Seed Hardening for drought tolerance crop seed

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Summary

Quality seeds play a major role, along with improved package of practices leading to enhanced productivity. Safe guarding seeds during initial stage of germination will give a special impetus for the seed to overcome the moisture stress condition and develop into a vigorous plant. In dryland agriculture, drought resistance of plant is one of the very important factor to get the higher yield. Though this is largely depends on genetic makeup of the variety, pre-sowing treatments like 'hardening' also practiced to defy the ill effects of drought on emergence and growth of crop.

Introduction

In India, nearly 70% of cultivated land is rainfed and accounts about 42 % of the total quantity of food grains produced. The low productivity under rainfed condition is due to use of poor quality seeds, soil moisture deficit, low and erratic rainfall and improper crop management. For enhancing productivity, quality seeds play a major role. Seed hardening is a practice adopted to alleviate the moisture stress or making the plant resistant to moisture stress. Seeds are exposed to changing and often adverse environments in the soil for a considerably long period beginning with sowing and ending with emergence. The period of imbibition is extremely sensitive to changes in the environment and slight and sudden changes appear to profoundly affect the seedling emergence. Researchers used water as a hydrating agent and reported that pre-sowing seed hardening (wetting and drying) modified the seed and seedling quality characters and thereby enhanced the yield. Hence, seed hardening is one of the physiological pre-sowing seed management practice given to seeds to resist drought and to boost up the yield and is being in practice from time immemorial owing to the better performance among the agriculturists.

Seed Hardening

It is the process of hydrating the seed to initiate the pre-germinative metabolism followed by dehydration which fixes the biochemical events. It is done to impart resistance against stress conditions *viz*., drought and cold to the emerging seedlings.

Different physiological activities within the seed occur at different moisture levels and the last physiological activity in the germination process is the emergence of radicle. The initiation of radicle emergence requires high seed water content (upto 30%). By limiting seed water content, all the metabolic steps necessary for germination can occur without the irreversible act of radicle emergence. Prior to radicle emergence, the seed is considered desiccation tolerant, thus the hardened seed moisture content can be reduced by drying. After drying, hardened seeds can be stored for a short time prior to sowing. Pre-sowing hardening is one of the best methods that results in modifying the physiological and biochemical nature of seed so as to get the characters that are favourable for drought resistance. It can be done with water / dilute chemical solutions / growth regulating compounds or using commonly available natural tonics like coconut water or milk.

How it is done?

Seeds are soaked in water and allowed to absorb moisture upto 30-35 per cent of their weight and kept in swollen condition for 1-12h depending upon the crop species at 25^0C. Then, the seeds are spread in a thin layer for shade drying for 1 to 2 days. After shade drying, they are sundried for 1 to 2 days to bring back to the original moisture content or weight. The hardened seeds are used for sowing. The treatment is repeated for more times depending upon the kind and variety of crops.

Mode of action

The basis for pre-sowing seed hardening is significant increase in hydrophilic property of protoplasmic colloids namely viscosity and elasticity; increased phosphorylation activity of their mitochondria. Reduction in solute leakage by regaining cell membrane integrity, resumption of rate of protein and RNA synthesis characterized in the first period of imbibition and shortening of the time of DNA replication in the second hydration period. Simulation of long lived mRNA

under moisture stress conditions; simultaneous protein and proline content increase after hardening treatments.

Principle involved in seed hardening

During hardening process, a number of physicochemical changes occur and modifies the protoplasmic characters and increases the physiological activity of the embryo and associated structures. Eventually, due to more absorption of water due to increase in the elasticity of cell and development of a stronger and efficient root system.

Dry seed

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Imbibition

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Permits initial process of germination (An advancement in germination processes)

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Dehydration

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Prevent cell and radicle emergence

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Shade and sun drying to bring back to its original water content or weight

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Stops the germination process

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Hardened seed

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Sowing

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Remember the germination process where it had stopped

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Rapid germination and quick establishment of seedling (survival) with available soil moisture

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Increased growth and productivity

Steps in seed hardening

Dry seed

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Soaking in water and/or dilute solutions of growth regulator and chemicals for 1-12h at 15-25^{0}C

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Shade drying (1 to 24h)

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Sun drying (1 to 2 days) to bring back to its original water content or weight

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Hardened seed

Chemicals used for seed hardening

In addition to water, the following chemicals, growth regulators, vitamin, botanical leaf extract and microbial enhancers are recommended.

