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Synthetic Seed Production Technology

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Abstract

Synthetic seeds are defined as artificially encapsulated somatic embryos, shoot buds, cell aggregates, or any other tissue that can be used for sowing as a seed and that possess the ability to convert into a plant under *in vitro* or *ex vitro* conditions and that retain this potential also after storage. The technology designed to combine the advantages of clonal propagation with those of seed propagation and storage. Also be as channel for new plant lines produced through biotechnology advances. The importance of synthetic seed is realized nowadays and this paper discuss about the synthetic seed production technology.

Introduction

A seed is the small, hard part of a plant from which a new plant grows. Among these functions are nourishment of the embryo, dispersal to a new location, and dormancy during unfavorable conditions.

Limitations of Natural Seed

- Maintaining genetic variations are difficult and many fruit crops are difficult to produce seed.
- Difficult in dioeciously plant for female plant.
- Seed borne disease and pest.
- Some seedless fruits cannot be propagated through seed.
- Dormancy of seed.

Research Interventions

To overcome those problems research were started in all over world,

- Seed quality improvement through priming and coating.
- Cost effective techniques in hybrid seed production.
- Standardization of tissue culture protocol wherever feasible.
- Standardizing the medium for nursery management and mechanization of nursery management.

Synthetic Seed

Synthetic seeds are defined as artificially encapsulated somatic embryos, shoot buds, cell aggregates, or any other tissue that can be used for sowing as a seed and that possess the ability to convert into a plant under *in vitro* or *ex vitro* conditions and that retain this potential also after storage. In simple words synthetic seed contains an embryo produced by somatic embryogenesis enclosed within an artificial medium that supplies nutrients and is encased in an artificial seed covering. The technology designed to combine the advantages of clonal propagation with those of seed propagation and storage.

Concept of Synthetic Seeds

P. R. White is father of tissue culture in the United States and was first to grow excised root tips of tomatoes. The concept was first introduced in 1970. The Production of artificial seeds is useful for plants which do not produce viable seeds. The term EMBLING means the plants originated from synthetic seed. The use of synthetic varieties for commercial cultivation was first suggested in Maize (Hays & Garber, 1919). The first synthetic seeds were produced by Kitto and Janick in 1982 using carrot.

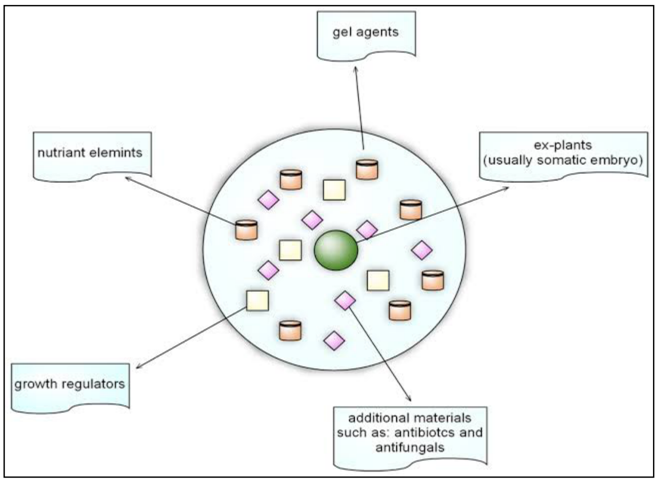

Figure 1: Diagramatic representation of synthetic seed

Why Synthetic Seeds?

In some of the horticultural crops seeds propagation is not successful due to;

• Heterozygosity of seeds particularly in cross pollinated crops.

• Minute seed size e.g.; orchids.

• Presence of reduced endosperm.

• Some seeds require mycorrhizal fungi association for germination e.g.: orchids.

• No seeds are formed.

• These crop species can be propagated by vegetative means like micro propagation and clonal propagation.

Characteristics of Synthetic Seed

• High volume.

• Large scale propagation method.

• Maintains genetic uniformity of plants.

• Direct delivery of propagules to the field, thus eliminating transplants.

• Lower cost per plant let.

• Rapid multiplication of plants.

Advantages of Synthetic Seeds over Somatic Embryos for Propagation

• Ease of handling while in storage.

• Easy to transport.

• Has potential for long term storage without losing viability.

• Maintains the clonal nature of the resulting plants.

• Serves as a channel for new plant lines produced through biotechnological advances to be delivered directly to the green house or field.

• Allows economical mass propagation of elite plant varieties.

Types of Synthetic Seeds

There are two types of synthetic seed.

• Desiccated synthetic seeds

• Hydrated synthetic seeds

Desiccated Synthetic Seed

The desiccated synthetic seeds are produced from somatic embryos either naked or encapsulated inpolyoxyethylene glycol (Polyox) followed by their desiccation. Desiccation can be achieved either slowly over a period of one or two weeks sequentially using chambers of decreasing relative humidity, or rapidly by unsealing the petri dishes and leaving them on the bench overnight to dry. Such types of synseeds are produced only in plant species whose somatic embryos are desiccation tolerant.

