Dynamics and Co-kinetics of Coconut Research and Development in India

Dr. H.P. Singh*

Among horticultural crops, coconut palm is a versatile tree crop, grown in an area of 1.9 million hectare with estimated production of 15.84 billion nuts annually. It influences the socio-economic prosperity of millions of small and marginal farmers. Therefore, understanding of dynamics and co-kinetics of coconut research and development is essential to prepare for the future challenges.

12. Challenges and opportunities

12.1 Emerging trends due to globalization policy

With globalization, the trade and agriculture are beginning to be governed by new rules of the game. The post WTO phase provides opportunity and also poses threats. Competitiveness is determined by the competitive advantages in terms of climate suitability, management strategies and infrastructure. Sanitary and phyto-sanitary measures would become a barrier, if it is not harmonized and conditions are made favourable to face the challenges. Value addition to each and every part of coconut palm is a way to make coconut cultivation profitable. In this era of free trade, comparative low cost of production and high quality standards are important requirements to be competitive in the world market. To cut down cost, there is a need to emphasis on non-monetary inputs like cultural practices and to recycle the farm bio-waste and permit free play of a host of bio-control agents. There is also a need to synthesize traditional wisdom with modern scientific technologies. The market intelligence may have to be shared among the buyers and sellers of coconut and coconut products in APCC countries for the growth of coconut industry in the world. The coconut based economy in various parts of India can expect a revival from the negative impact of liberalized imports only when the profitability of coconut farming is delinking from the price behaviour of coconut oil. This is possible to be achieved through efficient utilization of the land under coconut and also production of various products at farm and community level. As coconut farming has close linkage with other aspects of rural life, it is not to be treated in isolation but only as a component of integrated rural development.

Although technology led development is achieved over several decades in coconut sector, the loss in production coupled with negative trends in price levels created a crisis of unprecedented proportion to the coconut economy and to the farmers largely depending on coconut farming for their livelihood. The human dimensions of the crisis in Kerala State, for example, are that the discouraging trends have directly affected the livelihood of nearly one million farm households, representing almost 20 per cent of total farm holdings in Kerala State and indirectly another

*Deputy Director General (Horticulture), Indian Council of Agriculutral Research, New Delhi

two lakhs households, who solely depend on the processing of coir, a by-product of coconut, for their livelihoods. Majority of the coconut farmers affected are of small and marginal holding category, owning less than one hectare of coconut garden. As of now, India has the distinction of consuming almost all its domestic coconut production. The major challenge before us is to create adequate marketable surplus in production, so that we could enter into the competitive export market. There is an urgent need for an extensive rejuvenation programme in the case of coconut through which we can replace the existing old and senile palms with high yielding cultivars.

12.2 Opportunities

A paradigm shift in policy by placing the coconut from an oil seed crop to fruit crop is also important and this can be made possible by diversifying and popularizing the value added products from coconut among the consumers. Enhancing farm level income through productivity improvement and other production measures, product diversification and concurrent demand creation for the new products are the need of the hour.

Research efforts in the past few decades yielded fruitful results in terms of increasing the production and productivity through high yielding varieties, development of farming systems for increased profitability in different agro ecological zones of the country, technologies for management of major pests and diseases, development of processing technologies for value addition and farm mechanization for production and processing. The technologies developed over years and the network of extension agencies will be an important pavement to achieve the envisaged upliftment of coconut sector. There are possibilities of increasing the productivity and net return from coconut gardens by raising compatible subsidiary crops and integrating the system with livestock. The farming system models of CPCRI have conclusively proved that the scientifically designed coconut-based farming system is not only capable of generating higher income, but also employment potential of small-holdings. In a scientifically laid out coconut based farming system, unlike the traditional ones, the resource use efficiency gets considerably enhanced from crop interactions in the system.

