

Sea farming and saline water agriculture

Sea farming and saline water agriculture have been gaining interest as possible solutions for the limitations imposed by the world's freshwater supply, farmland availability, salinity ingress and the pressing future need for food supply. They also have the potential to contribute to important solutions to the climate change problem.

Freshwater resources form only 3% of the total water resource; the remaining 97% water in the sea is excessively saline and generally not suitable for large-scale use in agriculture. More than half of the world's groundwater supply is also saline. The application of saline water for agriculture is of great significance.

There are more than 833 m ha of salt-affected soils (SAS) around the globe, i.e. 8.7% of the planet, mainly in the semi-arid environments of Asia, Africa and Latin America. Also, between 20% and 50% of irrigated soil in all continents is salty – that is, more than 1.5 billion people face challenges in food production. Also, the rising sea levels threaten food security and livelihood.

Against the backdrop of climate change and overall environmental degradation, oceans are categorized as victims of warming, acidification, pollution and vanishing species. New and innovative ways of regenerative ocean farming and saline water agriculture can emerge as one of the most nutritionally, socially and environmentally sustainable food production methods. Seaweed and shell fish have the distinguished feature to feed on excessive nutrients for growth. They also capture part of the 30% atmospheric carbon which the oceans absorb. On top of buffering, ocean eutrophication and acidification, growing sea greens and bivalves together in a polyculture system contributes to a healthier marine environment.

Halophytes are among the few species of higher plants that can withstand high salinity without detrimental effects. We can make a broad classification of halophytes on the basis of their salt tolerance capacities.

- (i) Plants with a high salt tolerance. They are able to grow in sea water.
- (ii) Plants with average tolerance, consisting of brackish-water crops.
- (iii) Crops with moderate tolerance. They are tolerant to slightly brackish waters.

About 2600 species of halophytes are known and only a few are extensively studied for their potential in agriculture and as a source of oils, flavours, resins, pharmaceuticals, etc. Also, their environmental potential for protection and conservation of coastal ecosystems, soil improvement and as a source of biomass for biofuels, could be significant.

The mechanism of salinity tolerance is interesting. The reduction in germination and low productivity may be attributed to increased osmotic pressure of the soil solution, which diminishes the water absorption rate leading to moisture stress in seeds. Salt stress interrupts metabolic activity by excess of ions, imbalance and interference of toxic ions on the uptake of essential nutrients, which are detrimental to seed germination under saline conditions. A better understanding of the underlying mechanism involved in seed germination and growth under saline conditions is needed to confront this agronomic problem. The cell membranes form barriers between the plants and their environment, and thus membranes are of special importance to plants for regulating the ion content.

Management practices are being developed to enhance the productivity and success rate of germination of halophytes. These include irrigation methods, selection of crops and crop rotations, salt balance and drainage requirements, use of amendments and overall agronomic practices. The drip irrigation system, liquid bio-fertilizers like *Azospirillum* and seed treatment with calcium salts have been emphasized for inland farms.

For halophytes to succeed as useful crops, some basic conditions are necessary: (a) good yield, (b) proper irrigation and (c) growth in existing infrastructure.

Some major important halophytes are as follows:

- (1) For food and oilseeds: *Aster tripolium* (sea spinach), *Salicornia bigelovia*, *Salicornia brachiata*, *Kochia scoparia*, *Salvadora oleoides*, etc. *Salicornia* in particular, has been grown on a large scale. The seeds contain 31% protein, 28% oil and are also rich in polyunsaturated fatty acids (74% linoleic acid). The tips are used as vegetables.
- (2) As fuelwood and timber: More than a billion people in developing countries rely on wood for domestic

purposes. *Prosopis*, *Salsola*, *Acacia*, *Sueda*, *Pongamia*, *Pinnada* and *Avicenua* are good fuelwood species.

- (3) Environmental properties: Halophytes like *Avicennia marina*, *Spartina maritime* and *Avicennia germinans* (black mangrove), etc. are known to restore coastal area vegetation, and are an important part of coastal bioshields.
- (4) The use of halophytes for CO₂ absorption.

