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Seed Priming: An Approach to Enhance Weed Competitiveness and Productivity in Aerobic Rice: A Review

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ABSTRACT

Growing rice under aerobic soil conditions is a promising water-wise technology under the context of ever-mounting water scarcity, but it is subject to poor stand establishment and high weed pressure. This invites severe competition between weeds and rice, thus reducing the crop yields on an average of 50-60 per cent. Early weed control is essential in aerobic rice. Therefore, any effort to mitigate the ill effect of crop-weed competition in the early stages of crop growth will ultimately enhance yield of aerobic rice. So, 'seed priming' is one of the best options to manage crop-weed competition in the early stages of crop growth. Seed priming is an approach to add moisture to seeds allowing seeds to be hydrated partially without radicle emergence Beneficial effects of seed priming such as higher germination uniformity, better allometric attributes, rapid stand establishment and vigorous early plant growth were important components for weed competitiveness in aerobic rice. Higher and synchronized emergence of primed seeds can ensure vigorous crop stand with rapid canopy development giving rice plants a preliminary advantage over weeds. Different seed priming methods/ priming agents *viz*. hydro, osmo, halo, bio, solid matrix priming have been found effective in increasing the vigour and yield of aerobic rice. Therefore, seed priming is supposed to play a significant role in weed suppression. Seed priming also enhances the grain yield of rice mainly due to more vigorous seedlings resulting in earlier and enhanced resource capture, higher numbers of panicle-bearing tillers due to low mortality of seedlings, improved nutrient and moisture supply.

Key words: Aerobic, Allometric, Seed priming, Weed suppression.

Rice (*Oryza sativa* L.) is the most important cereal crop of the world as it forms the staple diet for 70 per cent of the world's population. Globally, rice is grown on 167.24 million hectares, with an annual production of 769.65 million tons (Anonymous, 2018). Out of which Asia accounts for 144.58 million hectares area and a production of 688.54 million tons (Anonymous, 2018). India has the largest area under rice cultivation in the world and is the second largest producer of rice after China, contributing nearly 20% of the world rice production Singh *et al*. (2011). In India, it is cultivated on an area of 43.77 million hectares, with the total annual production of 112.75 million tones and productivity of 2576 kg per hectare (Anonymous, 2018).

Rice cultivation by transplanting is the most common method for obtaining good economic yields. The availability of water for agriculture is declining steadily due to urbanization and rapid increase in population, which will pose problems for rice production in coming future years Xue *et al.* (2011). In the backdrop of declining water resources, the conventionally flooded rice which requires 100 to 125 cm of water is losing its sustainability and economic viability Guerra *et al.* (1998) and Bhushan *et al*. (2007). Therefore, of late, need has acutely been felt to develop technically viable and economically feasible alternate technique for growing rice. Hence researchers are developing water saving technologies, such as 'aerobic rice' which is considered to be one of the most promising technologies in terms of water saving. In this system, rice is sown directly into the dry soil and irrigation is given to keep the soil sufficiently moist for good plant growth, but the soil is never flooded (Bouman, 2005). This is an emerging agronomic production system intended to save irrigation water compared to flooded rice Tuong *et al.* (2003).

The major impediment to the successful cultivation of aerobic rice in tropical countries is a heavy infestation of weed which often ranges from 50-91% Paradkar *et al.* (1997). This invites severe competition between weeds and rice, thus reducing the crop yields on an average of 50-60 per cent. Early weed control is essential in aerobic rice. Therefore, any effort to mitigate the ill effect of crop-weed competition in the early stages of crop growth will ultimately enhance yield of aerobic rice. So, 'seed priming' is one of the best options to manage crop-weed competition in the early stages of crop growth. Seed priming is an approach to add moisture to seeds allowing seeds to be hydrated partially without radicle emergence Farooq *et al*. (2007). Most of the processes that precede germination are activated by priming and persist following the re-drying, thus primed seeds can imbibe and revive metabolic activities soon after sowing

