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Organic Agriculture in Coastal Areas

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India is endowed with heterogeneous landforms and variety of climatic conditions which provide macro relief of high plateau, open valleys, rolling upland, fertile plains, swampy low lands and barren deserts (Sehgal *et al*., 1992). Among them, the coastal region is most important because it includes both land and marine resources besides intense interactions between various natural processes and human activities takes place which are important factors for development. India has a long coastline of about 5422 km excluding islands which includes 8 states and 3 union territories (Table 1). Between the Western Ghats and West coast lies the narrow Western coastal plain, Eastern coastal plain stretches between Eastern Ghats and East coastal. Both the coastal regions are interspaced by several river systems which brings fertile silt and water from the mountain ranges. This region assumes its importance because of high productivity of its ecosystems, concentration of population, exploitation of natural resources, development of various industries, discharge of waste effluent increasing load on harbours and above all petroleum exploration activities. This region offers plenty of scope for organic farming by virtue of its potential (OFP, 2005) while it becomes necessary due to increasing rate of resource degradation.

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Table 1. Coastline of maritime states and UT's of India

State / UT	West coastline (Km)	State / UT	East coastline (Km)
Gujarat	1214.7	Tamil Nadu	906.9
Maharashtra	652.6	Pondicherry	30.6
Goa, Daman & Diu	160.5	Andhra Pradesh	973.7
Karnataka	280.0	Orissa	476.4
Kerala	569.7	West Bengal	157.5
Total	2877.5		2545.1

Agro-climatic conditions of coastal regions

The climate of most of the coastal sub-regions in India falls under the hot and humid or sub-humid condition with limited variations except the North Gujarat coast which is semi-arid. Almost the entire coastal area in the country, excluding the north Gujarat coast, receives normal annual rainfall in excess of 1000 mm. The west coast receives more than 2500 mm per year and 80% of it occurs during June to September in Gujarat, Maharashtra and Karnataka. In contrast, Tamil Nadu receives about 70% of its annual rainfall during October and November. The annual evaporation ranges from 1350 to 2150 mm which causes salinization of surface soil in several areas especially during dry season in the presence of high and poor quality ground water.

In general, the soils of coastal areas are deep to very deep, imperfectly to poorly drained, sandy to fine loamy to fine in texture. The sandy shores are covered partly with water during high tides and stormy periods. The soils are calcareous, slightly to moderately saline and alkaline. Heavy exploitation of groundwater coupled with changes in land configuration in many coastal areas has resulted in seawater intrusion and development of high soil salinity. As a result, this has become one of the impediments for improving farm production even though the agro-climatic condition is suitable for different crops and farming systems.

Resource characterization of coastal regions

This region is heavily populated with nearly 250 million people living within 100 km of India's coastline. Various economic activities and human settlement compete with agricultural land use causing decrease in land available for agricultural purpose. This region is also located in areas most vulnerable to natural disasters, areas that are already subject to periodic flooding and various type of land degradation.

Under such situation delineation of homogenous land units and understanding the problems and potentials of each unit are imperative to explore the possibilities for organic farming with improved efficiency and productivity. In this context, the essential features of characterization of such a large stretch of coastal areas involve systematic appraisal and grouping of relatively homogenous areas in terms of soil, climate, physiography and conducive moisture availability periods. The coastal region of India is divided into 3 Agro-Ecological Regions (AER). They are as given below;

- Gujarat plain / western plain hot arid eco-region.
- West Coastal plain, hot humid-perhumid eco-region.
- East Coastal plain, hot subhumid to semiarid eco-regions.

The three AER is subdivided into 12 AESR (Fig. 1) incorporating details about the climate, soils, area and districts, land use and constraints (Velayutham *et al*., 1999).

