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Seed Invigoration and Inducing Salinity Tolerance in Plants through Magneto Seed Priming

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The emergence of seedlings and synchronized plant stand mainly relies on seed quality that determines the intrinsic characteristics of seeds such as germinability, and ability to tolerate both biotic and abiotic stresses. Enhancement of seed quality can be achieved by various ways viz., seed priming, seed coating, seed pelleting, seed colouring, etc. to improve tolerance against abiotic and biotic stresses, to ease the precise sowing practices and to enhance the physiological activities of seed germination. Among these, seed priming is a simple and cost-effective technique that is practiced before sowing to attain uniform germination under both favourable and unfavourable/stressed conditions.

What is Magnetopriming and how it can be applied to seeds?

Magnetopriming is one of the physical seed invigoration techniques where a homogenous and stationary magnetic field is applied to treat the seeds. The seeds are exposed to static magnetic fields as a pre-sowing treatment for a specific period to enhance the seed vigour and tolerance against any biotic or abiotic stress, known as Magnetopriming (Sarraf et al., 2021). This method is a non-invasive dry seed priming treatment that differs from hydropriming, halopriming, and osmopriming in which the seeds are soaked in certain solutions and revert back to their original moisture content. By this activity, seeds initiate the pre-germinative metabolism needed for germination. As a result, seeds cannot be stored for a long period, if so, seeds deteriorate rapidly. Thus, physical seed priming methods like magnetopriming are the most preferred technique, if seeds need to be stored after priming treatment.

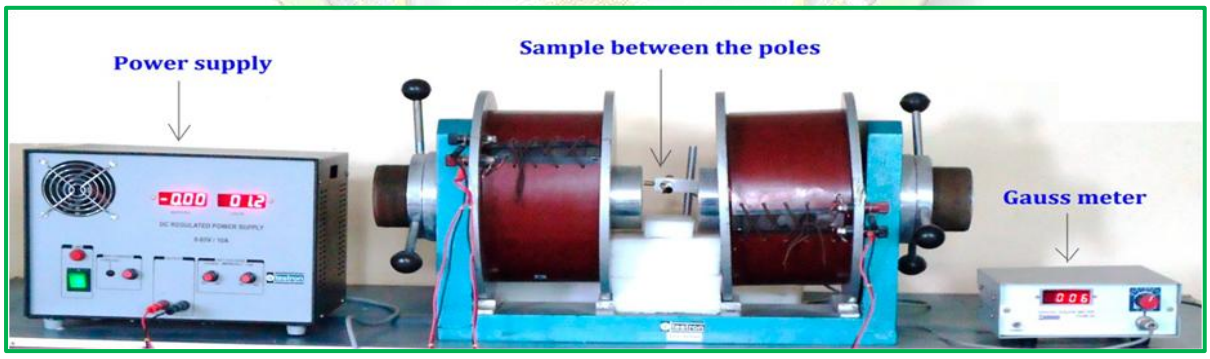

Fig 1: An electromagnetic field generator model for magnetic field seed priming (Joshi-Paneri *et al.*, 2023)

Any kind of seeds (field crops, vegetable crops, and forage crops seeds) can be treated with static magnetic field generated from an electromagnetic field generator with variable magnetic field strength. A simple electromagnetic field generator model comprises two cylindrical pole pieces, each 16 cm in length and 9 cm in diameter, with approximately 3000

turns of copper coil per pole. The coil has a resistance of 16 Ohms. A 5 cm gap between two poles allows the placement of a seed sample on a thin cardboard sheet (Joshi-Paneri et al., 2023). A variable-output DC power supply energizes the electromagnet, while a digital Gauss meter, working on the Hall effect principle, measures the magnetic field strength between the poles. The Earth's surface experiences a consistent geomagnetic field intensity of 30 to 70 µT (the SI unit of magnetic field is Tesla). Examining higher intensities may reveal effects on seedling development and overall plant growth.

Magnetopriming as Seed Invigoration technique for Salt tolerance

Seeds can undergo magnetic treatment through direct exposure to a magnetic field or immersion of seeds in magnetized water. Direct exposure to magnetic field extensively focused on enhancing the seed quality and to mitigate abiotic stresses systematically. Numerous studies demonstrated that magnetopriming enhances seed germination, plant growth, physiological parameters, antioxidant activities, photosynthetic efficiency, and crop yield under diverse abiotic stress conditions like drought, salt, UV-B, and arsenic stress. Magnetic priming accelerates the water intake of seeds to fasten the enzyme activation required for the germination process. It was noted that magnetically treated seeds showed 11% greater water imbibition than the untreated seeds especially with low water potential level (Alvarez et al., 2020).

An experiment conducted by Rathod and Anand (2016) proved that wheat seeds primed with 50 mT static magnetic field for 2 hours produced plants with more productive tillers, more number of seeds, increased thousand seed weight ultimately higher seed yield under salinity stress conditions. Root growth traits such as total root length, root surface area, root volume, and average root diameter also improved in wheat seedlings as a result of magnetopriming. This augments seedling water and nutrient absorption while providing structural support for anchorage. Apart from these, static magnetic field treatment regulated PSII efficiency, carbonic anhydrase enzyme and gas exchange responsible for carbon fixation; nitrate reductase activity, leghemoglobin content required for nitrogen fixation; malondialdehyde and antioxidant activities to mitigate oxidative stress in soybean crop (Joshi-Paneri et al., 2023). The decreased content of malondialdehyde due to magnetopriming supports diminishes the ill effects caused by reactive oxygen species accumulation under salt stress. Magnetoprimed chickpea seeds effectively alleviated the adverse impacts of salinity stress and increased the yield by 33%. The plants originating from magnetic field seed priming with optical intensity ranges from 50 to 200 mT showed tolerance against salinity stress by improving seedling vigour, growth attributes, and photosynthetic performances that ultimately led to higher biomass production and crop yield in soybean, chickpea, wheat, and maize. Antioxidant activities and Na^+/K^+ ratio are also regulated in plants produced from magneto-primed seeds to induce tolerance against salt stress (Sarraf et al., 2021).

Photosynthesis is an indispensable phenomenon in plant systems to synthesize various seed reserve molecules such as carbohydrates, proteins, lipids, etc. The plant originating from magnetoprimed seeds exhibited higher plant height, increased leaf area, and fresh weight. Along with these, it showed greater photosynthetic performance by enhancing chlorophyll, carotenoid content, PSII photosystem, stomatal conductance, and the enzymes required for photosynthesis such as Rubisco, PEP-carboxylase and carbonic anhydrase. Magnetopriming also promoted other biochemical changes to induce plant growth under salinity stress. Overall, Magnetopriming of seeds is responsible for improving seedling development, seedling vigour, photosynthetic activities, and antioxidant activities against abiotic stresses which collectively contribute for increased crop performance and yield.

Conclusion

Priming the seeds with physical agents such as magnetic fields is a eco-friendly option to improve seedling and plant growth and development as it aids in non-chemical solution that can be used in organic agriculture as well. As all plants are being exposed to existing Earth's geomagnetic field, the application of a static magnetic field to seeds could change the metabolism and enzyme activities thus enhancing tolerance against salinity stress.

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