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REVIEW ARTICLE

Role of seed priming to enhance growth and development of crop plants against biotic and abiotic stresses

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ABSTRACT: Abiotic and biotic stresses severely affect the crop's growth and development at every stage of growth cycle. Seed priming is helpful technique to enhance seed germination and growth in stress environment. Seed priming is a control procedure followed by re-drying which will allow the seed to imbibe water stimulate the internal biological process essential for germination but this process will not permit the seed to be truly germinate. Currently many seed priming method have been used like hydro-priming, osmo-priming, halo-priming, thermo-priming, bio-priming and solid matrix priming. Various studies confirmed that seed priming has several advantages including, early emergence high water use efficiency, stand establishment, deeper roots germination in broad range of temperature and resistance against disease and environmental stresses.

Keywords: oilseeds, seed priming, germination, tolerance, production

INTRODUCTION

Seed Priming is a process which increases the germination percentage and reduces the time of emergence; because the primed seeds of plants completed their chitting period (seed absorb maximum water and complete all processes before germination during priming). During priming process, seeds are soaked in different solutions with high osmotic potential. Different type of solutions according to the seed requirement was used for seed priming. The purpose of soaking of seed in the solution is to prevent the enough water absorption for radical emergence and expand the seed in lag phase. Seed priming protects the disease attack by apply the coating of fungicides, bactericides and nematicides. Seed priming is used to increase the germination percentage and seed vigor (Nawaz et al., 2013). Primed seeds have great potential to grow under stressful conditions. It has strong resistance against disease and insect attack. Primed seeds have much growth potential and give more production as compared to non-primed seeds. It showed that more yield and uniformity as compare to non-primed seeds. Seed germination process occurs in the three phases. First phase in which seed uptake the water rapidly is named as Imbibitional phase, second phase which just change in the water content and third or last phase is radical emergence. Primed seeds completed first two phases during priming process so immediately germinate after sowing (Ahmadvand et al., 2012).

Seed priming is a process of regulating the germination process by managing the temperature and seed moisture content, the seed is taken through the first biochemical processes within the initial stages of germination. The priming process regulates the seed's temperature and moisture content, bringing the

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seed closer to the point of germination. The process involves advancing the seed to an equal stage of the germination process, to enable fast and uniform emergence when planted. Seed priming involves taking seed through the early stages of the germination process. In the chart below, the green line corresponds to a standard germination process: during the phase 1 (imbibition), under suitable temperature and moisture, seed takes up water. During Phase II the biochemical processes are activated and will eventually start the germination in Phase III where (roots and hypocotyls emerge from the seed. During priming, the seed is taken part way through Phase II and then dried, before the root can emerge from the seed. Once conditions (temperature and moisture) are appropriate in the field, Phase III can continue, germination occurs in a much shorter time (Hasegawa, 2016).

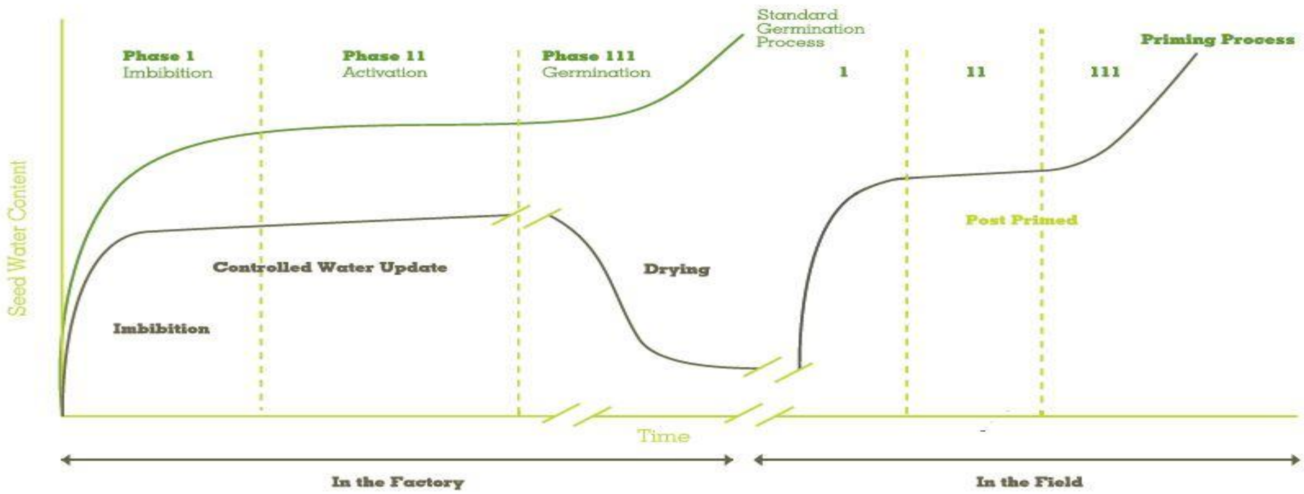

Chart1: *Standard Germination Process vs. Seed Priming Process* (Hasegawa, 2016)

