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# Seed priming: A effective method for enhancing seed quality and plant stand establishment in okra (*Abelmoschus esculentus* L.)

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## Abstract
The problem of low germination is due to the hard seed coat in okra can be overcome by seed priming include Hydro priming, Halo priming, Osmo priming and Solid matrix priming. Hydro priming is easy and more economical mode of priming which increases seed germination, reduce germination time and improves root-shoot ratio. Halo priming is performed by dipping seeds in salt solution and it positively affects the germination. Solid matrix priming enhances the salinity tolerance and improves the plant growth. Osmo-conditioning is the process of controlled hydration of seeds which is potentially able to promote rapid and more uniform seed germination and plant growth in okra. The present review highlights priming methods to increase seed germination rate, plant stand establishment and improve seedling vigor for better crop production in okra.

**Keywords:** Seed priming, germination, stand establishment, priming methods

## Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] is a native crop of Tropical Africa that belongs to the family Malvaceae. For its robust nature, dietary fibers and distinct seed protein balanced in both lysine and tryptophan amino acids; it is also called “a perfect villager’s vegetable” (Kumar *et al*., 2010) [19]. Germination is considered a critical stage in the life cycle of weed and crop plants (Radosevich *et al*., 1997) [33]. Genotype, sowing date, time of pod harvest, seed moisture content, and micronutrient applications affect the germination of okra seeds. (Purquerio *et al*., 2010) [32]. Okra seeds germinate very slowly and unevenly although they are viable seeds. Reduced, delayed, and erratic emergence is a serious problem in okra cultivation caused by seed hardness as it creates problems in rapid germination and uniform field stand. The hard seed coat restricts the water imbibitions and uniform growth and development of the embryo and as a result interferes with seed germination (Mereddy *et al*., 2015) [23]. The problem of low germination due to the hard seed coat in okra can be overcome by seed priming. Seed priming is the process of controlled hydration of seeds which is potentially able to promote rapid and more uniform seed germination and plant growth (Sharma *et al*., 2014). Priming allows some of the metabolic processes necessary for germination to occur without germination taking place. Seed priming induced synchronized germination, increased seed vigor, and growth of seedlings under stressful conditions i.e. increase in germination and emergence rate (Bajehbaj, 2010) [4]. Different seed priming methods has been used to enhance germination and seed vigor of okra. Among them, Hydro-priming i.e. seed soaking in pure water and re-drying to original moisture content before sowing; Osmo-priming i.e. soaking the seed in a solution of osmoticum; Hormonal priming i.e. soaking of seeds in different plant growth regulators(GA3, NAA, etc); halo-priming i.e. use of salt solutions for seed soaking, bio-priming i.e. seed imbibition together with biological inoculation(bacteria, fungi, etc.) of seed and solid-matrix priming i.e. seed soaking in solid medium(matrix) for controlled water uptake; are commonly used seed priming methods (Lutts *et al*., 2016) [21]. Priming (osmo-conditioning) is one of the physiological methods, which improves seed performance and provides faster and synchronized germination. Priming affects the lag phase and causes early DNA replication (Bray *et al*., 1983), increased RNA and protein synthesis (Fu *et al*., 1988) [13], greater ATP availability (Mazor *et al*., 1984) [22] and accelerates embryo growth (Dahal *et al*., 1990) [8]. However, osmopriming has been shown to activate the processes related to germination, through affecting the oxidative metabolism such as increasing superoxide

dismutase (SOD) and peroxidase (POD) (Jie *et al*., 2002) [18] or by the activation of ATPase as well as acid phosphatase and RNA synthesis (Fu *et al*., 1988) [13]. There are several reports that under diverse environmental stresses such as salinity, water deficiency and high and low temperatures, osmopriming leads to cellular, sub-cellular and molecular changes in seeds and subsequently promotes seed vigor during germination and emergence in different plant species

**Methods of seed priming in okra**

Seed priming involves hydro priming and halo priming, osmo priming and solid matrix priming. Every crop requires optimum and specific priming technique such as optimum time, amount, storage conditions and cultivar.