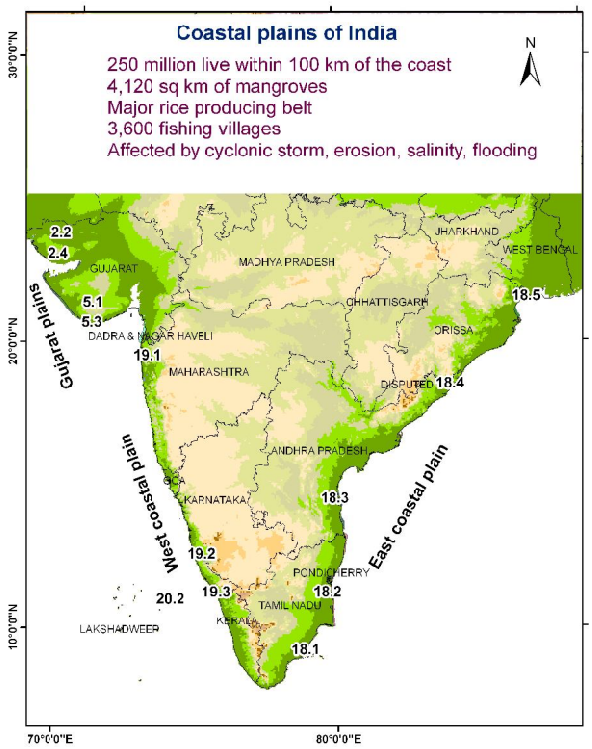

Fig. 1. Agro-ecological sub regions (AESR) of coastal areas and its distribution.

The status of agriculture

Un-surprisingly, this region is endowed with good amount of rainfall, surface and ground water resources, rich in biodiversity, mostly of deltaic soils, humid to sub-humid conditions suitable for cultivation of variety of crops. Although it does not rain as much along the east coast, the rivers bring water from areas of heavy rainfall in the west and also deposits large quantities of clay and silt in the deltas.

Rice is the main food crop grown in this region besides, plantations of bananas, coconut, arecanut, cashewnut and rubber mostly in the western coast and betel nut in many places in the deltas. In many places along the coastal plain double cropping with rice as main crop is commonly practised. Unlike eastern plains, the western coastal plains are narrow and the flat river valleys and areas near estuaries have good loamy soil. This is used to grow rice in the kharif season. After the monsoon, wells, rivers and streams are used to lift water for irrigation. In those fields that get irrigation, a second crop of rice is taken. In unirrigated fields, pulses and spices are planted. Plantation crops are very important component of western coast and islands. The major cropping system and constraints in each of the sub region are given in Table 2. In spite of good potential for agriculture, the yield gap for various crops varies from 0.5 to 2.6 t/ha and the cropping intensity ranges from 140% to 210%.

This is mainly due to inadequate awareness of production technology, inefficient organic waste recycling and inadequate supply of essential nutrients. Thus by providing organic production technologies for nutrients, plant protection, post harvest operations and other cultural practices the productivity can be increased. If the potential of production system and market demand are properly linked, this will address the issue of land degradation directly by the application of organic amendments and indirectly by market forces to take utmost care of the land resources which fetches high return.

Yield gap and potential of organic farming

A compilation of data indicated that the productivity of different crops in organic farming is 10-40% lower than the conventional farming and 5-15% lower than the organic farming under experimental conditions (Bhattacharya and Kumar, 2005; Ramesh *et al*., 2010; PDFSR, 2013). At the same time the average cost of cultivation in organic farming is less ranging from 1-12% compared to conventional farming (Table 3). However, due to the availability of premium price (20–40%) for organic produce in

Table 2. Major cropping system and yield of coastal region

Sub-zones	Predominant cropping system	Rice Equivalent Yield (t/ha/year)	Constraints
Western coastal plain			
Malabar coast	Rice-Rice-Fallow	8.0	• Use of local or traditional varieties
	Rice-Rice-Pulse/ Green manure/ Vegetable	9.4	• Non adoption of improved package of practices • Soil acidity, drainage congestion and high clay
Konkan coast	Rice-Rice	7.7	• Small and scattered land holdings, soil erosion
	Rice-pulse	7.0	• Low cropping intensity (115%), Uncontrolled field to field irrigation leading to flooding and less diversification
Gujarat plains			
North Gujarat plains	Pearl millet-Mustard Cluster bean-Mustard	12.5#	• Sandy soil, low rainfall #(Pearl millet eq. yield)
	Pulses-Mustard/wheat -summer pearl millet	14.0#	• Higher water requirement of the crops resulting in low water use efficiency
South Gujarat plains	Rice-Rice Rice-Sugarcane	7.1	• Calcareous, alkaline soils, more clay
South Saurashtra zone	Groundnut-wheat/ castor	4.8*	* (G.nut equivalent yield)
	Groundnut-pearl millet	3.9*	
	Cotton-fallow (yield of seed cotton)	1.5-2.5	
Eastern coastal plains			
Gangetic delta	Rice-rice	8.0	• Arsenic pollution
	Rice-vegetables	14.0	• Inundation of low and medium lands during early monsoon season
Orissa coast	Rice-green gram Rice/maize-cowpea	8.5 9.0	• Red and lateritic black, alluvial and saline soils
Andhra & Tamilnadu coast	Rice-rice Rice-vegetables	9.5 15.0	• Non availability of labour in time for agricultural operations

Source: Gangwar and Singh, 2011

most cases, the average net profit was 22.0% higher in organic compared to the conventional farming (Ramesh *et al*., 2010).

