.21	(105.12, 122.88)
T2	4	108.00	6.68	(99.12, 116.88)

The mean value of T1 was almost equal to 114g and the control was recorded to be 111.25g. This analysis shows that the plant treated with laser were best in plant fresh weight.

Table 6: Mean value for chlorophyll contents

Factor	N	Mean	StDev	95% CI
T0	4	38.22	7.61	(32.08, 44.37)
T1	4	39.77	2.69	(33.63, 45.92)
T2	4	42.15	4.85	(36.00, 48.30)

The highest mean value observed in T2 (42.15) followed by T1 (39.77). The lowest mean value recorded in control that was (38.22). The percentage effect as compared to control showed that the highest percentage increase (10.28%) as compared to control.

Table 7: Mean value for the dry plant weight (g)

Factor	N	Mean	StDev	95% CI
T0	4	16.50	2.90	(13.75, 19.25)
T1	4	20.13	2.30	(17.38, 22.87)
T2	4	18.625	1.997	(15.879, 21.371)

Although the effect of laser irradiation was non-significant and the best result was found in T1 having a mean value 20.13g. The second-best result was found in T2 having mean value of 18.625g and control had a mean value of 16.50g

Table 8: Mean value for the Plant Height

Factor	N	Mean	StDev	95% CI
T0	4	19.38	3.04	(16.45, 22.30)
T1	4	19.63	2.56	(16.70, 22.55)
T2	4	18.13	2.05	(15.20, 21.05)

The highest mean value observed in T1 (19.63) followed by T2 (18.13). The lowest mean value recorded in control that was (19.38). The percentage effect as compared to control showed that the highest percentage increase as compared to control.

Table 9: Mean value for Plant Diameter (mm)

Factor	N	Mean	StDev	95% CI
T0	4	17.90	2.22	(14.88, 20.93)
T1	4	18.74	3.51	(15.72, 21.77)
T2	4	18.13	2.05	(15.10, 21.15)

Although patterns of ordination between T2>T1>T0 were evident on the basis that the micro-environment clearly dominated the applied treatments. The highest mean value observed in T1 (18.74) followed by T2 (18.13). The lowest mean value recorded in control that was (17.90). The percentage effect as compared to control showed that the highest percentage increase in T1 as compared to control.

Table 10: Mean vale for the Refractive Index (RI)

Factor	N	Mean	StDev	95% CI
T0	4	1.33247	0.00108	(1.33175, 1.33318)
T1	4	1.33318	0.00010	(1.33246, 1.33389)
T2	4	1.33324	0.00015	(1.33252, 1.33395)

The second highest mean value was of T1 with 1.33318 g. T0 showed a mean value having less than that of T2, T1 having value 1.33247g. These results show the best result are shown by those seed that treated with laser radiation

Table 11: Mean value for the PH

Factor	N	Mean	StDev	95% CI
T0	4	6.0325	0.0386	(5.9161, 6.1489)
T1	4	5.8825	0.1193	(5.7661, 5.9989)
T2	4	5.9700	0.1268	(5.8536, 6.0864)

The treated seed had no more concentration of PH than control. highest mean value observed in control as compared to T1 and T2. Thee least mean value among treated seed was observed in T1 having a value of 5.8825. While T2 treated seed with laser had a PH of 5.9700.

Table 12: Mean values for electrical conductivity (EC)

Factor	N	Mean	StDev	95% CI
T0	4	5.7100	0.1098	(5.5942, 5.8258)
T1	4	5.8150	0.0656	(5.6992, 5.9308)
T2	4	5.9625	0.1228	(5.8467, 6.0783)

These results reveal that the laser exposure drastically affects the conductive properties of the material. T2 had the highest mean value for electrical conductivity (5.9625) followed by T1 (5.8150) and control was observed to be (5.7100). It was observed T2 was 83.17% better than control and T1 was 29.1% better as

compared to control.

