TITLE: ARTIFICIAL SEEDS

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M.U.C WOMEN'S COLLEGE

COLLEGE ROLL NO.: ***460***

UNIVERSITY ROLL NO.: ***1706116100038***

REGISTRATION NO.: ***201701010553***

BSC GENERAL 6TH SEMESTER BOTANY (DSE 2)

DISSERTATION REPORT PRESENTATION

ACKNOWLEDGEMENT:

I would like to express my special thanks of gratitude to my teacher Dr. Pritam Chattopadhyay as well as our principal Dr. Sukriti Ghosal who gave me the golden opportunity to do this wonderful project on the topic "ARTIFICIAL SEEDS", which also helped me in doing a lot of Research and I came to know about so many new things I am really thankful to them.

INDEX:

SUMMERY:

Artificial seeds were produced successfully from encapsulated plant propagules in different plant species. Procedures were optimized and proper plantlets were obtained. This technique has great advantages such as: a cost-effective delivery system, minimization of the cost of plantlets, simple methodology with high potential for mass production, a promising technique for the direct use of artificial seedlings in vivo, and a high storage capacity. The advances of this technique depend on the plant species in the first step.

However, despite the advantages of artificial seeds, further research is required in order to improve root formation of non-embryogenic artificial seeds. More investigations are needed to improve the capacity of artificial seed cultivation in commercial substrates and under non-sterilized conditions. This could be improved by the use of suitable types and concentrations of anti-diseases and antibiotics, and further detailed research is needed for improvement in the artificial seed cryopreservation capacity in some plant species.

INTRODUCTION

DEFINITION OF SEED:

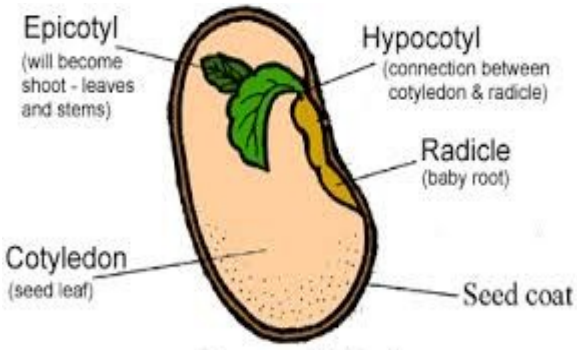
A seed is an embryonic plant enclosed in a protective outer covering. The formation of the seed is part of the process of reproduction in seed plants, the spermatophytes, including the gymnosperm and angiosperm plants. Seeds are the product of the ripened ovule, after fertilization by pollen and some growth within the mother plant. The embryo is developed from the zygote and the seed coat from the integuments of the ovule.

In general there are two types of seeds which can be used for propagation of plants and thus help in the maintaining the survival of plants in nature:

- Natural Seed
- Artificial Seed

NATURAL SEED:

The seed stage of plants represents a unique developmental phase of the spermatophyte life-cycle, and as such involves structures, not characteristic of other stages of development. The essential structure of seed is defined as a ripened ovule consisting of an embryo and its coat. The normal seed contains materials which it utilizes during the process of its germination. There substances are frequently found in the endosperm. Thus endosperm may contain variety of stored materials such as starch, oils, proteins etc. In some plants, however, the reserve food material is present in cotyledons.



Bean seed (dicot)

IMPORTANCE OF NATURAL SEEDS:

The seed provides an expedient living unit for the study of wholeness that is a complex of biological factors which can be considered simultaneously. The seed occupies that sector of an organism life cycle form mega sporogenesis (genetic) to the formation of seedling (ecological). However, a seed is not truly a reproductive structure, but rather an adaptive mechanism to facilitate suspending growth and interrupting the coutinum of homeostasis in the life cycle. Natural seeds are the corner stone of agriculture because when seeds are planted in the soil and given water, nutrients, light and some protection from pests would reproduce plant and seeds identical to that planted and also produce number of seeds which could be used for food or feed.

STRUCTURE OF A SEED: A natural seed has following parts.

- **Seed Coat:** In the seed of cereals such as maize, the seed coat is membranous and generally fused with the fruit wall, called Hull.
- **Endosperm:** The endosperm is bulky and stores food. Generally, monocotyledonous seeds are endospermic but some as in orchids are non-endospermic.
- **Aleuron layer:** The outer covering of endosperm separates the embryo by a proteinous layer called aleurone layer.
- **Embryo:** The embryo is small and situated in a groove at one end of the endosperm.
- **Scutellum:** This is one large and shield-shaped cotyledon.
- **Embryonal axis:** Plumule and radicle are the two ends.
- **Coleoptile and coleorhiza:** The plumule and radicle are enclosed in sheaths. They are coleoptile and coleorhiza.

