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Effects of Priming on Seed Germination, Emergence and Field Performance

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ABSTRACT

Germination and seedling establishment are critical stages in the plant life cycle. In crop production, stand establishment determines plant density, uniformity and management options. A method to improve the rate and uniformity of germination is the priming or physiological advancement of the seed lot. The general purpose of seed priming is to partially hydrate the seed to a point where germination processes are begun, but not completed. Treated seeds are usually re-dried to primary moisture before use, but they would exhibit rapid germination when re-imbibed under normal or stress conditions. Such controlled imbibitions of seed followed by dehydration were shown to improve germination and early seedling growth under compared to seedlings grown from untreated seed. Various pre-hydration or priming treatments have been employed to increase the speed and synchrony of seed germination. In this paper the effects of seed priming on germination, seedling growth and field performance of different crops were reviewed.

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INTRODUCTION

Stand establishment is of primary importance for optimizing field production of any crop plant. At sub-optimal environmental conditions poor seed germination, and subsequently poor field establishment, is a common phenomenon. For example, it has been reported that one of the major obstacles to high yield and production of crop plants is the lack of synchronized crop establishment due to poor weather and soil conditions (Mwale *et al*., 2003). On the other hand, seed are occasionally sown in seedbeds having unfavorable moisture because of the lack of rainfall at sowing time (Angadi and Entz, 2002), which results in poor and unsynchronized seedling emergence. Another major constraint to seed germination is soil salinity, a common problem in irrigated areas of Anatolia, with low rainfall (Kaya *et al*., 2003). Soil salinity may affect the germination of seeds either by creating an osmotic potential external to the seed preventing water uptake, or through the toxic effects of Na+ and Cl− ions on the germinating seed (Khajeh-Hosseini *et al*., 2003). Salt and osmotic stresses are responsible for both inhibition or delayed seed germination and seedling establishment (Almansouri *et al*., 2001, Sharafi *et al* 2012). Under these stresses there is a decrease in water uptake during imbibitions and furthermore salt stress may cause excessive uptake of ions (Murillo-Amador *et al*., 2002).

Strategies for improving the growth and development of crop species have been investigated for many years. Seed priming is a pre-sowing strategy for influencing, seed germination and seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Bradford, 1986). During priming, seeds are partially hydrated so that pre-germinative metabolic activities proceed, while radicle protrusion is prevented, then are dried back to the original moisture level (McDonald, 2000, Sharafi *et al* 2010). For better realization of seed priming, we need to know more about water uptake by seed.

Seed Water Imbibition Curve:

Seed water uptake during seed germination, can be divided into three stages (Fig. 1). First stage or phase one named imbibition is usually rapid, commencing with the seed being placed on water where it quickly hydrates the cells and their constituents.

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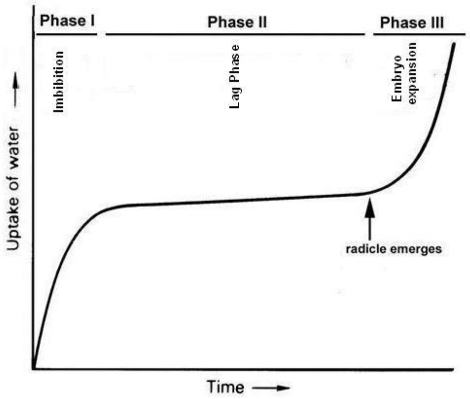

Fig. 1: Variation of water uptake by seed during seed germination process.

The second stage or phase two is lag phase of water uptake, where there is very little net gain of water. This is not to say that water is not taken up by the seed. In reality there is a steady state reached between the amount of water lost by the seed due to evaporation and that taken up by the seed from its surroundings. In natural conditions, the amount of water lost by a seed that is placed on the surface of the ground can actually exceed the amount it takes up from the soil and limits germination. The third phase of water uptake is one of rapid hydration to support the expansion of the embryo as it completes germination and emerges from the seed (Fig 1). Due to the impermeability of the testa or other covers, some seeds cannot take up water freely when placed in contact with it but must wait for some physical abrasion or partial chemical breakdown to occur prior to imbibing (Simon, 1984).