Hydrated Synthetic Seed

Hydrated synthetic seeds are produced in those plant species where the somatic embryos are recalcitrant and sensitive to desiccation. Hydrated synthetic seeds are produced by encapsulating the somatic embryos in hydrogel capsules.

Procedure for Synthetic Seed Production

The somatic embryos foe synthetic seeds are produced in the lab through culturing of somatic cells and treating with different hormones to produce root and shoot. The following are the different steps involved in artificial seeds production;

1. Establish somatic embryogenesis

2. Mature somatic embryogenesis

3. Synchronize and singulate somatic embryos

4. Mass production of somatic embryos

5. Standardization of encapsulation

6. Standardization of artificial endosperm
7. Mass production of artificial seeds
8. Greenhouse and field planting

Somatic Embryos

Somatic embryos are bipolar structure with both apical and basal meristematic regions which are capable of forming shoot and root, respectively. Somatic embryogenesis is the development of embryos form vegetative cells with in vitro systems. Specific tissues have a capacity for somatic embryogenesis in cultural systems. This allows the clonal propagation of normally seed-propagated crops analogous to the production of apomictic seedlings. Somatic embryos develop through stages similar to zygotic embryos, however, the final size for the cotyledons are usually reduced and there is no development of endosperm or seed coat. After pollination, a zygotic embryo of a dicotyledonous species develops through a series of morphological stages termed globular, heart and torpedo. Cotyledons develop and expand as the storage reserves of protein, starch and/or oil are deposited. At some stages before the embryo achieves its maximum weight, it acquires the ability to tolerate drying. Then, the seed's vascular connections to the maternal plant are severed, it stops importing nutrients and it begins to lose water. Seeds of most crop plants can survive drying and can be stored for several years. Once they are hydrated, germination commences culminating in the emergence of a radicle and then the mobilization of the storage reserves by the seedling.

Table 1: Difference between Zygotic Embryos and Somatic Embryos

Zygotic embryos	Somatic embryos
Is the result of a sexual process	Produced as a result of asexual process
involve fusion of male and female gametes	Doesn't involve male and female
Produced form sexual cells	Produced from vegetative cells
contains genetic constituent form both parents	contains genetic constituent form
Genetic recombination takes place	No genetic recombination will take
Contains embryo, endosperm and seed coat	Contains only embryo and endosperm and seed coat are absent

Encapsulation of Matured Somatic Embryos

Somatic embryos produced naked embryos without storage materials and protective layer (seed coat). This is very difficult for handling so this demand the encapsulation and coating. The somatic embryos are encapsulated using gel agents like agar, alginate, polyco, carboxy methyl cellulose, guar gum, sodium pectate etc.

Why Alginates were used in Encapsulation?

Among these alginates encapsulation was found to be more suitable and practicable. Alginate hydrogel is frequently selected as a matrix for synthetic seed because of its moderate viscosity and low spinnability of solution, low toxicity for somatic embryos and quick gellation, low cost and bio-compatibility characteristics. The use of agar as gel matrix was considered inferior to alginate with respect to long term storage. Alginate was chosen because it enhances capsule formation and also the rigidity of alginate beads provides better protection to the encased somatic embryos against mechanical injury.

Two Standard Methods have been used for Encapsulation of Somatic Embryos

1. Gel Complexation via a Dropping Procedure

This is the most useful encapsulation system. Drip 2-3 % sodium alginate drops from at the tip of the funnel and the somatic embryos are inserted. Keep the encapsulated embryos complex in calcium salt for 20 min. Rinsed the capsules in water and then stored in air tight container.

2. Automate Encapsulation Process

This is the quick method. Alginate solution with embryo is feed from supply tank. Alginate capsules were planted in speeding trays using a vacuum seeder. The capsules are planted in the field using a Stan hay planter. A hydrophobic coating is required for mechanical handling for the rapid drying and the thickness of the alginate capsules. For coating, an Elvax 4260 copolymer is suitable for producing a slow drying, non tacky coating which allows embryo conversion (Figure 1).

Potential Uses of Artificial Seeds

• Reduced costs of transplants.
• Direct greenhouse and field delivery of: elite, select genotypes, hand-pollinated hybrids, genetically engineered plants and sterile and unstable genotypes.
• Large-scale mono cultures.
• Mixed-genotype plantations.
• Carriers for adjuvants such as microorganisms, plant growth regulators, pesticides, fungicides, nutrients and antibiotics.
• Protection of meiotically- unstable, elite genotypes.
• Can be conceivably handled as seed using conventional planting equipment.