Table 3. Gaps in productivity, cost and net return in the coastal region

S. No.	State	Crops	Productivity (t/ha)		Organic farming as % (±) of conventional farming	
			Organic	Conventi-onal	Cost of cultivation	Net return
1.	Maharastra	Vegetables	11.0	13.0	-3.8	-13.8
		Fruit crops	11.4	13.6	-10.2	+6.4
2.	Karnataka	Soybean	0.9	1.1	-7.7	-13.0
		Chickpea	0.8	0.8	-7.6	-1.1
		Fruit crops	8	9	-14.9	+30.2
		Groundnut	1.2	1.4	-10.3	-26.0
		Sugarcane	120	140	-8.3	-6.5
3.	Kerala	Pepper	1.38	1.4	-9.2	+100.0
		Banana	23.6	27.2	-18.6	+33.8
		Coconut (nuts)	31,000	30,500	-16.6	+38.3
		Coffee	1.23	1.31	-25.9	+56.2
		Turmeric	22.5	25	-37.8	+52.9
4.	Tamilnadu	Cotton	0.6	0.8	-0.5	+10.0
		Cashew	1.3	1	-10.7	+125.0
		Banana	25	30	-25.0	+41.2
		Mango	8	6	-16.6	+50.0
		Guava	20	23	-20.0	-5.0
		Coconut (nuts)	28,250	28,750	-11.7	+1.8
5.	Andhra & Orissa	Rice	5	6	+9.5	-5.5
		Banana	25	30	-14.5	+30.0

Source: Ramesh *et al*., 2010

Yields relative to comparable conventional systems are directly related to the intensity of farming of the prevailing conventional systems. This is not only the case for comparison between regions, but also between crops within a region, and for individual crops over time. In areas of

intensive farming system, shifting to organic agriculture decreases yield; the range depends on the intensity of external input use before conversion (Stanhill, 1990; Offermann and Nieberg, 1999). In the so-called green revolution areas (irrigated lands), conversion to organic agriculture usually leads to almost identical yields (Rajendran *et al.*, 2000). In traditional rainfed agriculture (with low external inputs), organic agriculture has shown the potential to increase yields (Ramesh *et al*., 2008).

The replacement of external inputs by on farm organic resources leads to reduction in variable input costs under organic management. In several situations expenditure on manures and sprays is substantially lower than in conventional systems. In a few cases, higher input costs due to the purchase of compost and other organic inputs have been reported. Studies have shown that the common organic agricultural combination of lower input costs and favourable price premiums can offset reduced yields and make organic farms equally and often more profitable than conventional farms (Hanson, 1997). But, farms that did not include organic price premiums have given mixed results on profitability. On the other hand the results of effects of organic input use suggested that the yield can be increased ranging from 10-30% by best organic management practices suitable for different crops and soil conditions.

In Malabar Coast (AESR 19.3) organic cultivation of pepper, banana, turmeric, coffee and coconut has relative advantage over conventional system due to comparable yield, reduced cost of cultivation besides improvement in soil quality. Similarly organic cultivation of fruits and chickpea in Karnataka, vegetable and fruits in Maharashtra has relative advantage. Similarly, in east coastal region organic cultivation of cotton, cashew, mango, banana gives higher return attributed to the availability of premium price. Fine quality / scented rice with value addition can be promoted in Andhra coast which fetches premium price in the international organic rice market.

The economics of organic cotton cultivation over a period of six years indicated that there is a reduction in cost of cultivation and increased gross and net returns compared to conventional cotton cultivation in India (Rajendran *et al*., 2000). South Saurashtra coastal zone has relative advantage for organic cultivation of cotton than other coastal zones.

The Agricultural and Processed Food Products Export Development Agency (APEDA) is encouraging the rice sector to produce and export organic rice, especially basmati, to European countries. Returns from organic farming of rice could be maximized by management practices

and judicious use of inputs (CIKS, 2006). Organic system of rice production needs two years period to stabilize rice productivity and bring about perceptible improvement in soil quality and economic returns under intensive, irrigated rice-rice system in tropical climate (Surekha *et al*., 2010). Basmati rice which cook with a pleasant fragrance enjoy a preferential price treatment both in domestic and international markets, however further research is required on its adaptability in coastal areas with organic management. It is also very important to integrate livestock component with crop production so as to sustain the organic production system.