DEFINITION OF ARTIFICIAL SEED:

Artificial seeds are the living seed-like structure which are made experimentally by a technique where somatic embryoids derived from plant tissue culture are encapsulated by a hydrogel and such encapsulated embryoids behave like true seeds if grown in soil and can be used as a substitute of natural seeds.

They are artificially encapsulated somatic embryos or other vegetative parts such as shoot buds, cell aggregates, auxiliary buds, or any other micropropagules which can be sown as a seed and converted into a plant under in vitro or in vivo conditions.

The demand for artificial seed technology started after the discovery of somatic embryo production in various plant species in vitro. Artificial seeds, which are also known by other names such as “synseeds”, are firstly described by Murashige. He defined artificial seeds as “an encapsulated single somatic embryo”. An artificial seed was later defined by Gray et al. as “a somatic embryo that is engineered for the practical use in commercial plant production”. The concept of artificial seeds was then limited to those plant species in which the production of their somatic embryos could be demonstrated.

The definition of artificial seeds depends on the similarity in physiology, morphology, and biochemistry of somatic embryos to

zygotic embryos. Considering the recalcitrance to somatic embryogenesis in some plant species, the concept of artificial seeds was later extended to be the encapsulation of a range of in vitro-derived propagules. The definition of artificial seeds was then extended to be artificially coated somatic embryos (usually) or other vegetative parts such as shoot buds, cell aggregates, auxiliary buds, or any other micropropagules, provided that they have the capacity to be sown as a seed and converted into a plant under in vitro or ex vitro conditions. They should also be able to keep this ability for an extended period (storage ability). Therefore, artificial seeds can eliminate the acclimation steps necessary in micropropagation and give breeders greater flexibility. Various plant materials have since been used for artificial seed production including somatic embryos, shoot tips, auxillary buds, nodal segmants, protocorm-like bodies (PLBs), microshoots, and embryogenic calluses.

Artificial seed could provide a cost advantage to those vegetable crops that currently have high seed costs and high per-plant value. For example, many hybrid varieties are very expensive to produce. Some are produced as transplants in greenhouses before transfer to the field. For seedless watermelon, the combination of high seed cost, due to barriers to seed production, and low germination rates can result in transplants costing US$1.00 each. For seedless watermelon, artificial seed could reduce per-plant costs by circumventing barriers to seed production. Artificial seed, in this case naked or encapsulated hydrated somatic embryos, could be treated in the same manner as conventional seed in transplant production.

HISTORY OF ARTIFICIAL SEEDS:

The origin of the idea of an artificial seed is difficult to determine. Certainly, those who first produced somatic embryos may have considered such application (Steward, et al., 1958 and Reinert, 1958). The discovery of somatic embryogenesis in carrot in the year 1958 was almost simultaneously by F. C. Steward (USA) and J. Reinert (Germany). F. C. Steward a renowned plant physiologist at Cornell University in New York. However, it was not until the early 1970's that the concept of using somatic embryos began to be presented as a potential propagation system for seed sown crops. Toshio Murashige gave a number of survivors in tissue culture propagation where he concluded with this concept. He formally presented his ideas on artificial seeds at the symposium on tissue culture for horticultural purposes in Belgium, September 6-9, 1977. His terse comments in the proceedings, however, were to be applicable, the cloning method must be extremely rapid, capable of generating several million plants daily and competitive economically with the seed method (Mugashinge, 1977). Drew (1979) was active in developing methods to commercially propagate crops using somatic embryos. He suggested delivering carrot somatic embryos in a fluid drilling system, but was able to produce only three plants from carrot embryos on a carbohydrate free medium. He could not get success in producing many plants through this system. He faced a crucial problem and found the very slow rate of development of plantlets derived from culture. Kitto and Janick (1982) coated dumps of carrot embryos, roots and Cellus with polyongethylene. Some embryos survived the coating process as well as a desiccation step (Kitto and Janick, 1985a and 1985b). The early assessment of Murashigesirect (1977) on the difficulty of somatic embryogeny

are still valid today. The quality and fidelity of somatic embryos are
the limiting factors for development and scale up of artificial seeds.

