Journal of Coastal Development ISSN : 1410-5217
Volume 11, Number 2, February 2008 : 62-69

BIO PROSPECTING MARINE HALOPHYTE *Salicornia brachiata* FOR MEDICAL IMPORTANCE AND SALT ENCRUSTED LAND DEVELOPMENT

Oswin D. Stanley

Eco Balance Consultancy (EBC) 6B, Umiya Park Society, Subhanpura
Vadodara-390 023, Gujarat, India

Received : November, 8, 2007 ; Accepted :January, 8, 2008

ABSTRACT

Halophytes continue to be either under or unexplored in India. Many halophytic plants are of economic value and have industrial applications in the form of essential oils, medicinal, alcohol, fiber, latex, pulp, cosmetics etc. Salicornia spp extensively occur along Gujarat and Tamil Nadu coasts in the regularly (20-50 tides month^{-1}) inundated inter tidal zones. Expanding saline wastelands, dubious rains, recurring droughts and soil erosion due to absence of green belt between sea and land ultimately lead to low productivity and poverty in these coastal regions.

Seawater Agriculture is the strategy to link ecology and livelihood. Utilizing Salicornia to rehabilitate the land and bio-prospecting biomedical compounds is a promising concept besides addressing the issues of desertification, salt intrusion and ultimately poverty alleviation. It is rational to implement pilot projects in different locations with commercial motives entangled with research concepts standardization.

Key words : *Salicornia - Bio prospecting - Medicinal values - Salt land Rehabilitation - Poverty Alleviation*

***Correspondence** : Phone : +6-265-2339115 ; Fax : +6-265-2330036 ;
email : oswinbaby@rediffmail.com

INTRODUCTION

Frequent natural calamities coupled with human exploitation along the coastal belt of the India had fastened the process of salt intrusion causing vast saline fallow lands. Salt intrusion has to be viewed in local and regional contexts. Productive land and fresh water are becoming lesser due to several developmental activities and exploitation with out water recharge. The agriculture productivity has been declining due to increasing salinity in land and water. The problem forces women to spend major portion of their time and energy to get water, fodder, and fuel for the family. The poor quality of water affects the productivity and income from dairy activity as well. The port and industrial development process has adversely affected the quantum and quality of life along the coastal region, threatening the livelihood of many families surviving on fisheries. The hostile natural conditions and growing degradation of natural resources have resulted in large-scale poverty in the region.

 ISSN : 1410-5217

High incidence of poverty, large-scale under-employment and unemployment, high degree of indebtedness, extremely low paid agricultural labor force and the continuing process of land alienation among small and marginal farmers are common phenomena among the Coastal villages. Saline intrusion has also catalyzed migration of local community.

Seawater Agriculture is the strategy to link ecology and livelihood. Biotechnological implication (Mass scale Micro-propagation) of the identified halophyte and exploration of novel bioactive compounds for biomedical applications are the strategies high lightened in this paper.

Availability of extensive arid and semi-arid saline coastal areas without economic and ecological development and seawater; demand for the vegetative portion of *Salicornia* in international markets gave the impetus to conceptualize the concept of providing Integrated Coastal Protection and Saline Land Development with linkages to empowered Livelihood Security and Sustainable Utilization for biomedical applications. Illegal collection/exploitation of marine halophytes (especially *Salicornia*) for many clinical applications is a major threat all over globe to most of the halophytes which alarms the scientists to seek strategy to conserve and utilize.

SALICORNIA SPECIES DESCRIPTION

For centuries it is said that the ancient Greeks ate succulent and tasty tips before going in to battle, and in 1605, Shakespeare wrote about this in his play, King Lear. Before 1800, George Washington said *Salicornia* was his favorite herb. Belonging to the family *Chenopodiaceae*, *Salicornia* is a halophyte (literally a plant that grows in salty soil), and its seeds yield high quality edible oil, which is highly poly-unsaturated and similar to safflower oil in fatty acid composition. It has a pleasant nut-like flavor and a texture similar to olive oil. *Salicornia*, is a succulent, bushy plant with a high salt tolerance that grow in water with salt contents equal to or even higher than seawater and found in the salty-terrains near the coast. These are found right on the sea (low on the tidal marshes) and that have very specialized mechanisms for dealing with salt. It holds a lot of promise as an ideal edible-oil yielding crop and a green vegetable, which can be raised using seawater. An improved variety of *Salicornia* developed by crossing with other highly drought-resistant and salt-resistant species of *Salicornia*, is being grown extensively in several parts of the world, including India.

