

Effect of Seed Priming on Germination and Seedling Growth of Wheat (*Triticum aestivum* L.)

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Wheat is a vital cereal crop grown around the world, forming a staple in the everyday meals of countless individuals. A member of the *Triticum* group, it has been farmed for centuries, primarily for its seeds, which are ground into a powder. The plant thrives in cooler climates that receive average levels of rain and have soils that allow water to pass through easily. Among the many varieties, *Triticum aestivum*, commonly known as bread wheat, is the most widespread, while *Triticum durum* is used chiefly for pasta. Nutritionally, wheat offers a good amount of carbohydrates, along with protein, dietary fibre, B vitamins, and essential minerals like iron and magnesium. The cereal is one of the cheapest sources of energy, provides a major share of protein (20%) and calorie intake (19%) from consumption (Ramadas *et al.*, 2019).

Wheat (*Triticum aestivum* L.) has a central role in world food security, as it represents more than 1/4th of the global total grain production, which serves as a major source of staple food for over 1/5th of the human population worldwide (FAO, 2011). Wheat is arguably the most important food crop in the world. World wheat production currently stands at about 550 million metric tons (MMT) (International Wheat Council, 1994). Of this, about 100 MMT is traded each year on the international market (C.F. Morris & S.P. Rose, 1996). The cultivated area under wheat in India has shown an increasing trend, from 29.04 million hectares to 30.54 million hectares with a magnitude of 1.5 million hectares (5%) net gain in terms of area. Uttar Pradesh has largest share in area with 9.75 million hectare (32%), followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (9.74%), Haryana (8.36%) and Bihar (6.82%). However, a major expansion in wheat area was observed in the states such as Jharkhand (51%), Madhya Pradesh (27%) and Rajasthan (13%) (Ramadas *et al.*, 2020).

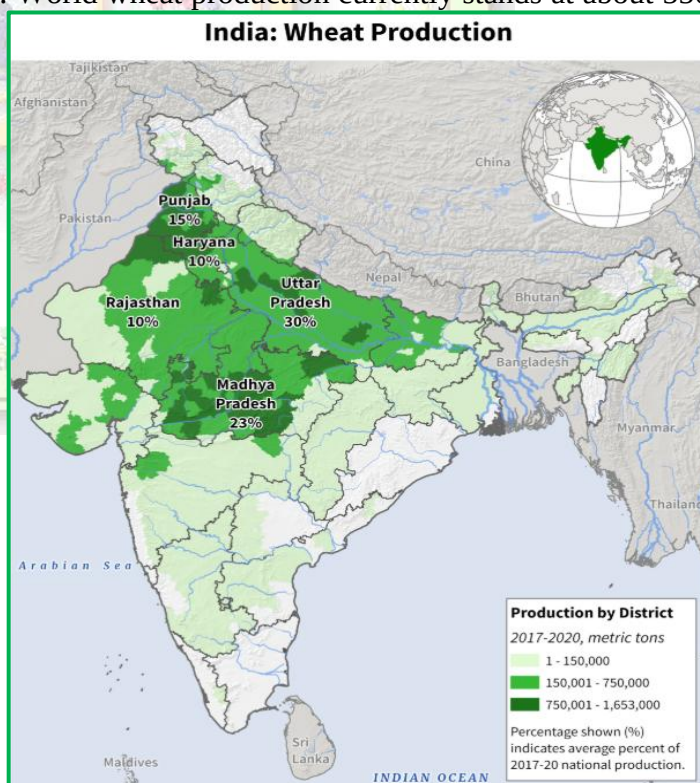


Fig 1.: Wheat Production in India (India Ministry of Agriculture, Directorate of Economics and Statistics, Market Year 2017/18-2019-2020 data by districts)

What is Seed Priming

Seed priming is a process where seeds are soaked in water or a special solution for a certain amount of time before planting. This kick-starts some of the natural processes inside the seed, like enzyme activation and energy production, but the seed isn't allowed to sprout just yet. After soaking, the seeds are dried and can be planted just like untreated seeds. Depending on the materials used, seed priming is classified into several types:

1. Hydropriming: Soaking seeds in plain water.
2. Osmopriming: Using osmotic solutions like polyethylene glycol (PEG).
3. Halopriming: Using salt solutions such as KNO_3 or NaCl .
4. Hormonal priming: Using growth regulators like gibberellic acid (GA_3).
5. Biopriming: Inoculating seeds with beneficial microbes or biofertilizers.

Recent Studies on Effect of Seed Priming in Wheat Crop:

In priming, seeds are soaked in different solutions with high osmotic potential. This prevents the seeds from absorbing in enough water for radicle protrusion, thus suspending the seeds in the lag phase (Taylor *et al.*, 1998). Seed priming has been commonly used to reduce the time between seed sowing and seedling emergence and to synchronize emergence (Parera & Cantliffe, 1994). Seed priming is a form of seed readiness in which seeds are pre-soaked before planting (Ahmad *et al.* 2012).