13. Constraints hampering coconut production

Fragmented holdings, scattered production, the homestead nature of cultivation, incidence of pests and diseases and the large stock of senile palms are the major constraints in coconut cultivation. Lack of adoption of scientific cultivation practices including balanced nutrient management is one of the reasons for declining productivity trends in some regions of the country. Coconut palm is infested by a number of pests and diseases. Some are lethal in nature while others reduce the production potential of the palm. Root (wilt) disease has adversely affected coconut production throughout Kerala and is spreading to nearby states like Tamil Nadu and Karnataka also. Apart from this, the bud rot disease, pets like eriophyid mite, red palm weevil and rhinoceros beetle also have adverse effect on production of coconut. A general decline in consumption demand for coconut oil has been observed while examining the domestic consumption scenario on household level consumption of coconut oil for culinary purpose among the major states of India. However, in the recent years, quantum of contribution of coconut towards the vegetable oil requirements in India has shown a declining trend in view of the significant increase in the per capita consumption of vegetable oils in the country along with concurrent reduction in the percentage of coconut utilized for extraction of coconut oil in the country.

The stagnation in coconut market prices over a long period of time has literally curbed the interest of coconut farmers and many of them have started neglecting the coconut gardens. Escalating labour cost has been another factor that uprooted the confidence of the coconut farmers. Many farmers turned away from coconut farming and several among them have switched over to rubber and other remunerative crops, lured by the higher returns on land.

13.1. Milestones in coconut research

Research in India on coconut started way back in 1916 through the establishment of Coconut Research Station at Kasaragod by the then Government of Madras and subsequently, it was taken over by the Indian Central Coconut Committee in 1948. Central Plantation Crops Research Institute (CPCRI) was established in 1970 as

one of the agricultural research institutes under the Indian Council of Agricultural Research (ICAR), by merging Central Coconut Research Station, Kasaragod, Central Coconut Research Station, Kayamkulam as well as Central Arecanut Research Station, Vittal and its five substations at Palode and Kannara (Kerala), Hirehalli (Karnataka), Mohitnagar (West Bengal) and Kahikuchi (Assam). Seed Farm was established at Kidu (Karnataka) to produce quality planting materials in coconut, arecanut and cocoa in 1972. A Field Station at Irinjalakuda (Kerala) was established to monitor the northward spread of coconut root (wilt) disease in 1978. An International Coconut Gene Bank for South Asia (ICG-SA) was established at Kidu and the seed farm at Kidu was upgraded as a Research Centre in 2003.

The CPCRI deals with the research and frontline extension aspects of coconut, arecanut and cocoa under five Divisional viz., Crop Improvement, Crop Production, Crop Protection, Physiology, Biochemistry and Post Harvest Technology and Social Sciences. The Institute has three Regional Stations at Kayamkulam (Kerala), Vittal (Karnataka) and Minicoy (Lakshadweep and three Research Centres - Kahikuchi (Assam), Mohitnagar (West Bengal) and Kidu (Karnataka). It has adequate infrastructural facilities like well established research farmers, well equipped laboratories at Headquarters, regional Stations and Research Centres, besides Library cum Documentation Centres at headquarters and Regional Stations. The transfer of technology of the Institute is carried out through Extension Section, Agricultural Technology Information Centre and Krishi Vigyan Kendras (one each at Kasaragod and Kayamkulam). The Research Centre at Kidu helps to cater to the needs of the farmers by supplying elite planting materials of the mandate crops, in addition to serving as the International Coconut Gene Bank for South Asia.

The All India Coordinated Research Project on Palms, started in the year 1972, is coordinating research in coconut, oil palm and palmyrah in different agro-climatic regions for the identification of location specific technologies. The project provides adaptive research support for coconut through collection, conservation, cataloguing and evaluation of germplasm, evaluation of new hybrid and high yielding varieties of coconut, standardization of agrotechniques for various agro-climatic regions including development of appropriate farming systems and development of efficient pest and disease management strategies especially for pests like leaf eating caterpillar and rhinoceros beetle and diseases like Tatipaka and Ganoderma/Tanjavur wilt. At present 12 coconut research centres viz., Ambajipeta (Andhra Pradesh Horticultural University), Kahikuchi (Assam Agricultural University), Sabour (Rajendra Agricultural University), Arsikere (University of Horticultural Sciences, Bagalkot), Pilicode (Kerala Agricultural University), Ratnagiri (Konkan Krishi Vidyapeeth), Jagadalpur (Indira Gandhi Krishi Viswa Vidyalaya), Bhubaneshwar (Orissa University of Agriculture and Technology), Aliyarnagrar and Veppankulam (Tamil Nadu Agricultural University), Navsari (Navsari Agricultural University) and Mondouri (Bidhan Chandra Krishi Viswa Vidyalaya) are functioning under the All India Co-ordinated Research Project on Palms.