Characteristics of organic farming technologies

The key characteristics of organic farming technology suitable for the coastal region should include the followings;

- Enhance biological cycles within the farming system, involving micro-organisms, soil flora and fauna, plants and animals.
- Protect the long term fertility of soils by maintaining organic matter levels, encouraging soil biological activity, and careful mechanical intervention;
- Nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, as well as effective recycling of on and off farm organic materials;
- Organic farming technology should provide crop nutrients from relatively insoluble nutrient sources by the magnified action of native soil micro-organisms;
- Weed, disease and pest control primarily rely on crop rotations, natural enemies, diversity, organic manuring, resistant varieties and organic products;
- Achieve higher water productivity through healthy use and proper care of water resources;
- Organic production model should pay full regard to livestock evolutionary adaptations, behavioural needs and animal welfare issues and integrate them with crop production;
- Progress towards an entire production, processing, and distribution chain which is both socially just and ecologically responsible for the region

Organic production methods

Organic farming advocates growing of crops without man-made agricultural chemicals and using production strategies that consider a holistic, systems-based management approach results in food that is healthier to eat and an environment that is safer to live in. In organic production system the farm is also certified as organic after conversion and integration. The general organic production methods suitable for the coastal regions are given below-

- In organic cultivation, seeds of any four crops mentioned above are grown 45 days prior to the cultivation of paddy, decomposed for 10 days after which Paddy seedlings can be transplanted.
- In situ cultivation and incorporation of green manures around the palm tree improves the nutrient content and provides better growing environment.
- Similarly, 60 days prior to the cultivation of Sugarcane, Banana and Turmeric adequate quantity of FYM / Poultry manure / Vermicompost are applied to the field followed by the sowing of above mentioned crops that can be ploughed insitu. Through this practice, 25–35 tonnes of green manure are incorporated into the field. In addition, the first weeding operation should be followed by the raising of green manure crops and insitu mulching in alternative rows.
- With respect to Banana cultivation, within 5 months of planting, green manure crops are grown twice; they are cut and are evenly spread in between the rows of Banana. This practice will suppress the weed growth.
- In slightly compact and higher clay soils, 100 litres of cow dung solution is mixed with 50 litres of starter solution and applied for 1 acre twice in a month while irrigating the crop. This solution will increase the beneficial microorganisms in the soil through which, the process of decomposition of the materials become faster. Moreover consistency of the soil will increase by which the crops could obtain all types of nutrients.

2. Mulching

Mulching is the application of layers of organic residues or other permitted materials on the surface of the soils to reduce the impact of splash erosion, rate of evaporation and increase the infiltration capacity of

the soil besides suppression of weed growth. It becomes essential in coastal areas where it rains heavily and luxuriant growth of weeds occurs. In this region, coir waste, coconut husk, farm waste, dried leaves, dried grasses, sugarcane trash, paddy straw and groundnut husk can be used as mulching materials.

3. Bio-fertilizers

Micro-organisms convert the unavailable form of nitrogen, phosphorus and potash present in the vicinity of plant roots and atmosphere into available form. They also enrich the crops with vitamins, amino acids and growth promoters. Generally seeds are treated with bio-fertilizers or applied to the soil after mixing with farmyard manure. In case of legumes suitable *Rhizobium* sp. is applied as seed inoculants. In the transplanted crops, *Azospirillum* is inoculated through seed, seedling root dip and soil application methods. For direct sown crops, *Azospirillum* is applied through seed treatment and soil application. Phospho-bacteria is inoculated through seed, seedling root dip and soil application methods as in the case of *Azospirillum*. Phospho-bacteria can also be mixed with *Azospirillum* and *Rhizobium*. The recommended dosages of bio-fertilizers in the form of dry and liquid formulations for different crops are given below (Table 4 & 5).

Table 4. Recommended dosage of bio-fertilizers (one packet - 200 g).

Crops	Seed	Nursery	Seedling dip	Main field	Total requirement/ha
Rice	5	10	5	10	30
Cotton	3	-	-	10	13
Sunflower	3	-	-	10	13
Sugarcane	10	-	-	36 (3 split)	46
Turmeric	-	-	-	24 (2 split)	24
Papaya	2	-	-	10	12
Orange	2	-	-	10 g/pit	-
Tomato	1	-	3	10	14
Banana	-	-	5	10 g/pit	-

Table 5. Requirement of liquid bio-fertilizers.