Chemicals	**Role**
Potassium nitrate	Involved in the physiological process of stomatal movement, osmo-regulation, cell wall and membrane permeability
Calcium chloride	Used to activate ATPase and amylase enzymes, participate in starch metabolism
Ammonium sulphate	Used as a constituents of amino acids like cystine, methionine, cystenine
Potassium chloride	Required for activation of enzyme process
Zinc sulphate	It induces the dehydrogenase, alcohol dehydrogenase and lactic dehydrogenase enzyme activity
Potassium di hydrogen phosphate	Used as a constituents of phospholipids, nucleotides and sugar phosphate
Growth regulators	**Role**

Gibberellic acid	Increases hydrolytic enzymes
CCC, Kinetin	Biosynthesis of tRNA and closely related to nucleic acid synthesis
Ascorbic acid	Involved in several oxidation and reduction reactions
Riboflavin	Participate in photo oxidation of IAA
Biotin	Involved in amino acid fatty acid metabolism.
Vitamins	**Role**
Vit.K3	Involved in catalytic and regulating functions in cell metabolism.
Ni**c**otinic acid	It interacts with IAA in auxin mediated process, involved in hydrogen transfer process
Pantothenic acid	Used as a component of many co enzymes
Adenine	Increases the rate of DNA replication, rate of RNA and protein biosynthesis.
Botanical leaf extract	**Role**
Pongamia (*Millettia pinnata*)	Bio enhancement due to presence of synergistic plant metabolites
Prosopis (*Prosopis juliflora*)	Stimulatory effects caused by plant growth hormones
Moringa (*Moringa oleifera*)	Stimulatory effects caused by PGR
Pulse sprout extract	Induction of sugars and vitamins that promotes growth
Microbial enhancers	**Role**
Azosprillum	Weak source of IAA
Rhizobia	Plant growth hormones and induction of root nodulation
Azatobacter	Source of PGR
Trichoderma viridi	Fungal antagonist and PGR source

Seed hardening techniques recommended for crops

Crops	Chemicals and concentration	Methodology
Pearlmillet	2% Potassium chloride	Dissolve 20 gm of the salt in 1000 ml of water. Soak 1 kg of seed in 650 ml of this solution for 10h. and dry back to original moisture.

Sorghum	2% Potassium dihydrogen phosphate	Dissolve 20g of salt in 1000 ml of the solution for 16h. and dry back to original moisture or weight
Maize, Varagu, Tenai and Samai	2% Potassium dihydrogen phosphate	Dissolve 20g of salt in 1000 ml of the solution for 8h. and dry back to original moisture or weight
Cotton	2% Potassium chloride	Dissolve 20g of the salt in 1000ml of water. Soak 1kg of seed in 650 ml of solution for 10h and dry back to original moisture or weight.
Sunflower	2% Potassium chloride	Dissolve 20g of the salt in 1000 ml of water. Soak 1 kg of seed in 650 ml of solution for 12h. and dry back to original moisture.
Pulses Black gram Green gram	100ppm Zinc sulphate 100ppm manganese sulphate	Dissolve 100 mg of the salt in 1000 ml of water. Soak 1 kg of seeds in 350 ml for 3h and dry back to original weight or moisture. Before soaking them in water or solution, precondition the seeds for 1h by keeping them in between two moist gunny bags
Ragi	0.2% Sodium chloride	Dissolve 2 g of salt in 1000ml of water. Soak 1 kg of seed in 700 ml of solution for 6 hrs and dry back to original moisture content or weight.
Groundnut	0.5% calcium chloride	Dissolve 5 g of salt in 1000ml of water. Soak 1 kg of seed in 300 ml of solution for 4 hours and dry back to original moisture or weight.
Redgram	100ppm Zinc sulphate	Dissolve 1000mg salt in 1000ml of water. Soak 1 kg of seed in 300 ml of solution for 4 hrs and dry back to original moisture or weight.
Bengal gram	1% potassium dihydrogen	Dissolve 10g salt in 1000ml of water. Soak 1

	phosphate	kg of seed in 350 ml of solution for 4 hrs and dry back to original moisture or weight

Advantages

- Accelerate rapid germination and growth rate of seedling
- Plants from the treated seeds recover quickly from wilting when compared to plants from untreated seeds
- Flowering is slightly accelerated in treated plants
- Induces resistance to drought and salinity
- Seeds also withstand higher temperature (80-105^{o}C) for prolonged periods (24-48h) without loss of viability
- By emerging early, seedlings will be able to compete more effectively with weeds
- Treated plants are generally better in growth and yield.
- It increases the speed of germination and germination percentage

Caution

For seed hardening to be very effective, hard seeds / dormant seeds must not be included. Because, hard seeds will not imbibe while dormant seeds need treatments to alleviate dormancy. Hence, prior to seed hardening, seed lots must be tested for germination and measures taken to reduce dormancy inducing factors.

Conclusion

It can be concluded that, seed hardening are now being practiced in many parts of the world to reduce germination time, synchronize germination, improve germination rate and produce better seedling stands. There is considerable evidence to show that drought resistance of plants can be increased by subjecting seeds to a soaking and drying before sowing. To achieve uniformity and synchrony of growth of plant under drought or salt stress condition, seed hardening can be adopted as a regular practice to boost the yield of rainfed crops. However, simple on farm, no cost or low cost techniques like hydration-dehydration with water or cow urine provides all the enhancements as received from salt induced hardening treatments.