13.2. Coconut Research Achievements in India

- World's largest germplasm collection of coconut comprising 398 accessions is being maintained in the Institute. The Gene Bank includes exotic collections from 28 countries of South Asia, South-East Asia, Africa, Caribbean Islands, Indian Ocean Islands and Pacific Ocean Islands.
- Breeding efforts at CPCRI and State Agricultural Universities have resulted in the release of eighteen varieties and fifteen hybrids suitable for different parts of the country.
- A protocol for asceptic collection of embryo in coconut, their storage during transport and successful culture to develop plantlets has been standardized and used in collection of exotic coconut accessions for conservation in the gene bank. This is found to be very useful in field collection of coconut germplasm from distant places.
- The protocol for plumule culture of coconut has been standardised.
- In vitro active conservation of coconut zygotic embryos (short-term) was standardized.
- Cryopreservation of coconut zygotic embryos after desiccation pre-treatment was standardized

and these embryos could be retrieved into plantlets.

- A total of 405 embryo cultured coconut accessions collected from eight countries have been field planted.
- Molecular characterisation of coconut and cocoa germplasm accessions using SSRs, ISSRs and RAPD markers.
- The protocol for AFLP, DAF and micro satellite analysis of coconut DNA for tagging resistance gene for root (wilt) studies was standardized.
- Cryopreservation of coconut pollen was standardized and viability/germinability could be maintained even after the pollen was cryopreserved for 16 months.
- A total of 16 comprehensive database for mandate crops were developed under bioinformatics.
- Significant achievement has been made in establishing the etiology of the root (wilt) disease, which is the most serious production constraint for coconut in India, by application of molecular techniques. Phylogenic analysis of root (wilt) phytoplasma by BLAST search revealed that the phytoplasma belongs to 16Sr DNA XI group.

14. Coconut Technologies for Adoption

Varieties

Kalpa Dhenu: The variety is giving 26.07% higher copra yield and 21.44% higher oil yield as compared to IND 069 S. The tender nut quality is also good. The oil extracted from the copra of this variety has higher lauric acid content. The variety is also performing well in both East Coast region and Andaman area.

Kera Keralam: Coconut accession IND 069 S is performing well in Kerala, Tamil Nadu and West Bengal States. In addition, it is also widely cultivated in different regions of the country. The accession responds well to management and any incremental level of management in terms of water and nutrients results in better productivity.

Kera Baster: The coconut accession IND 004 S has performed well in Ambajipeta (Andhra Pradesh), Ratnagiri (Maharashtra), Veppankulam (Tamil Nadu) as well as in the non-traditional area of Jagdalpur (Chattisgarh). The accession could give a nut yield of 110 nuts/palm/year with a copra yield of 2.97 tonnes/ha and oil yield of 2.04 tonnes/ha. Under these circumstances, this variety is recommended for Kerala, Andhra Pradesh, Tamil Nadu and Chattisgarh States.

Kalpa Prathibha: Based on the good performance of the accession at Kasaragod (Kerala) with higher copra and oil yield 40.11% and 38.05% respectively than Coconut accession IND 069 S and better performance at Ambajipeta (Andhra Pradesh) Veppankulam (Tamil Nadu) and Aliyarnagar (Tamil Nadu), accession is promoted as a "National variety".

Kalpa Mitra: The accession performs well (copra and oil yield was 16.01% and 13.45% higher than IND 069 S) at Kasaragod (Kerala) as well as at Mondouri Centre of AICRP on Palms (West Bengal state). The tender nut quality is also good. Hence, it is promoted as a dual purpose "National Variety".

Kalpatharu: Considering the higher nut yield (15,750 nuts/ha), better copra out turn of 2.7 tonnes/ha. @ 15.48 kg/palm/year with oil content 67.2%, drought tolerance attributes and adaptability to water deficit regions, the accession IND 125 S was recommended for cultivation in Karnataka, Tamil Nadu and Kerala states.