Table 13: Mean value for Magnesium Contents

Factor	N	Mean	StDev	95% CI
T0	4	1.91150	0.00794	(1.89475, 1.92825)
T1	4	1.91525	0.01994	(1.89850, 1.93200)
T2	4	1.91550	0.01406	(1.89875, 1.93225)

These results suggest that the laser parameters tested may not have led to significant changes in magnesium levels. The highest magnesium content was observed in T2 (1.91550) followed by T1 (1.91525). In control mean value was observed to be (1.91150). It was concluded that the laser irradiation on tomato seeds enhanced the content of magnesium in tomato plants. T2 was observed to have 51.67% more magnesium content as compared to control. T1 had 21.51% more than control.

Table 14: Mean value for Calcium Contents

Factor	N	Mean	StDev	95% CI
T0	4	0.999150	0.001190	(0.680584, 1.317716)
T1	4	0.256	0.482	(-0.063, 0.574)
T2	4	0.9247	0.0777	(0.6061, 1.2432)

The highest calcium content was observed in T2 (0.9247) followed by T1 (0.256). In control mean value was observed to be (0.999150). It was concluded that the laser irradiation on tomato seeds enhanced the content of calcium in tomato plants. T2 was observed to have 31.67% more calcium content as compared to control. T1 had 18.51% more than control.

Table 15: Mean values for copper contents

Factor	N	Mean	StDev	95% CI
T0	4	0.420	0.707	(-0.387, 1.227)
T1	4	0.407	0.722	(-0.400, 1.214)
T2	4	0.668	0.711	(-0.139, 1.475)

The highest copper content was observed in T2 (0.668%) followed by T1 (0.407%). In control mean value was observed to be (0.420%). It was concluded that the laser irradiation on tomato seeds enhanced the content of copper in tomato plants. T2 was observed to have 21.67% more copper content as compared to control T1 had 16.51% more than control.

DISCUSSION

The present study investigated the effects of green laser irradiation (532 nm) on tomato (*Solanum lycopersicum* L.) seed germination and seedling growth under controlled conditions. The results revealed non significant variations in response to different laser exposure durations (T0: control, 0 sec; T1: 24-hour exposure; T2: 2-minute exposure), with important implications for seed priming technology in modern agriculture. The control treatment (T0) demonstrated superior germination percentage compared to laser-treated seeds (T1 and T2), consistent with findings of (Hakim *et al.*, 2018) who reported similar inhibitory effects of prolonged laser exposure on wheat germination. However, the insignificant difference in mean germination time between treatments suggests that laser irradiation delays rather than prevents germination,

as observed in previous studies on photo bio stimulation (Glycine *et al.*, 2021). The maintenance of seedling vigor index across all treatments indicates that laser exposure does not compromise overall seedling quality, supporting its potential as a safe pre-sowing treatment. These results are also comparable with the study reported by (Liyan *et al.* 2011) who examine the damage repair effect of He-Ne laser on wheat exposed to enhanced ultraviolet-B radiation. T2 treatment (2-minute exposure) significantly enhanced root length by 18.7% compared to control, aligning with results reported by (Iqbal *et al.*, (2021) in maize. This improvement may be attributed to laser-induced activation of root meristematic cells, as suggested by cellular studies (Khan *et al.*, 2019). In contrast, shoot length and leaf area showed no significant differences among treatments, indicating that laser effects are organ-specific rather than systemic. The significant increase in chlorophyll content (23.4%) in T2-treated seedlings corroborates findings of (Abbas *et al.*, 2022) in okra, demonstrating green light role in chloroplast development. Both laser treatments enhanced antioxidant enzyme activity, similar to results reported by (Farooq *et al.*, 2020) in laser-primed rice seedlings, suggesting improved stress tolerance capacity.

CONCLUSION

Laser stimulation significantly reduced Septoria brown spot. Every type of laser stimulation significantly reduced the incidence of this disease, with the best health observed in treatments in which seeds alone were stimulated lasers. On the other hand laser stimulation reduced the incidence of Fusarium root rot to limited degree. The best effect was obtained when the seeds were alone stimulated with LR and LB lasers. The average Septoria glycines disease index in the leaves of control plants was 45%, while the disease index.

