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## Seed priming: A comprehensive approach to alter the biotic and abiotic stresses of field crops

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### Abstract

Seed may be considered as the most important and vital factor which is structurally a fertilized matured ovule. Seed priming, the process of controlled hydration of seeds up to a level that permits pre-germinative metabolic activity of seed to proceed, but prevents actual emergence of the radicle. Seed priming is a simple, safe and effective technology which can be easily adopted by resource-poor farmers and moreover it has the potential to benefit such farmers in a numbers of other ways. Commercialisation of the seed priming technology has been expanded rapidly now a day. Seed priming is a popular, low cost and commercially used technique. For combating biotic and abiotic stress in crops and alleviating the detrimental effects of stress without much affecting its fitness seed priming emerges as a promising technology. Extensive study was done by various workers using different seed priming techniques viz. hydro-priming, halo-priming, osmo-priming, matrix priming, hormonal priming, nutri-priming, bio-priming etc.

**Keywords:** Seed priming, biotic stress, abiotic stress

### Introduction

In modern agriculture, advance technologies are being deployed for breaking yield barriers and enhancing crop productivity (Prasad *et al.*, 2016) <sup>[25]</sup>. Abiotic and biotic stress severely affects the crops growth and development at different stages of growth cycle. This unwanted and unfortunate event ultimately leads to crop failure or yield loss, thus makes crop production expensive or can lead resource poor farmers committing suicide. However, plants get higher level of fitness or readiness to overcome the harmful effects of stress situation due to priming. The primed plants are generally able to respond more rapidly and more effectively for stress protection. Being unavoidable, abiotic stresses have major negative impact on crop production worldwide. These stresses such as inadequate and inconsistent rainfall, alkalinity, salinity, extreme temperature, and some other factors aren't only limiting crop yield but also seem to be inevitably worsening.

### Seed priming

Seed priming indicates control hydration of seed up to a certain level that permits the pre-germinative metabolic activity to proceed but it prevents the normal emergence of the radicle (Hemender *et al.*, 2018) <sup>[9]</sup>. Seeds are dried to the initial moisture content after soaking. The seed is taken through a biochemical process within that activates the initial stages of germination. The priming process regulates the seed's temperature and moisture content, bringing the seed closer to the point of germination and then carefully dried to stop germination for planting. When the primed seeds are planted, we are shortening the germination time and improving the uniformity of the crop upon emergence.

### Physiological and biochemical changes induced by seed priming

When the primed seeds are sown, the imbibition phase and lag phase of water absorption are shortened. The swelling of the embryo inside the primed seed speeded up germination by facilitating water absorption. Seed priming stimulates the pre-germination metabolic processes and makes the seed ready for radicle protrusion (Pawar *et al.*, 2018) <sup>[23]</sup>.

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### Advantages of seed priming

1) Seed priming helps to overcome induced dormancy 2) It reduces the time necessary for germination and for subsequent emergence to occur. 3) Seed priming improves the stand uniformity, thus maintained plant population and enhance uniformity at the time of harvest (Debbarma *et al.*, 2017) [6] 4) It also extends the range of temperature for seed germination. 5) Priming enables seeds of many species to germinate and emerge at supra-optimal temperatures (Das *et al.*, 2015) [5]. 6) It also eliminates or greatly reduces the amount of seed-borne pathogen (Basra *et al.*, 2002) [3] 7) Priming enhances the crop yield. 8) Germination inhibitors from seeds are also leached out from seed by seed priming. 9) And finally it also improves the resistance towards different kind of biotic and abiotic stresses.

Debbarma *et al.* (2017) [6] represent the yield benefit obtained through different method of seed priming of several field crops for the different soaking hours;

**Table 1:** Soaking time and the percentage of benefits observed due to priming

Crop	Soaking hour	Maximum yield benefits obtained (%) over control
Wheat	12	37
Barley	12	40
Aerobic Rice	12-18	70
Maize	12-18	22
Sorghum	10	31
Pearl millet	10	56
Chick pea	8	50
Mung bean	8	206
Finger millet	8	15

Source: Debbarma *et al.*, 2017 [6]

### Abiotic and biotic stresses faced by crop plants

Crop plants encounter a complex set of abiotic and biotic stresses very frequently. Among them insect, pathogen, pest, weed (biotic stress), drought, water logging, salinity, alkalinity (abiotic stress).

### Different types of priming

#### Hydro-priming

Hydro-priming involves soaking of seeds in water before sowing (Pill and Necker, 2001) [24] which allows the seed to imbibe water and go through the first phase of germination in which pre-germination metabolic activities are started while the latter two phases of germination are inhibited. The technology of hydro priming is very simple and cost effective also. Alias *et al.* (2018) [1] concluded that Kailan, Menang and Hybrid dwarf Pak Choy variety of Brassica shows less mean germination time in hydro-priming than control plot.

