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Seed Treatment Strategies for Enhancing Crop Resilience and Performance

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SUMMARY

Seed treatment strategies play a crucial role in enhancing crop resilience and performance. Through the application of various seed treatments, such as seed priming, seed coating, and seed disinfection, the germination potential, vigor, and overall health of seeds are improved. These treatments can provide protection against pathogens, pests, and environmental stresses, ensuring a higher rate of successful germination and establishment. Additionally, seed treatments can enhance nutrient uptake, promote early seedling growth, and increase crop productivity. By implementing effective seed treatment strategies, farmers can enhance crop resilience, maximize yield potential, and contribute to sustainable agriculture practices.

INTRODUCTION

A significant majority of the Indian population, approximately 60%, depends on agriculture and its related sectors as their primary source of livelihood. Enormous improvement in food grain production was achieved through the Green Revolution with the adoption of modern approaches such as high-yielding varieties, agrochemicals and intensified farming (Akhilesh and Kavitha, 2020). Despite the promotion of high-yielding varieties, a substantial portion of tropical land lacks favorable growth conditions for these crops, resulting in low yields even with the application of necessary agrochemicals. The indiscriminate use of these chemicals not only leads to environmental pollution and soil degradation but also imposes an economic burden on farmers. Further, the regional agricultural hubs under tropical conditions are highly affected by extreme events of climate change, e.g., heavy rainfall, floods and droughts (Sarkar *et al*., 2020). Addressing fragile ecosystems poses a significant challenge for agricultural researchers in their quest to develop restorative solutions. In this context, to curtail the effects of climate change and continue cultivation practices under fragile ecosystems, the adoption of eco-friendly and economical techniques such as seed priming, low-input sustainable agriculture, conservation agriculture, etc., are imperative (Sarkar *et al*., 2020). Pre-sowing techniques like seed priming grabbed the attention of researchers and grew into the subject of extensive investigation and interest when it addressed the problems of slow and non-uniform germination, low seed vigor, poor crop stand, biotic and abiotic stresses, poor product quality, etc. (Zulfiqar, 2021). Seed priming eases germination even under adverse conditions, lifts crop performance and enhances yield potential (Marthandan *et al*., 2020).

Definitions and terminology

Seed treatment can be generally defined as all operations that are executed on seeds after taking them from mother plant. The process of treating seeds is referred to by a number of names, such as Seed Priming, Seed Treatment, Osmo Priming, and Osmo Condition Matrix proming, Matrio-conditioning. Priming is a technique to accelerate the physiological development of a seed lot and increase the rate and uniformity of germination.

Techniques used for seed treatment

Pre-Soaking hydration

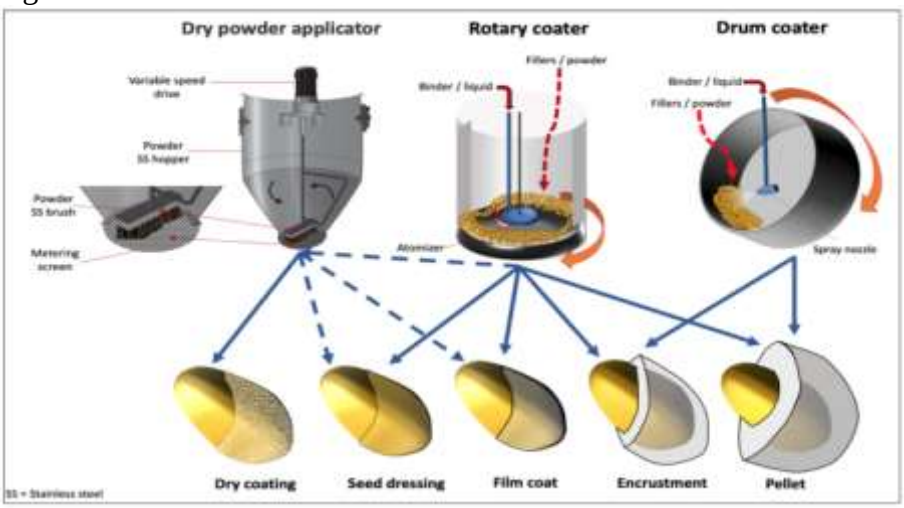
Treatments for water-absorbing plants include uncontrolled (those in which seeds have free access to water with no environmental restrictions) and controlled (those in which the humidity level is changed and root

emergence is inhibited) systems. Priming with solutions, solid matrices, and manually regulated water are three alternative methods for regulating water absorption.