Interestingly, artificial seed prepared from shoot buds can also be used for plant propagation and this was reported by P. S.
Rao's group from BARC, Mumbai. Research
on artificial seeds in rice is still in infancy and this technology through somatic embryogenesis, would offer a great scope for large scale propagation of superior, elite hybrids (Brar and Khush, 1994).

DISCUSSION

The concept of synthetic seed has been developed as a result of an increased understanding of the phenomenon of somatic embryogenesis and method of encapsulation. An imbalance between the efficiency of in vitro propagation and the delivery of regenerants possess certain limitations on the practical application of tissue culture technologies. In this connection, the use of “synseeds” (encapsulated propagules/‘somatic seeds’) as an efficient storage and delivery system is being increasingly realized. Initially synthetic seed preparations were limited to somatic embryos (Kitto and Janik, 1982) only. In recent times, in addition to using somatic embryos, research has also been focused on the use of unipolar vegetative propagules for this purpose (Rao et al., 1996). Production of synthetic seeds using vegetative propagules such as shoot tips and axillary nodes have been reported by many workers.

Sodium alginate is a copolymer composed of D-mannuronic acid and Lglucuronic acid units and has been extensively studied because of its biocompatibility, biodegradability and its capability to form hydrogels in the presence of divalent cations. The ridge structure and large pore size of these gels, which are insoluble in water, make them useful for the encapsulation of live cells of plants. Polymer concentration, degree of viscosity of the alginate used, CaCl2 concentration and curing time are important parameters determining the permeability, resistance and hardness of the resulting beads and the subsequent successes of the encapsulation method.

Method for Making Artificial Seeds:

Several steps are followed for making artificial seeds:

(1) Establishment of callus culture

(2) Induction of somatic embryogenesis in callus culture

(3) Maturation of somatic embryos

(4) Encapsulation of somatic embryos

After encapsulation, the artificial seeds are tested by two steps:

(1) Test for embryoid to plant conversion

(2) Green-house and field planting.

Maturation of somatic embryos means the completion of embryo development through some stages. Initially, embryo develops as globular-shaped stage, then heart-shaped stage and finally torpedo-shaped stage. In the final stage, embryo attains maturity and develops the opposite poles for shoot and root development at the two extremities.

This embryo then starts to germinate and produces plantlet. However, in some plant species, such sequential development may not be followed. Again, in some species requiring cold treatment for embryo germination, it may be necessary to chill young or mature embryos for their normal maturation and development into plantlets.

Application of GA_3 is also required for root and shoot development during embryo germination in citrus. Water soluble hydrogels have been found suitable for making artificial seeds. A list of

some useful hydrogels for encapsulation of somatic embryos are given in Table.

