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Pre sowing seed enhancement techniques in vegetable crops

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Abstract
Seed augmentation methods are employed to enhance germination rates, boost seedling strength, overcome germination limitations through consistent plant stands, expedite crop growth, and achieve improved yields. Seed enhancement techniques involve priming, different seed treatments including magnetic field, electric field, hormonal seed treatment, radiation seed treatment, plasma seed treatment etc. The increased germination rate of primed seeds can be attributed to enzymatic stimulation, accumulation of metabolites that promote germination, metabolic restoration during imbibition, and osmotic regulation. The speedy germination, consistent crop emergence, high yield, and mitigation of disease susceptibility can be ensured through magnetic and electric fields. Nano-priming offers a countless of benefits to seed performance, including elevated ∞-amylase activity, elevated levels of soluble sugars to foster initial seedling growth, upregulating the expression of aquaporin genes within seeds, diminished ROS production resulting in enhanced stress resilience, and the formation of nanopores to facilitate improved water absorption. A special technique called plasma treatment of seeds uses ionised gases to change the chemical and physical characteristics of the seeds.

Keywords: Seed enhancement techniques, vegetable crops, Reactive oxygen species (ROS)

Introduction
Seed quality plays a vital role for sustainable crop production & food security. Good quality seeds should have the attributes like high purity both physical, genetical, high degree of seed germination, high degree of seed vigour and freedom from seed borne diseases and pests. Seed enhancement rejuvenate seeds to enhance germination and the seedling growth.

Seed Enhancement Techniques
Seed fortification
In this process, bioactive compounds are used for enhancement of seeds. Nutrient solution of one third of the seed volume is mixed with the seeds, and then the seeds are allowed to imbibe for 6-24 hours, depending on the crop variety. The imbibed seeds should be dried in shade. Eg., In cow pea, $ZnSO_4$+$MnSO_4$+Na_2MO_4 is used @ 100 mg/kg for 3 hours. Seed fortification improves seed germination and vigour because of the additional nutrients. The bioactive chemicals used in fortification may help to overcome chemical dormancy. Fortification with $FeSO_4$ increases storability of seeds by significantly reducing lipid peroxidation.

Seed infusion
Saturation of seeds with bioactive chemicals along with organic solvents instead of using water. It is suitable for seeds that suffer from soaking and seed coat injury. Seeds are immersed in solvent for a duration of 5-24h depending upon species. Bio active like plant growth regulators, macro and micronutrients, fungicide, bactericide, herbicides etc and organic solvents like acetone, petroleum ether, dichloromethane, ethanol etc are used. Seed infusion causes mechanical integration of cell membrane is altered by increasing its permeability. Membrane proteins are denatured. Inhibitors in seed coat embryo are leached out. Enzymes systems are activated.

Seed priming
The process of seed priming involves the soaking of seeds in a controlled environment for a predetermined period of time in order to enable the seed to perform its metabolic functions.

This method of hydration stimulates metabolic processes, resulting in a higher rate of germination. This is largely due to the activation of enzymes, the accumulation of germination-enhancing metabolites, metabolic correction during imbibition, and osmotic adaptation. Priming also helps to activate cellular defense mechanisms, which can lead to tolerance to various environmental conditions. Additionally, seed priming can be beneficial for the germination of seeds that are weak, damaged, or aged (Dragicevic *et al*., 2013) [9]. Primed seeds tend to have a higher germination rate, more uniform growth, a faster emergence rate, and, in some cases, a higher total germination percentage (Basra *et al*., 2005) [5].

Hydro priming

This seed priming technique involves immersing seeds in water and subsequently drying them back to their storage moisture content prior to sowing. This method assists the plant to deal with the abiotic pressures it confronts while growing in the field (Leubner, 2019) [16]. Hydropriming can be accomplished by incubating seeds in a rotating drum with specified amount of water addition as fine mist to insure uniformly hydration. Hydropriming has been successfully applied to a number of crops, including many vegetables, field crops and flowers.

Osmo priming

The process involves soaking seeds in osmotic solutions of mannitol, PEG (polyethylene glycol), sorbitol, and glycerol. Seeds are rejuvenated by osmotic priming, leading to increased and uniform vigour and better emergence in the field, resulting in a better crop stand (Leubner, 2019) [16]. The osmotic solution is usually aerated to ensure oxygen supply, especially when PEG is used. Depending on the specific characteristics of the species, the amount of time seeds are allowed to soak in osmotic solutions can range from several hours to a few weeks before being redried.

Halo priming

Seeds are soaked in salt solutions like $NaCl_2$, KCl, KNO_3, K_2SO_4, $ZnSO_4$ in order to improve germination and to increase salinity tolerance. It improves seed germination and vigour. It facilitates uniform, rapid growth, enhanced seedling germination and vigour. It is cost effective, free from harmful chemicals and eco-friendly method. Additionally, it increases the shelf life of seeds in storage and provides reliable performance in a variety of environmental circumstances.