Seed Coating technologies

A thin, even covering of a specific material is applied to the surface of the seed in a process known as seed coating technology. This creates a proper living environment surrounding the budding area and allows for the activation of advanced movement at crucial growth phases. The first time this method was used was in 1977, in Canada. applying a film coating to the seeds' outer surface. Because they come in all sizes, shapes, and colours, coating can be used as a distribution system. Types of seed coating: Dry coating, seed dressing, film coat, entrustment and seed pellet. Obviously, the coating technology is not able to make any changes in genetic traits of seeds. However, regarding to the financial advantages of this process, coated seeds are considered valuable products. This process is worth to be offered to farmers who farm forages and oilseeds.

In fact, coating technologies are the most effective, simplest, and safest methods in seeds improvement. 1) Pre-germination: once the sowing operation is accomplished, it takes several weeks or months for knots to be formed by rhizobia bacteria. However, through seed coating technology the bacteria are close enough to budding area that lead to an early knot forming. 2) Nutrients: in seed coating process seeds are provided with a healthy environment in which the growing energy during the initial stages will be increased. 3) Protection against stress, animals, birds, and fertilizers: most of the rodents and birds cannot identify the coated seed as an edible material. Using polymeric seed coating technique increases the percentage of germination through direct fertilizing of the soil.



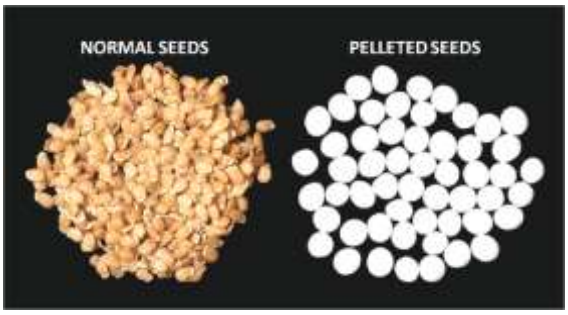
Smart Seed Coating techniques

Planters of maize are fully aware of how crucial each minute is throughout the planting process. Frequently, the window of opportunity when the weather and soil are favourable for planting is relatively little. Farmers still use the ancient ways of planting seeds in cold soil in the spring and waiting till the conditions are right, but the young plant is fragile and susceptible to cold weather when it emerges and may perish. To address this issue, intelligent seed coating methods have been created.

Advantages of Smart Seed Coating techniques: 1) early farming 2) the coating takes the form of a rigid shell around the seed.

Seed Pelleting or rounding

To increase the sowing yield and aesthetics of economically valuable crops like sugar beet and lettuce, the seeds are frequently pelleted after coating. Clay or fillers with an organic composition perform the majority of the pelleting process. Additionally, the filler could include strengthening components or be sufficiently hard to prevent abrasion during sowing. After planting, the pelleted seeds must begin to break down right away to prevent the seeds from sprouting. During the pelleting process, the irregular seed assumes the shape of a symmetrical hemisphere. According to the findings of the pertinent studies, utilising polymers in the pelleting process raises the potassium content of crops while also minimising any potential plant harm due to their antifungal properties.