Table 8.1 Useful Hydrogel for Encapsulation

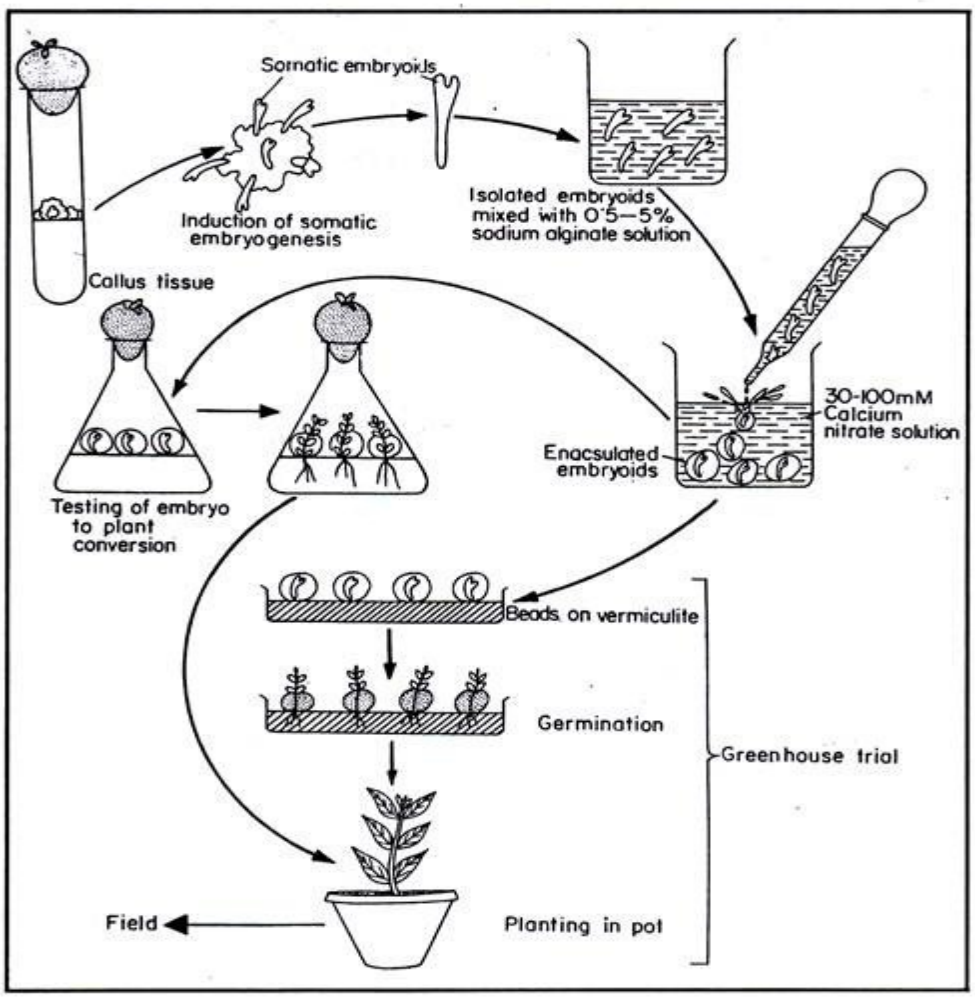
Gel	Conc. % W/V	Complexing agents	Conc. mM
1. Sodium Alginate	0.5–5.0	Calcium salts	30–100
2. Sodium Alginate	2.0	Calcium Chloride	30–100
with Gelatin	5.0		
3. Carragenan with	0.2–0.8	Potasium or	500
Locust Beam Gum	0.4–1.0	Ammonium chloride	
4. Gel-rite™	0.25	Temperature lowered	

Two standardized methods have been used to coat somatic embryos:

(i) Gel complexation via a dropping procedure;

(ii) Molding.

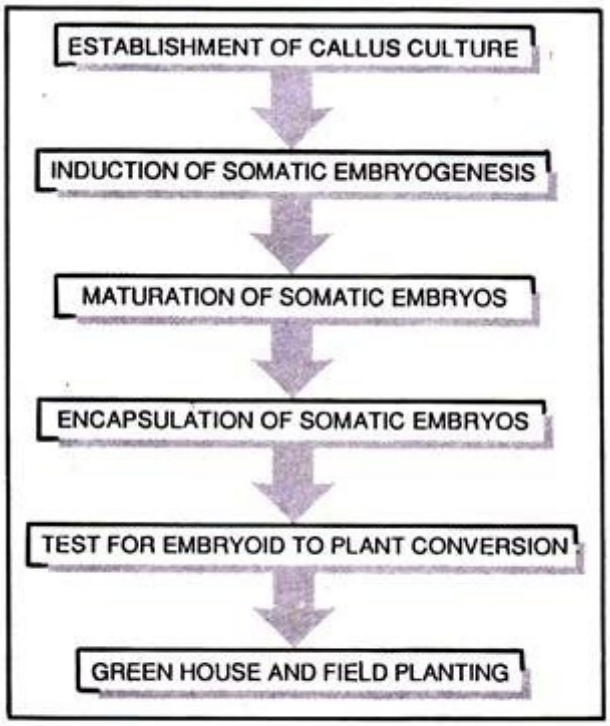
In the first method, isolated somatic embryos are mixed with 0.5 to 5% (W/V) Sodium alginate and dropped into 30-100 µM Calcium nitrate solution. Surface complexation begins immediately and the drops are gelled completely within 30 minutes



❒ Fig 8.5

Flow diagram showing the method for making artificial seeds

In the second method, isolated somatic embryos are mixed in a temperature-dependent gel such as Gel-rite and placed in the well of a micro-titer plate and it forms gel when the temperature is cooled down.



❒ Fig 8.6

Flow diagram showing the steps of production of artificial seeds

To achieve the satisfactory results, research is required in several areas for making artificial seeds. Somatic embryos need to be produced on a large scale, matured to a stage where germination will be at a high rate and frequency and encapsulated embryos will probably need to be coated to prevent capsule desiccation and allow for singulation during planting.

After encapsulation, initially, the effect of coating on somatic embryos is very difficult to assess because the germination and continued development of the encapsulated embryos are sometimes very inconsistent after planting into soil.