Kalyani Coconut-1: In addition to better nut yield and oil yield, the tender nut of the coconut accession IND 031 S is recording a higher quantity of 360 ml of nut water as compared to 260 ml in IND 127 S and also higher levels of total sugar, potassium and sodium content in nut water. West Bengal, being a tender coconut production area, IND 031 S suits for dual purpose as a tender nut coconut variety as well as a commercial variety for oil. Hence, IND 031 S is promoted as a dual purpose variety with the name "Kalyani Coconut-1" for West Bengal State.

Gauthami Ganga: IND 003 S is a high yielding coconut variety (12813 nuts/ha/annum) with sweet taste of nut water (sugar content 6.40g/100ml) with a very high quantity of nut water (446 ml) and high potassium content (2035 ppm). Performance of the variety in farmers' fields is also good. In addition, the IND 003 S is one of the best known dwarf types contributing to the development of a number of hybrids like Keraganga, Anandaganga, Lakshaganga and Godavari Ganga. Hence, the variety

is approved for release in Andhra Pradesh. It could also be noted that the variety is performing well in different States like Andhra Pradesh, Tamil Nadu and Maharashtra. Considering the wide adaptability, the variety is promoted with the name "Gauthami Ganga".

Konkan Bhatye Coconut Hybrid-1: The IND 003 S x IND 127 S hybrid seedlings, supplied by Ambajipeta and tested at Ratnagiri Centre has yielded 20,300 nuts/ha/annum. The overall mean yield was 116 nuts/palm/year (for the last 10 years). This hybrid is recording 24.5% more nut yield than Pratap, 61% higher than IND 069 s and 73% higher than IND 127 S. The hybrid gives a copra yield of 3.43 tonnes/ha and oil yield of 2.30 tonnes/ha. As this hybrid is performing better than the earlier released Pratap variety as well as the 11 other hybrid tested under this project, it s promoted as "Konkan Bhatye Coconut Hybrid-1" for the Konkan coastal region.

14.1. Crop management technologies

- Nursery management techniques comprising selection of garden, mother palm and seed nuts, planting and maintaining the nursery and the technique for raising polybag nursery were standardized.
- Square system of planting at a spacing of 7.5 x 7.5 m with a plant density of 175 palms/ha is recommended for monocrop and coconut based cropping system.
- Recommended dose of fertilizer for coconut palm is application of 500 g N, 320 g P_2O_5 and 1200 g K_2O/palm/year in two split doses during September and May. Application of magnesium @500 g MgO per palm was found to be advantageous in areas where palms show yellowing of leaves through soil application.
- Integrated nutrient management packages are recommended for the cultivation of coconut varieties and hybrids in Assam, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and West Bengal.
- Application of 200 litres of water once in four days was recommended for irrigating coconut palms as by basins irrigation method.
- Fifty percent of the recommended dose of fertilizer when applied through drip fertigation is sufficient to give an yield equivalent to 100% of the recommended dose of fertilizer. Fertilizers viz., 70 g Urea, 60 g DAP and 170 g Muriate of Potash are recommended for a single dose for one palm. For phosphorus application, commercial phosphoric acid also can be used.
- Sprinkler irrigation or perfo irrigation with 20 mm (IW/CPE = 1) water was found to be the best suited to inter or mixed cropping systems where the entire surface requires wetting.
- Drip irrigation @ 66% of the open pan evaporation (32 litres of water per palm per day under Kasaragod conditions) from December to May is ideally suited for coconut resulting in 34 per cent saving of water.
- As a component of drip irrigation schedule, in summer months, 65 litres of water/palm/day is recommended for interior peninsular region in Tamil Nadu.
- Drip irrigation @ 100% Eo is recommended for coconut in the maidan tract of Karnataka. During summer months (February-May), 65-75 litres per palm per day is to be applied, while for winter and rainy months (June - January), water requirement is 40-50 litres/palm/day.
- Moisture conservation methods such as mulching with coconut husk, coir dust, green leaves, fried coconut leaves etc. addition of organic manures or green manures, husk burial, inter cultivation, bunding, terracing etc. are recommended.
- In sloppy terrains, trench filled with coconut husk, half moon bund, staggered catch pit reinforced with pineapple and growing Co 3 grass across the slope are proved successful in soil and water conservation techniques.
- Utilization of leguminous cover crops such as *Pueraria phaseoloides*, *Mimosa invisa* and *Calopogonium* species as green manures to supply biologically fixed nitrogen and easily decomposable biomass to coconut, to substitute 50% nitrogen fertilizer.
- Growing Glyricidia as green manure crop and using the biomass as green manure was found to be ideal for management of littoral sandy soils.
- The technology for vermicomposting of coconut

palm wastes by using a local earthworm, *Eudrilus sp.*, closely related to the African night crawler, was standardized.