Solid Matrix priming

The process of matrix priming involves the addition of seeds to insoluble, solid matrix particles in a predetermined amount of water. Before the solid matrix particle is sieved out and the seeds are redried, the seeds are allowed to hydrate to an equilibrium level. To reach the desired water potentials for priming, seeds are treated with a solid substrate (compost, clay, peate, sand, vermiculite, etc.) soaked with water for 24 hours to several weeks. Matripriming mimics the natural water imbibition process of seed from soil particles; the aeration condition of this technique is the best among three priming techniques.

Bio-priming

Priming procedure involving biological agents is known as biopriming. It is an eco-friendly method without use of chemical substances. Bio-control agents are used as a protective layer over the seed surface. Beneficial microorganisms are used like *Trichoderma* spp., *Pseudomonas* spp. and *Bacillus* spp. which are known to enhance biotic/abiotic resistance and improve crop performance.

Hormonal priming

This process involves the soaking of seeds in solutions of phytochemicals and plant growth regulators, including auxins (IAA, IBAs, and NAA) as well as gibberallinss, cytokinins, brassinosteroids, and abscisic acids. Many naturally occurring growth-promoting chemicals are frequently used for seed priming, including chitosan, sorghum water extract, seed weed extract, and moringa leaf extract.

Table 1: Percentage improvement (%) in germination due to different priming on vegetable crops

Crop	Seed priming technique	Improvement (%) in germination
Tomato	Hydropriming (24h)	24
Brinjal	Sand matrix (3 days)	43
Chillies	Sand matrix (3days)	34
Onion	Sand matrix (2days)	22
Carrot	Hydropriming (36h)	11
Beet root	Hydropriming (12h)	15
Okra	Sand matrix (3 days)	27
Radish	Hydropriming (12h)	47

(Umarani, R and Vigneswari, R., 2010) [28]

Osmotic priming also increased number of mitochondria in leek seeds. Morphological changes in seeds were reported as another effect of priming treatments, e.g. free space around the embryo of tomato seeds was increased following priming due to the endosperm degradation, which may allow greater water uptake and greater turgor, leading to faster growing through the embryo and earlier penetration of the enclosing tissue by the radicle.

After hydropriming and osmopriming, the perisperm and endosperm layers of cucumber seeds were found to lose their dormancy (Aroonrungsikul, 2001) [4]. Onion, radish and eggplant seeds were found to have lower electrical conductivity after hydropriming (signifying less membrane leakage) (Choudhuri and Basu, 1988) [8]. These beneficial effects may be due to the stimulation of the activity of peroxide-scavenging enzymes, which preventing the phospholipid bilayer from being attacked by free radicals, and in turn preserving the membrane integrity. Improvement in mitochondrial membrane integrity of pea seeds after priming was also investigated by Benamar *et al*. (2003) [6].

Magnetic seed treatment

Magneto priming is a technique that allows seeds to be exposed to a strong magnetic field for a certain amount of time to help them germinate and grow stronger. It can also help with crop growth, yield, and stress tolerance (Kataria, 2017) [13]. For example, it has been reported that tomato seeds exposed to a 100 mT magnetic field for 30 minutes, followed by 12 hours of imbibition, can increase the vigour of the seedlings (Anand *et al*., 2019) [2]. It also increases the activity of enzymes like alpha amylase, beta dehydrogenase, and beta-protease in the seeds during the imbibition, which can lead to better germination and stronger seedlings (Araujo *et al*., 2016) [13].

Electric seed treatment

Exposure of seeds to electric field before planting. Electric field stimulates metabolic activities of seeds, destroys seedborne pests and diseases, excites the activity of proteins and enzymes to increase seed vigour (Morar *et al*, 1999) [21]. In monecious cucurbits it induces femaleness and reduces male: Female ratio.

Radiation seed treatment

The mechanism of radiation is based on production of free radicals that activates antioxidant system which helps in defense mechanisms against different stresses. Pre sowing irradiation of seeds is followed to increase the yield potential through improvement of germination and early maturity, salinity tolerance, improving yield and quality and preventing pathogen infestation.

Nano seed treatment

Nanoparticles like AgNPs, AuNPs, MWCNTs etc. can be used to priming seeds. They help in improving seedling growth by increasing the sugar content, upregulating aquaporin gene in seeds and increasing stress tolerance by reducing the production of reactive oxygen species (ROS). They can also create nanopores to increase water uptake, activate antioxidant systems and speed up the process of breaking down starch into nanocatalysts. (Mahakham *et al*., 2017) [19].

Plasma seed treatment

Plasma treatment uses ionized gas to improve chemical and physical properties of seed *viz*, water absorption, porosity, wettability, activity of antioxidant enzymes. It can also decontaminate the seed surface and enhances soluble sugar content; protein content reduces lipid peroxidation, activation of enzymes activities which in turn improves the seed germination.

Conclusion

Seed enhancement techniques improve germination rate of seeds, quality and vigour of seeds, improves crop yield along with efficient use of resources such as fertilizers, nutrients and water. Seed enhancement techniques develop different defense mechanisms in seeds against abiotic & biotic stresses.

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