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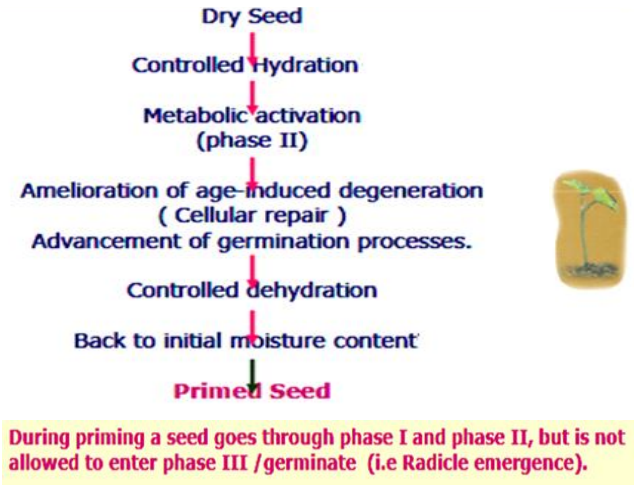
resulting in higher and faster emergence along with reduced physiological heterogeneity in germination (Rowse, 1995). Beneficial effects of seed priming include increased germination rate, higher germination uniformity, better allometric attributes and faster emergence of seedlings Kaya *et al*. (2006) and Farooq *et al*. (2006). Moreover, priming leads to crops growing faster, flowering earlier and yielding higher Harris *et al*. (2002) and Kaur *et al*. (2002).



Principle of seed priming

Priming methods and priming agents

Several methods of seed priming have been developed in order to invigorate seeds and alleviate the environmental stresses. A common feature of water-based priming techniques, which distinguishes them from other pre-sowing treatments, is partial seed pre-hydration and the activation of early germination events in seed. Priming efficiency is affected by many factors and strongly depends on treated plant species and chosen priming technique. Physical and chemical factors such as osmotica and water potential, priming agent, duration, temperature, presence or absence of light, aeration and seed condition also influence priming success and determine germination rate and time, seedling vigor and further plant development.

Hydro-priming

Hydro-priming 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. No use of additional chemical substances as a priming agent makes this method a low-cost and environmentally friendly. The major disadvantage of hydro-priming is uncontrolled water uptake by seeds.

Osmo-priming

Osmo-priming involves soaking seeds in osmotic solution with low water potential instead of pure water. Due to low water potential of osmotic solutions, water enters seed slowly which allows gradual seed imbibition and activation of early phases of germination but prevents radicle protrusion. Usually water potential of priming agent varies from –1.0 down to –2.0 MPa. Different compounds are used in osmo-priming procedure including polyethylene glycol (PEG), mannitol, sorbitol and glycerol. Seed priming with PEG has been shown as an effective method to improve seed germination, seedling emergence and stress tolerance of several crop plants under unfavorable conditions such as salt, water, chilling and nano-ZnO stresses Zhang *et al*. (2015).

Halo-priming

Haigh and Barlow (1987) observed the beneficial effect of soaking of seeds in solution of inorganic salts *i.e*. NaCl, KNO_3, $CaCl_2$, $CaSO_4$ etc. An additional beneficial effect of halogen is antimicrobial and insecticidal properties which increase the longitivity of seeds during storage. This priming makes seeds to improve their performance under salt stressed conditions.

Bio-priming

Bio-priming involves seed imbibition together with bacterial inoculation of seed. 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 bio-priming is a much more effective approach to disease management than other techniques such as pelleting and film coating. The use of bio-priming with plant growth-promoting bacteria (PGPB) as an integral component of agricultural practice shows great promise (Glick, 2012).

Solid matrix priming

Solid matrix priming (SMP), in which water uptake by seeds is controlled, has been developed as an alternative method to osmo-priming because of high cost of osmotic agents and technical problems with aeration. 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. 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. In fact, vermiculite, peat moss, charcoal, sand, clay and some commercially offered substrate such as Celie or Micro Cell are exemplary solid carries applied in solid matrix priming. In order to obtain the best priming performance, time of treatment and optimal water content must be determined separately for each matrix (Mereddy, 2015).