- Multiplication technique for the local *Eudrilus sp.* of earthworm using 1:1 cow dung-decayed leaves mixture was standardized and the earthworms are being distributed to the farmers to initiate vermicomposting.
- Utilization of coconut wastes for oyster mushroom cultivation (*P. florida*, *P. sajor caju*, *P. flabellatus*, *P. opuntia* and *P. eous*) was found to be economically feasible.
- *Beijerinckia indica*, *Azospirillum* spp., *Burkholderia* sp., *Azoarcus* sp. etc. were effective bioinoculants for better establishment of nursery seedlings.
- Coconut based cropping systems involving cultivation of compatible crops like tubers, flowering, medicinal and aromatic crops, fruits, vegetables, spice crops, in the interspaces of coconut was economically superior to coconut monocropping.
- Coconut-based high-density multispecies cropping systems (HDMSCS) involving many crops like banana, pineapple, clove and pepper was established.
- Three models of coconut based cropping systems with major emphasis on the cultivation of "spices" as inter crops are popularized as "Lakhi Baug" Scheme in Maharashtra State.
- Depending on the irrigation water potential available in the coconut gardens of maidan tract of Karnataka, the following intercrops are recommended for cultivation in coconut gardens.
  - ❖ Coconut + banana (High water requirement)
  - ❖ Coconut annual drumstick (Medium water requirement)
  - ❖ Coconut red gram (Low water requirement)
- The following models of Coconut Based Cropping Systems are recommended for different regions:
  - ❖ Chattisgarh: Coconut + black pepper + bottle gourd + cowpea
  - ❖ Assam: Coconut + black pepper + turmeric
  - ❖ West Bengal: Coconut + black pepper + pineapple
  - ❖ Coastal Tamil Nadu: Coconut + black pepper + banana + elephant foot yam + coriander
- Intercropping (of medicinal and aromatic plants) in coconut gardens with lemon grass (Cymbopogon flexuosus), garden rue (Ruta graveolens), thulsi (Ocimum sanctum), Kalmegh (Andrographuis paniculata), Arrow root (Maranta arundinaceae), and Makoi (Solanum nigrum) were found to be economically profitable and hence recommended for maidan tract of Karnataka.
- Mixed farming system including coconut, dairy, poultry, rabbitry, sericulture and pisciculture has been successfully demonstrated in coconut.
- Banana variety, Grand Naine was found to be a suitable intercrop for coconut gardens in littoral sandy soil with coir pith and husk as amendments.
- Using Remote Sensing and GIS map, coconut plantation area and coconut root (wilt) disease affected coconut palms were identified with > 98% accuracy.
- The physiological and biochemical basis of seedling vigour in coconut and its relationship to productivity was worked out.
- Coconut cultivars/hybrids were characterized based on fatty acid profiles for edible and industrial purposes.
- Shelf life of coconut oil can be enhanced by storing it in brown bottles, plastic cans or clay jars with preservatives like tamarind (2%), common salt (1%) or citric acid (0.05%).
- Coconut hybrids such as Keraganga, Chandralaksha, Kerasankara and talls like Chandrakalpa and West Coast Tall were identified as relatively drought tolerant compared to the other varieties and hybrids.
- Chandrasankara is found to be more susceptible to drought under sandy and sandy loam soil than laterite soils under rainfed condition.
- Prediction models to predict the nut yield in coconut were developed based on the weather data.
- Drought management practices such as husk burial and composted cor pith application were found to increase the nut yield under rainfed conditions.
- Integrated Pest Management schedule for major pest have been

evolved and popularized among the farming community.

- Integrated Disease Management package for root (wilt) disease, leaf rot disease, bud rot, stem bleeding, leaf blight and pencil point disease have been worked out.

