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Seed priming an improvement for late sown wheat: A review

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Abstract
Germination and seedling emergence are the critical stages in the plant life cycle. Insufficient seedling emergence and inappropriate stand establishment are the main constraints in the production of crops. Under various adverse conditions and late sowing cereal crops are affected like late sowing of wheat generally experience terminal heat stress which adversely affects crop growth and yield. Seed soaking with water in cereal crops especially wheat and rice has been found to be better in mitigating the detrimental effect of adverse climatic conditions. Pre-germinated seeds and seed priming is helpful in early germination and reducing the risk of poor stand establishment. On the other hand, good crop establishment increases competitiveness against weeds, increase yield and avoids the need for re-sowing that is costly too.

Keywords: priming, wheat, phenological stages, growth, yield

Introduction
Wheat sowings get delayed due to late harvesting of *kharif* crops particularly paddy and cotton; insufficient irrigation water availability and sometimes due to excess moisture and water logging as a result of heavy rainfall delay sowing of crops. Water deficit during initial stage of crop results in delayed and erratic seedling emergence and stand establishment and in severe cases, complete inhibition of seedling emergence may also result (Kaya *et al*., 2006) [15]. There is need to improve the yield of late sown in the existing systems.
Seed priming has been shown to improve the performance of late-sown wheat (Farooq *et al*., 2008) [5] as it reduces time between sowing and seedling emergence and promotes synchronized emergence, improve germination giving better crop stand and final yield (Parera and Cantliffe, 1994; Harris *et al*., 2001; Gupta *et al*., 2008; Khan *et al*., 2011) [20, 8, 9, 7, 17]. It is the simple, cost effective and useful technique to combat drought and other abiotic stress and advance the wheat emergence by about 10 days which is beneficial for increasing wheat yield (Jafar *et al*., 2012; Kaya *et al*., 2006) [13, 15]. Seed priming provides a moisture level sufficient to start pre germination metabolic processes but prevents radical protrusion (Bradford, 1986) [4]. Direct benefits due to seed priming includes, faster emergence, better and more uniform stands, more vigorous plants, great tolerance to environmental stress, reduced dormancy, earlier flowering and higher grain yield in many crops (Harris *et al*., 1999; Harris and Hollington, 2001) [10, 8, 9]. On-farm seed priming is a low-cost and low risk method in which seeds are soaked in water overnight, surface-dried and then sown on the same day while seeds are in a hydrated state (Harris *et al*., 1999) [10].

Emergence, phenology and plant growth parameters
Development of plants and crop production depend upon effective germination and establishment of seedling. Seed priming is used to shorten germination time and to achieve high vigour. Actually it allows some of the metabolic processes necessary for germination.
Harris *et al*. (2001) [8, 9] found that the mean time for 50% germination at 20 ^{0}C of 12 Indian wheat cultivars was reduced from 51 hrs to 27 hrs by soaking seed in water for 8 hrs prior to sowing. Similarly, Hartman *et al*. (2002) [11] reported that once sown, seeds spend significant amount of time in just absorbing water from the soil. So, by reducing the imbibition time to minimum (through seed priming), germination rate of seed can be increased and seedlings emergence improved. Suryakant *et al*. (2001) [27] reported that the seedlings emerged earliest in sprouted seed sowing followed by priming with IAA, KCl, water, $ZnSO_4$ and Na_2SO_4 as compared to control.
Mohammadi and Mozafari (2012) [18] reported that primed seeds performed better than unprimed seeds in terms of germination percentage especially under higher salt stress levels.

Bhati and Rathore (1996) [3] from Udaipur (Rajasthan) revealed significant reduction in period of seedling emergence (days) in wheat with soaking of seeds. It was to the tune of 6.67, 7.33, 7.50 and 7.67 days with KH_2PO_4 (5%), distilled water, $CaCl_2$ (0.25%) and NaCl (2.5%), respectively in comparison to control (8.33 days). Similarly, Kant *et al.* (2004) [14] reported that priming of wheat seed with solutions of indole-3-acetic acid, KCl, water, $ZnSO_4$ and Na_2SO_4 gave more plant dry matter and grain yield than unprimed seeds. The plants from primed seeds took less time than the control to reach tillering, jointing, heading and flowering, but physiological maturity in all the treatments was at the same time.