**Hydro-priming:** Soaking the seeds in water before sowing which may or may not be followed by air drying of the seeds. Hydro-priming may enhance seed germination percentage and seedling emergence under saline and non- saline conditions (Roy and Srivastava, 1999)

**Effect of Hydro-priming in okra**

Hydropriming is a very simple, economical and environment friendly technique. This technique has been found to improve seed germination and seedling growth. Positive impact of hydropriming in rapid seed germination and uniform crop establishment has been reported in various crops (Adebisi *et al* 2013) [2]. hydration-dehydration treatment proved beneficial in reducing thloss of germ inability of okra Saha and Basu (1981) [36]. hydropriming in rapid seed germination and uniform crop establishment has been reported in various crops. Jagadish *et al*. (1994) [17] reported that hydration-dehydration treatment improved germination capacity of slightly deteriorated seeds in okra. Priming duration is an important factor in harnessing the beneficial effects of hydropriming. Significant effect of basil seed hydropriming on seed germination (%), dry weight and vigour of seedlings was achieved by hydropriming seeds for 12 hours. (Farahani *et al* 2011) [12]. Similarly Sikhondze and Ossom (2011) [41] observed that out of the four hydropriming durations (6, 12, 24 and 36 h) studied on okra, the best seedling growth and development in terms of mean length and diameter of the stem were noticed in the seeds primed for 24 h. Soaking of seeds in simple water prior to sowing increase germination speed, homogeneity of emergence and better plant stand. This process increases the germination rate. Hydro-priming significantly affect root length, roots number, shoot length, vigor index and time taken to 50% percent emergence in okra. Seed priming with water is cheap and simple method, which have potential to improve seedling emergence homogeneity, germination percentage under water stress (drought) conditions and this technique can be easily used and adopted by the farmers. Hydro priming increased seed germination, seedling vigor and fruit yield of okra 3. Sharma *et al* (2014). Hussein (2015) [16] conducted an experiment with Hydro-priming and different concentration of salicylic acid and found significant increase in seed germination percentage, germination speed index compared with control treatment. Seeds of okra were hydropriming the results showed that seed hydroprimed treatments enhance the synchronous germination and speed of germination in genotypes IC411698 and IC89936 (Yadav *et al*., 2012) [42]. Pre-sowing treatment of seeds resulted in better establishment of okra seedlings Shahid *et al*. (1991) [39]. Treated seeds exhibited high percentage of germination, vigour index, seedling growth and dry weight of seedlings against untreated seed. Hydration-dehydration treatments, also known as priming is most effective in low vigour seed lots of okra. Dehydration of primed seed to their initial moisture content without embryo damage or loss of the metabolic enhancement induced during imbibition has been documented Shahid *et al*. (1991) [39]. Saha and Basu (1981) [36] concluded that hydration-dehydration treatment proved beneficial in reducing thloss of germ inability of okra Sharma *et al*. (2014) worked with four methods of seed priming, all the treatments of hydro-priming enhanced the seed germination even up to 76% in comparison to non-primed seeds i.e. control as 66%. Hegazi and Hamideldin (2010) [15] studied the effect of different gamma irradiation doses (300, 400, 500 Gy) and water soaking (hydropriming) on okra seeds of two varieties (Sabahia and Balady). Both varieties showed similar trends in response to different treatments. From the result, it was concluded that pre- 13 sowing treatments were effective in improving plant growth, seed yield and seed quality.

**Osmo priming:** It is a technique where seeds are soaked in sugar solution in PEG for a certain period followed by air drying of seeds before sowing. This technique improves germination under non-saline or saline conditions (Salehzade *et al*., 2009). Osmo priming is soaking of seeds prior to sowing in osmotic priming solutions (polyethylene glycol, sugar, mannitol and vermiculite compounds) for certain period time.

**Effect of osmo-priming in okra**

Osmo priming has a positive effect on enhancement of seeds germination and seedlings growth, especially under stress conditions. Carried out the research work to find out whether through prestorage seed priming treatments. Mature okra seeds were primed with water, PEG 8000 and mannitol solutions while dry seeds used as control. Results showed the reduction in unsaturated fatty acids and protein content during storage for all the priming treatments Rahman *et al*. (2013) [34]. Osmopriming strengthens the antioxidant system and increases seed germination potential, resulting in an increased stress tolerance in germinating seeds (Chen and Arora, 2011) [6]. Response of seed to priming is affected by priming duration, osmotic potential of priming solution (Arif *et al*., 2008) [3], priming agent (Farooq *et al*., 2005) and oxygen supply to seed. Osmotic potential significantly affected germination percentage. Moosavi *et al*. (2009) [25] had also reported that osmotic potential of priming solution effect percent germination. Yaseen *et al*. (1994) [43] reported that high osmotic potential of priming solution caused rapid penetration of water into seeds thereby rupturing seed coat which encouraged autooxidation and leakage from seed resulting in poor germination. Very low osmotic potential (-1.6 and below) has resulted in poor germination of okra seeds in present study. According to Okamoto and Joly (2000) [28] solution potential lower than certain level may cause hypoxia (low oxygen regime) which may in turn impair germi-nation. Priming duration affected percent germination because seeds of each species need specific amount of water to get into lag phase of germination in which all the pre-germinative metabolic processes occurs. So, if priming is done for short period then seed would not get enough water that is required for getting seed into lag phase of germi-nation. On the other hand priming for prolong period will allow excess of water that may exceeds the quantity required for the initiation of lag phase of germination and radicle protrusion will occur due to which seed lose its desiccation tolerance thereby results in loss of seed viability (Dekkers *et al*., 2015; Pereira *et al*., 2014) [10, 30]. According to Okamoto and Joly (2000) [28] prolong-ed submergence also causes hypoxia which may reduce germination percentage. Arif *et al*. (2008) [3] had also reported that seed priming duration affected germination percentage. Nezhad *et al*. (2013) [26] conducted that osmopriming (poly ethylene glycol 6000 (PEG) with 5%, 10% and 15% concentration, potassium nitrate (KNO3) with 1%, 2% and 3% concentration, potassium chloride (KCL) with 1%, 2% and 4% concentration) and hydropriming (distilled water) in two 12 and 24-hour periods. Results showed that the qualities of germination rate, germination index, mean germination time, germination percentage and normal germination 9 percentage are meaningful at 1% probability level. Maximum mean germination time is obtained by KCL 4% and PEG 15% treatment during 24 hours. Raza *et al*. (2013) [35] studied the effect of seed priming in okra in saline soil under field environment. A split plot design with two main factors including six priming treatments (control, hydropriming, ascorbic acid 50mgL-1, 100mgL-1 and salicylic acid 50mgL-1 ) and two stress levels (control and 1.25ml NaCl) was implicated. Results showed that hydropriming was quite effective in improving growth, pigments and yield as compared to control under both stress levels.