14.2. Pre and post harvest technologies

- Buckling device or a coconut bunch support consisting of a GI strap to fix on the trunk and telescopic supports having GI pipes and rods costing Rs. 150/- was developed, to prevent dropping of heavy coconut bunches.
- Simple smoke free collapsible copra dryers have been developed in which about 1000 coconuts/batch can be dried in 24 hours. The cost of the dryer is in the range of Rs. 7000/- to Rs. 25000 depending on the capacity and the fuel used.
- A solar cum electric dryer with agriculture waste as third source of energy has been developed for copra drying with a capacity of more than 1500 nuts per batch at a cost of Rs. 50,000/-
- A technology for making snow ball tender nut (SBTN) from 8 months old coconut has been developed. Along with the process, a suitable machine has also been developed for making SBTN. The cost of the machine is Rs. 22,500/-.
- A portable snowball tendernut machine was developed by making improvement in earlier model.
- A technology for the production of sweet coconut chips has been developed, by the process of osmotic dehydration, with a shelf life of 6 months.
- A tender nut punch and a cutter has been developed at a cost of Rs. 1365/-.
- A process for production of coconut chips with different flavours, medicated, spicy as well as instant coconut chips by microwave oven has also been developed.
- A copra moisture meter has been developed to determine moisture content of copra, rapidly and accurately.
- An automatic irrigation system suitable for all high frequency irrigation systems has been developed at an approximate cost of Rs. 2000/-, excluding the cost of irrigation system.
- A safe coconut splitting device was developed.
- A check dam for storing run-off water during rainy season has been constructed using Ferro cement technology.
- The design for a farm pond lines with HDPE film with a storage capacity of 15 lakh liters of water has been developed.
- Automatic Pumping System to extract fresh water from skimming wells has been developed.
- A coconut grating machine has been prepared to grate the kernel after removal of the testa for the production of virgin coconut oil.
- A coconut testa removing machine has been developed.

15. Strategy for coconut development

The strategy for coconut development must be multifaceted and at the same time people centred with farm-households forming the target group. The primary objectives of such a strategy could be

- To create opportunities for enhanced on-farm income and employment.
- To promote efficient product and bye product utilization both at the on-farm and community levels.
- Utilize frontier science of genomics, bioinformatics and nano technology.
- To strengthen marketing infrastructure for domestic and export marketing and
- To direct research on varietal improvement for higher output of primary products from coconut and technology development.
- To promote organic farming in coconut.

16. Organic Farming

Cultivation of the coconut without any artificial/synthetic/ chemical input is being practiced in India by large number of farmers in different growing regions for several years. Invariably, most of such farms have high organic matter content to support satisfactory yield level. However in many cases, potassium level was observed to be low. In general, incidence of pests and diseases are minimal. In organically maintained farms, coconut palm had 35-40 leaves and produced 50-100 nuts per palm per year. Use of vermicompost and on-farm vermiculture, utilization of palm waste and growing of flowers like

marigold, tulsi (*Ocimum* sp.), a medicinal plant in plantations are common. Mixed cropping with cocoa, banana, black pepper etc. are also being practiced.

In Maharashtra, a farm has been maintained with a zero-tillage, as a natural farming for the past several years. The soil supports excellent natural flora and fauna and the average nut yield is 100 nuts per palm per year. As per the experience of the farmer, natural farming adopted by him not only improved the soil health and quality of nuts but also kept the environment free from pollution. Further, the cost of production was also minimal. However, some of the farms maintained under the natural conditions in West Bengal have poor productivity as no cultivation practices were followed. Several farms in Kerala have been maintained organically for the last 10-15 years. Fields in some of the farms are under drip irrigation, besides kitchen waste and other palm waste are utilized as a compost and plant based pesticides are used for the management of insects. After conversion to organic farming system, there has been an increase in the yield by 90% in a period of 6 years. Increase of yield in the coconut plantation by adoption of organic farming was invariably acknowledged by all the farmers. A survey on the organically grown farms of the coconut indicated that organic farming in coconut is a viable proposition. The findings from the survey are given below:

