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Seed Hardening: A Way to Tolerate Against Abiotic Stress in Rainfed Areas

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Abstract

Pre-sowing hardening or priming of seeds is one of the best methods for altering the biochemical and physiological process of seeds for favourable condition to induce drought tolerance in emerging seedlings. The recurrent phenomenon in rainfed areas i.e. soil moisture stress immediately after sowing affects seeds germination and their establishment. Under sub-optimal environmental conditions like rainfed farming, poor seed germination followed by poor field establishment is a common phenomenon. Seed hardening enables seedlings to survive this early moisture stress. hydration of seeds for short term before planting greatly benefits stand establishment along with the uses of chemicals like potassium or sodium phosphate would give additional advantage. It is defined as the process of soaking seeds in chemical solution for specified time and then drying to induce tolerance to drought. Various seed priming/hardening techniques have been developed including hydro-priming, halo-priming, osmo-priming and hormonal priming. Micronutrient seed treatments, which include seed priming and seed coating, are an attractive and easy alternative. Seed hardening promotes early establishment provides more strengthen to plant and it became competitive against infections and diseases is related to gene regulation and expression under stress conditions. The discovery of plant hormones in the 1920s underlined the crucial role of these compounds in seed desiccation tolerance, reserve mobilization, as well as cell division and cell elongation occurring during germination. The seed hardening is considered as low cost technology and is the most important requirement for pre-monsoon sowing. Seed hardening offer an attractive option for resource poor farmers. During seed hardening, seeds are subjected to partial hydration followed by dehydration before sowing.

Keywords: Benefit, methods, rainfed area, seed hardening

1. Introduction

Rajasthan is the largest state comprised of 11% of the total geographical area experienced a vast diurnal variation in weather variables. The soil and climatic constraints affect the production resulted into wide variation and instability in crop yields. The low productivity of rainfed crops is a result of abiotic and biotic factors including cultural/agronomical like germination problems, soil quality constraints, poor fertility, scarcity of water, poor quality of water, high weed infestation etc. These constraints affect the production resulted into wide variation and instability in crop yields (Jain and Parewa, 2017). Improved and quality seeds or planting material play an important role in success of crop production besides recommended cultural package of practices. The low productivity of crops in rainfed areas is contributed by the use of poor quality seeds or seeds of previous harvest, improper selection of pre-sowing, lack of seed treatment practices and improper crop management. The features like rapid and identical seedling emergence are the two essential prerequisites to increase seed yield and seed quality in a number of field crops (Krishnotar et al., 2009). Further, Seed priming/ hardening is a common practice followed to improve seed performance with respect to rate and consistency of germination (De Lespinay et al., 2010).

Seeds are soaked in chemical solutions of prescribed concentration. Soaked seeds are then dried in shade back to original moisture content. During soaking, seeds imbibe water and germination process is started but not completed. The hardened seeds are thus in a ready state for germination. When sown in moist soils, seeds germinate immediately (Farooq et al., 2019). Such early germination helps in seedling emergence before surface soil dries up. Seed hardening is, therefore, done to overcome the adversity of moisture stress that is common in dry farming areas those normally faced the recurrent drought just after sowing under normal seed sowing resulted in poor crop establishment. The seed hardening of cotton seeds reported improved germination percentage, total dry matter, relative water content and yield attributes like number of bolls, boll weight and seed cotton yield significantly (Patil et al., 2014). In general seed hardening treatment of rice before sowing significantly increased the seed quality characteristics and yield attributing characters when compared to untreated seeds. Hardening with $CaCl_2$ recorded the best seed quality viz., germination percentage, speed of germination, root length, shoot length, seedling length, dry matter production and other characteristics (Prabhu et al., 2018).

When dry seeds are soaked in water/chemical solution, a number of physicochemical changes occur like the quiescent cells get hydrated and germination initiated, enhanced mitochondrial activity leading to the formation of high energy compounds, vital bio-molecules etc. and modify the protoplasmic characters, increasing the embryo physiological activity and associated structures, eventually leading to higher absorption of water, increase in the elasticity of the cell and development of a stronger and efficient root system (Prabhu et al., 2018). Finally the latent embryo gets enlarged. When the imbibed seeds are dried again, the triggered germination is halted. When such seeds are sown, reimbibition begins and the germination event continues from where it stopped previously. As a consequence there will be multitudes of benefits, which make the plants prepared to resist the adverse weather if any.

