J. Basic. Appl. Sci. Res., 2(4)3503-3507, 2012
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Does Priming Improve Seed Performance under Salt and Drought Stress?

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ABSTRACT

Seed priming is a pre-sowing strategy for improving seed performance during germination and field performance. During priming seeds are partially hydrated so that pre-germination activities proceed but radical protrusion will be prevented. Thus, when seeds are sown in the field, they can germinate and emerge sooner. Drought and salinity are two main factors limiting crops growth and development worldwide. In this paper the potential effects of priming for improving seed performance under environmental stress conditions are discussed.
KEY WORDS: drought, germination, salt, seed priming.

INTRODUCTION

Droughts are recognized as an environmental disaster which occur in virtually all climatic zones, such as high as well as low rainfall areas and are mostly related to the reduction in the amount of precipitation received over an extended period of time, such as a season or a year. Temperatures; high winds; low relative humidity; timing and characteristics of rains, including distribution of rainy days during crop growing seasons, intensity and duration of rain, play a significant role in the occurrence of droughts. Salinity stress is a major environmental constraint to irrigated agriculture in the arid, semi-arid and coastal regions. Salinity stress is a major environmental constraint to irrigated agriculture in the arid, semi-arid and coastal regions. Flowers (1986) estimated that about 40% of the world's irrigated agricultural lands could be considered as saline. Another major constraint to seed germination is soil salinity. 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). 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).

The theory of seed priming was proposed by Heydecker in 1973. It is a technique for controlling seed slow absorption and post-dehydration (Heydecker, 1977). After treatment with initiators, plant seeds exhibit enhanced emergence rate and even emerge of seedlings (Harris et al 1999, Bradford et al 1986) During sub-optimal environmental condition, such as salinity and drought, the contents of compatible solute inside the seeds, such as malondialdehyde (MDA), proline, and soluble sugar (SS), and the activity of protective enzymes, such as superoxide dismutase (SOD), peroxidase (POD), catalase (CAT) are important indicators (Mital et al 1995, Bohnert and Shen 1999). Priming may increases these factors which can increase crop resistance to drought and salinity (Wang et al 1991, Liao et al 1994). Thus, in this paper the potentially effects of priming on germination performance of different crop under salt and drought stress were discussed.

SEED PRIMING

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 seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Taylor and Harman, 1990). 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). Various pre hydration or priming treatments have been employed to increase the speed and synchrony of seed germination 5. Common priming techniques include osmopriming (soaking seeds in osmotic solutions such as polyethylene glycol), halopriming (soaking seeds in salt solutions) and hydropriming (soaking seeds in

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water) (Ghassemi-Golezai et al 2008). Improvement of seed germination performance of different crop plants has been reported (Table 1).

Table 1. Improvement of seed germination performance in different crop plants induced by seed priming.

Crop	Reference
Watermelon	Sung and Chiu (1995)
Brassica	Thornton and Powell (1992)
Mustard	Srinivasan et al (1999)
Cauliflower	Fujikura et al (1993)
Wild sunflower	Akinola et al (2000)
Onion	Caseiro et al (2004)
Lentil	Ghassemi-Golezani et al (2008)
Wheat	Kibite and Harker (1991)
Rice	Harris et al (1999)
Barley	Abdulrahmani et al (2007)
Lettuce	Gray and Steckel (1976)
Carrot	Szafuwska et al (1981)

GERMINATION UNDER DROUGHT AND SALT CONDITION

The effects of tress conditions, especially salt and drought, on seed germination have been evaluated in many crops. Demir and Van De Venter (1999) reported that drought and salinity may affect germination by decreasing the water uptake. Kaya et al (2006) compared the effects of two salt and drought inducing factors (NaCl and PEG, respectively) on germination properties of sunflower and concluded that seeds always germinated better in NaCl than PEG at the equivalent water potential. This may be due to the uptake of Na^+ and Cl^- ions by the seed, maintaining a water potential gradient allowing water uptake during seed germination. Lower germination percentage obtained from PEG compared with NaCl at equivalent water potential in each priming method suggest that adverse effects of PEG on germination were due to osmotic effect rather than specific ion accumulation. While Na^+ and Cl^- may be taken up by the seed and toxic effect of NaCl might appear. More inhibition of seed germination by drought (Induced by PEG) compared to salt stress (induced by NaCl) was seen in shorter root length and lower seedling fresh weight. In cowpea drought stress significantly reduced root and shoot growth (El-Midaoui et al 2003). Eskandari and Kazemi (2011) working on the germination of wheat cultivars under salt stress reported that by increasing NaCl concentration, seed germination delayed and decreased in all cultivars. They also reported that increasing salinity concentrations often cause osmotic and/or specific toxicity which may reduce germination percentage. Kazemi and Eskandari (2011) evaluated germination of rice seeds under salinity stress and observed that germination, plumule and radicle length and weight were decreased with increasing in salt concentration where extent of these reductions was related with the variations in rice cultivar under different salt stress condition. By increasing NaCl concentration, seed germination delayed and decreased in all cultivars.