**Halo-priming:** In this technique seeds are soaking in solution of inorganic salts i.e. NaCl, KNO3, CaCl2 and CaSO4 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 (Khan *et al*., 2009).

**Effect of halo-priming in okra**

Hegazi (2014) [14] worked with priming solutions (Na2HPO4, MgSO4 and KCl) that showed significant increase in seedling height over the control. MgSO4 gave higher values for plant height, fresh weight and dry weight. Dkhil *et al*. (2014) conducted that KCl priming increased final germination percentage, radical length and seedling dry weight with non-primed seeds. Also reported that NaCl didn"t show any significant effect on fresh weight of primed seeds. Abbes *et al*. (2014) observed that the germination index (GI) of tested okra cultivars depicted that it decreased significantly in response to salinity magnitude as maximum decrease in GI was noted fewer than 8.0, followed by 6.0, 4.0 and 2.0 dS m-1 NaCl. All cultivars submitted to saline conditions, had minimum values for germination index than plants grown under non saline condition. Sahib *et al*. (2013) both hydro and KH2PO4 solution priming caused significant increase in seeds germination percentage. Lakkundi *et al*. (2013) [20] visioned that the inorganic salt (KI 1%) recorded significantly maximum germination (75.29%) which was superior over other inorganic salts used in the study and also over the control. Mishra and Dwibedi (1980) [24] found that seed soaking in 2.5% KCl for 12 hour before sowing increased okra yield by 15%. KCl and KH2PO4 have been introduced as the osmotica which have shown good potential to enhance emergence and germination in okra. Yadav *et al*. (2012) [42] conducted an experiment on 15 genotypes of okra planted in Augmented Block Design and subsequently seeds obtained were treated with three priming solutions in three replications. Three primers used for seed treatments were hydropriming, halopriming with calcium chloride and halopriming with potassium nitrate. The results showed that all seed priming treatments enhance the synchronous germination and speed of germination in genotypes IC411698 and IC89936. Shah *et al*. (2011) [38] studied the effect of seed priming on okra cv. Sabaz Pari with different sources of phosphorous and soaking durations. There were four priming resources (distilled water, 1% phosphorous, solution of each of Diammonium phosphate (DAP), single super phosphate (SSP), SSP+Na2Co3 ) with soaking durations from 4 hours and their two folds up to 48 hours alongwith unprimed seeds (control). Results showed that seed priming with SSP solution for 24 hours duration gave the best results, followed by DAP, while unprimed seeds proved to be the poorest.

**Solid matrix priming:** This is techniques or method in which seeds are mix with wet solid water basically water uptake by seeds can be controlled. Afterward, seeds are separated from matrix and washed thoroughly and dried. When seeds are gone through this process natural imbibition process of the soil stimulated and seeds are hydrate slowly. Vermiculite, peat moss, charcoal, sand, clay and some exemplary solid carries applied in solid matrix priming.

