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Seed Priming: A Strategy to Improve Abiotic Stress Tolerance in Crops

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Introduction

Fragile Ecosystems are highly susceptible to climate change which adversely affects our crop productivity and food security. It is difficult for agricultural researchers to offer restorative remedies when dealing with such fragile ecosystems. In this context, to curtail the effects of climate change and continue cultivation practices under fragile ecosystems, the adoption of ecofriendly and economical techniques such as seed priming is need of the hour (Devika et al., 2021). A pre-sowing procedure called "seed priming" induces a physiological state of seeds that improves germination. Most seed treatments rely on seed imbibition, which allows the seeds to proceed through the initial reversible stage of germination but prevents radicals from protruding out from the seed coat. Priming often involves soaking seed in predetermined amounts of water or suitable priming solutions for a prescribed time period. Seeds after priming for a particular time period, they are then dehydrated and can be stored until final sowing. During subsequent germination, primed seeds exhibit a quicker and more synchronized germination and young seedlings are often more vigorous and resistant to biotic and abiotic stresses than seedlings obtained from unprimed seeds.

Numerous studies have been conducted on the use of seed priming to increase crop growth, nodulation, stand establishment, seed germination, seedling emergence, and production in a variety of field and vegetable crops. Seed priming reduces lipid peroxidation, increases antioxidant enzyme activity, and solubilizes storage proteins. Priming dramatically increases the number of mitochondria and upregulates the production of proteins (α- and β-tubulin) necessary for cell division. Major cellular changes in seeds are brought about by rehydration through seed priming, including the de novo synthesis of nucleic acids and proteins, the generation of ATP (adenosine triphosphate), the activation of sterols and phospholipids, and the repair of damaged DNA during threshing.

For successful agriculture, efficient seed germination is very much essential. Successful establishment of early seedling indeed requires a rapid and uniform emergence and root growth. Germination of orthodox seeds commonly implies three distinct phases (Figure 1) consisting in (1) Phase I: seed hydration process related to passive imbibition of dry tissues associated with water movement first occurring in the apoplastic spaces; (2) Phase II: activation phase associated with the re-establishment of metabolic activities and repairing processes at the cell level; and (3) Phase III: initiation of growing processes associated to cell elongation and leading to radicle protrusion. Phases I and III both involve an increase in the water content while hydration remains stable during Phase II. It is commonly considered that before the end of Phase II, germination remains a reversible process: the seeds may be dried again and remain alive during storage and able to subsequently re-initiate germination under favorable conditions. Water-based seed priming is a pre-sowing seed treatment that partially hydrates seeds without allowing radical emergence (Chen *et al*.,2011). Various chemical compounds and harmone treatments are applied during the reversible phase of germination (point 3). They widely differ according to the osmotic potential of the priming solution, the external temperature, the duration of the treatment, and the presence of specific chemical compounds in the priming solution. The efficient treatments trigger metabolic processes activated during the phase II of germination, which are then temporally stopped before a loss of desiccation occurs (Figure 1) (Paparella *et al*.,2015).