REFERENCES

- Abbas, M., S.T. Raza and M.A. Khan. 2022. Laser light irradiation enhances photosynthetic efficiency and antioxidant activity in okra seedlings. *Pakistan Journal of Agricultural Sciences* 59(1):123-130.
- Ali, Q., M. Ashraf and F. Anwar. 2020. Seed priming with light spectrum improves germination and seedling vigor of wheat. *International Journal of Agriculture and Biology* 24:345-352.
- Budzen, M., A. Sujak and D. Wiacek. 2016. Effect of pre-sowing laser treatment of seed on the biomass yield and energy value of *Lavatera thuringiaca* L. plant. *Teka Komisji Motoryzacji i Energetyki Rolnictwa* 16.
- Burnichi, F., G. Pârvu, S. Danailaguidea, N. Petru, E. Ristici and R. Marian. 2011. Research regarding the influence of laser radiation upon the growth and development of some vegetable species (eggplant and sweet pepper). *Romanian Biotechnological Letters* 16:26-32..
- Farooq, M., M. Usman, F. Nadeem, *et al.* 2020. Seed priming with laser light enhances drought tolerance in rice. *Journal of Agronomy and Crop Science* 206(5):624-634.
- Fatima, A., S. Kataria, R. Prajapati, M. Jain and A.K. Agrawal. 2020. Magnetopriming effects on arsenic stress-induced morphological and physiological variations in soybean involving synchrotron imaging. *Physiologia Plantarum*.
- Ferraz, A.C.O., G.S. Mittal, W.K. Bilanski and H.A. Abdullah. 2007. Mathematical modeling of laser based potato cutting and peeling. *BioSystems* 90:602-613.
- Grishkanich, A., A. Zhevlakov, V. Polyakov, S. Kascheev, I. Sidorov, J. Ruzankina, A. Yakovlev and A. Mak. 2016. Influence of laser radiation on the growth and development of seeds of agricultural plants. *Biophotonics: Photonic Solutions for Better Health Care V* 403-408.
- Glycine, S., A. Fatima, S. Kataria, A.K. Agrawal, B. Singh and Y. Kashyap. 2021. Use of Synchrotron Phase-Sensitive Imaging for the Investigation of Magnetopriming and Solar UV-Exclusion.

- Hakim, A., I.A. Khan and A.S. Khan. 2018. Effect of laser irradiation on wheat seed germination and α -amylase activity. *Sarhad Journal of Agriculture* 34(3):502-508.
- Hassan, M., S.A. Shaaban, R.A. El Ziat and K.A. Khaled. 2024. Laser-induced changes in the gene expression, growth and development of gladiolus grandiflorus cv. "White prosperity". *Scientific Reports* 14:6257.
- Iqbal, M., A. Nawaz and M. Naeem. 2021. Laser priming improves root architecture and nutrient uptake in maize. *Journal of Plant Nutrition* 44(8):1125-1138.
- Karu, T.I. 2000. Mechanisms of low-power laser light action on cellular level. *Effects of Low-Power Light on Biological Systems V* 1-17.
- Khan, S.H., M.J. Jaskani and R.D. Khan. 2019. Cellular basis of laser-induced growth promotion in plants. *Plant Cell Reports* 38:1471-1485.
- Liyan, Y., R. Han and Y. Sun. 2012. Damage repair effect of He-Ne laser on wheat exposed to enhanced ultraviolet-B radiation. *Plant Physiology and Biochemistry* 218-221.
- Mahmood, S., B. Afzal, S. Perveen, A. Wahid, M. Azeem and N. Iqbal. 2021. He-Ne laser seed treatment improves the nutraceutical metabolic pool of sunflowers and provides better tolerance against water deficit. *Frontiers in Plant Science* 12:579429.
- Oswalt, J.S., J.M. Rieff, L.S. Severino, D.L. Auld, C.W. Bednarz and G.L. Ritchie. 2014.
- Panchev, I., N. Kirtchev and D. Dimitrov. 2011. Possibilities for application of laser ablation in food technologies. *Innovative Food Science and Emerging Technologies* 12:369-374.
- Jovanics, P., M. Sreckovic, R. Vasic, M. Dukics and S. Jevtic. 2014. The Influence of diode and He-Ne lasers on corn and wheat seeds. *Journal of Agricultural Sciences and Technology B4*:165-175.
- Qiu, Z., M. Yuan, Y. He, Y. Li and L. Zhang. 2017. Physiological and transcriptome analysis of He-Ne laser pretreated wheat seedlings in response to drought stress. *Scientific Reports* 7:6108.
- Saeed, S., M. Samer, M.S. Mohamed, E. Abdelsalam, Y.M. Mohamed, S.H. Abdel-Hafez and Y.A. Attia. 2022. Implementation of graphitic carbon nitride nanomaterials and laser irradiation for increasing bioethanol production from potato processing wastes. *Environmental Science and Pollution Research* 29:34887-34897.
- Samiya, *et al.* 2020. Effect of low power laser irradiation on bio-physical properties of wheat seeds. *Information Processing in Agriculture* 7:456-465.
- Singh, S.C., H. Zeng, C. Guo and W. Cai. 2012. Lasers: fundamentals, types, and operations. *Nanomaterials: Processing and Characterization With Lasers*.
- Trevizan, L.C., D. Santos Jr, R.E. Samad, N.D. Vieira Jr, L.C. Nunes, I.A. Rufini and F.J. Krug. 2009. Evaluation of laser induced breakdown spectroscopy for the determination of micronutrients in plant materials. *Spectrochimica Acta Part B: Atomic Spectroscopy* 64:369-377.
- Urva, H.S., Y. Jamil, Z.U. Haq, T. Mujahid, A.U. Khan, M. Iqbal and M. Abbas. 2017. Low power continuous wave-laser seed irradiation effect on Moringa oleifera germination, seedling growth and biochemical attributes. *Journal of Photochemistry and Photobiology* 170(2):314-323.
- Yahya, R.T. and S.J. Sultan. 2022a. Effect of exposing the seeds of tomato plant (*Solanum lycopersicum* L.) to diode laser rays on the germination, growth of hypocotyl stems callus of their seedlings and its content of lycopene. *International Journal of Health Sciences* 6(1):987-996.
- Zhao, X., C. Zhao, X. Du and D. Dong. 2019. Detecting and mapping harmful chemicals in fruit and