Seed priming and weed competitiveness

Under aerobic soil condition, poor germination results in sparse and patchy stands (Balasubramanian and Hill, 2002), which encourages weed growth Acre *et al*. (2009) and reduces the competitive ability of rice against weeds Boyd *et al*. (2009). Rapid stand establishment and vigorous early plant growth Zhao *et al*. (2006) are important components

of weed competitiveness in upland rice, which can be obtained through primed seeds (Harris and Jones, 1997). Seed priming produces more vigorous, faster and uniform seedlings and their establishment (Hampton and Tekrony 1995; Ruan *et al*. (2002) and Zheng *et al*. (2016). Higher and synchronized emergence of primed seeds can ensure vigorous crop stand with rapid canopy development giving rice plants a preliminary advantage over weeds Anwar *et al*. (2012a). Therefore, seed priming is supposed to play a significant role in weed suppression. Due to seed priming, rice seedlings could compete more successfully with weeds Harris *et al*. (2002). Priming of rice seeds with different priming methods (hydropriming, hardening and zappa priming) found to be more competitive against weeds than unprimed seeds and as indicated by lower weed rating and weed dry matter (ranged from 22-27% compared with control) (Anwar *et al*. (2012b). A robust seedling stand obtained from primed seeds enhanced rice competitiveness against weeds and improved tolerance to environmental stress Clark *et al*. (2001). Anwar *et al*. (2012a) observed a positive influence of seed priming on the weed competitiveness of rice variety AERON1 under direct seeded condition. On the other hand, no significant effect of seed priming on weed suppression in aerobic rice was observed by Zhao *et al*. (2007). Evidence of no positive or even negative effects of seed priming on emergence and vegetative crop growth were found in wheat (Giri and Schillinger, 2003), corn (Subedi and Ma, 2005) and cotton (Murungu *et al*. (2004), suggesting that seed priming in these cases is unlikely to improve weed suppression. Further study seems to be necessary to define the effects of priming on weed control in aerobic rice under field conditions.

Seed priming and yield advantage

Increased grain yield from primed seeds might be due to more vigorous seedlings resulting in earlier and enhanced resource capture than is possible by poor seedlings from unprimed seeds Farooq *et al*. (2007). Higher numbers of panicle-bearing tillers due to low mortality of seedlings might contribute to increased grain yield of primed stands. Improved nutrient and moisture supply by primed stands might have resulted in enhanced fertilization and finally higher grain yield. Increased rice yield due to priming has also been reported by many researchers Harris *et al*. (2002); Kaur *et al*. (2002) and Farooq *et al*. (2007). Boron priming induced an obvious decrease in panicle sterility and consequently improved the number of grains per inflorescence in rice Rehman *et al*. (2012). Binang *et al*. (2012) 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. Singh and Chatterjie (1981) reported increases in plant population, leaf area, root growth and yield in primed upland rice in India.

Seed priming, especially with 14% KCl solution and saturated $CaHPO_4$, can enhance crop emergence, increase established plant density, increases tiller number and lead to an increase in yield of dry-seeded rice when seeds are sown under low soil moisture content and drought during crop establishment. Yield advantage obtained by farmers in priming upland rice seed before planting over unprimed seed ranged between 33-84 % Farooq *et al*. (2007). On the other hand, Priming, however, suppresses crop establishment when soil moisture (near or at saturation) is high at seeding and during emergence and may lead to some decrease in final yields.

Limitations of seed priming

1. Priming treatments may imply a risk of medium contami-
-nation by fungi and bacteria.
2. It reduces the longevity of primed seeds as compared with the nonprimed seeds.
3. Storability of primed seed material is consequently reduced.
4. In extreme cases, priming-induced advantages may even disappear after only 14 days of storage and the obtained seedling may then perform worse than those issued from unprimed seeds.

CONCLUSION

The major impediment to the successful cultivation of aerobic rice in tropical countries is a heavy infestation of weed. This invites severe competition between weeds and rice in the early stages of crop growth. So, 'seed priming' is one of the best options to manage crop-weed competition in the early stages of crop growth. It produces more vigorous, faster, uniform seedlings and found to be more competitive against weeds and play a significant role in weed suppression. It also enhances grain yield due to more vigorous seedlings, increased plant density, increases tiller number resulting in earlier and enhanced resource capture, improved nutrient and moisture supply and decrease in panicle sterility lead to an increase in yield.

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