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Advanced Seed Invigoration Treatments for Enhancing Seed Quality

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Seed treatment encompasses the application of an array of physical, chemical, and biological agents and methodologies to seeds, serving to fortify them against adverse conditions and bolster the establishment of robust crops. The genetic constitution dictates seed quality, which may deteriorate during subsequent stages such as harvesting, threshing, processing, and storage. Remediation of low-vigour seeds is achievable through diverse seed treatment modalities, thereby enhancing the availability of high-quality seeds. The term "seed treatment" is inclusive, denoting the exposure of seeds to compounds (nutrients, chemicals, hormones), processes (e.g., wetting and drying), or energetic forces (e.g., heat radiation, electricity, magnetism), all aimed at augmenting the planting efficacy of the seeds.

An array of refined seed treatment methodologies presents a promising avenue for enhancing crop performance and resilience. These methodologies, characterized by their non-destructive nature, cost-effectiveness, environmental friendliness, and expeditiousness, including emerging techniques such as magnetic field, electric field, ultrasound, ozone, microwave, and laser treatments, exert a profound influence on seed quality, storage, and performance throughout the stages of seed production and agricultural cultivation. These interventions instigate changes at the cellular and molecular levels, precipitating enhancements in physiological and biochemical processes within seeds, encompassing shoot and root elongation, photosynthetic efficiency, plant nutrient uptake, and the modulation of gene expression associated with photoreceptors (Marcu et al., 2013).

Emerging Technologies

Electric field seed treatment, Magnetic field seed treatment, Microwave seed treatment, X-rays seed treatment, Ultrasonic seed treatment, Laser seed treatment, Electron beam seed treatment, Ozone seed treatment, Cold plasma seed treatment, Chitosan seed treatment, Endophyte seed treatment, Intelligent seed coating.

Electric field seed treatment: Space surrounding an electric charge or a group of charges in which another charge experiences a force is said to constitute an electric field. Two electrodes are there, supply high voltage, disk will be there to contact between seed and direct electrode. Electric field passed it triggers ROS and enzymatic activity and other metabolic activity and germination increased.

Magnetic field seed treatment: Magnetic seed treatment is one of the pre-sowing seed treatments which involve **exposure of seeds to a magnetic field,** Magnetic Field is the region around a magnet where its pole exhibits a force of attraction or repulsion. Tesla: The unit of magnetic flux density.

Ultrasonic seed treatment: Mechanical form of energy, due to pressure variances in medium it propagates as waves from a vibrating source (sensation of hearing)

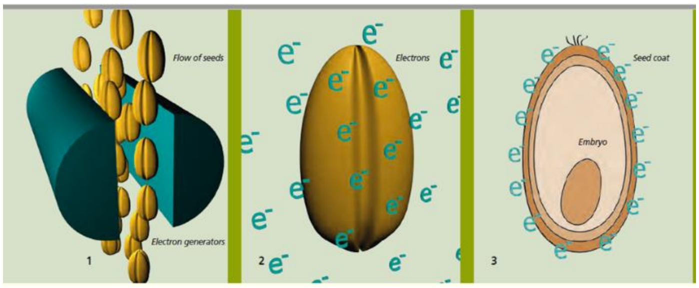
- Sonic (20 hz to 20,000 hz)
- Infrasonic (< 20 hz)
- Ultrasonic (> 20,000 hz)

It is one othe fast, water saving and energy saving technique. When seeds are treated with leads to creation of pores, increases water uptake, oxygen availability, increases uptake of nutrients into seed, increases mass transfer thereby increases gibberlic acid and increases metabolic process and germination.

Electron beam seed treatment: Set of electron beam is available. When electric current passes through this leads to generation of electrons. Treatment duration and strength of current varies from crop to crop.

Laser seed treatment

Monochromatic, linear polarization, coherence and high density due to these properties it can be used widely. Lens are mounted into a mechanical support to eliminate light scattering, partial screening of seeds. Protect seeds against fungal diseases, break dormancy, trigger biological reactions - influence alpha-amylase activity, depends on radiation dose, intensity, plant material thickness, distance between source -material and absorption capacity. When laser is passed it triggers ROS and enzymatic activity and other metabolic activity and germination increased.