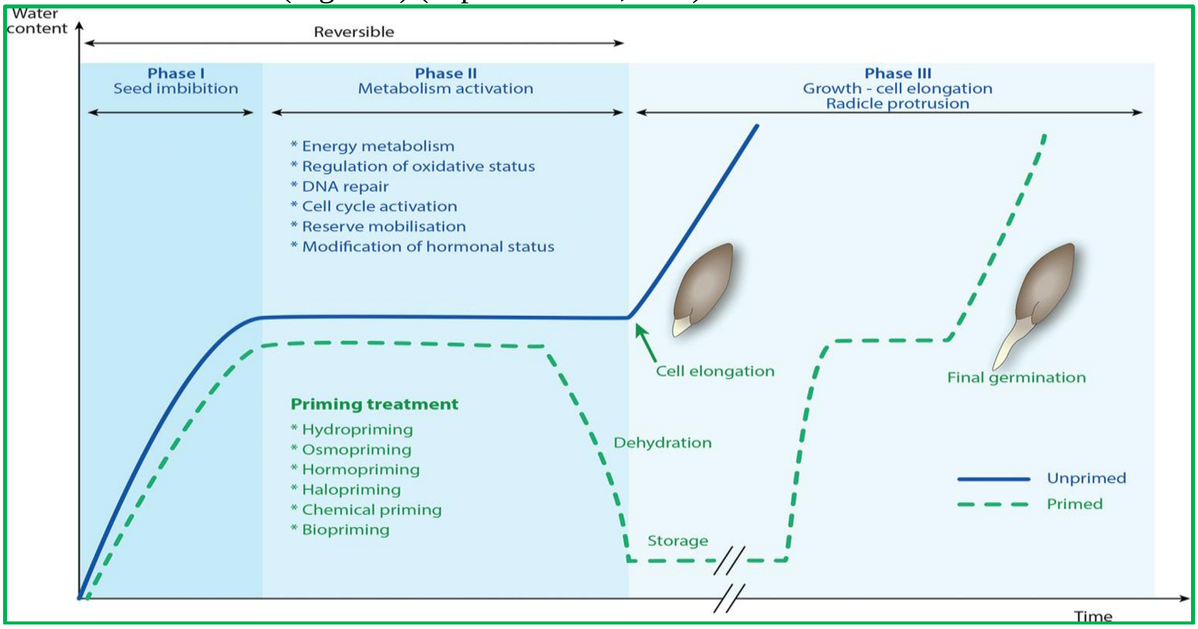

Figure 1. Seed hydration curves and germinating phases in unprimed and primed seeds. (Lutts *et al*.,2016)

Different methods of seed priming

Numerous techniques for seed priming have been devised to stimulate seeds and mitigate negative effects of abiotic stresses. Water-based priming techniques are distinguished from other pre-sowing treatments by their characteristic of partially pre-hydrating seeds and initiating early germination events in seeds. Priming efficiency is affected by various factors and strongly depends on treated plant species and chosen priming technique. The success of seed priming depends upon various physical and chemical factors such as osmotica and water potential, priming agent, duration, presence or absence of light, temperature, aeration, and seed condition which ultimately determines germination rate and time, seedling vigor, and further plant development (Varier et al.,2010). The different priming methods and priming agents are briefed in figure 2.

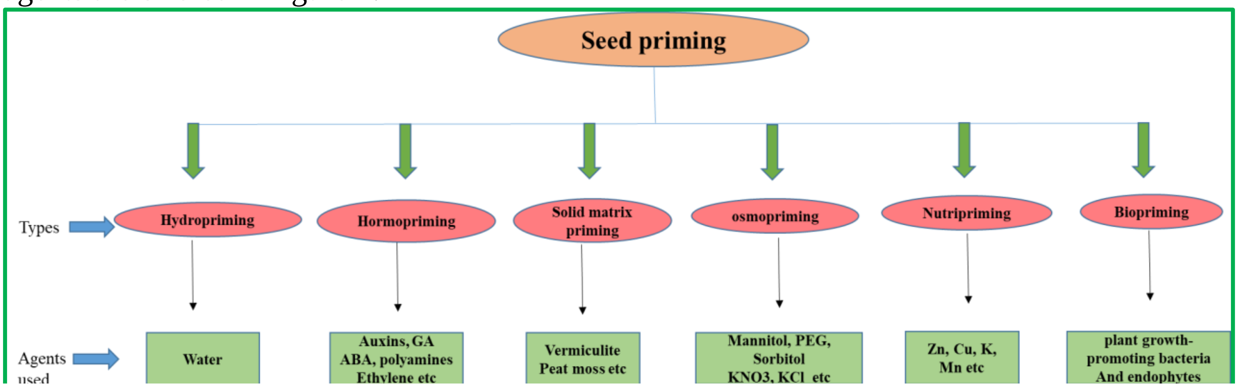

Figure 2: Different seed priming methods and priming agents used to improve the abiotic stress tolerance in crops.