Crops	Recommended Bio-fertilizer	Application method	Quantity to be used
Pulses / legumes	*Rhizobium* spp.	Seed treatment	200ml/acre
		Soil treatment	1-2 ml/plant
Rice, Millets	*Azospirillum*	Seed treatment	200ml/acre
Oil seeds	*Azotobacter*	Seed treatment	200ml/acre
Plantation Crops	*Azotobacter*	Seedling treatment	500ml/acre
Tea, Coffee	*Azotobacter*	Soil treatment	400ml/acre
Rubber, Coconuts	*Azotobacter*	Soil treatment	2-3 ml/plant
Fruits	*Azotobacter*	Soil treatment / seedling dip	2-3 ml/plant at nursery

Source: TNAU, 2005

For coconut in multiple cropping mix 50 g of *Azospirillum*, 50 g of Phospho-bacteria or 100 g Azophos and 50 g of VAM with sufficient quantity of compost or FYM and apply near feeding roots once in 6 months/ palm starting from planting.

4. Crops and seed treatment The crops are planned in such a manner that the nutrients used by the first crop should be replaced by the following crop (Table 6). The nutrient requirement of the second crop should be different. This will help greatly to maintain the nutrient balance in the soil.

Table 6. Rice-based cropping systems for the Southern coastal areas (CIKS, 2006).

Seasons	Samba (July–Jan.)	Navarai (Dec– Mar.)	Sornavari (April–Aug.)
Crops	Paddy	Black gram	Sesame
	Paddy	Ground nut	Paddy
	Paddy	Cotton	-
	Paddy	Vegetables	Green manure

Seeds of traditional and improved cultivars with high degree of adaptability and free from pest and disease have to be selected. Selected seeds can be treated with 3-4ml of Panchagavya / coconut water and 3-4gm of Pseudomonas/kg of seeds, kept for 24 hours and used for sowing.

5. Growth Promoters

- **Starter solution**: Properly mix 20 kg of cow dung, 20 litres of cow urine, 3-4 kg of jaggery in 200 litres of water. After 24 hours,

the solution is applied to crops by mixing it with irrigation water (1:10). The solution is applied 2-3 times for 3-4 months old crop and for long duration crops apply twice in a month. Along with this solution, water may also be mixed and is sprayed over the crops.

- **Fermented solution**: 5 litres of fermented buttermilk and 5 litres of coconut milk are mixed and kept in a mud pot or plastic drums for 1 week during which period it has to be stirred often. Then the solution is mixed with water @ 1 litre solution in 10 litres of water which can be applied as foliar spray.
- ***Panchagavya*:** In general, depending upon the growth of crops. 25-30 ml of panchagavya is mixed with 1 litre of water and sprayed once in 7 – 10 days by which the plant growth gets enhanced. It is sprayed before and after flowering in short duration crops. For fruit trees, it should be sprayed one month before flowering, 15 days after flowering, pea size stage, after harvesting, it is applied to all fruit trees once.
- **Plant growth promoting bacterial (PGPB) solution**: The solution containing suitable PGPB can also be used for seeds, seedling and soil treatment which will promote root and shoot growth.

6. Pest management

Pest repellent: The herbal pest repellents should be prepared either by soaking or boiling method from,

- Leaves that could not be eaten by cattle e.g. *Lantana camera.*
- Plants with milky latex e.g. *Calotropis.*
- Leaves with bitter taste e.g. *Neem, Aloe vera.*
- Leaves with sour taste e.g. *Jatropha.*

Natural enemies: Parasitoids such as wasps and flies live on other insect's eggs, larvae & pupa ultimately leading to their death. There are three types of parasitoids suitable for organic farming such as,

- Egg parasitoid - Parasitoid will search and oviposit on the eggs of harmful insects thereby eating the egg yolk of the host. e.g. The eggs of sugarcane internode borer, paddy stem borer, tomato and cotton fruit borer are destroyed by an egg parasitoid (*Trichogramma*)

- Larval parasitoid - Parasitoids will lay their eggs directly on larvae, on hatching the parasite eats and kills host larvae. e.g. Coconut black headed caterpillar is controlled by *Ichneumonid, Bracconid* and *Bethylid* species
- Pupal parasitoid – In this case, the parasitoid will catch the pupa of harmful pests and will oviposit on it. So the adults will not emerge and thus get killed. e.g. Coconut black headed caterpillar is controlled by *Tetracadikkus* and *Trichospilus.*
- Predators are larger than its prey therefore; they can eat the smaller insects which are pest on crop plants. Some specific examples are, Brown plant hopper affecting paddy are eaten by *Tortoise* Beetle and Spiders; Aphids affecting cotton, lablab and cowpea are eaten by *Chrysopa;* Wasps will carry the larvae of other insects to feed their young ones; and Spiders, Praying mantids, ants, dragon fly and some flees will also eat the harmful pests.