2. Beneficial Effect of Seed Hardening

Beneficial effects of seed hardening under rainfed areas are as under suggested by Solaimalai and Subburamu (2004).

• The seed hardening accelerated rapid germination and ensures early germination by 2–3 days compared to untreated seeds.

• It induces better root development and rapid growth of seedlings, which enables absorption of more moisture.

• Germination and seedling emergence are completed before surface soil dries out.

• It induces drought tolerance by increasing the resistance to protoplasmic dehydration in young seedlings subjected to moisture stress.

• Quick germination of seedlings favour more effective competence with weeds.

• Hardened plant recover much more quickly from wilting than those from untreated plants, includes resistance to salinity.

• Seeds withstand higher temperature for prolonged period without loss of viability.

• Flowering is slightly accelerated in treated plants.

• Plants developed from primed/ hardened seeds often exhibit a faster growth due to an improved nutrient use efficiency besides higher relative growth rate (Muhammad et al., 2015).

• Overall hardened/primed seeds perform better, overcome constraints and results in more yield.

3. Types of Seed Priming

Heydecker (1973) used different terms depending upon the method adopted for priming and are as follows;

• Hydropriming: It is the simplest method of seed priming, which relies on seed soaking in pure water and re-drying to original moisture content prior to sowing.

• Osmopriming: It is technique refers to soaking of seeds for a certain period in solution of sugar example PEG 8000.

• Halopriming. It refers to soaking of seeds in solution of inorganic salts i.e., NaCl, $CaCl_2$, KNO_3 and $CaSO_4$ etc of varying concentrations.

• Biopriming: Biopriming involves seed imbibition together with bacterial inoculation of seed.

• Solid matric priming: Solid matrix priming or matriconditioning in which water uptake by seeds is controlled.

4. Materials and Chemicals Used for Seed Hardening

The material used for seed hardening may be inorganic salts like NaCl, Na_2SO_4 KCl, KH_2PO_4, $CaCl_2$ and $MgSO_4$; organic acids like succinic acid, CCC and auxins and water (Patil et al., 2014). The details are as follows:

• Water

• Aqueous salt solutions like chlorides of sodium, potassium and calcium. Sulphates of sodium and ammonium. Potassium nitrate (Halo priming).

• Growth regulators like Gibberallic acid, chlorocholine chloride, kinetin, 2-chloroethyl phosphoric acid, Ascorbic acid (Harmonal primimg).

• Vitamins like K3 Nicotin acid, pantothenic acid etc.

• Plant products like garlic extract, coconut water etc.

• Polyethylene glycol

• Osmotic priming material like D-Manitol, poly ethylene glycotect (Osmo priming).

• Treatment of seed with low or high temperatures (Thermopriming)

5. Uses in Crops

• Seed hardening with 2% potassium di-hydrogen phosphate or potassium chloride.

• For cotton in black soils, pre-monsoon dry seeding is recommended at 2–4 -weeks before commencement of monsoon, with a sowing depth of 5 cm and seed hardening with CCC (500 ppm) or potassium chloride or DAP at 2% (Patil et al., 2014).

• Khan et al. (2009) reported that the priming of seeds using NaCl improved seedling vigour and establishment under salt stress conditions. Seed hardening improves seedling performance by boosting rapid, uniform, and vigorous germination which helps seedlings to grow in stressed conditions. Further, it was concluded that the use of priming techniques can enhance the germination of wheat seed under saline conditions and overcome the effect of salt under conditions of mild salt stress entirely (Fuller et al., 2012).

• Priming the seeds of sunflower with osmo-primers, i.e. KH_2PO_4 (KDP) and $NH_4H_2PO_4$ (ADP) and followed by imposing salt stress with NaCl up to 60 mM affected significantly seed germination, seedling growth and ionic concentrations. KDP proved to be better source because it contains potassium and phosphate ions simultaneously for priming of sunflower seeds under salt stress. (Badar-uz-Zaman et al., 2017).