Pre-sowing seed treatments (seed priming) include hydropriming, biopriming, seed soaking, hormonal-priming, magneto-priming. Osmopriming is special type of seed priming that has been used to describe the soaking of seeds in aerated low water potential solutions. Osmoprimed in polyethylene glycol, KNO_3 , KH_2PO_4 , NaCl , K_3PO_4 , and CaCl_2 solutions are usually performed at water potential ranging from -0.2 to -2.0 MPa depending plant and species (Hsu *et al.*, 2003; Duman, 2006; Ghiyasi *et al.*, 2008). Many recent researches suggested that seed priming of crop seeds might be a useful way for better germination, seedling growth, establishment and yield (Ghiyasi *et al.*, 2008; Tajbakhsh *et al.*, 2004; Sharafzadeh *et al.*, 2006).

In addition to better establishment, farmers reported that primed crops grew more vigorously, flowered earlier and yielded higher (Farooq *et al.*, 2008). It has also been reported that seed priming improves emergence, stand establishment, tillering, allometry, grain and straw yields, and harvest index (Farooq *et al.*, 2008). Different seed priming treatments in wheat seeds improved the salinity tolerance nonetheless osmopriming (with CaCl_2) was the most effective treatments to get higher grain yield and net return in both wheat varieties whereas kinetin was the least effective (Jafar *et al.*, 2012).

Improved Stress Tolerance

Drought stress influences the plant performance from germination to maturity stage. At the seed germination and seedling stage, it is a major determinant of wheat production in many parts of the world. In particular, seed vigour index and shoot length are the most sensitive to drought stress, followed by root and coleoptile length (Dhanda *et al.*, 2004). Seed priming with antioxidants, hormones, and inorganic and organic compounds has ensured extensive survivability in wheat under salt stress (Hameed *et al.* 2014).

Terminal drought stress substantially decreased wheat productivity in response to reduction in allometric and morphological traits; nonetheless, osmoprimed seeds with CaCl_2 over dry seeds and large sized seeds over small sized seeds maintained their dominance due to early and uniform stand establishment, improving crop allometry and productivity due to significant expansion in all yield related parameters under well-watered and drought stress conditions (Hussain *et al.*, 2018).

Effects on Germination and Seedling Growth

Seed priming is an accessible, economical and effective phenomenon for the enhancement of seed germination, early seedling growth and yield under stressed environment. One of the most noticeable benefits of seed priming in wheat is improved germination rate and

uniformity. Several studies have confirmed that primed wheat seeds germinate faster and more consistently than untreated ones. This early and synchronized germination helps wheat seedlings establish themselves more effectively, especially under stressful conditions like cold or drought-prone soils (Farooq *et al.*, 2006).

Recent studies have shown that treating wheat seeds with chitosan as a priming agent not only improves germination but also supports better seedling growth when the plants are under osmotic stress, such as conditions caused by polyethylene glycol (PEG). The noticeable improvements in both germination and early plant vigor suggest that chitosan is a highly promising option for helping wheat plants cope with water-related stress during the early stages of growth.

Improved Seed Yield

Better seedling establishment and improved stress resilience often translate into higher yields. Studies have reported that primed wheat plants produce more tillers, have better spike development, and ultimately result in increased grain yield (Harris *et al.*, 2001). This is especially relevant for smallholder farmers who depend on consistent yields but often lack access to expensive chemical treatments. Seed priming has been found to significantly improve irrigation water use efficiency (IWUE) and overall grain yield in wheat. Research indicates that primed seeds perform better across all irrigation levels, with the highest yields observed at full irrigation (100% ETo) and the most efficient water use achieved at slightly reduced irrigation (80% ETo) (Ali *et al.*, 2013). These results highlight that simple methods like on-farm priming or hydropriming seeds for around 12 hours can effectively boost grain yields, even in late-sown wheat and under water-limited conditions. This makes seed priming a valuable strategy for enhancing productivity while making more efficient use of water resources.

Conclusion

Seed priming is a straightforward and efficient approach that significantly boosts wheat crop development. It promotes quicker and more even sprouting, enhances early growth, and strengthens plants' ability to cope with tough surroundings. This technique supports faster root establishment, improves the plant's ability to absorb nutrients and moisture, and results in greater grain output, even when faced with limited water or delayed planting. Options like soaking seeds in water or simple on-site treatments are low-cost and easy to apply, making them ideal for widespread adoption by growers. In essence, priming offers an effective means of increasing wheat performance in both favourable and adverse growing conditions.

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