**Effect of Solid matrix priming in okra**

Nirmala and Umarani (2014) [27] conducted an experiment where the seeds of okra and beet root were subjected to four methods of priming, by including two durations *viz.*, hydro priming (12, 24 hours), sand matrix priming (60 % WHC; 3, 6 hours), halopriming (3% NaCl; 12, 24 hours) and osmopriming (PEG, 24 hours two osmotic levels -1 and -1.5 MPa).The results revealed that sand matrix priming (3 hours in 60% WHC of sand) was found to be the best for okra, while for beet root; hydropriming (for 12 hours in water) was most suitable. Conway *et al*. (2001) evaluated the efficacy of solid matrix priming techniques, alone or in combination with fungicide seed treatment on seedling emergence and reduction of damping-off of okra in field soil naturally infested with Pythium ultimum. Pandita *et al*. (2010) [29] evaluated solid matrix priming (SMP) alone and in combination with Trichoderma viride or captan, hydropriming and non-primed seeds for seedling emergence at sub-optimal temperature. Hydropriming improved laboratory germination similar to SMP. The results suggested that solid matrix priming in combination with Trichoderma viride can be successfully used to improve seedling emergence and productivity of okra under low temperature. Selvarani and Umaran (2011) [37] conducted to standardize the best methodology and method of priming, specific to each crop seed *viz*., okra. Four methods of priming *viz*., hydropriming, sand matricpriming, halopriming and osmopriming were evaluated by screening a range of durations and concentrations. The observation of parameters *viz*., i) percentage of radicle protrusion ii) days for 50 % germination iii) days for maximum germination iv) speed of germination and v) germination percentage revealed that the best methodology varied with the crop species. For okra, sand matric priming (24 h in 80% WHC of sand) recorded the highest improvement of 44, 43, 40, 58 and 7 percent over control, respectively for the above parameters.

**Bio-priming:** In this method seeds are mainly inoculated with bacterial inoculation. The seed bio priming is not only involves in germination and seedling emergence of crop plants but also involves in protection of seeds against soil borne pathogens. Seed hydration may occur during priming and seeds are infected by pathogens it may results in a stronger microbial growth and consequently impairment of plant health. The best ecological approaches to overcome this kind of problems are applying antagonistic microorganism during seed priming. Even some bio control agents or bacteria can support the seeds or plant after germination by colonizing rhizosphere. It can be consider that bio priming is the effective method approach of disease management than other techniques such as film coating and pelleting.

### Effect of Bio-priming in okra

In recent days the use of bio-priming with plant growth-promoting bacteria (PGPB) as an integral component of agricultural practices. Pravisya and Jayaram (2015) investigation aimed to evaluate the effect of priming of Abelmoschus esculentus (okra) seeds with liquid phosphobaterium (LPB) on water stress. In the present study the seeds of okra cv. Arka anamika were subjected to priming treatment with 5% and 10% liquid phosphobaterium, and the parameters like biomass, relative water content, chlorophyll content, total protein and yield were studied. Priming with liquid phosphobaterium showed considerable variation in both the physiological and biochemical parameters. Among the concentrations of liquid phosphobaterium tested seeds primed with 10% liquid phosphobaterium were found to effective in mitigating the effect of water stress, stimulating early flowering and also increase in yield.

### Mechanism for improved seed quality and field performance by priming

The possible reason for improved germination with priming might be synthesis of proteins and leaching of growth inhibitors, repair of deteriorative DNA in seeds and activation of antioxidant enzymes which lower per oxidation in seeds. Moreover, it has been reported that seed priming enhances the production of the enzyme α-amylase which plays a crucial role in starch mobilization and provides the embryo with carbohydrates for respiration during germination and seedling growth. In line with this result, Rahman *et al*. (2013) [34] reported that priming with PEG improved percent germination of okra seeds as osmotic potential was lowered from 0 to -1.2 Mpa while further lowering osmotic potential to -1.6 Mpa and below adversely affected germination. Similarly priming okra seeds with PEG was not effective in reducing mean germination time in this study which is in agreement with the result reported by Rahman *et al*. (2013) [34] Priming significantly reduced mean germination time (MGT) over unprimed seeds. Varierf *et al*. (2010) reported that priming activate and synthesize hydrolytic enzymes e.g. lipases, amylases and proteases which mobilize storage materials in seed. On rehydration quick emergence take place because all pregerminative processes had already taken place. Pukacka and Ratajczak (2005) [31] had reported that priming activates antioxidant enzymes which lower per oxidation in seed thereby maintaining seed vigour which may result in quick germination. Bray *et al*. (1989) [5] and Davison and Bray (1991) [9] reported protein synthesis in seeds

### Conclusions

It can be concluded that from this review Seed priming controls the hydration level of seed and also controls the metabolic activity within the seed which is necessary for seed germination. Seed priming not only done with chemical and plant growth regulators it also can be done with antagonistic microorganisms which can be reduce soil and seed borne pathogens. Seed priming is not only adopted to improve uniform seed germination of different vegetable crops under nonsupporting conditions but also used to reduce the different diseases.

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