#### Halo-priming

Halo priming refers to soaking of seeds in solution of inorganic salts like NaCl, KNO<sub>3</sub>, CaCl<sub>2</sub>, CaSO<sub>4</sub>, etc. (Nawaz *et al.*, 2013) [21]. Priming of seed with NaCl or KCl is helpful in removing the harmful effects of salts (Iqbal *et al.*, 2006) [10]. Halogenation treatment is also done with different halogen like Cl, Br, Fe, F and vapour is used for this purpose. Priming with 2.5% KNO<sub>3</sub> and Priming with 2.0% KCl result more seed yield, straw yield and test weight over control and

also required less days to mature control (Kumar *et al.*, 2016) [16].

#### Osmo-priming

In osmo-priming seeds are treated with Na<sub>2</sub>HPO<sub>4</sub> or K<sub>2</sub>HPO<sub>4</sub> which act as an antioxidant into the seed. Seeds are soaked for a certain period in solutions of sugar, poly-ethylene glycol (PEG), glycerol or sorbitol followed by air drying under shade before sowing (Nawaz *et al.*, 2013) [21]. Priming with 1.0% KH<sub>2</sub>PO<sub>4</sub> result more seed yield, straw yield and test weight over control and also require less days to mature over control (Kumar *et al.*, 2016) [16]. With comparing primed and control seeds, it is clear that seed priming enhanced seed germination speed and by the way hydro priming treatment is more suitable than osmo-priming treatments and the adverse effect of germination synchrony in osmo-priming treatments may be related to the decreased water uptake in osmo-priming treatments (Yucel, 2012) [31].

#### Matrix-priming

Matrix priming refers to incubation of seeds in a solid insoluble matrix (vermiculite, diatomaceous earth) with a limited amount of water (McDonald, 2000) [20]. The different soil matrix carriers are micro celle, celite, press mud, jute mat, peat soil, compost. Solid matrix priming (SMP) in which water uptake by seeds is controlled and developed as an alternative method of osmo-priming because of high cost of osmotic agents and technical problems with aeration (Lutts *et al.*, 2016) [17]. During solid matrix priming, seeds are mixed and incubated with wet solid water carrier for a certain period and then seeds are separated from matrix, rinsed, and back-dried. Vermiculite, peat moss, charcoal, sand, clay, and some commercially offered substrate such as celie or micro cell are generally used solid carries which are applied in solid matrix priming. Soil matrix priming utilizes the chemical and physical characteristics of a solid material to control the water uptake of seeds (Jisha *et al.*, 2013) [12].

#### Hormonal priming

Hormonal priming is the pre seed treatment with different hormones *i.e.* abscisic acid, auxins, gibberellins, kinetin, ethylene, polyamines, and salicylic acid (SA) (Lutts *et al.*, 2016) [17] etc., which promote the growth and development of the seedlings (Sing *et al.*, 2015). Kousar *et al.* (2018) [15] reported that the test weight (36.60 g) and yield (137.66 g/plant) is less in control plot than the salicylic acid treated plot of wheat and days to maturity also less in treated plot than control.

#### Bio-priming

Bio-priming involves seed imbibition together with bacterial inoculation of seed and some bacteria used as bio control agents are able to colonize rhizosphere and support plant in both direct and indirect way after germination stage. Some fungal antagonists used in bio-priming are 1) *Trichoderma hamatum* 2) *Trichoderma hamatum* 3) *Trichoderma harzianum* 4) *Trichoderma viridae* and common bacterial antagonists used are 1) *Bacillus subtilis* 2) *Pseudomonas fluroscence* 3) *Serratia polymuthica* 4) *Pseudomonas aeruginosa*

**Table 2:** Role of Bio-priming in abiotic stress tolerance

Strains under study	Crop	Role in stress tolerance	Plant growth promoting activities	Reference
<i>Bacillus pumilus</i>	Potato	Salinity, drought, heavy metal stress tolerance	Increase in plant height, No. of leaves plant <sup>-1</sup> , No. of tubers plant <sup>-1</sup> , tuber yield plant <sup>-1</sup>	Gururani <i>et al.</i> (2012)
<i>Bacillus cereus</i>	Rice, Mungbean, Chickpea	Salinity tolerance	Salinity tolerance Increase in seedling height, number and length of leaves, root and shoot biomass	Chakraborty <i>et al.</i> (2011)