Seed priming is a technique in which seeds are soaked in any priming agent and dried before radical protrusion. Different types of priming techniques are used such as hydro-priming (soaked seed in water), halo- priming (soaked of seed in inorganic salt solutions), osmo-priming (soaked of seed in organic osmotic solution), thermo-priming (treated the seed with low or high temperature depend upon species), solid matrix priming (treated the seed solid matrices) and bio-priming (seeds treated by biological compounds) (Ashraf and Foolad, 2005).

Priming improves the uniformity, rate of germination of seed lots and also used to determine the plant density. Seed priming has found beneficial effects on many field crops. Priming increase the proteins synthesis, repairing of membranes and also building up of nucleic acids. It also enhances the activities anti-oxidative enzymes in treated seeds and also increases the glyoxime enzyme in seeds. Seed priming is influenced by many factors such as water potentiality of priming agent, priming agent duration, temperature, seed vigour and seed storage condition (Ghassemi-Golezani et al., 2010b). Priming decreases the time between the planting and emergence and protect seed from abiotic and biotic stresses (Basra et al., 2003). Primed seeds showed greater adaptability in wider range of abiotic and biotic stress conditions as compared to un-primed seeds (Nazir et al., 2014). Temperature is most effective limiting factor in plant growth. Study on different crops showed that seed priming techniques had been effectively enhanced the germination and early seedling growth mainly at

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abnormal condition and also developed resistance against stress conditions (Pouramir Dashtmian and Khajeh Hosseini, 2014). Environmental stresses, as salinity, drought and disease induce changes in gene expression and enzyme activities in crop plant which reduce the growth and productivity. In response to many stresses plants produce a number of proteins to defend cell metabolism the production of hydrophilic protein is a main part of plant response to stress condition. Late embryo genesis protein reduces the damage caused by adverse condition (Liu et al., 2013). High quality seed is the key component for high crop production. Seed vigor is the main factor for good quality seeds. Seedling germination, emergence and crop establishment are vital aspects for crop production. Aging minimize the germination percentage and produce weak seedling. Several seed priming techniques are used to combat the damage of aging and stimulate their performance in various crops (Abdolahi et al., 2012). The objective of this manuscript is to review the role of seed priming in different oilseed crops to enhance their growth and development.

1. GERMINATION AND GROWTH ENHANCEMENT

Seed priming is a technique which controls the hydration level of seed and also controls the metabolic activity within the seed which is necessary for seed germination (Atalou.F.R, 2014). Seed priming is mainly used to increase germination and uniformity of different crops under non-supporting conditions. Mostly priming is used to get uniform and healthy crop stand and it increase the vigour of seed (Draganic and Lekic, 2012). During priming treatments seed absorbed the water which is sufficient for hydration and necessary for metabolic activities inside the seed. Primed seeds were complete their germination processes early as compared to non-primed seeds (Dezfuli et al., 2008). During seed priming seed can imbibe water more rapidly before radical protrusion then re-dried to its original weight and can store under suitable conditions for long time (Tabatabaei, 2013).

1.1. SESAME

Seed priming technique improved the seedling establishment and modulating pre-germination metabolic activity. Seed priming enhances the protrusion of the radical, germination rate and plant performance (Shabbir et al., 2014). Priming treatments lead to earlier emergence, bigger seedling shoot and fresh weight than was achieved with non-primed seed in sesame (Shim et al., 2009). Hormonal priming is technique in which different types of hormones are used such as Gibberellic acid, Ascorbic acid and Salicylic acid which increase the germination percentage and seed vigor. Seed priming increases high germination index, enzyme action and normal seedling in Sesame crop. After seed priming the antioxidant activity of seed has increased. A solution of Gibberellic acid and Kinetin were made with different concentration as 0, 50,100,150 and 200 ppm and seeds were soaked. After this seeds were put in plastic cup for twelve hours, then remove the seeds from solution and washed with distilled water (Atalou.F.R, 2014).