Seed priming and abiotic stress tolerance

Over the recent few years, seed priming has emerged as a promising strategy in modern stress management because it protects plants against various abiotic stresses without heavily affecting fitness. Moreover, seed priming offers a smart, effective and realistic option for effective plant protection. Moisture stress, extreme temperatures (heat and chilling stress) salinity, and oxidative stress are often interconnected, and may cause similar damage. As a consequence, these diverse environmental stresses often activate similar cell signaling pathways and cellular responses. It is known that seed priming can activate these signaling pathways in the early stages of growth and result in faster plant defense responses and triggers the expression of downstream genes which imparts stress stress tolerance. Different seed priming methods and priming agents used in different crop species to improve abiotic stress tolerance is listed in the below table. (Table 1)

Table 1: Seed priming methods and agents used in different crop species to improve abiotic stress tolerance

Abiotic stress	Priming method	Crop	Reference
Drought	Hydropriming	*Oryza sativa*	Zheng et al 2016
	Osmo priming	*Oryza sativa*	Zheng et al 2016
	Osmo priming	*Oryza sativa*	Farooq et al 2009
	Biopriming	*Triticum aestivum*	Timmusk et al 2014
	Osmo priming	*Zea mays*	Anosheh et al 2011
	Osmo priming	*Vigna radiata*	Jisha and Puthur 2015
	Osmo priming	*Triticum aestivum*	Farooq et al 2013
	Nutri priming	*Triticum aestivum*	Ahmed et al 2016
Salinity	Hormopriming	*Triticum aestivum*	Afzal et al.,2006
	Osmo priming	*Helianthus aanus*	Kaya et al.,2006
	hydro/osmopriming	*Brassica juncea*	Srivastava et al.,2010
	Biopriming	*Raphanus sativus*	Kaymak et al.,2009
High temperature stress	Osmo and hydropriming	*Oryza sativa*	Maumba et al.,2018
	Osmo and chemical priming	*Oryza sativa*	Kata et al.,2014
	Hormopriming	*Oryza sativa*	Fu et al.,2019
	Hydropriming	*Lactuca sativa*	Schwember et al., 2010
Chilling stress	Osmo priming	*Oryza sativa*	Yuying Fu et al., 2019
	Hormopriming	*Oryza sativa*	Pouramir et al.,2014
	Nutripriming	*Zea mays*	Imran et al.,2013
	Osmo priming	*Glycine max*	Sun et al.,2011

Conclusion

Seed priming improves seed germination and seedling vigour due to the modifications in physiological and biochemical state of the seed. Different priming agents are being used for seed priming, which make the seeds more accustomed to withstand the abiotic stresses such as drought, salinity, high temperature and chilling stress, submergence, metal toxicity and even biotic stresses such as disease and pests.

References

1. Chen, K., and Arora, R. (2011). Dynamics of the antioxidant system during seed osmopriming, post-priming germination, and seedling establishment in spinach (*Spinacia oleracea*). *Plant Sci*. 180, 212–220.doi: 10.1016/j.plantsci.2010.08.007.
2. Devika OS, Singh S, Sarkar D,Barnwal P, Suman J and Rakshit A (2021). Seed Priming: A Potential Supplement in Integrated Resource Management Under Fragile Intensive Ecosystems. *Front. Sustain. Food Syst*. 5:654001. doi: 10.3389/fsufs.2021.654001.
3. Lutts, S., Benincasa, P., Wojtyla, L., Kubala, S., Pace, R., Lechowska, K.(2016). "Seed priming: new comprehensive approaches for an old empirical technique," in New Challenges in Seed Biology – Basic and Translational Research Driving Seed Technology, eds S. Araújo and A. Balestrazzi (Rijeka, Croatia: InTechOpen), 1–46. doi: 10.5772/64420.
4. Paparella, S., Araújo, S. S., Rossi, G., Wijayasinghe, M., Carbonera, D., and Balestrazzi, A. (2015). Seed priming: state of the art and new perspectives. *Plant Cell Rep*. 34, 1281–1293. doi: 10.1007/s00299-015-1784-y.
5. Varier, A., Vari, A. K., and Dadlani, M. (2010). The subcellular basis of seed priming. Curr. Sci. 450–456.