Halophytes are rich in proteins, oils and fats that are suitable for human consumption. However *Salicornia* sp is rich in vitamins A and C, calcium, iron, iodine, magnesium, sodium, and amino acids, low in calories and fat, contain no cholesterol, and add fiber to the diet.

Serving size of 75 grams Salicornia sp contain:

- Calories, 26-Calories from fat, 0
- Total fat and cholesterol, 0
- Sodium, 1.2 g-Percentage of daily value, 50%
- Total carbohydrates, 5g-Percentage of daily value, 1.8%
- Dietary fiber, 2.6g-Percentage of daily value, 11%
- Sugars, 0
- Protein, 1 g
- Vitamin A-Percent of daily value, 36% (100% as beta carotene)
- Vitamin C-Percent of daily value, 13%

Other minerals present include magnesium, potassium, copper, iron, manganese, and zinc.

 ISSN : 1410-5217

HALOPHYTE, *Salicornia Brachiata* CULTIVATION

A few private companies have taken up large-scale *Salicornia* cultivation in Rajasthan and Gujarat with improved variety SOS 10, and some research institutions such as the Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavanagar, Gujarat, and the M. S. Swaminathan Research Foundation (MSSRF), Chennai, are conducting research on the nutritional value and the cultivation techniques for growing *Salicornia*.

Government and Entrepreneurs collaborative attempts on Sea water agriculture and grass root level technology transfer for long-term sustainable utilization of land and higher economic development through established national/ international market is suggested as the appropriate approach.

CULTIVATION METHOD

Though the farming pattern is anything like a regular farming the duration of irrigation, water logging systems, soil porosity and land elevation makes difference. Irrigation is the major part of the cultivation process. Direct salt water from sea or estuaries/creeks may be irrigated. Normal farm and irrigation equipment can be modified so that it is protected from salt damage from the seawater. Normally, crops are irrigated only when the soil dries to about 50 percent of its field capacity, the amount of water it is capable of holding. In addition, in freshwater irrigation, farmers add only enough water to replace what the plants have used. In contrast, seawater irrigation requires copious and frequent -even daily- irrigation to prevent salt from building up in the root zone to a level that inhibits growth.
Earlier estimations reveal that the water and salt balances required for a seawater-irrigated crop as that the amount of biomass a seawater-irrigated crop yields depend on the amount of seawater used. Although *Salicornia* can thrive when the salinity of the water bathing its roots exceeds 100 ppt- roughly three times the normal saltiness of the ocean-it needs approximately 35 percent more irrigation when grown using seawater than conventional crops grown using freshwater. *Salicornia* requires this extra water because as it selectively absorbs water from the seawater, it quickly renders the remaining seawater too salty for use.

The greatest expense in irrigated agriculture is in pumping the water. The pumping costs are directly proportional to the amount of water pumped and the height to which it is lifted. Although halophytes require more water than conventional crops, seawater farms near sea level require less water lifting than conventional farms, which often lift water from wells deeper than 100 meters. Because pumping seawater at sea level is cheaper than pumping freshwater from wells, seawater agriculture should be cost-effective in desert regions-even though its yields are smaller than traditional, freshwater agriculture. Seawater irrigation does not require special equipment. Either flood irrigation of large basins or moving-boom sprinkler irrigation can be used. Moving booms can be used in many types of crop production. For seawater use, a plastic pipe is inserted in the boom so the seawater does not contact metal.

The plant grows well in sand and sandy loam soils endowed well adequate drainage. The crop responds to increased application of nitrogen and phosphorus. However, the plant takes from the sea all the nutrients it needs, so it does not consume any of the precious fresh water that by human need so desperately. Seawater contains sufficient quantities of other nutrients and micronutrients to eliminate the need for supplementation with other fertilizers.

 ISSN : 1410-5217

PRODUCTION ANALYSIS

Salicornia brachiata, is an erect annual herb distributed mainly in the salt marshes of Tamil Nadu, Andra, Orissa, Gujarat, Bengal and Sri Lanka. Extensive *Salicornia* beds occur along the Gulf of Kachchh (northwest) and Tamilnadu (southeast) coasts with width of the beds varying from approximately 5 m to 1000 m, depending upon the topography and tidal influence. The large and healthy *Salicornia* formation occur in the regularly (20-50 tides month^{-1}) inundated inter tidal zones. The width of *Salicornia* beds in the Gulf of Kutchchh is greater than those along the Tamilnadu coast due to greater (0.83-7.2 m) tidal amplitude and flat topography.