1.2. SUNFLOWER

Seeds primed with PEG-8000 solution at temperature of 15^0C increased the germination rate and seedling growth. Plant growth regulators are also used with priming agent to increase crop performance. Dry heat treatment also ensures better seed germination through the breakdown of seed dormancy. Treatments of H_2O_2, SA, TU and GA_3 are involved in the

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synthesis of de novo protein and worked as repair mechanism and increase vigour of seed for rapid germination and early seedling growth (Wahid et al., 2008).

1.3. BRASSICA

Seed priming enhanced the germination performance and emergence of seed in Brassica (Jett et al., 1996). Seed priming techniques are used to increase rapid germination and also achieve the high vigor and yield in field crops. In wheat seed priming enhanced the emergence, stand establishment, tillering, straw length, healthy grains, high yield and high harvested index (Farooq et al., 2008). It had been found that water was used as successful priming medium. In wheat crop mostly three priming agent potassium hydro phosphate, potassium chloride (Misra and Dwivedi, 1980; Paul and Choudhury, 1991) and polyethylene glycol (Basra et al., 1989) are used. These agents have high potential to enhance germination, emergence and grain yield of wheat. Seeds were soaked in 0.5 % solution of potassium sulfate (K_2SO_4) increased plant height, yield attributes and grain yield. Seed priming with PEG 10% increased the stem, radicle dry weight germination percentage and rate of germination (Lemrasky and Hosseini, 2012).
Polyethylene glycol (K_2HPO_4) and potassium (KNO_3) salts are used for corn seed priming (Basra et al., 1989). Seeds were soaked in the 2.5% solution of KCl for 16 hours which reduced coleoptile and radicle length (Nagar et al., 1998). Seeds were soaked in solution of 20ppm GA_3 by which germination trait was improved but it has no effect on grain yield (Dezfuli et al., 2008). Seedling growth and Seedling performance were increased by using dilute solutions of Phosphorus. Seeds were soaked one percent solution of phosphorus to increase the crops growth and yield. Seeds were treated with 1% solution of Phosphorus. Phosphorus increases the rate of photosynthesis in maize (Miraj et al., 2013). Seeds were treated with solution of KNO_3, $CaCl_2$, KCl and KH_2PO_4 for 14 hours. Root and shoot length influenced by the seed priming. Seed priming increase the yield of maize crop. Seed priming soften the endosperm to increase the germination as compared to non-primed seeds. Seed vigour influenced by the treatments of seed priming (Hanegave et al., 2011).

1.4. COTTON

Seeds are treated with water to get high germination rate and seed vigour. Hydro-priming with KNO3 is most effective as compared to hydro-priming alone (Nazir et al., 2014). Seed priming affected physiological and biochemical changes in seeds. Hydro-priming also increase seed vigour and control the dormancy in seeds. Primed seeds give greater yield then non-primed seeds. Osmo-priming gave high germination rate in delinted seed as compared to fuzzy seeds. Priming in cotton seeds affect the metabolic reactions and increase the endosperm analysis due to fast hydrolysis functions and this gives higher germination rate and percentage (Rezaee, 2015). Hydro-priming repair the genetic and structural damages. Hydro-priming increases the mean germination of cotton seed as compared to non-primed seeds (Basra et al., 2003). Priming of cotton seed for seed germination, emergence and seedling vigour is changed according to genotypes, chemicals and different doses of chemicals. KNO_3 is priming agent used for cotton seeds, (4% or 2%) KNO_3 showed highest germination rate in cotton genotypes. All priming techniques are used to improve seed vigor, rate of germination and seedling growth. When cotton seeds are primed with NaCl (2%) gave higher germination rate then KNO3 (4%). Priming with

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KNO_3 and PEG-6000 showed best lateral root production. Different priming agents gave different vigour rate such as NaCl gave highest vigour rate (91.88) and then KNO_3 (4%) with vigour rate (90.63) and KH_2PO_4 gave lowest results of seed vigour (86.43). Various agents of priming showed different germination rate in cotton seed. KNO_3 gave highest germination rate while priming with KH_2PO_4 showed lowest result with (93.65%) germination rate. Mannitol gave longest seedling in cotton plants while KH_2PO_4 caused shortest seedling growth. PEG-6000 had also positive effect on length of seedling. KNO_3 showed highest results inspite of all other priming agents. So to get highest results KNO_3 (4%) is used as priming medium. Cotton seeds are soaked in KNO_3 solution for 2 hours and then dried to moisture contents ~8% for KNO_3 priming (Çokkizgin and Bölek, 2015).

