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Advances in Farming of Seaweeds and Its Cultivation Methods in India

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Introduction:

Seaweeds are macroscopic marine algae and non-flowering plants without true roots stems and leaves and it is largely intertidal and subtidal species. It reproduces both sexually and asexually. Some algae exhibit biphasic (gametophyte, carp sporophyte) type of alternative generation and some are diphasic (gametophyte, carp sporophyte, tetra sporophyte). Many edible seaweeds require temperatures between 10 -20˚C for rapid growth. It has high protein content and high levels of vitamins A, B, B_2, B_6, B_{12}, C and biotin, Further, it Contains higher amounts of important minerals like calcium and iron than vegetables and fruits.

Types of Seaweeds:

1.Green Algae (Chlorophyceae): *Enteromorpha compressa*, *Monostroma*

2.Brown Algae (Phaeophyceae): *Undaria pinnatifida*, *Laminaria* spp.

3.Red Algae (Rhodophycea) : *Porphyra* spp.

Red algae **Green algae** **Brown algae**



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Red Algae:

Red algae, or Rhodophyta are one of the oldest groups of eukaryotic algae. The Rhodophyta also comprises one of the largest phyla of algae, containing over 7,000 currently recognized species with taxonomic revisions ongoing. The majority of species (6,793) are found in the Florideophyceae (class), and mostly consist of multicellular, marine algae, including many notable seaweeds. Red algae are abundant in marine habitats but are relatively rare in freshwaters. Approximately 5% of the red algae occur in freshwater environments with greater concentrations found in warmer areas. Except for two coastal cave dwelling species in the asexual class Cyanidiophyceae, there are no terrestrial species, which may be due to an evolutionary bottleneck where the last common ancestor lost about 25% of its core genes and much of its evolutionary plasticity. These, help form coral reefs.

Green Algae:

About 700 of the 7,000 species of green algae are marine. Of those, few are multicellular. They are very common in high salinities water (Bays, Estuaries, Tide Pools). They are usually bright green because the chlorophyll is not masked by other pigments. They have a simple thallus when compared to red and brown algae. Many forms are filamentous or form paper-thin sheets. Others form spongy fingers as in this example of Dead Man's Fingers.

Brown Algae:

Almost all species of brown algae are marine. The best known and the most complex species are the kelps. Color varies from olive green to dark brown because there are many yellow-brown pigments that mask the color of the chlorophyll. Besides, the well-known kelps, Sargassum weed is also a well-known brown algae. Sargassum weed often forms into large mats in the ocean and create habitat for lots of unique animals and communities.

General Structure of Seaweed:

Seaweeds are very diverse group although they lack true leaves, stems and roots, they have a few common structures. The leaf-like flattened portions are called blades. The blades are main photosynthetic region. These are not true leaves because they lack veins. The complete body is called the thallus. Usually, all regions of the thallus can

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photosynthesize. Most seaweeds have gas-filled bladders or floats that will help them maximize sunlight exposure. Sometime these floats contain carbon monoxide. Some seaweeds have a stem-like structure called the stipe. This structure is not found on all seaweeds. The stipe provides support and can be long and tough, as in the Giant Kelp. The stipe also allows a place for the attachment of the blades. A holdfast is a root-like structure that holds the seaweed to the bottom. This structure does not aid in gathering nutrients. The holdfast does not penetrate through sand or mud and most of the microalgae are only found on hard sediments.

Features of seaweeds

Seaweed Group	**Photosynthetic and other Pigments**	**Storage Product**	**Cell Wall**
Green Algae Chlorophyta	Chlorophyll a & b	Starch	Cellulose
Brown algae Phaeophyta	Chlorophyll a & c, fucoxanthin, xanthophylls	Laminarin, Mannitol	Alginate
Red Algae Rhodophyta	Chlorophyll a & d r-phycoerythrene r-phycocyanin	Floridian Starch	Agar, Carrageenan

Criteria for selecting good site in open waters and in seawater ponds for seaweed culture:

- Unpolluted seawater supply.
- Salinity: 25 – 35 ppt.
- Water temperature: 27 - 30°c.
- Moderate water movement of 25 – 50 m/min.
- Water depth of 0.5 – 1 at low tides and not more than 2 – 3m at high tides.
- Firm bottom protected from strong waves for some seaweeds like *Eucheuma* and muddy loam bottom for Caulerpa ponds.

