Int.J.Curr.Microbiol.App.Sci (2017) *6*(12): 2390-2396

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 12 (2017) pp. 2390-2396**
Journal homepage: http://www.ijcmas.com

Review Article

https://doi.org/10.20546/ijcmas.2017.612.276

Priming of Seed: Enhancing Growth and Development

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A B S T R A C T

Keywords

Seed priming, Crop establishment, Germination, Seedling growth and storability.

Article Info

Accepted:
17 October 2017
Available Online:
10 December 2017

Seed priming is a pre-sowing treatment which leads to a physiological state that enables seed to germinate more efficiently. Priming often involves soaking seed in predetermined amounts of water or limitation of the imbibition time. The imbibition rate could be somehow controlled by osmotic agents such as PEG and referred as osmopriming. Halopriming implies the use of specific salts while "hormopriming" relies on the use of plant growth regulators. A better understanding of the metabolic events taking place during the priming treatment and the subsequent germination should help to use this simple and cheap technology in a more efficient way. The general purpose of seed priming is to partially hydrate the seed to a point where germination processes are begun, but they would exhibit rapid germination when re-imbibed under normal or stress conditions. A lot of work has been done on seed priming and results of these studies indicate well the importance of priming to get a good crop stand in many crops.

Introduction

High quality seeds play an important role in successful crop production. Rapid germination and emergences are essential for successful crop establishment, for which seed priming could play an important role. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances rapid, uniform emergence and plant performance to achieve high vigour and better yields (McDonald, 2000). During priming, seeds are soaked in different solutions with high osmotic potential so that pre-germinative metabolic activities proceed, while radicle protrusion is prevented and then seeds are dried back to the original moisture level. Harris *et al.,* (2007) reported that seed priming led to better establishment, growth, earlier flowering, increase seed tolerance to adverse environment and greater yield in maize. The beneficial effects of seed priming have been demonstrated for many field crops such as wheat, sweet corn, mung bean, barley, lentil, cucumber etc. (Sadeghian and Yavari, 2004). Rehman *et al.,* (2011) reported that seed priming is a cost effective technology that can enhance early crop growth leading to earlier and more uniform stand with yield associated benefits in many field crops including oilseeds. Various seed priming techniques have been developed which include hydro-priming, halo-priming, osmo-priming and hormonal priming. Priming applications contribute to significant improvement in seed germination and seedling growth in vegetables (Dursun and Ekinci, 2010; Korkmaz, 2005; Korkmaz and Pill, 2003) and some field crops (Yari *et al.*, 2010; Sağlam *et al.*, 2010; Dezfuli *et al.*, 2008; Ghassemi-Golezani *et al.*, 2008; Sadeghi *et al.*, 2011; Saeidi *et al.*, 2008 and Elkoca *et al.*, 2007).

Types of seed priming

Heydecker (1973) used different terms depending upon the method adopted for priming, namely;

Hydropriming

Hydropriming is the simplest method of seed priming, which relies on seed soaking in pure water and re-drying to original moisture content prior to sowing. Hydro-priming plays an important role in the seed germination, radical and plumule emergence in different crop species under saline and non-saline conditions and also have beneficial effect on enzyme activity required for rapid germination.

Beneficial effect of hydropriming on seed germination and seedling growth under both optimal and stress conditions, in various crop plants such as chickpea, maize, rice mung bean and capsicum has been observed (Rahman *et al.*, 2011; Goswami *et al.*, 2013; Posmyk and Janas, 2007 and Patade *et al.*, 2012).

Harris (2006) has reported improvement in seed yield in various crops at farmer's field by seed priming with water. Caseiro *et al.*, 2004 found that hydro-priming was the most effective method for improving seed germination of onion, especially when the seeds were hydrated for 96 hr compared to 48 hr. The main disadvantage of hydropriming is uncontrolled water uptake by seeds.

Osmopriming

Osmo-priming technique refers to soaking of seeds for a certain period in solution of sugar, PEG etc followed by air drying before sowing. Osmo-priming not only improves seed germination but also enhance crop performance under non saline or saline conditions. Salehzade *et al.*, (2009) conducted a study to enhance germination and seedling growth of wheat seeds using osmo-priming treatments. Seeds were osmo-primed with PEG-8000 solution for 12 hours. Osmo-priming treatments improved the seedling stand establishment parameters. Shorrocks (1997) reported that priming with boric acid showed stimulatory and inhibitory effect on different crops plants. In papaya species the priming with boron increased the growth of all plants.

Halopriming

Halo-priming refers to soaking of seeds in solution of inorganic salts i.e., NaCl, KNO_3, $CaCl_2$ and $CaSO_4$ etc. A number of studies have shown a significant improvement in seed germination, seedling emergence and establishment and final crop yield in salt affected soil in response to halo-priming. Priming with NaCl and KCl was helpful in removing the deleterious effects of salts (Iqbal *et al.*, 2006). In sorghum seeds soaked in $CaCl_2$ or KNO_3 solution increased the activity of total amylase and proteases in germinating seeds under salt stress (Kadiri and Hussaini, 1999).

Biopriming

Biopriming involves seed imbibition together with bacterial inoculation of seed (Callan *et al.*, 1990). As other priming method, this treatment increases rate and uniformity of germination, but additionally protects seeds against the soil and seed-borne pathogens. It was found that biopriming is a much more effective approach to disease management than other techniques such as pelleting and film coating (Muller and Berg, 2008). Nowadays, the use of biopriming with plant growth-promoting bacteria (PGPB) as an integral component of agricultural practices (Gulick *et al.*, 2012; Timmusk *et al.*, 2014). In pearl millet, biopriming with *Pseudomonas fluorescens* isolates enhanced plant growth and resistance against downy mildew disease (Raj *et al.*, 2004). Biopriming with rhizobacteria improved germination parameters of radish seeds under saline conditions (Kaymak *et al.*, 2009).