So, to overcome this problem, embryo response in terms of embryo to plant development or conversion is tested under aseptic conditions. Embryo conversion frequency is the percent of the somatic embryos that produce green-plants having a normal phenotype.

Embryo to plant conversion includes the following steps:

(i) Encapsulated embryos are placed aseptically on simply agar medium with minimal nutrients.

(ii) Uniform germination of somatic embryos and growth and development of root and shoot systems.

(iii) Production of true leaves.

(iv) Absence of hypstrophy of the hypocotyl.

(v) A green-plant with a normal phenotype.

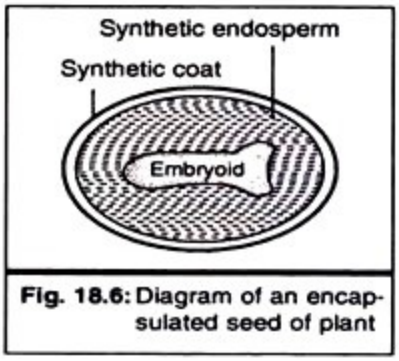


Fig. 18.6: Diagram of an encapsulated seed of plant

Two types of artificial seeds (encapsulated somatic embryos) are commonly produced:

1.Desiccated artificial seeds

Desiccated artificial seeds are achieved from somatic embryos either naked or encapsulated in polyoxyethylene glycol followed by their desiccation. Desiccation can be applied either rapidly by leaving artificial seeds in unsealed petri dishes on the bench overnight to dry, or slowly over a more controlled period of reducing relative humidity. These types of artificial seeds can be

only made in plants whose somatic embryos are desiccation-tolerant.

The desiccation tolerance of somatic embryos can be induced using a high osmotic potential of the maturation medium. The osmotic potential could be increased by using a high gel strength or by the addition of permeating osmoticants such as mannitol, sucrose, etc. Desiccation can also be induced by applying sub-lethal stresses such as nutrient deprivation or low temperature, since these treatments have been reported to have similar effects on desiccation tolerance

2.Hydrated artificial seeds

Hydrated artificial seeds can be produced by encapsulating somatic embryos in hydrogel capsules. They are produced in plant species which are recalcitrant and sensitive to desiccation. Encapsulation has been expected to be the best method to supply protection and to convert the in vitro micropropagules into 'artificial seeds' or 'synseeds', and it is an important application of micropropagation to develop the success of in vitro-derived plant delivery to the field. However, somatic embryos need to be encapsulated in a suitable material that promotes germination.

BASIC REQUIREMENT FOR THE PRODUCTION OF ARTIFICIAL SEEDS:

• One pre-requisite for the application of synthetic seed technology in micropropagation is the production of high quality,

1. Vigorous Somatic Embryos that can produce plants with frequencies comparable to natural seeds.

2. Inexpensive production of large numbers of high quality somatic embryos with synchronous maturation.

3. Encapsulation and coating systems, though important for delivery of somatic embryos, are not the limiting factors for the development of synthetic seeds.

4. Commercialization of synthetic seeds.

Effect of storage period and temperature on shoot emergence from encapsulated beads:

For the species, Acacia caesia, the shoot emergence from in vitro derived encapsulated node is directly depending on storage period and temperature (Tables 16). It has been observed that 4 months old in vitro derived nodal explants encapsulated beads recorded high emergence of shoots, ranging between 45.24 and 75.00% when compared to the 2 and 6 months old beads (42.43 – 72.10% and 40.32 – 68.57% respectively). On the other hand, it has been noted that 2 months old in vitro leaf callus derived somatic embryo encapsulated beads produced higher emergence of shoots (38.15 – 70. 00) in comparison with that of 4 and 6 months old beads (40.31 – 68.43 and 30.54 – 60.23 respectively). The suitable temperature determined for the storage of in vitro explants encapsulated beads for 2, 4 and 6 months durations is 25°C. For the other species, Acalypha fruticosa, the shoot emergence from in vitro leaf derived callus encapsulated seed is directly depending on storage period and temperature (Tables 24). It has been observed that 4 months old in vitro callus encapsulated beads recorded high emergence of shoots ranged

between 46.00 and 77.34% when compared to that of 2 and 6 months old beads (43.45 – 74.62% and 41.25 – 68.11% respectively). On the other hand, it has been noted that 2 months old in vitro node encapsulated beads produced higher emergence of shoots (44.21 – 71.10) in comparison with that of 4 and 6 months old beads (42.00 – 69.38 and 33.19 – 62.00 respectively). The suitable temperature for storage of in vitro explants encapsulated beads for 2, 4 and 6 months durations is determined to be 25°C.