Seed priming is a seed treatment that allows imbibition and activation of the initial metabolic events associated with seed germination, but prevents radicle emergence and growth. In other words, phase one and two of seed water imbibition curve are passed, but seeds do not enter the thirds phase of water uptake. Then seeds dried back to their original water content. Several types of seed priming are commonly used (Ashraf and Foolad, 2005):

- **Hydro-priming**: soaking in water
- **Halo-priming**: soaking in inorganic salt solution
- **Osmo-priming**: soaking in solutions of different organic osmotica
- **Thermo-priming**: treatment of seeds with low or high temperature
- **Solid matrix-priming**: treatment of seed with solid matrices
- **Bio- priming:** hydration using biological compounds

1- Seed Priming Effect On Seed Germination:

Effects of different seed priming techniques on germination and seedling growth and emergence have been well documented. Ghassemi-Golezani *et al* (2010) evaluate the effect of different osmopriming treatments (KNO3 and NaCl) on seed invigoration and field performance of winter rapeseed cultivars and concluded that Salt priming, particularly KNO33 priming, decreased mean germination time and increased seedling size, compared with non-primed seeds. They also reported that the highest improvement in grain yield per unit area was observed for seeds primed with KNO3 (31.5%) followed by those primed with NaCl (22.5%). Different seed priming methods may have different effects on seed and seedling performance. Ghassemi-Golezani *et al* (2008b) compared seed germination properties of lentil under two seed priming techniques (osmo and hydropriming). They observed that seed priming improved germination and field performance of lentil compared with unprimed treatment, but the effect of different priming was also significant, where invigoration of lentil seeds by hydropriming resulted in higher seedling emergence in the field, compared to control and seed priming with PEG. Seedling emergence rate was also enhanced by priming seed with water. Thus, they suggested hydropriming as a simple and effective method for improving seed germination and seedling emergence of lentil in the field.

It is concluded that superiority of hydropriming on germination could be due to soaking time effects rather than KNO3 treatment. Because, hydro primed seeds compared to KNO3 treated seeds were allowed to imbibe water for a longer time and went through the first stage of germination without protrusion of radicle (Kaya *et al* 2006). Akinola *et al*. (2000) reported that higher duration of exposure to seed treatment resulted in higher cumulative germination in wild sunflower. Positive effects of seed priming on seed invigoration depend on priming duration (Ashraf and Foolad, 2005).

Caseiro *et al*. (2004) found that hydropriming was the most effective method for improving seed germination of onion, especially when the seeds were hydrated for 96 h compared to 48 h. When seeds imbibe, the water content reaches a plateau and changes little until radicle emergence (Bradford, 1986). Priming up to this point can have a positive effect, while extended priming duration may negatively affect germination. In other words, Duration of seed priming, especially hydropriming, affects seed germination properties. Longer hydropriming duration has not always more positive effect on seeds germination properties. Ghassemi-Golezani (2010b) reported that the lowest mean germination time and the highest germination percentage and seedling dry weight of pinto bean were achieved with 7 and 14 hours priming duration which was significantly different from 21 hours of hydropriming.

Rapid and uniform field emergence of seedlings is two essential pre-requisites to increase yield, quality and ultimately profit in annual crops (Finch-Savage, 1993). Rapid emergence of seedlings could lead to the production of vigorous plants. The efficiency of seed hydro-priming for better seedling emergence is also reported (Abdulrahmani *et al* 2007, Ghassemi-Golezai *et al* 2008a). In some cases, the final seedling emergence percentage of primed and unprimed seeds is equal, but primed seeds emerge more quickly than those of unprimed. Demir and Mavi (2004) working on emergence of primed and unprimed watermelon seeds observed that unprimed seeds emerged with 4 days delay compare to primed seeds.

Effects seed priming on seed germination and seedling performance under environmental stresses are also studied. Sub-optimal conditions may result in reduced seedling growth where Sadeghian and Yavari (2004) reported that increasing drought stress resulted in increasing abnormal seedlings in sugar beet. Priming may be helpful in reducing the risk of poor stand establishment under drought and salt stress and permit more uniform growth under conditions of irregular rainfall and drought on saline soils. Kaya *et al* (2006) working on germination of sunflower under drought and salt stress reported that hydropriming improved both rate of germination and mean germination time both under salt and drought stress conditions. Fujikura *et al*. (1993) indicated the beneficial effects of hydropriming on aged or unaged seeds with respect to germination and percentage of normal seedlings in cauliflower. Singh (1995), Shivankar *et al*. (2003) and Sharafi *et al* (2010) also concluded that hydro priming has high potential in improving field emergence and ensures early flowering and harvest under stress conditions especially in dry areas.

2- Effect of priming on germination properties of differentially matured seeds:

It has been reported that seed priming has different effects on differentially matured seeds. However, it is necessary to clarify the variation of seed quality during maturity and development to determine the effect of seed priming on seeds with different maturity.