Seed Conditioning

This technique focuses on improving seed quality through physical standards. The seeds harvested from farmlands are rarely pure and are frequently mixed with undesired elements such as poor-quality, pest-affected, and crushed seeds, weeds, and solid particles that need to be removed from the seeds pile. The germination process accomplishes in three phases: 1) Water absorption by seed 2) Delaying phase 3) Radicle growing through emergence of testa. During the first two phases, seeds are tolerant of drought but once the third phase started they become highly intolerant of drought. Normally, the seeds sprout when the seed water potential reaches to the critical physiological level (0-2 Mega Pascal). Seeds with a penetrable seed coat usually pass three phases for being sprouted. During the first phase, they absorb water. When the water penetrates into the seed and reaches to embryo, the second phase begins during which the stored hormones and enzymes will be activated and stimulate in turn the physiological growing. Ultimately, growing of the radicle begins in third phase. Through priming operations, replication of DNA, increasing of protein and RNA synthesis, accessibility to more ATP, quick growing of embryo, repair of damaged sections of the seeds, and reducing of metabolites leaking into the seeds are all provided during the delaying phase. Performing seed priming, during G2 and S stages of mitosis the replication accomplishes and nucleus content becomes double but there is not any cell division yet and this condition will advance budding by one stage in later soaking operations. On the other hand, quick absorption of water leads to rupture of cell membrane, celluloid death of cotyledons and embryo axis of cells, and reaction of oxygen.

Non- Thermal Plasma Treatment: Agricultural Seeds for Stimulation of Germination, Removal of Surface Contamination and Other Benefits. The presence of pathogens and other stresses at germination and seedling stages affect the successful establishment of crops. The use of non- thermal plasma is a new approach to reduce such stresses. Plasma can interact with seeds and change their surface characteristics by etching, introducing functional groups and coating with exotic materials.

Positive effects of seed treatment

- In regions where manual farming is a common method seeds may be placed either too deep or too close to surface, so durability of seeds and stability of plant will be achieved through treatment.
- In cold areas where the farming period is short, using priming can lead to an early emergence of plant and hence, it will be provided with a proper opportunity to gain tolerance against cold weather.
- In regions where there is a delay in farming, seed treatment is recommended to compensate for this postponement.
- In regions where there is a limited access to water resources, seed treatment will come in handy for having a cost-effective irrigation.

- Seed treatment causes an increase in performance and also a decrease in waste of water due to early establishment of plant during the winter.
- Seed treatment enhances the tolerance of plant for any unfavorable conditions.
- Seed treatment can make improvements in the processes of germination and seedling emergence of new plants.
- It enhances the root growing.
- As a dynamic technology (increase in speed and consistency in emergence), it leads to a high vitality and better performance in flowering plants.
- Enabling adjusting factors of plant growing, it makes changes in growing, physiologic processes, enzyme activities, and absorption of nutria `nts which can resist nonliving stresses.

Negative effects of seed treatment

- Limited protection under high pest pressure. Under high pest pressure, significant crop damage may occur. Even through pests are killed when they feed on the treated seedling, each 'attack' causes damage and cumulatively this can still be significant enough to cause seedling loss.
- Duration of protection. Seed treatment may not provide protection for long enough to provide complete protection to the establishing crop. Pesticide breakdown is most rapid under warm, moist conditions.
- Limited shelf life of treated seed. Surplus treated seed cannot be sold for grain. This is a particularly serious limitation for seeds such as soybean, where seed germination and vigour decline relatively quickly..
- Phytotoxicity. Some seed treatments may be phytotoxic when applied at high rates. Cracked, sprouted, and scuffed seeds are particularly susceptible to toxic effects.

CONCLUSION

Seed treatment strategies are crucial for enhancing crop resilience and performance. They provide proactive protection against seed-borne diseases, pests, and environmental stresses, resulting in improved plant vigour and overall crop health. By optimizing seedling emergence, root development, and nutrient uptake, seed treatments contribute to higher yields, better quality, and increased profitability for farmers. Moreover, they reduce the reliance on excessive pesticide applications, promoting sustainable agricultural practices and minimizing environmental impact. Seed treatments offer flexibility in diverse agro-climatic conditions and cropping systems, addressing challenges in fragile ecosystems. However, responsible and judicious use is essential to mitigate potential environmental and health risks. Continued research and development are necessary to refine seed treatment technologies, formulations, and expand their efficacy against various pests and diseases. By integrating seed treatments into farming practices, farmers can effectively tackle climate change impacts, safeguard their investments, and contribute to global food security.

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