Trap crop: Some of the inter crops grown in between the main crop act as a trap crop for some of the major pests of main crop. Some of the examples are given in Table 7.

Table 7. Trap crops for some important main crops.

Main Crop	Trap Crop	Pests Controlled
Bhendi	Bitter Gourd (emits momordicin)	All pests
Pulses	Sun hemp	Beetles
	Castor	Spodoptera and Hairy caterpillar
Crossandra	Castor	All pests
Cabbage	Mustard (1 row of mustard for every 25 rows of cabbage sown 10 days before the planting of cabbage)	Diamond Back Moth
All crops	Marigold	Nematodes
Vegetables	Onion (emits allicin compound which irritates the pest)	All pests
Paddy	Live fencing of *Vitex negunda*	Stem borer & Earhead bug
Tomato	Marigold (1 row of marigold for every 16 rows of Tomato)	Fruit borer

Light trap: Plastic bucket or plastic plate filled with water and 200 ml Kerosene is placed at the bottom of light trap. This assembly is placed in the centre of the cropped field. In the evening time, it will attract the adult insects which get killed in the trap.

N. P. Virus Spray: There are two types of N.P. Virus, viz. *Protinea* and *Helicoverpa*. For 1 acre of cropped area, 1 litre of N .P. virus solution is mixed with jaggery solution (2 kg Jaggery in 2 litres of water) and added to 100 litres of water. This should be sprayed in the evening time to control the lepidopteron pests of cotton, tomato, castor, sunflower, and cowpea.

7. Management of plant diseases

Crop diseases can be controlled by means selection of proper season, crop rotation, weed control, use of resistant varieties, timely harvesting and field sanitation besides biological control.

- In case of banana and vegetables before planting, biocontrol agents such as *Pseudomonas florescence, Paecilomyces* and *Trichoderma viridi* are mixed with well decomposed FYM @ 2 kg / acre and are put inside the planting pits. Then a solution containing 1 litre water and 3 ml Panchagavya is also poured in the pits. The fungal agents can also be mixed with cowdung solution and are applied on 3rd, 5th & 7th months during irrigation.
- *Trichoderma* and *Pseudomonas* are used against wilts of grams, sheath blight and leaf spots of paddy and damping off of vegetables.
- Soil application of *Trichoderma* /*P. fluorescens* enriched FYM along with neem cake (1:100:10 ratio) before and after monsoon season @ 25 kg/tree controls many of the soil borne pathogens and supply essential nutrients to coconut palm.
- In vegetable crops, seed treatment with *Trichoderma* / *Pseudomonas fluorescens* @10 g/Kg seed; soil application of *Trichoderma* /*P. fluorescens* enriched FYM along with neem cake (1:100:10 ratio) in the nursery bed as well as in main field will able to manage both fungal and bacterial diseases.

Soil application of these biocontrol agents once in 15-20 days is essential for effective control of several diseases.

8. Weed Control

Use of synthetic/chemical weedicides is prohibited in organic farming therefore, natural enemies or cultural methods should be

encouraged for weed control. Crop leaf residues, farm wastes, dried leaves, dried leaves of banana and other trees are buried beneath the rows. Use of plastics mulch is very effective to control weeds and reduce moisture loss particularly during dry seasons.

9. Multiple cropping

In the coastal region, coconut as a monocrop does not fully utilize the basic resources such as soil and sunlight available in the garden. Adoption of multiple cropping practices in coconut garden ensures better utilization of basic resources and higher production. This includes multistoried cropping and intercropping which utilize the vertical and horizontal unutilized spaces. Organic farming techniques provide ample scope for the practice of multiple cropping in the coastal plains. Multistoried cropping refers to the cultivation of three or more crops having different morphological characteristics so as to intercept solar radiation at different levels and exploit different soil zones. The required nutrients can be met by effective recycling of the plantation and animal wastes within the farm. Once the palms attain a height of 5 to 6 m perennials like cocoa, pepper, cinnamon, clove and nutmeg can be grown (Table 8).

