

The Journey of Artificial Seeds in Modern Agriculture

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ABSTRACT

Artificial seeds with encapsulated somatic embryos and/or vegetative parts are now beginning to be seen in modern agriculture, promising both increased crop-yield and new plant varieties. Integrated with 21st-century technologies such storage and propagation of superior strains plant breeders have long sought for the solution, from two fronts, which are particularly important commercial hybrid rice clones rope in nanotechnology to its aid; trees defined by genome pattern in a way that man in the Street, whoever he Exposure to more than his share of Storage and seed germination have always been problematic, yet artificial seeds offer quick, regular germination and genetic preservation, which are helpful for this breed of plant to be bred. To speed up germination, farmers have developed a coating of biochar and added some active elements in the seed such as antifungal, nutrient solutions. These are enhancements in farming techniques. Using this artificial seed technology overcomes the vital problems originally associated with seed quality, germination and plant survival, bringing us closer now than ever before to a future of sustainable and efficient agriculture.

INTRODUCTION

The concept of artificial seeds has the potential to revolutionize modern agriculture by offering innovative

approaches to crop production and breeding. Artificial seeds are encapsulated somatic embryos or other vegetative parts that can be

sown and grown into plants under controlled conditions (Rihan *et al.*, 2017). This technology opens up new possibilities for improving a wide range of plant species, including cereals, fruit crops, medicinal plants, and vegetables (Abbas *et al.*, 2022). By enabling the self-propagation of elite varieties through clonal reproduction, such as apomixis, artificial seeds have the capacity to transform agriculture by ensuring the perpetuation of desirable traits, particularly in F1 hybrids (Mieulet *et al.*, 2016). Moreover, advancements in nanotechnology can enhance crop productivity and quality, thereby revolutionizing the food and agricultural industries (Acharya *et al.*, 2019). Techniques like biochar coating have been shown to improve seed vigor, promote seedling growth, and reduce the incidence of pests and diseases, contributing to overall plant performance (Zhang *et al.*, 2022). Additionally, the use of priming agents can enhance seed germination, vigor, and plant development under adverse conditions like water restriction and salinity, further emphasizing the potential of innovative seed technologies in agriculture (Oliveira *et al.*, 2021). Furthermore, the integration of artificial intelligence and robotics in precision agriculture offers solutions for various processes such as seeding, harvesting, and chemical applications, contributing to increased efficiency and productivity in the agricultural sector (Amer *et al.*, 2015). These technological advancements, combined with artificial seed technologies, have the potential to optimize agricultural practices, improve crop yields, and address challenges related to seed quality, germination, and plant growth (Qiu *et al.*, 2018).

Origins and Evolution of Artificial Seed Technology

Artificial seed technology has seen significant advancements over the years, with its origins dating back to the improvement of local germplasm through artificial selection,

particularly in maize evolution and diversity in Mexico, the crop's center of origin. The concept of artificial seeds has evolved to address challenges such as limitations in storage, somatic embryo development, maturation, and conversion into plantlets. Despite these challenges, artificial seed technology offers benefits like rapid and uniform seed germination, enhancing mechanized crop production in modern agricultural practices. The adoption of modern inputs, including improved seeds, fertilizers, and machinery, is crucial for increasing agricultural productivity in developing countries. However, the adoption of technologies like fertilizers and hybrid seeds remains low in some regions. To address this, there is a need for innovative approaches such as artificial seed technology to improve seed quality and availability.

In the context of modern agriculture, the integration of cutting-edge technologies like artificial intelligence and deep learning is becoming increasingly important for enhancing productivity and quality in crop production. Additionally, the use of synthetic seeds technology has shown promise in short-term storage and propagation of valuable genotypes, with high conversion rates from seeds to plants.

Furthermore, the preservation and faithful expression of transgenes through artificial seeds have been demonstrated in crops like alfalfa, highlighting the potential of artificial seed technology in genetic engineering and biotechnology applications. This technology offers a means to store and propagate transgenes efficiently, contributing to advancements in crop improvement and biotechnology research.

Engineering Artificial Seeds: Techniques and Components

Artificial seeds are a promising technology in modern agriculture, offering a range of

benefits such as ease of handling, storage, and transport. To engineer artificial seeds successfully, it is crucial to consider the components and techniques involved in their formulation. The process requires precision engineering techniques to ensure the viability and functionality of the artificial seeds. These techniques play a vital role in creating artificial seeds that mimic the characteristics of natural seeds, providing a reliable means for farmers to enhance crop production.