IMPROVEMENT SEED PERFORMANCE UNDER STRESS CONDITIONS

The effects of priming on seed germination properties have been well documented. Shirvankar et al (2003) reported high potential in improving field emergence and ensures early flowering and harvest under stress condition especially in dry areas and under drought stress. Patade et al (2009) suggest that salt priming is an effective pre-germination practice for overcoming salinity and drought induced negative effects in sugar-cane. Farhoudi and Sharifzadeh (2006) while working with canola reported salt priming induced improvement in seed germination, seedling emergence and growth under saline conditions. Priming led to an increased solubilization of seed storage proteins like the beta-subunit of the 11-S globulin and reduction in lipid peroxidation and enhanced antioxidative activity in seeds . Afzal et al. (2008) observed that the priming-induced salt tolerance was associated with improved seedling vigor, metabolism of reserves as well as enhanced K^+ and $Ca2^+$ and decreased Na^+ accumulation in wheat plants. Sivritepe et al (2002) evaluate the effect of salt priming on salt tolerance of melon seedling and reported that total emergence and dry weight were higher in melon seedlings derived from primed seeds and they emerged earlier than non-primed seeds. They also observed that total sugar and proline accumulation and prevented toxic and nutrient deficiency effects of salinity because less Na but more K and especially Ca was accumulated in melon in melon seedlings.

Seed germination performance under stress conditions may be affected by the following factors:

1- **Maturing time:** Response of seed germination to stress conditions depends on the seed maturity level. For example, Ozcoban and Demir (2006) evaluated germination performance of tomato (*Lycopersicun esculentum*) harvested at different maturity times (pink =50 days after anthesis, red firm =60 day after anthesis, red firm =70 days after anthesis, red soft = 80 days after anthesis and overripened = 90 days after anthesis) and concluded that tomato seeds harvested 70 days after anthesis showed the maximum germination not only under water but also salt stress. Seeds harvested earlier or later were more sensitive to stress at germinations. In other words, seeds of tomato have different resistance to salt and drought stresses at different maturity levels. Thus, harvesting at suitable maturity time resulted in increased salt and drought resistance. However, tomato seed germination was more dramatically influenced by osmotic water stress than salt stress despite osmotic potentials were similar. Welbaum et al (1990) in muskmelon and Still (1999) in broccoli reported that germination under low water potential was influenced by maturity stages.

2. Kind of priming: this factor can also affect the potential of seed germination under sub-optimal conditions. In this case, Sun et al 2010 treated the seeds of rice cultivars with H_2O and different concentrations of PEG before germination for disclosing the effects of seed priming with water and polyethylene glycol (PEG) on physiological characteristics in this important crop. Primed or non-primed (control) seeds were then germinated under drought stress conditions simulated with PEG in a serious of concentrations. Results revealed that both hydro-priming and PEG priming had the effects on accelerating germination and improving drought tolerance of seedlings. However, compared to hydro-priming, priming with PEG in a proper concentration had a better effect on seed germination and seedling growth under drought stress.

3. Priming concentration: seed performance under drought or salt stress is also affected by the concentration of priming materials. It has been reported that, Na-Cl priming generally requires long-term treatment periods using solutuins with relatively high concentrations of NaCl; however, short term seed priming with a low NaCl concentration also increases germination rate, field emergence and acquired stress tolerance (Nakaune et al, 2012). Sun et al (2010) also concluded that PEG priming with moderate concentration resulted in higher tolerance to drought stress than hydro-priming, while higher concentrations of PEG had negative effects on seed germination.

CONCLUSION

In general, it can be concluded that priming improved seed germination performance, especially under sub-optimal environmental condition such as drought and salinity. There are some factors affecting the response of seed to priming in terms of resistance to drought and salinity suggesting that seeds harvested at appropriate time and suitable material with precise concentration used for priming, the performance of seed germination will be improved under drought and salt conditions.

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