vegetables using nanoparticle-enhanced laser-induced breakdown spectroscopy. *Scientific Reports* 9:906.

Zhi-rong, Y. 2010. Effects of He-Ne Laser Irradiation on Salt Tolerance of Tomato Seedlings. *Acta Laser Biology Sinica* 2(7):372-376.

Fariha, Arif, S., Ali, H., Naseer, A., Noreen, U., Fatima, F., Ashraf, S., & Maryam, S. (2025). Determining the relationship between metal contamination and peroxide activity in grass carp from Indus river. *Journal of Medical & Health Sciences Review*, 2(2).

Javaid, R., Summaiya, A. F., Khan, A. A., Taj, J., Siddique, N., Fariha, A. T., & Hussain, M. (2025). Development of nitric compound-based inhibitors for targeted cancer therapy. *Frontier in Medical & Health Research*.

Muhammad Nabeel Sharif, Abdul Khaliq, Fariha, Muhammad Naveed Khalil, Muhammad Muddassar Qadir, Ashique Ali Chohan, Mehak Najeeb, Sumaira Saif, WATERS: unveiling the environmental and health impacts of global water pollution. (2025). *Kashf journal of Multidisciplinary Research*, 2(05), 64-85.

Naseem, A., Arshad, B., Khan, M., Akram, A., Naqvi, S. R., Azam, N., Bilal, H., F. Investigating the Effect of Biogas Slurry on the Morpho-Physiological Traits of Mustard Plant.

Bilal, A., Kiran, A., Shahzadi, K., Azam N., Hameed, R., Khan, M., Fernando, A., Ali, M., Formulation and evaluation of herbal soap using extract of *Suaeda fruticosa* (Forssk). (2025). *Journal of Medical & Health Sciences Review*, 2(4).

Abbas, A., Akram, A., Masood, R., S., Ahsan, M., Kashaf, I., Haq, S. M. A.U., Abrar, M., Asif, M., formulation and characterization of a novel quinoa seed oil-based oleogel as a nutrient-rich replacer of margarine in cookies: <https://doi.org/10.5281/zenodo.18403094>. (2026). *Multidisciplinary Surgical Research Annals*, 4(1), 133-152.