EXAMPLE:

ARTIFICIAL PRODUCTION OF SAL (SHOREA ROBUSTA)

1) Propagation and plantation of Sal is difficult due to three reasons.

1. Short viability of Sal seeds. 2. Sal seedling and Saplings have root shoot ratio 3:1 and after 5 month it is 6:1 3. Sal seedling and Sapling are moisture Sensitive. To solve the above constraints the technique adopted is Sal seeds mature in the month of June. Fresh mature seeds are collected. Seeds are germinated in nursery providing warm and moist condition. Seeds germinate in 7 to 10 days. Early transplantation of germinate radicals in poly begs having pot mixture is done. It is to prevent root damage. Because root shoot ratio is high. It gives root coiling. To prevent root coiling of primary root poly begs are given special treatment. Bottom ends of poly begs are cut smoothly to open the bottom end. Clay soil is pasted at bottom end to protect the pot mixture in the poly begs. Poly begs are kept over racks (MACHAN) which is

one or two feet above ground. This gives aerial pruning to the roots and prevents root coiling.

2) To fulfill the moisture requirement of seeding and sapling regular watering form September onwards done once a day and after December twice day. Green net shade is given in peak winter and summer to the plants. In the next June sapling size grows to the height 30 cm. to 60 cm. PLANTATION :- Site is prepared in advance. Area is fenced pits are dug. Pit size cm. Per pit FYM 2 kg, neem cake powder 100 gm is given. One year old saplings are planted in site. Just after the end of rainy season irrigation either drip or flood is given to the plants. Regular watering is done. 250 ml./per plant/ alternate day and in summer 500 ml./plant/alternate day. After one year Sal plantation has more than 95% survival with vigorous growth. Average height 1 meter having collar girth 9 to 12 cm. Adopting the above technique artificial plantation of Sal can be done successfully. KEYWORDS :- Early transplanting, root shoot ratio, Racks (MACHAN), Root Coiling, Aerial pruning, Clay soil pasted, Germinate radicals.

3) Sal forest is native to the Indian sub continent. Chhattisgarh has predominantly sal forest. Nearly Sq.km. sal forest area is about 40% of the total forest area. Shorea robusta (Sal) regenerates naturally through seeds and coppice. Direct seed sowing is the cheapest and best method of artificial propagation. But it can be practised in an area with assured rainfall over 1200 mm. to 1500 mm. In the degraded sal forest which has too much biotic pressure and where rainfall is below mm. that too of uneven distribution survival of natural regeneration is almost impossible. Artificial regeneration of S. robusta can be practiced to major extent primarily within its native habitat. Artificial propagation of Sal (S. robusta) is difficult due to three reason. 1. Viability of fresh seeds fall to zero after just a few weeks. 2. Root shoot ratio of seedling in nearly 3:1 saplings have ration up to 6:1. 3. Sal seeding and sapling are moisture sensitive. Irrigated plantation of Sal was done in Korba forest division of Chhattisgarh in in the compartment number P2190 Rajgamar beat of Korba forest.

4) range. To salve the above constraints the technique adopted is In the month of June when Sal seeds matures are collected. Fresh collected seeds are germinated in warm and moist condition. Seeds are kept under jute begs, moisture is maintained by spraying water. Early Trans planting :- Within 7 to 10 days seed start germinating. Germinate radicals along with seed are planted in poly begs having pot mixture (Soil+ Sand+ Fym etc) 2:1:1 early transplanting is done to prevent root damage. Sal seedling grown have root shoot ratio 3:1 which becomes 6:1 after 4-5 months whi ch causes root coiling.

5) To prevent primary roots from coiling poly begs are given treatment. Bottom ends of poly begs are cut smoothly to make bottom open. Clay soil is pasted in bottom end to protect pot mixture in the poly begs. To control the further growth in primary roots poly begs with plants are kept over rack or MACHAN. Which keeps the poly begs above ground. This given aerial pruning to

roots coming out of poly beg. Sal seedling are moisture sensitive. Just after rainy season, i.e. September regular watering of seedling is done since September end to November once in a day. From form November onwards upto April watering is done twice a day. In the peak summer i.e. May and first half of June watering is done thrice a day.