2. SALINITY STRESS

Salinity is major abiotic stress which effect germination, seedling growth and crop production in arid and semiarid areas. Seed priming increases the yield potential, quality and crop profit. Seed priming takes the early DNA replication, make more number of RNA and increase protein synthesis, boost embryo growth repairs deteriorated seed parts and decreases outflow of metabolites (McDonald, 2000). Priming with KNO_3 is more effective as compared with NaCl. Seed primed with KNO_3 performed well in the field under adverse conditions. Salt priming enhances the germination percentage as compared to the non-primed seeds. Priming with NaCl seed were produce larger seedling. It also increased number of pods and grains per plant (Ghassemi-Golezani et al., 2010a). Salinity problem of wheat crop can be overcome by using the priming techniques.

2.1. WHEAT

Seed treated with cytokinins to increase the germination, growth and yield of crop under saline soil. It affects the phyto-hormones which increased the rate of translocation of photosynthates from leaves to grain. Plant tissues which response the salinity was decline by using the cytokinins. Seed priming has beneficial effects under stressful conditions. Prepare the solution of 100, 150 and 200mgl^{-1} cytokinins and benzyl amino-purine for priming. Seeds washed with distilled water then soaked in prepared solution for 12 hours at room temperature. After complete the hours seed were re-dried under shadow and used it for further sowing in field. Seed treated with 150 mgl^{-1} of cytokinins tolerate the salt concentration very well and had greater shoots. Grain yield were also improved in primed seeds. Cytokinins make wheat plants the salt tolerant. It has beneficial effect on growth and grain yield of wheat crop under salt stress conditions (Iqbal and Ashraf, 2006).

2.2. MAIZE

Salinity stress affects the production of maize crop throughout the world. Maize plants have C_4 plant metabolic system. Salinity effects on seed germination, creating and osmotic potential outside and inhibiting absorption of water by toxic effect of Na^+ and Cl^- in maize crop. Salinity stress reduces the germination percentage. During early phase of germination seed priming stimulate many of the metabolic processes. Primed seed perform better in adverse conditions. Soil salinity decreases by the priming of seed with chemicals K and Fe. These chemicals make the plant defense stronger against of salinity (Sali et al., 2015).

2.3. SUNFLOWER AND BRASSICA

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Different priming agents are used to prime the Sunflower seeds such as ascorbic acid, tocopherol and glutathione. Hydro-priming preserved the sunflower seeds from damage during abiotic stresses, salinity and drought. Mostly, polyethylene is used to prime the sunflower seeds because it declines the ageing process. Priming of sunflower seed with antioxidants decreased the aging process that had positive effect on root and shoot length but it does not affect the germination rate (Draganic and Lekic, 2012). Seed priming increased the resistance under salt stress condition in Brassica (Jett et al., 1996).

2.4. COTTON AND RICE

Germination of cotton seed is sensitive to salinity. Priming improves germination rate of Cotton seeds in control treatment as well as salinity. Cotton seeds showed best results when they are treated with hydro-priming as compared to osmo-priming. KNO3 is best priming agent for cotton seed but hydro-priming gives highest germination rate in cotton seeds especially in delinted seeds as compared to fuzzy seeds (Rezaee, 2015). It was investigated the potential of seed priming for induction of salt tolerance in Rice. Priming with $CaCl_2$ followed by KCl were more effective in inducing salt tolerance of both rice cultivars owing to enhanced germination capacity, speed of germination, seedling length and dry weight in saline medium (Afzal et al., 2012).

3. DROUGHT STRESS

3.1. SUNFLOWER AND BRASSICA

Water stress has negative effect on growth of plant because during this condition respiration process is affected due to loss in evaluation of oxygen and decrease in CO_2 fixation which cause photo damage and oxidative stress in different components of cell. Plant growth promoting rhizo-bacteria (PGPR) are those bacteria which are present in roots of many plants and play important role in rapid plant growth. Sunflower seeds are inoculated with Azoto-bacteria chroococcum and bacillus polymyxa separately or combined to enhance adoptability of plants during water lack condition (Singh, 2015). Brassica seeds were soaked in distilled water at 25^0C for 18 hours under dark conditions. Before soaking the seed in the distilled water seeds were treated with 500 ppm KNO_3 solution at 25^0C for 2 hours in dark conditions. Then seeds were washed with tap water and then re-dried to their original moisture content under shadow. Hydro-priming enhanced the rapid uptake of water for germination. Hydro-priming also increased the shoot length and also enhanced the performance of plant under stress conditions (Omidi et al., 2009).

3.2. MAIZE

Under water deficit condition the seed priming and ridge sowing are highly useful for improving Maize performance. Drought tolerance was reduced by using $CaCl_2$ in maize. Seed were soaked in $CaCl_2$ solution and distilled water for priming process. Seeds were dipped in an aerated water and $CaCl_2$ solution for 24 hours to achieve osmo and hydro-priming. After priming, seed surface was washed with tap water and re-dried is done under shade to achieve its original weight. The seeds were wrapped in polythene bags and then stored at 5 °C till use. Priming with $CaCl_2$ showed improved yield of maize under drought stress conditions (Harris et al., 1999).