The components of artificial seed formulations are essential for their success. These components may include various ingredients tailored to meet specific requirements for seed germination and plant growth. For instance, incorporating grape seed extract in wound care product development has shown promising results in promoting wound healing. Similarly, the use of gelatin reinforced with cellulose nanocrystals in seed coatings has been found to improve the germination percentage and speed of germination in corn seeds. Such innovative formulations highlight the importance of selecting the right components to enhance the performance of artificial seeds. Moreover, the adoption of modern inputs, including improved seeds and fertilizers, is crucial for increasing agricultural productivity, especially in developing countries. Studies have shown that the systematic use of fertilizers and hybrid seeds can significantly boost productivity, emphasizing the importance of technology adoption in agriculture. Additionally, the likelihood of adopting improved seeds is higher among households with certain characteristics such as larger farm sizes and more extension contacts. Understanding the factors influencing technology adoption is essential for promoting the use of artificial seeds in agricultural practices.

Application of Synthetic Seeds in Agriculture

Synthetic seeds have numerous applications in agriculture, transforming the way crops are propagated and managed. These artificial seeds, which are encapsulated somatic embryos or shoot buds, offer several advantages over traditional seeds, making them a valuable tool for farmers and researchers alike.

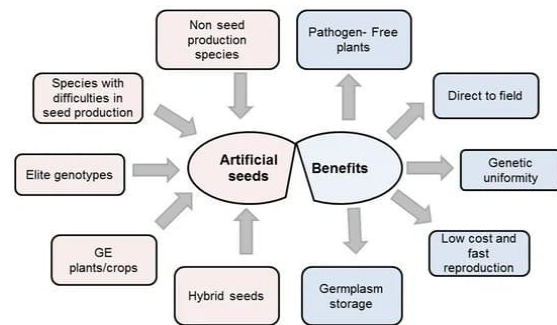


Figure 1. Artificial seed uses and benefits (Rihan et.al., 2017)

1. **Hybrid Plant Propagation:** Synthetic seeds enable the easy propagation of hybrid plants, which are often difficult to produce through traditional seed methods. This technology allows for the precise control of genetic traits, ensuring consistent and high-quality crop yields.
2. **Genetically Modified Crops:** Synthetic seeds can be used to propagate genetically modified crops, which can enhance crop resistance to diseases and pests, improve nutritional content, or increase yields. This technology helps in the large-scale production of genetically modified crops, making them more accessible to farmers and consumers.
3. **Endangered Species Conservation:** Synthetic seeds can be used to propagate endangered plant species, helping to conserve and preserve their genetic material. This technology ensures the long-term survival of these species, which are often threatened by habitat

destruction, disease, or other environmental factors.

4. **Elite Genotype Preservation:** Synthetic seeds can be used to preserve and propagate elite genotypes, which are high-performing crop varieties. This technology helps maintain genetic uniformity and ensures consistent crop yields, reducing the need for costly and time-consuming breeding programs.
5. **Cost-Effective and Efficient:** Synthetic seed production is cost-effective compared to traditional methods, as it eliminates the need for large-scale seed production facilities and reduces the risk of disease transmission. This technology also allows for the direct use of synthetic seeds in fields, eliminating the need for intermediate steps.
6. **Easy Transportation and Handling:** Synthetic seeds are small and easy to handle, making them ideal for transportation and storage. This technology also ensures that synthetic seeds do not contain any disease-causing agents, reducing the risk of contamination and disease spread.
7. **Environmental Benefits:** Synthetic seeds can be used to produce environment-friendly plantations. By using sterile plant materials and encapsulation techniques, synthetic seeds minimize the risk of disease transmission and environmental pollution. This technology also helps in the development of sustainable agricultural practices, reducing the ecological footprint of farming.
8. **Applications in Cereals, Fruits, and Medicinal Plants:** Synthetic seeds can be used to study and propagate cereals, fruits, and medicinal plants. This technology allows for the precise control of genetic traits and ensures consistent crop yields, making it an essential tool for

researchers and farmers working with these crops.

CONCLUSION

In conclusion, artificial and synthetic seed technologies hold transformative potential for modern agriculture. By offering enhanced crop propagation, disease resistance, and genetic uniformity, these innovations can significantly boost productivity and efficiency. They enable the preservation of elite genotypes, facilitate the propagation of genetically modified and endangered species, and provide cost-effective, environmentally friendly solutions. Moreover, their ease of handling, storage, and transport, combined with advancements in nanotechnology and artificial intelligence, underscore their critical role in addressing agricultural challenges and optimizing practices for diverse crops including cereals, fruits, and medicinal plants.

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