6) Green shade net is given over plant seedling in nursery in the peak winter and summer season. In the month of June (next) sapling size grows to the height 30 cm. to 60 cm. Plantation :- Site preparation is done in advance. Fencing of area, and pit size cm. are dug. Fym 2Kg. neem cake powder 100 gm. per pit is given. Sal saplings one year old are planted in the site. Weeding and insect control is done timely. Moisture:- Just after the end of rainy season irrigation either drip or flood is given. Regular watering of the sal plants is done alternate day. Nearly 250 ml./perplant/alternate day. In the peak summer quantity of water is increased to nearly 500 ml./perplant/alternate day.

7) Watering is required in second year of plantation. After second year irrigation is not required. After one year Sal plantation has more than 95% survival with vigorous growth of plants. Average height is nearly one meter, minimum 70 cm. and maximum 1.45 cm. having collar girth nearly 9 to 12 cm. RESULT :- 1. Because Sal seedling and sapling are moisture sensitive regular watering is key to survival of plants. In the areas which have less rainfall it is better to plant one year old saplings, so in the first year of planting root can grow around 1meter length in the site. 2. Prevention of root coiling is necessary otherwise plants will have stunted growth. A type of root trainer technique is adopted, can be done in root trainer pot using big size pot. Pasteing clay soil does not give hurdle to root growth at the same time aerial pruning happens.

CONCLUSION:- In the degraded site having to much biotic pressure, having rainfall less than 1200 mm. artificial plantation is required to improve Sal forest. Sal seedling and sapling have constraints, small period of viability of seeds, they are moisture sensitive root.

8) shoot ratio is 3:1 to 6:1, Adopting above technique constraints of Sal seedling are solved. Artificial plantation of Sal can be done successfully.

DIFFERENCE BETWEEN NATURAL SEED AND ARTIFICIAL SEED:

NATURAL SEEDS:

1. Hard seed coat present.

2. Embryos are much protected within cotyledons or endosperm.

3. Embryos undergo controlled desiccation by the maternal tissue and have a natural dormancy period.

4. The natural seeds have their own storage reserves like endosperm or cotyledons to provide food during germination.

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3. Embryos undergo controlled desiccation by the maternal tissue and have a natural dormancy period.

4. The natural seeds have their own storage reserves like endosperm or cotyledons to provide food during germination.

ARTIFICIAL SEEDS:

1. No seed coat, only encapsulated.

2. Embryos are not protected within any kind of maternal tissue.

3. Embryos do not pass through any kind of desiccation and they the do not have any dormancy period.

4. The artificial seeds do not have their own storage tissue, the nutrients or growth regulators can be supplied within the encapsulating material.

Natural seeds	Synthetic seeds
1. Hard seed coat present.	No seed coat, only encapsulated.
2. Embryos are much protected within cotyledons or endosperm.	Embryos are not protected within any kind of maternal tissue.
3. Embryos undergo controlled desiccation by the maternal tissue and have a natural dormancy period.	Embryos do not pass through any kind of desiccation and they the do not have any dormancy period.
4. The natural seeds have their own storage reserves like endosperm or cotyledons to provide food during germination.	The artificial seeds do not have their own storage tissue, the nutrients or growth regulators can be supplied within the encapsulating material.

APPLICATIONS OF ARTIFICIAL SEED:

Artificial seeds have a wide range of applications in agriculture.

1) Propagation of hybrid plants is very easy through artificial seeds.

2) Genetically modified crops and endangered species of plants can be propagated through artificial seed technology.

3) Germplasm of elite lines and endangered species can be preserved with artificial seed technology.

4) Cereals crops, fruits, vegetables and medicinal plants can be studied anywhere in the world using Artificial (synthetic) seeds.

5) Genetic uniformity of crops and varieties of crop can be easily maintained by using is Artificial seed technology.

6) Artificial seed provides disease free conditions to plant material or explants which is present inside of capsule.

7) During the production of artificial (synthetic) seed encapsulation herbicides can be added to the formulation, this herbicide will provide extra protection to the explants against pests and diseases.

8) In cross pollinated crops like maize where the production of hybrids is wide spread practice. Artificial seed technology helps in production of hybrids without creation of parental lines that are costly and time consuming.

9) Synthetic seed crops are easy to maintain because of uniform genetic constituent.

10) Artificial seed technology improves the food production and also produces environment friendly plantation.