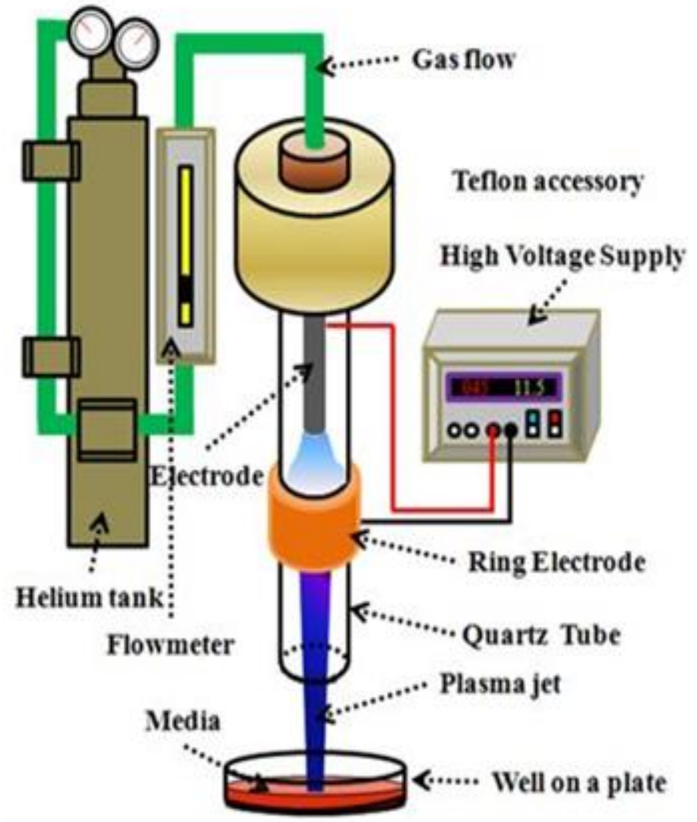


Endophyte Treatment: Endophytes, comprising fungi or bacteria, reside within a plant for a portion of its life cycle sans inducing disease pathology. Their presence fosters growth augmentation, facilitates nutrient assimilation, enhances tolerance to various abiotic stresses such as drought, and fortifies resistance against pests and diseases. This approach represents a non-invasive strategy aimed at mitigating crop damage.

Chitosan Seed Treatment: Chitin, a constituent of crustacean shells, insect cuticles, and fungal cell walls, serves as the precursor to chitosan, a carbohydrate biopolymer obtained through de-acetylation processes. Chitosan finds utility in diverse applications such as coating, dipping, and spraying. Its utilization promotes heightened water absorption, increased oxygen availability, enhanced nutrient uptake by seeds, augmented mass transfer processes, elevation of gibberellic acid levels, and stimulation of metabolic pathways conducive to germination.

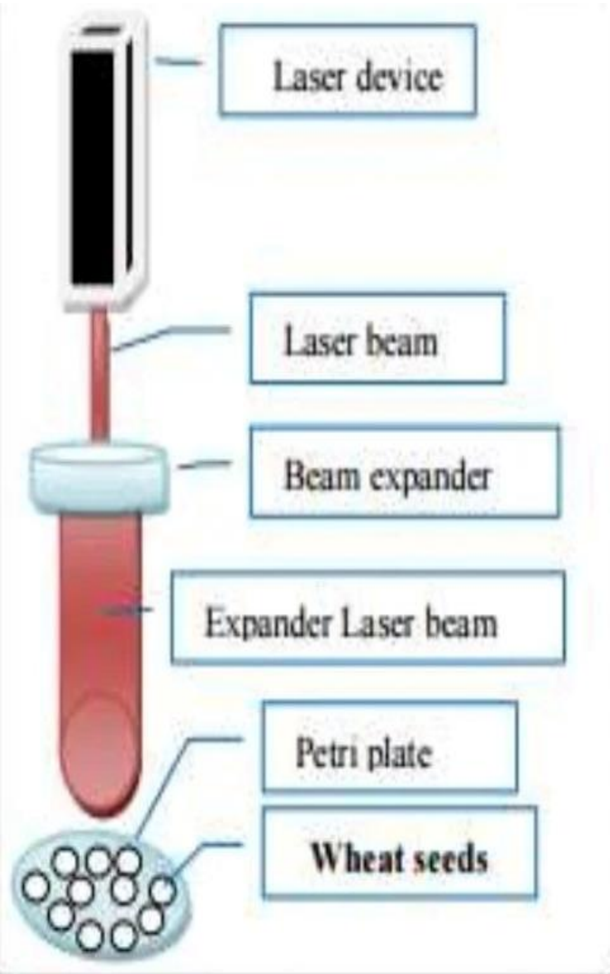
Cold Plasma Treatment: Cold plasma, representing an alternative state of matter, operates via principles of dissociation and ionization. Application of sufficient energy to gases such as helium, neon, argon, or oxygen cylinders engenders plasma production. Various methodologies, including dielectric barrier discharge and glow discharge tubes, facilitate plasma generation.