• Hasan et al. (2016) while studying on the osmopriming for paddy seed reported that priming the seeds with 3% $ZnSO_4$ and 5% KCl for different durations had significant influence on germination percentage, growth parameters (root length, root dry weight) and less germination time. The priming of rice seeds with KNO_3 also influenced significantly the yield of paddy.

• The wheat seed hardened with $CaC1_2$ overlook the negative effect of salinity (Roy and Srivastava, 1999).

• Harris et al. (2007) reported that maize seeds priming with in solution of 1% Zn for 16 hours increased the content of Zn.

• Rahman et al. (2011) found that soaking of seed in water i.e. hydropriming improved seed germination and early seedling growth under both optimal and stress conditions in various crop plants such as chickpea and maize. Mehri (2015) while studying at Iran found that seed yield of soybean was significantly affected by priming method and time. Seed priming with H_2O for 18 hours significantly increased the seed yield.

• Priming with growth regulator i.e. GA_3 found beneficial and increased grain yield in wheat. It also increased salt tolerance by modulating hormone homeostasis together with alterations of ion uptake and accumulation between shoots and roots (Iqbal and Ashraf, 2013).

• Biopriming includes bacterial inoculation of seed with plant growth-promoting bacteria (PGPB) i.e *Pseudomonas fluorescens, Rhizobacteria* etc., increases rate and uniformity of germination along with protection of seeds against the soil and seed-borne pathogens along with seed imbibition (Timmusk et al., 2014). Biopriming isolates enhanced plant growth and resistance against downy mildew disease in pearlmillet (Raj et al., 2004).

6. Methods of Seed Hardening

Seed hardening is the best solution of germination related problems especially when crops are grown under unfavourable conditions. Many hardening/priming techniques have been evolved which are being utilized in many crops now days. The following methods are mostly used for seed hardening for favourable crop establishment to utilize the available moisture for prolonged period as suggested by many workers and are as follows:

6.1. Water treatment (hydro priming)

Seeds are soaked in water at room temperature and allowed to absorb moisture up to considerable weight i.e. 35% of their weight and kept in imbibed condition for about six hours. These treated seeds spread as a thin layer in shed for 2-3 days to attain their original weight. These practice may be repeated for 3-4 times which depends on type of crop and variety.

6.2 Chemical treatment: The treatment of alternate wetting and drying of seeds as in the case of hydro priming has to be carried out with different chemical solution of varying concentration as recommended in Table 1. The time of soaking the seed in different solutions depends on type of seeds and other properties.

Table 1: Chemicals recommended for seed hardening in different crops

Maize	Cycocel (250 ppm) chemical
Rice	Potassium chloride 1%, Calcium chloride 0.5%
Sorghum	KH_2PO_4 (2%) , KCl (1 %) or $CaCl_2$ (2%)
Pearlmillet	NaCl (0.5%), KCl (1 %)
Paddy	KCl (1%)
Millets & cotton	KCl(2%)
Sesame	Calcium chloride 0.2%
Groundnut	$CaCl_2$ (0.5%)
Pigeonpea	$ZnSO_4$ (100 ppm)
Sunflower	GA_3 (500 ppm) or $MgSO_4$ (0.2 – 0.5%) , Zinc sulphate 2 %
Greengram	MgSO4 (100 ppm)
Chickpea	$KH_2 PO_4$ (1%)
Cotton	CCC 1000 ppm, KCl 2% , DAP 2%
Black gram and green gram	Mangenese sulphate 100 ppm
Bengalgram	Potassium di hydrogen phosphate, 1 %

(http://agritech.tnau.ac.in/seed_certification/seed%20treatments_seed%20harding%20drought%20trolence.html)

7. Precautions

• Hardened seeds can be sown immediately or within 30 days of treatment.

• For success in seed hardening, attention must be paid in selection of right chemical, its concentration, time of soaking, volume of solution and drying under shade to original moisture content.

8. Conclusion

The various seed hardening treatments influence growth and yield parameters in almost all field crops particularly in rainfed areas in particular and all crops in general. The hardening of seeds improved the initial establishment of plant significantly increased seed yield and seed quality compared to normal sowing.

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