Plant biomass, density, height, and frequency of occurrence is more in the frequently inundated inter tidal regions. The average total biomass of aboveground components varies from 0.2 to 4.5 kg (dry weight) m^{-2}. Peak biomass production of *Salicornia* is during September to February in the Gulf of Kutchchh, and in southeast coast, during December to March. The growth of the *Salicornia* is considerably influenced by the frequency of inundation, duration of atmospheric exposure at ebb tide, rainfall and salt content of the water and sediments.

Salicornia has a seed yield of 100 kg per hectare, and the oil content is 20 per cent. *Salicornia* produced an average annual crop of 1.7 kilograms per square meter of total biomass and 0.2 kilogram per square meter of oilseed. These yields equal or exceed the yields of soybeans and other oilseeds grown using freshwater irrigation in Mexico. Yield from portions of a two-hectare field at Jubail Industrial City in Saudi Arabia reached 3.5 tons per hectare.

The plants tend to lodge as harvest approaches, and the seeds, which are roughly one milligram in weight, may shatter. In addition, seed recoveries are only about 75 percent for *Salicornia,* compared with greater than 90 percent for most crops. Further, to support high seed yields *Salicornia* must grow for approximately 100 days at cool temperatures before flowering. Currently production of this crop is restricted to the subtropics, which have cool winters and hot summers; however, some of the largest areas of coastal desert in the world are in the comparatively hotter tropics.

In seven months the crop reaches maturity, and in many locales a high yield of 18 tonnes of dry biomass has been harvested. The field seed-yield is about 10-12 per cent of the total dry biomass. A 2000-hectare farm would yield a total biomass of 30,000 tonnes and a seed yield of 2,500-3000 tonnes of seeds.

In Indian context, at CSMCRI's demonstration project in the coastal village Hathab in Saurashtra, *Salicornia brachiata* farms give 1200-1500 kg seeds and 10 tonnes of biomass per hectare that would provide 3-4 tonnes of vegetable salt. The economics of vegetable salt has been worked out to be about Rs. 10-12 per kg which is expensive than the common salt.

MARKET DEMAND

There is a demand for *Salicornia* in different countries for food (salads), medical and pharmaceutical industries. Many of the pharmaceutical countries in the developed countries are illegally exploiting the halophytic resources from developing countries. The demand for *Salicornia* may be legally dealt with such massive cultivation process and illegal bio-piracy can be ceased. The local/Indian demand can be also explored to popularize the halophyte utilization.

Table 1. Cost Analysis of Salicornia Cultivation

Salicornia - Cost Analysis per hectare			
Detail	Kg /ha	Cost / kg	Total Cost (Rs)
Seeds	1200-1500 (1.2-1.5 tonnes)	Rs. 15	22, 500
Vegetative Biomass	10000 (10 tonnes)	Rs. 0.5	5, 000
Vegetable salt	3000 – 4000 (3-4 tonnes)	Rs. 10-12	30,000

MICRO-PROPAGATION

As a part of germ plasm preservation and mass scale extraction of effective biologically active principles, steps may be undertaken to develop techniques for regeneration and callus production through callus development or by protoplast isolation and regeneration. Root, stems, flowers and seeds from the *Salicornia* plant may be used as explants. Methods involving the prevention of microbial contamination and over production of oxidized phenolics in media will be standardized. Mass scale extraction of biologically effective active principles may be done by mass culturing of callus tissues by adopting appropriate methodology.

BENEFITS OF SALICORNIA CULTIVATION

Benefits of *Salicornia* cultivation qualify the 3 "E" criteria: (a) ecology (sustainability) (b) economy (viability) (c) equity (benefit sharing). Pilot projects on *Salicornia* cultivation would facilitate:

- Salt water Halophyte cultivation technology transfer
- Application of biotechnology in standardization of mass multiplication/micro propagation technology for sustainable utilization of the marine halophyte of biomedical importance.
- Through bio-prospecting marine halophyte *Salicornia*, potential bioactive compounds will be identified and brought to the sustainable commercial shelf through micro propagation technology.
- The major problem of salt ingression and vast areas of salt encrusted land left fallow in coastal areas is addressed.
- The ecological up gradation of degraded wasteland would be a noteworthy impact.
- The green belt created between the waters and inland would have a greater effect as a bio-shield against natural vagaries and soil erosion.
- Enhance the monthly economical income of the community or stakeholder involved during the processes of cultivation, drying, packing, transport and marketing or research activities.
- Resource base would be formed for identification and development of formulations of novel bioactive compounds through biotechnological modules
- The coastal "model village farm" may create opportunity for large scale

 ISSN : 1410-5217

technology extension with different new strategies designed by the scientists
- The entrepreneurship formations would pave way for the development of empowered benefit sharing mechanism and administration bodies.