Ozone Treatment: Ozone, renowned for its potent oxidizing properties, exhibits solubility in water and remarkable proficiency in breaking down compounds, rendering it efficacious as a disinfectant capable of eradicating contaminants. The generation of ozone gas entails the passage of dry oxygen gas through a corona discharge-type O3 generator (specifically, the V can Network model M221), followed by its introduction into a concentration equalization tank and subsequent bubbling into deionized water facilitated by a gas diffuser.



Cold plasma treater

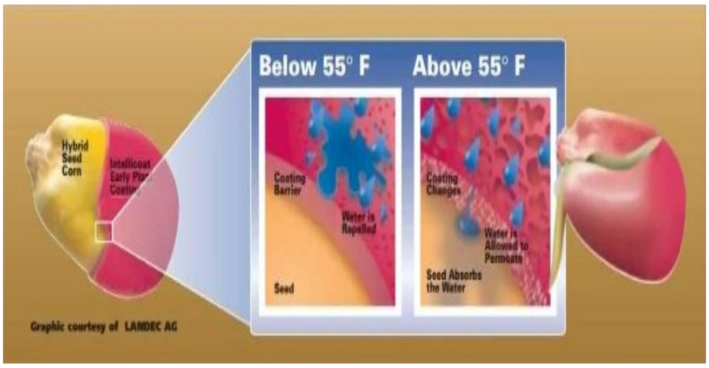
Intelligent Seed Coating: The process of intelligent seed coating involves the application of natural fatty acids extracted from seeds, such as those found in corn and soybeans, as a protective layer. This environmentally friendly approach yields a coating characterized by its hardness and crystalline structure. Operating on an on-off mechanism, the coating remains inert at temperatures below 55 degrees Celsius; however, when exposed to temperatures exceeding this threshold, it undergoes a transition into an amorphous state, facilitating water penetration and promoting uniform germination. Notably, this innovative technique is patented by LANDEC Corporation.



Laser treater

Pollinator Plus: The development of Pollinator Plus involves the utilization of polymers endowed with temporal responsiveness, enabling regulation of water uptake and facilitating the setting of the coating in accordance with varying heat units. Serving as an alternative method for staggered sowing, this technique entails the coating of male line seeds with fatty acids prior to sowing. While uncoated seeds exhibit active germination, coated seeds remain dormant until they reach the requisite heat unit threshold, thus optimizing germination timing.

Sudhakar et al. (2011), an experimental inquiry was undertaken to meticulously scrutinize the influence of ozone on mitigating tomato seed dormancy, with a specific objective aimed at delineating the role of oxygen gas generation in precipitating dormancy release. Their comprehensive analysis culminated in the pivotal observation that the application of ozone (O3) emerges as a critical phenomenon, significantly expediting seed



germination to an impressive rate of 86% by effectively rupturing the dormancy barrier. This remarkable enhancement was intricately linked with a discernible reduction in abscisic acid (ABA) levels, registering at a mere 0.3 mg in ozone-treated seeds in stark contrast to the control seeds, which exhibited a considerably lower germination rate of 72% alongside notably elevated ABA levels, reaching 1.8 mg.

In a parallel investigation conducted by Sharififar et al. (2015), an experimental paradigm was devised to meticulously assess the impact of ultrasonic wave exposure durations on the germination efficiency of seeds belonging to Atriplex lentiformis, Cuminum cymium, and Zygophyllum eurypterum, each manifesting initial germination rates of 40%, 45%, and 37%, respectively. Their exhaustive analysis yielded profound insights, revealing that ultrasonic treatment, particularly during effective exposure periods spanning 5 and 7 minutes, engendered markedly superior germination rates, reaching commendable levels of 70%, 80%, and 85%, respectively, for the aforementioned botanical species. However, prolonged exposure durations, such as 9 minutes, elicited a counterproductive effect, precipitating diminished germination rates, thus underscoring the nuanced dynamics inherent in ultrasonic treatment modalities.