- Farmers are aware about the benefits of organic farming and the ill effects of chemical fertilizers.
- Irrigation plays a major role in deriving full benefits of organic farming. Though drip, sprinkler, basin or flood methods of irrigation can be adopted, drip irrigation is preferable. Moisture stress is lessened and water use efficiency can be increased through organic mulching.
- Farmers firmly believe that coconut based cropping system, use of organic manures, mulching and protective irrigation would keep the soil and crops in good health. This is supported by the healthy and vigorous conditions of the palms in many of the gardens.
- The research information available clearly indicates that there is coconut based farming system to meet full requirement of nitrogen and phosphorus as well as 50% of potassium requirement.
- Application of organic helps to improve physical characters and mircrobial properties of the soil.
- Coconut productivity can be maintained through organic culture. This is especially so because of the fact that coconut palms permit adequate sunlight and offer less root competition allowing very successful inter/ mixed cropping system. 19 to 27 tonnes of organic matter is produced per hectare of coconut based high density multispecies cropping system.
- In view of costly nature of chemical fertilizer input and deleterious effect of pesticides and fungicides on the ecosystem, it is advisable to go in for organic farming of coconut which should include use of bio-pesticies and bio-fertilizers.

With increasing consciousness for sustainability in agriculture, best option for certain regions, appears to be organic farming. This is a holistic production management system that promotes and enhances agro system health including agricultural bio-diversity, bio-cycles, soil and biological activities. The organic farming system also emphasizes upon the use of management practices in preference to use of off-farm input taking into account the regional conditions that require locally adapted system. Since coconut is cultivated by small farmers, they have limited access to knowledge about requirement of certified organic coconut production. They may face the market constraints with respect to premium price for organic produce. The weakness in adopting the organic farming system is limited knowledge or experience of organic production with a farmer participatory approach. However, there is an opportunity especially for the small holders where the chemical inputs are largely out of their reach and they can convert their weakness into the opportunity by converting the present production system or natural farming into organic farming.

17. Coconut: the way ahead

- The strategies to overcome the present discouraging trends in coconut sector suggest the need for further intervention to enhance technology adoption through the generation of technologies for different agro ecological situations.
- Integrated farming system with due emphasis on multi-tier cropping systems needs to be

promoted in different agro ecological situations.

- Implementations of coconut development schemes with the intention of increasing productivity of coconut and generate more income from coconut gardens are important.
- In the evolving trade liberalization regime, to sustain coconut cultivation as a profitable enterprize is extremely challenging. Hence the policies should focus more on competitiveness through higher productivity. One way to achieve this goal is through reduction cost of production or in other words, an increase in the net returns.
- Molecular characterisation of genetic resources will provide the basic data for effective utilization of available genetic resources in breeding programmes.
- Identification of molecular markers associated with quantitative traits will accelerate breeding programmes.
- Since coconut is a perennial crop and can act as a large carbon sequestration sink, it is essential to understand more about the cause-effects of climate change on coconut plantations with respect to the physiological efficiency of carbon sequestration, growth and yield.
- Product diversification of coconut and development of value added products become very much essential to derive maximum economic returns for the farmer and the industry.
- Developing economically and commercially viable processes for the production of virgin coconut oil and standardization of quality parameters would enable their large-scale production and higher export.
- A holistic approach for pest management integrating IPM and INM practices with the involvement of highly efficient bio agents, botanical pesticides, pheromones and bio fertilizers is imperative to achieve higher productivity.
- Extension efforts are to be further strengthened so that the impact is trickled beyond the vast area/ people interacted.
- Research-extension-farmer-market linkage needs to be improved to achieve faster dissemination of technologies.
- There is a need to utilize more efficiently the power of ICT tools including cyber extension programmes to develop linkages and faster sharing of information with and among the stakeholders in this vital sector.
- The future research areas in coconut should look into the use of bioinformatics, biotechnology, remote sensing, decision support system, precision farming and nanotechnology for developing technologies which can facilitate improving production of coconut in the country.
- The emerging challenges could be addressed effectively through utilization of tools like bioinformatics and biotechnology for better understanding and their utilization. Bioinformatics and biotechnology tools are to be employed for understanding the phytoplasma associated with coconut, development of databases on coconut germplasm, molecular marker data base and analysis tools such as "Phyloclass" for characterization of phytoplasma.
- In future, computational tools in coconut would aid in high-throughput sequencing data analysis of coconut genome, genomics assisted selection and mapping the resistance genes.
- Remote sensing technique using space borne sensors is a powerful tool for obtaining repetitive, synoptic observations on spectral directed towards obtaining thematic maps depicting coconut plantations inventory and statistics, which facilitate the appropriate interventions at disintegrated level of coconut plantations.
- The concept of developing Decision Support System (DSS) for coconut stress management and to deliver farmer friendly portal for accessing spatial DSS is an important thrust area for future research. An interactive computer-based system which help decision makers to use communication technologies, data, documents, knowledge and/ or models to identify and solve problems, complete decision process tasks and make decisions. DSS enables farmers to quickly analyse and compare alternative courses of actions or strategies under different uncertain developments or scenarios to demonstrate the impact of different options and alternatives.