3.3. WHEAT

Seed priming improves the wheat seedling under drought stress conditions (Hussain et al., 2013). When Wheat was grown in dry land

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crucial factors affect the grain yield. Seed priming exceed the early DNA replication, increase RNA and protein synthesis. Osmo-priming in wheat seed promotes the vigorous root growth under stress conditions. Wheat seed were soaked in different solution water, 2% KCL, 4% KCl, 0.5% KH_2PO_4 and 10- 20% of PEG at 24^0C for different hours such as 12, 24, and 36. These all solutions were prepared in distilled water. Priming with water and PEG show rapid germination as compared to KCl and non-primed seed. Over all priming increase the wheat crop yield (Giri and Schillinger, 2003).

3.4. RICE AND COTTON

Many rain-fed areas are often restrained by drought. Moisture stress effect different growth stages of Rice like fertilization, pollination and grain filling. Priming techniques are used to decrease emergence time, better allo-metric attributes in the crop. These include osmo-conditioning, hydro-priming, hardening and hormonal priming. Rice seed hardened in many salt solutions rather than tap or distilled water. Osmo-hardening with $CaCl_2$ (-1.25MPa) was more efficient for vigour improvement than simple priming. Priming with 4% KCL solution enhance fertile tiller, grain yield and plant density under soil with low moisture content. This recommends that in drought areas, seed priming techniques are useful for good crop stand (Farooq et al., 2006). Osmo-priming promotes cellular and sub-cellular changes in Cotton seeds which increase seed vigour and viability during germination and emergence under salinity and water stress conditions (Rezaee, 2015).

4. TEMPERATURE STRESS

Late sown wheat completed growth stages in reduced time as compared to normal sown wheat and also matures nearly due to high temperature at maturity time. Heat stress decreases grain weight, small, shriveled and also reduce the reproductive stage crop. To improve the seedling growth, stand establishment and yield of crop, wheat seed is primed with KCl and $CaCl_2$. Seed priming can improve the vigor of seed, root, and shoot ratio. Hydro-priming enhance the vigor of seed and improved stand establishment. Osmo-priming increased the number of tillers, biological yield and harvest index of wheat under late sowing. The seeds of wheat crop were soaked in 1.2% solution of $CaCl_2$ for 12 hours and then sown in the field. Seed priming reduce the time to emergence as compared to non-primed seeds. It also improve the plant height, spikelets per spike, grains per spike, straw weight and overall increase the yield of crop (Hussain et al., 2013).

4.1. COTTON

Cotton is very sensitive to high temperature, it required relatively long period to complete vegetative growth period but this period can be decreased by providing optimum temperature at sowing time. Cotton is so critical to temperature that fluctuation in temperature may delay the seedling growth and growth rate of cotton seeds. Seed priming encourage rapid germination in various environments. Generally PEG with molecular weight 6000/8000 is used to prime cotton seed. For cold germination KNO3 is best priming agent for cotton seed to show best vigour rate. Mannitol priming agent gave rapid growth of seedlings for early harvesting and cold tolerant plants. Priming of cotton seeds with (2%) KNO_3 can be an efficient way to get vigorous cotton plants under cold stress (Çokkizgin and Bölek, 2015).

5. Disease Management:

Brassica is most susceptible crop for the attack of several fungal pathogens. These diseases are

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controlled by fungicides but it is very difficult and expensive method as compare to the seed priming or seed treatment. Seed priming is one of the most suitable and economically profitable methods for biocontrol agents in disease management. For this purpose, the bio priming is used which is most effective way to protect the plant form fungal pathogen attack. In the bio-priming bacteria are used which compete the pathogen and suppress their growth, thus it makes the plant defense mechanism more effective. Seeds were soaked in a solution of bio-priming agent and stop the process before seed dormancy is broken and seed are dried again to its original weight. Bio-priming is most commonly used method and advantage of this method is to protect the plant against adverse biotic and abiotic factors inside the seeds (Abuamsha et al., 2011). Seed priming in the Brassica crop reduces the risk of weak seed establishment in cold environment (Omidi et al., 2009).

CONCLUSION

It is concluded that seed priming is a method which is potentially able to promote rapid and more uniform seed germination and plant growth. It is also helpful to germinate seeds of different crop under adverse agro-climatic conditions with enhanced yield.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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