Furthermore, Kataria et al. (2017) elucidated the profound impact of magnetic field application on the germination dynamics of maize and soybean seeds. Employing a magnetic field of 200 mT for a duration of 1 hour, their investigations sought to ascertain the efficacy of magneto-priming in ameliorating germination and early growth under saline conditions. Their findings underscored the deleterious impact of salt stress on germination rates, juxtaposed against the ameliorative effects of magneto-priming, which yielded a notable improvement of up to 19% in maize germination rates at a salinity level of 100 mM NaCl compared to untreated controls. Moreover, static magnetic field treatment elicited a substantial enhancement in germination rates for both maize (99%) and soybean (95%), outperforming control groups that registered germination rates of 85% for maize and 90% for soybean. This enhancement was attributed to heightened activities of α-amylase and protease enzymes, facilitating expedited enzyme hydration and consequent enhancement of germination rates.

Similarly, Szopinska et al. (2021) embarked on an extensive investigation aimed at elucidating the effects of microwave treatment, both dry and wet, on the germination dynamics and health status of carrot seeds. Employing two seed lots exhibiting initial germination rates of 50% and 29%, respectively, alongside varying degrees of infestation by pathogens such as *Alternaria alternata, Alternaria dauci*, and *Alternaria radicina*, their findings revealed significant reductions in seed infestation with *Alternaria spp*. following microwave treatment, particularly when seeds were soaked in water, thereby yielding impressive germination rates of 85% and 46% for the respective seed lots. However, prolonged exposure durations exceeding 60 seconds frequently precipitated a deterioration in seed germination, underscoring the delicate balance between exposure duration and germination efficacy in microwave treatment protocols.

Conclusion

The pivotal role of high-quality seeds as a catalyst for optimizing the efficacy of all other agricultural inputs is widely acknowledged. In recent years, heightened attention has been directed towards the various advancements in seed treatment methodologies, heralding a promising paradigm shift towards enhancing crop performance and resilience. These innovative techniques, encompassing non-destructive and expeditious approaches such as magnetic field application, electric field stimulation, ultrasonic treatment, ozone exposure, and microwave irradiation, are instrumental in bolstering seed quality, storage capacity, and overall performance throughout the seed production cycle and within farmers' fields, all while mitigating adverse environmental impacts. Moreover, these strategies offer a viable alternative for mitigating agricultural pest and disease pressures, thereby curbing reliance on conventional insecticides and pesticides. Demonstrating efficacy across a diverse array of crops, further research and development endeavors hold the key to fully unlocking the potential of these techniques, thereby fostering food security, promoting sustainability, and safeguarding the well-being of farming communities at large.

References

Kataria, S., Baghel, L. And Guruprasad, K. N., 2017, Pre-treatment of seeds with static magnetic field improves germination and early growth characteristics under salt stress in maize and soybean. *Agric. Biotechnol.*, **10**: 83-90.

Marcu, D., Damian, G., Cosma, C. And Cristea, V., 2013, Gamma radiation effects on seed germination, growth and pigment content, and ESR study of induced free radicals in maize (*Zea mays*). *J. Biophys.*, **39**(4): 625-634.

Sharififar, A., Nazari, M. And Asghari, H. R., 2015, Effect of ultrasonic waves on seed germination of *Atriplex lentiformis, Cuminum cyminum*, and *Zygophyllum eurypterum*. *J. Appl. Res. Med. Aromat. Plants.*, **2**(3): 102-104.

Sudhakar, N., Nagendra Prasad, D., Mohan, N., Hill, B., Gunasekaran, M. And Murugesan, K., 2011. Assessing influence of ozone in tomato seed dormancy alleviation. *Amer. J. Plant Sci.*, **2**(03): 443.

Szopinska, D. And Dorna, H., 2021, The effect of microwave treatment on germination and health of carrot (*Daucus carota* L.) seeds. *J. Agron.*, **11**(12): 2571.

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