FURTHER SALICORNIA CULTIVATION OFFERS BENEFITS IN VARIOUS ASPECTS:

Climate

In a broader context it contributes to improvement of the world's climatic conditions. It positively responds to an international goal, the sequestration of CO_2, by planting on a large scale on otherwise worthless saline ground.

Utilization of saline land with halophytes

Besides ecological recovery and the formation of new local biological ecosystems, the salt lands branded as wastelands may be converted in to something special and more productive. The economical value of the land rises from nil to considerable dollars, which also improves the status of the dependent community thereof.

Coastal development and protection

Attempts are being made in different places throughout the world to establish new forms of coastal development and protection. It is essential to have an understanding of how the dynamic of the water and the land can be harnessed in order to make nature an ally rather than a foe. Different concepts and projects are being implemented in different areas. The combination of the saline land conservation and production of halophytes linked to sustenance of the local community is some thing prudent. The *Salicornia* sp cultivation renders development and protection by biomass production and checking soil erosion.

So much water is diverted from the rivers and tributaries for irrigation whereas; the downstream river is becoming more and more saline and have dramatic implications in the vast agricultural land in the delta. *Salicornia brachiata* cultivation would subsequently hold the land productive. It also improves land in terms of both landscape and ecological values in order to create more attractive areas for tourism.

Technology Transfer

Any technology is considered successful if it has the wholesome penetration and utilization among stakeholders. This project would provide opportunity for the technology transfer from the scientific community to the grass root user groups, bringing up refined standardized site-specific technologies, which users shall patent.

Market Exploration

The prospects for halophytes in the world markets for food, animal feed and fine chemicals seem unlimited. Halophytes have their greatest potential in contributing to the world's food and pharmaceutical supply. The domestic market is yet to be explored.

Biomedical Application

The grown up plants should be further analyzed for utility in the field of biomedicines. Parts of the plants may be collected and processed for the extraction of bioactive compounds by standard methods and further screening of extracts against various infectious diseases including AIDS should be undertaken in collaboration with several National Research Institutes for exploring novel bioactive principles and

 ISSN : 1410-5217

further by using the standard formulations, clinical and pre-clinical studies should be done as per the WHO guidelines. Further, from *Salicornia* structural elucidation of effective bioactive principles should also be explored.

CONCLUDING REMARKS

The issues which the coastal land posses are salt ingression due to over exploitation of fresh water bases without recharging, infrequent and less rainfall leading to recurrent drought, land degradation and crop failures, fallow salt encrusted land, reduced income from agriculture ultimately unemployment and poverty. Illegal exploitation of halophytes (salt tolerant plants) for various medical and other purposes is also a threat to biodiversity.
Utilizing the resources available in plenty in the coast may be a rational move to find solution. Cultivation of halophytes with seawater is a strategy suggested to address the issues mentioned. Cultivation of halophytes may render benefits based in terms of ecological, economical and equity.
The *ecological benefits* may be listed as salt encrusted wasteland utilization, model farm, technology, green belt, coastal development and protection, combating desertification, germ plasm preservation. The *economical benefits* are production, marketing and patenting of effective biomedical compounds, ecosystem restoration and employment opportunities for villagers, women entrepreneurship and poverty alleviation. The *equity benefits* may be counted as export market networking, technology extension facility, standard eco-techniques and bio-techniques, industry or institutional collaboration.

Salicornia cultivation brings about ecological recovery of saline areas that have fallen into disuse, coastal development and protection, production of cheap biomass for renewable energy, climate improvement and CO_2 sequestration. The project would end up in bringing up many private and community based entrepreneurs for sustainable coastland management. The further development of this potential field requires immediate attention as it brings out subsequent socio-ecology development.

REFERENCES

Arthur Clark, 1994. Samphire from Sea to Shining Seed, Saudi Aramco World**.** 45 (6) : 2-9

Bandaranayake, W.M. 1989. Traditional and medicinal uses of mangroves. *Mangroves. Salt. Marshes*. 2(3): 133-148.

Edward P. Glenn, J. Jed Brown and James W. O'Leary, 1998. Irrigating Crops with Seawater, Scientific American August 1998

Jagtap, T.G., S. H. Bhosale, and V. L. Nagle.2002. Ecological observation on major *Salicornia* beds from highly saline coastal wetlands of India. *Wetlands*. 22(3): 443-450.

Van Oosten H.J. and J.G. de Wilt, 2000. Bio-production and ecosystem development in saline conditions NRLO report 2000/10E *National Council for Agricultural Research,* The Hague

www.hindu.com/seta/2003/09/05/stories/2003090500300300.htm.

www.csmcri.org/PHP/Research/body_phytosalinity.php