Mixed / inter cropping increases the level of light interception about 95 per cent. A variety of inter crops like pineapple, banana, groundnut, chillies, sweet potato and tapioca can be raised in coconut gardens upto 8-10 years under organic management. Intercropping also leads to increased availability of organic matter for recycling. Crop combination, cultural and manurial requirements are given in the Table 8 (Dhanapal and Thamban, 2007).

In addition, the interspaces of plantation crops can be effectively used for growing vegetables and legumes to augment the production. Besides, 25 tonnes of organic wastes are also made available per ha which can be mixed with animal waste for efficient recycling and supply of nutrients to plantation crops by vermicomposting.

Soil and water conservation

Measures like contour cultivation, stone pitching/contour wall construction are to be taken up to prevent soil erosion in upland areas. Basin should be formed around the palm and arecanut trees. Coir waste, farm waste, dried leaves, dried grasses, sugarcane trash, paddy straw and groundnut husk can be employed as mulch to minimise soil and water loss. Organic production technology is incomplete without soil and water conservation measures.

Table 8. Cultural requirements for mixed cropping model in coconut garden of western coast

Crops	Propagation*	Planting pits	Spacing	No. of plants /ha	Nutrient requirement (g/plant/year)		
					N	P_20_5	K_20
Coconut + Cocoa	Grafts	75 x 75 x 75cm	3m x 3m (Single hedge)	450	100	40	140
Coconut + Pepper	Rooted cuttings	50 x 50 x 50cm	7.5m x 7.5m (At the base of the palm)	175	100	40	140
Coconut + Clove	Seedlings	60x60x 60cm	7.5m x 7.5m (At the centre of four palms)	148	300	250	750
Coconut + Nutmeg	Grafts	60x60x 60cm	7.5m x 7.5m (Centre of four palms)	148	500	250	1000
Coconut + Cinnamon	Seedlings/ layers		3.0-3.0m	750			
Arecanut + Pepper	Rooted cuttings		2.7-2.7m	1300			

Most of the saline areas in the coastal region remain fallow in the dry season because of high soil salinity and the lack of good-quality irrigation water. A careful water balance analysis of annual precipitation and potential evapotranspiration is essential to determine the water surplus/ deficit periods beforehand, so that all the agricultural operations can be adjusted accordingly. The concept of harvesting excess rainwater in on-farm reservoir (OFR) may be effectively utilized by micro irrigation methods for growing high value and potential export crops by employing organic practices. In addition, OFR helps organic rice production in the coastal saline soils which are normally monocropped with low-yielding, traditional rice varieties during the monsoon season from June to December. A combination of on-farm storage of surface water, to prolong freshwater availability beyond the end of the rainy season, together with the proper selection of rice varieties and green manuring can increase productivity of these areas. In the wet season, the traditional rice varieties should be replaced by long / scented, high-yielding varieties (HYV), which fetches premium price in the organic rice market. The stored water can be used to irrigate vegetables / pulses in the subsequent dry season.

Protected cultivation

Protected cultivation holds the key in the future for the production of high value crops under organic methods especially for efficient use of land and water. Protected structures (Fig. 2) such as green houses, poly houses, poly tunnels and net houses which protects the crop from high intensity of light, high rainfall, winds, insects through structure, polyethylene film/ polycarbonate sheet, shading nets/ thermal nets, insect net, cooling pad, exhaust fan, foggers and drip systems etc. which controls light, temperature, humidity and irrigation and other required growth substances directly into the root zone of the plant. Water and nutrients enter the soil from the emitters, moving into the root zone of the plants through the combined forces of gravity and capillary. In this way,

Fig. 2 Crop cultivation inside the protected structures

the plant's withdrawal of moisture and nutrients are replenished almost immediately, ensuring that the plant never suffers from water stress, thus enhancing quality, its ability to achieve optimum growth and high yield. The main benefits are,

- Protected structure increases the yield of several crops up to 5 to 8 times and saves water up to 50% compare to open field flood irrigation.
- Crop grows consistently, healthier, produce good quality fruits and matures fast.
- Early maturity results in higher and faster returns on investment.
- Undulating terrains, saline, water logged, sandy & hilly lands can also be brought under protected cultivation.

Cultivation of vegetables under protected structures aimed at both domestic and international market assumed significance In Gujarat plains and Maharastra coast. Grading and processing of organic produce from controlled conditions will enormously increase the value and marketability at the same enabling cultivation even in climatically disadvantaged areas. But, still research efforts are required to provide management options for the cultivation of high value crops to farmers / NGO's engaged in organic cultivation.