ADVANTAGES OF ARTIFICIAL SEEDS:

1. Easy handling and Inexpensive transport: As the synthetic seeds are small in size hence it is easier to store, transport and planting.
2. Storage life: Synthetic seeds posses long storage life and also the seed viability remains good for longer period of time.
3. Product uniformity: As somatic embryos are used for the production of artificial seeds hence most of the seeds are identical in there uniformity.
4. To avoid extinction of endangered species and seed less plants: The most important advantages of synthetic seed are such as it helps in conservation of endangered species e. g. in

hedgehog cacti (Echinocereus sp.) and seedless varieties e.g. grapes.
5. Large scale propagation: After the standardization of protocol it is very much suitable for large scale monoculture.
6. Germplasm conservation: A synthetic seed plays an important role in germplasm conservation.
7. Elite plant genotypes: artificial seed technology preserves, protects and permits economical mass propagation of elite plant genotypes such as orchids.
8. Independent of environmental conditions: The technologies of synthetic seeds production are not a season dependent as these are prepared inside the laboratory.
9. Permits direct field use: For tissue culture raised plants rooting, hardening is necessary but in case of synthetic seeds direct field sowing can give good yield.
10. Facilitates study: basic steps involved in the synthetic seed technology involves seed coat formation, function of endosperm in embryo development and seed germination, somaclonal variation provides wide open facility for study.
11. Supply of beneficial adjuvants: beneficial adjuvants like plant nutrients, plant growth regulators, microorganisms, fungicides, mycorrhizae, antibiotics can be made available to the developing plant embryo as per the requirement as these can be added in to the matrix.
12. Hybrid production: synthetic seed production technology can be used for production of hybrids which have unstable genotypes or show seed sterility such as not susceptible towards infection. It can be used in combination with embryo rescue technique. The rescued embryo can be encapsulated with this technique to form synthetic seeds.
13. In self-pollinated crops that currently have good seed production systems, synthetic seeds will not have any practical applications, but in cross pollinating species, especially those where seed production is difficult and expensive, synthetic seeds offer many advantages and opportunities.

LIMITATIONS OF ARTIFICIAL SEEDS:

Several intensive researches in the field of synthetic seed technology were applied in propagating and conserving a number of plant species, but practical implementation of the technology is limited due to the following main reasons.

1. Production and storage of synthetic seed is cost effective hence the production technique itself becomes costlier.
2. Production of viable micropopagules useful in synthetic seed production is less.
3. Anomalous and asynchronous development of somatic embryos.
4. All the embryos cannot mature at a time hence that makes them inefficient for germination and conversion in to normal plants.
5. Seed dormancy is considered as a problem but due to lack of dormancy and stress tolerance in somatic embryos the storage of synthetic seeds are limited.
6. The technology of synthetic seed is limited due to poor conversion of even apparently normally matured somatic embryos and other micropopagules into plantlets.

CONCLUSION:

During the last fifteen years, considerable improvement is seen in the case of artificial seed production but several problems remain associated with the commercialization of synthetic seed. The most important requirement about the practical application of artificial seed is the production of high quality micropropagules and large-scale production of seeds. Among tree species, regeneration of viable plantlets from somatic embryos is a frequently encountered problem, including germination, maturation, rooting of shoots or acclimatization and shoot apex elongation. Occurrence of high levels of somaclonal variations in tissue culture is another aspect to be considered seriously while recommending the use of artificial seeds for clonal propagation. Direct sowing of synthetic seeds in the soil does not need acclimatization often required for the tissue cultured plants; thus it provides an ideal delivery system and flexibility in handling and transport instead of large parcels of seeds or plants. Commercialization of synthetic seeds still requires some additional processes such as improvement in the tissue culture practices for the generation of adequate propagules. The production of synthetic seed must either reduce production cost or increase crop value. Improvement in the practices related to sorting of matured embryos, harvesting, encapsulation and germination can give higher yield and improvement of the quality of synthetic seed. However further study and research related to the improvement of technology can help in the global acceptance of synthetic seeds.

REFERENCES:

https://www.mdpi.com/2073-4395/7/4/71/htm

https://www.biologydiscussion.com/plant-tissues/artificial-seeds/artificial-seeds-meaning-method-for-making-and-importance/14674

https://www.ias.ac.in/article/fulltext/reso/006/05/0039-0047

https://www.researchgate.net/publication/230639949_Synthetic_Seeds

https://www.cell.com/trends/biotechnology/fulltext/0167-7799(87)90018-7

https://www.plantcelltechnology.com/blog/an-overview-of-synthetic-seeds/

https://www.biotecharticles.com/Agriculture-Article/Artificial-Seed-or-Synthetic-Seed-Production-4114.html