Pre-sowing seed hydration of wheat for 16-18 hrs followed by thiram dressing @ 0.2% was found to be the best as it significantly invigorated seed quality in terms of improved per cent germination, speed of germination, per cent field emergence and reduced the days to 50% flowering and maturity (Bassi, 2005) [2]. Rajpar *et al*. (2006) [22] reported that in non-saline clay soil seed priming with fresh water and 0.2% gypsum appeared to be the most effective treatments as the seedlings were significantly faster in emergence, increase in growth parameters, took fewer days to mature and gave significantly higher grain yield of wheat. Priming of wheat varieties resulted in an increased final per cent emergence and reduced time to 50% emergence when compared with the non-soaked seed (Murungu, 2011) [19]. Ali *et al*. (2013) [1] reported that seed priming treatments in wheat reduced the mean emergence time and promoted germination, early canopy development and tillering in comparison to the untreated control. Similarly, Verma *et al*. (2014) reported that priming improved the germination, seedling length, dry weight, vigour and speed of germination of oat.

Toklu *et al*. (2015) [29] reported that PEG, IAA, and distilled water treatments increased wheat seed germination percentage, seedling emergence percentage and seedling growth rate. A method to improve the rate and uniformity of germination is the priming or physiological advancement of the seed lot. Farooq *et al.* (2006) [6] reported that seed priming improved germination and emergence, allometry, kernel yield and its quality in rice. Ramamurthy *et al*. (2015) [23] and Singh *et al.* (2015) [26] reported that seed priming improved the emergence and vigour of the wheat crop which helped to establish a good plant stand. They further reported that seed priming helped in hastening germination, maturity and harvest and reduced the adverse effect of dry spell in wheat.

Yield and yield attributes

Sub optimal crop emergence and establishment is a problem in crop production owing to low soil moisture. Priming help in early emergence and earliness of the primed crops was maintained throughout the crops ontogeny to harvest resulting in earlier flowering, fruiting and ripening with change in final yield.

Suryakant *et al.* (2000) [28] reported that the grain, straw and biological yields of wheat were highest in sprouted seed sowing followed by priming treatment of IAA, KCl, water, $ZnSO_4$ and lowest in dry seed sowing (control). An increase of 21.7 and 15.6% in grain yield, 20.6 and 12.8% in straw yield and 21.1 and 15.0% in biological yield was observed with sprouted or primed seed sowing over dry seed sowing regularly. Rashid *et al.* (2006) [24] reported that priming was found to increase yields of both grain and straw of barley. Increase in grain yield due to priming was up to 53% in the participatory trials. Similarly, Rajpar *et al.* (2006) [22] reported that seed priming with fresh water and gypsum resulted in faster seedling emergence, took fewer days to mature and gave significantly higher grain yield in wheat.

Seed priming in late sown wheat improved emergence, stand establishment, tiller numbers, grain and straw yields and harvest index (Farooq *et al.*, 2008) [5]. Hussain *et al*. (2013) [12] reported that seed priming improved stand establishment, allometric traits, yield contributing parameters, biological yield, grain yield and harvest index, of late sown crop (December 10 and 25). Similar, results were obtained by Rehman *et al*. (2008) [25].

Raj Pal *et al.* (2013) [21] reported that pre-germinated seed produced significantly higher grain yield (5.49 t ha^{-1}), which was statistically similar to hydro-priming (5.30 t ha^{-1}). Interactive effect of different seed priming techniques along with seeding at sub optimal soil moisture level proved to be an efficient technique for enhancing water productivity of wheat**.** Ali *et al*. (2013) [1] reported that different seed priming techniques in wheat increased number of fertile tillers, plant height, 1000-grain weight, grain and biological yields. Similarly, Toklu *et al*. (2015) [29] reported that PEG, KCl and hydro-priming treatments increased grain yield of wheat compared to the control. Ramamurthy *et al*. (2015) [23] reported that seed priming in wheat led to significantly higher grain yield (17%) over non-primed.

Conclusion

From various studies given above, it can be concluded that in late sown wheat seed priming in water improves emergence and reduces the time taken to various phenological stages. Seed priming along with biofertilizers i.e. Biomix/AM fungi can gave significantly better results than unprimed and uninoculated seed. So priming is a better option for mitigating adverse effects of low moisture and improving growth ultimately yield of late sown wheat as well as other cereals also.

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