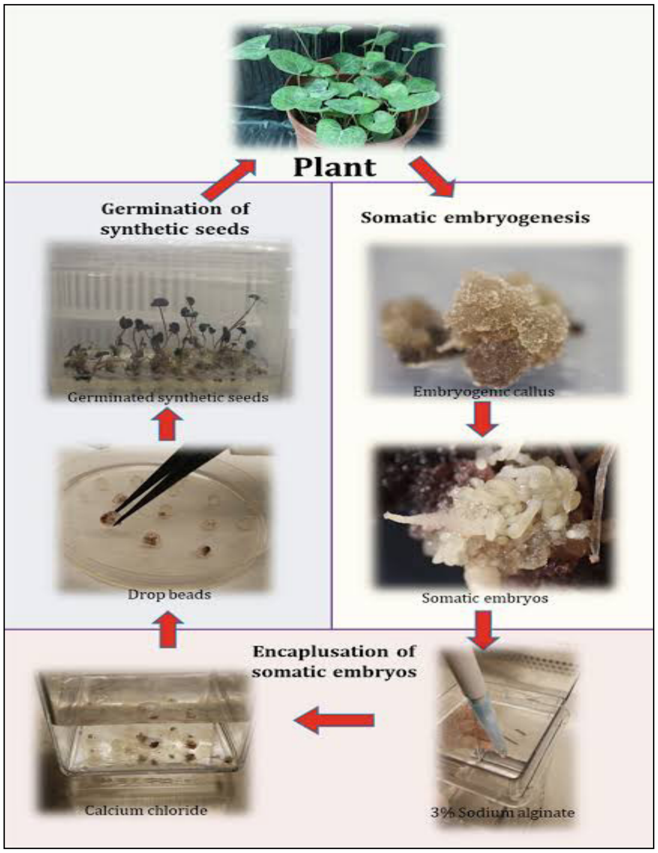

Figure 2: Procedure for synthetic seeds produced from soamtic embryos

Table 2: Effect of endosperm and encapsulation on zygotic somatic embryo germination and conversion

Embryos	Form	Germination %	Conversion %
zygotic	Non encapsulated	100	100
	Encapsulated	100	93.3
somatic	Non encapsulated	93.3	93.3
	Encapsulated	100	100

Table 3: Different types of propagules for synthetic seed production from horticultural crops

In vitro propagules for encapsulation	crop
Somatic embryos	Papaya, Brinjal, Mango, carrot, sandalwood, cauliflower, alfalfa, lettuce, celery, Cucumber
Auxiliary buds/adventitious bud	Grapes, eucalyptus, citrus, pineapple, cassava
Shoot tip	Banana, cardamom, apple, kiwifruit, potato

Applicability and Feasibility of Artificial Seed Production Technology

In order to be useful, synthetic seed must either reduce production costs or increase crop value.

- For e.g. synthetic seed of seedless water melon would actually cost less than conventional seed, providing a benefit at the outset of crop production.
- By combining the benefits of a vegetative propagation system with the capability of long-term storage and with the clonal multiplication, synthetic seeds have many diverse applications.
- Multiplication of non-seed producing plants, ornamental hybrids or polyploids plant.
- Propagation of male or female sterile plants for hybrid seed production.
- Germplasm conservation of recalcitrant species.
- Multiplication of transgenic plants.

Advantages

- High volume, large scale propagation method.
- Maintains genetic uniformity of plants.
- Direct delivery of propagules to the field, thus eliminating transplants.
- Lower cost per plantlet.
- Rapid multiplication of plants.
- Stored for a longer period of time even upto 6 months without losing viabilty, especially when stored at 40 °C.
- The Synthetic Seed Technology offers tremendous potential in micropropagation and germplasm conservation.

Limitations

- Limited production of viable micropropagules that are useful in synthetic seed producer.
- Asynchrous development of somatic embryos.
- Improper maturation of somatic embryos that makes them inefficient for germination and conversion in to normal plants.
- Lack of dormancy and stress tolerance in somatic embryos that limit the storage of synthetic seeds.
- Contamination of explants.
- Soma clonal variations which may alter the genetic constituent of the embryos.

Future Use of Synthetic Seed

Aerial Reforestation is a farming technique where trees and other crops are planted by being dropped from an aeroplane, when planes were used to distribute seeds over inaccessible mountains in Honolulu after forest fires devastated the area. More recent research has proven that dropping saplings in 'aerial darts' is far more successful, because saplings are stronger and more resilient than seeds. The aerial darts are made up of bio-degradable, cone-shaped containers filled with damp soil, a sapling and a dash of fertilizer. The neatly packaged sapling 'bombs' are dropped from a low-flying plane.

Conclusion

Synthetic seeds are defined as artificially encapsulated somatic embryos, shoot buds, cell aggregates, or any other tissue that can be used for sowing as a seed and that possess the ability to convert into a plant under *in vitro* or *ex vitro* conditions and that retain this potential also after storage. Synthetic seeds can be produced in larger quantities in case of seeds produced from conventional methods. In future, the synthetic seeds can be used in aerial reforestation using drones.

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