According to Harrington (1972), seeds attain maximum quality at the end of the seed filling period, a stage that has been termed physiological maturity. Thereafter seed viability and vigor of seeds as the seeds begin to age. Harrington's (1972) hypothesis has been supported by other finding such as those with triticale (Bishnoi, 1974), wheat (Rasyad *et al*., 1990), maize (Tekrony and Hunter, 1995) and soybean (Tekrony *et al*., 1984). However, several research reports have observed that maximum seed quality was only attained some time after the end of the seed filling period, thus contradicting Harrington's hypothesis (Demir and Ellis, 1992; Ellis and Pieta Filho, 1992; Ellis *et al*., 1987; Ellis *et al*., 1993; Kameswara *et al*., 1991; Pieta Filho and Ellis, 1991; Wilson and Trawatha, 1991; Zanakis *et al*., 1994; Venter *et al*., 1996; Still and Bradford, 1998; Demir and Smith, 2001; Demir *et al*., 2002). As a result the term "mass maturity" has been suggested to be a more appropriate term to describe the end of the seed filling period than "physiological maturity" which was potentially misleading (Ellis and PietraFilho, 1992).

We have represented the effect of maturity on seed quality factors of pea (pisum sativum) as an example. Seed moisture content, viability, electrical conductivity (EC) and seed weight were seed quality indicators which were measured.

Seed dry weight and viability increased after flowering, while EC and moisture content of cowpea seeds decreased (fig. 1). After the time of occurrence of maximum seed dry weight at 37 d after flowering (DAF), germination and seedling dry weight continued to increase and EC to decrease until 49-53 DAF (fig. 1). Thus, all assessment of seed quality reached their highest values between 12 and 16 days after the maximum seed dry weight was achieved. Viability fell and electrical conductivity increased significantly from 53 DAF. This suggested that seed deterioration had begun, leading to a reduction in quality. In other words, pea seeds had the highest quality at 49-53 DAF. In terms of the changes in seed moisture content (fig. 1), harvest at 53 DAF would be more suitable to harvest high quality seeds. The moisture content of pea seeds at 49 DAF was 33%; harvesting at this high seed moisture content, may lead to irrecoverable mechanical damage to seeds. However, at 53 DAF seed moisture content had fallen to 21.5%. Since there was no decline in seed quality in this period, 53 DAF is the more appropriate harvest time to produce have high quality seeds compared to 49 DAF. In conclusion, the maximum seed dry weight of pea was recorded at 37 DAF, while the highest seed quality was achieved at 49-53 DAF. Thus, pea “physiological maturity” did not coincide with maximum seed dry weight. This observation does not support Harington’s (1972) conclusion that the highest seed quality is attained at the end of seed filling period, when seeds reach their maximum dry weight. Pea seeds reached their highest quality (in terms of electrical conductivity, and viability) 12-16 days after reaching maximum seed dry weight.

Seed priming has also positive effects on differentially matured seeds (Ghassemi-Golezani and Esmaeilpour (2008) working on the effect of salt priming on the performance of differentially matured cucumber seeds reported that maximum advantage of priming seedling vigor was observed in seeds harvested at 25 day after anthesis compared to 35 and 45 days after anthesis. Smaller effects of priming were also seen in the decreased mean germination and emergence times and increased seedling dry weight of seeds harvested at 35 and 45 DAA. It was, also, reported that priming was more beneficial for muskmelon seeds of 40 DAA than those of 60 DAA, concerning germination under stress (Welbaum and Bradford, 1991). Demir and Mavi (2004) evaluated the effect of priming on seedling emergence of differentially matured watermelon seeds and observed that the maximum benefit of priming was observed in seeds of 20DAA for seedling emergence percentages, emergence rate, seedling weights, and hypocotyls compared to 30 and 40 DAA.

3- Conclusion:

Seed priming has been used to improve germination, reduce seedling emergence time and improve stand establishment and yield. The beneficial effects of priming have been demonstrated for many field crops. During priming, seeds are partially hydrated so that pre-germinative metabolic activities proceed, while radicle protrusion is prevented, and then seeds are dried back to the original moisture level. Seed priming, is an effective way to improve seed and seedling vigor of. Seed priming can enhance rates and percentages of germination and seedling emergence, which ensure proper stand establishment under a wide range of environmental conditions. These beneficial effects of priming are more evident in premature, rather than mature seeds.

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