Source: Mahmood *et al.*, 2016<sup>[18]</sup>

**Table 3:** Role of Bio-priming in biotic stress tolerance

Strains under study	Crop	Role in stress tolerance	Reference
<i>Tichoderma harzianum</i>	Maize	<i>Fusarium verticillioides</i> and <i>F. fumonisins</i> tolerance	Nayaka <i>et al.</i> (2010)
<i>Pseudomonas fluorescens</i>	Sunflower	<i>Alternaria blight</i> tolerance	Rao <i>et al.</i> (2009)
<i>Clonostachys rosea</i>	Carrot	<i>Alternaria dauci</i> and <i>A. radicina</i> tolerance	Jensen <i>et al.</i> (2004)
<i>Pseudomonas fluorescens</i>	Pearl millet	Downy mildew tolerance	Shetty <i>et al.</i> (2004)
<i>Pseudomonas fluorescens</i>	Sweet corn	Damping-off tolerance	Mathre <i>et al.</i> (1991)

Source: Mahmood *et al.*, 2016<sup>[18]</sup>

### Nano-priming

Nano-priming is the priming of seed with nanoparticles (NPs) such as zinc oxide, iron oxide, titanium dioxide, silver nano particles etc. (Pawar *et al.*, 2018)<sup>[23]</sup>. Due to nanoscale NPs over bulk it enhanced germination might be due to its nano size which allows them to penetrate through the seed coat easily and provide better absorption and utilization by seeds.

### Nutri-priming

Nutri-priming refers to the priming of seed with a solution of mineral nutrients instead of soaking in simple water which combines the positive effects of seed priming with an improved nutrient supply. Some mineral nutrients like potassium, zinc, magnesium etc., are very critical for improved performance of crop plants under environmental stress conditions. The idea of nutri-priming is to obtain nutritional effect together with biochemical advantages of priming to improve seed quality, germination parameters, and seedling establishment (Farooq *et al.*, 2012)<sup>[18]</sup>. Favourable effect on growth and nutrient status of cotton seedling under saline conditions was reported by K-priming (Shaheen *et al.*, 2015)<sup>[27]</sup>.

### Chemical Priming

Chemical priming means priming the seed with several chemicals which can promote seed performance under stress condition. It is help the plants to acquire resistance against abiotic stress by antioxidant production and other protective properties of several natural or synthetic compounds such as salicylic acid, ascorbic acid, ethanol, selenium, CuSO<sub>4</sub>, ZnSO<sub>4</sub>, KH<sub>2</sub>PO<sub>4</sub>, choline, and chitosan, etc., (Hemender *et al.*, 2018)<sup>[9]</sup>. Numerous studies indicate positive impact of chemical priming with various priming agents in a wide range of environmental conditions [Anosheh *et al.* (2011) Khaliq *et al.* (2015)]<sup>[2, 3]</sup>. Fercha *et al.* (2014)<sup>[7]</sup> concluded, priming with ascorbate counteracts the negative effects of salinity stress by changes in abundance of proteins involved in metabolism, protein destination, and storage.

### A few research reviews

In pigeon pea seed priming with CaCl<sub>2</sub> or KNO<sub>3</sub> improved in proteins, free amino acid and soluble sugars under salt stress (Jyotsna and Srivastava, 1998)<sup>[13]</sup>. Priming with NaCl and KCl was helpful in removing the deleterious effects of salts (Iqbal *et al.*, 2006)<sup>[10]</sup>. Prasad *et al.* (2016)<sup>[25]</sup> reported studied the effect of nano scale zinc oxide (ZnO) and chelated bulk zinc sulphate (ZnSO<sub>4</sub>) on peanut seeds. It was observed

that 1000 ppm concentration of nano scale ZnO improved growth as compared to chelated bulk zinc sulphate by promoting seed germination, seedling vigour, earlier adaptability, growth, flowering, chlorophyll content, root shoot length and pod yield per plant, however, higher concentration of 2000 ppm had negative effect on growth. Thirupathi *et al.* (2018)<sup>[30]</sup> concluded that seed priming with different agent such as KCl, KH<sub>2</sub>PO<sub>4</sub>, CaCl<sub>2</sub> and ZnSO<sub>4</sub>, water helps to increase the germination percentage, germination index, root length, shoot length than the control plot.

### Demerits of seed priming

1) The primed seeds are not suitable for long period storing 2) The shelf-life of seed may reduce after priming 3) The primed seeds must be sown as soon as possible to get the benefits – thus delay in sowing due to any abnormal situation may hamper the benefits 4) There may be uneven hydration and non-uniform germination 5) Depending on species, seed character, the ambient temperature and humidity at storage, the primed seed remains viable up to one year 6) If the primed seeds are stored in hot and humid conditions, it will lose its viability much more quickly

### Conclusion

Seed priming is perhaps the best solution of germination related problems especially when crops are grown under unfavourable conditions. Seed priming emerges as a promising technology for combating biotic and abiotic stress in crops and alleviating the detrimental effects of stress without much affecting its fitness. There is a need to standardize suitable priming methods in different crops to combat biotic and abiotic stress in a sustainable manner. For improving the livelihoods of the farmers, solutions must be found through simple and effective means. Fortunately, such solutions are available, among which seed priming is one of the important and effective measure to establish the crop successfully.

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