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- Good water exchange availability.
- Moderate wind speed

Cultivation of seaweeds depends on 4 important factors:

1. **Types of seaweed used:**

   The seaweeds cultured must be healthy and resistant to disease. It is must be able to grow and give high yield during harvest.

2. **Ecological condition of the farms:**

   The farm must be well sited and fulfill the bio ecological requirements of the culture species.

3. **Access of sunlight:**

   Seaweeds being cultivated need abundant sunlight for photosynthesis.

4. **Regular supervision:**

   Farmers must visit the farm regularly and carry out routine inspection.

Recent technological advances in seaweed culture:

1. **Fixed off bottom culture:** Seaweeds are cultured above the sea bottom at fixed level. In this 'tie – tie' method, the seedlings are tied at one end of the plastic strip and the other end is tied to stretched out nylon monofilaments in the sea. In India, cultured on stretched lines or nets made of coir or synthetic fibers. The seedlings are inserted in twists of ropes in this method. *Gracilaria edulis, Gelidiella acerosa, Hypnea, Acanthophora sp, Sargassum sp,* are cultured in India in this method.
2. **. Floating raft/cage culture:** Seaweeds are cultured at sub – surface level of the sea using rafts and cages.
   - **Raft culture method** : culture of *Gracilaria spp*. in Caribbean, China, Namibia.
   - **Cage culture method** : culture of *Gracilaria heterocladia* along with fish in Philippines and *Hypnea* culture in Israel.
3. **Bottom culture:** Seaweeds are cultured at the bottom of sea, ponds, canals and onshore tanks. In Chile, *Gracilaria* seed material are planted directly at the sea bottom sand in the intertidal region. In India, *Gelidiella acerosa* is cultured by winding round seeded nylon twines to nails fixed on coral stones in sea. Some seaweeds are cultured along with prawn in ponds using net cages in Philippines. In

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Taiwan, Gracilaria spp. are cultured in ponds under polyculture system with Penaeus monodon, Chanos chanos and Scylla serrata.

4. **Green house culture:**In Canada, *Chondrus crispus* and *Gracilaria* are cultured in green houses by manipulating temperature and light. In India, culture of different commercially important seaweeds have been attempted in onshore condition with running seawater system and by providing aeration.
5. **Spray culture:** The main advantage – cultured seaweeds are free from epiphytes. Dripping, misting or spraying are done in land based seaweed farms to maintain a film of seawater over seaweed. The most practical reason is that less water is required. Sometimes seawater enriched with Sodium nitrate, as well as artificial seawater is also used. Also using artificial seawater *Ascophylum, Gracilaria, Ulva* etc. are cultured in this way.
6. **Raceway culture:** Seaweeds can be grown in any location without limitation imposed by natural shoreline locations. Production can be continued even during rainy season, protecting raceways with translucent covers to prevent dilution of seawater by rains. Land based culture system Limitation of natural shoreline. Fast growing tropical strain *Gracilaria* N Br. 10 which is cultivated in raceway (ponds with water current) and is popular in the Philippines.
7. **Tissue culture:**It is called as reproductive method / cell culture method. Mostly done in foreign countries as well as in India for *Porphyra*. *Gracilaria*, *Hypnea*, *Gelidium* (red algae), *Undaria*, *Laminaria*, *Enteromorpha*, *Sargassum*, *Codium*, Ulva and Monostroma. In this method, hybrid strains with disease free and better quantity phycocolloid can be obtained. Introduction of new species from other countries is also done to enhance the growth.

In India (commercial seaweed species & production): 700 species reported, 60 species are commercially important.

Distribution:

Luxuriant growth: Along the SE coast of TN from Mandapam to Kanyakumari, Gulf of Mannar, Gujarat coast, Lakshadweep, and Andaman Nicobar island, Mumbai, Ratnagiri, Karwar, Goa, Varkala, Vizhinjam, Vishakhapatnam and coastal lakes like Chilka & Pulicat have good amount of seaweed.*Sargassum* from Mandapam to Kilakkari and Tuticorin,

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Hypnea from Mandapam to Vembar, *Gracilaria* from Vembar to Nallatanni region. Large scale seaweed culture- Pepsi Foods Ltd. M.S. Swaminathan Research Foundation – *seaweed farming programme with technical help from* CMFRI More than 540 families -three districts Ramnad, Tuticorin and Tanjaor (TN) engaged in commercial propagation of this algae over 12700 rafts in the sea.