Table 1. Trend in export and import value of coconut products (Rs. in lakh)

Year	Exoport Value of Coconut and its products	Export Value of Coir Products
1999-	1933.72	30305.35
2000-01	2742.18	31366.25
2001-02	2530	32058.33
2002-03	4189.77	35270.53
2003-04	4261.43	40749.66
2004-05	4474.27	47340.25
2005-06	4365.15	50844.74
2006-07	5120.01	60016.59
2007-08	6901.06	59288.08
2008-09	17980.5	6399.43
2009-10	44256.56	80305.22

- Development of animation based information system on cultivation practices of coconut for the farmer and extension personnel would be an innovative future research area, where such depictions would facilitate the quick and effective dissemination of technologies.
- Research on precision farming facilitates location specific need based application of resources to increase the nutrient use efficiency and increased productivity. This could be used for better management of pests and diseases also. The global satellite positioning systems and remote sensing devises facilitate research on precision farming.
- The emerging field of nanotechnology is creating impact on the agriculture development and could be applied in disease diagnositcs, smart delivery of nutrients, pesticides, bio-processing and post harvest technology. Nano particle approach will surely pave the way for sensitive diagnosis of coconut root (wilt) disease. Nano particles could be effectively used for the effective release of pesticides and pheromones. Smart packaging with nanotechnology approach for the coconut products such as tender coconut water, coconut meat and inflorescence sap could increase their shelf life.

Out look

Coconut palm, referred to as Tree of Life has served the mankind and has been integrated with socio-economic of coconut growing countries. Coconut oil which was most traded vegetable oil has declined in its contribution and is no more competitive with other cheaper oils. Product diversification effort have resulted into enhanced trading of coconut products and market for coconut product as health food is attracting the consumers across the globe. However, for many products like oleo chemicals are facing the competition with palm kernel oil. In the interest of environment, there is need to have coconut plantation which could only be sustained if its uses and health aspect is appropriately addressed. Evidences suggest that coconut especially virgin coconut oil, tender water and many products have capacity of protect against various disease. This aspect needs more intensive studies. We have succeeded in developing new cultivars, hybrids, production system management and also large number of products which require to be adopted and researched together in partnership mode. Coconut wilt is a cause of concern across the globe which has been proved to be caused through "phytoplasma". Should we not take this issue as global initiative. Efforts have also been made to understand the gene function but it has been in isolated manner which could not provide lead for settling the problem. There is thus, need to take up "genomics of coconut" in "consortia mode" for speedier results. Information could be of immense values for addressing the many issues including biotic and abiotic stresses. Now, it is time to think together, share the information, build the knowledge together to make coconut more productive to sustain the "Tree of Life" for the benefit of mankind.

Table 3. Production of different vegetable oil in India

Sl. No.	Oil Source	% in total consumption
1.	Palm oil	42.00
2.	Soy bean oil	18.00
3.	Rape seed oil	15.00
4.	Groundnut oil	8.00
5.	Cotton seed oil	8.00
6.	Sunflower	4.00
7.	Coconut oil	3.00
8.	Sesame oil	1.00
9.	Palm kernel oil	1.00
10.	Other oils	1.00

Table 2. Investment for Research and Development on Coconut

Plan Period	Investment in Development (CDB)	Investment in Research (CPCRI)		Total
		Plan	Non-Plan	
VI Plan	36.80	49.8	61.8	111.6
VII Plan	102.20	35.5	123.0	158.5
VIII Plan	714.30	71.1	222.6	293.7
IX Plan	1655.67	103.2	446.8	550.0
X Plan	1517.14	127.0	586.8	713.8
XI Plan	2020.0*	399.5	1272.6	1672.1

*Tentative plan allocation for 11 Plan is Rs. 370 crores, besides Rs. 478 crores sanctioned for Rejuvenation scheme.