Solid matric priming

Solid matrix priming (SMP, matriconditioning), in which water uptake by seeds is controlled. During solid matrix priming, seeds are mixed and incubated with wet solid water carrier for a certain period. Afterward, seeds are separated from matrix, rinsed, and back-dried. The use of solid medium allows seeds to hydrate slowly and simulates natural imbibition process occurring in the soil (McDonald, 2000). To successfully accomplish SMP, materials utilized as matrices should possess specific physical and chemical features such as low matrix potential, minimal water solubility, high water holding capacity and surface area, no toxicity to seeds, and ability to adhere to seed surface.

Solid matrix priming enhanced field performance of carrot as well as improved germination and seed vigour. More recently published data demonstrated that solid matrix priming with *Trichoderma viride* improved seedling emergence and yield of okra under low temperatures (Pandita *et al.*, 2010) (Table 1).

Table.1 The required soaking time for different crops and the percentage of benefits observed after soaking the crops

Crop	Soaking (hour)	Countries	Largest yield benefits consistently observed to date (%)
A. Crop in which benefits have been repeatedly confirmed			
Wheat	12	India, Nepal, Pakistan	37
Barley	12	Pakistan	40
Upland rice	12-18	India, Nigeria, Sierra, Leone, Gambia, Cameriin	70
Maize	12-18	India, Nepal, Pakistan Zimbabwe	22
Sorghum	10	Pakistan Zimbabwe	31
Pearl millet	10	Pakistan	56
Chickpea	8	Bangladesh, India, Nepal, Pakistan	50
Mungbean	8	Pakistan	206
Finger millet	8	India	15

Importance of seed priming in agriculture

Germination

Primed seeds enhanced uniform seedling emergence which may contribute to regular crop establishment, it often exhibit an increased germination rate and greater germination uniformity. Priming may also induce structural and ultrastructural modifications that could facilitate subsequent water uptake and attenuate initial differences between the seeds in terms of imbibition, thus resulting in a more uniform germination (Galhaut *et al.*, 2014). In mung bean plants, a faster seedling establishment resulting from priming may contribute to a total increase in yield up to 45% (Rashid *et al.,* 2004).

Priming-induced increase in germination may be associated to a change in plant hormone biosynthesis and signaling. Priming has been reported to increase gibberellins (GA)/abscisic acid (ABA) ratio (El-Arab *et al.,* 2006) and this may be a direct consequence of a priming impact in gene expression pattern (Schwember *et al.*, 2010). Ethylene also directly influences germination speed and percentage. Increase in ethylene production during priming may promote endo-β-mannase activity facilitating endosperm weakening and post-priming germination (Chen and Arora, 2013).

Plant growth and development

Plants produced from primed seeds often exhibit a faster growth than unprimed ones. The beneficial impact of priming on plant growth may be due to an improved nutrient use efficiency allowing a higher relative growth rate (Muhammad *et al.,* 2015). A higher growth of seedlings issued from primed seeds may also be analyzed in relation to a direct impact of pretreatment on cell cycle regulation and cell elongation processes (Chen and Arora, 2013). The growth parameters of chickpea were significantly affected by seed priming (Gupta and Singh, 2012).

Yield

Yield increase may also result from a higher plant density observed as a consequence of priming-induced increase in germination percentage (Murungu *et al.,* 2004 and Harris *et al.,* 2004). Seed priming treatment resulted in increased crop growth rate in treated sets which encouraged deposition of more photo-assimilates in key plant parts, greatly affecting the final yield (Srivastava and Bose, 2012). Highest grain yield of Pusa Basmati 1121 was obtained with hydro-priming at 60 kg/ha of N application applied in 3 splits (Mahajan *et al.,* 2011). Binang *et al.,* (2012) also demonstrated that priming had a significant effect on the number of tillers, number of fertile panicles, and consequently grain yield of new NERICA rice varieties.

Storability

Seed storage would increase the metabolic activity of the seeds and consequently decrease the reserve substance content and reduced the dry material weight of the seed (Bewley and black, 1982). Tarquis and Bradford (1992) reported that hydropriming of lettuce seeds improved seed germination rate decreased the longevity faster than the nonprime control seed under controlled deterioration conditions even under mild storage conditions (45^0C and 50% relative humidity). Mohan Kumar and Manonmani (2011) reported that haloprimed in sunflower seeds with 2% KNO_3 maintain the storage potential by recording maximum germination and field emergence after six month of storage than unprimed seed.

It is concluded that in most agricultural and horticultural crops, seed priming led to improvement in germination and seedling establishment. It is the best solution of germination related problems especially when crops are grown under unfavourable conditions. Many priming techniques have been evolved which are being utilized in many crops now days. It enhances the percentage of germination and seedling emergence which ensures proper crop stand establishment under a wide range of environmental conditions.

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How to cite this article:

Mampi Debbarma and Shubhashree Priyadarshinee Das. 2017. Priming of Seed: Enhancing Growth and Development. *Int.J.Curr.Microbiol.App.Sci.* 6(12): 2390-2396.
doi: https://doi.org/10.20546/ijcmas.2017.612.276