Processing and value addition of organic products

The harvested products of coconut, vegetables and spices can be processed using technologies like solar drying, freeze drying, hot air chambers which add value to the organic products and minimise the spoilage under the hot and humid conditions. Irradiation of agricultural produce is not permitted. No synthetic additives/dyes are to be added during processing.

In the coastal regions organic beverages prepared by blending tender coconut water with any tropical fruit juices will find good market demand. CPCRI has standardized a technique for preparing this in which the tender coconut water and pineapple juice are separately collected from organically grown crops, filtered and pasteurized. The two preparations are then blended and acidulants are added Carbonation of the product enhances the taste and shelf life. Processed young tender coconut kernel could be in the form of sweetened dehydrated or dried buko or young tender coconut kernel in syrup or dried buko chips. These young coconut kernel products are ideal for desserts or as snack food (CPCRI, 2015).

Good packaging is very important to enhance the marketability of any organic products. Recyclable and reusable materials like clean jute bags and other bio-degradable materials should be used. Unnecessary packaging material should be avoided. Organic and non-organic products shall not be stored and transported together except when labeled.

Strategies for future development of organic farming

The strategies to promote organic farming should essentially encompass organic farming technologies, adequate infrastructure, appropriate policy framework and capacity building of the stakeholders. The approach should be in a phased manner and from selected to wide area (KSPOF, 2004; OFP, 2005 and KSOFP, 2008). Some of the strategies are given below;

- In general**,** promotion of organic farming in the coastal region is to be achieved focusing on potential crops in each AESR in a phased and compact manner with the aim of converting a minimum cultivable land into entirely organic every year and thus achieving the target within five to ten years. On completion of the third year of implementation of the organic farming, a committee of experts should make a comprehensive assessment of the farmer's well being, economy and environment and, only after rectifying the drawbacks, if any, can the policy be implemented in rest of the areas.
- Compact area group approach should be employed by encouraging the formation of organic farmers groups, clubs, SHG's and cooperatives for the purpose of cultivation, input production, seed / seedlings / planting materials production, certification and marketing.
- Implementation of a simple certification process for all the organic farmers and promotion of specific brand name.
- Ensure availability of quality and enriched organic manure to the farmers by technology transfer and capacity building. The strategy should also encourage private entrepreneurs to produce and sale of quality manures with special schemes and subsidies.
- Improve soil quality, ensure water conservation measures and establish testing facilities.
- Establishing bio-diversity with plant species and livestock of the local area is a key factor for successful organic farming. In fact, a

combination of tree crop species to meet fodder/ timber/fuel/and bio-mass demand apart from providing habitat for birds and beneficial insects would go a long way in ensuring the sustainability of organic farming.

- Promotion of farm level processing, value addition and encouragement of the use of organic farm produce in food industry.
- Government policies should support and establish producer companies with financial support promoted by organic farmers. In addition, create organic production and marketing network by establishing separate and decentralized storage facilities and markets for organic farm produce to ensure its organic integrity.
- Promote a mixed farming approach for livelihood security and ecological sustainability so as to conserve and improve agro-biodiversity and undomesticated biodiversity

These strategies are aimed to promote innovations and technologies in organic farming system simultaneously ensuring efficient management of land and water resources.

Conclusions

The land area available for cultivation is getting reduced and little scope is left for its expansion on the other hand land degradation has become a threatening proportion. The judicious use of existing land and remediation of degraded coastal land through organic farming practices are viable alternate strategy for sustainable development of coastal region. There is a huge potential for organic farming in these areas especially cultivation of spices, coconut, tropical fruits, high value vegetables and to some extent fine quality rice varieties in an integrated farming system mode which provide more stability and income to the farmer. It is economically feasible to practice organic farming when the farmers are able to get premium price for their produce and with the reduced cost of cultivation by not depending upon the purchased off-farm inputs.

There is a wide scope of diversification of farming practices such as manure, water, pest management and also generation of rural employment and sustainable livelihood outcomes. The imminent efforts should be to promote organic farming by increasing capacity building of the farmers through interventions of government, research organization and NGO for high margin crops in the suitable AESR for which organic production technology is available. It is also essential to develop suitable technologies

for other potential crops which has comparative advantage over conventional cultivation and has high market demand. There is also much scope to establish organic input preparation units in villages where favorable agro-climatic conditions suitable for organic farming exist. Given the same profitability, organic farming is more advantageous than conventional farming in selected crops in addition to its contribution to health, environment, and sustainability.

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