Seaweed species	**Production in metric Tonne**
Gelidiella acerosa (red)	232
Gracilaria edulis (red)	215
Hypnea musciformis (red)	195
Kappaphycus alvarezii (red)	200
Sargassum wighti (brown)	2249
Turbinaria conoides (brown)	307
Total production	3,398 mt/yr.

Seaweed resources and their distribution in India:

The total resources of seaweeds in India are about 70,000 tonnes. Luxuriant growth of several species of green, brown and red algae occur along the south east coast of Tamil Nadu, from Mandapam to Kanyakumari and Gulf of Mannar islands, Gujarat coast, Lakshadweep and Andaman and Nicobar islands. Fairly rich seaweed beds are present in the vicinity of Mumbai, Ratnagiri, Karwar, Goa, Varkala, Vishakhapatnam and in coastal lakes like Chilka and Pulicat. There are about 20 agars, 10 algin and few LSF industries in Tamil Nadu, Karnataka, Andhra Pradesh and Gujarat. CMFRI, CSMCRI and other research organizations are involved in carrying out research on seaweeds. Different types of commercially important species of seaweeds are cultivated in India like *Gracilaria acerosa*, *Gracilaria edulis*,

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Hypnea musciformis, Acanthophora spicifera, Kappaphycus alvarezii, Enteromorpha flexuosa are cultivated for experiment or base of the small scale culture. Mostly CSMCRI & CMFRI are done experiment on the culture. Based on the results obtained, according to vegetative method 1kg of seed material would yield on average of 3kg m sq. of net after 60 days.In India, experimental culture of red (*Gracilaria edulis*), brown (*Sargassum plagiophyllum*) and green (*Enteromorpha flexuosa and Ulva lactuca*) algae were carried out successfully by reproductive method.

Harvest:

Harvest the plants after 35 - 40 days depending upon the growth and the weight on the lines. Clean the harvested plants of foreign material and select the best plants for stocking the next crop.

Processing and market:

For selling of the plants, it is dried by spreading them on platform or on mesh net or dried coconut fronds. The plants are regularly turned the plants regularly for drying and protect from rain. The plants are washed after drying for 2 to 3 days by placing them in to the basket in seawater. It is again spread to dry.

Utilization of seaweeds:

Seaweeds used for production of phytochemical like agar, carrageenan and alginate, which are widely used as gelling, stabilizing and thickening agents in food, pharmaceutical, dairy, textile, paper and paint industries.

Agar: manufactured from RED algae like *Gelidiella, Gracilaria, Gelidium.*

Carrageenan: obtained from RED algae like *Eucheuma, Kappaphycus, Chondrus, Hypnea.*

Alginates: obtained from brown algae like *Sargassum, Turbinaria, Laminaria, Macrocystis* and *Ascophyllum.* Other products like Mannitol, Iodine, Laminarin are also produced.

Several protein rich edible seaweeds like *Ulva, Enteromorpha, Codium* (green algae), *Porphyra, Gracilaria, Eucheuma, Kappaphycus, Acanthophora* (red algae), *Sargassum, Laminaria, undaria, macrocystis* (brown algae) are consumed in soups, salads and vegetables. The red algae like *Gelidella acerosa, Gracilaria edulis,* and etc are used for agar manufacture, brown algae like *Sargassum spp, Turbinaria spp, Cystoseira trinodis* for production of alginate and SLF(Seaweed Liquid Fertilizer).

Application of seaweeds as Pharmaceuticals:

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- *Bryopsis* – Kahalalide F – Lung cancer, tumors, AIDS
- *Spatoglossum schmittii* – spatol – toxicity against human melanoma and astrocytomat cells in culture
- *Stypopodium zonale* – cytotoxins – inhibit cancer cell damage
- Kelp – used in clinical trials to lower BP in heart patients
- *Porphyra* – porphyoson – anti-shay ulcer activity
- *Porphyra umbilicalis* (Purple laver) – porphyran – inhibit growth of sarcoma 180 tumor in mice
- *Sargassum vulgare* – alginate – inhibit growth of sarcoma 180 tumor in mice

Conclusion:

Several environment problems can result from seaweed farming. Seaweed plays a huge role in fighting climatic changes by absorbing carbon emissions, regenerating marine ecosystems, creating biofuel and renewable plastics as well as generating marine protein. Sea weed farming help to preserve coral reefs by increasing diversity where the algae and seaweed have been introduced and it also provides an added ecological niche for various coral species of fish and invertebrates, Further, the seaweed farms buffer the ocean's growing acidity conditions for the cultivation of a variety of shellfishes.