Halophytes like *Salicornia* are rich in vitamins, minor quantities of nutrients and essential amino acids. *Salicornia* oil has a pleasant nut-like flavour and texture similar to olive oil.

A study was carried out to assess the effect of *Salicornia brachiata* on soil quality over temporal and spatial scales in the coastal areas of Gujarat, India. *Salicornia* is just one example of halophytes. Others like *Atriplex entiformis*, *Atriplex lentiformis*, *Atriplex holocarpa*, *B. maritima*, etc. have also been gaining attention.

Seaweeds or macro-algae hold great potential for a large number of high-value, high-performance products. Use of biostimulants in agriculture increases germination, nutrient uptake and use efficiency, and increases tolerance to and recovery from abiotic stress (salt, water, heat, heavy metals, etc.). Biostimulants derived from seaweeds like *Ascophyllum nodosum*, *Kappaphycus alvarezii*, *Eucheuma*, *Sargassum*, *Gracilaria*, etc. have already attracted the attention of industries around the world. This segment of new-generation agri-bio industry is growing at a fast rate. Seaweed farming has frequently been developed to improve economic conditions, and reduce fishing pressure and overexploited fisheries. Global production of aquatic plants, mainly dominated by seaweeds has grown several folds in the last decade. Seaweeds have a variety of uses from food, medicine, edible packaging, bioremediation, animal feed, fertilizers and fuel to carbon removal by ocean afforestation. IPCC special report on The Ocean and Cryosphere in Changing Climate, further emphasizes as a mitigation tactic.

The emerging market of biofertilizers/biostimulants and biofuels has been attracting increasing attention especially in Asia. Halophytes form an important part of the bioshields including mangroves, to help protect coastal areas against disasters like tsunamis.

India has about 7516.6 km coastline in nine maritime states and two Union Territories. It harbours four million fishermen in 3288 fishing villages of 70 coastal districts. The last few decades have witnessed resource degrada-

tion, poverty and marginalization in the fisheries sector. By considering 193,834 km² of territorial waters (up to 12 nautical miles from the coastline) accessible to artisanal fishermen, prospects of taking up seaweed farming at the pan-India level are encouraging. India is fast emerging as an important centre in Southeast Asia for *Kappaphycus alvarezii* production due to path-breaking work at the Council of Scientific and Industrial Research-Central Salt and Marine Chemicals Research Institute (CSIR-CSMCRI) (Manthri, V. and Agarwal, P., CSIR-CSMCRI Report, 2021). According to a recent FAO statistics, India stands in the 13th position with 5300 wet tonnes seaweed harvest corresponding to only 0.2% of the global seaweed production. It is encouraging to note that the Ministry of Fisheries, Animal Husbandry and Dairying, Government of India allocated Rs 640 crores during 2020–2021 spanning five years under the flagship scheme ‘Pradhan Mantri Matsya Sampada Yojana (PMMSY)’ to ambitiously expand the fisheries sector and accelerate its growth in the next five years, with a production target of 10 million tonnes fresh weight. The Finance Minister announced in the 2021–22 budget the establishment of a Seaweed Park in Tamil Nadu, with an investment of Rs 100 crores, which would serve as a one-stop park for the entire seaweed value chain linking all the pre- and post-harvest activities.

Aqua agro complexes should become an important part of our future planning. In the late 1960s, a dream project on nuclear-powered agro-industrial complex for coastal areas was planned under the leadership of Vikram Sarabhai. A large nuclear power plant along with a sea-water desalination plant was the core of such a project. Later, the effluent sea water from the desalination plant was planned to be used as a feed for halophyte plantation. Though this project was shelved, the setting up of small aqua-agro units, has been proposed (Mehta, M. H., *Eco Agri Revolution – Practical Lessons and the Way Ahead*, NIPA, New Delhi, 2017). Such units will consist of (a) an aqua farm with shrimp and other high-value fishes, and (b) coastal halophyte plantation. Large-scale sea-water aqua-agro farms have come up in Mexico and Eritrea. In India too, a large number of such small aqua-agro units can be established and this will be a boon to millions of fishermen in the country.

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